BIBLIOGRAPHIC DATA SHEET	1. CONTROL NUMBER PN-AAJ-307	2. SUBJECT CLASSIFICATION (695) AP10-0000-G662

3. TITLE AND SUBTITLE (240)
Jratunseluna Basin updated development plan; appendix H, sedimentation studies (Jragung Watershed)

4. PERSONAL AUTHORS (100)

5. CORPORATE AUTHORS (101)
PRC Engineering Consultants, Inc.

6. DOCUMENT DATE (110)	7. NUMBER OF PAGES (120)	8. ARC NUMBER (170)
1980	279p.	ID627.8.P921

9. REFERENCE ORGANIZATION (130)
PRC/ECI

10. SUPPLEMENTARY NOTES (500)
(Report consists of executive summary, main report, and appendices A - H: PN -AAJ-297 | PN- AAJ-307)

11. ABSTRACT (950)

12. DESCRIPTORS (920)

Water resources	Indonesia	River basins
Flood control	Sediments	Water supply
Development strategy		

13. PROJECT NUMBER (150)

14. CONTRACT NO.(140)
AID/SOD/PDC-C-0215

15. CONTRACT TYPE (140)

16. TYPE OF DOCUMENT (160)

AID 590-7 (10-79)

DIRECTORATE GENERAL OF WATER RESOURCES DEVELOPMENT
MINISTRY OF PUBLIC WORKS
REPUBLIC OF INDONESIA

JRATUNSELUNA BASIN
UPDATED DEVELOPMENT PLAN

APPENDIX H

SEDIMENTATION STUDIES
(JRAGUNG WATERSHED)

MAY 1980

SUBMITTED BY

PRC ENGINEERING CONSULTANTS, INC.
ENGLEWOOD, COLORADO, U.S.A. SEMARANG, INDONESIA

DIRECTORATE GENERAL OF WATER RESOURCES DEVELOPMENT
MINISTRY OF PUBLIC WORKS
REPUBLIC OF INDONESIA

JRATUNSELUNA BASIN

UPDATED DEVELOPMENT PLAN

APPENDIX H

SEDIMENTATION STUDIES

(JRAGUNG WATERSHED)

MAY 1980

SUBMITTED BY

PRC ENGINEERING CONSULTANTS, INC.
ENGLEWOOD, COLORADO, U.S.A. SEMARANG, INDONESIA

PREFACE

The Directorate General of Water Resources Development (DGWRD) of the Ministry of Public Works, Government of Indonesia (GOI) contracted PRC Engineering Consultants, Inc. (PRC/ECI) to provide consulting engineering services for preparing an integrated development plan for the Tuntang/Jragung Rivers in the Jratunseluna Basin. The study for the preparation of the plan started on May 16, 1979 and was scheduled to be completed on November 30, 1979.

An interim report on the study was submitted by PRC/ECI on August 15, 1979 which was reviewed and discussed on September 24, 1979 in a meeting held by the DGWRD at Jakarta. In that meeting and in subsequent discussions between PRC/ECI and DGWRD, it was decided that the study on the Tuntang/Jragung Rivers should be modified by including the entire Jratunseluna Basin in certain aspects of the study. The original contract between GOI and PRC/ECI for the engineering services was, therefore, amended to include the revised scope of work for the modified study, completion date for which was set at June 15, 1980.

In the revised scope of work, provision was also made to train, assist and advise the GOI in carrying out a river sediment measuring program within the Jratunseluna Basin during the 1979-80 rainy season. The training of GOI personnel on obtaining and analyzing river sediment data would constitute the major portion of that effort.

In pursuance of the above stipulation, PRC/ECI assigned its staff consultant, Dr. M.A. Stevens, at Semarang for a period of one month to carry out the sediment measurement and training program. As a part of that program, Dr. Stevens gave a series of lectures to the staff of the Jratunseluna Basin office on Erosion and Sedimentation. The results of the study and the lecture notes are given in this Appendix H to the final report on the Jratunseluna Basin Updated Development Plan. Certain tables related to this appendix and Appendix A - Part I Hydrology are also included herein.

Semarang, May 1980

PRC Engineering Consultants, Inc.

TABLE OF CONTENTS

APPENDIX H

SEDIMENTATION STUDIES

(JRAGUNG WATERSHED)

TABLE OF CONTENTS
(Cont.)

APPENDIX H

SEDIMENTATION STUDIES

(JRACUNG WATERSHED)

LIST OF TABLES

APPENDIX H

SEDIMENTATION STUDIES

(JRAGUNG WATERSHED)

LIST OF TABLES
(Cont.)

APPENDIX H

SEDIMENTATION STUDIES

(JRAGUNG WATERSHED)

LIST OF FIGURES

APPENDIX H

SEDIMENTATION STUDIES

(JRAGUNG WATERSHED)

Jratunseluna Basin

Updated Development Plan

APPENDIX H

SEDIMENTATION STUDIES JRAGUNG WATERSHED

H.1. GENERAL

The Jragung River drains a part of the northeastern slopes of the extinct volcano Gunung Ungaran. This basin is bordered by others of similar form as the volcano is drained by streams flowing from the top of the volcano out in a radial pattern.

The headwaters of the Jragung River are at El. 1,250 Mean Sea Level (M.S.L.) on the side of the volcano (the peak elevation is 2,050 M.S.L.). The streams drop down steeply to the coastal plains. As shown in Figure H-1, the Jragung River is formed at the confluence of the Kali Klampok (drainage area of 60 km^2) and the Kali Trimo (drainage area of 30 km^2).

Approximately 2.5 km downstream of this confluence, the Jragung River cuts through a 70-m high ridge, the proposed site for the Jragung Dam. The drainage area upstream from the damsite is 94 km^2.

Another 15 km downstream, the Jragung River enters the coastal plain. Here the Jragung Weir was built in 1932 to divert irrigation water from the river. The riverbed level at the weir is approximately at El. 16 M.S.L.

Runoff from the Jragung Watershed is very rapid. In the headwaters, the slopes of the landscape are up to 200 m/km and along the incised streams the hillside slopes are very steep, on the order of 1 vertical to 1 horizontal. Farther downstream, hill slopes are flatter and there are alluvial deposits along the river.

H.1.1. River Profiles

The profiles of the Kali Klampok and the Kali Trimo curve gradually from very steep in the headwaters to approximately 10 m/km at their confluence. The Jragung River bed slope at the proposed damsite is 5.3 m/km. At the Borangan Bridge, the site of the stream-gaging station, it is 4.2 m/km.

H.1.2. Land Use

In 1969, nearly one-half of the Jragung Watershed upstream from the damsite is used for growing rice. Villages occupied 10 percent of the land, teak forests and rubber plantations covered 29 percent and the remaining area was used for dry land farming.

H.1.3. Borangan Bridge

Shown in Photographs 1 and 2, Borangan Bridge is a steel super structure resting on two massive masonry piers set in the river. The bridge was part of the old narrow gage railroad system used to transport teak logs from the forest. The railroad has been abandoned for a long time; the bridge deck has been covered with loose planks and is now used for light vehicular traffic.

The bridge is in the center of a straight, uniformly sloping river reach and has been used as the site for stream measurements since the beginning of this century.

H.2. HISTORY OF SEDIMENT STUDIES

H.2.1. Early Century

The first reported measurements of water and sediment in the Jragung River at the Borangan Bridge were made in the calender year 1907. The analysis of these measurements were published by Rutten in 1917 [R1] and have been quoted extensively thereafter. An English translation of Rutten's 1917 paper was given to PRC/ECI by Snowy Mountains Engineering Corporation.

The suspended sediment measurements were made twice daily for the entire year. Most of the samples were obtained at the surface of the water but several times surface water and water at the bed were sampled at the same time.

The amount of dissolved solids in the streamflow was determined

> "... no more than once every two months or even less often."

There is no indication of how the water discharge was measured. Rutten wrote that there existed tables

> "... indicating the amount of water flowing past the point of observation in cubic meters per second."

Rutten recognized that his data did not satisfy "... high demands of accuracy." However, his concern was to obtain the order of magnitude of denudation in Java. For this purpose, he reasoned that the data

> "... does not have to be very accurate ... not even within several tens of per cent."

Based on the 1907 data Rutten calculated the rate of denudation in the Jragung Watershed to between 1.6 and 2.5 mm. The value of 1.6 mm was that determined from the measurements. The value of 2.5 mm was Rutten's estimate taking into account the fact that the method of taking samples results in an underestimate of sediment transport.

The denudation value of 1.6 mm represents an average loss of rock over the entire catchment and is equivalent to a removal of 4,000 $t/km^2/y$ (metric tons per square kilometer per year) of sediment and dissolved solids.

Rutten had added the total weight of sediment to the total weight of dissolved solids passing the gage, then divided by 2.5 the assumed specific weight of rock in the catchment and by 101 km^2, the catchment area. The result was his value for "denudation", the removal of rock. Note that

$$1.6 \text{ mm} \times 2,500 \frac{\text{kg}}{\text{m}^3} \times \frac{1 \text{ m}}{1,000 \text{ mm}} \times \frac{1\text{t}}{1,000 \text{ kg}} \times \frac{10^6 \text{ m}^2}{\text{m}^3}$$

$$= 4,000 \text{ t/km}^2/\text{y}.$$

In scrutinizing his results, Rutten noted that the calculated amount of water which passed the Borangan Bridge in 1907 was only 80×10^6 to 100×10^6 m^3 whereas the river basin rainfall was 2,570 mm, equivalent to 260×10^6 m^3 over the entire area. The ratio of runoff to rainfall was too low.

According to PRC Engineering Consultants Inc's latest analysis [P2], the runoff resulting from an annual rainfall of 2,570 mm should be approximately 1,400 mm or 141×10^6 m^3.

If one prorates the 1.6 mm of denudation according to the estimate of the 1907 runoff, the denudation would be

$$1.6 \text{ mm} \times \frac{141 \times 10^6 \text{ m}^3}{90 \times 10^6 \text{ m}^3} = 2.5 \text{ mm}$$

Rutten noted that the maximum amount of sediment transported in the Jragung River in one day in 1907 amounted to 31 percent of the annual transport. That is equivalent to 0.5 mm of denudation. The 10 largest storms accounted for 75 percent of the annual transport.

Later Rutten [R2, R3] published a graph showing the daily amounts of denudation in the Jragung catchment in 1907. The 0.5 mm occurred towards the end of January, approximately 0.3 mm occurred near the 10 of December. There were 7 days in which the denudation was between 0.02 and 0.08 mm. The rest of the days had rates less than 0.02 mm.

H.2.2. Year 1973

To our knowledge, the next measurements in the Jragung River at Borangan Bridge were not taken until 1973, sixty-six years after the first measurement.

In 1973, the Jratunseluna Basin Project Office in Semarang established an automatic water level recorder on the downstream side of the left pier (looking downstream) at the bridge. Since May 1973 continuous stage records are available. At the same time, measurements of water discharge at low flow were started.

In 1973, NEDECO [N2] reported the results of their feasibility study for a dam and reservoir on the Jragung. Therein, it was assumed that the average denudation rate was now approximately 3.0 mm/y. This value was chosen almost twice as large as that of Rutten; NEDECO had no other source of sediment data available in 1973 other than Rutten's.

NEDECO used the 3.0 mm of denudation to estimate that the rate of reservoir sedimentation would be 6×10^6 m^3 at the damsite in 30 years. The catchment area upstream from the damsite is 94 km^2. The trap efficiency of the reservoir was taken as two-thirds (2/3) i.e. this part of the sediment coming down in the river would be deposited in the reservoir and one-third (1/3) would pass on downstream.

As the anticipated annual reservoir sedimentation rate was only 0.2×10^6 m^3, this low value did not warrant any apprehension concerning the feasibility of the proposed Jragung Project.

H.2.3. Year 1974

In 1974, Tudor Engineering Company [T2] reviewed NEDECO's feasibility report. Concerning reservoir sedimentation in the proposed Jragung reservoir, Tudor wrote;

> "Reservoir deposition appears to be no problem but studies should be updated."

H.2.4. Year 1976

In 1975, Engineering Consultants Inc. began a 6-month program to update NEDECO's feasibility study completed in 1973. Part of the work was to review the estimate of reservoir sedimentation.

To accomplish this review, the Jratunseluna Project undertook a sediment measuring program at the gaging station at the Borangan Bridge. The Delft Bottle sampler was used to measure the bed-material load (in this case, sediment with a median diameter greater than 50 microns). The water trap was employed to determine the wash load, assumed to be all suspended sediment with median diameter smaller than 50 microns.

The measuring program began on 5 February 1976 and continued on until 3 March 1976. A total of 100 Delft bottle samples and 133 water trap samples were collected. A summary of these measurement is given in Tables H-1, H-2 and H-3.

These 1976 measurements indicated that the sediment load in the river was larger than had been estimated previously. Also, the suspended sediment was the major portion of the sediment load transported by the river. Most of the suspended sediment is silt and clay. The largest suspended sediment concentration measured was 32,600 mg/l and occurred during a flood with a peak discharge of only 56 m^3/s.

A summary of the measured suspended sediment data collected during 4 floods in February and March, 1976 is given in Table H-4. The volume of water discharged during these 4 floods was 5.1×10^6 m^3, only 4 percent of the annual volume of runoff. The amount of suspended sediment carried out during the 4 floods was 101,000 meteric tons.

For these 4 floods, there was no correlation between discharge and suspended sediment concentration nor between concentration and measured rainfall. The indication was that most of the sediment was produced by raindrop erosion. Yet, the storm of 22 March 1976 with the smallest maximum station rainfall (28 mm) produced the largest measured peak suspended sediment concentration (32,600 mg/l). The storm of 18 March 1976 with the largest station rainfall (106 mm) produced the smallest peak concentration (15.000 mg/l).

Engineering Consultants, Inc. summed up the knowledge gained in 1976 with the following statements [E1]:

"The measurements indicate that the sediment transport rate in the Jragung River at the proposed damsite may be as large as 1,500,000 t/y. This is 3 to 4 times as large as the estimate made from 1907 measurements. Assuming a density of 1.2 t/m^3 for the deposited sediment and 90 percent trap efficiency, the initial decrease in reservoir capacity is approximately 1.1×10^6 to 1.5×10^6 m^3/y; 5 to 7 times greater than NEDECO's estimate. However, this new estimate must be considered very approximate. The lack of correlation between water discharge, measured rainfall and suspended sediment concentration means that projections based on a small number of measurements could be in error by a large amount.

Considering the size of the proposed investment in the Jragung Dam and uncertaininty in the above estimate of the sediment transport rate in the river, it would be prudent to conduct sediment measurements throughout the entire wet season in 1976-1977. The data collection program should be modified and simplified from that program used in February and March 1976".

The Jratunseluna Project did undertake another measuring program during the 1976 - 1977 wet season but this program was soon abandoned. First, the Delft bottle and its sled proved too cumbersome for the fast velocities in the Jragung River at the Borangan Bridge. The apparatus would drift far downstream. Then it became impractical to measure the velocity at the points where the samples were taken.

H.3. CURRENT PROGRAM

H.3.1. General

On 1 November 1977, a new program for measuring sediment in the Jragung River at the Borangan Bridge was undertaken. Based on the knowledge that more than 90 percent of the total sediment load in the river is suspended load and furthermore the suspended load is almost entirely silt and clay, only suspended sediment samples were collected.

The new program was continued until 30 April 1978, discontinued during the 1978 dry season and then repeated from 1 October 1978 through the present.

This program along with a summary of the data collected and the analysis of these data are presented herein. The purpose of this report is three-fold:

1. To provide detailed information to others working in Java on sedimentation problems.
2. To help train the Jratunseluna project people working in the hydrology division.
3. To document the work accomplished to date.

H.3.2. Gaging Station

H.3.2.a. The Reach

As described previously, the Jragung River streamgaging station is located at the Borangan Bridge. The catchment area for this gage is 101 km^2. Photographs 1 and 2 showing the reach upstream and downstream of the bridge were taken on 26 February 1980 when the river flow was approximately 1 m^3/s.

H.3.2.b. Hydraulic Geometry

The plan view of the Jragung River at the Borangan Bridge is given in Figure H-2.

The approach reach is very uniform in plan. Immediately upstream from Section D-D there is a bend as shown by the arrow in the sketch. The river is constant in width upstream from the bridge, gradually expands in width downstream from the bridge and then bends to the right.

The cross-section of the channel is trapezoidal with 2.5 horizontal to 1 vertical side slopes. Upstream from the bridge the hydraulic geometry of the river is as follows:

Bed width	21 m
Bankfull width	32 m
Bankfull depth	2 m
Riverbed slope	4.2 m/km.

At Section A - A, the bankfull width increased to 41 m and the left bank is nearly vertical.

H.3.2.c. Bed Material

Bed material samples were collected 9 times at low flow during the 1977 dry season. A total of 257 samples were taken at the four cross sections shown in Figure H-2.

The method of sampling was as follows. The bed width of the cross section was measured from the toe of one bank to the toe of the other. The toe was identified by a change from bed sediment to bank sediment and any change in vegetation. Then, samples of bed material at the surface were taken at each toe and at 9 equidistant-points across the bed.

Some samples were sieved individually for sediment size determination. Other samples which were very similar in particle size were combined in appropriate amounts and sieved as a composite sample. The bed sediment size of the reach was determined by combining the results obtained at the four cross sections.

A summary of the gradation data for each set of samples is given in Table H-5. The gradations of the bed material did not change appreciably during the low-flow season.

The bed material in the reach can be represented by the composite gradation curve given in Table H-5. The bed material is classified as medium gravel and has these properties:

$$d_{84} = 29 \text{ mm}$$

$$d_{50} = 10 \text{ mm}$$

$$d_{16} = 0.84 \text{ mm}$$

$$\sigma_g = \sqrt{d_{84}/d_{16}} = 5.9$$

$$d_m = \sum_i p_i \, d_{si} = 14.0 \text{ mm}$$

The values of p_i and d_{si} are given below.

Geometric mean of grain size class, d_{si} mm	Faction of Material in this class, p_{si}
.12	.02
.27	.06
.59	.08
1.30	.09
3.09	.11
7.78	.21
15.5	.12
22.0	.09
31.1	.13
44.0	.09
	1.00

H.3.2.d. Equipment

The gaging station is equipped with a staff gage, and a float operated OTT automatic water level recorder, with a weekly chart. The locations of these are shown in Photograph 3 and Figure H-2. The wet well for the recorder requires cleaning after each flood; otherwise sediment collected in the well during the flood impedes the movement of the float in the well.

A working platform has been constructed at the upstream side of the bridge on the centerline of the river. The platform has a roof to protect the streamgagers from rain. An A-pack reel has been fixed to the platform. The cable from the reel passes over an A-frame bolted to the platform midway between the piers. The flow and sediment measuring equipment are attached to this cable.

A Teledyne Gurley No. 665 direct reading Price current meter is used to measure the velocity at 0.6-m depth for low flow or 0.2 and 0.8 depth for floods. The depth is sounded with a 34-kg Columbus weight. The weight and meter are shown in Photograph 4. A spare readout meter, batteries, meter pivots and other critical parts are kept at the gage.

The suspended sediment is measured with a US P61 used as a depth-integrating sampler. Shown in Photograph 5 the unit weighs 45 kg and is suitable for all but the largest flow. A P63, which weighs 137 kg, is needed for the super floods.

The entire water surface, the working platform, the staff gage and the automatic water level recorder house are illuminated at night by electric power generated with a 10-Kva portable gas generator.

H.3.3. Sampling Program

The suspended load can be divided into two parts. First, there is the wash load - suspended sediment particles not found in appreciable quantities on the bed of the river. Wash load is usually silt and clay but if the velocity of the river is very fast, sand can be wash load.

Second, there is bed-material in suspension. These are particles of the same sizes as those found on the bed but they are moving along in suspension. This load is called the suspended bed-material load.

The samples collected with the water trap in 1976 were almost entirely silt and clay. Some gravel was obtained with the Delft Bottle.

To judge whether the suspended sediment in a river at any location is wash load or not, the relationship between the Rouse number, the concentration and depth in the flow is used.

The Rouse number is

$$Z = \frac{W}{\beta k V_*}$$

Here W = fall velocity of the sediment particle, m/s

β = a coefficient with a value near unity

k = von Karman universal coefficient with a value of approximately 0.4

V_* = the shear velocity, m/s

The term V_* is defined by the equation

$$V_* = \sqrt{\frac{\tau}{\rho}}$$

Here τ = mean or average bed shear stress, kg/m^2

ρ = density of water, $kg\text{-}sec^2/m^4$

For the reach of Jragung River at the gaging station, the average bed shear stress can be estimated with the equation

$$\tau = \gamma y S$$

in which

γ = unit weight of water, kg/m^3

y = depth of flow, m

S = bed slope of the river

The slope is 4.2 m/km for bankfull depth so

$$\tau = 1{,}000 \frac{kg}{m^3} \times 2\ m \times 4.2 \times 10^{-3} \frac{m}{m} = 8.4\ kg/m^2.$$

The shear velocity is

$$V_* = \sqrt{\frac{8.4}{102}} = 0.29\ m/sec.$$

The fall velocity of fine sand is on the order of 0.01 m/sec. Thus, for this sand, the Rouse number is

$$Z = \frac{0.01}{1.0 \times 0.4 \times 0.29} \simeq \frac{1}{10}$$

The variation of concentration with depth and with Rouse number is given in Figure H-3. The terms are:

C = the concentration of sediment at a level y above the bed.

C_a = the concentration of sediment at distance a = 0.05d above the bed.

d = the total depth of flow

The units of concentration are

$$\frac{\text{Weight of Sediment}}{\text{Volume of Water and Sediment}} = \text{mg/l}$$

Concentration is then milligrams of sediment per liter of water and sediment.

For a Z of 1/10, the concentration of fine sand is approximately one-third less at the surface than near the bed.

For very small Z, the concentration of suspended sediment is nearly uniform with depth, i.e. the concentration of suspended sediment is the same at the surface as at the bed. For the gaging station, for the silt and clay particles with fall velocities in the order of 0.001 m/sec, the Z value is approximately 1/100. Grab samples taken at the surface are suitable to measure this wash load.

The Z value for gravel is large indicating that it is necessary to place a sediment trap on the bed of the river to measure gravel load.

The P-61 sampler is designed to take in water and sediment at the local velocity v (See Figure H-4). That is, the rate at which of sediment enters the sampler at any level y is proportional to v.c and for water the rate is proportional to v.

Here v = local velocity, m/sec

c = local concentration of suspended sediment, mg/l

When lowered from the surface to the bed at a constant rate, the sampler collects water and sediment in appropriate amounts from all levels in the section. This type of sampling is called "depth integrating".

The total amount of sediment in the sample is proportional to

$$A \int_{0}^{d} v.c \; dy$$

in which A = cross sectional area of the nozzle. The total amount of water in the sample is proportional to

$$A \int_{0}^{d} v \; dy$$

The average concentration for the vertical section is

$$\bar{c} = \frac{\int v.c \; dy}{\int v \; dy}$$

Therefore, the depth-integrated sample obtained with the P-61 sampler has an average concentration equal to that at the vertical section.

Define $$\bar{v}\,\bar{c} = \frac{1}{d}\int_{0}^{d} v.c\ dy$$

and $$\bar{v} = \frac{1}{d}\int_{0}^{d} v\ dy$$

Henceforth $\bar{v}$ = the average velocity in the vertical

$\bar{c}$ = the depth-integrated average concentration in the vertical.

Normally, depth-integrated samples should be collected at 3 or 5 vertical sections across the river. This could not be accomplished at Borangan Bridge, because of the hydrologic and geomorphi characteristics of the Jragung watershed and the limited resources available to measure the sediment data.

Runoff from the Jragung catchment is primarily surface runoff from rainstorms occuring in the afternoon during the wet season, November through May. Because the slope of the watershed is large, the flow rises rapidly to a peak discharge and then recedes rapidly. The unit hydrograph for 50 mm of excess rainfall in 0.5 hour has a time-to-peak of only 1.5 hours and a duration of only 4.7 hours.

It is apparent that with only one sampler, one cannot obtain samples at one discharge at more than one vertical. In lieu of this, the program was to measure the velocity, depth and suspended sediment at the midpoint of the river on the upstream side of the bridge out of the influence of the bridge piers and to deduce the water and sediment discharges for the entire cross section from these measurements.

The initial program for the measurements was as follows:

1. Have all equipment set up and ready to operate prior to the rainfall and preferably before darkness.

2. At the start of the rain measure the depth, velocity and suspended sediment.

3. As soon as the river level starts to rise begin continuous measurements of depth, velocity and suspended sediment.

4. Maintain this program of continuous measurements until 0.5-hour after the peak of the flood has passed.

5. On the recession portion of the flood, measure the depth, velocity and suspended sediment every hour until the water level has dropped below a gage height of 1.0 m. Then measure again at 0700 and 1700 hours each day until a new flood comes.

6. Once a week during a low-flow period, make a standard discharge measurement by wading using the small current meter.

The procedure to follow in making and recording the measurement was as follows:

1. As soon as all the equipment is ready to operate, mark the recording chart for water level recorder with the time and gage height.

2. Begin by taking the velocity measurements. The current meter is 20 cm above the bottom of the sounding weight.

   In making the measurement, lower the assembly into the water until the current meter centerline is at the water surface. Set the meter on the sounding cable winch to zero. Lower the assembly until the sounding weight merely touches the bed. Read the meter on the sounding cable winch. The depth of flow is the meter reading plus 20 cm.

   If the depth of flow is less than 33 cm, put the sounding weight lightly on the bed and record the depth of observation (the distance the current meter is below the water surface) and the velocity.

If the depth of flow is greater than 33 cm but less than 100 cm, measure the velocity at 0.4 depth below the surface. For example, suppose the sounding cable meter reading is 28 cm with the sounding weight on the bed. The depth of flow is 28 + 20 = 48 cm. Therefore, the velocity should be measured at 0.4 x 48 = 19 cm below the surface. Therefore, raise the assembly up from the bed until the sounding cable meter reads 19. Then record the depth of observation (0.19 m) and the velocity.

If the depth of flow is greater than 100 cm, measure the velocity at 0.2 and 0.8 depth. For example suppose the sounding cable meter reading is 216 with the sounding weight resting lightly on the bed. The depth of flow is 216 + 20 = 236 cm. Therefore, the velocity should be measured at 0.2 x 236 = 47 cm and 0.8 x 236 = 188 cm. Raise the assembly up from the bed until the sounding cable meter reads 188. Record the depth of observation (1.88 m) and the velocity. Then raise the assembly again until the sounding cable meter reads 47 cm. Record the depth of obsercation (0.47 m) and the velocity.

3. When the velocity measurement is completed, record the time and gage height.

4. Immediately thereafter, attach the US P61 sediment sampler and obtain three 1-pint samples but place in the same plastic sample bottle.

If the depth of flow is less than 33 cm, place the sampler lightly on the bed and sample at this point.

If the depth of flow is greater than 33 cm, obtain a depth-integrated sample. Open the sampler nozzle above the surface of the water; then lower the sampler to the bed at a slow uniform rate. As soon as the sampler touches the bed, raise it immediately at the same slow uniform rate through the entire flow.

Do not fill the pint bottle completely. If the pint bottle is filled by accident, discard that sample and collect a new one.

5. When the sediment sampling is completed, record the time and the gage height. That completes a set of measurements.

All data and other information are to be recorded in the streamgagers notebook. There are no exceptions.

Some modifications to this program have been made. Instead of packing up and removing the equipment each day, guards were hired to sit at the site and protect the equipment set up and ready to go at all times. That prevented damage and wear-and-tear on the more delicate instruments. At the end of the 1978-79 wet season, the current meter and P61 sampler were moved to another basin. Starting in October 1979, surface grab samples were taken with a bucket on a rope at the centerline of the river at Borangan Bridge.

In summary, the measurements are

1. Gage height, G, by automatic water level recorder and by staff gage. One is used to check the other.
2. Velocity $\bar{v}$ and depth d at the centerline.
3. Depth-integrated suspended sediment sample with concentration $\bar{c}$.
4. Surveyed cross sections in the reach.

These records are listed in Tables H-6 and H-7.

H.3.4. Laboratory Analysis

The suspended sediment sample contains sediment, dissolved solids and water. The concentrations of sediment and dissolved solids are obtained in the laboratory according to the procedures recommended by the U.S. Geological Survey. [G4].

Unless the sample contains considerable sand, it is assumed that the concentration measured at the centerline represents the average concentration for the cross section.

H.3.4.a. Dissolved Solids

From the 294 samples of water and sediment collected from the Jragung River at the Borangan Bridge in the period from 1 November 1977 to 6 March 1978, the following figures for total dissolved solid content were obtained:

Highest measured total dissolved solid concentration was 1,930 mg/l. This sample was collected on 28 December 1977 at 0830 hours when the discharge was 0.65 m^3/s.

The second highest measured total dissolved solid concentration was 1,070 mg/l also on 28 December 1977. The sample was collected at 2120 hours when the discharge was 10.8 m^3/s.

The lowest measured total dissolved solid concentration was 204 mg/l measured on 2 February 1978 at 0850 hours when the discharge was 11.6 m^3/s. This was the recession limb of a large flood on the previous day.

The largest discharge for which a sample was collected was 297 m^3/s. This occured at 1930 hours on 1 February 1978. The dissolved solids concentration was 276 mg/l and the sediment concentration was 33,900 mg/l.

The second largest discharge for which samples were collected was 177 m^3/s. This discharge occurred at 1715 hours and 1730 hours on 22 February 1978. The respective concentrations were 348 and 310 mg/l.

