No. 02

GOVERNMENT OF JAMAICA

FEASIBILITY REPORT
ON
THE MODERNIZATION AND EXPANSION
OF
THE RIO COBRE IRRIGATION SCHEME

VOLUME II
ANNEX REPORT

JUNE 1987

JAPAN INTERNATIONAL COOPERATION AGENCY

GOVERNMENT OF JAMAICA

FEASIBILITY REPORT
ON
THE MODERNIZATION AND EXPANSION
OF
THE RIO COBRE IRRIGATION SCHEME

VOLUME II
ANNEX REPORT

JUNE 1987

JAPAN INTERNATIONAL COOPERATION AGENCY

THE MODERNIZATION AND EXPANSION
OF
THE RIO COBRE IRRIGATION SCHEME

LIST OF VOLUMES

VOLUME I - MAIN REPORT

VOLUME II - ANNEXE REPORT

A. TOPOGRAPHIC SURVEY

B. METEOROLOGY AND HYDROLOGY

C. GEOLOGY AND HYDROGEOLOGY

D. SOILS AND LAND CAPABILITY CLASSIFICATION

E. SOIL MECHANICS

F. SOCIO-ECONOMY

G. AGRO-ECONOMY

H. AGRICULTURE

I. IRRIGATION AND DRAINAGE

J. ON-FARM DEVELOPMENT

K. PRELIMINARY DESIGN

L. PROJECT ORGANIZATION

M. IMPLEMENTATION PROGRAMME AND PROJECT COST

N. PROJECT EVALUATION

VOLUME III - DRAWINGS

DATA BOOK

ANNEX - A

TOPOGRAPHIC SURVEY

ANNEX-A

TOPOGRAPHIC SURVEY

TABLE OF CONTENTS

LIST OF TABLE

LIST OF FIGURE

1. GENERAL

1.1 Objectives of the Works

The objectives of the topographic survey were:

(1) To revise the 1 to 5,000 and 1 to 12,500 scale maps prepared by the Government of Jamaica in 1961 covering the project area, as necessary, and

(2) To carry out direct topographic survey such as cross section and profile survey and plane table survey of major structure sites.

1.2 Activities of the Works

The spot height survey and the detailed topographic surveys for major structure sites were carried from July to October 1986.

1.3 The Study Area

The study area is bounded by the mountain side on the north, by the seashore and Hellshire on the south, by the parish of St. Andrew and the seashore on the east, and the boundary of the parish of Clarendon on the west. Spanish Town, the capital of the parish, lies in the centre of the study area, and approximatelymately 14 km west of Kingston. The study area covers approximately 21,000 ha excluding urban, mangrove and rocky lands, sloping gently from north to south with micro-relief, ranging elevation from 3 m to 40 m above mean sea level.

2. IDENTIFICATION OF GROUND CONTROL POINTS

Prior to the field survey, a field reconnaissance was carried out in collaboration with Jamaican counterparts provided by the Survey Department to identify the national ground control points such as triangulation points and bench marks in the study area.

The location of the bench marks (B.M.) and temporary bench marks (T.B.M.) are shown in Fig. A-1. Table A-1 shows the elevation of all the bench marks and the temporary bench marks established during the field survey.

3. FIELD SURVEY

3.1 Direct Levelling

Direct levelling was executed in July and August 1986 in collaboration with Jamaican counterpart to set up the temporary bench marks which were the basis of detailed topographic survey.

The accuracy of the direct levelling was as follows:

(1) Closure of loop from B.M. to B.M. 10 mm $\sqrt{S}$
(2) Closure of loop with other T.B.M. 10 mm + 10 mm $\sqrt{S}$
where, $\sqrt{S}$ is length of running in km.

3.2 Topographic Surveys

Topographic surveys including plane table surveys, and cross-sectional and profile surveys were carried out from August to October 1986 to supplement existing maps at scales of 1 to 5,000, 1 to 12,500 and 1 to 50,000 as well as the aerial photos, at the following places and routes:

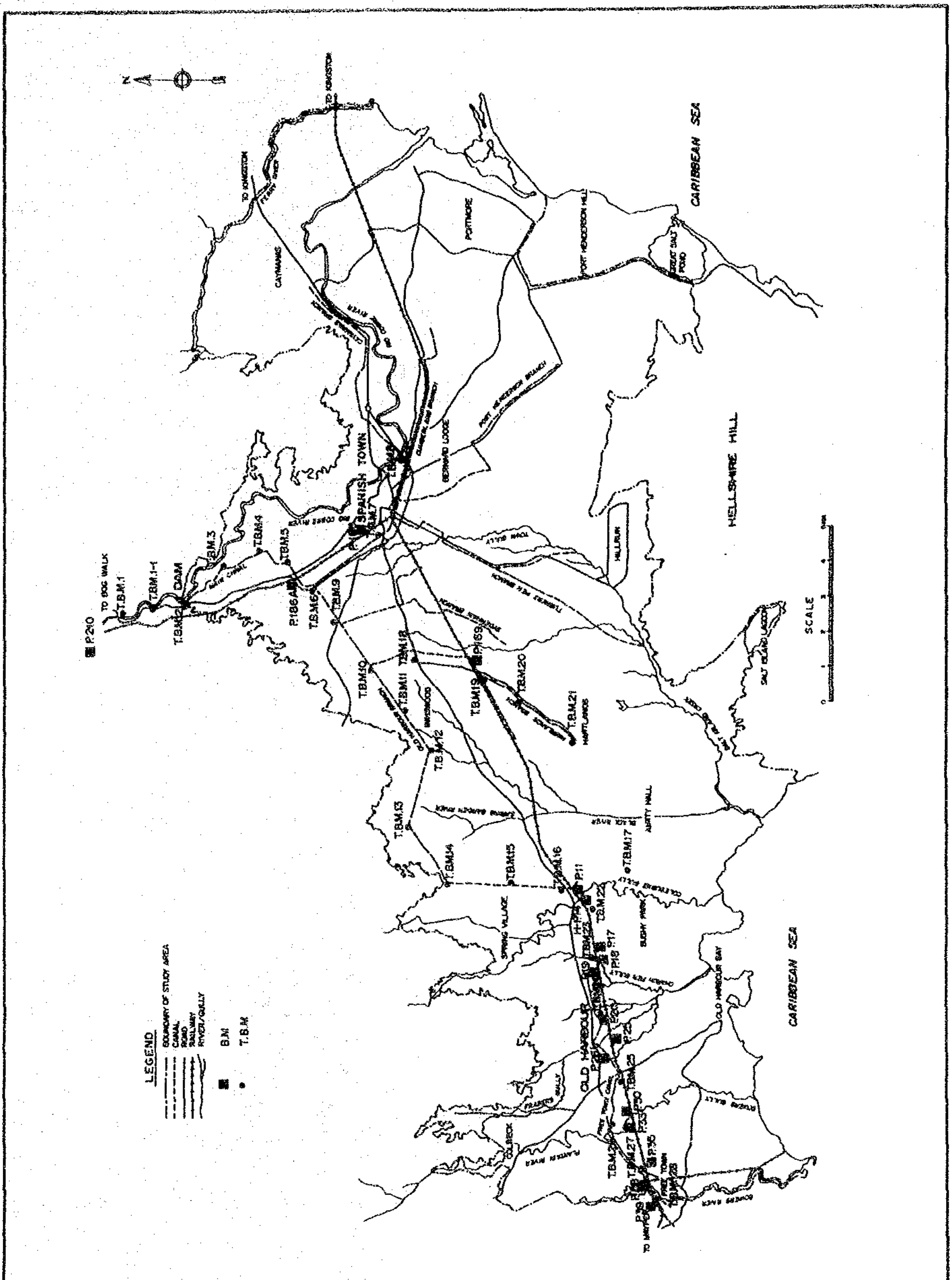
(1) Existing dam site (Plane table survey),
(2) Proposed alternative dam site (Plane table survey),
(3) Existing bifurcation (Plane table survey),
(4) Existing syphon site (Plane table survey),
(5) Reservoirs and ponds (Plane table survey),
(6) Upper stream of the Rio Cobre River (Profile and cross sectional levelling),
(7) Main canal (Profile and cross sectional levelling),
(8) Old Harbour branch canal (Profile and cross sectional levelling),
(9) Hartlands branch canal (Profile and cross sectional levelling),
(10) Pipeline and concrete flume of St. Dorothy Irrigation Authority (Profile and cross sectional survey),
(11) Existing and proposed drains (Profile and cross sectional levelling), and
(12) Typical on-farm development sites.

In addition to the above surveys, the proposed dam sites on Coleburns Gully and Plantain River were surveyed in September by means of direct levelling. All the results of the above works were utilized as basic data for preliminary design of the proposed structures.

Table A-1 SUMMARY TABLE OF BENCH MARKS

Name of B.M.	Elevation (m)
P. 11	15.257
P. 17	15.381
P. 18	13.899
P. 19	13.338
P. 20	14.229
P. 25	19.825
P. 26	21.171
P. 30	21.387
P. 33	21.505
P. 35	21.451
P. 38	29.030
P. 39	28.545
P. 169	20.172
P. 180	30.799
P. 186A	42.366
P. 210	106.067
H.P. 14	15.662

Name of T.B.M.	Elevation (m)
TBM - 1	44.358
TBM 1-1	47.035
TBM - 2	39.118
TBM - 3	46.177
TBM - 4	48.571
TBM - 5	44.102
TBM - 6	39.255
TBM - 7	27.672
TBM - 8	20.275
TBM - 9	36.688
TBM - 10	30.599
TBM - 11	26.244
TBM - 12	20.325
TBM - 13	18.305
TBM - 14	17.723
TBM - 15	18.143
TBM - 16	16.538
TBM - 17	12.140
TBM - 18	25.430
TBM - 19	19.190
TBM - 20	14.377
TBM - 21	10.702
TBM - 22	13.503
TBM - 23	16.620
TBM - 24	17.161
TBM - 25	23.164
TBM - 26	27.334
TBM - 27	21.586
TBM - 28	29.184



THE MODERNIZATION AND EXPANSION OF
THE RIO COBRE IRRIGATION SCHEME

Fig. A-1
LOCATION MAP OF BENCH MARKS

JAPAN INTERNATIONAL COOPERATION AGENCY

ANNEX - B

METEOROLOGY AND HYDROLOGY

ANNEX B

METEOROLOGY AND HYDROLOGY

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

1. INTRODUCTION

The study area is composed of alluvium from the Rio Cobre and small rivers and covers approximately 27,400 ha of which about 12,000 ha is presently irrigated by both the Rio Cobre Irrigation Scheme and the St. Dorothy Irrigation Scheme.

The Rio Cobre basin located in the center of Jamaica, lies within the Parish of St. Catherine. It is located between 76°49' and 77°10' west longitude and 17°53' and 18°14' north latitude. The basin is about 40 km in length in the east - west direction and about 45 km from north to south. It covers an area of approximately 1,180 km^2 and can be divided into two distinct parts, the Lower Rio Cobre basin in the south and the Upper Rio Cobre basin in the north. (see Fig. B-1) The area lies in the North East Trade Belt and has a tropical oceanic climate.

Tertiary White Limestone Formations predominate over 80% of the Rio Cobre basin and alluviums occupy the study area. The highly Karstic nature of the White Limestone Formations, i.e. close surface depressions, the absence of surface drainage and well developed sub-surface drainage, made definition of the exact position of the surface water boundaries uncertain.

The main focus of this Annex is the Lower Rio Cobre basin but the other sub-catchments which drain directly into the Lower Rio Cobre basin are also surveyed.

2. METEOROLOGY

2.1 Rainfall

2.1.1 Gauging station networks

There are 56 non-recording rainfall stations in and around the Rio Cobre basin as shown in Fig. B-1. All stations are registered with the Jamaica Meteorological Services (Ministry of Public Utilities, Communications and Transport) in Kingston. Field checks showed that most of the rainfall gauging stations were well maintained.

Rainfall is usually measured in the morning between 7:00 and 9:00 a.m., and is recorded as rainfall on the previous day. The observed data are recorded on pre-franked post cards and mailed to Kingston every month. Collected data are published as monthly totals by the Meteorological Services.

2.1.2 Rainfall record

Monthly rainfall data for all 56 non-recording stations were collected from the Jamaica Meteorological Services and the Underground Water Authority (Fig. B–2). Several stations were eliminated from the study because of significant instance of missing data.

Monthly rainfall data were available for 20 rainfall stations for the period 1932 to 1985. The reliability of these data were examined by double mass curve analysis. In this analysis accumulated rainfall of one station was plotted against the arithmetic mean of all 56 stations. These plots are shown together with the respective correlation factors as Fig. B-3.

Thirty-four rainfall stations were thus selected for inclusion in the water resources study. The average monthly rainfall for each of these stations are shown in Table B-1.

2.1.3 Rainfall data

The monthly rainfall histograms of representative stations show a bimodal peak in May and October (Fig. B-4). About 70% of annual rainfall occurs during the period from May to October. The dry season usually extends from December to March.

Area rainfall distribution in the Rio Cobre basin was studied by annual isohyets and shown in Fig. B-5. The rainfall in the north - eastern part of the basin with elevation in excess of 400 m, has more than 2,000 mm per annum, while the southern part has less than 1,000 mm. The rainfall in the Lower Rio Cobre basin decreases from north to south in accordance with decreasing elevation.

Thiessen polygons were established using 34 base stations referred to in the previous section. The polygon network is shown in Fig. B-6. The weighted factor of each station was estimated as shown in Table B-2. The annual rainfall in the Upper Rio Cobre basin was determined as 1,640 mm (65 in.) at Linstead, and 1,980 mm (78 in.) at Sligoville.

There are eighteen rainfall stations in the study area as shown in Table B-3. The monthly rainfall data of the three stations are shown in Table B-4 and seasonal distributions are shown in Fig. B-4. The average annual rainfall varies from 720 mm to 1,180 mm as shown in Table B-3.

2.2 Climate

2.2.1 Meteorological stations

Three meteorological stations are located in the study area, at Bernard Lodge, Bodles and Innswood 2 as shown in Fig. B-1. The Bernard Lodge Meteorological Station has been operated by Bernard Lodge Sugar Estate (B.L.E.) since 1937. It is situated on the centre of the study area. Daily data provided by B.L.E. are presented as monthly summaries on Fig. B-7. The Bodles Meteorological Station was established by Meteorological Division in 1969. It is situated within the St. Dorothy Irrigation Scheme. The Innswood 2 Meteorological Station is located on the northern part of the study area. The station has been operating since 1948. Of the three climatological stations, Bernard Lodge has the longest period of climatological data and is therefore used in the irrigation and agronomic studies of this project. The data from the other two stations were useful reference checks on the Bernard Lodge data.

2.2.2 Climate data

(a) Temperature

The study area as well as the island of Jamaica lies within the Trade Wind Belt and has a tropical oceanic climate. The mean annual temperature from 1931 to 1980 was 25.2°C (77.4°F) at Bernard Lodge and 24.9°C (76.8°F) at Bodles. From January to March, the climate is cool with a mean temperature 23.7°C (74.7°F); June to September being the warm season, having a mean temperature 26.5°C (79.5°F). The absolute maximum was recorded at 37.2°C (99°F) in July and absolute minimum was recorded at 11.7°C (50°F) in February. The monthly temperatures from 1967 to 1978 at Bernard Lodge are shown in Table B-5 and 60 years average monthly temperatures from 1931 to 1980 at Bernard Lodge and Bodles are shown in Table B-6.

(b) Humidity

The annual mean relative humidity from 1968 to 1980 at Bernard Lodge was 74% and 76% at Bodles, and the annual and diurnal range of humidity less than 20%. Evening through early morning is high while the afternoon is low. The monthly values of relative humidity at Bernard Lodge and Bodles are shown in Table B-7.

(c) Evaporation

Evaporation from Class A pan from 1967 to 1978 at Bernard Lodge averaged 5.14 mm/day, (1,877 mm/annum) and 5.5 mm/day (2,007 mm/annum) at Bodles from 1972 to 1980. The monthly evaporations at Bernard Lodge and Bodles are shown in Table B-8.

(d) Sunshine

The daily sunshine hours from 1967 to 1978 at Bernard Lodge averaged 8.0 hr/day. The monthly sunshine hours at Bernard Lodge are shown in Table B-9.

(e) Wind

The average daily wind run from 1954 to 1982 at Manley is about 15 km per hour (8.1 knots) and the wind direction of highest frequency is East-South-East (ESE). The monthly wind speed and wind direction at Manley are shown in Table B-10 and B-11.

3. SURFACE WATER HYDROLOGY

3.1 Streamflow

3.1.1 River morphology

The Rio Cobre Basin can be divided into two distinct parts, the Upper Rio Cobre basin in the north, and the Lower Rio Cobre basin in the south.

There are three major tributaries of the Rio Cobre above Bog Walk, these are the Rio D'oro, the Rio Pedro and the Thomas river. Of these, the Rio Pedro is the largest tributary, with an average annual flow of 1.7 m^3/s (61.3 C.F.S.) at the Harkers Hall gauging station.

The Rio Cobre flows in a well-defined channel through the limestone of the Bog Walk to Spanish Town gorge. From Spanish Town it flows in an easterly direction to Crawle Ford, then it turns southeast and flows into the sea at Hunts Bay. The length of the Rio Cobre from Bog Walk to the headwork, from headwork to Crum Ewing and from Crum Ewing to the mouth of a river are 8.3 km, 16.3 km, and 7.8 km, respectively, which is a total of 32.4 km.

Ferry river rises on or near the contact between the limestone and alluvium. It emerges north of the Caymanas swamp which has a well-sustained flow. The river is peculiar in its salinity that there is increased salinity with increased flow but this has not been verified. The high salinity may result from sea water intrusion.

The Mountain river rises in the impermeable Cretaceous area in the northwest near Juan de Bolas Peak and flows in a southeasterly direction. It is joined by the Crooked river above Watermount. The river disappears into its channel gravels during periods of low rainfall, between Watermount and Barry, where it is known as Worlds End Gully. During periods of greater rainfall, Worlds End Gully joins Faiths Gully, which further on continues to the sea as Coleburns Gully.

Spring Garden river emerges as a spring just north of Spring Village. Below Spring Village, the stream is joins the Black river, before reaching the sea.

The Myttin river rises in the impermeable Cretaceous area in the north near Bellfield and flows in a southernly direction. It joins the Cedar Gully at about 4 km above Colbeck. From its confluence it is known as the Plantain river, and changes the name to Bowers Gully before reaching the sea. During the periods of heavy rainfall, some runoff occurs.

3.1.2 Surface water catchments

(a) Upper Rio Cobre

The three major tributaries, the Rio d'oro, the Thomas river and the Rio Pedro join near Bog Walk where water level gauging station is located. The discharge from the Upper Rio Cobre basin is measured at a streamflow gauging station in the Rio Cobre at Bog Walk. The mean flow for the period from 1972 to 1973 was found to be 11.5 m^3/sec from a drainage area of 537 km^2 (207 sq. miles).

(b) Lower Rio Cobre

The St. Catherine Plain is bounded by the Red Hills in the east, Point Hill in the north, Harris Savanna in the west and Hellshire Hills in the south. It is composed with eight sub-catchments namely the Rio Cobre, the Ferry river, the Salt Island Creek, the Black river, the Coleburns Gully, the Frasers Gully, the Bowers Gully and the Clarendon Gully. Total catchment area is estimated at 645 km^2 (249 sq. miles) and catchment area of each river is shown in Fig. B-1.

The Rio Cobre and the Spring Garden river have a perennial flow but the other six rivers are seasonal.

3.1.3 Streamflow records

(a) Gauging station network

Eight automatic continuous recorders and four manual staff gauges are presently installed in the Rio Cobre basin. The location of gauging stations installed by UWA are shown in Fig. B-8 and Table B-12.

Discharge measurements carried out once or twice a month are used to develop rating curves at each station. These rating curves allow computation of mean daily flow from the continuous stage recorder data or water level measured twice a day by an observer.

The locations of staff gauges installed during this study on the Rio Cobre at Crum Ewing, the Spring Garden river at #2, the Coleburns Gully at Bridge on Spring Garden Road and Resources Spring, and the Plantian river at Colbeck are shown in Fig. B-8. Rating curves have also been developed for these gauging stations.

(b) Discharge records

Daily and monthly discharge records are available for the Rio Cobre Main Canal, near Spanish Town, Crum Ewing and Bog Walk stations. Data on two gauging station on the Main Canal and near Spanish Town are available from 1954 to 1985, and these stations are well maintained. Data on two remaining gauging station are only available, one for two years and the other for five years because of the recorders had been washed out by hurricane floods in 1973. The monthly mean discharge records are shown in Table B-13.

The reliability of the streamflow data recorded of Rio Cobre at Bog Walk, Crum Ewing and Dam Site were checked using double mass curve analysis. The analysis involved plots of discharge versus basin rainfall and the discharge of one station versus another station. These curves are shown as Fig. B-9. The results indicated that streamflow records for gauging stations at Bog Walk, Crum Ewing and Dam Site were of acceptable accuracy.

(c) Discharge data

Mean monthly discharge on the Rio Cobre at Main Canal and near Spanish Town station from 1954 to 1984 are presented below:

Month	Rio Cobre Main Canal (03BY002)		Rio Cobre near Spanish Town (03BA003)		Rio Cobre Headwork Station	
	(m^3/sec)	(cusec)	(m^3/sec)	(cusec)	(m^3/sec)	(cusec)
Jan.	4.69	165.6	3.03	107.0	7.80	275.5
Feb.	4.55	160.5	1.63	57.5	6.19	218.5
Mar.	4.41	155.6	1.03	36.5	5.51	194.4
Apr.	4.23	149.2	1.66	58.6	5.98	211.0
May	4.21	148.7	3.81	134.6	8.14	287.5
Jun.	4.24	149.8	8.33	294.2	12.99	458.7
Jul.	4.61	162.7	3.66	129.1	8.33	294.1
Aug.	4.76	168.2	3.62	127.7	8.42	297.2
Sep.	4.72	166.8	7.56	267.0	12.41	438.2
Oct.	4.21	148.5	14.13	499.0	18.32	646.9
Nov.	4.40	155.5	11.33	400.0	15.36	542.2
Dec.	4.57	161.2	6.02	212.5	10.54	372.0
Mean	4.47	157.7	5.48	193.6	10.00	353.0

The discharge of the Rio Cobre Main canal varied between 2.1 m^3/sec and 6.2 m^3/sec and the average discharge from 1954 to 1984 was 4.5 m^3/sec. The discharge of the Rio Cobre near Spanish Town from 1954 to 1984 varied between 0.3 m^3/sec and 26.7 m^3/sec and averaged 5.5 m^3/sec. Each station showed considerable fluctuation depending on the season and the lowest flow for the system was less than 2.0 m^3/sec at the Rio Cobre Main canal and 0.03 m^3/sec at the Rio Cobre near Spanish Town, respectively.

Annual average rainfall in the catchment upstream of the Bog Walk station was determined at 1,670 mm. Annual runoff coefficient for this catchment was computed at 0.32.

(d) Measurement of discharge

The measurements of discharges on the Rio Cobre at Bog Walk, Main canal, Rio Cobre near Spanish Town and Crum Ewing gauging stations, on the Spring Garden river #2, on the Coleburns Gully at bridge on Spring Garden Road and Resources Spring and the Plantain river at Colbeck using digital current meter were carried out in order to make a rating curve or to check the rating curves developed from past measurement. The results are shown on Fig. B-10 to B-16.

The measurement of discharge on the canal of St. Dorothy Irrigation Authority were also carried out in this study in order to determine the loss along the woodenstave pipeline, which carries water from the well at Freetown (Palmetto A and B) to the canal at Bodles. The average discharge on the canal at Bodles between August and October 1986 was measured as 0.305 m^3/sec, and the discharge pumped up from the well (Palmetto A and B) were estimated as 0.341 m^3/sec based on the data obtained from UWA. The loss along the woodenstave pipeline, accordingly, was estimated as 0.036 m^3/sec (3,110 m^3/day).

The measurements of seepage through the foundations of the existing headworks were carried out in order to confirm the need for rehabilitation of the foundations. The results of four measurements were as follows:

(Unit: m^3/sec)

Date	Discharge at Dam Site	Discharge near Spanish T Gauging Station	Seepage Discharge
	(Q1)	(Q2)	(Q3=Q1-Q2)
17/9/86	5.22	5.10	0.12
25/9/86	6.63	6.53	0.10
8/11/86	5.58	5.38	0.20
12/11/86	4.52	4.37	0.15

From above result the seepage through the foundation of the headworks were estimated as 0.1 m^3/sec to 0.2 m^3/sec.

3.1.4 Study of the rating curves

(1) Rating curves at Rio Cobre Main Canal

(a) Observed data of discharge and water level

Measurement of discharge and water level were carried out at Rio Cobre Main Canal 414 times between 1954 and 1985, about 13 times a year on average (Fig. B-10). In the early years, very consistent and reliable flow was observed. Since 1982, however, discharge and water level tend to decrease because of siltation, and in later years, with excessive weed growth.

(b) Existing rating curve

The rating curves were reviewed every two or three years based on observed discharge and water level data. Daily discharges were computed from the revised rating tables. The existing rating curves prepared by the Underground Water Authority (UWA) in 1978 are shown in Fig. B-10. The daily discharge since 1979 is calculated by using rating curve No.2.

(c) Verification of existing rating curve

Verification of rating curve No. 2 as presently used, was based on discharge and water level data from 1979 to 1981 (Fig. B-10). These data give almost the same values as data obtained from 1954 to 1978. The following formula was obtained by using the least square method.

$$Q = 6.87\ H^{2.04}$$

From Fig. B-10 it is seen that the rating curve No. 2 is almost identical with the new one. Therefore, it is possible to use the rating curve No. 2 in order to calculate the daily discharge up to 1981.

As the discharge and water level data after 1982 do not fall on the rating curve No. 2, it is necessary to make a new rating curve. The rating curve formulas for 1982 and 1983 to 1985 were computed as follows, based on the observed data:

$$Q = 29.48\ H^{0.85} \quad (1982)$$
$$Q = 30.71\ H^{0.65} \quad (1983 \text{ to } 1985)$$

The daily discharge calculated with these formulas is shown in Table B–13.

(2) Rating curves at Rio Cobre near Spanish Town

(a) Observed data on discharge and water level

The measurements of discharge and water level were carried out on the Rio Cobre near Spanish Town 440 times between 1954 and 1985, 15 times a year. The data obtained are shown in Fig. B-11.

(b) Existing rating curves

The rating curves were reviewed every two or three years based on the observed discharge and water level data, and daily discharge was computed with revised rating tables. The existing rating curves prepared by the Underground Water Authority in 1973 are shown in Fig. B-11. The daily discharge since 1969 was calculated by using rating curve No. 5.

(c) Verification of existing rating curve

Verification of rating curve No. 5 as presently used, was based on the discharge and water level data from 1954 to 1985 (Fig. B-11). The present rating curve was calculated by the least square method using 37 selected data out of measurements numbered 194 to 247. The rating curve formula is as follows:

$$Q = 20.04\ (H-2.00)^{2.65}$$

The rating curves for former periods were calculated and prepared separately by using discharge and water level data from 1954 to 1978, and from 1979 to 1985, respectively. The formulae calculated by the least square method were as follows:

$$Q = 17.66\ (H-2.00)^{2.75} \quad (1954\ \text{to}\ 1978)$$
$$Q = 23.88\ (H-2.00)^{2.47} \quad (1979\ \text{to}\ 1985)$$

From Fig. B-11, it is seen that the present rating curve No. 5 is almost identical with both of these curves. Therefore, it is acceptable to calculate the daily discharge up to 1985 using rating curve No. 5.

(3) Rating curve for the Rio Cobre at Bog Walk

(a) Observed data of discharge and water level

Twenty nine (29) measurements of discharge were carried out on the Rio Cobre at Bog Walk between March and October 1986. The data obtained are shown in Fig. B-12.

(b) Rating curve

The rating curves were calculated separately using discharge and water level data from March to June, and from July to October, because the different discharges were observed even at the same water level after the big flood which occurred in June 1986. The formulae calculated by the least square method were as follows:

$$Q = 14.20\ H^{2.62} \quad (\text{March to June 1986})$$
$$Q = 89.93\ H^{1.90} \quad (\text{July to October 1986})$$

(4) Rating curve for the other staff gauge stations

The rating curves for the other staff gauge stations such as Rio Cobre at Crum Ewing, the Spring Garden river #2, the Coleburns Gully at the bridge on Spring Garden Road and Resources Spring are shown in Fig. B-13 to B-16. These rating curves were developed tentatively using a few data obtained between July and October 1986. The formulae calculated by the least square method were as follows:

Station	Rating Curve
1. Rio Cobre at Crum Ewing	$Q = 71.69\ (H-18.0)^{1.90}$ (c.f.s.)
2. Spring Garden River #2	$Q = 6.69\ (H-10.0)^{1.70}$ (c.f.s)
3. Coleburn Gully at bridge on Spring Garden Road	$Q = 7.71\ (H-0.08)^{1.79}$ (m^3/s)
4. Coleburns Gully at Resources Spring	$Q = 213\ H^{5.59}$ (m^3/s)

3.2 Stream Water Quality

3.2.1 Water quality analyses

Chemical analyses were carried out on samples of the Rio Cobre, the Spring Garden river and the Coleburns Gully. Sampling locations are shown on Fig. B–8. The results of these analyses are summarized in Table B-14.

3.2.2 Sediment load

Surface run-off originating on the Upper Rio Cobre Basin contributes to the suspended load on the Rio Cobre. Suspended load analyses carried out in this study for the Rio Cobre as well as the Spring Garden river and Coleburns Gully were included in Table B-14. The data obtained so far are insufficient for estimating sediment load transported from upstream, further investigations and measurements of sediment load are required particularly in the flood stage.

4. WATER RESOURCES STUDY

4.1 Probable Minimum Rainfall

Using the rainfall data, the probable minimum annual rainfall for thirteen rainfall stations are analysed for 2-year, 5-year, and 10-year events by the IWAI method.

Irrigation planning required knowledge of the distribution of rainfall as well as annual rainfall. A bimodel peak in May and October is observed in the study area as mentioned in previous sections. A monthly rainfall record for each year of data period was extracted and the results were subjected to frequency analysis. The probable minimum monthly rainfall at Bernard Lodge is calculated as 772 mm, 533 mm and 437 mm in 2–year, 5-year and 10-year return period respectively are shown in Table B-15.

4.2 Probable Low Flow

Irrigation water of the study area is mainly diverted from the Rio Cobre at the Dam Site. Using the discharge data on the Rio Cobre at the Dam Site, the mean annual low discharge frequency as well as monthly low discharge frequency are analysed for 2-year, 5-year, and 10-year events by the IWAI method. The minimum 5-year annual discharge was assessed to be 6.5 m^3/sec as shown in Table B-16 (Fig. B–17).

The minimum and 360 day dependable daily mean discharge in a year were studied for each year of data for the river, and the results were subjected to frequency analysis. The minimum 5-year, minimum and 360-day low flows, were assessed to be 2.7 m^3/sec and 3.0 m^3/sec as shown in Table B-16 (Fig. B-17).

4.3 Available Discharge

Irrigation water is mostly diverted from the Rio Cobre at the Dam Site and conveyed through main and branch canals. At main canal capacities of 8.0 m^3/sec, 10.0 m^3/sec and 12.0 m^3/sec average available discharges were estimated accordingly. These results based on gauged daily discharges from 1955 to 1983, may be summarized as follows:

(Unit: m^3/sec)

Month	Peak Capacity of the Main Canal			
	8.0 m^3/sec	10.0 m^3/sec	12.0 m^3/sec	unlimited
Jan.	6.50	6.99	7.21	7.80
Feb.	5.91	6.06	6.11	6.19
Mar.	5.28	5.36	5.40	5.51
Apr.	5.21	5.37	5.52	5.98
May	5.92	6.32	6.60	8.14
Jun.	6.40	7.14	7.72	12.99
Jul.	6.11	6.71	7.09	8.33
Aug.	6.43	7.13	7.52	8.42
Sep.	7.05	8.18	8.99	12.41
Oct.	7.44	8.82	9.97	18.32
Nov.	7.17	8.42	9.44	15.36
Dec.	6.54	7.48	8.09	10.54
Mean	6.33	7.00	7.47	10.00
Volume (million m^3)/year	200	221	236	315

4.4 Suitability of Water Quality

The water of the Rio Cobre at the point proposed for diversion is classified as C2-S2 according to the standards of the United States Department of Agriculture. This classification indicated excellent water quality for irrigation with respect to alkalinity and salinity.

5. FLOOD STUDY

5.1 Basic Concepts

Flood records are available for the Rio Cobre at the Dam Site from 1955 to 1984. It is very risky however to use such data for the main structure without cross checking with results obtained by other methods. A rating curve is generally developed from the results of discharge measurements during medium or low flow periods from which the peak discharge can be extrapolated. Records of more than 20 to 30 years are usually needed for a reliable frequency analysis since the return period of design flood for a main structure is currently taken as about 100 years.

Accordingly, the probable flood had to be estimated from probable rainfall of which the recording period was longer than that of runoff. In this study, the unit hydrograph method was employed for the conversion of rainfall into runoff and the estimated flood discharge was compared with that derived from the records to determine the design flood discharge.

5.2 The Rio Cobre

5.2.1 Flood records

Flood records are available since 1955. An automatic water level recorder has been operated at the dam site since 1955. The annual maximum peak discharges estimated from peak water levels vary from 30 m^3/sec to 1,300 m^3/sec. as shown in Table B–17.

Frequency analysis was made by the IWAI method, the Hazen method, the Gumbel method and the Chow method. The results analysed by the IWAI method were almost identical with the results calculated by the other methods. The resulting frequency data and curves are plotted on log-frequency paper as shown on Fig. B–18 and the results analysed by the IWAI method are shown below:

Return Period	Peak Discharge	
(Year)	(m^3/sec)	(c.f.s)
2	167	5,900
5	378	13,300
10	583	20,600
50	1,251	44,200
100	1,640	58,000

5.2.2 Probable maximum rainfall

Major floods on the Rio Cobre occur due to more than two days of continuous rainfall as shown in Table B-18. Accordingly, two days continuous rainfall is adopted to estimate the design peak flood discharge.

Using four rainfall stations data, namely Above Rocks, New Hall, Linstead and New Works Farm, recorded annual one day, two days, and three days continuous rainfall on each station are calculated from the daily rainfall records as shown in Table B-19. The probable annual two days rainfall are estimated by the IWAI method for each station. The arithmetic mean of these is adopted for estimation of the probable peak flood discharge. The results are shown below:

(Unit: mm)

Return Period	2	5	10	30	50	100
Above Rocks	133	227	307	454	531	648
New Hall	103	171	231	345	408	503
Linstead	145	256	349	517	606	740
New Works Farm	141	228	297	418	480	571
Average	131	221	296	434	506	616

5.2.3 Flood hydrograph analysis

(1) Unit hydrograph

Taking into account the availability of runoff and rainfall records, the unit hydrograph method may be appropriate for the present flood study. Fig. B-19 shows the representative major flood hydrographs observed at dam site, which includes the largest flood which occured in June, 1966.

These four flood hydrographs are converted into the dimensionless ones as shown on Fig. B-20. Judging from the shape of these hydrographs though there is no great difference, the hydrograph of June 1966 is adopted for the present study. From this dimensionless hydrograph, the unit hydrograph is derived defining the flood concentration time and the effective rainfall.

(2) Flood concentration time

The flood concentration time is found by summation of the time required for a flood to flow out into the river course from the furthest point in the catchment area and the time required for flood to flow down through the river course up to the point to be considered. Several empirical formulae have been proposed for the estimation of the flood concentration time. Most of these, however, are only valid in the specific region where they were developed. For example, the flood concentration time is estimated at 2.5 hr by Ruziha's formula as shown below:

$T = L/(72(H/L)^{0.6})$

where, T = flood concentration time in hr,
L = ength of river course in km (17.5 km), and
H = difference of elevation between the point to be considered and furthest point in km (0.35 km)

Judging from the observed hydrograph, 2.5 hr of flood concentration time is too short. From observation, it is obvious that a peak flood discharge is usually caused by the rainfall on the previous day on the Rio Cobre. The flood concentration time is therefore assumed to be 7 hr for the present study.

(3) Effective rainfall

The effective rainfall is that part of total rainfall, from which surface runoff is derived. The total amount of surface runoff of the major floods and areal rainfall were estimated from the recorded hydrograph shown on Fig. B-19. The total catchment area of the Rio Cobre is 578 km^2 at the dam site.

Flood Time	6/10/58	31/5/63	28/6/66	22/10/74
Surface runoff (million)	46.6	15.9	46.5	10.3
Areal rainfall Date	4-5	30-31	26-27	21-22
Rainfall (mm)	180	189	335	100
Volume (million)	104.0	109.2	193.6	57.8
Effective ratio (%)	45	15	24	18

Taking into consideration that the annual coefficient is estimated at 0.32 in Section 4.1.3, though the above results have large dispersion, the effective ratio was assumed to be 0.5 in this study.

As the flood concentration time and effective ratio are given, the dimensionless hydrograph can be converted into a unit hydrograph for a unit effective rainfall depth of 1 mm.

(4) Hyetograph

In order to determine a rainfall pattern for design, observed hyetograph of major storm rainfalls are necessary. As there is no automatic rainfall recorder in this area, the following formula is employed to estimate the rainfall intensity.

$t = R_{24}/R_t \times (t/24)^k$

where, R_t = rainfall intensity during t hr (mm/hr),
R_{24} = rainfall during 24 hr (mm),
t = time in hr, and
k = coefficient (1/2)

The above equation is extrapolated to apply to the probable two days rainfall in this study.

(5) Probable flood hydrograph

Using the unit hydrograph constructed and the assumed hyetograph from the previous sections, the probable flood hydrographs with return periods of 100-year and 50-year were obtained as shown in Fig. B-21.

(6) Design flood

The estimated flood discharge by the unit hydrograph and the one derived from the records may be compared as shown below:

(Unit: m^3/sec)

Return Period	50	100
the unit hydrograph	1,170	1,570
the frequency analysis of the records	1,251	1,640

The data period for flood records is similar to the period of rainfall records. The unit hydrograph method in this study necessitated many assumptions due to the shortage of data. Taking the above conditions into account, the design flood discharge on the Rio Cobre at the dam site was taken to be 1,251 m^3/sec and 1,640 m^3/sec for 50-year and 100-year return periods respectively.

5.3 The Coleburns Gully

5.3.1 Flood records

Flood records are available only for the period between August and November 1986. A staff gauge was installed in August 1986 at the bridge on Spring Garden Road. Annual maximum discharge in 1986 was estimated at 110 m^3/sec with a catchment area of 87.3 km^2 based on flood marks.

5.3.2 Probable maximum rainfall

A major flood which occurred on the Coleburns Gully was due to one day's rainfall because the catchment area of this Gully is less than one sixth compared with that of the Rio Cobre. For that reason, one day's rainfall was adopted in estimating the design peak flood discharge.

The records of rainfall at Old Harbour rainfall station which is located in the southern part of the catchment area is useful for calculating the probable maximum rainfall. The probable annual one day rainfall was estimated by the IWAI method for this station. The results are shown below:

(Unit: mm)

Return Period	2-year	5-year	10-year	30-year	50-year	100-year
Old Harbour	91	136	169	225	252	291

5.3.3 Flood hydrograph analysis

(1) Unit hydrograph

Taking into account the availability of runoff and rainfall records, the unit hydrograph method was considered suitable for the present study. Judging from the flood records, the triangular unit hydrograph method was adopted for the present study.

(2) Flood concentration time

Flood concentration time was estimated at 5 hr by Ruziha's formula as shown below:

$$T = L/(72(H/L)^{0.6})$$

where, T = flood concentration time in hr,
L = length of river course in km (33.6 km), and
H = difference of elevation between the point to be considered and furthest point in km (0.72 km).

The recession time was taken as three times the flood concentration time judging from the flood records.

(3) Effective rainfall

The effective ratio was assumed to be 0.5 by the same method as performed for the Rio Cobre.

(4) Hyetograph

As there is no automatic rainfall recorder in this area, the following formula was employed to estimate the rainfall intensity.

$$t = R_{24}/R_t \times (t/24)^k$$

where, R_t = rainfall intensity during t hr (mm/hr),
R_{24} = rainfall during 24 hr (mm),
t = time in hr, and
k = coefficient (1/2)

(5) Design flood discharge

Using the triangular unit hydrograph described in the previous sections, values of the design flood discharge in a return period of 100 years, 50 years, 30 years, 10 years and 5 years were obtained as shown below:

(Unit: m^3/sec)

Return Period	5-year	10-year	30-year	50-year	100-year
Design Flood Discharge	70	95	152	189	248

5.4 The Plantain River

5.4.1 Flood records

Flood records are available only for the period between August and November 1986. A staff gauge was installed in August 1986 at Colbeck. Annual maximum discharge in 1986 was estimated at 65 m^3/sec with a catchment area of 31.5 km^2 based on flood marks.

5.4.2 Probable maximum rainfall

A major flood which occurred on the Plantain river was due to one day's rainfall because the catchment area of this river is very small comparing with that of the Rio Cobre. Accordingly, one day's rainfall was adopted to estimate the design peak flood discharge.

The records of rainfall at Old Harbour rainfall station which is located in center of this catchment area were useful to calculate the probable rainfall. The probable annual one day's rainfall was estimated by the IWAI method for this station. The results are shown below:

(Unit: mm)

Return Period	2-year	5-year	10-year	30-year	50-year	100-year
Old Harbour	91	136	169	225	252	291

5.4.3 Flood hydrograph analysis

(1) Unit hydrograph

Taking into account the availability of runoff and rainfall records, the unit hydrograph method was considered suitable for the present study. Judging from the flood records, the triangular unit hydrograph method was employed for the present study.

(2) Flood concentration time

Flood concentration time was estimated at 2 hr by Ruziha's formula as shown below:

$$T = L/(72(H/L)^{0.6})$$

where, T = flood concentration time in hr,
L = length of river course in km (14.6 km), and
H = difference of elevation between the point to be considered and farthest point in km (0.47 km).

The recession time was taken as three times the flood concentration time judging from the flood records.

(3) Effective rainfall

The effective ratio was assumed to be 0.5 by the same method as performed for the Rio Cobre.

(4) Hyetograph

As there is no automatic rainfall recorder in this area, the following formula was employed to estimate the rainfall intensity.

$$t = R_{24}/R_t \times (t/24)^k$$

where, R_t = rainfall intensity during t hr (mm/hr),
R_{24} = rainfall during 24 hr (mm),
t = time in hr, and
k = coefficient (1/2)

(5) Design flood discharge

Using the triangular unit hydrograph described in the previous sections, values of the design flood discharge in a return period of 100 years, 50 years, 30 years, 10 years and 5 years were obtained as shown below:

(Unit: m^3/sec)

Return Period	5-year	10-year	30-year	50-year	100-year
Design Flood Discharge	26	49	77	100	146

6. IMPACT OF THE LOWER RIO COBRE DEVELOPMENT

6.1 Impact on Irrigation and Drainage

A specific agricultural modernization and expansion plan for both the Rio Cobre Irrigation Scheme and the St. Dorothy Irrigation Scheme is proposed for a 14,620 ha study area. The study area will be irrigated by both surface water which is diverted from the Rio Cobre and groundwater.

At this stage, it is possible only to provide qualitative indicators of the likely impact of the proposed irrigation and drainage system on the hydrology of the Lower Rio Cobre basin.

6.2 Impact on Streamflow

Since 1874, the Rio Cobre has provided irrigation and municipal water to beneficiaries in the Lower Rio Cobre basin through the present irrigation scheme. The total water diverted at present is about 108 million m^3 (88 thousand acre ft.) per year which is about one third of the average annual flow of 315 million m^3 or about 47% of annual flow with 20% chance of occurrence. This means that more than 60% of the runoff is wasted to the sea every year.

As the results of the water balance study made in Annex-I show, the design capacity of the main canal should be 9.63 m^3/sec after implementation of the Project. The future average annual inflow from the Rio Cobre to be diverted to the St. Catherine Plains will be approximately 315 million m^3 in an average year and about 221 million m^3 in drought years with a twenty (20)% chance of occurrence. This represents a more than doubling of available surface water in comparison with the present availability and tremendous benefits to the St. Catherine Plains. Even if the whole of the available surface water were to be diverted to the main canal for irrigation, there would be no adverse impact on downstream flow as there are no water rights for irrigation or any other purposes below the existing dam.

6.3 Water Quality

The study area will be irrigated by both surface and ground water as described in previous sections. Under present conditions, it is considered that the water quality is quite suitable for irrigation as regards alkalinity and salinity, as shown by the results of water quality analysis. It is necessary nevertheless to monitor the quality of groundwater as increasing use is made of fertilizer within the study area especially in view of the tremendous use of groundwater when surface water is limited during a drought year. The same will apply to the need to monitor the effects on groundwater of the use of pesticides and other toxic chemicals if used on a large scale.