The sample having the largest suspended sediment concentration was collected on 22 February 1978 at 1645 hours when the discharge was 102 m^3/s. This concentration was 71,400 mg/l. The corresponding total dissolved concentration was 356 mg/l.

The dissolved solids concentrations were larger at the beginning of the wet season in November than they were later in the season.

The arithmetic average of the 294 sample values is approximately 400 mg/1.

An average concentration of 400 mg/1 for the year results in a total dissolved solid load of 52,000 t/y at the bridge or 510 $t/km^2/y$ for the catchment.

H.4. CALCULATIONS

H.4.1. Discharge Rating Curve

The discharge rating curve for the Jragung River at the Borangan Bridge has been prepared from low-flow measurements made across the entire river and velocity and depth measurements made at the centerline of the river on the upstream side of the bridge.

For the centerline measurements the plot of gage height versus depth of flow shown in Figure H-5 was prepared. The plot indicates that the riverbed elevation at the centerline varies approximately 0.2 m up and down. Next a plot of average velocity versus depth of flow was made. Shown in Figure H-6, there is poor correspondence indicating factors other than streambed friction are affecting the depth of water in the reach. These other factors have been investigated. Methods used to investigate these factors include advanced mathematics and are not included here. The main finding was that the bridge piers provide the main force retarding the flow of water in the reach during floods.

The relations shown in Figure H-5 and H-6 were used along with the survey of the cross sections in the reach to prepare a relation between gage height and water discharge. This relation can be represented by the equation

$$Q = 39.4\ (H - 0.73)^{2.167}$$

in which Q = water discharge, m^3/sec.

G = gage height, m

The data used to obtain this equation were those collected during the first year of measurement. The equation should be adjusted, if necessary, to reflect the new measurements obtained in subsequent years. The upgrading should be done at the end of May and then the new rating curve used for the prior year.

The calculations for the flood of 1 February 1979 are given herein as an example. The calculations are done in Table H-8. The sediment concentrations are listed in Table H-6.

H.4.2. Digital Record

First, the automatic water level record is checked with the records in the streamgager's notebook. Any discrepancies are resolved.

Next, the gage record on the chart is converted to digital form in such a manner that all changes in stage are dutifully described in the digital record. Also, short time periods are used when the stage is changing rapidly, even though linearly. The stages at moments when sediment samples were taken are also included in the digital record. The stages are then converted to discharge using the rating equation given previously.

H.4.3. Concentrations

Next a graph of measured concentration versus time is prepared to check the consistency of the data and to see if any estimations are required. As the record for the flood of 1 February 1979 is very complete, another flood has been chosen to illustrate how estimations of concentrations are made.

The hydrograph for the largest flood in the 7-year period of record at the Borangan Bridge is given in Figure H-7 along with the

25 measurements of suspended sediment concentration at the water surface. The rainfall for this flood occurred on the 21 and 22 of January 1980.

As the streamgager was late in arriving at the site, there are no measurements of concentration for the rise of the flood. The concentrations for this period and other short periods during the flood are estimated from other measurements as shown in Figure H-8. The numbers beside the points are the sample numbers and are sequential with time.

Next the sediment concentrations for all discharges in the digital record are entered in the calculation Table H-8 and the suspended sediment discharge rate is determined.

H.4.4. Sediment Discharge

The suspended sediment load is computed using the expression

$$Q_s = 0.001\, CQ$$

in which Q_s = suspended sediment discharge at any instant of time, kg/sec

C = concentration of suspended sediment, mg/l

Q = water discharge, m^3/sec

The time periods have been chosen so that a linear approximation is appropriate. That is

$$W = \frac{Q_{s1} + Q_{s2}}{2} \Delta t$$

Here W = is the weight of sediment discharged in time Δt

Q_{s1} = suspended sediment discharge at the beginning of the time step Δt

Q_{s2} = suspended sediment discharge at the end of the time step Δt

and

$$V = \frac{Q_1 + Q_2}{2} \Delta t$$

Here V = volume of water discharged in time period Δt

Q_1 = water discharge at the beginning of the time period Δt

Q_2 = water discharge at the end of the time period Δt

H.4.5. Storm Values

During the 1 February 1979 storm, the maximum measured suspended concentration was 68,600 mg/l. The flood peak was 197 m^3/s. The total suspended sediment discharged between 0800 hours on 1 February and 0800 hours on 2 February was 75,800,000 kg. The volume of water passing the station was 2,450,000 m^3. The average concentration for the storm was

$$\bar{C} = \frac{75,800,000}{2,450,000} \times 1,000 = 30,900 \text{ mg/l}$$

which is very large.

During the largest flood in the record, the maximum measured suspended sediment concentration (at the surface) was 98,700 mg/l. The flood peak was 752 m^3/s. The total suspended sediment discharged between 2030 hours on 21 January and 0800 hours on 23 January 1980 was 805,000,000 kg. The volume of water passing the station was 17,600,000 m^3. The average concentration for the storm was

$$\bar{C} = \frac{805,000,000}{17,600,000} \times 1,000 = 45,700 \text{ mg/l}$$

H.4.6. Daily Records

The suspended sediment load has been calculated for all days in the period 1 November 1977 to 30 April 1978 and from 1 October 1978 to 31 May 1979. The daily values are given in Tables H-9 and H-10, respectively. The values of water and sediment load in the tables are those occurring from 0800 hours on the day listed to 0800 hours on the succeeding day.

The measured values of suspended sediment concentration and their corresponding discharges are plotted in Figures H-9 and H-10.

The plots prove that there is no suspended sediment rating curve for the Jragung River. The concentrations depend mostly on intensity of rainfall, and the conditions of the watershed where it is raining; not on the water discharge in the river. Ground cover, soil type, soil moisture and topography are the prime factors which determine to what degree a given rain intensity erodes the soil.

If the time becomes available, one could study the relation between daily sediment yield and daily rainfall at each of the raingages in the catchment. The daily raingage records are included as Table H-11. The values listed are for the period from 0700 hours on the previous day to 0700 hours on the day listed.

The mean daily discharges for the Jragung River at the Borangan Bridge for the period 1 May 1973 to 31 May 1979 are given in Table H-12.

H.4.7. Monthly Records

The monthly values of measured suspended sediment yield for the Jragung catchment obtained by measurements at the Borangan Bridge are given in Table H-18. The values for volume of water discharged for the entire period of record are in Table H-14.

H.4.8. Season Records

On a season basis, nearly twice as much sediment was discharged in 1977-78 as in 1978-79 even though the runoff was greater in the latter period. On the average, concentrations were much larger in the 1977-78 wet season than in the 1978-79 season. That is, the cloud of points in Figure H-9 is displaced farther to the right than in Figure H-10.

Comparison of monthly basin rainfall and streamflow during the months when suspended sediment samples were taken are shown in Table H-15.

Both years were equally drier than normal; the rainfalls for the seasons were 81 and 85 percent of the long-term normal. Streamflows were also less than normal only more so. In 1977-78 streamflow was only 59 percent of the long-term average and in 1978-79, 65 percent.

There is an another difference in the two years record. In 1977-78, it was extremely dry at the start of the wet season whereas in the next year there was more rain at the beginning of the season.

There is enough evidence in the record to indicate that sediment yield is greater for a given storm rainfall at the beginning of the wet season than at the end. At the beginning, vegetation is sparse and the soil is dry. At the end, the vegetation is more luxuriant and the soil is wet most of the time.

As the two years of record were extremely dry (the rainfall in 1977-78 was the second lowest in the entire 52 years of record), it is necessary to estimate the suspended sediment for a normal year.

The method employed in the final design report for Jragung Dam [E2] to obtain the suspended sediment load was to multiply the monthly average concentration for the 1977-78 wet season given in Table H-4 by the long-term monthly streamflow given below.

LONG-TERM MONTHLY STREAMFLOW AT BORANGAN BRIDGE

(10^6 m^3 and %)

Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Annual
3.7	8.8	14.9	26.1	20.8	22.2	14.7	10.0	3.8	2.4	1.1	1.1	129.6
2.8	6.8	11.5	20.2	16.1	17.2	11.3	7.8	2.9	1.8	0.8	0.8	100.0

The estimate of the average long-term suspended sediment load for the months November through April was 1,800,000 metric tons. At that time it was estimated that the suspended sediment discharged in the remainder of the year was less than 1 percent of that discharged in the other months and could be ignored.

Using the same method with two years of record results in a suspended sediment load for the entire year of 1,400,000 metric tons. The calculations are shown in Table H-16.

H.4.9. Bed Load

The bed load in the Jragung River is almost entirely gravel. The river is not totally alluvial in form as the bed degrades down to bedrock is some reaches.

Calculations of bed load using 5 different bed-load formulas, the instantaneous flow duration curve and the assumption that there is a plentiful supply of bed material indicate the load is in the range of 50,000 to 300,000 t/y. A value of 200,000 t/y is used for the estimate of sediment yield.

H.4.10. Average Annual Sediment Yield

The total yield of sediment from the Jragung catchment upstream from the Borangan Bridge is the sum of the suspended and bed loads.

Employing only the first year estimate of suspended load, the long-term average sediment yield is 20,000 $t/km^2/y$. This is the value used to design the Jragung Dam [E2].

Employing both years of record of suspended sediment, the long-term average sediment yield is 16,000 $t/km^2/y$. This is the value used in this reconnaissance.

The distribution of the long-term sediment yield by month is shown in Figure H-11, along with the distribution of long-term monthly rainfall and streamflow.

H.4.11. Words of Caution

It must be emphasized that two years of record is not considered a suitable length of record to estimate long-term sediment yield. In the first place, sediment yield can vary greatly from year to year even when the rainfall and land use remain relatively constant. This point is illustrated by the data collected in two years at the Borangan Bridge. In these cases, ten to thirty years of record are required to obtain an accurate estimate of average sediment yield. Secondly, changes in land use in the future can affect the sediment yield by a very large factor.

The value of 16,000 t/km^2/y for long-term average sediment yield is the "best estimate" available at this time. The method of interpolating the meaning of the 2 years of record is not proven. Other interpretations are possible. As more data are collected in the future, the "best estimate" will improve.

The flood of 22 January 1980 produced the largest peak and the greatest volume of runoff in the hydrographic history of the Jragung River. Moreover, the measured sediment yield for this single storm was approximately 8,000 t/km, equivalent to a soil erosion of 8 mm over the entire catchment. Considering the fact that the rubber plantation and the rice terraced parts of the watershed produce very little sediment, one is lead to conclude that erosion in the teak forest and in the dry-farming areas was nearly catastrophic.

H.5. OTHER INFORMATION

H.5.1. Flow Duration

A mean daily flow duration curve for the Jragung River at the Borangan Bridge had been prepared in 1976 [E1] from data collected between 3 May 1973 and 31 December 1975.

That flow duration curve has been adjusted for shape and volume so as to represent an estimate of the instantaneous flow and with an annual runoff of 129.6×10^6 m^3. The values for this curve are given in Table H-17.

The mean daily flow duration curve should be revised to include the data collected in the more recent years. Actually, for such small watersheds as Jragung, the instantaneous stage-duration curve could be produced directly from the automatic water level recorder chart. The instantaneous stage-duration curve could then be converted to the instantaneous flow duration curve by employing the latest discharge rating curve.

H.5.2. Twice Daily Method

As discussed in the section titled "Previous Studies", the 1907 suspended sediment samples were taken at 0800 and 1800 hours each day. In general, one could reason that the amount of sediment measured in this manner would be less than the actual amount passing the gage ... the same for water. In fact, Rutten noted that his calculated volume of runoff for 1907 was too small as compared to the rainfall.

With the data available now, there is the opportunity to check how much difference there is between the amount computed by integration using many samples during storms and the amount computed using only the samples collected at 0600 and 1800 hours.

A summary of the monthly values for water and suspended sediment calculated using sediment samples collected at 0600 and 1800 hours for 1 year is given in Table H-18.

The monthly values given in Table H-18 differ by a large amount from those calculated by integration and listed in Table H-11. For example, the correct suspended sediment load for April 1979 was 214,000,000 kg, whereas the value for the twice daily method was 430,000,000 kg, nearly twice as large. The reason for this difference is that at 1800 hours on 6 April, the discharge was 305 m^3/sec and the concentration was 26,000 mg/1. These values accounted for 80 percent of the monthly sediment.

The comparison with the integration method for the year is given below

	Twice Daily Method	Integrated Method
Annual volume of water, m^3	100,200,000	88,700,000
Annual weight of suspended sediment, kg	830,000,000	668,000,000

On a yearly basis, the two sets of values agree fairly well. Moreover, the twice daily method resulted in a larger volume of water and weight of sediment than actually occurred.

This one effort at evaluating the twice daily method indicates that useful annual information can be obtained. On a monthly basis, the method results in very erratic values.

H.5.3. Sediment Rating Curve Method

Developed for rivers transporting mainly sand or gravel, the sediment rating curve method has been used extensively in Java where the sediment load is primarily silt and clay. The method can be tested using the data collected at the Borangan Bridge.

In some manner, the location of rating curve for the two sets of concentration versus water discharge data shown in Figures H-9 and H-10 can be estimated. Then by employing the instantaneous flow duration curve along with the concentrations obtained from the sediment rating curve, annual values of suspended sediment can be calculated as shown in Tables H-19 and H-20.

As the individual annual flow duration curves have not yet been derived, the long-term average flow duration curve has been used for these calculations. The average of the two annual suspended sediment yield values is

$$\frac{17,800 + 8,500}{2} \simeq 13,000 \ t/km^2/y$$

This value is only 7 percent smaller than that obtained by integration and adjustment.

H.5.4. Flood of Record

During the evening of 21 January and the morning of 22 January 1980, continuous low-intensity rainfall over the Jragung catchment produced the largest flood recorded in the brief hydrologic history of the Jragung River at the Borangan Bridge. Herein, the analysis of this flood is presented.

H.5.4.a. Daily Rainfall

The daily rainfall records for the non-recording raingages within the catchment are given below. The values are for the period between 0700 hours on the day listed and 0700 hours on the next day.

DAILY RAINFALL IN THE CATCHMENT

(mm)

Station	Jan 17	Jan 18	Jan 19	Jan 20	Jan 21	Jan 22	Jan 23
Jragung	-	10	16	4	163	25	5
Sambiroto	-	10	14	3	113	48	10
Jatirunggo	-	10	11	4	133	25	11
Klepu	na	na	na	-	101	8	na
Pagersari Klepu	na	na	na	-	60	80	na
Karangjati	30	50	70	-	100	110	-
Jimbaran	-	57	54	2	27	29	4

Note: The designation "na" means not available yet.

The most intense rainfall was to the north of the Jragung catchment. The daily rainfall at some of the gages to the north are as follows.

DAILY RAINFALL TO THE NORTH

(mm)

Station	Station No.	Jan 20	Jan 21	Jan 22
Gunung Pati	46	58	181	65
Susukan	64	15	379	-
Ungaran	65	26	371	18
Sumurjurang	65	26	367	-

Ungaran which is only 6 km north of the Karangjati gage received 389 mm from this one storm.

H.5.4.b. Basin Rainfall

The storm rainfall for the record breaking flood on the Jragung catchment was estimated using the data from the five raingages in the catchment upstream from the Borangan Bridge. The Thiessen weights for these gages are given in Table A-6 Appendix A - Part I.

The basin rainfall for the storm is calculated below.

Station	Storm rainfall, mm	Thiessen Weight	Contribution mm
Jimbaran	56	.1846	10.3
Karangjati	210	.1185	24.9
Pagersari/Klepu	140	.1679	23.5
Jatirunggo	158	.1742	27.5
Sambiroto	161	.3548	57.1
			143.3

H.5.4.c. Rainfall Intensity

There were 4 functioning recording raingages within the Jragung catchment in January 1980. The intensities recorded during the storm of 21 and 22 January are given in Figure H-12. These were obtained from the weekly charts and are only approximate.

The apparent largest 30-minute rainfall intensity was approximately 40 mm/hr and occured at the Jragung and Jatirunggo gages around 0500 hr in the morning of 22 January.

H.5.4.d. Peak Stage

The peak stage at the Borangan Bridge was 4.63 m and occurred at 2240 hours on 21 January. The stage for zero discharge is approximately 0.73 m making the peak flood wave 3.9 m high.

H.5.4.e. Discharge

Based on the 1978 rating curve, the peak discharge was 752 m^3/s. The complete flood hydrograph is shown in Figure H-7.

The volume of streamflow occurring between 2030 hours on 21 and 0800 hours on 23 January was 17.6×10^6 m^3. This is the value for the storm as groundwater flows previous and subsequent to this period are inconsequential.

The volume of streamflow is equivalent to an excess rainfall of 174 mm over the entire catchment.

H.5.4.f. Discrepancies

First, the volume of streamflow is greater than the estimated volume of rainfall. Even with the wet antecedent conditions which existed (a flood with a peak greater than 230 m^3/s passed by 2 days earlier), the streamflow should be at least 12 mm less than the rainfall.

The estimate of rainfall may be wrong; the gages are a poor sample of the storm rainfall. Also, the extended stage-discharge rating curve may be in error for very large floods.

The rainfall records must stand as measured. However, the new 1978-79 data on depth and velocity should be analysed and the discharge rating curve adjusted if necessary.

The rainfall intensities derived from weekly raingage charts are too low to produce a peak discharge of 752 m^3/s.

Daily charts of rainfall and expanded time scales for stage are necessary in order to accomplish a meaningful hydrograph analyses on the Jragung River.

H.5.4.g. Annual Peak Flood

The most recent estimate of the mean annual flood peak for the Jragung river at Borangan Bridge is 368 m^3/s. The catchment area is 101 km^2. The annual peaks are as follows.

ANNUAL PEAK FLOOD

Year	Date	Peak Discharge m^3/s	Volume of Flood 10^6 m^3
1*	9 Mar 1974	294	4.41
2	5 Jan 1975	280	3.13
3	18 Mar 1976	345	3.35
4	23 Apr 1977	158	1.12
5	31 Dec 1977	387	3.55
6	6 Apr 1979	358	3.13
7	22 Jan 1980	752	17.6

* Record begins on 4 May 1973.

The coefficient of variation for this flood record is 0.504.

H.5.4.h. Flood Volume

The volumes of the floods measured in the Jragung River at the Borangan Bridge have been determined for each of the annual peak hydrographs. These volumes are listed with the peaks in the table given previously in the table of annual peak floods.

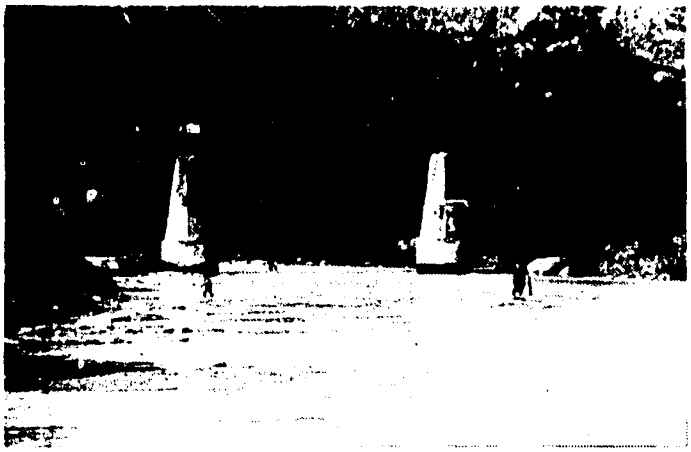
Based on flood volume alone, the 7 largest annual flood volumes for rainfall during a single day are as follows:

ANNUAL FLOOD VOLUME

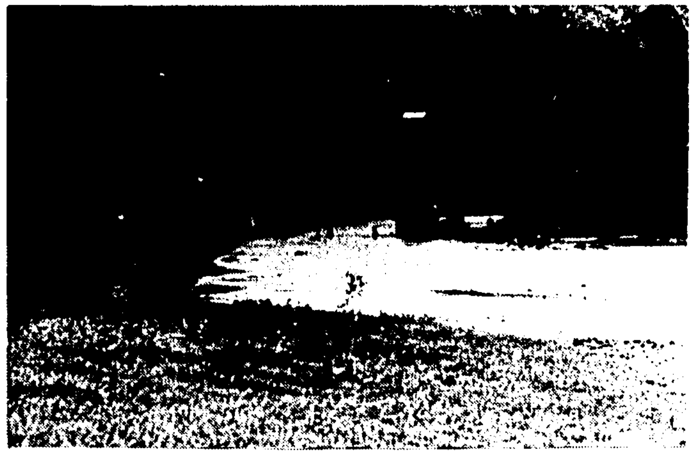
Year	Date	Peak Discharge m^3/s	Volume of Flood 10^6 m^3
1*	29 May 1973	185	5.33
2	11 Jan 1975	139	4.28
3	25 May 1975	287	6.55
4	20 Mar 1977	177	2.48
5	1 Feb 1978	356	4.58
6	15 Jan 1979	191	4.31
7	22 Jan 1980	752	17.6

* Record begins on 4 May 1973.

Using these data, the average annual flood volume for the Jragung River at the Borangan Bridge is 6.45×10^6 m^3. The period of record is too short to estimate the frequency distribution of these flood volumes accurately.

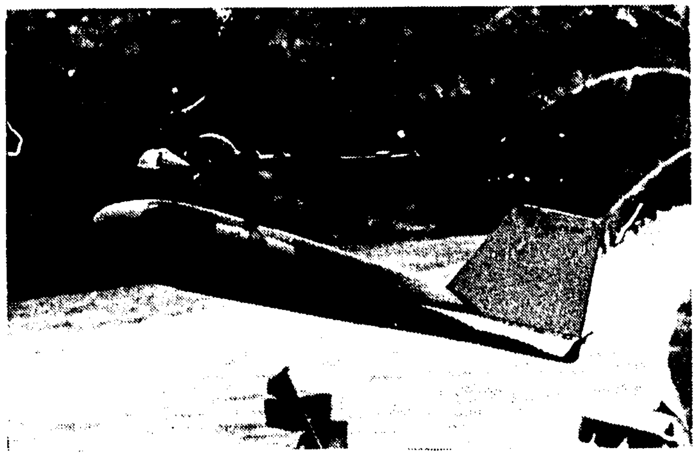


Photograph 1: Jragung River at the Borangan Bridge. View looking downstream. Automatic water level recorder house is on the left pier. The working platform is at the center of the bridge. The piers are 3 meters in width at the base.



Photograph 2: Jragung River at the Borangan Bridge. View looking upstream. Automatic water level recorder is in the house attached to the downstream side of the pier.

Photograph 3: The recorder house and wet well on the downstream side of the pier. The 2 to 6 meter sections of the staff gage are attached to the abutment on the left side of the photograph.



Photograph 4: Price current meter and Columbus weight

Photograph 5: US P61 sampler used to depth-integrate the suspended sediment transport.

TABLE H-1

JRAGUNG RIVER AT BORANGAN BRIDGE

BED-MATERIAL LOAD, LOWER PART, 1976

Date	Sample No.	Hour	Gage Height m	Velocity	Water Discharge In The Measured Range $m^3/s/m$	Volume Concentration of Bed-Material Load $\times 10^{-6}$
Feb 14	001	1714	1.88	2.05	0.70	1,220
	003	1800	1.46	1.14	0.37	680
	005	1823	1.38	1.02	0.40	449
Feb 17	007	1759	1.55	1.52	0.56	1,080
	009	1839	1.51	1.42	0.54	760
Feb 18	011	1638	1.95	1.70	0.65	1,090
	013	1710	1.77	1.33	0.52	789
	015	1727	1.75	1.40	0.53	958
	017	1803	1.77	1.42	0.55	683
	019	1827	1.80	1.49	0.59	685
	021	1907	1.72	1.40	0.53	512
	023	1932	1.68	1.40	0.37	1,790
Feb 23	025	2000	2.28	1.87	0.69	799
	027	2025	2.30	2.14	0.81	693
	029	2100	2.12	1.85	0.69	325
	031	2120	2.03	1.54	0.59	535
	033	2157	1.89	1.38	0.57	465
	035	2216	1.80	1.56	0.54	900
	037	2246	1.74	1.65	0.62	1,210
Feb 25	039	1430	1.55	1.32	0.50	922
	041	1458	1.85	1.34	0.45	1,410
	043	1514	1.77	1.54	0.51	966
	045	1545	1.72	1.34	0.49	1,214
	047	1600	1.66	1.28	0.49	1,730
	049	1623	1.60	1.11	0.42	1,230
Mar 4	051	1750	1.60	2.40	0.82	797
	053	1817	1.54	2.26	0.80	410
	055	1829	1.52	1.38	0.51	682

TABLE H-1 (Cont.)

JRAGUNG RIVER AT BORANGAN BRIDGE

BED-MATERIAL LOAD, LOWER PART, 1976

Date	Sample No.	Hour	Gage Height m	Velocity	Water Discharge In The Measured Range $m^3/s/m$	Volume Concentration of Bed-Material Load $\times 10^{-6}$
Mar 9	057	1522	2.22	2.12	0.77	1,017
	059	1541	2.14	1.91	0.73	683
	061	1615	1.92	1.77	0.67	886
	063	1628	1.87	1.40	0.54	717
	065	1653	1.76	1.46	0.57	1,241
	067	1706	1.74	1.13	0.67	930
Mar 18	069	1459	3.00	3.45	1.38	890
	071	1530	2.40	1.71	0.69	1,060
	073	1602	2.30	1.81	0.70	668
	075	1631	2.02	1.36	0.51	1,610
	077	1700	1.89	1.12	0.47	955
	079	1729	1.85	1.24	0.47	573
	081	1741	1.83	1.12	0.43	300
Mar 19	083	1948	1.83	1.38	0.52	756
	085	1957	1.80	1.24	0.46	2,100
	087	2029	1.65	1.07	0.39	1,670
	089	2043	1.70	1.24	0.45	265
Mar 22	091	1424	1.83	1.30	0.52	928
	093	1459	1.75	1.28	0.49	1,670
	095	1515	1.65	1.22	0.40	2,850
Mar 29	097	2105	1.70	1.24	0.50	1,100
	099	2133	1.60	1.13	0.44	995

TABLE H-2

WATER TRAP SAMPLES

JRAGUNG RIVER AT BORANGAN BRIDGE

1976

Date	Sample No.	Hour	Gage Height m	Discharge m^3/s	Concentration mg/l
Feb 5	JRWT 001	1240	1.03	2.90	67
6	002	0730	1.03	2.90	48
7	003	0700	1.02	2.69	64
9	004	0800	1.02	2.69	24
10	005	0803	1.07	3.80	180
11	006	0730	1.13	5.41	268
12	007	0700	1.06	3.57	95
13	008	0730	1.03	2.90	73
14	009	1800	1.09	4.31	508
16	010	0748	1.09	4.31	434
17	011	0730	1.05	3.34	118
18	012	0810	1.08	4.05	429
	013	1615	1.70	36.9	24,200
	014	1630	1.90	55.4	21,100
	015	1645	1.89	54.3	20,000
	016	1700	1.79	44.7	17,100
	017	1715	1.75	41.1	18,100
	018	1730	1.73	39.4	22,700
	019	1745	1.70	36.9	17,200
	020	1800	1.75	41.1	17,300
	021	1815	1.80	45.6	17,300
	022	1830	1.78	43.8	17,700
	023	1845	1.75	41.1	8,160
	024	1900	1.72	38.6	8,370
	025	1915	1.70	36.9	8,620
	026	1930	1.68	35.3	12,600
Feb 19	027	0815	1.26	10.0	500
20	028	0900	1.12	5.12	419
21	029	0810	1.08	4.05	244
22	030	0820	1.09	4.31	315
23	031	0820	1.05	3.34	126
	032	1930	1.70	36.9	11,300
	033	1945	1.90	55.4	5,240
	034	2000	2.25	97.6	12,900
	035	2015	2.30	105	12,600
	036	2030	2.30	105	10,700

TABLE H-2 (Cont.)

WATER TRAP SAMPLES

JRAGUNG RIVER AT BORANGAN BRIDGE

1976

Date	Sample No.	Hour	Gage Height m	Discharge m^3/s	Concentration mg/l
Feb 23	JRWT 037	2040	2.20	90.8	9,740
	038	2100	2.12	80.4	9,630
	039	2115	2.05	71.9	14,300
	040	2130	2.02	68.4	9,250
	041	2045	1.92	57.4	14,300
	042	2200	1.84	49.4	15,000
	043	2215	1.82	47.5	14,200
	044	2230	1.78	43.8	9,860
	045	2245	1.74	40.3	9,670
	046	2300	1.73	39.4	13,300
Feb 24	047	0720	1.33	13.0	8,420
25	048	0745	1.20	7.67	608
	049	1425	1.59	28.4	8,540
	050	1440	1.54	25.0	13,700
	051	1455	1.75	41.1	8,910
	052	1510	1.80	45.6	16,400
	053	1525	1.70	36.9	13,700
	054	1540	1.73	39.4	14,300
	055	1555	1.67	34.5	15,000
	056	1610	1.66	33.7	9,990
	057	1625	1.60	29.1	12,300
Feb 26	058	0745	1.04	3.11	18,900
27	059	0800	1.21	8.03	536
28	060	0800	1.13	5.41	292
29	061	0800	1.09	4.31	88
Mar 1	062	0800	1.11	4.84	108
Mar 2	063	0700	1.30	11.7	1,720
3	064	0800	1.28	10.8	555
4	065	0715	1.35	14.0	8,130
	066	0735	1.68	35.3	6,150
	067	0745	1.64	32.1	8,570
	068	0800	1.57	27.0	615
	069	0815	1.54	25.0	8,760
	070	0830	1.52	23.6	7,800

TABLE H-2 (Cont.)