REFERENCES

(1) Development and Management of Water Resources, Jamaica, Rio Cobre Basin (1974), UNDP and FAO
Annex I - Geology
Annex II - Water Resource Appraisal
Annex III - Water Quality
List of Table
List of Plates

(2) South East St. Catherine Water Supply Survey Water Resources Study, Summary of Final Report (1972), Government of Jamaica
Final Report (1972) GOJ

(3) Sugar Industrial Studies, Irrigation, Phase II Review (1985) MOA

(4) Weather Report 1967 to 1970, Meteorological Division

(5) Monthly Streamflow Data for Jamaica, Water Resources Division, MLG (1980)

(6) Streamflow Data for Hydrometric Station 1955 to 1970, MLG (1982)

(7) Water Resources Development Master, Plan, Jamaica (1985), UNDP
Report 1 : Water Resources Inventory
Report 2 : Water Demand Inventory

Table B-1 AVERAGE MONTHLY RAINFALL (1931 - 1985)

(Unit: mm)

No.	Station	Jan.	Feb.	Mar.	Apr.	May.	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Total
1	Harmony Pen	24	27	28	31	83	102	10	98	105	165	93	40	806
2	March Pen	24	29	21	40	88	72	29	72	104	181	76	37	773
3	Half Way Tree	18	25	27	40	82	70	34	72	90	182	82	32	754
4	Bernard Lodge	21	26	23	42	92	78	35	80	100	187	98	38	820
5	Spanish Town	28	38	34	53	129	88	40	103	112	197	99	44	965
6	Hartlands 1	41	26	41	58	86	87	28	77	132	135	72	50	833
7	Amity Hall	51	16	38	69	82	76	36	58	59	120	82	48	735
8	Smallwoods	29	15	26	44	92	61	17	89	92	146	74	36	721
9	Innswood 5	37	35	27	61	68	45	28	90	90	145	73	61	760
10	Innswood 1	32	36	37	55	120	94	45	83	131	207	108	59	1,007
11	Warwick Castle 2	34	40	37	64	126	88	41	80	145	209	90	54	1,008
12	Innswood 2	39	35	42	64	125	89	42	87	134	244	100	54	1,055
13	Old Harbour	46	46	53	67	141	105	53	131	146	223	118	54	1,183
14	Bodles Rose Hall	34	51	55	61	70	50	32	116	102	151	66	52	840
15	Farm 2	26	32	25	43	109	81	53	72	119	193	84	41	878
16	Caymanas C.	30	34	33	60	127	89	53	100	126	223	106	53	1,034
17	Lagoon	24	30	34	50	119	90	62	107	130	224	106	52	1,028
18	Dawkins	24	37	28	46	99	80	50	79	110	178	83	40	854
19	Sligoville	59	66	69	131	231	185	174	246	251	318	167	85	1,982
20	Bellas Gate	45	62	72	103	185	128	117	189	210	326	139	76	1,652
21	Point Hill	83	65	88	104	249	187	160	217	215	340	176	90	1,974
22	Above Rocks	58	48	64	126	256	176	157	236	270	317	205	96	2,009
23	Glengoffe	78	57	61	137	233	183	152	249	241	268	197	133	1,989
24	New Hall	47	53	54	100	194	174	166	188	181	220	116	79	1,572
25	Enfield	65	61	58	115	191	189	159	171	173	208	138	94	1,622
26	Bog Walk	64	45	52	98	209	166	146	210	171	273	114	51	1,599
27	Bybrook	52	65	53	98	191	171	139	178	186	240	114	76	1,563
28	Wakefield	43	63	60	102	173	175	140	167	174	248	113	77	1,535
29	Linstead	52	50	57	105	211	191	170	186	186	236	122	76	1,642
30	New Works Farm	48	49	56	97	202	189	175	189	187	211	129	76	1,608
31	Ewarton	49	51	53	78	188	167	120	140	155	222	105	69	1,397
32	Worthy Park	53	54	50	79	187	165	113	157	172	245	124	68	1,467
33	Rio Magno	109	76	70	122	240	184	163	206	178	245	214	172	1,979
34	Angels	30	38	52	82	119	95	84	128	198	202	110	74	1,212

Table B-2 WEIGHTED COEFFICIENT OF THIESSEN POLYGONS

(Unit:%)

No.	Rainfall Station	Rio Cobre at Bog Walk (537 km2)	Rio Cobre at dam site (578 km2)	Rio Cobre at Crum Ewing (636 km2)	Spring Garden River at #2 (32.7 km2)	Coleburns Gully at bridge (87.3 km2)	Plantain River at Colbeck (31.5 km2)
1	Harmony Pen	-	-	-	-	-	-
2	March Pen	-	-	-	-	-	-
3	Half Way Tree	-	-	0.3	-	-	-
4	Bernard Lodge	-	-	0.2	-	-	-
5	Spanish Town	-	-	2.6	-	-	-
6	Hartlands 1	-	-	-	-	-	-
7	Amity Hall	-	-	-	-	-	-
8	Smallwoods	-	-	-	-	-	-
9	Innswood 5	-	-	-	20.3	14.5	-
10	Innswood 1	-	-	-	-	-	-
11	Warwick Castle 2	-	-	-	-	-	-
12	Innswood 2	-	-	-	79.7	11.1	-
13	Old Harbour	-	-	-	-	0.3	5.3
14	Bodles Rose Hall	-	-	-	-	-	18.2
15	Farm 2	-	-	-	-	-	-
16	Lagoon	-	-	-	-	-	-
17	Dawkins	-	-	0.9	-	-	-
18	Caymanas C.	-	-	2.1	-	-	-
19	Sligoville	5.4	6.7	6.8	-	-	-
20	Bellas Gate	-	-	-	-	33.9	76.5
21	Point Hill	6.0	5.6	5.1	-	32.2	-
22	Above Rocks	7.1	6.6	6.0	-	-	-
23	Glengoffe	7.2	6.8	6.1	-	-	-
24	New Hall	5.1	4.8	4.3	-	-	-
25	Enfield	8.0	7.4	6.7	-	-	-
26	Bog Walk	2.3	4.1	3.7	-	-	-
27	Bybrook	1.8	1.6	1.5	-	-	-
28	Wakefield	5.5	5.1	4.6	-	-	-
29	Linstead	2.7	2.5	2.3	-	-	-
30	New Works Farm	2.6	2.4	2.2	-	-	-
31	Ewarton	12.0	11.2	10.1	-	-	-
32	Worthy Park	21.5	20.0	18.1	-	-	-
33	Rio Magno	12.8	12.0	10.8	-	-	-
34	Angels	-	3.2	5.6	-	8.0	-
	Total	100.0	100.0	100.0	100.0	100.0	100.0

Table B-3 AVERAGE ANNUAL RAINFALL RECORDS IN THE STUDY AREA

Station No.	Station Name	Location		Altitude	Period of	No. of Complete	Average Annual
		Latitude	Longitude	(m)	Record	Years	Rainfall(mm)
179769690	Harmony Pen	17-55-24	76-59-53	8	1969-1981	8	806
179769770	March Pen	17-57-02	76-56-48	15	1937-1985	29	773
179769850	Half Way Tree	17-58-24	76-54-29	18	1937-1985	31	754
179769860	Bernard Lodge	17-58-12	76-55-48	17	1937-1985	36	820
179769971	Spanish Town	17-59-28	76-57-03	30	1901-1985	71	965
179770660	Hartlands 1	17-56-23	77-01-30	9	1969-1981	11	833
179770670	Amity Hall	17-55-45	77-02-52	12	1969-1980	6	735
179770750	Smallwoods	17-57-06	77-00-26	14	1969-1981	10	721
179770780	Innswood 5	17-57-08	77-03-37	24	1969-1977	9	760
179770860	Innswood 1	17-58-47	77-01-18	26	1948-1985	32	1,007
179770950	Warwick Castle 2	17-58-52	77-00-00	24	1948-1985	31	1,008
179770970	Innswood 2	17-59-09	77-02-29	27	1948-1983	29	1,055
179771650	Old Harbour	17-56-12	77-06-54	30	1901-1985	64	1,183
179771670	Bodles Rose Hall	17-56-20	77-08-25	37	1972-1981	12	840
180768590	Farm 2	18-00-40	76-53-18	9	1948-1985	31	878
180769650	Caymanas C.	18-01-14	76-54-38	6	1935-1985	38	1,034
180768690	Lagoon	18-02-00	76-53-18	3	1948-1982	26	1,028
180769550	Dawkins	18-00-22	76-54-12	6	1948-1984	29	854

Table B-4 (1/3) MONTHLY RAINFALL

Station NO. 179769860 Station name: Bernard Lodge (Unit: mm)

Year	Jan.	Feb.	Mar.	Apr.	May.	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Total
1937	11.4	4.6	3.3	20.6	256.5	15.5	29.7	91.2	94.7	244.6	187.5	10.4	970.0
1938	6.6	2.8	7.6	25.7	79.5	22.9	50.5	225.0	248.2	145.0	59.2	10.2	883.2
1939	12.4	43.7	35.1	65.0	27.2	56.1	23.6	79.8	63.2	468.6	789.2	10.9	1,674.9
1940	31.0	47.2	26.7	12.7	93.0	9.1	7.6	-	43.9	140.7	41.9	99.1	-
1941	78.5	157.5	24.6	134.1	109.0	7.4	66.3	18.5	60.5	141.0	21.6	37.1	856.0
1942	19.3	0.8	1.0	21.8	105.9	263.7	4.1	241.3	112.0	198.1	5.1	94.0	1,067.1
1943	-	55.9	59.7	19.1	165.6	19.1	5.3	34.0	37.3	213.4	1.3	19.1	-
1944	2.8	5.6	4.6	2.0	27.4	113.8	110.2	233.2	91.7	358.6	287.0	9.4	1,264.4
1945	42.2	5.3	-	23.4	77.2	29.7	50.3	171.5	168.4	197.1	194.8	121.2	-
1946	-	37.8	17.8	44.7	9.1	9.9	6.6	2.5	61.7	93.2	140.7	25.9	-
1947	20.3	79.0	-	2.0	21.1	7.9	89.4	63.8	188.2	56.4	18.3	12.2	-
1948	36.8	1.3	2.3	66.3	329.4	221.5	35.3	10.9	163.6	112.8	66.8	3.8	-
1949	1.3	-	18.0	28.2	91.2	50.8	45.5	43.7	159.0	64.8	25.7	24.1	-
1950	11.2	8.9	7.9	14.7	21.6	23.4	11.9	151.6	144.5	419.1	105.2	41.4	961.4
1951	0.0	0.0	6.4	22.4	129.3	20.1	26.7	276.6	21.8	134.4	80.8	3.6	722.1
1952	36.8	24.6	0.0	136.7	0.0	10.2	143.3	66.5	42.2	72.1	51.1	47.0	630.5
1953	13.2	6.4	13.7	5.1	145.3	61.2	45.7	27.4	220.0	86.9	38.9	17.5	681.3
1954	31.2	52.1	72.6	12.7	107.2	5.8	6.6	93.7	117.3	117.6	58.4	0.0	675.2
1955	11.4	37.3	6.9	35.3	45.5	121.2	101.1	116.3	112.3	62.2	99.1	3.6	752.2
1956	4.1	27.2	43.4	49.3	23.9	71.1	148.8	16.3	8.9	264.2	47.2	38.1	742.5
1957	18.5	37.1	42.4	51.3	181.4	11.9	11.9	39.9	131.3	142.2	18.5	5.3	691.7
1958	62.5	62.2	47.5	0.0	451.9	121.9	98.0	27.4	82.8	433.3	93.7	36.3	1,517.5
1959	3.8	9.7	10.2	42.9	82.3	0.0	0.0	17.5	4.3	105.9	71.9	37.6	386.1
1960	61.0	7.6	46.7	16.0	12.2	470.4	28.2	65.5	168.7	323.1	148.3	65.8	1,413.5
1961	9.1	1.5	10.4	70.6	30.2	22.9	48.3	30.5	94.0	491.2	12.4	82.8	903.9
1962	18.3	11.4	7.1	55.1	87.6	58.2	10.4	41.7	65.0	171.2	110.0	63.0	699.0
1963	25.7	49.5	24.9	57.2	272.5	118.6	11.7	128.5	25.9	700.5	93.5	41.2	1,549.7
1964	14.5	5.6	1.8	28.4	134.4	16.3	22.6	104.1	87.9	152.1	74.2	23.4	665.3
1965	10.2	0.0	9.9	14.2	105.2	12.7	0.3	30.0	101.6	66.0	137.4	69.1	556.6
1966	38.9	0.8	10.7	7.9	165.6	281.2	26.9	58.4	72.9	155.2	266.7	40.9	1,126.1
1967	1.5	13.2	54.1	65.0	4.3	19.6	0.5	3.6	62.0	56.1	145.0	0.0	424.9
1968	23.4	17.5	37.3	1.8	5.6	48.0	0.0	61.7	29.7	242.6	42.2	42.7	552.5
1969	91.2	15.5	7.4	16.5	188.2	311.2	0.0	102.6	120.1	184.2	59.2	93.7	1,189.8
1970	37.1	5.3	0.0	0.0	216.9	18.0	82.6	117.3	80.5	51.6	92.7	21.6	724.7
1971	23.1	37.8	17.5	56.6	2.5	0.0	3.0	63.8	20.1	164.3	118.4	58.9	566.2
1972	7.9	47.0	35.6	73.9	75.9	153.9	0.0	36.8	23.6	189.7	0.0	93.0	737.4
1973	41.4	13.5	0.0	34.3	2.5	6.9	3.8	75.4	40.4	397.8	51.6	93.0	760.5
1974	5.6	11.9	8.6	29.7	23.9	2.5	28.4	198.4	352.3	284.0	28.7	1.3	975.4
1975	2.8	0.0	0.0	2.0	33.3	0.0	13.5	16.8	156.5	79.2	83.8	20.1	407.9
1976	3.3	32.5	10.2	22.1	0.0	10.2	0.0	20.6	24.1	66.0	15.5	3.8	208.3
1977	5.1	20.6	0.0	133.4	77.2	7.4	0.0	70.9	2.0	79.2	21.6	39.4	456.7
1978	61.0	22.4	171.7	56.1	74.4	11.4	9.4	33.0	15.7	150.1	85.1	-	-
1979	16.8	73.7	0.0	298.5	44.5	352.3	133.4	10.4	637.5	-	23.6	-	-
1980	0.0	5.6	4.3	33.0	122.9	195.1	15.7	113.8	26.2	10.2	-	-	-
1981	3.8	0.0	50.8	13.0	60.2	157.0	47.8	130.6	9.1	337.3	170.4	-	-
1982	0.0	0.0	-	-	11.7	83.8	26.9	28.2	131.7	49.4	223.5	-	-
1983	-	94.8	0.7	22.6	7.7	90.2	-	71.0	21.0	78.1	-	-	-
1984	-	38.2	84.3	28.1	-	-	-	-	-	141.4	8.1	-	-
1985	10.0	25.0	15.0	60.0	69.7	3.0	22.5	80.0	45.0	20.0	95.0	18.0	523.2
Mean	21.5	26.2	23.1	42.3	91.9	77.6	35.2	79.6	99.9	186.9	98.1	37.6	819.9

Table B-4 (2/3) MONTHLY RAINFALL

Station No. 180769650 Station name: Caymanas C (Unit: mm)

Year	Jan.	Feb.	Mar.	Apr.	May.	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Total
1935	-	-	-	-	-	-	-	134.9	223.5	208.8	15.0	14.7	-
1936	10.4	7.6	68.8	110.7	304.8	484.9	19.1	104.6	56.6	99.6	80.0	32.5	1,379.7
1937	21.8	10.9	20.3	98.0	167.1	23.1	41.9	111.0	105.9	141.0	98.0	97.0	936.2
1938	4.8	21.3	26.4	119.9	48.3	30.5	47.0	239.3	160.3	97.8	55.4	19.6	870.5
1939	8.1	18.8	12.4	57.4	46.0	48.8	52.3	84.1	146.6	175.0	767.1	54.9	1,471.4
1940	52.3	31.5	1.3	52.3	139.2	30.2	20.8	1.3	19.1	141.2	57.2	69.3	615.7
1941	113.8	183.4	42.2	113.3	92.5	4.3	56.9	56.4	31.8	186.2	45.0	102.9	1,028.4
1942	44.7	15.7	24.1	48.0	121.9	301.0	22.4	217.4	113.0	223.5	21.1	58.9	1,211.8
1943	21.6	25.9	60.7	61.0	117.6	90.9	12.7	69.3	84.8	308.9	38.9	13.7	906.0
1944	24.9	-	5.6	24.9	90.7	79.2	51.1	152.1	91.7	542.5	51.1	42.4	-
1945	29.1	22.1	1.0	50.3	93.2	4.3	57.4	173.5	190.5	177.0	160.5	124.5	1,083.6
1946	-	30.7	24.4	124.7	4.8	11.4	57.2	34.3	97.9	141.0	157.0	14.0	-
1947	25.1	66.5	8.4	17.5	53.1	14.0	62.5	59.7	237.7	54.4	13.0	14.5	626.4
1948	79.2	2.5	-	66.8	368.0	191.0	27.7	82.3	154.4	125.2	135.9	34.5	-
1949	0.8	9.7	53.6	0.0	142.7	47.0	97.0	6.1	65.3	45.5	15.7	51.3	534.7
1950	23.6	30.7	21.3	46.2	67.1	55.9	13.5	147.1	119.9	428.5	71.4	16.3	1,041.4
1951	0.0	21.8	58.7	17.8	115.3	17.3	120.7	260.4	49.0	306.6	185.4	2.5	1,155.4
1952	32.3	18.5	22.9	46.7	46.7	94.5	71.6	40.6	54.4	763.5	94.2	36.1	1,322.1
1953	43.9	38.1	21.8	5.1	140.7	49.5	46.2	41.4	263.7	111.5	86.1	70.4	918.5
1954	16.3	87.1	42.9	39.9	181.6	31.5	56.1	283.2	104.6	243.1	84.1	0.0	1,170.4
1955	-	-	-	-	-	-	-	-	-	-	-	-	-
1956	-	-	-	-	-	-	-	-	-	-	-	-	-
1957	27.4	24.4	57.9	43.7	104.6	3.0	12.4	47.0	131.6	149.9	9.9	6.4	618.2
1958	50.0	33.0	48.8	15.0	508.5	114.3	68.6	137.2	151.4	371.1	93.2	46.7	1,637.8
1959	13.5	3.0	12.4	80.0	226.6	0.0	19.6	5.1	33.3	143.5	169.9	110.0	816.9
1960	105.7	41.7	40.6	54.1	19.3	487.2	169.9	136.9	247.7	428.5	118.9	91.9	1,942.3
1961	71.4	12.2	42.9	52.3	19.1	61.7	109.7	60.5	177.0	513.6	146.3	201.2	1,467.9
1962	17.3	36.1	10.2	103.6	121.9	86.4	29.2	73.7	134.9	194.3	63.5	174.0	1,045.0
1963	20.3	66.0	48.3	77.5	456.4	106.7	71.1	137.2	86.9	974.9	169.7	94.0	2,308.9
1964	30.5	30.2	0.0	122.4	184.4	39.4	21.6	166.6	33.0	154.9	52.6	24.4	860.0
1965	24.1	0.0	47.0	7.6	201.9	0.0	5.1	61.0	215.9	95.3	181.6	110.5	950.0
1966	85.1	0.0	0.0	0.0	95.3	292.1	188.0	86.4	111.5	241.3	249.7	21.1	1,370.3
1967	6.4	30.5	8.9	163.8	27.9	39.4	10.2	17.8	48.3	100.3	53.3	7.6	514.4
1968	0.0	12.7	64.8	11.4	11.4	81.3	35.6	72.6	54.1	192.0	135.9	27.9	699.8
1969	69.9	17.8	30.5	58.4	190.0	362.0	0.0	90.2	177.8	258.1	57.2	62.2	1,373.9
1970	83.8	6.4	0.0	14.0	287.0	44.5	201.9	106.7	125.7	105.4	106.2	0.0	1,081.5
1971	27.9	25.4	66.0	25.4	25.4	5.1	10.2	175.3	92.7	147.3	175.3	24.1	800.1
1972	8.9	106.7	64.8	27.9	146.1	165.1	33.0	72.4	-	-	-	-	-
1973	34.3	16.5	6.4	33.0	10.2	33.6	30.5	76.2	113.0	435.6	55.9	139.7	986.8
1974	6.4	21.6	22.9	53.3	33.0	5.1	48.3	232.7	307.3	337.8	115.6	62.2	1,246.1
1975	5.1	0.0	6.4	25.4	22.9	8.9	82.6	53.3	194.3	138.4	95.3	47.0	679.5
1976	8.9	53.3	29.2	11.4	11.4	5.1	3.8	48.3	36.8	45.2	49.5	8.9	311.9
1977	1.3	25.4	11.4	171.5	71.1	3.8	57.2	89.7	7.6	50.8	66.0	90.2	645.9
1978	72.4	22.9	137.2	48.3	132.1	25.4	10.2	144.8	96.5	336.6	109.2	0.0	1,135.4
1979	6.4	43.7	25.4	179.1	66.5	331.7	179.6	85.1	509.8	54.4	-	-	-
1980	-	-	-	-	-	-	-	-	-	-	-	-	-
1981	19.6	3.6	78.7	8.6	118.1	78.7	91.9	109.7	66.0	140.0	160.0	-	-
1982	3.0	51.0	0.0	95.4	88.4	4.0	19.0	22.6	187.0	99.0	3.0	10.2	582.6
1983	0.0	157.0	28.0	51.0	381.0	117.0	5.1	65.1	6.1	146.3	1.8	-	-
1984	21.0	80.5	106.0	-	41.0	31.5	44.0	46.0	122.1	34.0	114.0	-	-
1985	9.0	17.5	16.0	100.5	28.5	20.0	6.0	77.0	68.0	83.0	-	-	-
Mean	30.0	34.4	33.2	59.5	127.1	88.6	53.1	99.9	125.5	223.2	106.3	53.1	1,033.9

Table B-4 (3/3) MONTHLY RAINFALL

Station No. 179771650 Station name: Old Harbour (Unit: mm)