WATER TRAP SAMPLES

JRAGUNG RIVER AT BORANGAN BRIDGE

1976

Date	Sample No.	Hour	Gage Height m	Discharge m^3/s	Concentration mg/l
Mar 5	JRWT 071	0700	1.44	18.8	1,600
6	072	0815	1.20	7.67	323
7	073	0645	1.11	4.84	134
8	074	0630	1.08	4.05	192
9	075	0803	1.02	2.69	138
	076	1520	2.25	97.6	11,700
	077	1535	2.17	86.8	19,600
	078	1550	2.04	70.7	19,500
	079	1605	1.95	60.6	17,400
	080	1620	1.90	55.4	17,200
	081	1635	1.86	51.3	15,700
	082	1650	1.76	42.0	15,100
	083	1705	1.72	38.6	16,700
	084	1720	1.72	38.6	24,500
Mar 10	085	0830	1.31	12.1	1,330
Mar 11	086	1055	1.29	11.2	1,000
12	087	0800	1.16	6.33	421
16	088	0745	1.19	7.32	260
17	089	0810	1.12	5.12	210
18	090	0715	1.22	8.40	730
	091	1429	3.50	358	24,000
	092	1445	3.25	292	23,600
	093	1500	3.00	233	23,700
	094	1515	2.80	191	23,100
	095	1530	2.52	139	23,700
	096	1545	2.40	120	12,500
	097	1600	2.20	90.8	17,700
	098	1615	2.15	84.2	18,300
	099	1630	2.10	77.9	17,800
	100	1645	2.02	68.4	18,600
	101	1700	2.00	66.1	17,900
	102	1717	1.89	54.3	16,600
	103	1737	1.85	50.4	17,600
	104	1745	1.84	49.4	17,600
	105	1805	1.80	45.6	23,400

TABLE H-2(Cont.)

WATER TRAP SAMPLES

JRAGUNG RIVER AT BORANGAN BRIDGE

1976

Date	Sample No.	Hour	Gage Height m	Discharge m^3/s	Concentration mg/l
Mar 19	JWRT 106	0705	1.45	19.3	7,100
	107	1915	1.50	22.4	10,300
	108	1932	1.74	40.3	10,600
	109	1945	1.85	50.4	9,980
	110	2000	1.80	45.6	10,000
	111	2015	1.70	36.9	9,960
	112	2031	1.65	36.1	9,580
	113	2045	1.70	36.9	7,680
Mar 20	114	0715	1.41	17.1	10,100
21	115	0716	1.16	6.33	910
Mar 22	116	0720	1.09	4.31	454
	117	1425	1.58	27.7	22,200
	118	1440	1.90	55.4	21,200
	119	1445	1.80	45.6	22,500
	120	1500	1.69	36.1	32,600
	121	1525	1.63	31.4	17,300
Mar 23	122	1600	1.10	4.57	1,680
24	123	0800	1.07	3.80	841
25	124	0730	1.17	6.65	1,290
26	125	0745	1.15	6.01	808
27	126	0630	1.05	3.34	336
28	127	0840	1.15	6.01	795
29	128	0800	1.07	3.80	452
	129	2102	1.70	36.9	6,440
	130	2117	1.65	32.9	6,020
	131	2132	1.55	25.6	6,140
30	132	0730	1.22	8.40	1,560
31	133	0700	1.09	4.31	438

Note: All samples were taken at middepth at the vertical section approximately midway between the two 3-meter diameter piers in the river.

TABLE H-2 (Cont.)

WATER TRAP SAMPLES

JRAGUNG RIVER AT BORANGAN BRIDGE

1976

Date	Sample No.	Hour	Gage Height m	Discharge m^3/s	Concentration mg/1
Feb 5	JRWT 001	1240	1.03	2.90	67
6	002	0730	1.03	2.90	48
7	003	0700	1.02	2.69	64
9	004	0800	1.02	2.69	24
10	005	0803	1.07	3.80	180
11	006	0730	1.13	5.41	268
12	007	0700	1.06	3.57	95
13	008	0730	1.03	2.90	73
14	009	1800	1.09	4.31	508
16	010	0748	1.09	4.31	434
17	011	0730	1.05	3.34	118
18	012	0810	1.08	4.05	429
	013	1615	1.70	36.9	24,200
	014	1630	1.90	55.4	21,100
	015	1645	1.89	54.3	20,000
	016	1700	1.79	44.7	17,100
	017	1715	1.75	41.1	18,100
	018	1730	1.73	39.4	22,700
	019	1745	1.70	36.9	17,200
	020	1800	1.75	41.1	17,300
	021	1815	1.80	45.6	17,300
	022	1830	1.78	43.8	17,700
	023	1845	1.75	41.1	8,160
	024	1900	1.72	38.6	8,370
	025	1915	1.70	36.9	8,620
	026	1930	1.68	35.3	12,600
Feb 19	027	0815	1.26	10.0	500
20	028	0900	1.12	5.12	419
21	029	0810	1.08	4.05	244
22	030	0820	1.09	4.31	315
23	031	0820	1.05	3.34	126
	032	1930	1.70	36.9	11,300
	033	1945	1.90	55.4	5,240
	034	2000	2.25	97.6	12,900
	035	2015	2.30	105	12,600
	036	2030	2.30	105	10,700

TABLE H-2 (Cont.)

WATER TRAP SAMPLES

JRAGUNG RIVER AT BORANGAN BRIDGE

1976

Date	Sample No.	Hour	Gage Height m	Discharge m^3/s	Concentration mg/1
Feb 23	JRWT 037	2040	2.20	90.8	9,740
	038	2100	2.12	80.4	9,630
	039	2115	2.05	71.9	14,300
	040	2130	2.02	68.4	9,250
	041	2045	1.92	57.4	14,300
	042	2200	1.84	49.4	15,000
	043	2215	1.82	47.5	14,200
	044	2230	1.78	43.8	9,860
	045	2245	1.74	40.3	9,670
	046	2300	1.73	39.4	13,300
Feb 24	047	0720	1.33	13.0	8,420
25	048	0745	1.20	7.67	608
	049	1425	1.59	28.4	8,540
	050	1440	1.54	25.0	13,700
	051	1455	1.75	41.1	8,910
	052	1510	1.80	45.6	16,400
	053	1525	1.70	36.9	13,700
	054	1540	1.73	39.4	14,300
	055	1555	1.67	34.5	15,000
	056	1610	1.66	33.7	9,900
	057	1625	1.60	29.1	12,300
Feb 26	058	0745	1.04	3.11	18,900
27	059	0800	1.21	8.03	536
28	060	0800	1.13	5.41	292
29	061	0800	1.09	4.31	88
Mar 1	062	0800	1.11	4.84	108
Mar 2	063	0700	1.30	11.7	1,720
3	064	0800	1.28	10.8	555
4	065	0715	1.35	14.0	8,130
	066	0735	1.68	35.3	8,150
	067	0745	1.64	32.1	8,570
	068	0800	1.57	27.0	615
	069	0815	1.54	25.0	8,760
	070	0830	1.52	23.6	7,800

TABLE H-2 (Cont.)

WATER TRAP SAMPLES

JRAGUNG RIVER AT BORANGAN BRIDGE

1976

Date	Sample No.	Hour	Gage Height m	Discharge m^3/s	Concentrat: mg/l
Mar 5	JRWT 071	0700	1.44	18.8	1,600
6	072	0815	1.20	7.67	323
7	073	0645	1.11	4.84	134
8	074	0630	1.08	4.05	192
9	075	0803	1.02	2.69	138
	076	1520	2.25	97.6	11,700
	077	1535	2.17	86.8	19,600
	078	1550	2.04	70.7	19,500
	079	1605	1.95	60.6	17,400
	080	1620	1.90	55.4	17,200
	081	1635	1.86	51.3	15,700
	082	1650	1.76	42.0	15,100
	083	1705	1.72	38.6	16,700
	084	1720	1.72	38.6	24,500
Mar 10	085	0830	1.31	12.1	1,330
Mar 11	086	1055	1.29	11.2	1,000
12	087	0800	1.16	6.33	421
16	088	0745	1.19	7.32	260
17	089	0810	1.12	5.12	210
18	090	0715	1.22	8.40	730
	091	1429	3.50	358	24,000
	092	1445	3.25	292	23,600
	093	1500	3.00	233	23,700
	094	1515	2.80	191	23,100
	095	1530	2.52	139	23,700
	096	1545	2.40	120	12,500
	097	1600	2.20	90.8	17,700
	098	1615	2.15	84.2	18,300
	099	1630	2.10	77.9	17,800
	100	1645	2.02	68.4	18,600
	101	1700	2.00	66.1	17,900
	102	1717	1.89	54.3	16,600
	103	1737	1.85	50.4	17,600
	104	1745	1.84	49.4	17,600
	105	1805	1.80	45.6	23,400

TABLE H-2 (Cont.)

WATER TRAP SAMPLES

JRAGUNG RIVER AT BORANGAN BRIDGE

1976

Date	Sample No.	Hour	Gage Height m	Discharge m^3/s	Concentration mg/l
Mar 19	JWRT 106	0705	1.45	19.3	7,100
	107	1915	1.50	22.4	10,300
	108	1932	1.74	40.3	10,600
	109	1945	1.85	50.4	9,980
	110	2000	1.80	45.6	10,000
	111	2015	1.70	36.9	9,960
	112	2031	1.65	36.1	9,580
	113	2045	1.70	36.9	7,680
Mar 20	114	0715	1.41	17.1	10,100
21	115	0716	1.16	6.33	910
Mar 22	116	0720	1.09	4.31	454
	117	1425	1.58	27.7	22,200
	118	1440	1.90	55.4	21,200
	119	1445	1.80	45.6	22,500
	120	1500	1.69	36.1	32,600
	121	1525	1.63	31.4	17,300
Mar 23	122	1600	1.10	4.57	1,680
24	123	0800	1.07	3.80	841
25	124	0730	1.17	6.65	1,290
26	125	0745	1.15	6.01	808
27	126	0630	1.05	3.34	336
28	127	0840	1.15	6.01	795
29	128	0800	1.07	3.80	452
	129	2102	1.70	36.9	6,440
	130	2117	1.65	32.9	6,020
	131	2132	1.55	25.6	6,140
30	132	0730	1.22	8.40	1,560
31	133	0700	1.09	4.31	438

Note: All samples were taken at mid-depth at the vertical section approximately midway between the two 3-meter diameter piers in the river.

TABLE H-3

JRAGUNG RIVER AT BORANGAN BRIDGE

SUSPENDED BED-MATERIAL LOAD, UPPER PART, 1976

Date	Sample No.	Hour	Gage Height m	Discharge m^3/s	Water Discharge In The Measured Range $m^3/s/m$	Volume Concentration of Suspended Load $\times 10^{-6}$
Feb 14	002	1728	1,77	42.9	2.16	721
	004	1751	1,53	24.3	0.97	5,850
	006	1834	1,37	15.0	0.73	2,770
Feb 17	008	1810	1.67	34.5	1.13	4,280
	010	1831	1.56	26.3	1.45	3,000
Feb 18	012	1648	1.86	51.3	2.96	2,560
	014	1704	1.77	42.9	2.51	2,130
	016	1739	1.72	38.6	2.18	2,210
	018	1756	1.69	36.1	1.96	1,190
	020	1837	1.78	43.8	2.32	1,360
	022	1859	1.78	43.8	1.99	824
	024	1946	1.65	32.9	1.93	2,830
Feb 23	026	1950	2.00	66.1	2.24	721
	028	2040	2.22	93.5	5.45	3,700
	030	2055	2.15	84.2	5.12	971
	032	2132	1.97	62.8	4.47	252
	034	2147	1.92	57.4	3.68	1,590
	036	2228	1.77	42.9	2.90	1,840
	038	2242	1.74	40.3	2.75	1,330
Feb 25	040	1440	1.54	25.0	1.46	2,880
	042	1443	1.57	27.0	1.59	1,650
	044	1527	1.74	40.3	2.76	2,920
	046	1539	1.73	39.4	2.68	1,848
	048	1608	1.66	33.7	2.24	1,490
	050	1617	1.64	32.1	1.98	1,510
Mar 4	052	0801	1.65	32.9	0.85	1,140
	054	0813	1.54	25.0	0.91	1,350
	056	0834	1.51	23.0	0.65	3,400

TABLE H-3(CONTINUED)

JRAGUNG RIVER AT BORANGAN BRIDGE

SUSPENDED BED-MATERIAL LOAD, UPPER PART, 1976

Date	Sample No.	Hour	Gage Height m	Discharge m^3/s	Water Discharge In The Measured Range $m^3/s/m$	Volume Concentration of Suspended Load $\times 10^{-6}$
Mar 9	058	1520	2.28	102	2.88	1,010
	060	1557	2.02	68.4	2.41	1,940
	062	1620	1.92	57.4	2.18	1,480
	064	1639	1.85	50.4	1.84	1,620
	066	1648	1.79	44.7	1.36	1,250
	068	1715	1.70	36.9	1.01	7,480
Mar 18	070	1504	2.78	187	14.08	1,060
	072	1515	2.52	139	5.27	1,880
	074	1613	2.10	77.9	3.96	2,040
	076	1628	2.03	69.6	2.93	922
	078	1713	1.88	53.3	2.33	1,340
	080	1726	1.87	52.3	2.01	543
	082	1751	1.80	45.6	2.04	709
Mar 19	084	1948	1.83	48.4	1.74	2,460
	086	1957	1.80	45.6	1.77	2,300
	088	2029	1.65	32.9	1.82	1,430
	090	2043	1.70	36.9	1.50	776
Mar 22	092	1440	1.90	55.4	1.73	4,870
	094	1450	1.80	45.6	2.12	2,130
	096	1526	1.63	31.4	1.34	5,800
Mar 29	098	2175	1.70	36.9	2.02	916
	100	2125	1.60	29.1	1.30	1,660

TABLE H-4

SUSPENDED SEDIMENT DISCHARGED DURING STORMS

	Hydrograph of			
	18-2-76	23-2-76	18-3-76	22-3-76
Peak discharge, m^3/s	57	105	358	56
Peak measured suspended sediment concentration, mg/l	24,200	15,000	24,000	32,600
Volume of water discharged, m^3	460,00	980,000	3,300,000	350,000
Amount of suspended sediment transport, metric tons	7,600	11,500	76,000	6,500
Suspended sediment transport rate, tons/10^6 m^3	16,000	12,000	23,000	19,000
Maximum station rainfall, mm	50	106	71	28

TABLE H-5

BED MATERIAL GRADATION
JRAGUNG DAM AT BORANGAN BRIDGE

Year	Date	Percent finer by weight than this size (mm)											
		50.8	38.1	25.4	19.0	12.7	4.76	2.00	0.84	0.42	0.18	0.125	0.74
1977	21 Apr	100	92	79	68	54	32	22	14	6	1	0	0
	5 May	100	92	79	69	55	35	24	16	9	3	1	0
	27 May	100	94	78	68	51	28	18	11	6	1	0	0
	21 Jun	100	87	73	64	52	31	20	13	7	1	1	0
	11 Jul	100	93	81	73	61	40	27	16	9	2	1	0
	1 Aug	100	91	77	69	59	39	28	17	8	3	2	1
	19 Aug	99	86	71	62	52	36	25	16	8	2	1	0
	6 Sep	98	93	80	71	61	40	29	19	10	3	2	1
	20 Sep	99	94	82	75	67	44	32	20	11	3	2	1
	Composite	100	91	78	69	57	36	25	16	8	2	1	0
Standard deviation		0.7	2.9	3.7	4.1	5.4	5.1	4.5	2.8	1.7	0.9	0.8	0.5

TABLE H-6

UNIT DISCHARGE MEASUREMENT SUMMARY
AT CENTERLINE OF THE JRAGUNG RIVER
AT THE BORANGAN BRIDGE

Date	Hour	Measurement No.	Gage Height m	Depth m	Observation Depth m	Velocity m/s	Unit Discharge $m^3/s/m$
Record starts Nov 9, 1977							
Nov 9	1714	1	0.90	0.24	0.03	0.40	0.096
	1908	2	0.96	0.28	0.08	0.40	0.112
Nov 10	1745	3	0.88	0.23	0.03	0.40	0.092
Nov 11	1700	4	0.84	0.23	0.03	0.30	0.069
Nov 12	1825	5	0.82	0.21	0.00	0.10	0.021
Nov 16	2400	6	1.36	0.90	0.36	1.50	1.35
Nov 17	0230	7	1.13	0.50	0.20	1.00	0.500
Nov 20	2030	8	1.00	0.37	0.15	0.70	0.259
	2130	9	1.04	0.36	0.14	0.60	0.216
Nov 22	2215	10	0.88	0.20	0.00	0.30	0.060
Nov 26	0120	11	1.02	0.36	0.14	0.60	0.216
	0150	12	0.98	0.32	0.12	0.40	0.128
Nov 29	2020	13	1.16	0.50	0.20	1.00	0.500
	2110	14	1.14	0.47	0.19	0.95	0.447
	2140	15	1.10	0.45	0.18	0.80	0.360
	2240	16	1.06	0.42	0.17	0.80	0.336

TABLE H-6 (CONTINUED)

UNIT DISCHARGE MEASUREMENT SUMMARY
AT CENTERLINE OF THE JRAGUNG RIVER
AT THE BORANGAN BRIDGE

Date	Hour	Measurement No.	Gage Height m	Depth m	Observation Depth m	Velocity m/s	Unit Discharge $m^3/s/m$
Nov 30	1755	17	0.92	0.20	0.00	0.30	0.060
Dec 1	1300	18	1.06	0.37	0.15	0.70	0.259
	1330	19	1.22	0.60	0.24	1.20	0.720
	1500	20	1.18	0.54	0.21	1.00	0.540
	1607	21	1.07	0.40	0.16	0.70	0.280
	1700	22	1.04	0.35	0.13	0.70	0.245
	1805	23	1.00	0.27	0.10	0.60	0.162
Dec 2	1415	24	0.95	0.22	0.00	0.30	0.066
	1445	25	1.50	1.02	0.20	2.30	1.99
					0.80	1.60 e	
	1520	26	1.50	1.03	0.20	2.50	2.16
					0.80	1.70	
	1630	27	1.38	0.81	0.32	1.80	1.46
	1735	28	1.36	0.78	0.31	1.60	1.25
	1910	29	1.30	0.73	0.29	1.50	1.10
Dec 3	1600	30	1.20	0.44 e	0.13	1.30	0.572
	1810	31	1.18	0.45	0.14	1.20	0.540
Dec 4	1600	32	0.97	0.20	0.00	0.60	0.120
	1635	33	1.55	0.96	0.39	2.10	2.02
	1700	34	1.54	0.91	0.37	2.10	1.91
	1815	35	1.30	0.60	0.24	1.50	0.900
	2020	36	1.20	0.45	0.18	1.10	0.495

TABLE H-6 (CONTINUED)

UNIT DISCHARGE MEASUREMENT SUMMARY
AT CENTERLINE OF THE JRAGUNG RIVER
AT THE BORANGAN BRIDGE

Date	Hour	Measurement No.	Gage Height m	Depth m	Observation Depth m	Velocity m/s	Unit Discharge $m^3/s/m$
Dec 5	1530	37	0.98	0.32	0.12	0.40	0.128
Dec 6	1720	38	0.99	0.30	0.12	0.70	0.210
	1745	39	1.11	0.38	0.15	0.85	0.323
	1840	40	1.23	0.46	0.18	0.85	0.391
	1900	41	1.35	0.74	0.29	1.80	1.33
	1955	42	1.40	0.71	0.14	1.60	1.14
	2030	43	1.32	0.59	0.23	1.40	0.826
	2137	44	1.21	0.51	0.20	1.30	0.663
Dec 7	1510	45	1.03	0.23	0.03	0.60	0.138
	1800	46	1.20	0.56	0.22	1.25	0.700
	1818	47	1.29	0.63	0.25	1.70	1.07
	1850	48	1.29	0.52	0.20	1.60	0.832
	1930	49	1.26	0.49	0.20	1.50	0.735
	2130	50	1.19	0.50	0.20	1.40	0.700
Dec 8	1740	51	0.97	0.20	0.00	0.30	0.060
Dec 14	1405	52	1.21	0.52	0.21	1.30	0.676
	1500	53	1.12	0.40	0.16	0.90	0.360
Dec 16	1415	54	1.22	0.53	0.21	1.40	0.742
	1500	55	1.20	0.47	0.18	1.30	0.611
	1550	56	1.16	0.45	0.18	1.10	0.495
	1700	57	1.10	0.35	0.14	0.90	0.315
	1810	58	1.06	0.34	0.13	0.80	0.272

TABLE H-6 (CONTINUED)

UNIT DISCHARGE MEASUREMENT SUMMARY

AT CENTERLINE OF THE JRAGUNG RIVER

AT THE BORANGAN BRIDGE

Date	Hour	Measurement No.	Gage Height m	Depth m	Observation Depth m	Velocity m/s	Unit Discharge $m^3/s/m$
Dec 22	1535	59	1.11	0.32	0.12	0.90	0.288
	1515	60	1.34	0.67	0.27	1.80	1.20
	1632	61	1.32	0.68	0.27	1.80	1.23
	1715	62	1.23	0.50	0.20	1.40	0.700
Dec 23	0800	63	1.02	0.27	0.07	0.60	0.162
Dec 24	0725	64	1.01	0.24	0.04	0.50	0.120
	1525	65	1.05	0.31	0.12	0.75	0.233
	1545	66	1.20	0.49	0.19	1.60	0.784
	1600	67	1.30	0.67	0.26	1.85	1.24
	1615	68	1.31	0.65	0.26	1.80	1.17
	1730	69	1.19	0.44	0.17	1.45	0.638
Dec 25	0700	70	0.99	0.27	0.10	0.60	0.162
Dec 28	2045	71	1.27	0.58	0.24	2.20	1.28
	2112	72	1.25	0.61	0.24	1.60	0.976
	2130	73	1.28	0.68	0.27	1.70	1.16
	2210	74	1.21	0.51	0.20	1.30	0.663
	2320	75	1.11	0.33	0.13	1.00	0.330
Dec 29	1750	76	1.15	0.39	0.16	1.00	0.390
	1830	77	1.10	0.33	0.13	0.90	0.297
Dec 30	1910	78	1.90	1.33	0.63	3.15	4.19
	1950	79	1.77	1.23	0.61	3.00	3.69
	2130	80	1.70	1.16	0.57	2.08	2.42

TABLE H-6 (CONTINUED)

UNIT DISCHARGE MEASUREMENT SUMMARY
AT CENTERLINE OF THE JRAGUNG RIVER
AT THE BORANGAN BRIDGE

Date	Hour	Measurement No.	Gage Height m	Depth m	Observation Depth m	Velocity m/s	Unit Discharge $m^3/s/m$
Jan 5	1910	81	1.03	0.32	0.12	0.70	0.224
Jan 6	0810	82	0.99	0.22	0.08	0.55	0.121
	1540	83	1.06	0.45	0.18	0.90	0.405
Jan 7	0710	84	1.07	0.33	0.12	0.70	0.231
	1545	85	1.09	0.45	0.18	0.90	0.405
	1605	86	1.21	0.49	0.17	1.10	0.539
Jan 8	0605	87	0.99	0.25	0.00	0.55	0.138
	1600	88	0.98	0.20	0.00	0.50	0.100
Jan 9	0610	89	0.97	0.25	0.10	0.45	0.113
	1530	90	1.60	1.07	0.53	2.15	2.30
	1545	91	1.68	1.16	0.57	1.80	2.09
	1615	92	1.65	1.01	0.50	1.90	1.92
	1805	93	1.48	0.87	0.34	1.80	1.57
	2200	94	1.28	0.64	0.25	1.50	0.960
Jan 10	0605	95	1.13	0.38	0.15	0.80	0.304
	1645	96	1.05	0.28	0.10	0.70	0.196
Jan 11	0920	97	0.99	0.21	0.13	0.35	0.074
	1805	98	1.00	0.23	0.00	0.45	0.104
Jan 12	0755	99	0.99	0.21	0.13	0.55	0.116
	1710	100	0.97	0.19	0.00	0.50	0.095

TABLE H-6 (CONTINUED)

UNIT DISCHARGE MEASUREMENT SUMMARY
AT CENTERLINE OF THE JRAGUNG RIVER
AT THE BORANGAN BRIDGE

Date	Hour	Measurement No.	Gage Height m	Depth m	Observation Depth m	Velocity m/s	Unit Discharge $m^3/s/m$
Jan 13	0610	101	1.03	0.25	0.08	0.60	0.15
	1320	102	1.25	0.55	0.22	1.70	0.935
	1400	103	1.26	0.54	0.21	1.70	0.918
Jan 14	0620	104	1.09	0.35	0.14	0.80	0.280
	1610	105	1.03	0.27	0.07	0.65	0.176
	1815	106	1.23	0.60	0.24	1.50	0.900
	1835	107	1.30	0.65	0.26	1.60	1.04
	2010	108	1.23	0.59	0.21	1.40	0.826
Jan 15	0610	109	1.09	0.39	0.13	0.85	0.332
	1810	110	1.00	0.22	0.08	0.60	0.132
	1845	111	1.15	0.45	0.18	1.10	0.495
Jan 16	0635	112	0.99	0.27	0.09	0.45	0.122
	1800	113	1.58	0.89	0.35	2.30	2.05
	1825	114	1.50	0.87	0.34	1.80	1.57
Jan 17	0600	115	1.01	0.21	0.08	0.60	0.126
	1729	116	1.00	0.18	0.08	0.40	0.072
Jan 19	0745	117	0.98	0.13	0.00	0.40	0.052
	1518	118	1.42	0.74	0.29	1.90	1.41
	1535	119	1.58	0.95	0.38	2.05	1.95
	1555	120	1.70	1.22	0.60	2.68	3.27
	1625	121	1.60	1.03	0.51	2.20	2.27
	1855	122	1.40	0.78	0.31	1.85	1.44

TABLE H-6 (CONTINUED)

UNIT DISCHARGE MEASUREMENT SUMMARY
AT CENTERLINE OF THE JRAGUNG RIVER
AT THE BORANGAN BRIDGE

Date	Hour	Measurement No.	Gage Height m	Depth m	Observation Depth m	Velocity m/s	Unit Discharge $m^3/s/m$
Jan 20	1715	123	2.00	1.65	0.83	3.13	5.16
	1735	124	1.99	1.58	0.79	2.55	4.03
	1755	125	2.07	1.64	0.82	2.75	4.51
	1900	126	1.65	0.94	0.37	2.20	2.07
	2015	127	1.45	0.71	0.28	1.50	1.07
Jan 21	0540	128	1.09	0.41	0.16	1.00	0.410
	1810	129	1.07	0.34	0.13	0.80	0.272
Jan 22	0610	130	1.13	0.39	0.15	1.20	0.468
	1805	131	1.06	0.30	0.12	0.75	0.225
Jan 23	0820	132	1.02	0.28	0.11	0.60	0.168
	1415	133	2.00	1.63	0.81	3.08	5.02
	1445	134	2.08	1.70	0.85	2.75	4.68
	1540	135	1.92	1.42	0.73	2.55	3.62
	1625	136	1.77	1.27	0.68	2.50	3.18
	1750	137	1.70	1.02	0.50	2.05	2.09
Jan 24	0600	138	1.20	0.49	0.19	1.00	0.49
	2035	139	1.10	0.31	0.12	0.70	0.217
Jan 25	0915	140	1.08	0.35	0.14	0.65	0.228
	1800	141	1.04	0.30	0.12	0.60	0.180
Jan 26	0850	142	1.40	0.76	0.30	1.45	1.10
	1000	143	1.36	0.63	0.25	1.00	0.63

TABLE H-6 (CONTINUED)

UNIT DISCHARGE MEASUREMENT SUMMARY
AT CENTERLINE OF THE JRAGUNG RIVER
AT THE BORANGAN BRIDGE

Date	Hour	Measurement No.	Gage Height m	Depth m	Observation Depth m	Velocity m/s	Unit Discharge $m^3/s/m$
Jan 27	0800	144	1.20	0.46	0.18	0.80	0.368
	1800	145	1.13	0.38	0.15	0.85	0.323
Jan 28	0800	146	1.07	0.34	0.13	0.65	0.221
	1800	147	1.05	0.30	0.12	0.65	0.195
Jan 29	0700	148	1.03	0.27	0.10	0.60	0.162
	1805	149	1.01	0.22	0.08	0.45	0.099
Jan 30	0640	150	0.99	0.20	0.08	0.45	0.090
	1810	151	0.99	0.12	0.08	0.45	0.054
Jan 31	0910	152	1.16	0.45	0.18	0.80	0.360
	1955	153	1.02	0.29	0.12	0.50	0.145
Feb 1	0910	154	1.00	0.28	0.11	0.45	0.126
	1725	155	1.60	1.11	0.22	2.00	2.11
					0.88	1.80	
	1750	156	2.10	1.68	0.33	2.60	4.20
					1.34	2.40	
	1840	157	1.94	1.50	0.30	2.40	3.30
					1.20	2.00	
Feb 11	1720	158	1.00	0.30	0.12	1.00	0.300
Feb 12	0630	159	1.03	0.34	0.13	0.80	0.272
	1800	160	1.06	0.36	0.14	0.80	0.288

TABLE H-6 (CONTINUED)