Year	Jan.	Feb.	Mar.	Apr.	May.	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Total
1901	46.5	2.5	54.6	24.1	100.3	402.3	80.3	127.3	333.2	158.8	21.8	118.1	1,469.8
1902	32.8	38.1	31.2	74.7	76.2	184.7	20.3	130.8	44.7	52.1	68.6	71.6	825.8
1903	23.6	20.3	37.1	102.6	316.2	100.3	46.2	431.0	37.1	141.7	84.1	151.1	1,491.5
1904	59.7	52.1	121.2	54.1	64.0	261.6	54.6	56.1	124.5	642.9	45.7	39.4	1,575.8
1905	-	61.0	76.2	62.2	130.8	485.1	10.9	170.2	189.7	305.6	50.8	169.7	-
1906	48.3	78.0	73.7	110.7	337.6	587.0	0.0	94.2	253.0	79.0	106.7	-	-
1907	10.2	50.8	0.0	0.0	71.9	47.0	0.0	19.3	143.3	460.2	37.1	35.2	825.0
1908	117.3	-	176.5	32.0	-	304.8	35.3	57.9	33.0	317.2	59.7	111.0	-
1909	-	1.8	43.9	34.8	-	102.9	75.7	-	506.2	-	527.1	29.2	-
1910	47.0	0.0	149.9	19.6	40.4	42.9	83.8	92.7	122.7	348.2	42.9	10.2	1,000.3
1911	63.5	0.0	114.8	49.5	205.7	18.3	16.5	12.7	33.0	100.3	181.9	20.6	816.9
1912	133.9	24.1	75.4	27.9	27.9	2.5	3.6	38.1	177.8	139.7	686.8	95.5	1,433.3
1913	67.3	33.0	83.8	125.7	59.2	68.6	21.6	149.9	177.5	43.9	66.8	28.7	926.0
1914	53.4	62.5	139.7	97.8	19.1	19.1	4.3	126.5	25.9	78.2	131.1	95.5	853.9
1915	79.0	63.5	50.8	-	103.9	306.6	21.6	126.5	265.2	227.3	100.8	0.0	-
1916	7.6	86.4	29.2	117.3	293.4	59.7	120.1	393.4	138.4	473.7	276.6	11.7	1,907.5
1917	-	-	-	-	53.8	62.7	54.1	53.3	342.1	88.4	-	39.4	-
1918	17.8	49.0	148.6	121.9	178.1	38.1	0.0	76.2	42.7	118.6	39.1	50.3	880.4
1919	140.5	5.1	105.4	169.2	794.5	47.8	7.6	47.8	117.6	358.6	0.0	162.6	1,956.6
1920	0.0	81.5	389.0	0.0	128.8	0.0	0.0	79.5	39.9	37.8	71.9	59.7	538.0
1921	88.4	48.8	159.3	176.5	266.7	119.9	34.3	61.0	118.9	98.8	31.8	23.4	1,227.6
1922	31.0	10.7	54.4	33.5	40.4	21.8	12.7	84.6	43.2	228.6	136.9	29.7	728.5
1923	18.3	65.3	19.8	54.6	181.2	14.0	8.1	96.8	29.2	160.5	55.9	0.0	707.6
1924	48.3	23.9	14.5	0.0	2.5	82.0	54.4	171.2	261.1	164.8	343.9	129.3	1,295.6
1925	16.8	58.4	24.9	118.4	77.5	21.3	55.1	59.9	161.0	34.0	83.6	52.3	763.3
1926	10.7	40.4	26.2	57.9	114.8	5.6	36.8	205.0	257.0	216.7	84.6	24.6	1,080.3
1927	73.7	110.7	5.6	10.2	347.0	24.9	71.9	95.3	76.7	391.9	117.9	10.2	1,335.8
1928	4.8	14.0	77.7	54.9	87.4	40.1	5.1	389.4	190.5	174.0	44.2	35.6	1,117.6
1929	41.7	88.1	57.9	23.4	18.0	60.2	4.6	163.6	125.0	258.3	79.0	75.9	995.7
1930	59.7	212.6	27.4	101.6	146.3	88.4	10.2	75.9	54.6	122.4	110.5	97.3	1,106.9
1931	80.3	105.7	26.7	199.4	241.0	198.1	523.2	113.3	186.4	339.9	122.7	42.4	2,179.1
1932	18.5	39.9	3.6	474.5	203.2	228.6	15.5	48.8	136.4	230.9	134.4	6.4	1,540.7
1933	5.1	20.3	64.8	14.0	90.9	225.6	303.8	449.1	305.1	730.8	294.4	73.7	2,577.3
1934	99.8	102.9	131.3	71.1	87.6	84.6	15.2	199.4	87.6	245.4	82.8	29.2	1,236.0
1935	3.8	82.3	109.7	2.5	60.5	62.5	19.1	149.4	290.6	283.2	11.2	20.6	1,095.2
1936	83.6	57.9	73.4	62.7	362.7	455.9	20.6	92.2	117.9	218.4	14.7	51.3	1,611.4
1937	15.0	12.7	15.7	40.6	310.4	28.4	40.1	189.5	79.5	315.5	205.7	28.2	1,281.4
1938	8.1	21.1	55.1	152.9	10.7	24.1	16.0	265.4	129.0	211.3	70.4	3.6	967.7
1939	42.7	25.1	36.3	76.7	7.1	48.0	91.4	258.3	135.6	351.0	868.4	64.3	2,005.1
1940	67.3	51.6	5.3	72.9	206.2	12.2	39.4	17.3	50.3	135.4	135.4	127.8	921.0
1941	63.5	164.3	49.0	47.8	117.6	6.6	3.3	8.4	118.4	201.9	72.4	56.1	909.3
1942	71.1	24.9	43.7	66.3	167.4	452.6	17.8	372.6	329.2	136.7	2.5	148.1	1,832.9
1943	31.0	90.2	81.8	105.2	171.2	35.8	2.8	152.1	57.9	555.5	95.8	3.6	1,382.8
1944	55.1	3.6	1.0	25.4	43.9	196.6	189.5	246.4	95.8	263.4	-	0.0	-
1945	19.8	67.3	16.8	82.3	72.9	47.5	67.3	281.9	290.3	237.2	174.8	80.3	1,438.4
1946	16.3	52.1	23.7	143.5	3.3	5.1	43.7	55.1	45.7	176.8	100.1	50.5	717.9
1947	34.5	85.1	54.1	13.2	84.1	13.7	158.8	114.6	146.6	105.4	43.7	71.9	925.7
1948	99.1	22.6	1.3	128.8	301.2	192.5	15.2	57.4	221.5	193.3	90.7	85.3	1,408.9
1949	14.2	45.2	31.5	42.4	121.7	79.5	113.8	47.0	195.3	164.8	61.0	36.3	952.2
1950	55.4	26.4	42.7	20.6	39.6	28.4	14.7	303.5	193.8	619.3	147.3	24.1	1,515.8
1951	14.2	7.9	6.4	33.0	217.4	45.0	36.1	273.5	107.7	102.9	91.7	6.6	942.4
1952	42.7	40.6	13.2	102.9	33.3	19.1	63.5	95.8	142.2	81.3	80.0	55.9	770.5
1953	71.9	7.6	50.8	7.6	278.6	65.8	143.8	13.0	259.2	185.7	22.9	13.5	1,130.4
1954	48.3	85.9	96.5	48.8	191.0	30.5	41.9	175.0	281.2	159.3	101.3	43.4	1,303.1
1955	7.6	62.7	41.1	52.1	85.1	177.5	147.8	284.0	201.2	166.9	22.4	73.2	1,321.6
1956	54.6	45.7	53.6	38.6	126.7	54.1	174.2	54.4	75.4	592.3	20.6	84.6	1,374.8
1957	33.8	65.8	81.0	68.6	175.3	15.2	22.1	15.2	240.0	217.2	6.1	18.3	958.6
1958	164.1	58.7	77.2	23.6	511.0	-	-	38.9	115.3	-	56.1	115.1	-
1959	30.2	9.1	3.3	45.2	109.7	-	7.1	25.9	72.1	127.3	54.1	109.2	-
1960	-	-	-	41.7	-	484.6	45.0	-	113.3	366.8	130.3	87.4	-
1961	59.4	21.6	55.4	95.5	117.1	3.8	87.1	48.8	120.4	438.9	27.4	48.0	1,123.4
1962	-	-	28.4	158.0	121.9	-	11.4	232.4	41.1	120.4	127.3	65.5	-
1963	0.0	58.9	35.8	29.0	188.7	275.8	80.0	38.1	23.9	413.5	106.4	70.4	1,320.5
1964	36.6	7.4	17.0	64.5	199.4	34.3	162.6	162.6	51.1	158.8	118.6	5.6	1,018.3
1965	54.9	26.7	3.8	28.2	307.1	10.9	0.0	86.6	170.2	90.4	111.8	24.9	915.5
1966	13.0	0.8	0.0	0.0	87.1	117.6	22.4	0.0	8.1	148.3	182.1	22.4	601.8
1967	41.4	-	90.7	106.7	26.7	55.1	60.1	18.8	144.3	95.8	197.9	13.5	-
1968	18.5	21.1	97.3	21.1	7.4	24.4	3.3	31.5	77.7	390.7	115.1	0.0	808.1
1969	47.0	39.1	6.6	44.2	201.7	187.2	38.4	306.8	43.2	472.9	413.8	44.7	1,845.6
1970	41.9	6.6	44.2	44.2	265.7	-	157.7	154.9	18.8	93.2	289.8	9.4	-
1971	49.3	21.6	17.0	54.9	120.4	0.0	51.3	102.9	63.0	239.0	227.8	59.7	1,006.9
1972	27.9	69.6	124.2	40.9	-	101.1	9.0	12.7	96.5	97.1	5.6	96.0	-
1973	38.1	82.3	32.0	56.6	40.6	35.1	5.0	233.4	202.7	473.5	24.4	145.0	1,368.7
1974	31.2	55.1	116.8	70.6	46.2	0.0	17.8	273.3	234.2	239.5	80.3	2.5	1,167.5
1975	16.0	5.1	0.0	23.6	42.9	0.0	78.1	113.3	162.8	82.6	61.5	39.9	625.8
1976	45.2	49.5	64.0	20.8	26.7	80.0	5.1	29.5	6.6	40.6	21.1	20.8	409.9
1977	11.9	18.5	31.0	64.5	206.8	14.5	10.7	145.8	31.5	61.7	69.3	61.5	727.7
1978	92.5	30.5	103.4	47.2	70.1	7.1	19.3	39.6	37.1	167.6	176.8	3.8	795.0
1979	41.7	62.2	23.4	130.6	86.9	326.4	137.2	48.0	762.8	162.8	-	-	-
1980	21.3	14.7	2.0	18.5	120.7	63.2	73.7	94.5	67.8	-	88.9	106.7	-
1981	78.0	35.1	26.2	54.9	139.7	95.8	48.0	338.1	62.7	126.0	155.7	-	-
1982	68.3	54.2	16.0	12.6	156.2	12.3	28.8	39.5	407.3	56.6	51.8	-	-
1983	2.5	104.6	9.1	56.6	35.3	82.3	-	147.6	31.0	168.4	19.3	26.3	-
1984	79.4	43.8	-	57.1	41.2	19.0	23.4	84.8	78.0	115.6	0.0	-	-
1985	29.0	36.4	32.7	124.5	72.7	16.1	14.7	75.3	140.0	114.2	11.6	49.8	-
Ave.	46.1	46.1	52.9	67.3	141.0	104.9	53.3	130.6	145.6	223.2	118.1	53.5	1,182.5

Table B-5 MONTHLY TEMPERATURE AT BERNARD LODGE

(Unit: oC)

Year		Jan.	Feb.	Mar.	Apr.	May.	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Mean
1967	Mean Max.	30.6	30.1	30.9	30.5	31.7	32.1	33.2	33.2	32.3	32.5	32.2	31.1	31.7
	Mean Min.	16.6	17.8	16.9	17.7	19.8	21.2	20.9	20.9	21.2	20.2	20.7	16.8	18.9
	Absolute Max.	32.8	31.7	32.8	31.7	32.8	33.9	34.4	33.9	34.4	33.9	35.0	31.7	-
	Absolute Min.	14.4	16.1	15.0	16.7	17.8	18.9	18.9	18.9	19.4	16.1	18.3	13.3	-
1968	Mean Max.	30.2	29.8	30.6	31.3	32.3	30.7	33.7	33.1	32.8	31.6	31.4	31.1	31.5
	Mean Min.	17.3	16.5	17.0	16.5	20.8	20.8	19.8	-	-	-	21.2	19.7	-
	Absolute Max.	32.8	31.7	31.7	32.8	33.9	33.9	37.2	35.0	34.4	33.9	32.8	32.8	-
	Absolute Min.	12.8	11.7	12.8	13.9	17.8	20.6	14.4	-	-	-	18.3	17.2	-
1969	Mean Max.	29.8	30.7	31.8	32.5	32.9	31.5	32.9	32.3	32.2	31.6	31.2	30.6	31.7
	Mean Min.	18.9	18.1	20.3	20.7	-	19.9	18.9	18.7	20.4	20.6	20.7	19.3	-
	Absolute Max.	31.1	32.2	32.8	33.9	35.0	33.3	33.9	35.0	33.3	33.9	33.3	31.7	-
	Absolute Min.	16.7	15.0	18.3	19.4	-	18.3	17.8	17.2	17.2	18.9	17.8	13.9	-
1970	Mean Max.	30.3	30.7	30.9	32.2	31.7	32.7	33.0	31.8	31.9	32.6	30.9	31.4	31.7
	Mean Min.	18.7	19.0	19.0	20.1	21.4	21.9	22.2	21.9	21.3	20.9	21.0	18.7	20.5
	Absolute Max.	33.3	32.2	32.8	34.4	34.4	34.4	35.0	34.4	32.8	33.3	33.3	33.3	-
	Absolute Min.	16.1	16.1	15.6	17.2	18.9	20.0	20.6	20.6	18.3	19.4	18.3	16.1	-
1971	Mean Max.	30.9	30.6	31.3	30.9	32.7	33.3	33.1	32.2	32.2	32.7	30.5	30.7	31.8
	Mean Min.	17.3	19.0	18.2	19.6	20.8	21.8	21.1	21.1	21.1	21.0	20.3	17.4	19.9
	Absolute Max.	32.2	31.7	32.8	32.8	33.3	35.0	34.4	33.9	33.9	33.9	31.7	32.8	-
	Absolute Min.	12.8	15.6	16.1	16.7	19.4	20.0	19.4	20.0	19.4	19.4	18.9	16.1	-
1972	Mean Max.	30.4	30.2	31.9	31.4	31.2	31.5	32.5	32.6	34.1	31.7	32.4	31.5	31.7
	Mean Min.	17.4	17.4	19.2	20.7	19.3	19.3	20.3	21.5	21.1	21.8	20.4	20.1	19.8
	Absolute Max.	31.6	32.8	33.3	33.3	32.8	32.8	33.3	33.3	35.0	32.8	33.9	33.9	-
	Absolute Min.	13.3	15.6	16.1	17.8	17.2	17.2	19.4	20.0	20.0	18.9	18.9	17.2	-
1973	Mean Max.	30.6	30.8	31.9	31.9	32.5	33.4	33.8	33.1	32.4	31.3	31.2	30.3	31.9
	Mean Min.	18.7	18.3	19.4	20.6	21.1	22.3	21.9	22.4	22.2	21.3	18.0	18.8	20.4
	Absolute Max.	31.6	32.8	33.3	33.3	33.9	35.0	35.0	35.6	33.3	33.9	33.3	31.1	-
	Absolute Min.	16.7	15.6	17.2	17.8	19.4	20.6	20.6	20.6	20.6	19.4	15.6	16.1	-
1974	Mean Max.	30.6	30.9	31.4	31.3	31.6	32.2	32.9	32.6	30.9	30.8	30.7	31.2	31.4
	Mean Min.	15.7	15.8	16.3	16.4	20.1	21.5	21.1	21.6	21.4	20.4	18.4	17.9	18.9
	Absolute Max.	31.1	31.1	31.7	31.7	32.8	33.9	33.9	34.4	33.3	32.2	32.2	32.2	-
	Absolute Min.	13.9	14.4	16.1	16.1	17.2	18.9	19.4	20.0	20.0	18.9	14.4	14.4	-
1975	Mean Max.	30.6	30.4	30.9	31.4	31.8	32.8	32.8	33.4	31.7	31.3	31.2	30.6	31.6
	Mean Min.	16.2	15.7	17.4	18.8	20.6	21.3	20.6	21.9	21.1	20.2	19.4	17.8	19.3
	Absolute Max.	32.2	31.1	32.2	32.2	32.8	33.9	33.3	34.4	34.4	32.8	31.7	31.1	-
	Absolute Min.	13.9	13.9	16.7	17.2	18.3	19.4	20.0	19.4	19.4	18.9	17.8	13.3	-
1976	Mean Max.	29.4	30.1	30.8	31.2	31.7	31.7	33.3	33.3	33.9	32.7	32.2	31.7	31.8
	Mean Min.	15.6	15.8	15.9	19.1	21.1	22.2	21.1	20.7	21.4	21.3	20.6	19.4	19.5
	Absolute Max.	31.1	31.7	32.2	32.8	33.3	33.9	34.4	35.0	36.1	34.4	34.4	34.4	-
	Absolute Min.	12.8	13.3	15.6	15.0	18.3	20.0	20.0	16.1	19.4	20.0	18.3	16.7	-
1977	Mean Max.	30.0	30.6	31.7	31.1	30.6	32.5	33.7	33.8	33.1	32.8	32.6	31.9	32.0
	Mean Min.	18.3	18.3	18.9	20.6	22.1	22.4	21.9	22.3	22.4	21.7	21.3	20.1	20.9
	Absolute Max.	32.2	32.8	33.3	32.8	31.7	33.9	35.0	35.0	33.9	35.0	34.4	33.3	-
	Absolute Min.	15.6	16.1	17.8	17.8	20.0	20.0	20.6	20.6	20.6	20.0	19.4	18.3	-
1978	Mean Max.	29.7	30.0	30.7	30.6	31.9	32.6	33.5	33.3	33.5	-	-	-	-
	Mean Min.	19.2	18.7	20.1	20.3	22.2	22.2	21.9	22.2	22.0	-	-	-	-
	Absolute Max.	31.7	31.7	32.2	32.8	33.9	33.3	34.4	34.4	34.4	-	-	-	-
	Absolute Min.	16.1	13.3	17.2	16.1	20.6	20.6	20.6	20.6	20.6	-	-	-	-

Table B-6 MEAN MONTHLY TEMPERATURE (1931-1980)

(Unit:oC)

	Jan.	Feb.	Mar.	Apr.	May.	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Mean
1 Bernard Lodge													
Mean Maximum	30.2	30.3	30.2	30.7	30.9	31.6	32.4	32.4	32.1	31.4	30.8	30.4	31.1
Mean Minimum	16.9	16.8	17.3	18.4	19.8	20.6	20.4	20.4	21.2	20.5	19.6	17.9	19.2
2 Bodles													
Mean Maximum	29.5	29.5	29.7	30.5	30.7	31.4	32.2	32.1	31.4	31.0	30.6	30.4	30.8
Mean Minimum	16.5	16.0	17.3	18.4	19.7	20.5	20.5	20.4	20.1	19.5	19.4	18.2	18.9

Table B-7 MONTHLY RELATIVE HUMIDITY

(Unit:%)

Station	Year	Hr.	Jan.	Feb.	Mar.	Apr.	May.	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Mean
Bemard Lodge	1968	08 hr	-	-	80	74	74	76	76	79	83	87	86	86	80
		15 hr	-	-	71	63	71	71	73	75	78	87	74	73	74
	1970	08 hr	-	-	77	72	76	79	74	78	82	82	84	79	78
		15 hr	-	-	58	57	65	64	63	67	67	67	76	68	65
Bodles	1970	07 hr	98	94	92	91	87	91	89	73	94	95	91	87	92
		13 hr	77	79	64	63	67	70	67	71	73	65	68	60	70
	1971	07 hr	93	91	91	84	89	85	87	89	93	94	92	92	90
		13 hr	60	61	59	60	67	59	60	71	72	67	64	61	63
	1972	07 hr	95	93	93	88	87	87	81	87	90	93	94	91	90
		13 hr	63	63	61	61	67	67	57	60	66	68	63	65	63
	1973	07 hr	94	92	94	85	84	87	83	89	93	94	90	92	90
		13 hr	64	59	61	65	61	64	57	66	70	72	64	62	64
	1974	07 hr	89	90	92	86	90	88	91	93	95	91	91	90	91
		13 hr	61	62	58	58	63	61	62	67	75	68	63	59	63
	1975	07 hr	91	94	91	86	87	82	88	91	91	93	90	86	89
		13 hr	55	58	61	65	67	-	62	62	68	65	68	56	-
	1976	07 hr	91	90	90	85	90	87	82	87	85	86	86	89	87
		13 hr	61	60	60	62	64	63	57	63	62	61	64	65	62
	1977	07 hr	90	92	82	83	85	81	81	83	88	93	86	90	86
		13 hr	65	67	66	65	70	62	60	66	68	73	65	70	66
	1978	07 hr	93	89	85	79	82	83	80	84	87	89	89	92	86
		13 hr	73	69	64	65	66	63	60	62	63	68	75	70	67
	1979	07 hr	91	85	77	78	85	86	84	83	90	87	85	85	85
		13 hr	74	64	62	66	67	71	64	66	76	69	65	61	67
	1980	07 hr	88	86	84	80	84	87	83	86	81	85	83	80	84
		13 hr	64	60	61	68	-	-	-	-	64	66	69	62	-
	Mean	07 hr	92	90	88	83	86	85	84	87	89	89	89	89	88
		13 hr	64	62	62	64	66	64	60	65	68	68	66	63	64

Table B-8 MONTHLY EVAPORATION

(Unit:mm/day)

Station	Year	Jan.	Feb.	Mar.	Apr.	May.	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Mean
Bemard Lodge	1967	3.6	4.1	4.8	4.6	6.4	5.6	8.4	6.9	5.3	4.6	3.6	5.1	5.3
	1968	3.8	4.3	4.8	6.1	7.4	6.4	6.9	5.6	5.1	3.6	4.1	3.8	5.1
	1969	3.6	4.8	6.9	6.1	6.1	5.6	6.6	5.8	4.6	4.1	3.0	3.0	5.1
	1970	3.8	4.6	6.1	7.1	4.6	5.8	5.8	5.3	4.8	5.6	3.8	3.8	5.1
	1971	4.1	5.3	5.3	5.6	6.6	7.9	7.4	5.3	5.8	4.8	4.1	3.3	5.6
	1972	4.1	4.8	5.1	5.6	6.4	5.6	7.1	6.9	5.3	4.8	4.3	3.8	5.3
	1973	3.3	3.8	5.3	5.3	6.9	5.8	6.9	5.3	4.8	4.1	4.6	3.6	4.8
	1974	3.0	3.3	4.8	4.6	7.1	6.9	6.1	4.8	3.8	4.1	3.0	3.6	4.6
	1975	3.3	4.8	5.6	5.3	6.6	-	6.9	5.1	3.8	3.0	3.6	3.6	4.6
	1976	3.6	3.3	4.8	5.1	6.9	6.6	7.6	5.8	6.1	4.6	4.1	4.1	5.3
	1977	4.1	4.6	6.1	4.8	4.6	6.9	6.4	6.1	6.1	5.3	4.6	-	5.3
	1978	-	-	-	6.1	6.9	7.1	6.4	6.4	5.6	-	-	-	6.4
	Mean	3.6	4.3	5.3	5.6	6.4	6.4	6.9	5.8	5.1	4.3	3.8	3.8	5.1
Bodles	1972	4.1	5.3	5.6	6.1	5.8	5.6	6.4	6.4	5.1	5.1	5.1	3.8	5.3
	1973	3.6	5.8	6.9	7.1	7.6	6.1	7.4	5.6	5.1	4.1	4.3	4.1	5.6
	1974	3.6	5.1	5.8	7.1	6.9	8.1	7.9	6.9	4.8	4.3	3.6	4.3	5.6
	1975	4.8	5.8	6.9	6.9	6.9	8.1	6.1	6.4	4.8	4.3	3.6	4.3	5.8
	1976	4.1	4.3	5.3	5.8	7.1	6.9	8.4	5.8	6.1	5.6	4.6	4.3	5.6
	1977	4.8	5.1	5.8	6.1	5.6	7.1	7.6	5.3	6.9	5.3	4.6	4.1	5.6
	1978	3.6	5.3	4.8	6.1	6.1	5.6	6.9	5.6	4.8	4.6	3.6	4.1	5.1
	1979	4.3	5.3	5.6	6.1	5.1	3.6	5.8	5.1	5.1	4.8	4.6	4.6	5.1
	1980	-	5.8	-	6.6	6.4	6.6	-	6.1	5.3	4.6	4.8	5.1	5.6
	Mean	4.1	5.3	5.8	6.4	6.4	6.4	7.1	5.9	5.3	4.7	4.3	4.3	5.5

Table B-9 MONTHLY SUNSHINE AT BERNARD LODGE

(Unit : hours)

Year	Jan.	Feb.	Mar.	Apr.	May.	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Mean
1967	8.9	7.9	7.8	8.5	9.0	8.1	9.3	8.5	7.9	8.1	7.3	8.1	7.6
1968	7.7	8.5	7.5	9.3	9.9	7.6	8.4	8.1	7.2	7.1	8.1	8.5	8.2
1969	8.5	9.4	8.7	8.9	7.9	7.2	9.2	8.1	7.6	7.6	6.6	7.8	8.0
1970	8.1	8.6	9.4	10.2	8.1	9.3	8.6	8.5	7.3	8.7	6.2	8.7	8.5
1971	8.5	8.6	8.3	9.4	9.3	10.3	10.1	7.7	7.9	8.7	7.2	8.3	8.7
1972	8.0	8.3	7.9	8.5	8.5	7.2	9.5	9.0	6.1	7.2	8.0	6.1	7.9
1973	6.8	7.0	7.8	8.6	9.0	6.0	8.0	6.1	8.0	5.5	8.5	7.5	7.4
1974	6.8	8.4	8.4	8.3	8.5	8.7	7.8	7.9	6.0	6.4	6.5	6.5	7.5
1975	5.7	7.8	8.5	7.9	8.9	-	9.0	8.1	6.7	7.3	8.0	9.0	-
1976	8.2	7.1	7.1	7.4	8.8	7.4	9.0	7.8	8.3	7.7	7.4	8.1	7.9
1977	7.4	7.3	8.5	6.7	5.7	8.0	7.8	7.3	6.5	7.8	7.2	-	-
1978	-	7.7	-	8.4	8.3	8.2	8.3	7.8	7.2	-	-	-	-
1979	-	-	-	-	-	-	-	-	-	-	-	-	-
Mean	7.7	8.1	8.2	8.5	8.5	8.0	8.8	7.9	7.2	7.5	7.4	7.9	8.0

Table B-10 MONTHLY WIND SPEEDS

(Unit : knots)

Time	Jan.	Feb.	Mar.	Apr.	May.	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
00 - 01	4.2	5.3	5.2	5.0	6.3	7.5	6.1	4.7	4.3	3.7	3.4	4.0
01 - 02	4.3	5.3	5.3	4.6	6.1	7.2	5.9	4.7	4.1	3.5	3.5	4.2
02 - 03	4.6	5.3	5.3	4.5	5.7	7.2	5.8	4.7	4.3	3.3	3.7	4.5
03 - 04	4.8	5.4	5.4	4.3	5.8	7.2	5.9	4.6	4.0	3.5	3.9	4.6
04 - 05	4.9	5.5	5.1	4.2	5.7	7.4	6.2	4.8	4.2	3.6	3.9	4.5
05 - 06	4.8	5.5	6.1	4.4	5.7	7.4	6.4	4.7	4.1	3.9	3.8	4.5
06 - 07	4.7	5.4	5.6	4.4	6.0	7.7	6.5	5.0	4.2	3.7	3.6	4.1
07 - 08	4.5	5.4	5.8	4.5	6.4	8.8	7.3	5.3	4.4	3.8	3.6	4.2
08 - 09	4.6	5.6	5.9	5.4	7.6	10.2	8.7	6.3	5.5	4.4	3.3	3.9
09 - 10	5.0	6.6	7.4	7.4	9.7	13.0	11.3	8.2	7.7	5.4	4.0	4.3
10 - 11	6.5	8.3	9.6	9.4	11.7	15.2	14.6	11.2	10.3	7.5	5.6	5.8
11 - 12	8.1	10.4	11.1	11.2	14.1	16.7	16.4	13.7	12.2	9.6	7.3	7.2
12 - 13	9.5	12.3	12.0	12.0	14.7	17.3	17.7	14.9	13.6	10.9	8.7	8.8
13 - 14	10.6	12.5	12.6	12.2	15.2	17.7	18.0	15.5	13.9	11.5	9.5	9.6
14 - 15	10.8	13.2	14.0	13.2	14.6	17.5	18.2	15.5	13.5	11.3	9.7	10.1
15 - 16	10.8	12.9	12.6	13.0	14.3	16.8	17.3	14.9	12.5	10.4	9.4	10.1
16 - 17	10.5	12.4	11.1	12.0	13.4	15.7	16.0	13.5	11.4	9.4	8.7	9.4
17 - 18	9.9	11.5	11.6	11.1	12.5	14.5	14.6	12.1	10.3	8.4	7.8	8.5
18 - 19	8.7	10.6	10.7	10.2	11.0	12.0	13.0	10.6	9.0	7.3	6.9	7.5
19 - 20	7.7	9.1	9.2	8.8	9.6	12.0	11.1	9.0	7.5	5.9	5.9	6.3
20 - 21	6.5	8.1	7.8	7.5	8.3	10.8	9.7	7.5	6.5	4.7	4.9	5.4
21 - 22	5.7	6.8	7.3	6.2	7.5	10.0	8.0	6.3	5.4	4.3	4.1	4.8
22 - 23	5.0	6.2	6.3	5.0	7.1	8.7	7.3	5.8	4.7	3.7	3.7	4.4
23 - 24	4.9	5.4	5.4	4.7	6.8	8.0	6.3	5.3	4.2	3.7	3.5	4.5
Mean	6.7	8.1	8.3	7.7	9.4	11.5	10.8	8.7	7.6	6.1	5.5	6.1

Remarks : Values of wind speed at 10 m
Date period: 1954 to 1982

Table B-11 WIND DIRECTION

D/R	1-3	4-6	7-10	11-16	17-21	22-27	28-33	34-40	41-47	48-55	56-63	GT63	4-10	11-21	22-23	GT34	GT4
NNE	549	1,208	625	199	26	11	5	1	0	0	0	0	1,833	225	16	1	2,075
NE	343	581	279	75	10	0	0	0	0	0	0	0	860	85	0	0	945
ENE	295	799	655	283	55	34	1	2	0	0	0	0	1,454	338	35	2	1,829
E	784	2,724	6,726	7,813	2,709	774	98	6	0	0	0	0	9,450	10,522	872	6	20,850
ESE	478	2,190	6,950	15,297	9,295	3,447	314	20	0	0	0	0	9,140	24,592	3,761	20	37,513
SE	606	2,037	4,668	8,013	5,919	2,620	311	14	0	0	0	0	6,705	13,932	2,931	14	23,582
SSE	562	1,908	2,343	1,694	875	410	64	2	0	0	0	0	4,251	2,569	474	2	7,296
S	878	2,814	2,277	353	80	28	5	0	0	0	0	0	5,091	433	33	0	5,557
SSW	395	1,351	863	122	21	6	2	0	0	0	0	0	2,214	143	8	0	2,365
SW	249	681	347	62	10	6	0	1	0	0	0	0	1,028	72	6	1	1,107
WSW	237	558	211	40	9	1	1	0	0	0	0	0	769	49	2	0	820
W	898	1,499	634	89	16	0	0	1	0	0	0	0	2,133	105	0	1	2,239
WNW	1,153	2,953	984	114	11	4	0	0	0	0	0	0	3,937	125	4	0	4,066
NW	1,921	4,006	1,750	236	37	16	6	2	0	0	0	0	5,756	273	22	2	6,053
NNW	2,269	5,827	3,444	525	136	62	8	3	0	0	0	0	9,271	661	70	3	10,005
N	3,540	7,849	6,023	1,399	305	112	66	16	0	0	0	0	13,872	1,704	178	16	15,770
AlDir	15,157	38,985	38,779	36,314	19,514	7,531	881	68	0	0	0	0	77,764	55,828	8,412	68	142,072

Station: Manley Latitude: 17 deg. 56 min. North Longitude: 76 deg. 47 min. West Elevation: 03 ft.
Record of Wind direction and speed in Knots (Kt) at 10 metres
D=direction R=speed range in Kt. GT4=greater than 4 Knots. GT63=greater than 63 Knots AlDir=all direction
data period 1957 to 1982

All Direction less than 3Kt=523
Less than 4Kt = 67518
No. of hours missed = 18314
Total = 209590

Table B-12 DISCHARGE GAUGING STATIONS

Station No.	Station Name	Location Lat.	Location Long.	Drainage Area km2	Status	Period of Record	No. of Complete years	Av. Annual Discharge (m3/s)
03BB001	Rio Pedro near Harkers Hall	18-06-35	76-56-35	83	R	54-85	30	1.7
03BY002	Rio Cobre main canal	18-21-10	76-58-35	-	R	54-85	30	4.7
03BA003	Rio Cobre near Spanish Town	18-21-10	76-58-35	578	R	55-85	28	5.4
03BC007	Spring-Vale River at Spring-Vale	18-05-45	77-03-15	-	M	70-75	0	-
03BC008	Rio Doro at Williams Field	18-09-18	76-55-40	19	R	70-85	2	0.7
03B2009	Pedro River at Kellits	18-10-50	77-13-00	-	R	70-85	12	0.2
03B2010	Murmuring Brook near Lluidas Vale	18-05-58	77-08-50	8	M	72-74	3	0.1
03BA011	Rio Cobre at Crum Ewing	18-00-00	76-54-30	636	R	71-75	5	5.4
03BA012	Rio Cobre at Bog Walk	18-05-21	77-00-22	537	R	71-73	2	-
03BC013	Indian River at Rio Magno	18-12-37	76-58-26	13	R	71-85	13	0.3
03BC015	Spring Garden River at Spring Village	17-59-10	76-04-00	-	M	72-85	9	0.02
03BA016	Mountain River at Watermount	18-03-27	77-05-42	18	M	72-85	2	0.2

Remarks: * M - Manual Gauge

Table B-13 MONTHLY STREAM FLOW DATA ON THE RIO COBRE

(Unit : m3/sec)

Year	Jan.	Feb.	Mar.	Apr.	May.	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Mean
1. At Dam Site (03Y002+03BA003)													
1954	-	-	-	-	-	-	-	-	-	-	13.92	8.35	-
1955	6.69	9.07	5.37	4.78	5.42	10.00	10.82	7.75	8.88	13.66	8.34	6.83	8.13
1956	5.79	5.21	4.78	5.67	7.15	11.45	9.22	11.68	11.37	21.91	14.29	9.42	9.83
1957	7.11	5.36	5.73	5.24	6.46	6.43	6.48	5.96	10.14	12.88	7.31	6.11	7.10
1958	9.95	5.10	4.48	3.97	11.78	16.63	10.38	12.12	13.59	63.78	15.00	12.72	14.96
1959	9.48	7.18	5.73	6.26	7.96	6.64	5.11	5.16	4.89	7.09	5.51	22.04	7.75
1960	10.60	7.01	5.49	10.56	8.61	33.03	12.53	9.86	9.26	14.30	20.35	14.43	13.00
1961	8.60	7.67	6.18	6.41	5.95	5.93	6.90	5.25	9.05	21.27	14.69	20.10	9.83
1962	11.66	7.40	5.79	8.53	9.04	12.11	8.70	9.24	11.13	14.02	16.17	11.72	10.46
1963	7.13	6.26	6.71	6.71	13.13	21.04	9.69	10.67	-	-	35.46	20.80	-
1964	13.28	9.35	7.61	10.95	7.79	10.23	10.49	13.20	12.95	18.20	10.58	8.52	11.10
1965	6.22	5.53	5.64	6.04	7.82	6.86	-	-	-	-	-	7.62	-
1966	7.80	5.11	4.74	5.19	7.28	43.16	27.51	11.75	13.41	19.37	26.17	11.44	15.24
1967	7.89	7.02	6.47	6.16	4.88	5.00	4.87	5.29	6.39	6.94	5.63	3.98	5.88
1968	4.25	3.56	2.80	2.55	3.14	3.49	3.83	3.61	3.91	9.54	11.05	5.81	4.79
1969	4.15	3.95	3.12	3.14	9.85	54.60	18.91	11.14	23.76	21.20	31.79	11.08	16.39
1970	16.51	6.94	6.39	5.34	15.66	11.11	8.32	9.97	16.67	20.66	54.95	13.61	15.51
1971	9.79	8.04	5.75	5.47	7.76	5.27	5.10	6.08	12.64	14.53	17.84	7.24	8.81
1972	8.44	5.52	4.84	5.13	9.05	7.82	5.42	6.62	8.91	18.68	8.01	11.79	8.35
1973	6.84	6.34	6.59	5.75	4.12	5.84	5.88	8.07	13.30	61.07	17.88	18.40	13.34
1974	9.10	8.88	12.30	6.87	6.12	6.26	4.36	7.44	22.01	20.36	20.84	12.57	11.43
1975	7.20	6.09	4.92	4.10	4.70	4.93	4.80	5.85	13.41	9.09	16.26	7.96	7.44
1976	5.97	3.73	3.98	4.19	3.29	3.44	2.60	3.69	3.89	5.59	4.70	3.08	4.01
1977	3.47	3.66	3.70	4.36	7.33	5.93	4.25	5.07	7.92	7.88	5.34	6.03	5.41
1978	5.79	5.67	6.04	7.31	12.30	12.19	6.67	7.15	7.50	26.19	11.85	6.54	9.60
1979	4.53	6.66	5.22	14.81	22.67	29.37	15.59	13.81	51.42	24.83	19.56	12.17	18.39
1980	8.93	6.05	5.59	6.16	5.94	7.69	4.80	10.63	10.28	9.89	8.16	18.48	8.55
1981	8.24	-	4.81	3.60	9.98	-	8.59	17.00	12.55	21.65	-	-	-
1982	-	-	-	-	-	-	-	-	-	5.64	4.29	3.46	-
1983	2.99	4.66	3.38	2.06	2.80	4.31	2.64	2.65	3.44	4.43	4.17	3.25	3.40
Mean	7.80	6.19	5.51	5.98	8.14	12.99	8.33	8.42	12.41	18.32	15.36	10.54	10.00
2. At Bog Walk													
1972	8.86	7.50	4.98	5.04	10.08	9.80	6.94	6.97	10.73	19.20	9.09	13.17	9.37
1973	7.22	6.54	6.43	5.98	4.53	6.85	6.09	8.18	13.28	61.74	18.07	19.34	13.69
Mean	8.04	7.02	5.71	5.51	7.30	8.33	6.51	7.58	12.01	40.47	13.58	16.26	11.53
3. At Crum Ewing													
1971	4.02	5.58	3.26	0.42	5.32	0.87	0.94	2.20	6.15	9.37	15.18	3.96	4.77
1972	3.74	0.47	0.20	0.57	3.77	4.13	0.65	1.62	3.40	12.77	2.92	6.66	3.41
1973	2.05	1.34	1.45	1.05	0.11	1.25	1.15	2.95	8.27	52.96	10.68	14.98	8.19
1974	4.59	4.13	8.95	2.08	1.48	1.32	0.24	2.27	18.58	19.82	10.94	8.44	7.40
1975	2.27	0.97	0.49	0.15	0.86	0.80	0.76	1.58	9.71	5.27	13.11	5.18	3.43
Mean	3.33	2.50	2.87	0.86	2.31	1.68	0.74	2.12	9.22	20.04	11.76	7.84	5.44

Table B-14 RESULTS OF WATER QUALITY ANALYSES

Sample No.	1	2	3	4	5	6	7	8	9	10
River	Rio Cobre	Rio Cobre	Main Canal	Spring Garden	Coleburns Gully	Rio Cobre	Rio Cobre	Main Canal	Spring Garden	Coleburns Gully
Site	Near Spanish Town	Crum Ewing	Spanish Town Water Works	Number Two	Resources Spring	Near Spanish Town	Crum Ewing	Spanish Town Water Works	Number Two Spring	Resources Spring
Date	23/9/86	23/9/86	23/9/86	23/9/86	23/9/86	15/10/86	15/10/86	15/10/86	15/10/86	15/10/86
Calcium (ppm)	70.0	67.0	66.0	95.0	80.0	57.0	55.0	58.0	86.0	74.0
Magnesium (ppm)	10.5	11.8	11.5	26.7	15.6	9.7	9.7	8.7	21.0	15.0
Sodtum (ppm)	15.6	16.0	14.5	66.8	10.3	14.0	11.5	10.0	40.0	9.4
Potassium (ppm)	0.90	0.90	0.85	4.35	0.80	1.4	1.4	1.2	3.5	1.0
C.O.D	0.95	3.95	1.00	6.27	1.15	2.6	2.6	2.6	15.7	-
DO/B.O.D	6.0/2.4	6.4/2.0	7.0/3.5	2.8/-	4.7/1.5	7.0/0.4	6.2/0.8	7.0/.04	3.8/0.4	6.0/0
Natrates (ppm)	3.3	3.7	2.7	0.9	5.1	3.9	3.1	3.3	2.2	5.0
Nitrites (ppm)	0.007	0.002	0.006	Trace	0.002	0.028	0.0	0.0	0.0	0.0
Sulphate (ppm)	6.80	8.80	6.30	3.64	7.20	8.6	7.8	7.0	19.4	7.8
Chlorides (ppm)	14.0	16.0	13.0	15.0	15.0	11.0	12.0	10.0	88.0	14.0
Solids Total	263.0	277.0	249.0	595.0	297.0	310.0	295.0	300.0	560.0	350.0
Suspended solids	8.4	25.8	7.9	5.7	2.4	39.0	64.0	18.0	13.0	15.0
pH value	7.96	7.96	7.97	7.62	7.15	7.64	7.8	7.8	7.4	6.9
EC (m.mhos/cm)	457.6	436.8	436.8	915.2	424.3	425.0	390.0	400.0	790.0	500.0
Turbidity N.T.U	1.00	8.50	1.00	1.50	0.69	-	-	-	-	-
Discharge (m3/s)	4.81	3.83	1.57	0.13	0.01	5.55	8.09	4.1	0.2	0.0

Table B-15 PROBABLE MINIMUM RAINFALL

(Unit:mm)

Month	Bernard Lodge			Caymanas C.			Innswood I			March Pen			Half-Way-Tree			Old Harbour			Farm 2		
	2-yr	5-yr	10-yr	2-yr	5-yr	10-yr	2-yr	5-yr	10-yr	2-yr	5-yr	10-yr	2-yr	5-yr	10-yr	2-yr	5-yr	10-yr	2-yr	5-yr	10-yr
Jan.	20	14	11	28	20	17	32	23	19	23	16	12	16	11	9	43	32	27	23	16	13
Feb.	25	17	14	33	23	19	36	26	21	27	19	15	22	15	12	43	32	27	29	20	16
Mar.	22	15	12	31	22	18	36	26	22	20	14	11	27	17	13	49	36	31	22	15	13
Apr.	40	27	23	56	40	33	54	39	32	37	26	21	36	25	20	62	46	40	38	26	21
May.	86	60	49	120	85	71	119	86	71	82	56	45	73	50	40	131	97	83	98	68	56
Jun.	73	50	41	84	59	49	93	67	56	68	46	37	62	43	34	97	72	62	72	50	41
Jul.	33	23	19	50	36	30	45	32	27	27	19	15	31	21	17	49	37	31	47	33	27
Aug.	75	52	42	94	67	55	82	60	49	67	46	37	65	44	36	121	90	77	64	45	37
Sep.	94	65	53	118	84	70	130	94	77	98	67	54	81	55	44	135	100	86	106	74	61
Oct.	176	121	100	210	150	124	204	148	122	169	116	93	160	118	89	207	154	132	172	119	98
Nov.	93	64	53	100	71	59	106	77	63	73	50	41	74	50	40	109	81	70	75	52	42
Dec.	35	25	20	50	36	29	58	42	35	35	24	19	29	20	16	50	37	32	37	25	21
Annual	772	533	437	974	693	574	995	720	594	726	499	400	680	463	370	1,096	814	699	783	543	446

Month	Innswood II			Warwick Castle2			Warwick Castle3			Spanish Town			Dawkins			Lagoon		
	2-yr	5-yr	10-yr	2-yr	5-yr	10-yr	2-yr	5-yr	10-yr	2-yr	5-yr	10-yr	2-yr	5-yr	10-yr	2-yr	5-yr	10-yr
Jan.	38	29	25	31	23	19	31	21	16	27	19	15	22	16	13	21	15	12
Feb.	34	26	23	36	26	23	36	24	19	36	25	21	33	24	20	27	19	16
Mar.	41	32	27	33	25	21	33	22	17	32	23	19	25	18	15	30	21	18
Apr.	62	48	41	58	42	37	49	33	26	50	35	29	41	29	24	44	31	26
May.	121	93	81	114	83	72	122	82	64	122	85	70	89	63	53	104	74	62
Jun.	86	67	58	79	58	50	87	59	46	83	58	48	72	51	42	78	56	46
Jul.	41	31	27	37	27	24	38	25	20	37	26	21	44	32	26	54	38	32
Aug.	84	64	56	72	53	45	62	42	33	97	68	55	71	50	42	93	66	55
Sep.	129	100	87	131	96	83	135	91	71	105	73	60	98	70	58	113	80	67
Oct.	237	182	159	189	139	119	198	134	104	186	130	106	159	113	94	195	138	116
Nov.	96	74	65	81	60	51	84	57	44	93	65	53	74	53	44	92	65	55
Dec.	52	40	35	49	36	31	49	33	26	41	29	24	35	25	21	46	32	27
Annual	1,021	786	684	910	668	575	924	623	486	909	636	521	763	544	452	897	635	532

Table B-16 PROBABLE MONTHLY AND ANNUAL DISCHARGES AT DAM SITE

(Unit : m3/sec)