UNIT DISCHARGE MEASUREMENT SUMMARY
AT CENTERLINE OF THE JRAGUNG RIVER
AT THE BORANGAN BRIDGE

Date	Hour	Measurement No.	Gage Height m	Depth m	Observation Depth m	Velocity m/s	Unit Discharge $m^3/s/m$
Feb 13	0815	161	1.08	0.44	0.17	0.80	0.352
	1800	162	1.01	0.31	0.12	0.50	0.155
Feb 14	0815	163	0.98	0.30	0.12	0.50	0.150
Feb 15	1635	164	1.67	1.18	0.23	3.25	3.22
					0.94	2.20	
	1650	165	1.75	1.26	0.25	2.75	2.99
					1.00	2.00	
	1708	166	1.85	1.39	0.27	3.00	3.48
					1.11	2.00	
	1800	167	1.80	1.27	0.25	2.75	3.21
					1.02	2.30	
	2100	168	1.44	0.84	0.34	1.90	1.60
Feb 16	0800	169	1.13	0.38	0.15	1.05	0.399
	1740	170	1.03	0.28	0.11	0.75	0.210
Feb 17	0730	171	1.05	0.32	0.13	0.75	0.240
	1800	172	1.16	0.41	0.16	1.15	0.472
Feb 21	0835	173	1.25	0.59	0.23	0.90	0.531
	1400	174	1.34	0.69	0.30	1.55	1.07
	1435	175	1.79	1.30	0.28	3.00	3.58
					1.10	2.50	
	1535	176	1.85	1.17	0.95	2.10	2.84
					0.23	2.75	

TABLE H-6 (CONTINUED)

UNIT DISCHARGE MEASUREMENT SUMMARY
AT CENTERLINE OF THE JRAGUNG RIVER
AT THE BORANGAN BRIDGE

Date	Hour	Measurement No.	Gage Height m	Depth m	Observation Depth m	Velocity m/s	Unit Discharge m³/s/m
	1630	177	2.02	1.61	1.29	2.25	4.31
					0.32	3.10	
	1905	178	1.82	1.28	1.02	1.00	2.24
					0.26	2.50	
	2120	179	1.60	0.90	0.36	2.10	1.89
Feb 22	0830	180	1.24	0.57	0.23	1.30	0.741
	1630	181	1.81	1.03	0.22	2.80	2.47
					0.82	2.00	
	1705	182	2.60	2.01	0.40	3.80	7.24
					1.61	3.40	
	1720	183	2.75	2.15	0.43	3.40	6.88
					0.72	3.00	
	1725	184	2.20	1.65	0.33	3.10	4.37
					1.40	2.20	
	2010	185	1.80	1.08	0.21	2.75	2.43
					0.86	1.75	
Feb 23	0800	186	1.30	0.61	0.24	0.60	0.366
	1855	187	1.18	0.43	0.17	0.80	0.344
Feb 24	0610	188	1.12	0.39	0.15	0.70	0.273
	1750	189	1.08	0.33	0.13	0.60	0.198
Feb 25	0610	190	1.05	0.35	0.11	0.60	0.210

TABLE H-6 (CONTINUED)

UNIT DISCHARGE MEASUREMENT SUMMARY
AT CENTERLINE OF THE JRAGUNG RIVER
AT THE BORANGAN BRIDGE

Date	Hour	Measurement No.	Gage Height m	Depth m	Observation Depth m	Velocity m/s	Unit Discharge $m^3/s/m$
Feb 26	1400	191	1.27	0.53	0.21	0.90	0.477
	1500	192	1.15	0.40	0.16	0.80	0.320
Feb 27	0710	193	1.10	0.33	0.13	0.60	0.198
	1610	194	1.06	0.32	0.12	0.65	0.208
Feb 28	0830	195	1.04	0.33	0.12	0.60	0.198
	1404	196	1.40	0.63	0.25	1.45	0.914
	1500	197	1.28	0.60	0.24	1.20	0.720
	1913	198	1.12	0.30	0.12	0.90	0.27
Mar 1	0715	199	1.05	0.33	0.13	0.60	0.198
	1817	200	1.04	0.27	0.10	0.60	0.162
Mar 2	0730	201	1.04	0.25	0.10	0.60	0.150
	1700	202	1.04	0.25	0.10	0.60	0.150
Mar 3	0605	203	1.03	0.22	0.08	0.60	0.132
	1530	204	1.03	0.22	0.08	0.60	0.132
Mar 4	0600	205	1.15	0.47	0.18	0.80	0.376
	1415	206	1.25	0.56	0.22	0.80	0.448
	1430	207	1.31	0.60	0.24	0.90	0.540
	1550	208	1.46	0.68	0.27	0.90	0.612
	1605	209	1.44	0.67	0.26	0.80	0.536
Mar 9	1755	210	0.98	0.23	0.09	0.40	0.092

TABLE H-6 (CONTINUED)

UNIT DISCHARGE MEASUREMENT SUMMARY
AT CENTERLINE OF THE JRAGUNG RIVER
AT THE BORANGAN BRIDGE

Date	Hour	Measurement No.	Gage Height m	Depth m	Observation Depth m	Velocity m/s	Unit Discharge $m^3/s/m$
Mar 10	0600	211	1.10	0.33	0.13	0.80	0.264
	1640	212	1.04	0.28	0.08	0.60	0.168
	2030	213	1.34	0.60	0.24	1.50	0.900
	2105	214	1.28	0.55	0.22	1.30	0.715
Mar 11	0600	215	1.16	0.34	0.13	0.90	0.306
	1800	216	1.06	0.29	0.11	0.70	0.203
Mar 18	2130	217	1.39	0.57	0.22	1.80	1.03
	2200	218	1.37	0.55	0.22	1.60	0.880
	2300	219	1.34	0.53	0.21	1.50	0.795
Mar 19	0805	220	1.17	0.34	0.13	0.90	0.306
	1740	221	1.05	0.23	0.10	0.40	0.092
Mar 20	1735	222	1.25	0.46	0.26	1.20	0.552
Mar 21	0555	223	1.07	0.28	0.08	0.65	0.182
	1750	224	1.14	0.30	0.10	0.60	0.180
Mar 22	0548	225	1.70	1.19	0.24	3.30	3.30
					0.95	2.25	
	0820	226	1.56	1.09	0.22	2.00	2.07
					0.87	1.80	
	0920	227	1.46	0.69	0.28	2.00	1.38
	1025	228	1.44	0.68	0.28	1.70	1.16
	1100	229	1.40	0.59	0.24	1.60	0.944
	1740	230	1.28	0.51	0.24	1.30	0.663

TABLE H-6 (CONTINUED)

UNIT DISCHARGE MEASUREMENT SUMMARY

AT CENTERLINE OF THE JRAGUNG RIVER

AT THE BORANGAN BRIDGE

Date	Hour	Measurement No.	Gage Height m	Depth m	Observation Depth m	Velocity m/s	Unit Discharge $m^3/s/m$
Mar 23	0820	231	1.24	0.43	0.17	1.00	0.430
	1735	232	1.10	0.35	0.14	0.90	0.315
Mar 24	0900	233	1.09	0.30	0.12	0.80	0.240
	1645	234	1.10	0.30	0.13	0.80	0.240
Mar 25	1005	235	1.01	0.28	0.11	0.50	0.140
	1545	236	1.00	0.25	0.05	0.50	0.125
Apr 3	1830	237	1.08	0.36	0.13	1.00	0.360
	2050	238	1.08	0.37	0.14	1.00	0.370
	2310	239	1.08	0.38	0.14	1.00	0.380
	2345	240	1.23	0.45	0.18	1.20	0.540
Apr 4	0230	241	1.17	0.40	0.16	1.15	0.460
	0600	242	1.13	0.43	0.17	1.10	0.473
	1740	243	1.03	0.30	0.12	0.40	0.120
Apr 5	0545	244	0.99	0.26	0.12	0.36	0.094
Apr 7	1830	245	1.11	0.34	0.13	0.82	0.279
Apr 12	0700	246	1.01	0.30	0.12	0.40	0.120
	1440	247	1.70	1.36	0.54	2.70	3.67
	1515	248	2.00	1.46	0.30	2.80	3.50
					1.16	2.00	

TABLE H-6 (CONTINUED)

UNIT DISCHARGE MEASUREMENT SUMMARY

AT CENTERLINE OF THE JRAGUNG RIVER

AT THE BORANGAN BRIDGE

Date	Hour	Measurement No.	Gage Height m	Depth m	Observation Depth m	Velocity m/s	Unit Discharge $m^3/s/m$
Apr 15	0535	266	1.11	0.37	0.16	1.00	0.370
	1700	267	1.02	0.25	0.10	0.50	0.125
Apr 16	0730	268	0.98	0.21	0.08	0.40	0.084
Apr 22	0130	269	1.10	0.36	0.14	1.00	0.360
	0215	270	1.20	0.42	0.16	1.05	0.441
	0235	271	1.26	0.48	0.18	1.20	0.576
	0715	272	1.00	0.24	0.16	0.45	0.108
Apr 26	1805	273	0.97	0.21	0.08	0.41	0.086

Record ends Apr 30, 1978

TABLE H-6 (CONTINUED)

UNIT DISCHARGE MEASUREMENT SUMMARY
AT CENTERLINE OF THE JRAGUNG RIVER
AT THE BORANGAN BRIDGE

Date	Hour	Measurement No.	Gage Height m	Depth m	Observation Depth m	Velocity m/s	Unit Discharge $m^3/s/m$
Apr 12	1540	249	2.10	1.57	0.31	2.60	3.45
					1.24	1.80	
	1630	250	1.70	1.10	0.22	2.20	2.09
					0.88	1.60	
	1815	251	1.40	0.73	0.29	1.55	1.13
	1920	252	1.37	0.69	0.27	1.60	1.10
Apr 13	0940	253	1.12	0.40	0.16	0.95	0.380
	1645	254	1.05	0.34	0.13	0.80	0.272
	1915	255	1.26	0.47	0.19	1.25	0.588
	2030	256	1.38	0.70	0.28	1.65	1.16
	2110	257	1.68	1.15	0.23	2.15	2.21
					0.92	1.70	
	2230	258	1.30	0.51	0.24	1.30	0.663
Apr 14	0735	259	1.06	0.34	0.13	0.80	0.272
	1540	260	1.03	0.25	0.05	0.50	0.125
	1945	261	2.10	1.50	0.30	3.50	4.69
					1.20	2.75	
	2015	262	2.18	1.58	0.31	3.75	5.06
					1.27	2.65	
	2050	263	1.82	1.21	0.24	2.65	2.70
					0.97	1.80	
	2200	264	1.43	0.71	0.28	1.50	1.07
	2315	265	1.30	0.59	0.23	1.45	0.856

TABLE H-6 (CONTINUED)

UNIT DISCHARGE MEASUREMENT SUMMARY
AT CENTERLINE OF THE JRAGUNG RIVER
AT THE BORANGAN BRIDGE

Date	Hour	Measurement No.	Gage Height m	Depth m	Observation Depth m	Velocity m/s	Unit Discharge $m^3/s/m$
Record starts Oct 3, 1978							
Oct 3	1630	1	0.92	0.20	0.08	0.45	0.090
	1638	2	0.94	0.25	0.10	0.45	0.113
	1814	3	1.02	0.32	0.12	0.70	0.224
	1920	4	1.90	1.30	0.26 1.04	2.95	3.98
	1945	5	2.00	1.35	0.27 1.08	3.10	4.19
	2030	6	2.00	1.35	0.27 1.08	2.90	3.92
	2130	7	1.80	1.15	0.23 0.92	2.80	3.22
	2230	8	1.63	1.00	0.40	2.70	2.70
Oct 4	0600	9	1.22	0.35	0.14	1.20	0.420
	1800	10	0.99	0.20	0.08	0.40	0.080
Oct 5	0800	11	0.94	0.20	0.08	0.40	0.080
	1800	12	0.90	0.20	0.08	0.35	0.070
Oct 6	0545	13	0.90	0.20	0.08	0.35	0.070
Oct 16	1930	14	0.92	0.20	0.08	0.50	0.100
Oct 19	0555	15	0.93	0.21	0.08	0.40	0.084
Oct 20	1750	16	0.93	0.20	0.08	0.35	0.070
Oct 21	0600	17	0.95	0.25	0.10	0.45	0.113
	1700	18	0.94	0.24	0.10	0.40	0.096

TABLE H-6 (CONTINUED)

UNIT DISCHARGE MEASUREMENT SUMMARY

AT CENTERLINE OF THE JRAGUNG RIVER

AT THE BORANGAN BRIDGE

Date	Hour	Measurement No.	Gage Height m	Depth m	Observation Depth m	Velocity m/s	Unit Discharge $m^3/s/m$
Oct 22	0600	19	1.02	0.39	0.15	0.45	0.176
	1630	20	0.98	0.33	0.13	0.40	0.132
Oct 23	0730	21	0.91	0.20	0.08	0.30	0.060
Oct 27	0530	22	0.92	0.22	0.08	0.30	0.066
	1650	23	0.92	0.20	0.08	0.30	0.060
Oct 31	1730	24	1.00	0.32	0.12	2.40	0.768
	1800	25	1.50	0.71	0.28	2.70	1.92
	1845	26	1.80	0.96	0.38	3.00	2.88
	1915	27	1.90	1.09	0.21 0.87	2.85	3.11
	1935	28	2.00	1.20	0.28 0.96	3.00	3.60
	2000	29	1.90	1.10	0.22 0.88	2.65	2.92
	2100	30	1.75	0.92	0.36	2.75	2.53
	2215	31	1.55	0.66	0.26	2.10	1.39
	2300	32	1.46	0.56	0.22	1.70	0.952
Nov 1	0600	33	1.12	0.28	0.11	1.05	0.294
	1658	34	0.98	0.21	0.08	0.40	0.084
Nov 2	0800	35	1.02	0.35	0.14	0.45	0.158
	1830	36	0.96	0.20	0.08	0.40	0.080
Nov 4	0535	37	0.94	0.20	0.08	0.40	0.080

TABLE H-6 (CONTINUED)

UNIT DISCHARGE MEASUREMENT SUMMARY

AT CENTERLINE OF THE JRAGUNG RIVER

AT THE BORANGAN BRIDGE

Date	Hour	Measurement No.	Gage Height m	Depth m	Observation Depth m	Velocity m/s	Unit Discharge $m^3/s/m$
Nov 5	1750	38	1.22	0.33	0.13	1.40	0.462
	1830	39	1.16	0.24	0.09	1.00	0.240
	2000	40	1.08	0.24	0.09	0.85	0.204
Nov 6	0500	41	0.97	0.20	0.08	0.70	0.140
Nov 7	0525	42	1.04	0.28	0.11	0.80	0.224
	1700	43	1.35	0.84	0.37	3.25	2.73
	1721	44	1.60	0.85	0.38	2.20	1.87
	1734	45	1.70	1.07	0.21	2.15	2.30
					0.86		
	1855	46	1.45	0.73	0.29	2.60	1.90
	2000	47	1.35	0.69	0.28	1.60	1.10
	2125	48	1.25	0.60	0.24	1.30	0.780
Nov 8	0101	49	1.15	0.40	0.16	0.90	0.360
	0515	50	1.07	0.35	0.14	0.80	0.280
	1545	51	0.99	0.20	0.08	0.60	0.120
Nov 9	1600	52	0.98	0.20	0.08	0.60	0.120
Dec 2	1325	53	1.05	0.26	0.10	1.00	0.260
	1355	54	1.30	0.65	0.26	1.8	1.17
	1410	55	1.45	0.78	0.30	2.4	1.87
	1425	56	1.18	0.45	0.18	1.4	0.630
	1555	57	1.52	0.81	0.32	2.4	1.94
	1608	58	1.60	0.88	0.35	2.4	2.11
	1710	59	1.50	0.80	0.32	1.7	1.36

TABLE H-6 (CONTINUED)

UNIT DISCHARGE MEASUREMENT SUMMARY

AT CENTERLINE OF THE JRAGUNG RIVER

AT THE BORANGAN BRIDGE

Date	Hour	Measurement No.	Gage Height m	Depth m	Observation Depth m	Velocity m/s	Unit Discharge $m^3/s/m$
	1825	60	1.38	0.73	0.29	1.55	1.13
	1930	61	1.32	0.63	0.25	1.35	0.851
Dec 3	0030	63	1.17	0.41	0.08	1.00	0.410
	0330	64	1.10	0.38	0.16	1.00	0.380
	0530	65	1.07	0.33	0.13	0.85	0.281
	0940	66	1.03	0.30	0.12	0.85	0.255
	1305	67	1.00	0.26	0.10	0.60	0.156
	1515	68	1.37	0.72	0.28	1.40	1.01
	1530	69	1.45	0.80	0.32	2.20	1.76
	1602	70	1.45	0.79	0.31	1.80	1.42
	1709	71	1.40	0.59	0.23	1.80	1.06
	1800	72	1.31	0.70	0.28	1.45	1.02
	1910	73	1.27	0.60	0.24	1.40	0.84
	2015	74	1.21	0.45	0.18	1.25	0.56
	2300	75	1.14	0.40	0.16	1.00	0.400
Dec 4	0230	76	1.12	0.37	0.14	1.00	0.370
	0530	77	1.04	0.29	0.11	0.80	0.232
	0845	78	1.03	0.27	0.10	0.65	0.176
	1430	79	1.03	0.28	0.11	0.70	0.196
	1500	80	1.07	0.33	0.13	0.90	0.297
	1530	81	1.10	0.37	0.15	1.00	0.370
	1630	82	1.06	0.32	0.13	0.95	0.304
	1730	83	1.02	0.27	0.10	0.65	0.176

TABLE H-6 (CONTINUED)

UNIT DISCHARGE MEASUREMENT SUMMARY

AT CENTERLINE OF THE JRAGUNG RIVER

AT THE BORANGAN BRIDGE

Date	Hour	Measurement No.	Gage Height m	Depth m	Observation Depth m	Velocity m/s	Unit Discharge $m^3/s/m$
Dec 5	2150	84	1.05	0.32	0.13	0.95	0.304
	2300	85	1.04	0.31	0.13	0.95	0.295
Dec 6	0010	86	1.03	0.30	0.12	0.85	0.255
	0100	87	1.02	0.28	0.11	0.70	0.196
	0200	88	1.02	0.28	0.11	0.65	0.182
	0630	89	0.98	0.24	0.10	0.65	0.156
	1725	90	0.95	0.22	0.08	0.80	0.176
Dec 7	0155	91	1.04	0.35	0.14	1.00	0.350
	0345	92	1.16	0.45	0.18	1.70	0.765
	0500	93	1.14	0.44	0.13	1.25	0.550
	0630	94	1.13	0.43	0.17	1.20	0.516
	1600	95	1.03	0.43	0.17	1.10	0.473
Dec 8	0600	96	0.99	0.23	0.09	0.65	0.150
	1730	97	0.96	0.20	0.01	0.60	0.120
	1925	98	1.02	0.27	0.10	0.85	0.230
	2022	99	1.24	0.49	0.19	1.60	0.784
	2130	100	1.25	0.49	0.20	1.30	0.637
	2240	101	1.22	0.42	0.16	1.25	0.525
Dec 9	0003	102	1.20	0.40	0.16	1.20	0.480
	0100	103	1.18	0.39	0.16	1.20	0.468
	0415	104	1.13	0.36	0.15	1.10	0.396
	0700	105	1.08	0.35	0.14	0.75	0.263
	0948	106	1.05	0.34	0.13	0.75	0.255
	1305	107	1.02	0.28	0.12	0.80	0.224
	1600	108	1.00	0.26	0.10	0.60	0.156

TABLE H-6 (CONTINUED)

UNIT DISCHARGE MEASUREMENT SUMMARY

AT CENTERLINE OF THE JRAGUNG RIVER

AT THE BORANGAN BRIDGE

Date	Hour	Measurement No.	Gage Height m	Depth m	Observation Depth m	Velocity m/s	Unit Discharge $m^3/s/m$
Dec 10	0700	109	0.99	0.25	0.10	0.55	0.138
	1755	110	0.96	0.21	0.08	0.50	0.105
Dec 11	1820	111	1.30	0.65	0.26	1.70	1.11
	1832	112	1.37	0.74	0.29	2.00	1.48
	1841	113	1.45	0.84	0.33	2.05	1.72
	1905	114	1.44	0.73	0.28	2.75	2.01
	2000	115	1.35	0.67	0.26	1.50	1.01
	2120	116	1.35	0.67	0.26	1.45	0.972
	2240	117	1.30	0.62	0.25	1.35	0.837
Dec 12	0100	118	1.25	0.52	0.20	1.30	0.676
	0405	119	1.16	0.43	0.17	1.25	0.538
	0700	120	1.13	0.32	0.13	1.00	0.320
	1000	121	1.00	0.33	0.13	0.90	0.297
	1305	122	1.05	0.29	0.11	0.80	0.232
	1610	123	1.02	0.27	0.10	0.80	0.216
	1626	124	1.08	0.36	0.14	0.95	0.342
	1739	125	1.02	0.29	0.11	0.80	0.232
Dec 13	1715	126	1.27	0.57	0.23	1.50	0.855
	1745	127	1.24	0.50	0.20	1.40	0.700
	2030	128	1.10	0.37	0.15	1.00	0.370
Dec 14	0645	129	1.03	0.28	0.11	0.80	0.224
	1745	130	0.98	0.23	0.09	0.50	0.115

TABLE H-6 (CONTINUED)

UNIT DISCHARGE MEASUREMENT SUMMARY

AT CENTERLINE OF THE JRAGUNG RIVER

AT THE BORANGAN BRIDGE

Date	Hour	Measurement No.	Gage Height m	Depth m	Observation Depth m	Velocity m/s	Unit Discharge $m^3/s/m$
Dec 15	0030	131	1.26	0.51	0.20	1.40	0.714
	0122	132	1.15	0.45	0.18	1.20	0.540
	0230	133	1.11	0.37	0.15	1.00	0.370
	0405	134	1.05	0.30	0.12	0.85	0.255
	0740	135	1.01	0.26	0.10	0.80	0.208
	1800	136	0.96	0.21	0.08	0.70	0.147
Dec 16	0601	137	0.97	0.22	0.08	0.65	0.143
	1730	138	0.98	0.23	0.09	0.65	0.150
	2342	139	1.12	0.38	0.15	1.00	0.380
Dec 17	0100	140	1.09	0.37	0.14	0.95	0.352
	0220	141	1.08	0.35	0.14	0.95	0.333
	0530	142	1.05	0.32	0.12	0.90	0.288
	1745	143	1.00	0.26	0.10	0.60	0.156
Dec 21	2015	144	1.00	0.27	0.12	0.50	0.135
Dec 22	0600	145	0.99	0.27	0.12	0.50	0.135
	1605	146	1.15	0.46	0.18	1.20	0.552
	1620	147	1.18	0.51	0.20	1.30	0.663
	1800	148	1.34	0.65	0.25	1.80	1.17
	1815	149	1.45	0.81	0.32	2.20	1.78
	1835	150	1.50	0.84	0.33	2.00	1.68
	1927	151	1.48	0.77	0.31	1.75	1.35
	2055	152	1.38	0.68	0.27	1.70	1.16
	2200	153	1.34	0.62	0.24	1.65	1.02
	2304	154	1.30	0.59	0.23	1.65	0.974

TABLE H-6 (CONTINUED)

UNIT DISCHARGE MEASUREMENT SUMMARY

AT CENTERLINE OF THE JRAGUNG RIVER

AT THE BORANGAN BRIDGE

Date	Hour	Measurement No.	Gage Height m	Depth m	Observation Depth m	Velocity m/s	Unit Discharge $m^3/s/m$
Dec 23	0215	155	1.22	0.52	0.20	1.55	0.806
	0530	156	1.15	0.38	0.15	1.20	0.456
	1100	157	1.09	0.34	0.13	0.85	0.289
	1415	158	1.06	0.31	0.12	0.80	0.248
	1530	159	1.50	0.88	0.35	1.90	1.67
	1540	160	1.54	0.86	0.34	1.85	1.59
	1547	161	1.60	1.00	0.20	1.95	1.95
					0.80		
	1600	162	1.70	1.14	0.22	2.30	2.62
					0.88		
	1620	163	1.70	1.00	0.20	0.90	0.900
					0.80		
	1735	164	1.42	0.68	0.27	1.75	1.19
	1950	165	1.26	0.57	0.19	1.30	0.741
	2155	166	1.18	0.48	0.19	1.20	0.576
Dec 24	0200	167	1.17	0.46	0.18	1.10	0.506
	0530	168	1.13	0.33	0.12	1.10	0.363
	0900	169	1.10	0.31	0.12	0.90	0.279
	1600	170	1.06	0.25	0.10	0.80	0.200
Dec 25	0605	171	1.04	0.29	0.12	0.80	0.232
	1750	172	1.02	0.27	0.11	0.75	0.203
Dec 28	1440	173	1.20	0.57	0.23	2.00	1.14
	1412	174	1.45	0.87	0.35	2.30	2.00
	1420	175	1.90	1.49	0.30	3.02	4.50
					1.20		

TABLE H-6 (CONTINUED)

UNIT DISCHARGE MEASUREMENT SUMMARY

AT CENTERLINE OF THE JRAGUNG RIVER

AT THE BORANGAN BRIDGE

Date	Hour	Measurement No.	Gage Height m	Depth m	Observation Depth m	Velocity m/s	Unit Discharge $m^3/s/m$
	1435	176	2.15	2.12	0.42	3.13	6.64
					1.70		
	1505	177	2.18	2.19	0.43	3.25	7.12
					1.70		
	1622	178	2.20	1.98	0.37	2.97	5.88
					1.58		
	1805	179	1.88	1.30	0.26	2.50	3.25
					1.02		
	2000	180	1.60	0.99	0.40	1.80	1.78
	2210	181	1.45	0.82	0.33	1.75	1.44
Dec 29	0105	182	1.30	0.62	0.24	1.60	0.992
	0400	183	1.20	0.57	0.22	1.50	0.855
	0605	184	1.18	0.52	0.20	1.20	0.624
	0911	185	1.17	0.50	0.20	1.10	0.550
	1400	186	1.10	0.38	0.12	1.00	0.380
	1700	187	1.35	0.80	0.32	1.30	1.04
	1713	188	1.50	0.83	0.33	1.50	1.25
	1724	189	1.54	0.99	0.39	2.00	1.98
	1735	190	1.60	0.98	0.39	2.20	2.16
	1910	191	1.68	1.05	0.21	2.20	2.31
					0.84		
	1930	192	1.79	1.03	0.20	2.10	2.16
					0.82		
	1950	193	1.72	1.13	0.22	2.20	2.49
					0.90		

TABLE H- 6 (CONTINUED)

UNIT DISCHARGE MEASUREMENT SUMMARY

AT CENTERLINE OF THE JRAGUNG RIVER

AT THE BORANGAN BRIDGE

Date	Hour	Measurement No.	Gage Height m	Depth m	Observation Depth m	Velocity m/s	Unit Discharge $m^3/s/m$
	2115	194	1.64	1.09	0.22 0.87	2.20	2.40
	2235	195	1.51	0.99	0.40	2.20	2.18
	2335	196	1.48	0.90	0.36	1.90	1.71
Dec 30	0245	197	1.34	0.74	0.29	1.50	1.11
	0518	198	1.27	0.60	0.24	1.20	0.720
	0920	199	1.19	0.55	0.22	0.90	0.495
	1315	200	1.09	0.48	0.19	0.80	0.384
	1545	201	1.05	0.43	0.17	0.75	0.323
	1900	202	1.02	0.40	0.16	0.70	0.280
	1600	203	1.00	0.33	0.12	0.70	0.231
	2100	204	1.11	0.50	0.20	0.95	0.475
Jan 1'79	0030	205	1.20	0.55	0.22	1.20	0.660
	0315	206	1.17	0.53	0.21	1.00	0.530
	0700	207	1.12	0.48	0.19	1.00	0.480
	1105	208	1.12	0.47	0.19	1.00	0.470
	1230	209	1.30	0.68	0.27	1.55	0.105
	1330	210	1.58	0.96	0.38	2.00	1.92
	1350	211	1.48	0.86	0.34	1.80	1.55
	1500	212	1.28	0.61	0.24	1.20	0.732
	1700	213	1.25	0.57	0.20	1.15	0.656
	2000	214	1.20	0.54	0.13	1.10	0.594
Jan 2	0000	215	1.20	0.53	0.12	1.10	0.583
	0520	216	1.18	0.48	0.19	0.90	0.432

TABLE H-6 (CONTINUED)

UNIT DISCHARGE MEASUREMENT SUMMARY
AT CENTERLINE OF THE JRAGUNG RIVER
AT THE BORANGAN BRIDGE

Date	Hour	Measurement No.	Gage Height m	Depth m	Observation Depth m	Velocity m/s	Unit Discharge $m^3/s/m$
	1620	217	1.08	0.41	0.16	0.85	0.349
	1940	218	1.65	1.03	0.20	2.30	2.37
					0.82		
	1950	219	1.64	0.96	0.38	2.20	2.11
	2115	220	1.50	0.88	0.35	2.00	1.76
	2230	221	1.38	0.69	0.27	1.90	1.31
Jan 3	0250	222	1.24	0.57	0.23	1.20	0.684
	0535	223	1.20	0.51	0.20	1.10	0.561
	1125	224	1.12	0.44	0.13	1.00	0.440
	1536	225	1.15	0.48	0.14	1.10	0.528
Jan 4	0620	226	1.02	0.35	0.14	0.90	0.315
	1600	227	0.98	0.33	0.13	0.80	0.264
	2245	228	1.15	0.50	0.20	1.20	0.600
Jan 5	0010	229	1.15	0.49	0.20	1.10	0.539
	0300	230	1.12	0.46	0.18	1.10	0.506
	0520	231	1.10	0.44	0.18	1.10	0.484
	1205	232	1.04	0.37	0.15	0.95	0.352
	1900	233	1.62	1.00	0.20	2.25	2.25
					0.80		
	1955	234	1.51	0.88	0.35	2.10	1.85
	2115	235	1.74	1.08	0.22	2.80	3.02
	2135	236	1.70	1.05	0.21	2.30	2.42
					0.86		
	2245	237	1.54	0.86	0.34	2.00	1.72

TABLE H-6 (CONTINUED)

UNIT DISCHARGE MEASUREMENT SUMMARY

AT CENTERLINE OF THE JRAGUNG RIVER

AT THE BORANGAN BRIDGE

Date	Hour	Measurement No.	Gage Height m	Depth m	Observation Depth m	Velocity m/s	Unit Discharge $m^3/s/m$
Jan. 6	0040	238	1.40	0.89	0.35	1.60	1.42
	0200	239	1.34	0.71	0.28	1.55	1.10
	0545	240	1.25	0.55	0.22	1.25	0.688
	1100	241	1.12	0.43	0.17	1.00	0.430
	1715	242	1.05	0.36	0.13	0.95	0.342
	1830	243	1.15	0.52	0.28	1.30	0.676
Jan. 8	1843	244	1.17	0.55	0.22	1.20	0.660
	2030	245	1.11	0.48	0.19	1.15	0.552
Jan. 9	0130	246	1.04	0.42	0.17	0.70	0.294
	0635	247	1.01	0.39	0.16	0.90	0.351
	1940	248	1.60	1.03	0.20 0.80	2.35	2.42
	2045	249	1.62	1.09	0.21 0.81	2.05	2.24
	2155	250	1.55	0.90	0.36	2.40	2.16
Jan. 10	0045	251	1.48	0.89	0.35	2.20	1.96
	0400	252	1.34	0.77	0.30	1.60	1.23
	0730	253	1.27	0.57	0.23	1.25	0.713
	1010	254	1.21	0.56	0.22	1.25	0.700
	1600	255	1.12	0.45	0.22	1.05	0.473
Jan. 11	0620	256	1.02	0.38	0.15	0.85	0.323
	1745	257	1.00	0.35	0.14	0.80	0.280

TABLE H-6 (CONTINUED)

UNIT DISCHARGE MEASUREMENT SUMMARY

AT CENTERLINE OF THE JRAGUNG RIVER

AT THE BORANGAN BRIDGE

Date	Hour	Measurement No.	Gage Height m	Depth m	Observation Depth m	Velocity m/s	Unit Discharge $m^3/s/m$
Jan 12	2006	258	1.21	0.59	0.23	1.45	0.856
	2020	259	1.27	0.62	0.24	1.50	0.930
	2126	260	1.88	1.51	0.30	2.67	4.03
					1.20		
	2137	261	1.92	1.34	0.27	3.25	4.36
					1.07		
	2325	262	1.65	1.07	0.21	2.05	2.19
					0.85		
Jan 13	0130	263	1.48	0.89	0.36	1.90	1.70
	0345	264	1.40	0.73	0.29	1.55	1.13
	0715	265	1.30	0.55	0.22	1.50	0.825
	1102	266	1.23	0.47	0.18	1.40	0.658
	1602	267	1.13	0.37	0.14	1.30	0.481
	2030	268	1.36	0.69	0.28	1.65	1.14
	2148	269	1.55	0.92	0.36	2.00	1.84
	2205	270	1.65	1.02	0.20	2.22	2.26
					0.81		
	2217	271	1.85	1.40	0.28	2.30	3.22
					1.12		
	2230	272	1.97	1.55	0.31	3.02	4.68
					1.24		
	2243	273	2.10	1.80	0.36	3.15	5.67
					1.44		
Jan 14	0010	274	2.05	1.73	0.34	3.22	5.57
					1.36		

TABLE H-6 (CONTINUED)

UNIT DISCHARGE MEASUREMENT SUMMARY

AT CENTERLINE OF THE JRAGUNG RIVER

AT THE BORANGAN BRIDGE

Date	Hour	Measurement No.	Gage Height m	Depth m	Observation Depth m	Velocity m/s	Unit Discharge $m^3/s/m$
	0130	275	1.89	1.33	0.26	2.47	3.29
					1.04		
	0257	276	1.68	1.12	0.22	2.05	2.30
					0.88		
	0615	277	1.45	0.85	0.34	1.75	1.49
	1130	278	1.28	0.57	0.22	1.35	0.770
	1305	279	1.55	0.89	0.35	2.00	1.78
	1435	280	1.44	0.82	0.32	1.65	1.35
	1543	281	1.38	0.74	0.29	1.65	1.22
	1920	282	1.37	0.72	0.28	1.65	1.19
	2355	283	1.27	0.65	0.26	1.30	0.845
Jan 15	0300	284	1.22	0.60	0.24	1.25	0.750
	0601	285	1.20	0.58	0.23	1.20	0.696
	1645	286	1.64	1.12	0.22	2.62	2.93
					0.89		
	1653	287	1.89	1.83	0.36	3.40	6.22
					1.46		
	1705	288	2.15	1.91	0.38	3.80	7.26
					1.52		
	1800	289	2.70	2.59	0.51	4.15	10.75
					2.07		
	1810	290	2.80	2.68	0.53	4.37	11.71
					2.14		
	2130	291	1.93	1.63	0.33	2.75	4.48
					1.32		
	2235	292	1.75	1.63	0.28	2.18	3.55
					1.12		

TABLE H-6 (CONTINUED)

UNIT DISCHARGE MEASUREMENT SUMMARY

AT CENTERLINE OF THE JRAGUNG RIVER

AT THE BORANGAN BRIDGE

Date	Hour	Measurement No.	Gage Height m	Depth m	Observation Depth m	Velocity m/s	Unit Discharge $m^3/s/m$
Jan 16	0235	293	1.50	0.85	0.34	2.00	1.70
	0610	294	1.40	0.72	0.29	1.40	1.01
	0930	295	1.34	0.62	0.25	1.30	0.81
	1230	296	1.30	0.60	0.24	1.10	0.660
	1825	297	1.22	0.54	0.21	0.90	0.486
Jan 17	0645	298	1.16	0.44	0.17	0.80	0.352
	1705	299	1.12	0.40	0.16	0.65	0.260
Jan 18	0705	300	1.02	0.37	0.14	0.60	0.222
	1615	301	1.00	0.36	0.14	0.50	0.180
Jan 19	0900	302	0.99	0.36	0.15	0.50	0.180
Jan 21	0905	303	1.03	0.40	0.16	0.60	0.240
	2125	304	1.14	0.55	0.22	0.80	0.440
	2350	305	1.30	0.73	0.29	1.40	1.02
Jan 22	0400	306	1.18	0.57	0.22	1.00	0.570
	0930	307	1.10	0.49	0.19	0.85	0.417
	1350	308	1.05	0.44	0.17	0.75	0.330
Jan 23	1250	309	0.95	0.35	0.14	0.60	0.210
Jan 24	1700	310	0.93	0.28	0.11	0.50	0.140
Jan 25	0830	311	0.90	0.25	0.10	0.40	0.100
	1445	312	1.18	0.61	0.24	1.10	0.671
	1503	313	1.24	0.67	0.27	1.20	0.804
	1550	314	1.16	0.57	0.22	1.10	0.627

TABLE H-6 (CONTINUED)

UNIT DISCHARGE MEASUREMENT SUMMARY
AT CENTERLINE OF THE JRAGUNG RIVER
AT THE BORANGAN BRIDGE

Date	Hour	Measurement No.	Gage Height m	Depth m	Observation Depth m	Velocity m/s	Unit Discharge $m^3/s/m$
	1740	315	1.08	0.46	0.18	0.80	0.368
	1930	316	1.04	0.44	0.17	0.70	0.308
Jan. 26	1730	317	1.00	0.40	0.16	0.65	0.260
Jan. 27	1030	318	0.99	0.36	0.14	0.50	0.180
Jan. 28	0908	319	0.91	0.29	0.11	0.50	0.145
Jan. 29	2015	320	1.25	0.68	0.27	1.20	0.816
	2145	321	1.21	0.62	0.24	1.30	0.806
Jan. 30	0130	322	1.12	0.52	0.20	1.00	0.520
	0600	323	1.05	0.41	0.16	0.85	0.349
	0900	324	1.02	0.29	0.11	0.70	0.203
Jan. 31	1730	325	0.90	0.27	0.10	0.65	0.176
	1750	326	1.18	0.58	0.23	1.20	0.696
Feb. 1	0645	327	0.99	0.38	0.14	0.60	0.228
	1950	328	1.60	1.02	0.22 0.80	2.35	2.40
	20.00	329	2.25	1.59	0.30 1.27	2.55	4.05
	2013	330	2.40	1.74	0.34 1.39	2.63	4.58
	2025	331	2.80	2.00	0.40 1.60	3.03	6.06
	2035	332	2.85	2.05	0.41 1.64	3.37	6.91

TABLE H-6 (CONTINUED)

UNIT DISCHARGE MEASUREMENT SUMMARY

AT CENTERLINE OF THE JRAGUNG RIVER

AT THE BORANGAN BRIDGE

Date	Hour	Measurement No.	Gage Height m	Depth m	Observation Depth m	Velocity m/s	Unit Discharge $m^3/s/m$
Feb 2	0005	333	1.75	1.41	0.28 1.12	1.75	2.47
	0300	334	1.48	0.92	0.36	1.65	1.52
	0620	335	1.30	0.70	0.28	1.40	0.980
	0920	336	1.22	0.66	0.26	1.00	0.660
	1700	337	1.60	1.23	0.24 0.98	2.45	3.01
	1715	338	1.80	1.45	0.29 1.16	2.75	3.99
	1730	339	2.25	1.60	0.32 1.28	2.68	4.29
	1745	340	2.30	1.60	0.32 1.28	2.70	4.32
	2055	341	1.75	1.39	0.26 1.11	2.50	3.48
Feb 3	0003	342	1.45	0.96	0.38	1.95	1.87
	0600	343	1.24	0.70	0.28	1.20	0.840
	1110	344	1.14	0.56	0.22	1.10	0.616
	1800	345	1.04	0.46	0.18	0.90	0.414
Feb 5	1520	346	1.26	0.70	0.28	1.50	1.05
Feb 8	1650	347	0.90	0.30	0.12	0.55	0.165
Feb 9	0837	348	0.90	0.29	0.12	0.50	0.145

TABLE H-6 (CONTINUED)

UNIT DISCHARGE MEASUREMENT SUMMARY

AT CENTERLINE OF THE JRAGUNG RIVER

AT THE BORANGAN BRIDGE

Date	Hour	Measurement No.	Gage Height m	Depth m	Observation Depth m	Velocity m/s	Unit Discharge $m^3/s/m$
Feb 10	1905	349	1.24	0.68	0.27	1.25	0.850
	1910	350	1.37	0.80	0.32	2.00	1.60
	1930	351	1.90	1.50	0.30 1.20	3.75	5.63
	2045	352	2.00	1.56	0.31 1.24	2.80	4.37
	2110	353	1.42	0.83	0.33	1.50	1.25
	2300	354	1.25	0.70	0.28	1.20	0.840
Feb 11	0103	355	1.23	0.67	0.26	1.10	0.737
	0600	356	1.12	0.48	0.19	1.05	0.504
	1525	357	1.36	0.78	0.31	1.80	1.40
	1537	358	1.40	0.79	0.32	1.80	1.42
	1825	359	1.28	0.67	0.26	1.60	1.07
	2310	360	1.18	0.56	0.24	1.30	0.728
Feb 12	0800	361	1.10	0.45	0.18	1.00	0.450
	1905	362	1.25	0.63	0.25	1.70	1.07
Feb 13	0840	363	1.08	0.29	0.11	0.85	0.247
Feb 14	1515	364	0.98	0.31	0.12	0.50	0.155
Feb 15	0725	365	0.92	0.24	0.10	0.30	0.072
	1846	366	1.23	0.61	0.24	1.60	0.976

TABLE H-6 (CONTINUED)

UNIT DISCHARGE MEASUREMENT SUMMARY

AT CENTERLINE OF THE JRAGUNG RIVER

AT THE BORANGAN BRIDGE

Date	Hour	Measuremen No.	Gage Height m	Depth m	Observation Depth m	Velocity m/s	Unit Discharge $m^3/s/m$
Feb 16	0548	367	1.04	0.38	0.15	0.85	0.323
Feb 17	0630	368	0.96	0.30	0.12	0.45	0.135
Feb 18	1505	369	0.94	0.24	0.10	0.40	0.095
Feb 19	0630	370	0.97	0.27	0.11	0.60	0.162
Feb 20	1738	371	0.91	0.22	0.09	0.30	0.066
	2330	372	1.15	0.55	0.22	1.25	0.688
Feb 21	0100	373	1.10	0.50	0.20	1.00	0.500
	0600	374	1.07	0.43	0.17	0.90	0.387
Feb 22	0650	375	0.93	0.23	0.09	0.30	0.069
	2115	376	1.08	0.43	0.17	1.00	0.430
Feb 23	0605	377	1.06	0.39	0.16	1.00	0.390
	1800	378	1.01	0.23	0.09	0.80	0.184
	2104	379	1.30	0.67	0.27	1.50	1.01
	2227	380	1.23	0.65	0.26	1.45	0.943
Feb 24	0002	381	1.22	0.63	0.25	1.45	0.914
	0400	382	1.14	0.57	0.22	1.20	0.684

TABLE H-6 (CONTINUED)

UNIT DISCHARGE MEASUREMENT SUMMARY

AT CENTERLINE OF THE JRAGUNG RIVER

AT THE BORANGAN BRIDGE

Date	Hour	Measurement No.	Gage Height m	Depth m	Observation Depth m	Velocity m/s	Unit Discharge $m^3/s/m$
	0700	383	1.10	0.52	0.21	1.05	0.624
	1803	384	1.00	0.42	0.16	1.00	0.420
Feb 25	0035	385	1.21	0.56	0.22	1.30	0.728
	0110	386	1.13	0.44	0.17	1.00	0.440
	0700	387	0.99	0.32	0.12	0.95	0.304
Feb 26	0900	388	0.91	0.23	0.09	0.30	0.069
	1800	389	0.92	0.24	0.10	0.30	0.072
Feb 27	0815	390	0.92	0.24	0.10	0.30	0.072
Feb 28	0800	391	0.90	0.22	0.09	0.30	0.066
Mar 1	0630	392	0.90	0.21	0.08	0.30	0.063
Mar 4	0625	393	0.94	0.25	0.10	0.30	0.075
Mar 6	0110	394	1.14	0.50	0.19	1.00	0.500
	0835	395	1.03	0.33	0.13	0.85	0.281
	2100	396	1.16	0.54	0.21	1.10	0.594
Mar 7	0725	397	1.04	0.36	0.13	0.90	0.324

TABLE H-6 (CONTINUED)

UNIT DISCHARGE MEASUREMENT SUMMARY

AT CENTERLINE OF THE JRAGUNG RIVER

AT THE BORANGAN BRIDGE

Date	Hour	Measurement No.	Gage Height (m)	Depth (m)	Observation Depth (m)	Velocity (m/s)	Unit Discharge ($m^3/s/m$)
Apr 1	1503	398	1.06	0.41	0.16	1.10	0.451
	1630	399	1.06	0.40	0.16	1.00	0.400
	1830	400	1.02	0.34	0.14	0.75	0.255
Apr 2	0800	401	0.99	0.30	0.12	0.60	0.180
	1100	402	1.16	0.49	0.20	1.40	0.686
	1140	403	1.14	0.47	0.19	1.25	0.588
Apr 3	0110	404	1.12	0.42	0.16	1.15	0.483
	1100	405	1.03	0.34	0.13	0.70	0.238
Apr 4	0705	406	1.42	0.82	0.32	2.25	1.85
	0716	407	1.50	0.93	0.37	2.20	2.05
	0734	408	1.52	0.88	0.35	2.20	1.94
	0845	409	1.44	0.84	0.33	1.85	1.55
	1055	410	1.30	0.65	0.26	1.60	1.04
	1400	411	1.20	0.39	0.15	1.50	0.585
	1900	412	1.27	0.67	0.29	1.60	1.07
	1940	413	1.34	0.68	0.27	1.65	1.12
Apr 5	0105	414	2.06	1.28	0.26 1.04	2.95	3.78
	0117	415	2.30	1.70	0.34 1.36	3.15	5.36
	0135	416	2.60	2.00	0.40 1.60	3.18	6.36
	0150	417	2.70	2.20	0.44 1.76	3.20	7.04

TABLE H-6 (CONTINUED)

UNIT DISCHARGE MEASUREMENT SUMMARY

AT CENTERLINE OF THE JRAGUNG RIVER

AT THE BORANGAN BRIDGE

Date	Hour	Measurement No.	Gage Height m	Depth m	Observation Depth m	Velocity m/s	Unit Discharge $m^3/s/m$
	0225	418	2.55	1.98	0.39 1.59	3.05	6.04
	0335	419	1.95	1.35	0.27 1.08	2.63	3.55
Apr 5	0445	420	1.92	1.30	0.26 1.04	2.35	3.06
	0555	421	1.83	1.20	0.24 0.96	2.25	2.70
	0705	422	1.70	1.12	0.22 0.90	2.05	2.30
	1100	423	1.55	1.00	0.20 0.80	1.70	1.70
	1720	424	1.45	0.86	0.34	2.00	1.72
	1925	425	1.40	0.80	0.32	1.60	1.28
Apr 6	0805	426	1.10	0.54	0.21	0.80	0.432
	1715	427	2.45	1.80	0.36 1.44	4.05	7.29
	1900	428	2.30	1.70	0.35 1.35	2.90	4.93
	2025	429	1.90	1.68	0.33 1.34	2.50	4.20
	2210	430	1.60	1.07	0.21 0.85	1.60	1.71
Apr 7	0140	431	1.40	1.12	0.22 0.90	1.55	1.74
	0635	432	1.25	0.88	0.35	1.20	1.06

TABLE H-6(CONTINUED)

UNIT DISCHARGE MEASUREMENT SUMMARY
AT CENTERLINE OF THE JRAGUNG RIVER
AT THE BORANGAN BRIDGE

	Hour	Measurement No.	Gage Height m	Depth m	Observation Depth m	Velocity m/s	Unit Discharge $m^3/s/m$
	1814	433	1.08	0.72	0.29	0.80	
	1852	434	1.48	1.10	0.22	1.50	0.576
					0.88		
	1952	435	1.38	0.99	0.36	1.50	1.49
	2303	436	1.20	0.88	0.35	1.20	1.06
Apr 8	0652	437	1.12	0.73	0.29	0.80	0.584
	1737	438	1.02	0.61	0.24	0.60	0.366
	2340	439	1.30	1.05	0.21	1.25	1.31
					0.84		
Apr 9	0050	440	1.75	1.47	0.29	2.50	3.68
					1.18		
	0200	441	1.56	1.12	0.22	2.20	2.46
					0.90		
	0715	442	1.37	0.92	0.37	1.50	1.38
	1740	443	1.10	0.52	0.21	1.00	0.520
	1845	444	1.50	0.97	0.39	1.70	1.65
	2050	445	1.40	0.89	0.36	1.30	1.16
Apr 10	0610	446	1.10	0.51	0.20	1.10	0.561
	1845	447	1.01	0.43	0.17	0.80	0.344
Apr 11	2020	448	1.40	0.96	0.38	1.50	1.44
	2130	449	1.35	0.84	0.37	1.30	1.09
	2330	450	2.00	1.45	0.29	2.65	3.84
					1.16		

TABLE H-6 (CONTINUED)

UNIT DISCHARGE MEASUREMENT SUMMARY
AT CENTERLINE OF THE JRAGUNG RIVER
AT THE BORANGAN BRIDGE

Date	Hour	Measurement No.	Gage Height (m)	Depth (m)	Observation Depth (m)	Velocity (m/s)	Unit Discharge ($m^3/s/m$)
Apr 12	0030	451	1.90	1.40	0.28 1.12	2.55	3.57
	0235	452	1.46	0.97	0.39	2.10	2.04
	0400	453	1.35	0.90	0.36	1.50	1.35
	0645	454	1.24	0.85	0.34	1.10	0.935
	1815	455	1.08	0.51	0.20	0.95	0.459
Apr 13	2000	456	1.80	1.29	0.26 1.03	2.10	2.709
	2105	457	1.72	1.11	0.22 0.89	1.95	2.17
	2235	458	1.52	0.98	0.39	1.20	1.18
Apr 14	0015	459	1.42	0.96	0.38	1.80	1.73
	0745	460	1.22	0.59	0.24	1.20	0.708
	1650	461	1.50	1.02	0.20 0.82	1.80	1.84
	2130	462	1.35	0.76	0.32	1.70	1.29
	2245	463	1.30	0.68	0.27	1.40	0.952
Apr 15	0600	464	1.16	0.61	0.24	1.10	0.671
	1715	465	1.05	0.55	0.22	0.80	0.440
Apr 16	1640	466	1.40	0.90	0.36	1.60	1.44
	1830	467	1.31	0.77	0.31	1.50	1.16
Apr 17	0700	468	1.12	0.53	0.21	0.90	0.477
	1610	469	1.04	0.44	0.17	0.80	0.352

TABLE H-6 (CONTINUED)

UNIT DISCHARGE MEASUREMENT SUMMARY
AT CENTERLINE OF THE JRAGUNG RIVER
AT THE BORANGAN BRIDGE

Date	Hour	Measurement No.	Gage Height m	Depth m	Observation Depth m	Velocity m/s	Unit Discharge $m^3/s/m$
Apr 18	0600	470	1.00	0.40	0.16	0.70	0.280
	2045	471	0.96	0.34	0.14	0.60	0.204
Apr 19	1530	472	0.94	0.32	0.12	0.50	0.160
Apr 20	0730	473	0.96	0.35	0.14	0.55	0.193
	2040	474	1.13	0.52	0.20	1.00	0.520
Apr 21	1630	475	0.96	0.35	0.13	0.60	0.210
	2220	476	1.15	0.56	0.22	1.10	0.616
Apr 22	2000	477	1.00	0.34	0.13	0.50	0.170
	2040	478	1.21	0.56	0.22	1.20	0.672
	2200	479	1.61	0.51	0.20	1.10	0.561
	2255	480	1.26	0.62	0.24	1.25	0.775
Apr 23	0825	481	1.09	0.46	0.17	0.60	0.276
	1730	482	0.99	0.38	0.15	0.50	0.190
Apr 24	0815	483	0.96	0.35	0.13	0.50	0.175
	1820	484	0.94	0.31	0.11	0.50	0.155
Apr 25	0700	485	0.90	0.27	0.10	0.50	0.135
Apr 26	0815	486	0.94	0.30	0.12	0.50	0.150
Apr 27	0800	487	0.91	0.28	0.09	0.50	0.140
	1920	488	1.18	0.62	0.24	1.20	0.744
	2035	489	1.02	0.42	0.16	0.70	0.294

TABLE H-6(CONTINUED)

UNIT DISCHARGE MEASUREMENT SUMMARY
AT CENTERLINE OF THE JRAGUNG RIVER
AT THE BORANGAN BRIDGE

Date	Hour	Measurement No.	Gage Height m	Depth m	Observation Depth m	Velocity m/s	Unit Discharge $m^3/s/m$
Apr 28	0630	490	0.96	0.33	0.13	0.50	0.165
	1800	491	0.90	0.26	0.10	0.50	0.130
Apr 29	0800	492	0.89	0.30	0.12	0.50	0.150
Apr 30	0800	493	0.92	0.32	0.12	0.60	0.192
May 1	0700	494	0.88	0.26	0.09	0.45	0.117
May 2	0300	495	1.10	0.50	0.20	1.10	0.550
	0540	496	1.07	0.46	0.18	0.90	0.414
May 3	0100	497	1.40	0.95	0.38	2.00	1.90
	0230	498	1.90	1.46	0.29	2.05	2.99
					0.84		
	0320	499	1.54	0.80	0.32	1.80	1.44
	0645	500	1.32	0.72	0.28	1.40	1.01
	1130	501	1.15	0.55	0.22	1.10	0.605
	1630	502	1.06	0.45	0.18	0.80	0.360
May 4	0710	503	0.96	0.34	0.13	0.60	0.204
May 5	0820	504	0.90	0.25	0.10	0.50	0.125
	1430	505	1.70	1.33	0.27	2.40	3.19
					1.06		
	1445	506	1.80	1.30	0.26	2.30	2.99
					1.40		
	1550	507	1.44	0.93	0.37	1.70	1.58
	1730	508	1.25	0.72	0.29	1.30	0.936

TABLE H-6 (CONTINUED)

UNIT DISCHARGE MEASUREMENT SUMMARY AT CENTERLINE OF THE JRAGUNG RIVER AT THE BORANGAN BRIDGE

Date	Hour	Measurement No.	Gage Height m	Depth m	Observation Depth m	Velocity m/s	Unit Discharge $m^3/s/m$
May 6	0705	509	1.05	0.43	0.16	0.90	0.387
May 7	0600	510	1.01	0.40	0.16	0.50	2.00
	0805	511	0.98	0.35	0.13	0.50	0.175
May 8	0610	512	0.93	0.29	0.12	0.80	0.232
May 9	0700	513	0.88	0.23	0.09	0.35	0.081
May 10	0230	514	1.00	0.40	0.16	0.60	0.240
	0300	515	1.13	0.55	0.22	1.10	0.605
	0900	516	1.02	0.43	0.17	0.80	0.344
	1805	517	0.97	0.37	0.14	0.60	0.222
May 11	0730	518	0.92	0.31	0.12	0.50	0.155
	1600	519	1.05	0.43	0.17	0.80	0.344
May 12	0820	520	0.93	0.34	0.13	0.60	0.204
May 13	0800	521	0.90	0.30	0.12	0.40	0.120
May 14	0800	522	0.88	0.28	0.11	0.40	0.112
May 15	0900	523	0.90	0.30	0.12	0.40	0.120
May 16	0830	524	0.86	0.24	0.09	0.30	0.072
May 17	0710	525	0.85	0.22	0.08	0.30	0.066
May 20	2200	526	1.17	0.56	0.22	1.10	0.616
May 21	0600	527	1.02	0.31	0.12	0.80	0.248

TABLE H-6 (CONTINUED)

UNIT DISCHARGE MEASUREMENT SUMMARY
AT CENTERLINE OF THE JRAGUNG RIVER
AT THE BORANGAN BRIDGE

Date	Hour	Measurement No.	Gage Height m	Depth m	Observation Depth m	Velocity m/s	Unit Discharge $m^3/s/m$
May 22	0615	528	0.89	0.27	0.11	0.45	0.122
	1530	529	1.25	0.55	0.22	1.20	0.660
	1545	530	1.50	0.94	0.37	2.10	1.97
	1600	531	1.70	1.22	0.24 0.96	2.05	2.50
	1625	532	1.60	1.19	0.23 0.96	1.85	2.20
	1735	533	1.48	0.99	0.39	1.70	1.68
	1835	534	1.40	0.90	0.36	1.50	1.35
	1950	535	1.30	0.71	0.28	1.40	0.994
May 23	0010	536	1.14	0.55	0.22	1.10	0.605
	0800	537	1.02	0.42	0.16	0.80	0.336
	1530	538	1.20	0.63	0.25	1.30	0.819
	1715	539	1.35	0.94	0.37	1.50	1.41
	1830	540	1.40	0.98	0.39	1.70	1.67
	2000	541	1.35	0.94	0.37	1.40	1.32
	2130	542	1.30	0.71	0.28	1.30	0.923
May 24	0100	543	1.22	0.63	0.25	1.20	0.756
	0800	544	1.09	0.50	0.20	1.00	0.500
	1500	545	1.00	0.40	0.16	0.80	0.320
May 25	0600	546	0.94	0.34	0.14	0.60	0.204
	1730	547	0.91	0.30	0.12	0.50	0.150
May 26	0820	548	0.88	0.24	0.09	0.40	0.096
	1710	549	0.87	0.23	0.09	0.40	0.092

TABLE H-6 (CONTINUED)

UNIT DISCHARGE MEASUREMENT SUMMARY
AT CENTERLINE OF THE JRAGUNG RIVER
AT THE BORANGAN BRIDGE

Date	Hour	Measurement No.	Gage Height m	Depth m	Observation Depth m	Velocity m/s	Unit Discharge $m^3/s/m$
May 27	0800	550	0.86	0.21	0.08	0.35	0.074
May 28	0800	551	0.87	0.24	0.09	0.40	0.096
May 29	0630	552	0.87	0.24	0.09	0.40	0.096
May 30	0700	553	0.88	0.24	0.09	0.40	0.096
May 31	1000	554	1.10	0.49	0.20	1.10	0.539
	1200	555	1.01	0.43	0.17	0.70	0.301
Jun 1	0730	556	0.94	0.33	0.13	0.60	0.198
	2300	557	1.10	0.50	0.20	1.10	0.550
Jun 2	0100	558	1.22	0.64	0.25	1.50	0.960
	0305	559	1.18	0.61	0.24	1.30	0.793
	0600	560	1.10	0.52	0.21	1.00	0.520
Jun 3	0600	561	0.90	0.29	0.11	0.60	0.174
Jun 4	0910	562	0.86	0.25	0.10	0.40	0.100
Jun 5	2400	563	1.12	0.52	0.21	1.20	0.624
	0640	564	0.89	0.27	0.12	0.55	0.149
	1430	565	1.15	0.57	0.23	1.10	0.627
Jun 6	0745	566	0.90	0.35	0.14	0.50	0.175
Jun 7	0800	567	0.88	0.27	0.11	0.40	0.108
	2200	568	1.04	0.46	0.19	0.80	0.368

TABLE H-6 (CONTINUED)