T: return period	2-year	5-year	10-year
Jan.	7.4	5.1	4.0
Feb.	5.9	4.0	3.2
Mar.	5.2	3.6	2.8
Apr.	5.7	3.9	3.1
May.	7.7	5.3	4.1
June	12.4	8.4	6.6
July	7.9	5.4	4.2
Aug.	8.0	5.5	4.3
Sep.	11.8	8.1	6.3
Oct.	17.4	11.9	9.4
Nov.	14.6	10.0	7.8
Dec.	10.0	6.8	5.4
Annual	9.5	6.5	5.1
Minimum discharge	3.7	2.7	2.3
360 day flow	3.8	3.0	2.7

Table B-17 RECORDED ANNUAL PEAK DISCHARGE ON THE RIO COBRE AT THE DAM SITE

Year	Date	Discharge m3/sec	Rio Cobre River m3/sec	Main Canal m3/sec
1955	7th Oct.	60	55	5
1956	15th Oct.	142	139	3
1957	13th Nov.	45	39	6
1958	6th Oct.	916	914	2
1959	2nd Dec.	141	136	5
1960	10th Jun.	345	343	2
1961	5th Dec.	320	315	5
1962	12th Dec.	117	116	1
1963	31th May.	499	497	2
1964	29th Aug.	90	84	6
1965	31st Dec.	42	37	5
1966	28th Jun.	1,316	1,314	2
1967	23rd Oct.	56	51	5
1968	14th Oct.	116	115	1
1969	16th Nov.	477	472	5
1970	8th Nov.	441	437	4
1971	30th Oct.	108	104	4
1972	18th Dec.	121	118	3
1973	17th Oct.	575	573	2
1974	22nd Oct.	375	371	4
1975	15th Nov.	113	111	2
1976	20th Jan.	62	59	3
1977	30th May.	102	96	6
1978	3rd Oct.	125	121	4
1979	12th Sep.	469	468	1
1980	7th Aug.	273	271	2
1981	15th Aug.	223	220	3
1982	11th Jun.	30	25	5
1983	27th Feb.	102	98	4
1984	16th Nov.	159	152	7

Table B-18 RAINFALL IN FLOOD TIME ON THE RIO COBRE

(Unit : mm)

Flood on 6th October, 1958

Station	Date						
	3	4	5	6	7	8	9
Above Rocks	-	-	-	-	-	-	-
New Hall	0	16	0	54	140	149	43
Linstead	73	153	116	64	0	0	0
New Works Farm	66	131	124	74	0	0	0
Average	46	100	80	64	47	50	14

Flood on 31st May, 1963

Station	Date						
	25	26	27	28	29	30	31
Above Rocks	102	102	128	102	152	89	19
New Hall	0	49	41	10	58	75	102
Linstead	0	37	46	11	54	113	161
New Works Farm	3	34	13	4	0	51	145
Average	26	56	57	32	66	82	107

Flood on 28th June, 1966

Station	Date						
	22	23	24	25	26	27	28
Above Rocks	0	11	3	18	53	38	0
New Hall	3	9	0	6	75	318	5
Linstead	10	25	0	9	102	369	0
New Works Farm	9	11	0	6	67	318	9
Average	6	14	1	10	74	261	4

Flood on 8th November, 1970

Station	Date						
	5	6	7	8	9	10	11
Above Rocks	25	30	119	147	13	43	15
New Hall	30	0	105	51	24	80	0
Linstead	-	-	-	-	-	-	-
New Works Farm	19	18	150	160	32	81	0
Average	25	16	125	119	23	68	5

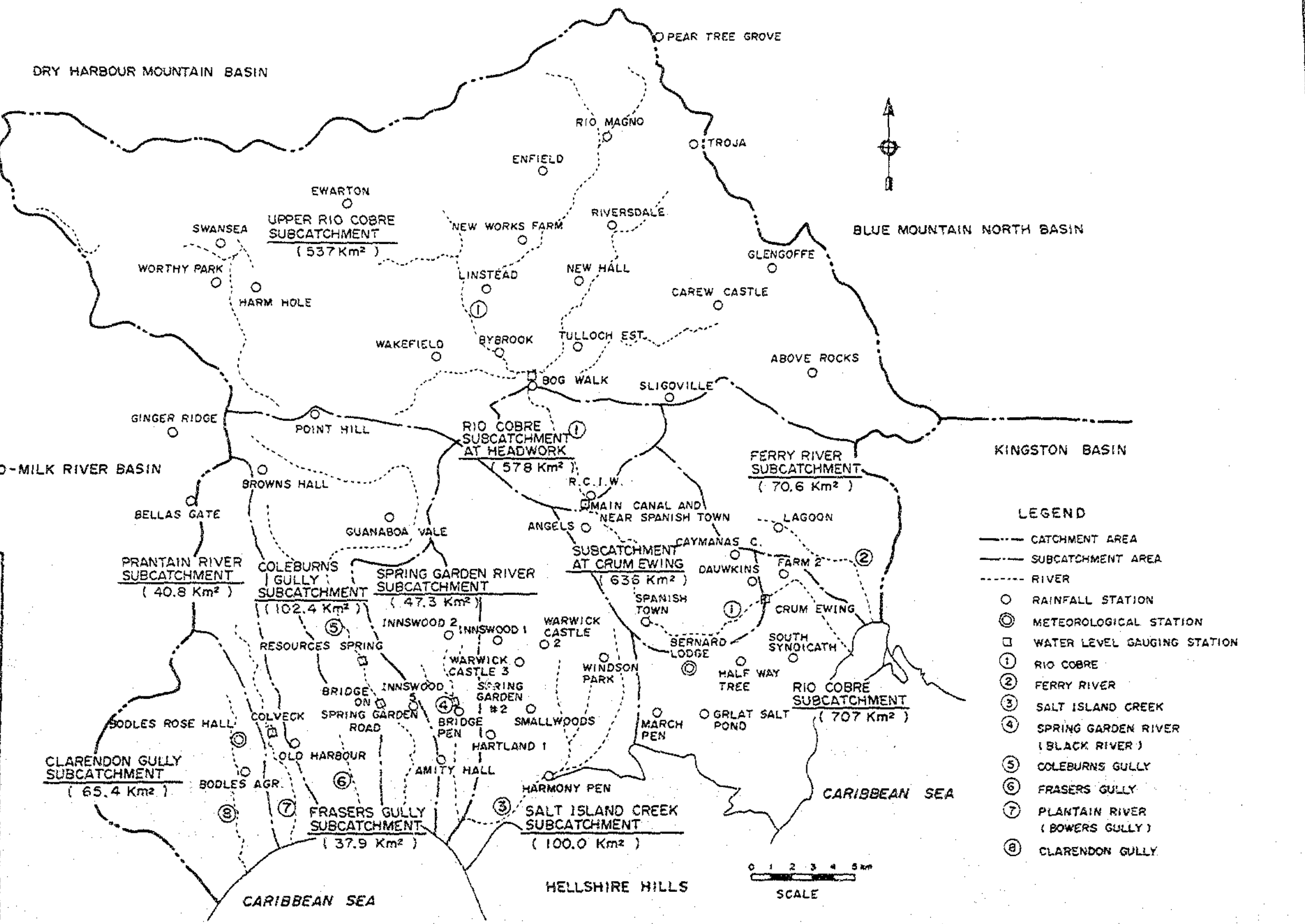
Flood on 22nd October, 1974

Station	Date						
	19	20	21	22	23	24	25
Above Rocks	-	-	-	-	-	-	-
New Hall	0	0	20	89	0	0	0
Linstead	0	0	13	91	0	0	0
New Works Farm	0	3	25	64	4	0	0
Average	0	1	19	81	1	0	0

Table B-19 ANNUAL MAXIMUM RAINFALL

(Unit : mm)

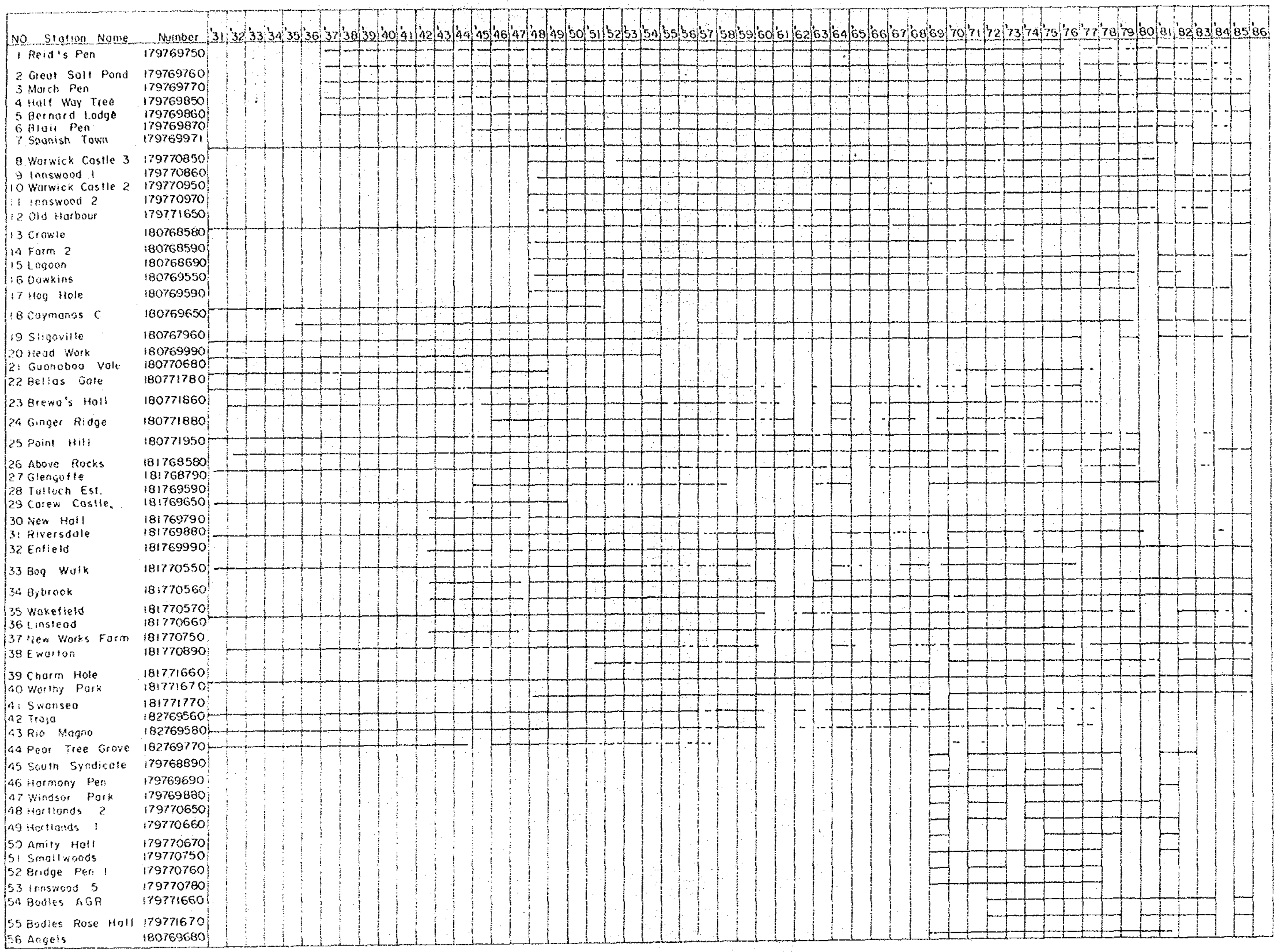
Station	1960	1961	1962	1963	1964	1965	1966	1967	1968	1978	1979	1980	1981	1982	1983	1984	1985	1986	1978	1979	1980	1981	1982	1983	1984	1985	1986
1. Day																											
March Pen	146	81	43	229	70	95	187	43	109	-	131	83	62	29	29	-	43	126	-	131	83	62	29	29	-	43	126
Half Way Tree	95	74	76	224	65	51	160	46	-	-	280	180	75	41	104	-	42	-	-	280	180	75	41	104	-	42	-
Bernard Lodge	104	107	71	278	61	55	142	68	96	-	144	195	79	84	86	-	43	148	-	144	195	79	84	86	-	43	148
Innswood 1	-	-	-	-	-	-	-	-	81	-	157	54	125	81	85	72	67	132	-	157	54	125	81	85	72	67	132
Old Harbour	112	114	52	154	70	187	72	123	160	-	135	55	177	-	98	40	55	140	-	135	55	177	-	98	40	55	140
Farm 2	115	91	90	297	41	48	152	41	64	-	132	-	91	-	83	52	42	-	-	132	-	91	-	83	52	42	-
Lagoon	118	167	90	342	48	61	114	69	-	119	-	90	110	-	-	-	-	-	119	-	90	110	-	-	-	-	-
Above Rocks	84	102	159	152	88	45	85	47	52	81	193	-	-	-	-	108	68	282	81	193	-	-	-	-	108	68	282
New Hall	104	84	66	194	64	102	318	44	-	91	-	170	68	57	72	39	46	-	91	-	170	68	57	72	39	46	-
Linstead	111	-	66	201	55	96	369	56	-	-	235	-	-	-	74	-	-	250	-	235	-	-	-	74	-	-	250
New work Farm	97	92	75	191	51	70	318	59	112	-	107	237	72	54	76	52	95	223	-	107	237	72	54	76	52	95	223
2. Days																											
March Pen	230	132	58	451	114	111	233	78	210	239	145	65	114	-	232	109	51	68	-	251	133	114	50	42	-	61	186
Half Way Tree	157	138	76	444	71	65	228	48	-	168	140	65	142	-	230	83	16	42	-	290	190	125	41	104	-	58	-
Bernard Lodge	174	176	72	497	109	56	229	73	184	215	144	71	121	-	248	99	24	53	-	277	195	157	84	86	-	59	181
Innswood 1	-	-	-	-	-	-	-	-	157	188	144	57	108	-	209	123	61	41	-	249	94	168	105	85	80	128	231
Old Harbour	189	191	73	269	78	210	122	154	254	133	136	89	65	-	146	59	56	83	-	213	88	239	-	98	40	60	242
Farm 2	150	168	96	527	74	64	232	41	103	160	196	81	114	-	249	123	25	47	-	246	-	137	-	83	114	64	-
Lagoon	209	252	97	653	58	75	178	72	-	211	197	102	104	-	165	122	36	61	126	-	133	165	-	-	-	-	-
Above Rocks	145	168	244	254	128	84	114	54	80	464	299	148	68	-	329	126	93	116	131	193	-	-	-	-	121	125	407
New Hall	127	109	102	309	78	118	392	51	-	217	156	84	82	-	164	88	63	71	106	-	268	123	65	103	63	58	-
Linstead	155	-	109	357	59	117	471	60	-	223	198	79	100	273	147	61	83	94	-	418	-	-	-	109	-	-	411
New work Farm	143	131	102	286	74	78	385	68	173	267	309	103	145	-	183	115	73	108	-	212	272-	142	66	82	65	106	369
3. Days																											
March Pen	235	173	61	495	136	111	254	78	216	277	154	69	119	-	238	109	27	88	-	371	133	141	65	42	-	61	222
Half Way Tree	160	160	88	506	105	65	236	56	-	203	178	69	149	-	236	83	16	52	-	290	255	168	41	104	-	58	-
Bernard Lodge	179	225	74	561	126	56	229	99	195	267	179	71	121	-	254	99	24	53	-	349	195	198	84	86	-	62	231
Innswood 1	-	-	-	-	-	-	-	-	163	222	149	62	108	-	216	123	56	41	-	275	94	178	110	85	84	128	277
Old Harbour	214	228	81	293	112	210	146	164	331	184	173	112	78	-	149	59	55	118	-	290	108	269	81	98	42	60	289
Farm 2	209	221	96	575	109	64	237	48	113	220	236	81	114	-	255	123	25	47	-	262	-	137	-	83	114	64	-
Lagoon	252	291	97	736	74	75	183	72	-	262	235	102	104	-	175	122	36	79	126	-	173	198	-	-	-	-	-
Above Rocks	177	168	269	382	187	89	169	90	83	490	350	199	99	-	329	186	79	116	159	193	-	-	-	-	151	125	460
New Hall	156	131	102	320	83	135	399	57	-	245	180	122	82	-	164	88	53	83	106	-	268	139	66	103	71	75	-
Linstead	181	-	109	372	75	123	480	69	-	254	222	79	138	368	150	68	76	104	-	568	-	-	-	109	-	-	491
New work Farm	162	167	128	299	78	83	392	93	192	294	342	112	150	-	189	123	56	109	-	220	479	148	66	83	65	111	440