UNIT DISCHARGE MEASUREMENT SUMMARY

AT CENTERLINE OF THE JRAGUNG RIVER

AT THE BORANGAN BRIDGE

Date	Hour	Measurement No.	Gage Height m	Depth m	Observation Depth m	Velocity m/s	Unit Discharge $m^3/s/m$
Jun 8	0245	569	1.34	0.94	0.37	1.40	1.32
	0325	570	1.20	0.63	0.25	1.20	0.756
	0630	571	1.10	0.53	0.21	1.00	0.530
	1800	572	1.00	0.42	0.16	0.90	0.378
Jun 9	0805	573	0.98	0.40	0.16	0.75	0.300
	1610	574	0.96	0.38	0.15	0.70	0.266
Jun 10	0820	575	0.90	0.31	0.12	0.50	0.155
Jun 11	0730	576	0.86	0.26	0.10	0.40	0.104
Jun 12	0850	577	0.88	0.23	0.09	0.45	0.104
Jun 13	0800	578	0.86	0.26	0.11	0.40	0.104
Jun 14	0805	579	0.84	0.24	0.10	0.40	0.096
Jun 15	0705	580	0.83	0.23	0.10	0.40	0.092
Jun 16	0830	581	0.83	0.23	0.10	0.40	0.092
Jun 17	0610	582	0.83	0.23	0.10	0.40	0.092
Jun 18	1000	583	0.81	0.20	0.08	0.30	0.060

TABLE H-7

SUSPENDED SEDIMENT MEASUREMENT SUMMARY

JRAGUNG RIVER AT BORANGAN BRIDGE

Date	Hour	Gage Height m	Depth m	Sample No.	Suspended Sediment Concentration mg/l
Record starts Nov 9, 1977					
Nov 9	1745	0.90	0.21	1	2360
	1845	0.96	0.28	2	5360
	1925	0.96	0.28	3	3640
	2020	0.94	0.24	4	3010
	2105	0.92	0.25	5	2330
Nov 10	1800	0.88	0.20	6	1720
Nov 11	1715	0.84	0.22	7	526
Nov 12	1850	0.82	0.15	8	205
Nov 14	1950	0.79	0.12	9	90
Nov 16	0025	1.40	0.76	10	34500
	0245	1.09	0.43	11	23500
	1645	0.86	0.13	12	780
Nov 18	1900	0.82	0.13	13	360
Nov 20	2055	1.05	0.36	14	6980
	2150	1.01	0.29	15	7140
Nov 21	1755	0.82	0.14	16	560
Nov 22	1810	0.82	0.09	17	502
	2220	0.88	0.18	18	1250
Nov 26	0130	1.00	0.31	19	21800
	0200	0.96	0.26	20	19900
Nov 29	1710	0.87	0.14	21	6800
	2035	1.17	0.50	22	38900
	2100	1.15	0.47	23	57500
	2120	1.13	0.42	24	49800
	2150	1.10	0.41	25	34000
	2250	1.06	0.37	26	23600

TABLE H-7(CONTINUED)

SUSPENDED SEDIMENT MEASUREMENT SUMMARY

JRAGUNG RIVER AT BORANGAN BRIDGE

Date	Hour	Gage Height m	Depth m	Sample No.	Suspended Sediment Concentration mg/l
Nov 30	1805	0.92	0.18	27	1500
Dec 1	1320	1.18	0.52	28	17800
	1340	1.19	0.53	29	27400
	1515	1.18	0.48	30	20400
	1605	1.06	0.37	31	19400
	1710	1.02	0.31	32	11500
	1815	0.99	0.26	33	6200
Dec 2	1425	0.95	0.23	34	1590
	1500	1.50	0.91	35	66200
	1530	1.43	0.80	36	56800
	1635	1.38	0.69	37	37400
	1745	1.36	0.70	38	26200
	1920	1.30	0.59	39	18960
Dec 3	1620	1.20	0.44	40	7090
	1825	1.17	0.34	41	8720
Dec 4	1610	0.97	0.19	42	1040
	1640	1.57	0.99	43	58100
	1710	1.52	0.87	44	57800
	1830	1.30	0.55	45	32800
	2035	1.18	0.37	46	12800
Dec 5	1610	0.98	0.26	47	4600
Dec 6	1730	1.09	0.29	48	17800
	1755	1.10	0.35	49	24300
	1850	1.28	0.53	50	30300
	1920	1.37	0.65	51	21600
	2005	1.39	0.67	52	19000
	2040	1.29	0.54	53	16500
	2150	1.19	0.43	54	13900
Dec 7	1520	1.03	0.22	55	2070
	1810	1.27	0.54	56	11100
	1825	1.30	0.56	57	17100
	1900	1.29	0.56	58	17800

TABLE H-7(CONTINUED)

SUSPENDED SEDIMENT MEASUREMENT SUMMARY

JRAGUNG RIVER AT BORANGAN BRIDGE

Date	Hour	Gage Hei, m	Depth m	Sample No.	Suspended Sediment Concentration mg/l
	1930	1.26	0.53	59	9100
	2140	1.19	0.42	60	844
Dec 8	1800	0.97	0.15	61	251
Dec 9	1525	0.92	0.10	62	88
Dec 10	1730	0.89	0.09	63	15400
Dec 11	1615	0.89	0.09	64	65
Dec 12	1650	0.90	0.09	65	58
Dec 13	2015	0.89	0.09	66	28
Dec 14	1320	0.94	0.15	67	2300
	1420	1.20	0.38	68	33100
	1520	1.12	0.37	69	14100
Dec 15	1120	0.91	0.10	70	349
Dec 16	0850	0.88	0.08	71	156
	1430	1.21	0.50	72	10300
	1525	1.19	0.47	73	22500
	1610	1.15	0.42	74	18200
	1715	1.10	0.32	75	12200
	1825	1.05	0.31	76	7390
Dec 17	0805	0.95	0.19	77	850
	1700	0.92	0.16	78	351
Dec 18	0710	0.89	0.09	79	153
	1750	0.88	0.09	80	103
Dec 19	0715	0.88	0.08	81	56
Dec 22	1545	1.16	0.38	82	4100
	1615	1.33	0.65	83	24800
	1635	1.29	0.57	84	28500
	1725	1.20	0.48	85	19300

TABLE H-7(CONTINUED)

SUSPENDED SEDIMENT MEASUREMENT SUMMARY

JRAGUNG RIVER AT BORANGAN BRIDGE

Date	Hour	Gage Height m	Depth m	Sample No.	Suspended Sediment, Concentration mg/l
Dec 23	0810	1.02	0.27	86	2850
	1600	0.94	0.18	87	815
Dec 24	0740	1.00	0.21	88	3820
	1535	1.03	0.27	89	8680
	1555	1.29	0.57	90	15500
	1610	1.31	0.63	91	28400
	1625	1.29	0.63	92	18500
	1740	1.17	0.41	93	11200
Dec 25	0720	0.99	0.26	94	418
	1835	0.95	0.16	95	321
Dec 26	0710	0.94	0.14	96	169
	1800	0.89	0.14	97	119
Dec 27	0600	0.89	0.09	98	76
	1630	0.86	0.09	99	50
Dec 28	0830	0.88	0.13	100	504
	1820	0.87	0.09	101	179
	2100	1.27	0.54	102	29600
	2120	1.28	0.57	103	13400
	2140	1.28	0.60	104	15200
	2225	1.21	0.50	105	13600
	2330	1.10	0.32	106	10100
Dec 29	0605	0.94	0.13	107	816
	1810	1.11	0.32	108	17800
	1840	1.10	0.31	109	13600
Dec 30	0515	0.94	0.13	110	1260
	1825	1.41	0.80	111	25400
	1840	1.78	1.13	112	28400
	1920	1.93	1.38	113	45700
	2110	1.77	1.06	114	30500
	2140	1.68	1.06	115	16500
	2215	1.65	1.04	116	20400
	2315	1.59	1.01	117	22800

TABLE H-7(CONTINUED)

SUSPENDED SEDIMENT MEASUREMENT SUMMARY

JRAGUNG RIVER AT BORANGAN BRIDGE

Date	Hour	Gage Height m	Depth m	Sample No.	Suspended Sediment Concentration mg/l
Dec 31	0020	1.45	0.89	118	23900
	0140	1.39	0.78	119	21600
	0210	1.33	0.67	120	28300
	0320	1.26	0.55	121	22100
	0610	1.22	0.48	122	5410
	1220	1.13	0.40	123	2580
Jan 5	1850	1.00	0.28	124	1120
Jan 6	0820	0.99	0.22	125	697
	1550	1.06	0.33	126	4630
Jan 7	0715	1.07	0.33	127	1380
	1515	1.22	0.48	128	7070
	1620	1.19	0.46	129	11500
Jan 8	0610	0.99	0.25	130	825
	1615	0.98	0.20	131	215
Jan 9	0620	0.97	0.23	132	532
	1540	1.69	1.21	133	25200
	1555	1.68	1.14	134	29700
	1625	1.64	1.00	135	28615
	1815	1.48	0.78	136	7340
	2210	1.28	0.74	137	8380
Jan 10	0615	1.13	0.38	138	2010
	1650	1.05	0.26	139	1290
Jan 11	0930	0.99	0.21	140	670
	1810	1.00	0.23	141	305
Jan 12	0805	0.99	0.21	142	300
	1720	0.97	0.19	143	256
Jan 13	0620	1.03	0.25	144	667
	1335	1.25	0.55	145	3950
	1410	1.26	0.55	146	6850

TABLE H-7 (CONTINUED)

SUSPENDED SEDIMENT MEASUREMENT SUMMARY

JRAGUNG RIVER AT BORANGAN BRIDGE

Date	Hour	Gage Height m	Depth m	Sample No.	Suspended Sediment Concentration mg/l
Jan 14	0630	1.09	0.35	147	1220
	1620	1.03	0.27	148	565
	1825	1.28	0.60	149	5590
	1840	1.30	0.60	150	6530
	2020	1.23	0.52	151	6580
Jan 15	0630	1.09	0.38	152	1240
	1820	1.00	0.22	153	457
	1855	1.15	0.41	154	1160
Jan 16	0645	0.99	0.21	155	772
	1810	1.57	0.86	156	18800
	1840	1.37	0.64	157	18300
Jan 17	0610	1.01	0.22	158	811
	1735	1.00	0.19	159	518
Jan 19	0750	0.98	0.13	160	127
	1530	1.53	0.90	161	22000
	1545	1.57	0.85	162	25000
	1605	1.80	1.19	163	28900
	1640	1.53	0.84	164	39400
	1905	1.38	0.75	165	16800
Jan 20	1725	1.91	1.51	166	57900
	1745	2.09	1.78	167	37400
	1805	2.06	1.62	168	36700
	1910	1.65	0.93	169	19500
	2025	1.44	0.71	170	13600
Jan 21	0600	1.09	0.36	171	2580
	1820	1.07	0.30	172	1050
Jan 22	0620	1.13	0.36	173	1500
	1820	1.06	0.31	174	618
Jan 23	0830	1.02	0.28	175	588
	1425	2.05	1.67	176	41500
	1455	2.08	1.68	177	34200

TABLE H-7 (CONTINUED)

SUSPENDED SEDIMENT MEASUREMENT SUMMARY

JRAGUNG RIVER AT BORANGAN BRIDGE

Date	Hour	Gage Height m	Depth m	Samp. No	Suspended Sediment Concentration mg/l
	1550	1.91	1.39	178	24200
	1640	1.76	1.17	179	13100
	1805	1.70	1.03	180	6510
	2020	1.68	0.97	181	15000
Jan 24	0605	1.20	0.47	182	4710
	2050	1.10	0.39	183	2300
Jan 25	0930	1.08	0.34	184	1090
	1810	1.04	0.31	185	4290
Jan 26	0900	1.40	0.76	186	9880
	1000	1.36	0.66	187	5430
Jan 27	0810	1.20	0.47	188	2330
	1820	1.13	0.38	189	1250
Jan 28	0810	1.07	0.34	190	510
	1810	1.05	0.30	191	36400
Jan 29	0710	1.03	0.27	192	260
	1820	1.01	0.22	193	216
Jan 30	0630	0.99	0.20	194	320
	1800	0.99	0.20	195	540
Jan 31	0900	1.16	0.45	196	182
	2000	1.02	0.30	197	3820
Feb 1	0920	1.00	0.28	198	859
	1735	1.79	1.37	199	510
	1810	2.05	1.63	200	19100
	1850	1.94	1.50	201	42500
	1930	3.27	2.87	202	33900
	2010	3.16	2.77	203	46300
Feb 2	0850	1.30	0.64	204	19300
	1540	1.98	1.58	205	9650

TABLE H-7(CONTINUED)

SUSPENDED SEDIMENT MEASUREMENT SUMMARY

JRAGUNG RIVER AT BORANGAN BRIDGE

Date	Hour	Gage Height m	Depth m	Samp No	Suspended Sediment Concentration mg/l
	1610	1.70	1.09	206	47600
	1640	1.65	1.04	207	40000
Feb 3	0630	1.19	0.50	208	20500
	1730	1.12	0.38	209	9960
Feb 4	0840	1.05	0.32	210	4680
	1800	1.02	0.30	211	1490
Feb 5	0630	1.06	0.35	212	1460
	1630	1.20	0.55	213	1500
	1650	1.30	0.71	214	9050
	1730	1.75	1.28	215	14200
	1830	1.65	1.15	216	46800
	1940	1.38	0.78	217	21300
Feb 6	0620	1.10	0.36	218	2780
	1800	1.06	0.33	219	1280
Feb 7	0810	1.04	0.28	220	996
	1920	0.99	0.25	221	678
Feb 8	0730	0.98	0.23	222	554
	2030	0.97	0.22	223	363
Feb 9	0940	1.00	0.25	224	640
Feb 10	0830	1.03	0.28	225	358
	1750	0.98	0.24	226	511
	2150	1.29	0.66	227	10300
Feb 11	0800	1.08	0.35	228	531
	1730	1.00	0.28	229	557
Feb 12	0650	1.03	0.33	230	808
	1810	1.06	0.34	231	769
Feb 13	0830	1.08	0.43	232	1940
	1810	1.01	0.26	233	481

TABLE H-7(CONTINUED)

SUSPENDED SEDIMENT MEASUREMENT SUMMARY

JRAGUNG RIVER AT BORANGAN BRIDGE

Date	Hour	Gage Height m	Depth m	Sample No.	Suspended Sediment Concentration mg/l
Feb 14	0830	0.98	0.28	234	423
	1820	0.98	0.23	235	250
Feb 15	0750	0.91	0.21	236	189
	1640	1.73	1.20	237	64300
	1700	1.82	1.33	238	57700
	1720	1.90	1.43	239	41400
	1810	1.78	1.25	240	24000
	2120	1.42	0.81	241	9930
Feb 16	0810	1.13	0.39	242	3440
	1750	1.03	0.26	243	1110
Feb 17	0740	1.05	0.27	244	1200
	1820	1.16	0.42	245	858
Feb 18	0720	1.02	0.23	246	856
	1810	0.97	0.20	247	358
Feb 19	1010	0.95	0.19	248	423
	1730	0.95	0.18	249	272
Feb 20	0940	0.90	0.14	250	263
	1500	0.89	0.13	251	299
Feb 21	1430	1.43	0.78	252	15300
	1442	1.92	1.32	253	43100
	1550	1.91	1.32	254	44800
	1640	2.10	1.69	255	32700
	1915	1.81	1.17	256	14200
	2125	1.59	0.91	257	9260
Feb 22	0840	1.52	0.49	258	3390
	1645	2.28	1.83	259	71400
	1715	2.73	2.05	260	50800
	1730	2.73	2.12	261	49000
				262	27500
	2020	1.76	1.03	263	15900

TABLE H-7 (CONTINUED)

SUSPENDED SEDIMENT MEASUREMENT SUMMARY

JRAGUNG RIVER AT BORANGAN BRIDGE

Date	Hour	Gage Height m	Depth m	Sample No.	Suspended Sediment Concentration mg/l
Feb 23	0815	1.30	0.57	264	5610
	1900	1.18	0.41	265	2350
Feb 24	0620	1.12	0.35	266	1890
	1800	1.08	0.32	267	1310
Feb 25	0630	1.05	0.29	268	1140
	1640	1.03	0.27	269	830
Feb 26	0715	1.03	0.28	270	660
	1410	1.27	0.50	271	4220
	1510	1.15	0.40	272	3330
Feb 27	0720	1.10	0.31	273	688
	1620	1.06	0.30	274	642
Feb 28	0840	1.04	0.30	275	515
	1415	1.40	0.66	276	38900
	1510	1.26	0.49	277	36700
	1920	1.12	0.35	278	5940
Mar 1	0730	1.05	0.27	279	1680
	1830	1.04	0.25	280	1200
Mar 2	0740	1.04	0.23	281	701
	1710	1.04	0.23	282	670
Mar 3	0620	1.03	0.21	283	522
	1540	1.03	0.21	284	446
Mar 4	0620	1.15	0.45	285	3170
	1420	1.31	0.57	286	7490
	1440	1.31	0.59	287	3500
	1555	1.46	0.69	288	15100
	1615	1.44	0.67	289	18700
Mar 5	0830	1.11	0.35	290	1440
	1815	1.04	0.24	291	1320

TABLE H-7(CONTINUED)

SUSPENDED SEDIMENT MEASUREMENT SUMMARY

JRAGUNG RIVER AT BORANGAN BRIDGE

Date	Hour	Gage Height m	Depth m	Sample No	Suspended Sediment Concentration mg/l
Mar 6	0610	1.04	0.25	292	1770
	1455	1.49	0.73	293	5530
	1510	1.56	0.86	294	4340
	1540	1.41	0.61	295	5370
Mar 7	0815	0.99	0.22	296	527
	1740	1.60	0.92	297	48600
	1800	1.42	0.67	298	55900
	2000	1.35	0.55	299	25000
	2130	1.38	0.56	300	12900
Mar 8	0730	1.17	0.35	301	2140
	1805	1.04	0.24	302	979
Mar 9	0705	0.99	0.18	303	747
	1805	0.98	0.17	304	885
Mar 10	0600	1.10	0.31	305	2230
	1645	1.04	0.22	306	2180
	2040	1.34	0.58	307	2660
	2115	1.28	0.53	308	979
Mar 11	0615	1.16	0.32	309	1140
	1810	1.06	0.25	310	742
Mar 12	0620	1.01	0.19	311	347
	1835	0.98	0.15	312	307
Mar 13	0620	0.96	0.14	313	158
	1720	0.95	0.13	314	169
Mar 14	0950	0.95	0.13	315	124
	1735	0.94	0.12	316	138
Mar 15	0820	0.94	0.12	317	93
Mar 16	0830	1.00	0.16	318	323
	1810	0.99	0.15	319	144

TABLE H-7(CONTINUED)

SUSPENDED SEDIMENT MEASUREMENT SUMMARY

JRAGUNG RIVER AT BORANGAN BRIDGE

Date	Hour	Gage Height m	Depth m	Sample No.	Suspended Sediment Concentration mg/l
Mar 17	0935	0.97	0.14	320	107
	1715	0.98	0.14	321	103
Mar 18	0805	0.95	0.11	322	67
	1810	0.94	0.11	323	47
	2140	1.39	0.56	324	970
	2210	1.37	0.55	325	980
	2310	1.34	0.53	326	1190
Mar 19	0815	1.17	0.34	327	824
	1750	1.05	0.21	328	430
Mar 20	0610	1.00	0.15	329	139
	1750	1.28	0.42	330	34400
Mar 21	0605	1.07	0.28	331	2810
	1810	1.14	0.30	332	3920
Mar 22	0610	1.69	1.18	333	6330
	0820	1.55	1.08	334	5690
	0930	1.46	0.68	335	11200
	1035	1.43	0.65	336	6060
	1115	1.40	0.57	337	7340
	1750	1.28	0.49	338	2310
Mar 23	0830	1.24	0.42	339	2610
	1750	1.10	0.30	340	941
Mar 24	0910	1.09	0.28	341	818
	1655	1.10	0.30	342	1070
Mar 25	1025	1.01	0.26	343	454
	1555	1.00	0.23	344	394
Mar 26	0835	0.95	0.19	345	308
	1730	0.96	0.21	346	326
Mar 27	0610	0.94	0.18	347	217
	1610	0.95	0.16	348	185

TABLE H-7(CONTINUED)

SUSPENDED SEDIMENT MEASUREMENT SUMMARY

JRAGUNG RIVER AT BORANGAN BRIDGE

Date	Hour	Gage Hei m	Depth m	Sample No.	Suspended Sediment Concentration mg/l
Mar 28	0720	0.95	0.16	349	118
	1810	0.96	0.21	350	171
Mar 29	0715	0.95	0.17	351	302
	1810	0.94	0.17	352	136
Mar 30	0830	0.94	0.16	353	124
	1710	0.93	0.15	354	95
Mar 31	0755	0.90	0.12	355	45
	1535	0.90	0.12	356	44
Apr 1	0850	0.90	0.11	357	38
	1535	0.89	0.10	358	28
Apr 2	0920	0.89	0.10	359	22
	1720	0.90	0.11	360	17
Apr 3	0710	0.89	0.10	361	12
	1535	0.90	0.11	362	28
	1840	1.08	0.35	363	3550
	2110	1.08	0.35	364	3380
	2235	1.08	0.35	365	9270
	2400	1.23	0.42	366	2430
Apr 4	0245	1.11	0.39	367	2430
	0635	1.11	0.38	368	2390
	1800	1.03	0.26	369	624
Apr 5	0600	0.99	0.22	370	366
	1805	0.95	0.17	371	113
Apr 6	0905	0.92	0.14	372	117
	1750	0.92	0.14	373	70
Apr 7	0625	0.89	0.10	374	60
	1650	0.90	0.11	375	41
	1840	1.10	0.33	376	4030

TABLE H-7(CONTINUED)

SUSPENDED SEDIMENT MEASUREMENT SUMMARY

JRAGUNG RIVER AT BORANGAN BRIDGE

Date	Hour	Gage Height m	Depth m	Sampl No.	Suspended Sediment Concentration mg/l
Apr 8	0710	0.94	0.15	377	664
	1805	0.92	0.14	378	249
Apr 9	0640	0.89	0.11	379	115
	1605	0.90	0.13	380	48
Apr 10	0840	0.91	0.13	381	77
	1545	0.90	0.12	382	173
Apr 11	0735	0.92	0.14	383	135
	1350	0.91	0.13	384	92
Apr 12	0700	1.01	0.28	385	1400
	1505	2.10	1.52	386	47700
	1525	2.00	1.48	387	43800
	1555	2.10	1.58	388	47200
	1640	1.66	1.01	389	29000
	1825	1.40	0.70	390	17400
	1930	1.35	0.65	391	13200
Apr 13	0945	1.12	0.36	392	2720
	1655	1.05	0.31	393	1310
	2030	1.27	0.49	394	2830
	2055	1.40	0.72	395	2860
	2130	1.67	1.09	396	2770
	2245	1.30	0.49	397	2860
Apr 14	0750	1.06	0.32	398	2620
	1550	1.03	0.24	399	1640
	1955	2.36	1.76	400	31400
	2025	2.13	1.53	401	34700
	2055	1.82	1.22	402	38000
	2215	1.40	0.68	403	15100
	2325	1.28	0.57	404	15600
Apr 15	0550	1.11	0.32	405	4260
	1710	1.02	0.23	406	1560

TABLE H-7(CONTINUED)

SUSPENDED SEDIMENT MEASUREMENT SUMMARY

JRAGUNG RIVER AT BORANGAN BRIDGE

Date	Hour	Gage Height m	Depth m	Sample No.	Suspended Sediment Concentration mg/l
Apr 16	0740	0.98	0.16	407	2310
	1725	0.95	0.12	408	415
Apr 17	0810	0.94	0.11	409	2680
	1550	0.93	0.10	410	391
Apr 18	0720	0.91	0.10	411	1640
	1710	0.91	0.10	412	2850
Apr 19	0600	0.90	0.10	413	1980
	1810	0.89	0.09	414	278
Apr 20	0710	0.92	0.12	415	358
	1705	0.91	0.11	416	308
Apr 21	0715	0.90	0.10	417	149
	1545	0.90	0.10	418	167
Apr 22	0140	1.10	0.35	419	7590
	0230	1.20	0.40	420	8510
	0245	1.26	0.46	421	7880
	0725	1.00	0.23	422	8730
	1700	0.90	0.12	423	395
Apr 23	0800	0.90	0.12	424	388
	1820	0.90	0.12	425	320
Apr 24	0620	0.89	0.10	426	174
	1810	0.90	0.11	427	161
Apr 25	0810	0.90	0.12	428	102
	1600	0.91	0.12	429	215
Apr 26	0810	0.89	0.10	430	13
	1815	0.97	0.15	431	3610

TABLE H-7(CONTINUED)

SUSPENDED SEDIMENT MEASUREMENT SUMMARY

JRAGUNG RIVER AT BORANGAN BRIDGE

Date	Hour	Gage Height m	Depth m	Sample No.	Suspended Sediment Concentration mg/l
Apr 27	0930	0.90	0.10	432	211
Apr 28	0850	0.88	0.10	433	64
Apr 29	0900	0.88	0.10	434	29

TABLE H-7(CONTINUED)

SUSPENDED SEDIMENT MEASUREMENT SUMMARY

JRAGUNG RIVER AT BORANGAN BRIDGE

Date	Hour	Gage Height m	Sample No.	Suspended Sediment Concentration mg/l
The measurements for the 1978-79 wet season were made by depth-integrating with a P-61 sampler at the center of the river				
Oct 2	1500	0.82	44	888
Oct 3	0815	0.84	45	167
	1630	0.92	46	584
	1638	0.94	47	1,130
	1814	1.02	48	2,620
	1920	1.90	49	39,700
	1945	2.00	50	43,700
	2030	2.00	51	38,900
	2130	1.80	52	26,800
	2230	1.63	53	22,300
Oct 4	0600	1.22	54	2,860
	1800	0.99	55	432
Oct 5	0800	0.94	56	335
	1800	0.90	57	301
Oct 6	0545	0.90	58	263
	1700	0.88	59	133
Oct 7	0600	0.88	60	175
Oct 9	0900	0.88	61	128
	1700	0.85	62	33
Oct 10	0755	0.85	63	77
	1700	0.84	64	43
Oct 11	0745	0.82	65	237
	1700	0.82	66	71
Oct 12	0800	0.82	67	114
	1700	0.82	68	107
Oct 13	0725	0.82	69	151
	1700	0.82	70	80

TABLE H-7(CONTINUED)

SUSPENDED SEDIMENT MEASUREMENT SUMMARY

JRAGUNG RIVER AT BORANGAN BRIDGE

Date	Hour	Gage Height m	Sample No.	Suspended Sediment Concentration mg/l
The measurements for the 1978-79 wet season were made by depth-integrating with a P-61 sampler at the center of the river				
Oct 14	0735	0.80	71	113
	1630	0.81	72	46
Oct 15	0525	0.80	73	96
	1725	0.80	74	111
Oct 16	0740	0.81	75	149
	1715	0.80	76	89
	1930	0.92	77	3,600
Oct 17	0545	0.84	78	573
	1645	0.82	79	120
Oct 18	0950	0.82	80	120
	1655	0.82	81	109
	1850	0.87	82	5,620
Oct 19	0555	0.93	83	1,260
	1800	0.89	84	470
Oct 20	0530	0.86	85	221
	1750	0.93	86	297
Oct 21	0600	0.95	87	498
	1700	0.94	88	297
Oct 22	0600	1.02	89	2,080
	1630	0.98	90	872
Oct 23	0730	0.91	91	421
	1715	0.90	92	393
Oct 24	0800	0.87	93	202
	1615	0.86	94	310
Oct 25	0750	0.85	95	192
	1800	0.84	96	201
Oct 26	0555	0.84	97	200
	1720	0.85	98	141

TABLE H-7 (CONTINUED)

SUSPENDED SEDIMENT MEASUREMENT SUMMARY

JRAGUNG RIVER AT BORANGAN BRIDGE

Date	Hour	Gage Height m	Sample No.	Suspended Sediment Concentration mg/l
The measurements for the 1978-79 wet season were made by depth-integrating with a P-61 sampler at the center of the river				
Oct 27	0530	0.92	99	845
	1650	0.92	100	417
Oct 28	0730	0.88	101	223
	1645	0.87	102	163
Oct 29	0915	0.85	103	122
	1540	0.85	104	142
Oct 30	0745	0.84	105	101
	1800	0.84	106	311
Oct 31	0815	0.84	107	589
	1700	0.84	108	78
	1730	1.00	109	4,010
	1800	1.50	110	2,500
	1845	1.80	111	3,480
	1915	1.90	112	2,270
	1935	2.00	113	7,750
	2000	1.90	114	18,200
	2100	1.75	115	15,100
	2215	1.55	116	15,900
	2300	1.46	117	16.800

TABLE H-7 (CONTINUED)

SUSPENDED SEDIMENT MEASUREMENT SUMMARY

JRAGUNG RIVER AT BORANGAN BRIDGE

Date	Hour	Gage Height m	Sample No.	Suspended Sediment Concentration mg/l
The measurements for the 1978-79 wet season were made by depth-integrating with a P-61 sampler at the center of the river				
Nov 1	0600	1.12	118	3,120
	1658	0.98	119	1,120
Nov 2	0800	1.02	120	953
	1830	0.96	121	806
Nov 3	0555	0.90	122	454
	1800	0.91	123	416
Nov 4	0535	0.94	124	672
	1736	0.90	125	538
Nov 5	0805	0.88	126	267
	1735	0.88	127	406
	1750	1.22	128	7,770
	1830	1.16	129	8,750
	2000	1.08	130	9,360
Nov 6	0500	0.97	131	1,730
	1730	0.92	132	660
Nov 7	0525	1.04	133	1,430
	1700	1.35	134	23,200
	1721	1.60	135	24,700
	1734	1.70	136	20,300
	1855	1.45	137	17,100
	2000	1.35	138	21,400
	2125	1.25	139	10,000
Nov 8	0101	1.15	140	4,240
	0515	1.07	141	2,130
	1545	0.99	142	1,050
Nov 9	0755	0.95	143	1,660
	1600	0.98	144	916

TABLE H-7 (CONTINUED)

SUSPENDED SEDIMENT MEASUREMENT SUMMARY

JRAGUNG RIVER AT BORANGAN BRIDGE

Date	Hour	Gage Height m	Sample No.	Suspended Sediment Concentration mg/l

The measurements for the 1978-79 wet season were made by depth-integrating with a P-61 sampler at the center of the river

Date	Hour	Gage Height (m)	Sample No.	Suspended Sediment Concentration (mg/l)
Nov 10	0800	0.95	145	457
	1630	0.93	146	406
Nov 11	0630	0.95	147	653
	1750	0.95	148	289
Nov 12	0800	0.91	149	233
	1617	0.92	150	198
Nov 13	0745	0.91	151	166
	1700	0.90	152	155
Nov 14	0745	0.88	153	119
	1735	0.90	154	130
Nov 15	0810	0.90	155	76
	1720	0.90	156	209
Nov 16	0608	0.94	157	652
	1705	0.90	158	152
Nov 17	0730	0.87	159	152
	1800	0.85	160	98
Nov 18	0600	0.85	161	69
	1715	0.85	162	69
Nov 19	0545	0.95	163	289
	1725	0.93	164	74
Nov 20	0610	0.89	165	309
	1715	0.89	166	173
Nov 21	0800	0.86	167	296
	1702	0.84	168	238
Nov 22	0715	0.85	169	103
	1703	0.85	170	182

TABLE H-7(CONTINUED)

SUSPENDED SEDIMENT MEASUREMENT SUMMARY

JRAGUNG RIVER AT BORANGAN BRIDGE

Date	Hour	Gage Height m	Sample No.	Suspended Sediment Concentration mg/l
The measurements for the 1978-79 wet season were made by depth-integrating with a P-61 sampler at the center of the river				
Nov 23	0650	0.85	171	102
	1800	0.84	172	146
Nov 24	0600	0.84	173	106
	1714	0.84	174	157
Nov 25	0800	0.83	175	120
	1800	0.83	176	86
Nov 26	0600	0.82	177	112
	1715	0.82	178	117
Nov 27	0703	0.80	179	121
	1758	0.80	180	121
Nov 28	0840	0.81	181	150
	1755	0.81	182	89
Nov 29	0558	0.81	183	100
	1800	0.81	184	66
Nov 30	0700	0.81	185	54
	1700	0.80	186	529

TABLE H-7 (CONTINUED)

SUSPENDED SEDIMENT MEASUREMENT SUMMARY

JRAGUNG RIVER AT BORANGAN BRIDGE

Date	Hour	Gage Height m	Sample No.	Suspended Sediment Concentration mg/l
The measurements for the 1978-79 wet season were made by depth-integrating with a P-61 sampler at the center of the river				
Dec 1	0630	0.81	187	69
	1600	0.80	188	68
Dec 2	0600	0.80	189	165
	1325	1.05	190	74
	1355	1.30	191	82
	1410	1.45	192	13,900
	1425	1.18	193	5,500
	1555	1.52	194	29,200
	1608	1.60	195	27,000
	1710	1.50	196	15,100
	1825	1.38	197	10,900
	1930	1.32	198	10,800
	2045	1.28	199	6,480
Dec 3	0030	1.17	200	3,350
	0330	1.10	201	2,310
	0530	1.07	202	1,870
	0940	1.03	203	1,240
	1305	1.00	204	1,020
	1515	1.37	205	4,710
	1530	1.45	206	10,800
	1602	1.45	207	19,100
	1709	1.40	208	10,200
	1800	1.31	209	6,460
	1910	1.27	210	5,770
	2015	1.21	211	4,150
	2300	1.14	212	2,820
Dec 4	0230	1.12	213	2,100
	0530	1.04	214	2,040
	0845	1.03	215	1,080
	1430	1.03	216	3,740
	1500	1.07	217	3,900

TABLE H-7 (CONTINUED)

SUSPENDED SEDIMENT MEASUREMENT SUMMARY

JRAGUNG RIVER AT BORANGAN BRIDGE

Date	Hour	Gage Height m	Sample No.	Suspended Sediment Concentration mg/l
The measurements for the 1978-79 wet season were made by depth-integrating with a P-61 sampler at the center of the river				
Dec 4	1530	1.10	218	3,890
	1630	1.06	219	3,830
	1730	1.02	220	1,870
Dec 5	0700	0.94	221	632
	1710	0.92	222	424
	2150	1.05	223	1,490
	2300	1.04	224	902
Dec 6	2410	1.03	225	902
	0100	1.02	226	843
	0200	1.02	227	2,520
	0630	0.98	228	833
	1725	0.95	229	543
Dec 7	0155	1.04	230	1,470
	0345	1.16	231	2,610
	0500	1.14	232	3,100
	0630	1.13	233	2,230
	1600	1.03	234	1,060
Dec 8	0600	0.99	235	521
	1730	0.96	236	445
	1925	1.02	237	2,760
	2022	1.24	238	10,500
	2130	1.25	239	5,830
	2240	1.22	240	4,640
Dec 9	0003	1.20	241	3,740
	0100	1.18	242	3,740
	0415	1.13	243	1,020
	0700	1.08	244	1,590
	0948	1.05	245	1,220
	1305	1.02	246	994
	1600	1.00	247	754

TABLE H-7 (CONTINUED)

SUSPENDED SEDIMENT MEASUREMENT SUMMARY

JRAGUNG RIVER AT BORANGAN BRIDGE

Date	Hour	Gage Height m	Sample No.	Suspended Sediment Concentration mg/1
The measurements for the 1978-79 wet season were made by depth-integrating with a P-61 sampler at the center of river				
Dec 10	0700	0.99	248	589
	1755	0.96	249	400
Dec 11	0600	0.91	250	281
	1820	1.30	251	6,910
	1832	1.37	252	30,200
	1841	1.45	253	38,000
	1905	1.44	275	18,700
	2000	1.35	255	14,800
	2120	1.35	256	4,980
	2240	1.30	257	4,840
Dec 12	0100	1.25	258	5,000
	0405	1.16	259	3,030
	0700	1.13	260	2,330
	1000	1.00	261	1,840
	1305	1.05	262	1,450
	1610	1.02	263	1,570
	1626	1.08	264	5,840
	1739	1.02	265	2,180
Dec 13	0820	0.96	266	1,010
	1715	1.27	267	2,950
	1745	1.24	268	5,710
	2030	1.10	269	3,410
Dec 14	0645	1.03	270	888
	1745	0.98	271	557
Dec 15	0030	1.26	272	8,350
	0122	1.15	273	8,290
	0230	1.11	274	8,260
	0405	1.05	275	4,220
	0740	1.01	276	1,240
	1800	0.96	277	513
Dec 16	0601	0.97	278	538
	1730	0.98	279	377
	2342	1.12	280	1,510

TABLE H-7 (CONTINUED)

SUSPENDED SEDIMENT MEASUREMENT SUMMARY

JRAGUNG RIVER AT BORANGAN BRIDGE

Date	Hour	Gage Height m	Sample No.	Suspended Sediment Concentration mg/l
The measurements for the 1978-79 wet season were made by depth-integrating with a P-61 sampler at the center of the river				
Dec 17	0100	1.09	281	2,000
	0220	1.08	282	1,320
	0530	1.05	283	1,070
	1745	1.00	284	546
Dec 18	0700	0.92	285	288
	1705	0.91	286	330
Dec 19	0630	0.90	287	162
	1745	0.90	288	229
Dec 20	0605	0.90	289	344
	1830	0.88	290	182
Dec 21	0545	0.89	291	152
	1800	0.89	292	149
	1915	1.00	293	3,340
Dec 22	0600	0.99	294	1,050
	1605	1.15	295	5,700
	1620	1.19	296	4,560
	1800	1.34	297	5,490
	1815	1.45	298	6,150
	1835	1.50	299	7,960
	1927	1.48	300	10,900
	2055	1.38	301	8,110
	2200	1.34	302	3,500
	2304	1.30	303	5,120
Dec 23	0215	1.22	304	6,400
	0530	1.15	305	2,210
	1100	1.09	306	1,360
	1415	1.06	307	1,090
	1530	1.50	308	2,380
	1540	1.54	309	1,630
	1547	1.60	310	1,560
	1600	1.70	311	2,580
	1620	1.70	312	1,700
	1735	1.42	313	2,960

TABLE H-7 (CONTINUED)

SUSPENDED SEDIMENT MEASUREMENT SUMMARY

JRAGUNG RIVER AT BORANGAN BRIDGE

Date	Hour	Gage Height m	Sample No.	Suspended Sediment Concentration mg/l
The measurements for the 1978-79 wet season were made by depth-integrating with a P-61 sampler at the center of river				
Dec 23	1950	1.26	314	2,750
	2155	1.18	315	2,330
Dec 24	0200	1.17	316	4,570
	0530	1.13	317	1,400
	0900	1.10	318	1,210
	1600	1.06	319	1,030
Dec 25	0605	1.04	320	1,660
	1750	1.02	321	1,760
Dec 26	0615	0.98	322	686
	1750	0.98	323	440
Dec 27	0620	0.95	324	535
	1604	0.94	325	352
Dec 28	0550	0.94	326	245
	1404	1.20	327	5,540
	1412	1.45	328	6,160
	1420	1.90	329	12,600
	1435	2.15	330	24,100
	1505	2.18	331	28,300
	1622	2.20	332	22,200
	1805	1.88	333	13,500
	2000	1.60	334	9,200
	2210	1.45	335	6,510
Dec 29	0105	1.30	336	4,400
	0400	1.20	337	3,210
	0605	1.18	338	2,930
	0911	1.13	339	2,360
	1400	1.05	340	1,580
	1700	1.35	341	3,720
	1713	1.50	342	10,400
	1724	1.54	343	17,500
	1735	1.60	344	24,000
	1910	1.68	345	21,800

TABLE H-7 (CONTINUED)

SUSPENDED SEDIMENT MEASUREMENT SUMMARY

JRAGUNG RIVER AT BORANGAN BRIDGE

Date	Hour	Gage Height m	Sample No.	Suspended Sediment Concentration m/l
The measurements for the 1978-79 wet season were made by depth-integrating with P-61 sampler at the center of river				
Dec 29	1930	1.70	346	11,200
	1950	1.72	347	20,600
	2115	1.64	348	15,600
	2235	1.51	349	17,300
	2335	1.48	350	22,800
Dec 30	0245	1.34	351	25,600
	0518	1.27	352	24,800
	0920	1.19	353	4,990
	1315	1.09	354	2,050
	1545	1.05	355	1,810
	1900	1.02	356	1,580
Dec 31	0800	0.98	357	924
	1600	1.00	358	446
	2100	1.11	359	2,880

TABLE H-7 (CONTINUED)

SUSPENDED SEDIMENT MEASUREMENT SUMMARY

JRAGUNG RIVER AT BORANGAN BRIDGE

Date	Hour	Gage Height m	Sample No.	Suspended Sediment Concentration mg/l
The measurements for the 1978-79 wet season were made by depth-integrating with a P-61 sampler at the center of the river				
Jan 1 1979	0030	1.20	360	2,640
	0315	1.17	361	1,610
	0700	1.12	362	1,410
	1105	1.12	363	1,790
	1230	1.30	364	2,670
	1330	1.58	365	14,700
	1350	1.48	366	18,300
	1500	1.28	367	14,500
	1700	1.25	368	6,190
	2000	1.20	369	3,960
Jan 2	0000	1.20	370	2,430
	0520	1.18	371	2,000
	1620	1.08	372	949
	1940	1.65	373	29,000
	1950	1.64	374	27,300
	2115	1.50	375	18,000
	2230	1.38	376	11,800
	2335	1.32	377	7,760
Jan 3	0250	1.24	378	3,770
	0535	1.20	379	3,520
	1125	1.12	380	1,890
	1536	1.15	381	2,320
Jan 4	0620	1.02	382	1,120
	1600	0.98	383	851
	2245	1.15	384	1,930
Jan 5	0010	1.15	385	1,680
	0300	1.12	386	1,280
	0520	1.10	387	667
	1205	1.04	388	944
	1900	1.62	389	11,200
	1955	1.51	390	16,400
	2115	1.74	391	24,400
	2135	1.70	392	16,100
	2245	1.54	393	8,940

TABLE H-7 (CONTINUED)

SUSPENDED SEDIMENT MEASUREMENT SUMMARY

JRAGUNG RIVER AT BORANGAN BRIDGE

Date	Hour	Gage Height m	Sample No.	Suspended Sediment Concentration mg/l
The measurements for the 1978-79 wet season were made by depth-integrating with a P-61 sampler at the center of the river				
Jan 6	0040	1.40	394	5,610
	0200	1.34	395	3,820
	0545	1.25	396	2,880
	1100	1.12	397	1,320
	1715	1.05	398	1,150
Jan 8	1830	1.15	399	1,230
	1843	1.17	400	1,770
	2030	1.11	401	6,810
Jan 9	0130	1.04	402	1,210
	0635	1.01	403	1,380
	1940	1.60	404	9,450
	2045	1.62	405	11,000
	2155	1.55	406	7,710
Jan 10	0045	1.48	407	4,670
	0400	1.34	408	3,140
	0730	1.27	409	2,200
	1010	1.21	410	1,780
	1600	1.12	411	1,140
Jan 11	0620	1.02	412	634
	1745	1.00	413	567
Jan 12	2006	1.21	414	2,160
	2020	1.27	415	4,810
	2126	1.88	416	14,300
	2137	1.92	417	17,100
	2325	1.65	418	9,810
Jan 13	0130	1.48	419	4,490
	0345	1.40	420	3,260
	0715	1.30	421	2,270
	1102	1.23	422	1,560
	1602	1.13	423	1,070
	2030	1.36	424	2,300
	2148	1.55	425	2,560
	2205	1.65	426	6,520
	2217	1.85	427	7,300
	2230	1.97	428	12,800

TABLE H-7 (CONTINUED)

SUSPENDED SEDIMENT MEASUREMENT SUMMARY

JRAGUNG RIVER AT BORANGAN BRIDGE

Date	Hour	Gage Height m	Sample No.	Suspended Sediment Concentration mg/l
The measurements for the 1978-79 wet season were made by depth-integrating with a P-61 sampler at the center of the river				
Jan 13	2243	2.10	429	13,900
Jan 14	0010	2.05	430	10,900
	0130	1.89	431	6,620
	0257	1.68	432	6,260
	0615	1.45	433	2,540
	1130	1.28	434	2,050
	1310	1.55	435	2,970
	1445	1.44	436	7,870
	1550	1.38	437	11,900
	1920	1.37	438	3,730
	2400	1.27	439	1,950
Jan 15	0305	1.22	440	1,380
	0601	1.20	441	1,440
	1645	1.64	442	3,220
	1653	1.89	443	8,680
	1705	2.15	444	19,200
	1720	2.25	445	20,700
	1725	2.38	446	18,400
	1740	2.60	447	19,500
	1750	2.65	448	15,000
	1800	2.70	449	17,300
	1810	2.80	450	18,100
	1900	2.60	451	18,900
	2015	2.10	452	13,300
	2130	1.93	453	8,320
	2235	1.75	454	8,330
Jan 16	0235	1.50	455	4,660
	0610	1.40	456	3,230
	0930	1.34	457	2,480
	1230	1.30	458	2,100
	1825	1.22	459	1,440
Jan 17	0645	1.16	460	967
	1705	1.12	461	946

TABLE H-7 (CONTINUED)

SUSPENDED SEDIMENT MEASUREMENT SUMMARY

JRAGUNG RIVER AT BORANGAN BRIDGE

Date	Hour	Gage Height m	Sample No.	Suspended Sediment Concentration mg/l
The measurements for the 1978-79 wet season were made by depth-integrating with a P-61 sampler at the center of the river				
Jan 18	0705	1.10	462	553
	1615	1.00	463	384
Jan 19	0900	0.99	464	376
Jan 21	0905	1.03	465	834
	2125	1.14	466	1,730
	2350	1.30	467	4,370
Jan 22	0400	1.18	468	936
	0930	1.10	469	873
	1350	1.05	470	196
Jan 23	1200	0.95	471	293
Jan 24	1700	0.93	472	263
Jan 25	0830	0.90	473	94
	1445	1.18	474	996
	1503	1.24	475	2,510
	1550	1.16	476	14,900
	1740	1.08	477	6,200
	1930	1.04	478	4,040
Jan 26	1730	1.00	479	958
Jan 27	1030	0.99	480	351
Jan 28	0800		481	135
Jan 29	0800		482	3,690
	2005		483	4,590
			484	2,710
Jan 30	0800	1.10	485	897
Jan 31	0800	1.00	486	659
	1735	1.10	487	340
	1755	1.15	488	6,330

TABLE H-7 (CONTINUED)

SUSPENDED SEDIMENT MEASUREMENT SUMMARY

JRAGUNG RIVER AT BORANGAN BRIDGE

Date	Hour	Gage Height m	Sample No.	Suspended Sediment Concentration mg/l
The measurements for the 1978-79 wet season were made by depth-integrating with a P-61 sampler at the center of the river				
Feb 1	0652	0.99	489	1,170
	1955	1.68	490	68,600
	2005	2.30	491	52,000
	2018	2.57	492	50,200
	2030	2.83	493	35,900
	2040	2.82	494	33,500
Feb 2	0015	1.74	495	21,400
	0308	1.48	496	5,920
	0630	1.30	497	3,830
	0927	1.21	498	2,830
	1705	1.62	499	6,160
	1722	1.82	500	37,600
	1737	2.28	501	25,600
	1750	2.29	502	23,350
	2100	1.75	503	10,800
Feb 3	0010	1.45	504	6,340
	0607	1.24	505	4,710
	1113	1.14	506	7,120
	1807	1.04	507	1,800
Feb 5	1523	1.26	508	13,900
Feb 8	1652	0.90	509	391
Feb 9	0838	0.90	510	388
Feb 10	0602	0.85	511	2,420
	1910	1.24	512	9,390
	1920	1.52	513	8,120
	1940	2.10	514	17,100
	2052	2.00	515	25,000
	2117	1.42	516	15,000
	2307	1.25	517	5,820

TABLE H-7 (CONTINUED)

SUSPENDED SEDIMENT MEASUREMENT SUMMARY

JRAGUNG RIVER AT BORANGAN BRIDGE

Date	Hour	Gage Height m	Sample No.	Suspended Sediment Concentration mg/l
The measurements for the 1978-79 wet season were made by depth-integrating with a P-61 sampler at the center of the river				
Feb 11	0110	1.23	518	2,880
	0670	1.12	519	1,790
	1530	1.37	520	5,900
	1542	1.39	521	12,300
	1830	1.28	522	3,840
	2315	1.18	523	1,060
Feb 12	0805	1.10	524	1,090
	1910	1.25	525	1,880
Feb 13	0847	1.08	526	813
Feb 14	1527	0.98	527	403
Feb 15	0730	0.92	528	975
	1855	1.22	529	5,920
Feb 16	0555	1.04	530	2,540
Feb 17	0635	0.96	531	602
Feb 18	1512	0.94	532	321
Feb 19	0637	0.97	533	594
Feb 20	1745	0.91	534	210
	2335	1.15	535	2,830
Feb 21	0107	1.10	536	2,500
	0605	1.07	537	326
Feb 22	0657	0.93	538	302
	2122	1.08	539	5,770
Feb 23	0610	1.07	540	1,780
	1307	1.03	541	767
	2110	1.30	542	7,380
	2228	1.23	543	6,080

TABLE H-7 (CONTINUED)

SUSPENDED SEDIMENT MEASUREMENT SUMMARY

JRAGUNG RIVER AT BORANGAN BRIDGE

Date	Hour	Gage Height m	Sample No.	Suspended Sediment Concentration mg/l
The measurements for the 1978-79 wet season were made by depth-integrating with a P-61 sampler at the center of the river				
Feb 24	0005	1.22	544	1,490
	0402	1.14	545	1,318
	0710	1.10	546	1,340
	1810	1.00	547	323
Feb 25	0045	1.21	548	4,060
	0117	1.13	549	14,600
	0707	0.99	550	847
Feb 26	0905	0.91	551	238
	1805	0.92	552	197
Feb 27	0818	0.92	553	160
Feb 28	0805	0.90	554	153

TABLE H-7(CONTINUED)

SUSPENDED SEDIMENT MEASUREMENT SUMMARY

JRAGUNG RIVER AT BORANGAN BRIDGE

Date		Hour	Gage Height m	Sample No.	Suspended Sediment Concentration mg/l
The measurements for the 1978-79 wet season were made by depth-integrating with a P-61 sampler at the center of the river					
Mar	1	0635	0.90	555	175
Mar	2	0620	0.88	556	146
Mar	3	0600	0.87	557	110
Mar	4	0630	0.94	558	331
Mar	5	0600	0.90	559	228
Mar	6	0115	1.14	560	2,360
		0840	1.03	561	1,430
		2110	1.16	562	2,680
Mar	7	0730	1.04	563	695
		1405	2.11	564	26,400
		1505	1.70	565	11,200
		1605	1.35	566	22,900
		1905	1.65	567	12,700
		2205	1.48	568	4,270
Mar	8	0105	1.30	569	4,200
		0410	1.26	570	4,350
		0620	1.22	571	2,970
		1450	1.32	572	6,000
		1600	1.30	573	3,920
		1730	1.27	574	3,640
		1915	1.23	575	3,190
		2105	1.60	576	9,310
		2400	1.36	577	5,670
Mar	9	0400	1.26	578	3,150
		0600	1.22	579	2,620
		1500	1.15	580	1,330
		1900	1.19	581	1,400
Mar	10	0625	1.10	582	1,080

TABLE H-7 (CONTINUED)

SUSPENDED SEDIMENT MEASURMENT SUMMARY

JRAGUNG RIVER AT BORANGAN BRIDGE

Date	Hour	Gage Height m	Sample No.	Suspended Sediment Concentration mg/l
The measurements for the 1978-79 wet season were made by depth-integrating with a P-61 sampler at the center of the river				
Mar 11	0620	0.98	583	511
Mar 12	0610	0.98	584	497
Mar 13	0610	1.00	585	659
Mar 14	0625	0.93	586	263
Mar 15	1230	1.34	587	191
	1245	1.46	588	2,870
	1515	1.13	589	27,400
Mar 16	0800	0.94	590	4,400
Mar 17	0600	0.90	591	1,240
	2000	1.29	592	475
	2100	1.40	593	-
Mar 18	0630	1.15	594	
Mar 19	0800	0.99	595	436
Mar 20	0600	0.98	596	570
Mar 21	0030	1.10	597	1,510
	0800	1.06	598	3,460
Mar 22	0830	0.96	599	357
Mar 23	0720	0.90	600	328
Mar 24	0715	0.88	601	220
	1245	1.05	602	3,820
Mar 25	0715	0.96	603	490
Mar 26	0645	0.90	604	255
Mar 27	0730	0.88	605	288

TABLE H-7 (CONTINUED)

SUSPENDED SEDIMENT MEASUREMENT SUMMARY

JRAGUNG RIVER AT BORANGAN BRIDGE

Date	Hour	Gage Height m	Sample No.	Suspended Sediment Concentration mg/l
The measurements for the 1978-79 wet season were made by depth-integrating with a P-61 sampler at the center of the river				
Mar 28	0715	0.87	606	197
Mar 29	0915	0.87	607	196
Mar 30	0800	0.90	608	544
Mar 31	0800	0.88	609	202

TABLE H-7 (CONTINUED)

SUSPENDED SEDIMENT MEASUREMENT SUMMARY

JRAGUNG RIVER AT BORANGAN BRIDGE

Date	Hour	Gage Height m	Sample No.	Suspended Sediment Concentration mg/l
The measurements for the 1978-79 wet season were made by depth-integrating with a P-61 sampler at the center of the river				
Apr 1	0300	0.99	610	1,570
	0645	1.02	611	644
	1510	1.02	612	1,340
	1640	1.06	613	2,080
	1835	1.02	614	602
Apr 2	0805	0.99	614	523
	2305	1.16	616	802
	2340	1.14	617	2,450
Apr 3	0115	1.12	618	1,960
	1110	1.03	619	1,530
Apr 4	0710	1.42	620	6,440
	0720	1.52	621	8,280
	0740	1.53	622	8,930
	0850	1.44	623	7,450
	1100	1.30	624	3,060
	1405	1.20	625	2,030
	1910	1.27	626	2,470
	1945	1.34	627	4,120
Apr 5	0110	2.10	628	20,100
	0125	2.50	629	10,800
	0140	2.65	630	32,200
	0155	2.70	631	25,800
	0230	2.49	632	22,400
	03[illegible]	1.95	633	14,700
	0450	1.92	634	16,200
	0600	1.83	635	7,810
	0710	1.70	636	8,460
	1110	1.55	637	6,290
	1725	1.46	638	4,280
	1930	1.40	639	-

TABLE H-7 (CONTINUED)

SUSPENDED SEDIMENT MEASUREMENT SUMMARY

JRAGUNG RIVER AT BORANGAN BRIDGE

Date	Hour	Gage Height m	Sample No.	Suspended Sediment Concentration mg/1
The measurements for the 1978-79 wet season were made by depth-integrating with a P-61 sampler at the center of the river				
Apr 6	0810	1.10	640	1,730
	1720	2.70	641	28,700
	1730	3.00	642	26,200
	1735	3.15	643	32,100
	1740	3.30	644	27,900
	1805	3.40	645	26,500
	1810	3.30	646	27,200
	1905	2.30	647	34,200
	2030	1.90	648	14,600
	2215	1.60	649	9,670
Apr 7	0145	1.40	650	11,900
	0640	1.25	651	8,220
	1820	1.08	652	1,520
	1900	1.48	653	3,390
	2000	1.38	654	12,400
	2310	1.20	655	5,100
Apr 8	0700	1.12	656	2,170
	1745	1.02	657	1,210
	2345	1.34	658	15,400
Apr 9	0055	1.72	659	13,400
	0205	1.55	660	10,700
	0720	1.36	661	4,380
	1745	1.10	662	1,330
	1845	1.50	663	6,700
	2055	1.38	664	7,390
Apr 10	0615	1.10	665	1,430
	1850	1.01	666	679
Apr 11	0620	1.02	667	789
	2025	1.39	668	627
	2135	1.35	669	36,700
	2335	2.20	670	30,900

TABLE H-7 (CONTINUED)

SUSPENDED SEDIMENT MEASUREMENT SUMMARY

JRAGUNG RIVER AT BORANGAN BRIDGE

Date	Hour	Gage Height m	Sample No.	Suspended Sediment Concentration mg/l
The measurements for the 1978-89 wet season were made by depth-integrating with a P-61 sampler at the center of the river				
Apr 12	0037	1.83	671	23,700
	0242	1.46	672	10,700
	0408	1.35	673	5,260
	0657	1.24	674	3,890
	1822	1.08	675	1,280
Apr 13	0010	1.40	676	6,430
	0020	1.70	677	30,300
	0055	2.50	678	21,400
	0100	2.60	679	22,900
	0130	2.30	680	21,600
	0230	1.75	681	5,140
	0330	1.40	682	10,300
	0430	1.32	683	6,680
	0740	1.20	684	3,680
	1730	1.50	685	13,800
	1755	1.60	686	15,200
	1810	1.74	687	15,100
	1825	2.20	688	22,300
	1840	2.40	689	31,600
	1855	2.35	690	26,400
	1910	2.15	691	22,500
	2007	1.78	692a	18,200
	2112	1.70	692b	-
	2240	1.52	693	12,800
Apr 14	0025	1.42	694	8,880
	0310	1.35	695	6,490
	0757	1.22	696	2,860
	1658	1.57	697	9,180
	1717	1.65	698	15,000
	1807	1.50	699	13,100
	2137	1.35	700	5,200
	2245	1.30	701	4,300
Apr 15	0607	1.16	702	2,110
	1722	1.05	703	600

TABLE H-7 (CONTINUED)

SUSPENDED SEDIMENT MEASUREMENT SUMMARY

JRAGUNG RIVER AT BORANGAN BRIDGE

Date	Hour	Gage Height m	Sample No.	Suspended Sediment Concentration mg/l
The measurements for the 1978-89 wet season were made by depth-integrating with a P-61 sampler at the center of the river				
Apr 16	1647	1.40	704	5,780
	1837	1.30	705	15,600
Apr 17	0707	1.12	706	1,520
	1617	1.04	707	962
Apr 18	0608	1.00	708	778
	2057	0.96	709	681
Apr 19	1537	0.94	710	391
Apr 20	0737	0.96	711	421
	2045	1.13	712	903
Apr 21	1637	0.96	713	321
	2227	1.15	714	1,140
Apr 22	2005	1.00	715	230
	2045	1.21	716	8,540
	2205	1.17	717	1,620
	2300	1.26	718	1,550
Apr 23	0832	1.09	719	1,250
	1737	0.99	720a	411
Apr 24	0823	0.96	720b	-
	1827	0.94	721	242
Apr 25	0710	0.96	722	510
Apr 26	0823	0.94	723	456
Apr 27	0807	0.91	724	163
	1925	1.18	725	3,020
	2043	1.20	726	19,300
Apr 28	0637	0.96	727	843
	1810	0.90	728	161