THE MODERNIZATION AND EXPANSION OF THE RIO COBRE IRRIGATION SCHEME

Fig. B-1
THE RIO COBRE BASIN

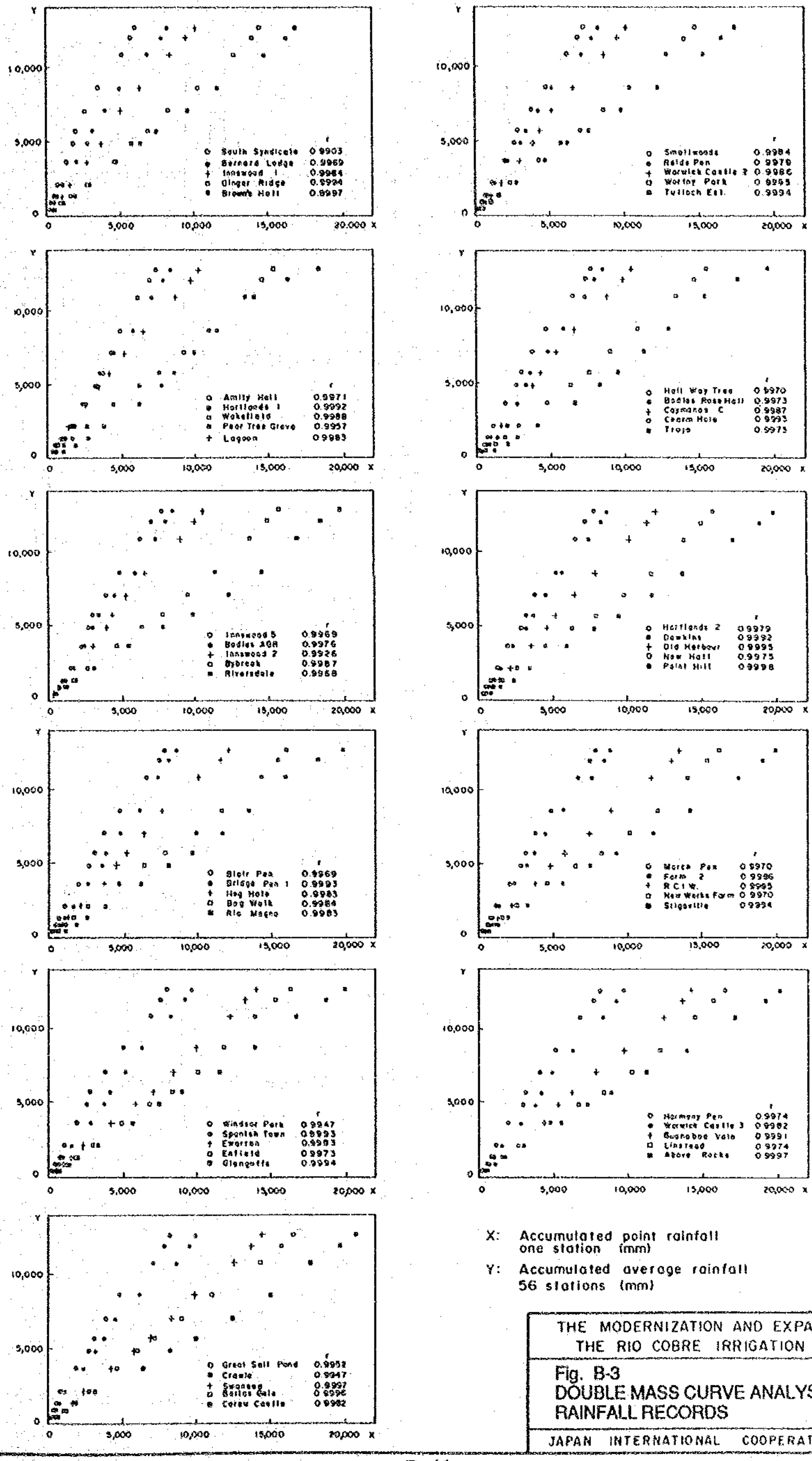
JAPAN INTERNATIONAL COOPERATION AGENCY



THE MODERNIZATION AND EXPANSION OF THE RIO COBRE IRRIGATION SCHEME

Fig. B-2
AVAILABLE MONTHLY RAINFALL RECORDS

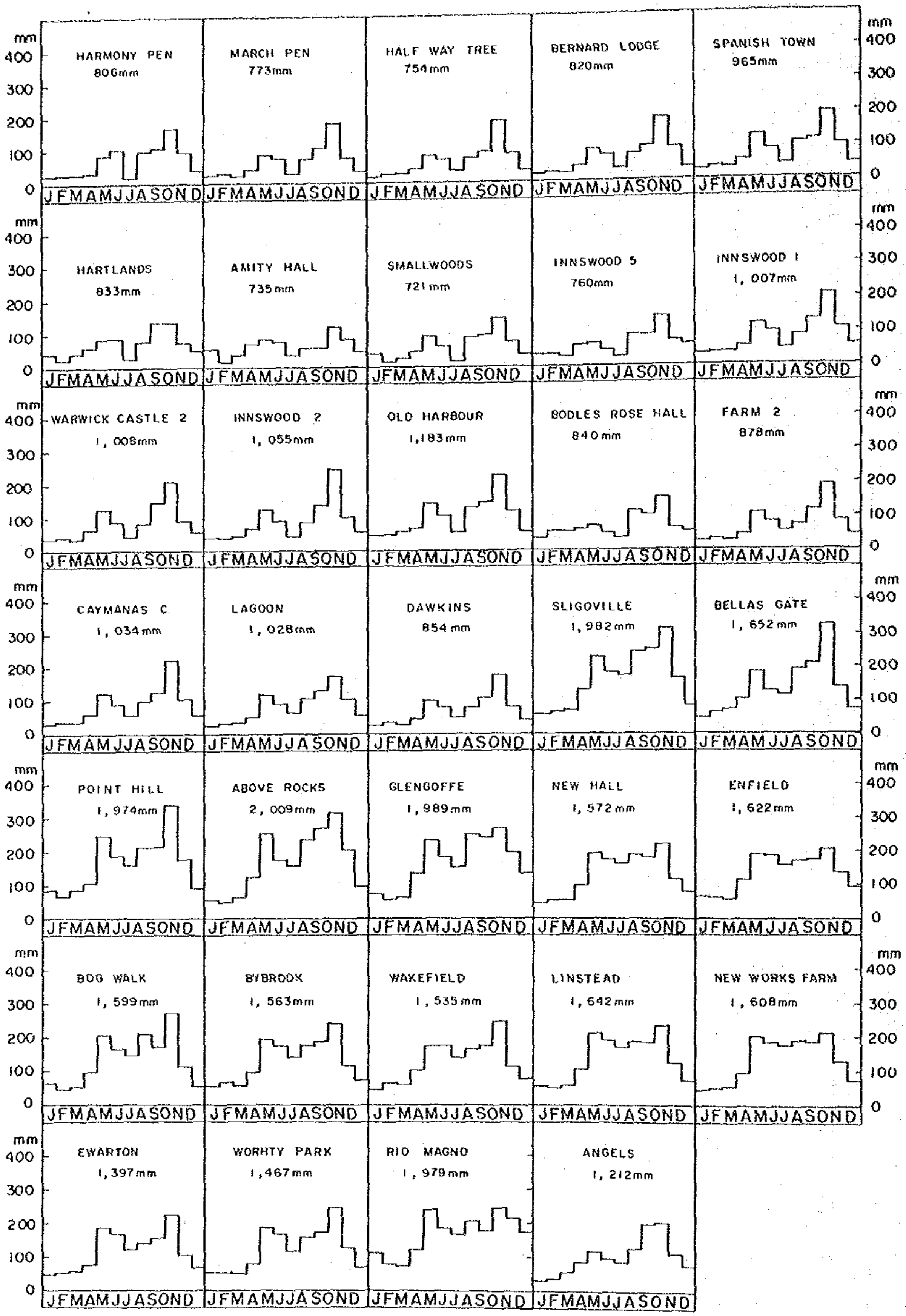
JAPAN INTERNATIONAL COOPERATION AGENCY



THE MODERNIZATION AND EXPANSION OF THE RIO COBRE IRRIGATION SCHEME

Fig. B-3
DOUBLE MASS CURVE ANALYSES FOR RAINFALL RECORDS

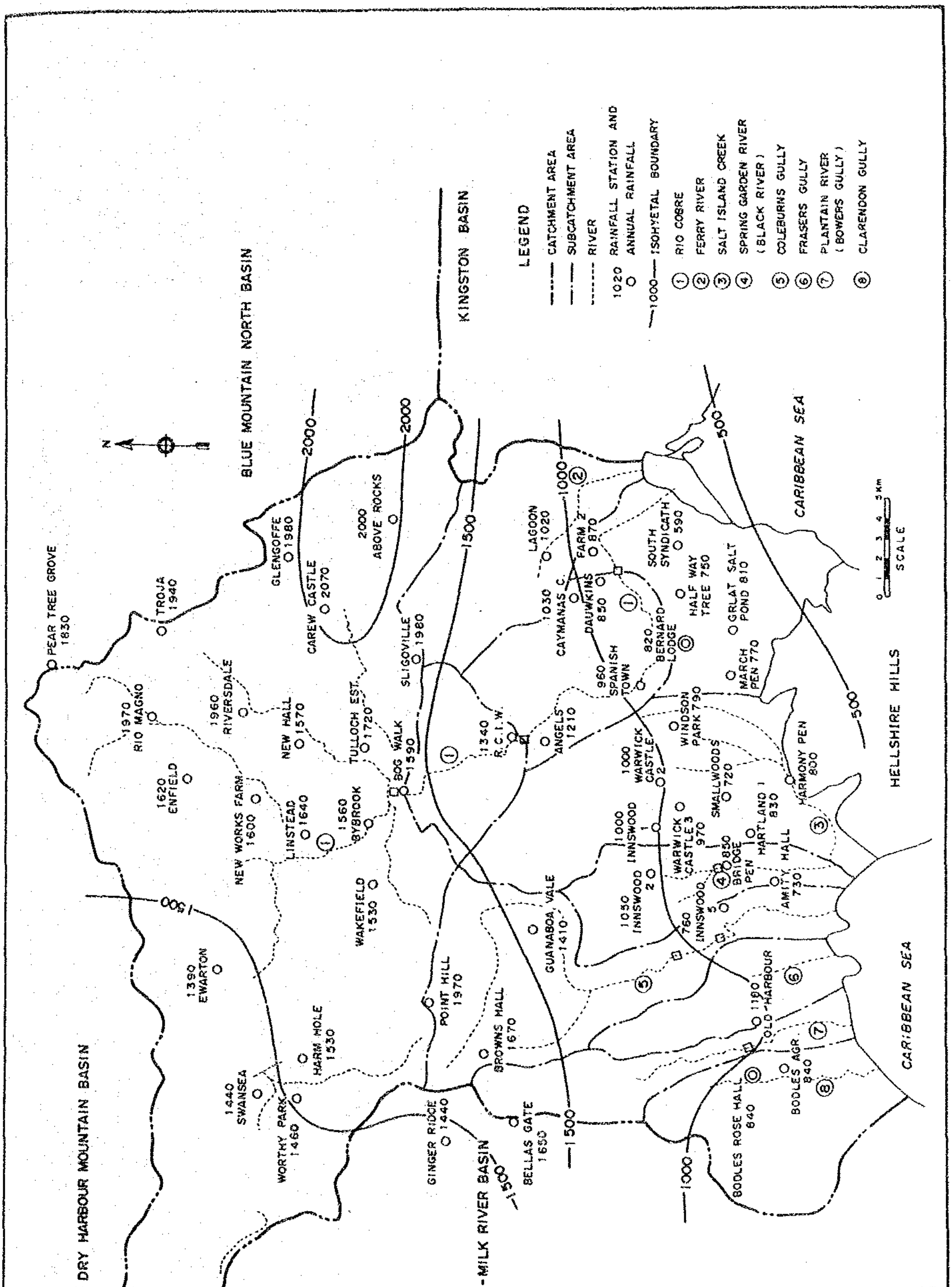
JAPAN INTERNATIONAL COOPERATION AGENCY



THE MODERNIZATION AND EXPANSION OF THE RIO COBRE IRRIGATION SCHEME

Fig. B-4
MONTHLY RAINFALL HISTOGRAMS

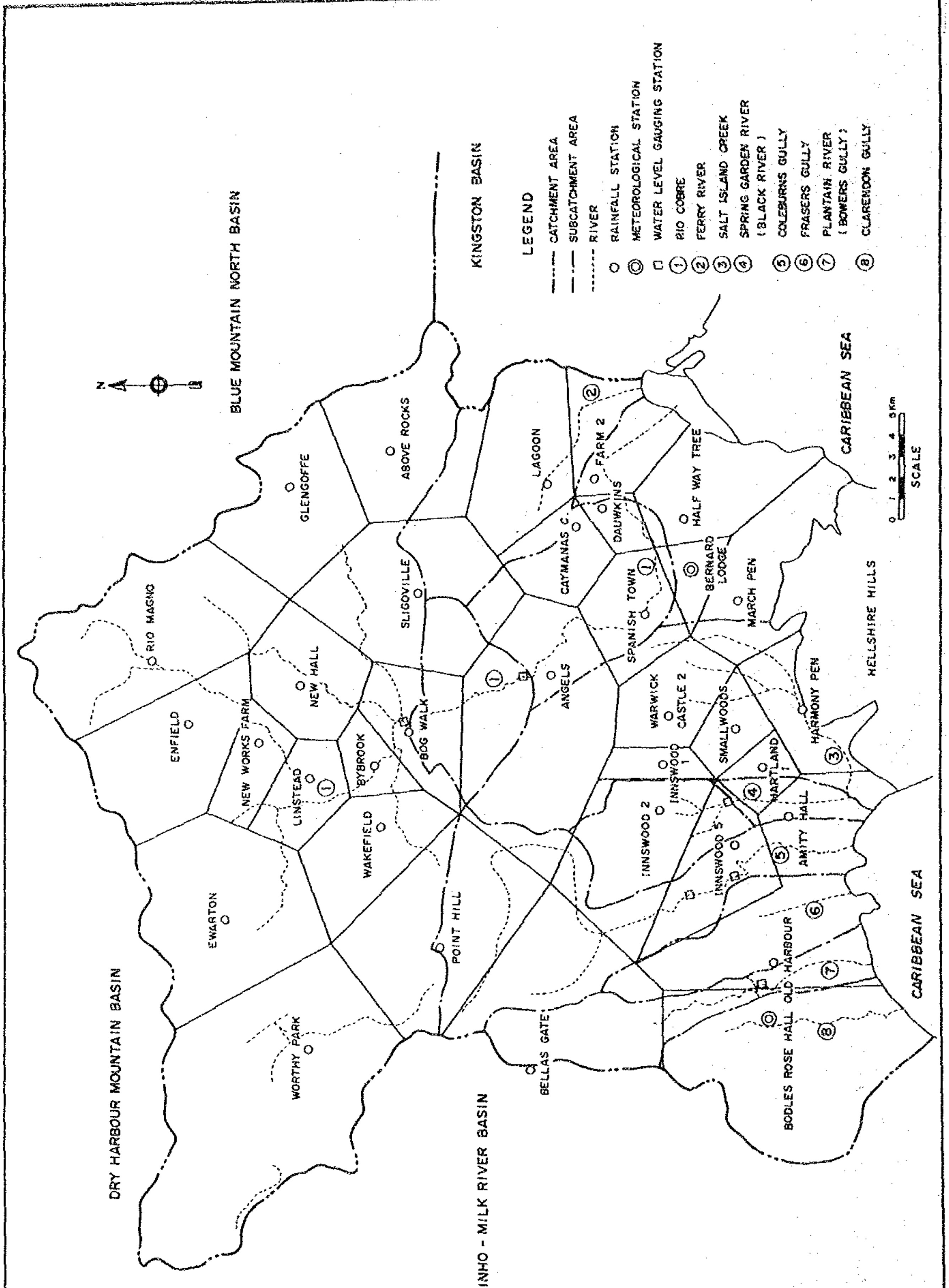
JAPAN INTERNATIONAL COOPERATION AGENCY



THE MODERNIZATION AND EXPANSION OF
THE RIO COBRE IRRIGATION SCHEME

Fig. B-5
ANNUAL ISOHYETS IN THE RIO COBRE BASIN

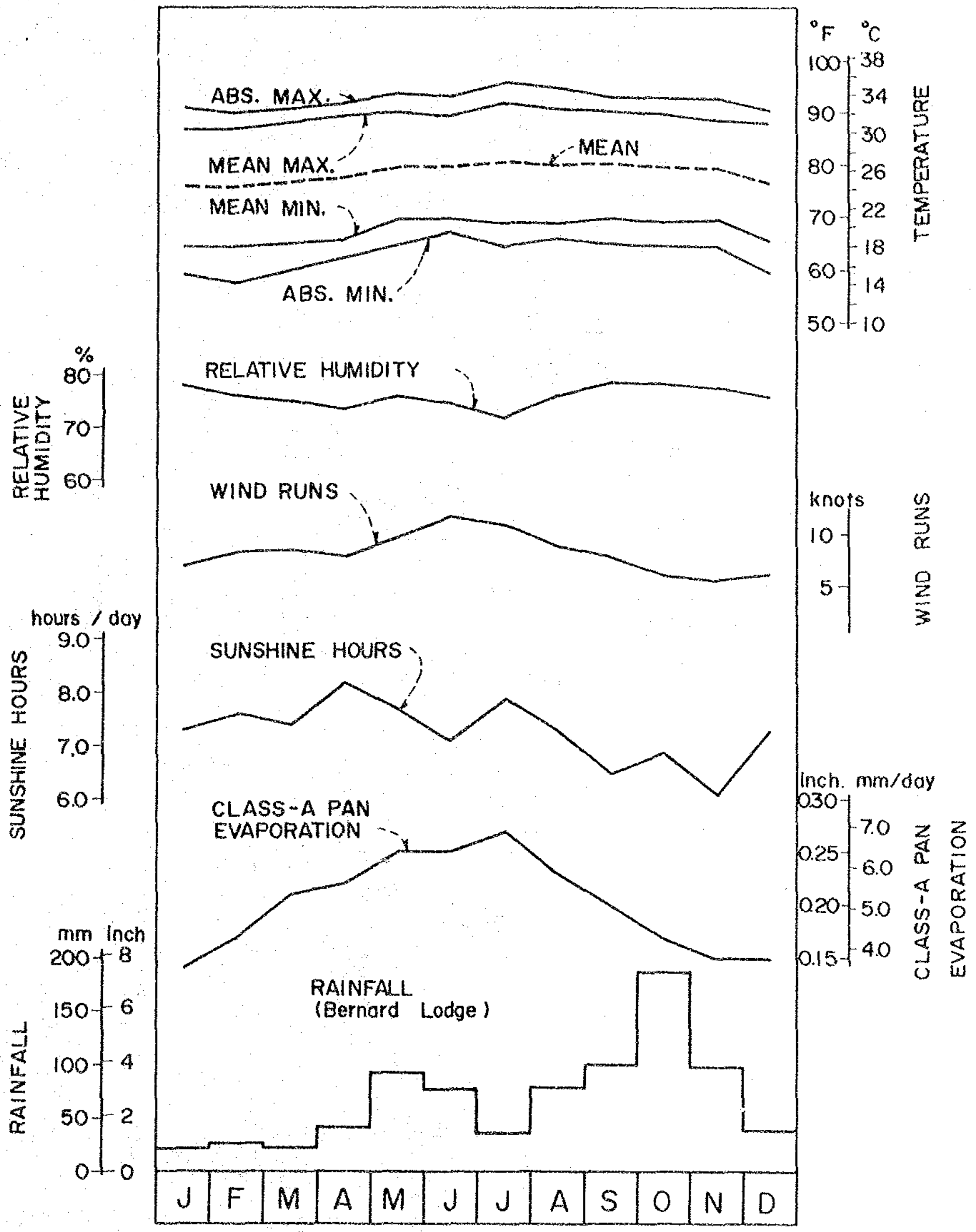
JAPAN INTERNATIONAL COOPERATION AGENCY



THE MODERNIZATION AND EXPANSION OF THE RIO COBRE IRRIGATION SCHEME

Fig. B-6
THIESSEN POLYGONS NETWORKS

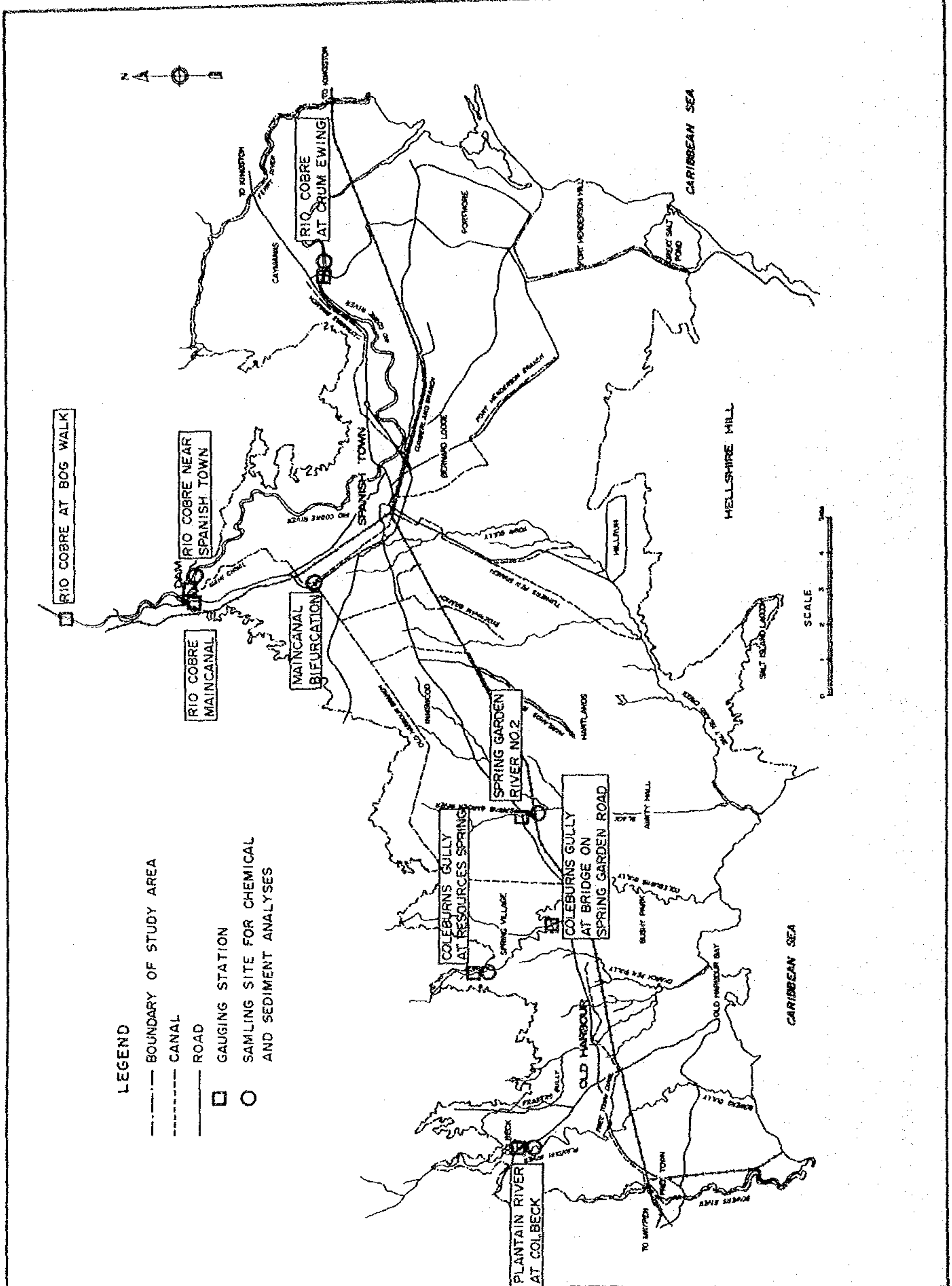
JAPAN INTERNATIONAL COOPERATION AGENCY



THE MODERNIZATION AND EXPANSION OF THE RIO COBRE IRRIGATION SCHEME

Fig. B-7
CLIMATIC FEATURES (BERNARD LODGE)

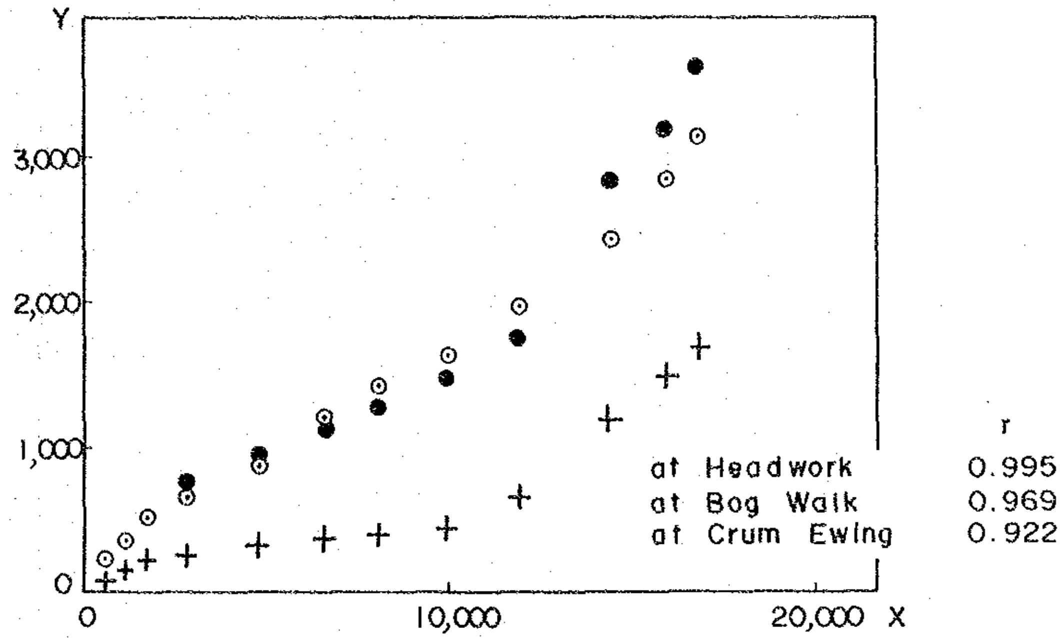
JAPAN INTERNATIONAL COOPERATION AGENCY



THE MODERNIZATION AND EXPANSION OF THE RIO COBRE IRRIGATION SCHEME

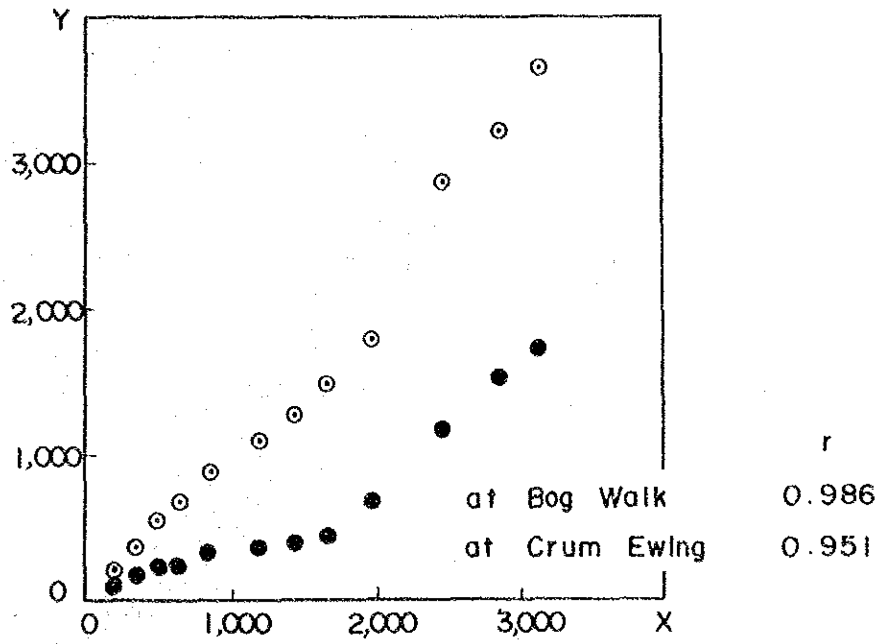
Fig. B-8
LOCATION OF GAUGING STATION AND SAMPLING SITE

JAPAN INTERNATIONAL COOPERATION AGENCY



X : Basin Rainfall (mm)

Y : Discharge (*10 M^3)



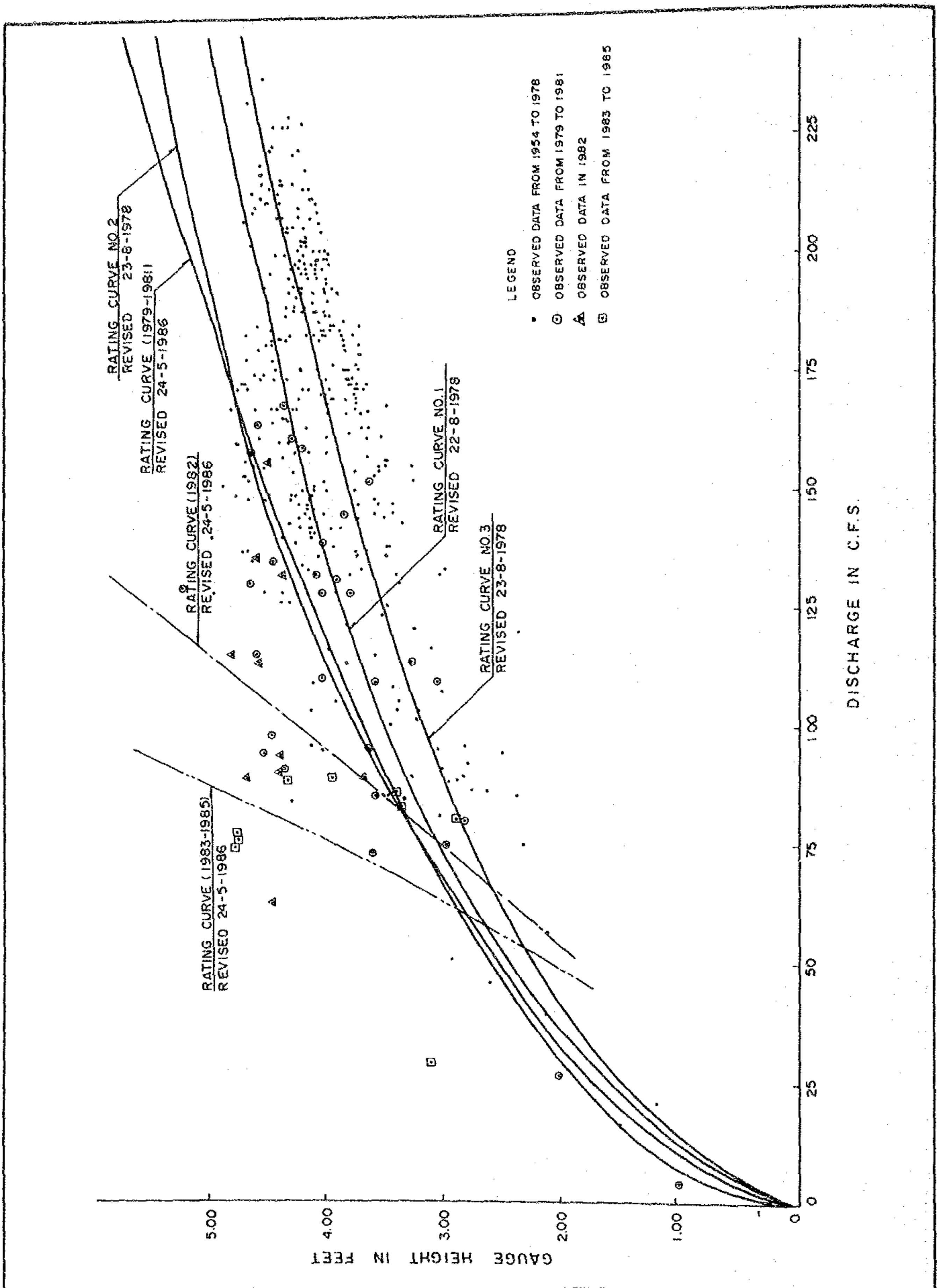
X : at Dam Site (*10 M^3)

Y : at Bog Walk (*10 M^3)

THE MODERNIZATION AND EXPANSION OF THE RIO COBRE IRRIGATION SCHEME

Fig. B-9
DOUBLE MASS CURVE ANALYSES OF DISCHARGE RECORD

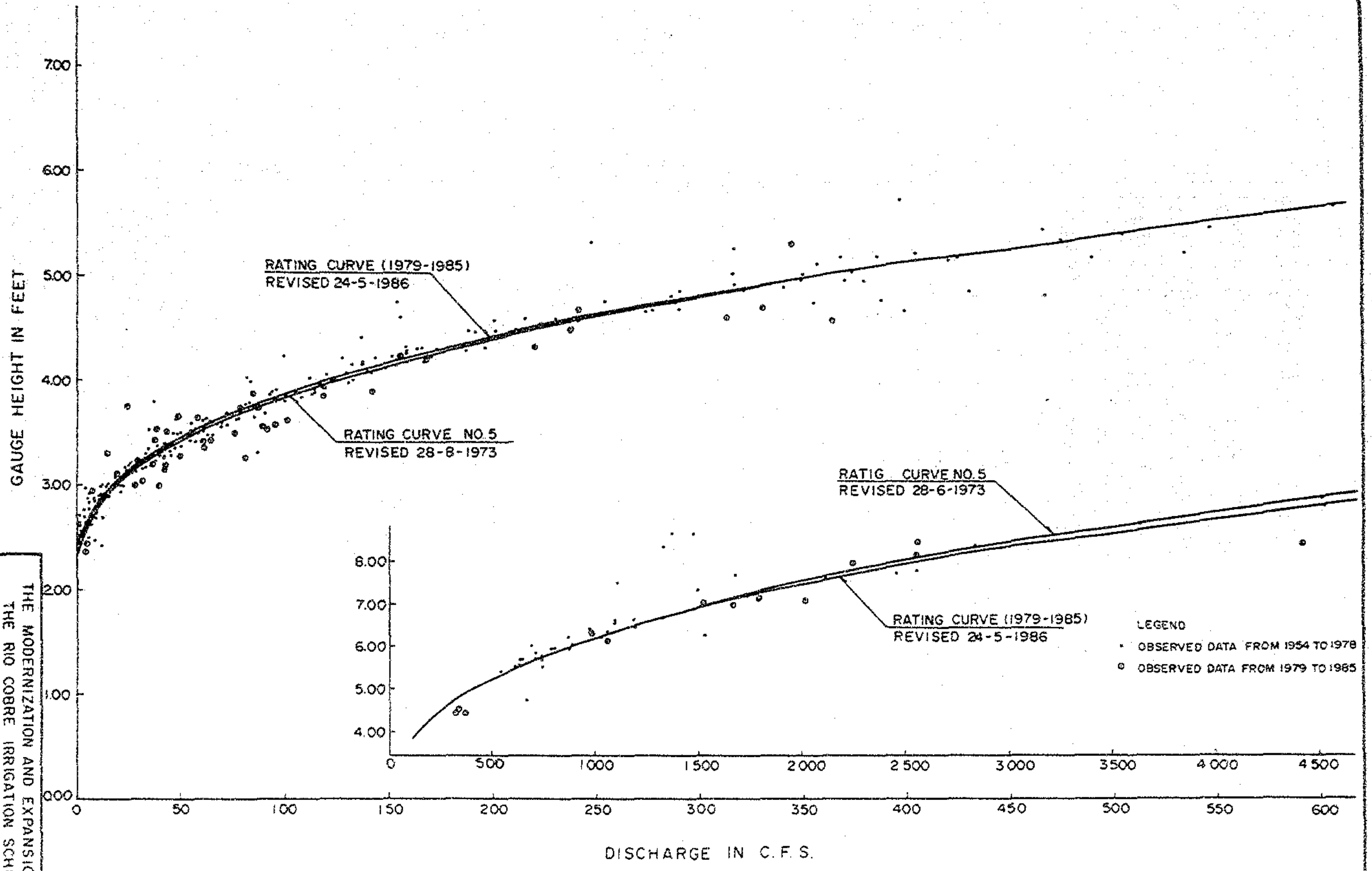
JAPAN INTERNATIONAL COOPERATION AGENCY



THE MODERNIZATION AND EXPANSION OF THE RIO COBRE IRRIGATION SCHEME

Fig. B-10
RATING CURVE AT RIO COBRE MAIN CANAL

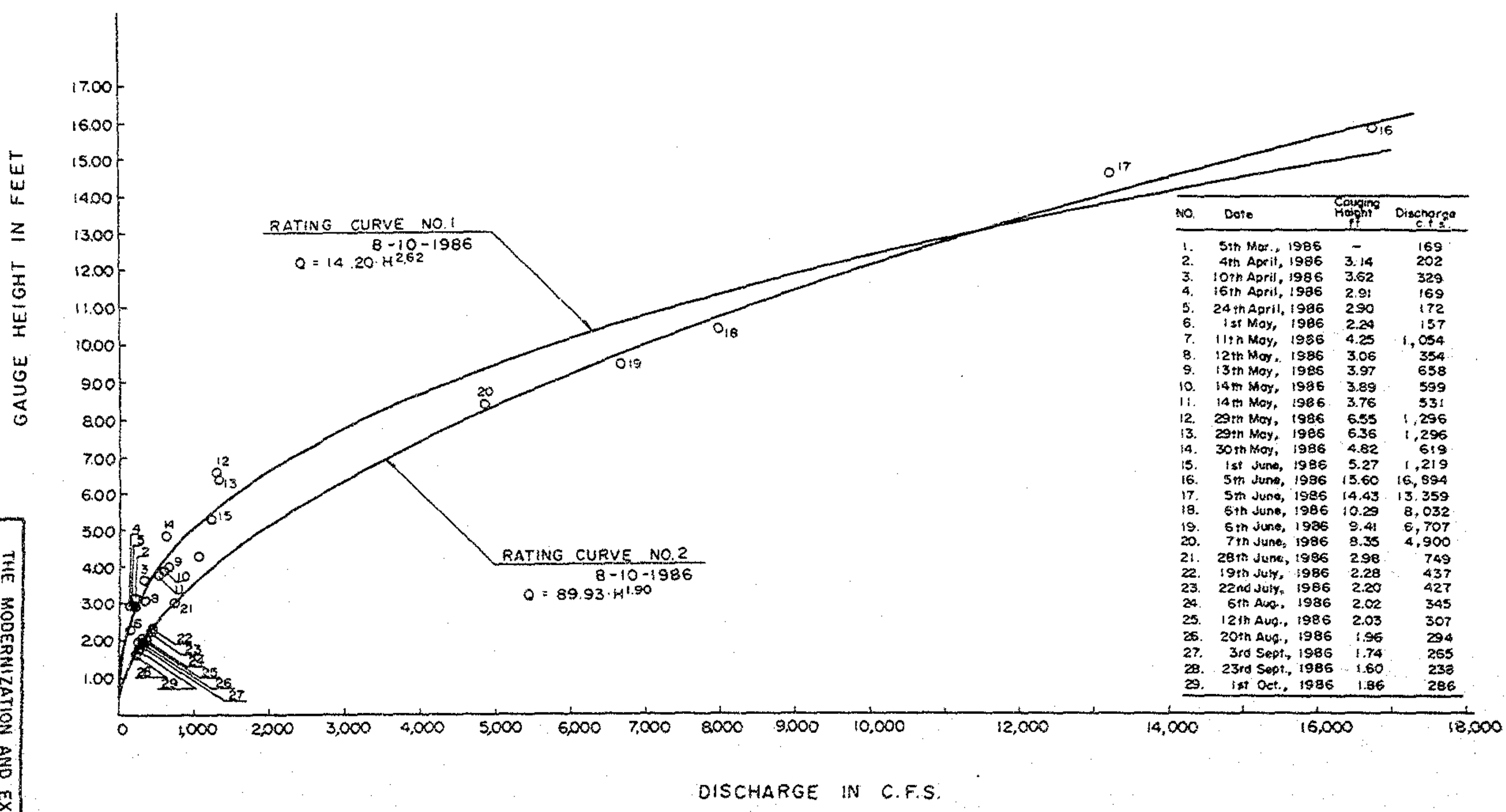
JAPAN INTERNATIONAL COOPERATION AGENCY



THE MODERNIZATION AND EXPANSION OF THE RIO COBRE IRRIGATION SCHEME

Fig. B-11
RATING CURVE ON THE RIO COBRE NEAR SPANISH TOWN

JAPAN INTERNATIONAL COOPERATION AGENCY

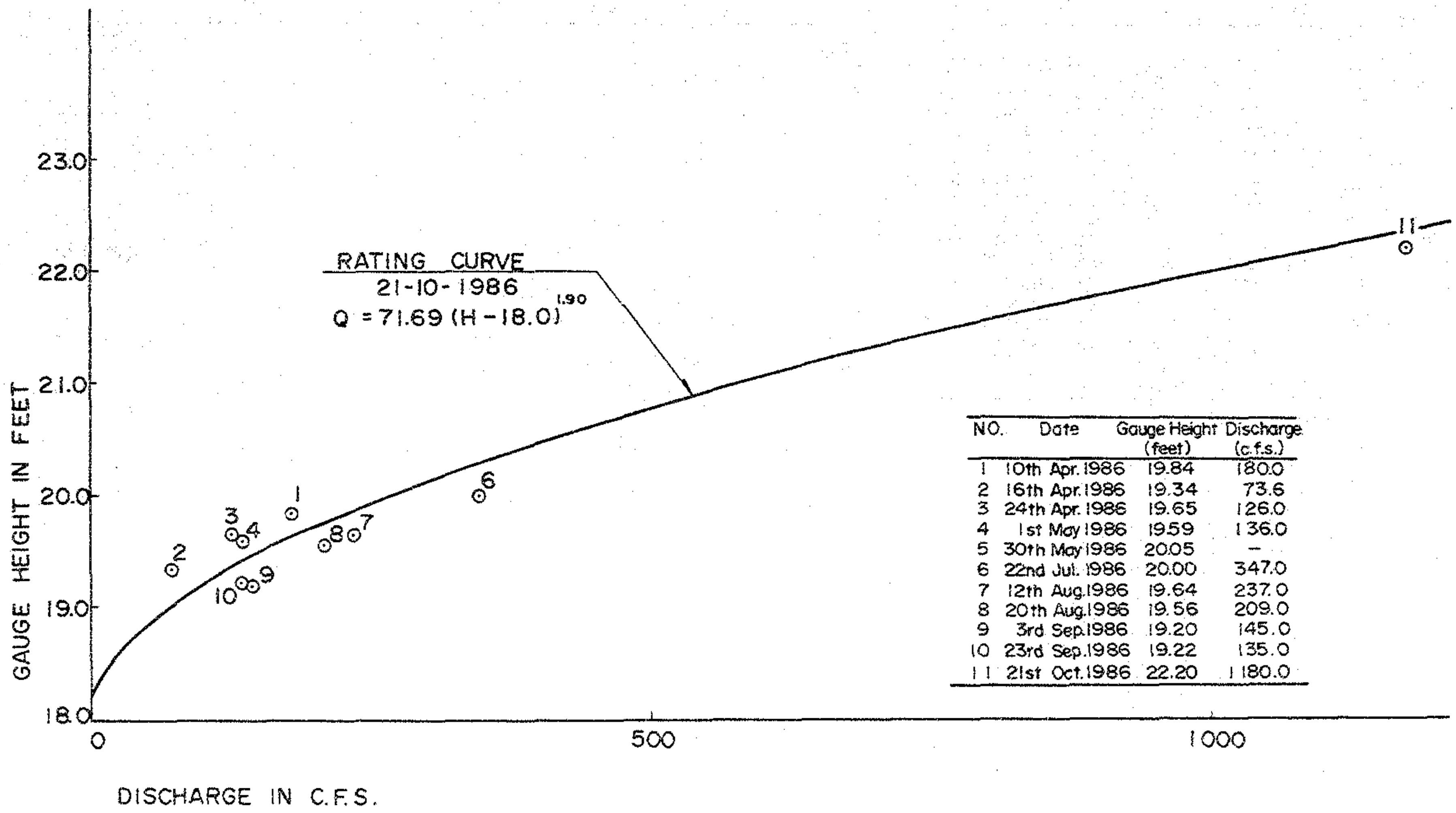


NO.	Date	Gauging Height ft	Discharge c.f.s.
1.	5th Mar., 1986	–	169
2.	4th April, 1986	3.14	202
3.	10th April, 1986	3.62	329
4.	16th April, 1986	2.91	169
5.	24th April, 1986	2.90	172
6.	1st May, 1986	2.24	157
7.	11th May, 1986	4.25	1,054
8.	12th May, 1986	3.06	354
9.	13th May, 1986	3.97	658
10.	14th May, 1986	3.89	599
11.	14th May, 1986	3.76	531
12.	29th May, 1986	6.55	1,296
13.	29th May, 1986	6.36	1,296
14.	30th May, 1986	4.82	619
15.	1st June, 1986	5.27	1,219
16.	5th June, 1986	15.60	16,894
17.	5th June, 1986	14.43	13,359
18.	6th June, 1986	10.29	8,032
19.	6th June, 1986	9.41	6,707
20.	7th June, 1986	8.35	4,900
21.	28th June, 1986	2.98	749
22.	19th July, 1986	2.28	437
23.	22nd July, 1986	2.20	427
24.	6th Aug., 1986	2.02	345
25.	12th Aug., 1986	2.03	307
26.	20th Aug., 1986	1.96	294
27.	3rd Sept., 1986	1.74	265
28.	23rd Sept., 1986	1.60	238
29.	1st Oct., 1986	1.86	286

THE MODERNIZATION AND EXPANSION OF THE RIO COBRE IRRIGATION SCHEME

Fig. B-12
RATING CURVE ON THE RIO COBRE AT BOG WALK

JAPAN INTERNATIONAL COOPERATION AGENCY

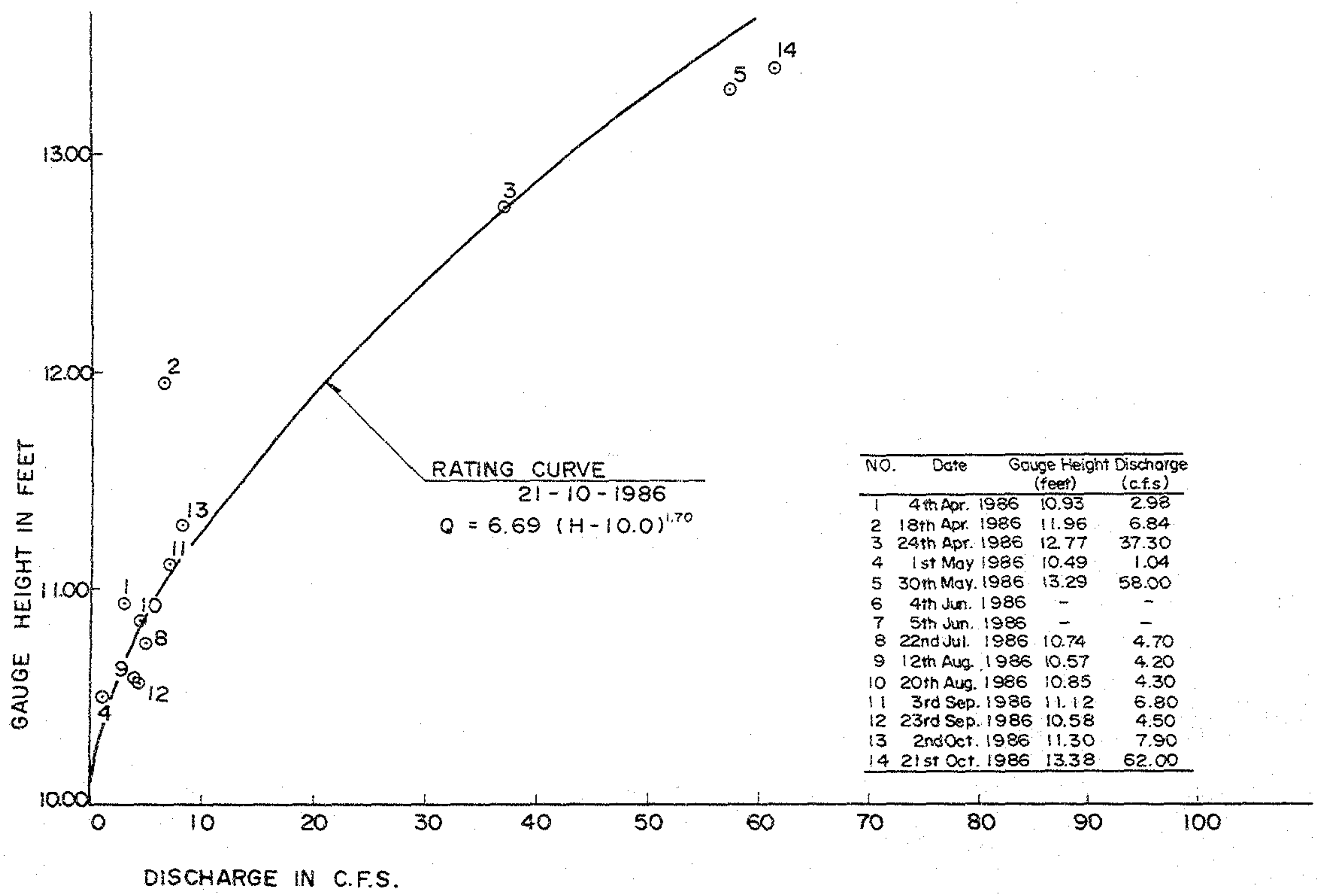


NO.	Date	Gauge Height (feet)	Discharge (c.f.s.)
1	10th Apr. 1986	19.84	180.0
2	16th Apr. 1986	19.34	73.6
3	24th Apr. 1986	19.65	126.0
4	1st May 1986	19.59	136.0
5	30th May 1986	20.05	–
6	22nd Jul. 1986	20.00	347.0
7	12th Aug. 1986	19.64	237.0
8	20th Aug. 1986	19.56	209.0
9	3rd Sep. 1986	19.20	145.0
10	23rd Sep. 1986	19.22	135.0
11	21st Oct. 1986	22.20	1180.0

THE MODERNIZATION AND EXPANSION OF THE RIO COBRE IRRIGATION SCHEME

Fig. B-13
RATING CURVE ON THE RIO COBRE AT GRUM EWING

JAPAN INTERNATIONAL COOPERATION AGENCY



NO.	Date	Gauge Height (feet)	Discharge (c.f.s)
1	4th Apr. 1986	10.93	2.98
2	18th Apr. 1986	11.96	6.84
3	24th Apr. 1986	12.77	37.30
4	1st May 1986	10.49	1.04
5	30th May. 1986	13.29	58.00
6	4th Jun. 1986	–	–
7	5th Jun. 1986	–	–
8	22nd Jul. 1986	10.74	4.70
9	12th Aug. 1986	10.57	4.20
10	20th Aug. 1986	10.85	4.30
11	3rd Sep. 1986	11.12	6.80
12	23rd Sep. 1986	10.58	4.50
13	2nd Oct. 1986	11.30	7.90
14	21st Oct. 1986	13.38	62.00

THE MODERNIZATION AND EXPANSION OF THE RIO COBRE IRRIGATION SCHEME

Fig. B-14
RATING CURVE ON THE SPRING GARDEN RIVER NO. 2

JAPAN INTERNATIONAL COOPERATION AGENCY