TABLE H-7 (CONTINUED)

SUSPENDED SEDIMENT MEASUREMENT SUMMARY

JRAGUNG RIVER AT BORANGAN BRIDGE

Date		Hour	Gage Height m	Sample No.	Suspended Sediment Concentration mg/1
The measurements for the 1978-79 wet season were made by depth-integrating with a P-61 sampler at the center of the river					
Apr	29	0810	0.89	729	213
Apr	30	0805	0.92	730	207

TABLE H-7 (CONTINUED)

SUSPENDED SEDIMENT MEASUREMENT SUMMARY

JRAGUNG RIVER AT BORANGAN BRIDGE

Date		Hour	Gage Height m	Sample No	Suspended Sediment Concentration mg/l
The measurements for the 1978-79 wet season were made by depth-integrating with a P-61 sampler at the center of the river					
May	1	0705	0.88	731	440
May	2	0305	1.10	732	190
		0545	1.07	733	1,510
May	3	0105	1.41	734	514
		0130	2.36	735	21,900
		0237	1.99	736	24,200
		0327	1.54	737	24,200
		0645	1.32	738	18,900
		1137	1.15	739	3,770
		1635	1.06	740	1,370
May	4	0715	0.96	741	563
May	5	0825	0.90	742	262
		1435	1.80	743	8,040
		1450	1.80	744	8,700
		1555	1.43	745	12,900
		1735	1.24	746	7,220
May	6	0710	1.05	747	914
May	7	0605	0.99	748	908
		1815	0.96	749	473
May	8	0615	0.91	750	281
May	9	0705	0.88	751	166
May	10	0235	1.00	752	5,740
		0305	1.13	753	6,120
		0905	1.02	754	8,880
		1810	0.97	755	910
May	11	0735	0.92	756	384
		1605	1.05	757	15,000

TABLE H-7 (CONTINUED)

SUSPENDED SEDIMENT MEASUREMENT SUMMARY

JRAGUNG RIVER AT BORANGAN BRIDGE

Date	Hour	Gage Height m	Sample No.	Suspended Sediment Concentration mg/l
The measurements for the 1978-79 wet season were made by depth-integrating with a P-61 sampler at the center of the river				
May 12	0825	0.93	758	335
May 13	0805	0.90	759	235
May 14	0805	0.88	760	164
May 15	0905	0.90	761	505
May 16	0835	0.86	762	192
May 17	0715	0.85	763	120
May 18	0740	0.84	764	118
May 19	0805	0.84	765	212
May 20	0820	0.82	766	666
	2205	1.17	767	2,870
May 21	0605	1.02	768	1,220
May 22	0620	0.89	769	335
	1535	1.30	770	4,230
	1550	1.55	771	28,800
	1605	1.65	772	11,300
	1630	1.60	773	1,500
	1740	1.48	774	5,600
	1840	1.40	775	7,180
	1955	1.30	776	12,400
May 23	0015	1.14	777	5,460
	0805	1.02	778	1,060
	1535	1.20	779	6,920
	1720	1.35	780	2,340
	1835	1.40	781	44,100
	2005	1.35	782	68,500
	2135	1.30	783	38,700
	0105	1.22	784	12,300

TABLE H-7 (CONTINUED)

SUSPENDED SEDIMENT MEASUREMENT SUMMARY

JRAGUNG RIVER AT BORANGAN BRIDGE

Date	Hour	Gage Height m	Sample No.	Suspended Sediment Concentration mg/l
The measurements for the 1978-79 wet season were made by depth-integrating with a P-61 sampler at the center of the river				
May 24	0805	1.09	785	2,610
	1505	1.00	786	1,260
May 25	0605	0.94	787	334
	1735	0.91	788	329
May 26	0825	0.88	789	446
	1715	0.87	790	406
May 27	0805	0.86	791	314
May 28	0805	0.87	792	845
May 29	0635	0.87	793	163
May 30	0705	0.88	794	277
May 31	0635	0.85	795	194
	1005	1.10	796	659
	1205	1.01	797	866

TABLE H-7(CONTINUED)

SUSPENDED SEDIMENT AND DISCHARGE

MEASUREMENT SUMMARY

JRAGUNG RIVER AT BORANGAN BRIDGE

Date	Hour	Gage Height m	Sample No.	Velocity m/s	Discharge m^3/s	Suspended Sediment Concentration mg/l
Dry season measurements made in 1978 by wading and using a DH48 sediment sampler						
May 2	1000	1.15	1	1.06	9.53	1,330
5	1600	1.00	2	0.53	2.56	1,210
8	1115	0.90	3	0.49	1.58	144
11	1250	0.90	4	0.42	1.54	171
15	1015	1.20	5	1.08	12.03	1,420
18	1230	1.05	6	0.71	4.62	397
22	1100	1.05	7	0.70	3.74	389
25	1000	0.94	8	0.49	1.64	366
31	1100	0.85	9	0.17	0.30	206
Jun 1	1015	0.97	10	0.48	1.98	323
5	1100	0.98	11	0.53	1.92	372
7	1200	0.90	12	0.36	0.97	256
13	0819	0.86	13	0.26	0.55	230
15	1022	0.93	14	0.43	1.20	521
19	1445	0.90	15	0.30	0.67	259
22	0930	0.88	16	0.29	0.48	138
27	1030	0.92	17	0.43	1.19	300
29	0810	0.90	18	0.31	0.65	167
Jul 4	1130	0.90	19	0.43	1.36	200
6	1030	0.89	20	0.28	0.55	287
10	0950	0.97	21	0.46	1.69	150
12	1100	1.10	22	0.83	6.20	989
17	1040	0.91	23	0.36	0.80	388
20	1100	0.85	24	0.27	0.51	47
24	1055	0.86	25	0.31	0.61	162
27	1000	0.83	26	0.21	0.33	69
31	1038	0.84	27	0.26	0.47	78
Aug 3	1015	0.95	28	0.53	2.02	200
7	1020	1.13	29	0.83	5.98	1,620
10	1035	0.86	30	0.35	0.78	150
14	1055	0.82	31	0.21	0.30	111
21	1015	0.89	32	0.37	0.99	133
25	1015	0.84	33	0.21	0.31	133
28	1100	0.79	34	0.18	0.18	89
31	1055	0.79	35	0.21	0.27	122

TABLE H-7 (CONTINUED)

SUSPENDED SEDIMENT AND DISCHARGE

MEASUREMENT SUMMARY

JRAGUNG RIVER AT BORANGAN BRIDGE

(Cont.)

Date	Hour	Gage Height	Sample	Velocity	Discharge	Suspended Sediment Concentration
		m	No.	m/s	m^3/s	mg/l
Dry season measurements made in 1978 by wading and using a DH48 sediment sampler						
Sep 7	1100	0.94	36	0.48	1.46	687
8	0900	0.90	37	0.39	1.04	322
11	1213	1.03	38	0.82	5.06	1,230
14	0940	0.90	39	0.33	0.88	255
18	1205	0.89	40	0.32	0.77	148
21	1030	0.85	41	0.25	0.50	89
25	1115	0.86	42	0.25	0.55	300
28	1130	0.83	43	0.21	0.34	103

TABLE H-8

SUSPENDED SEDIMENT CALCULATIONS

JRAGUNG RIVER AT BORANGAN BRIDGE

Date	Hour	Gage height m	Water discharge m^3/s	Sediment concentration mg/l	Sediment discharge kg/s	Time increment min	Sediment discharge kg	Accumulated sediment kg	Water discharged m^3	Accumulated water m^3
1 Feb 1979	0800	0.98	1.95	1,100	2.15					
						460	50,091	50,091	47,395	47,395
	1540	0.95	1.48	1,000	1.48					
						180	15,194	65,285	15,993	63,389
	1840	0.95	1.48	900	1.33					
						60	7,249	72,535	7,516	70,905
	1940	1.02	2.69	1,000	2.69					
						15	1,088,747	1,161,283	17,077	87,983
	1955	1.68	35.26	68,550	2,416.74					
						10	2,359,212	3,520,495	41,991	129,974
	2005	2.30	104.72	52,020	5,447.30					
						13	5,017,108	8,537,604	98,438	228,413
	2018	2.57	147.69	50,220	7,417.08					
						12	5,214,787	13,752,392	123,971	352,384
	2030	2.83	196.67	35,940	7,068.44					
						10	4,076,174	17,828,567	117,396	469,781
	2040	2.82	194.65	33,490	6,518.81					
						80	24,526,835	42,355,402	773,423	1,243,205
	2200	2.45	127.61	29,000	3,700.70					
						60	10,510,037	52,865,439	383,649	1,626,855
	2300	2.16	85.53	25,000	2,138.21					
						75	6,751,234	59,616,674	283,020	1,909,875
2 Feb 1979	0015	1.74	40.26	21,420	862.34					
						75	2,825,287	62,441,961	156,138	2,066,014
	0130	1.60	29.14	13,500	393.34					
						98	1,524,060	63,966,021	147,762	2,213,776
	0308	1.48	21.12	5,920	125.05					
						202	1,027,571	64,993,592	198,628	2,412,405
	0630	1.30	11.65	3,820	44.52					
						90	206,203	65,199,795	58,342	2,470,747
	0800	1.26	9.95	3,200	31.85					

TABLE H-9

WATER AND SEDIMENT LOADS

JRAGUNG RIVER AT
THE BORANGAN BRIDGE

Date [1]	Water m^3	Suspended Sediment kg
November 1, 1977	144	9
2	864	52
3	63,800	412,000
4	57,200	199,000
5	183,000	3,280,000
6	51,900	152,000
7	28,800	42,400
8	181,000	3,640,000
9	72,300	203,000
10	30,300	49,000
11	25,800	14,400
12	18,400	3,840
13	15,300	2,730
14	13,800	1,350
15	185,000	5,430,000
16	27,300	91,000
17	5,180	1,970
18	5,180	1,900
19	4,030	1,900
20	33,100	177,000
21	7,060	5,130
22	10,200	10,100
23	7,060	3,530
24	5,180	2,590
25	25,000	352,000
26	15,300	63,600
27	2,300	1,320
28	864	360
29	115,000	2,290,000
30	65,900	194,000
Total	1,256,000	16,620,000

1/ The values of water and sediment load for the calendar day listed above are those occurring from 0800 hours on the day listed to 0800 hours on the succeeding day.

TABLE H-9 (CONTINUED

WATER AND SEDIMENT LO

JRAGUNG RIVER AT
THE BORANGAN BRIDGE

Date 1/	Water m3	Suspended Sediment kg
December 1, 1977	205,000	2,860,000
2	481,000	13,700,000
3	209,000	1,590,000
4	345,000	9,300,000
5	126,000	566,000
6	424,000	5,520,000
7	380,000	1,760,000
8	148,000	43,100
9	91,400	8,340
10	76,400	5,100
11	71,700	4,600
12	64,200	3,310
13	61,500	2,020
14	170,000	1,370,000
15	63,800	19,300
16	209,000	1,930,000
17	87,500	36,700
18	56,200	5,650
19	43,300	2,320
20	36,600	1,830
21	30,500	1,520
22	276,000	3,290,000
23	158,000	468,000
24	280,000	2,060,000
25	122,000	37,600
26	62,900	7,520
27	56,700	69,900
28	171,000	1,690,000
29	150,000	1,020,000
30	1,160,000	30,700,000
31	3,560,000	309,000,000
Total	9,377,000	386,073,000

1/ The values of water and sediment load for the calendar day listed above are those occurring from 0800 hours on the day listed to 0800 hours on the succeeding day.

TABLE H-9(CONTINUED)

WATER AND SEDIMENT LOADS

JRAGUNG RIVER AT
THE BORANGAN BRIDGE

Date 1/	Water m3	Suspended Sediment kg
January 1, 1978	1,470,000	54,400,000
2	350,000	1,340,000
3	169,000	139,000
4	581,000	9,900,000
5	225,000	387,000
6	376,000	2,040,000
7	294,000	1,030,000
8	165,000	63,600
9	818,000	9,780,000
10	275,000	370,000
11	194,000	249,000
12	238,000	306,000
13	700,000	3,520,000
14	484,000	1,740,000
15	290,000	586,000
16	470,000	4,870,000
17	166,000	83,900
18	146,000	55,000
19	880,000	14,900,000
20	1,110,000	23,300,000
21	396,000	797,000
22	300,000	204,000
23	1,770,000	29,600,000
24	374,000	952,000
25	750,000	8,720,000
26	910,000	3,860,000
27	462,000	627,000
28	369,000	117,000
29	226,000	63,700
30	330,000	894,000
31	331,000	184,000
Total	15,619,000	175,078,000

1/ The values of water and sediment load for the calendar day listed above are those occurring from 0800 hours on the day listed to 0800 hours on the succeeding day.

TABLE H-9 (CONTINUED)

WATER AND SEDIMENT LOADS

JRAGUNG RIVER AT
THE BORANGAN BRIDGE

Date 1/	Water m^3	Suspended Sediment kg
February 1, 1978	4,340,000	165,000,000
2	1,300,000	35,100,000
3	431,000	4,750,000
4	260,000	570,000
5	860,000	12,700,000
6	313,000	446,000
7	201,000	149,000
8	158,000	61,500
9	240,000	465,000
10	381,000	2,440,000
11	290,000	606,000
12	295,000	1,210,000
13	206,000	190,000
14	95,700	26,500
15	1,070,000	21,800,000
16	390,000	1,010,000
17	391,000	866,000
18	167,000	87,100
19	94,100	29,400
20	2,850,000	149,000,000
21	2,150,000	47,100,000
22	2,440,000	61,600,000
23	606,000	1,910,000
24	342,000	480,000
25	262,000	222,000
26	425,000	665,000
27	346,000	210,000
28	398,000	4,890,000
Total	21,301,800	513,583,500

1/ The values of water and sediment load for the calendar day listed above are those occurring from 0800 hours on the day listed to 0800 hours on the succeeding day.

TABLE H-9 (CONTINUED)

WATER AND SEDIMENT LOADS

JRAGUNG RIVER AT
THE BORANGAN BRIDGE

Date 1/	Water m3	Suspended Sediment kg
March 1, 1978	273,000	317,000
2	266,000	168,000
3	409,000	1,860,000
4	722,000	5,490,000
5	276,000	368,000
6	346,000	1,024,000
7	633,000	8,497,000
8	296,000	360,000
9	317,000	821,000
10	569,000	848,000
11	316,000	246,000
12	163,000	45,500
13	134,000	19,300
14	122,000	13,400
15	228,000	376,000
16	188,000	31,100
17	141,000	12,600
18	482,000	427,000
19	302,000	151,000
20	365,000	3,362,000
21	675,000	3,041,000
22	1,034,000	4,372,000
23	447,000	634,000
24	351,000	324,000
25	189,000	81,700
26	131,000	38,500
27	125,000	21,500
28	134,000	26,500
29	114,000	19,500
30	94,200	8,490
31	73,200	3,110
Total	9,915,000	33,007,000

1/ The values of water and sediment load for the calendar day listed above are those occuring from 0800 hours on the day listed to 0800 hours on the succeeding day.

TABLE H-9(CONTINUED)

WATER AND SEDIMENT LOADS

JRAGUNG RIVER AT
THE BORANGAN BRIDGE

Date 1/	Water m3	Suspended Sediment kg
April 1, 1978	66,000	1,890
2	74,200	1,060
3	316,000	950,000
4	261,000	270,000
5	129,000	24,400
6	87,300	6,810
7	133,000	41,100
8	87,000	28,000
9	74,100	5,150
10	81,000	11,400
11	113,000	76,300
12	1,146,000	29,465,000
13	551,000	1,413,000
14	997,000	21,094,000
15	243,000	480,000
16	133,000	198,000
17	100,000	126,000
18	80,000	190,000
19	74,500	48,800
20	82,200	22,900
21	158,000	888,000
22	73,200	109,000
23	70,600	20,900
24	71,300	10,400
25	75,400	10,700
26	95,000	159,000
27	64,500	9,500
28	55,800	2,590
29	55,800	1,510
30	202,000	895,000
Total	5,750,000	5,560,000

1/ The values of water and sediment load for the calendar day listed above are those occuring from 0800 hours on the day listed to 0800 hours on the succeeding day.

TABLE H-10

Water and Suspended Sediment Discharge

Jragung River at the Borangan Bridge

October 1978

Day	Volume of Water m^3	Weight of Suspended Sediment kg
1	28,800	25,800
2	20,800	11,800
3	1,337,000	35,700,000
4	245,000	290,000
5	81,600	24,000
6	57,400	8,820
7	55,800	8,090
8	55,800	6,970
9	38,400	2,560
10	26,500	2,350
11	18,400	2,070
12	18,400	2,260
13	16,000	1,620
14	12,500	1,910
15	22,200	27,100
16	26,900	33,600
17	20,300	3,890
18	61,700	118,000
19	65,700	39,100
20	112,000	146,000
21	366,000	817,000
22	173,000	177,000
23	67,300	23,600
24	40,000	10,000
25	31,400	6,090
26	64,600	41,200
27	81,300	30,700
28	45,100	7,190
29	31,400	3,490
30	28,500	9,690
31	1,061,000	11,151,000
	4,310,800	48,732,900

TABLE H-10 (CONTINUED)

Water and Suspended Sediment Discharge

Jragung River at the Borangan Bridge

November 1978

Day	Volume of Water m^3	Weight Suspended Sediment kg
1	224,000	360,000
2	148,000	116,000
3	94,600	47,500
4	97,600	49,900
5	179,000	944,000
6	173,000	537,000
7	588,000	8,000,000
8	196,000	261,000
9	155,000	144,000
10	117,000	59,100
11	115,000	37,300
12	88,000	16,900
13	75,000	10,800
14	73,200	8,130
15	87,000	33,000
16	66,900	16,200
17	35,800	3,540
18	91,200	69,100
19	90,100	13,100
20	55,400	11,900
21	32,700	6,740
22	34,400	5,050
23	29,700	3,810
24	26,900	3,650
25	21,800	2,180
26	16,100	1,870
27	11,800	1,540
28	14,300	1,470
29	14,300	873
30	12,500	719
	2,964,300	10,766,372

TABLE H-10 (CONTINUED)

Water and Suspended Sediment Discharge
Jragung River at the Borangan Bridge

December 1978

Day	Volume of Water m^3	Weight Suspended Sediment kg
1	11,300	1,110
2	646,000	6,757,000
3	576,000	3,509,000
4	192,000	270,000
5	161,000	176,000
6	225,000	362,000
7	256,000	284,000
8	373,000	1,270,000
9	219,000	203,000
10	130,000	52,300
11	143,000	91,900
12	221,000	426,000
13	298,000	740,000
14	259,000	797,000
15	165,000	116,000
16	226,000	205,000
17	178,000	111,000
18	81,700	24,300
19	73,200	17,100
20	62,000	12,600
21	132,000	215,000
22	745,000	4,403,000
23	770,000	1,800,000
24	309,000	393,000
25	215,000	304,000
26	155,000	73,800
27	118,000	37,500
28	1,956,000	30,177,000
29	1,244,000	22,498,000
30	288,000	698,000
31	374,000	694,000
	10,802,200	76,718,610

TABLE H-10 (CONTINUED)

Water and Suspended Sediment Discharge

Jragung River at the Borangan Bridge

January 1979

Day	Volume of Water m^3	Weight Suspended Sediment kg
1	746,000	4,640,000
2	853,000	10,047,000
3	401,000	811,000
4	299,000	344,000
5	1,002,000	9,465,000
6	285,000	340,000
7	144,000	100,000
8	227,000	594,000
9	1,088,000	6,091,000
10	424,000	546,000
11	194,000	108,000
12	1,139,000	9,480,000
13	1,948,000	13,603,000
14	1,079,000	3,937,000
15	3,174,000	38,919,000
16	781,000	1,333,000
17	389,000	338,000
18	200,000	81,200
19	151,000	47,100
20	155,000	135,000
21	504,000	1,057,000
22	245,000	88,100
23	128,000	53,700
24	109,000	22,900
25	286,000	996,000
26	186,000	154,000
27	191,000	81,700
28	146,000	63,800
29	386,000	1,108,000
30	234,000	201,000
31	234,000	994,000
	17,328,000	105,779,500

TABLE H-10 (CONTINUED)

Water and Suspended Sediment Discharge

Jragung River at the Borangan Bridge

February 1979

Day	Volume of Water m^3	Weight Suspended Sediment kg
1	2,471,000	65,200,000
2	1,653,000	19,836,000
3	307,000	650,000
4	86,500	40,500
5	251,000	1,815,000
6	155,000	56,300
7	122,000	24,400
8	78,900	27,100
9	53,800	17,600
10	828,000	11,256,000
11	744,000	3,202,000
12	466,000	651,000
13	275,000	225,000
14	146,000	91,800
15	305,000	1,315,000
16	199,000	307,000
17	141,000	49,300
18	134,000	57,600
19	117,000	42,100
20	191,000	231,000
21	201,000	60,500
22	217,000	686,000
23	424,000	1,044,000
24	283,000	851,000
25	131,000	70,700
26	91,000	17,700
27	83,200	13,000
28	73,200	12,000
	10,227,600	107,849,600

TABLE H-10 (CONTINUED)

Water and Suspended Sediment Discharge
Jragung River at the Borangan Bridge

March 1979

Day	Volume of Water m^3	Weight Suspended Sediment kg
1	64,500	9,670
2	51,900	6,830
3	15,600	15,700
4	88,600	21,400
5	153,000	232,000
6	326,000	544,000
7	1,747,000	28,517,000
8	976,000	4,996,000
9	575,000	1,071,000
10	253,000	209,000
11	169,000	84,100
12	185,000	109,000
13	141,000	65,900
14	88,600	17,700
15	358,000	5,597,000
16	92,600	282,000
17	566,000	7,512,000
18	313,000	482,000
19	174,000	109,000
20	242,000	529,000
21	224,000	557,000
22	107,000	36,700
23	64,500	18,100
24	197,000	529,000
25	105,000	36,500
26	64,300	17,100
27	51,900	10,300
28	48,000	9,440
29	74,300	46,800
30	56,100	22,300
31	84,100	52,400
	7,656,000	51,745,940

TABLE H-10 (CONTINUED)

Water and Suspended Sediment Discharge

Jragung River at the Borangan Bridge

April 1979

Day	Volume of Water m^3	Weight Suspended Sediment kg
1	229,000	167,000
2	246,000	322,000
3	237,000	891,000
4	2,668,000	40,475,000
5	1,378,000	11,799,000
6	3,072,000	67,460,000
7	625,000	3,606,000
8	910,000	7,183,000
9	669,000	2,848,000
10	310,000	508,000
11	1,144,000	20,757,000
12	1,326,000	19,492,000
13	1,631,000	24,072,000
14	922,000	5,853,000
15	306,000	257,000
16	576,000	5,357,000
17	264,000	255,000
18	148,000	87,000
19	129,000	54,400
20	243,000	259,000
21	284,000	207,000
22	444,000	683,000
23	207,000	153,000
24	106,000	38,300
25	88,600	39,100
26	152,000	58,600
27	171,000	801,000
28	79,600	14,500
29	93,000	49,100
30	73,800	21,700
	18,732,000	213,767,700

TABLE H-10 (CONTINUED)

WATER AND SUSPENDED SEDIMENT DISCHARGE

JRAGUNG RIVER AT THE BORANGAN BRIDGE

MAY 1979

Day	Volume of Water m^3	Weight Suspended Sediment kg
1	116,000	87,800
2	985,000	18,918,000
3	329,000	1,452,000
4	107,000	49,200
5	614,000	4,019,000
6	252,000	265,000
7	139,000	73,300
8	84,600	20,400
9	126,000	606,000
10	156,000	570,000
11	162,000	1,554,000
12	88,600	26,000
13	64,500	13,200
14	64,500	23,100
15	57,800	23,100
16	37,600	5,340
17	31,500	3,740
18	28,500	4,700
19	23,500	9,160
20	328,000	837,000
21	127,000	90,400
22	598,000	4,211,000
23	636,000	15,083,000
24	192,000	276,000
25	81,300	28,800
26	47,300	18,500
27	44,500	26,700
28	48,000	24,200
29	51,900	11,600
30	44,500	10,900
31	178,000	541,000
Total	5,843,600	48,882,140

TABLE H-11

STATION RAINFALL

The values of rainfall given in these tables are for the period from 0700 hours on the previous day to 0700 hours on the day listed.

The basin rainfall is obtained by using the data from 5 raingages within the basin. The Theissen weighting factors for these are as follows:

Station	Theissen weighting factors
Jimbaran	.1846
Karangjati	.1185
Klepu	.1679
Jatirunggo	.1742
Sambiroto	.3548

TABLE H-11
(Cont.)

1976 RAINFALL
(mm)

JATIRUNGGO

Day	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1	18	.	20	48	.	.	.	.	.	.	.	.
2	8	.	5	.	.	.	.	.	.	1	2	.
3	.	.	32	12	.	.	.	.	.	.	.	.
4	1	.	18	20	.	.	6	.	.	.	.	.
5	.	.	.	4	2	.	.	.	.	10	.	.
6	1	8	.	.	38	.	.	.	.	10	.	.
7	1	.	.	.	8	.	.	.	.	.	.	12
8	14	1	4	.	.	8	.	.	.	10	.	.
9	25	4	52	.	.	.	.	.	.	.	.	.
10	9	23	20	.	.	.	.	.	.	.	.	.
11	9	.	.	.	.	10	.	.	.	1	.	4
12	6	.	43	.	.	.	.	.	.	44	.	.
13	.	2	3	3	.	.	.	.	.	3	26	.
14	39	15	13	8	.	.	.	.	.	27	.	.
15	2	1	4	5	.	.	.	.	.	.	6	1
16	1	1	.	.	.	.	.	.	.	3	34	.
17	.	8	12	8	.	.	.	.	.	10	12	.
18	5	50	60	.	.	.	.	.	.	3	.	.
19	5	1	23	98	.	.	.	.	.	.	6	.
20	38	.	.	.	.	.	.	.	.	.	7	.
21	36	.	.	.	.	.	.	.	.	8	77	.
22	9	3	9	.	.	.	.	.	.	5	30	3
23	6	59	.	4	.	.	.	.	.	.	1	.
24	12	5	5	14	.	.	.	30	.	.	7	.
25	1	20	31	.	.	.	.	.	7	.	3	.
26	21	.	.	.	.	.	.	.	.	2	37	.
27	.	.	.	.	2	.	.	6	.	10	2	.
28	3	.	4	.	.	.	.	.	.	2	.	.
29	2	1	29	.	.	.	.	21	.	38	.	31
30	1	.	.	7	.	.	5	.	.	21	9	10
31	14	.	.	.	.	.	.	.	.	.	.	.
Total	287	202	387	231	50	18	11	57	7	208	259	61

TABLE H-11
(Cont.)

1977 RAINFALL
(mm)

JATIRUNGGO

Day	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1	.	15	8	.	.	.	3	.	.	.	.	8
2	.	11	10	11	.	33	.	.	.	.	1	31
3	5	9	9	6	1	6	.	.	.	.	13	10
4	.	9	37	.	.	4	.	.	.	.	.	11
5	7	.	22	.	.	1	.	.	.	.	23	.
6	1	9	14	.	.	4	.	.	.	.	.	16
7	17	.	14	23	5	4	.	.	.	.	3	.
8	11	4	18	19	7	38	.	.	.	.	15	.
9	3	37	11	3	1	47	.	.	.	.	3	2
10	.	.	.	8	20	2	.	.	.	.	.	1
11	.	3	.	.	.	2	.	.	2	.	.	1
12	.	.	.	1	9	.	.	.	.	.	.	4
13	.	3	.	.	.	.	.	.	2	.	.	.
14	3	45	.	.	4	.	.	.	.	.	3	7
15	12	6	6	.	.	.	.	.	.	.	15	.
16	1	.	1	.	.	.	.	.	.	.	1	14
17	.	.	2	.	.	.	.	.	.	.	.	1
18	9	.	4	1	.	.	.	.	.	.	.	.
19	2	.	13	.	.	.	.	.	.	5	.	1
20	.	.	32	.	.	.	.	.	.	.	6	.
21	5	11	.	38	.	1	.	.	3	.	.	.
22	55	.	.	19	37	1	.	.	.	.	2	20
23	.	2	14	2	.	.	.	.	2	.	.	.
24	.	.	17	25	3	11	.	.	.	1	3	10
25	3	43	8	.	6	.	.	.	1	.	2	3
26	37	31	6	4	55	17	.	.	.	.	.	.
27	.	37	5	.	.	2	.	.	.	.	.	5
28	2	.	.	.	7	.	.	.	.	3	.	.
29	.	.	.	.	100	.	.	.	.	.	26	1
30	3	.	.	.	.	.	.	.	.	.	4	52
31	3	.	.	.	14	.	.	.	.	.	.	68
Total	179	275	251	160	269	173	3	0	10	9	120	266

TABLE H-11
(Cont.)

1978 RAINFALL
(mm)

JATIRUNGGO

Day	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1	17	18	11	.	7	.	1	10	.	.	.	.
2	4	15	.	.	1	.	.	.	10	.	.	50
3	5	.	20	33	.	12	1	.	30	40	10	40
4	8	6	3	.	16	2	1	.	.	.	.	2
5	.	10	1	.	.	.	.	.	.	.	10	16
6	2	1	.	.	1		1	.	.	.	.	13
7	2	.	40	.	.	.	1	.	.	.	.	.
8	2	2	.	.	.	14	11	.	10	.	10	24
9	42	15	23	6	.	.	5	.	70	.	.	2
10	5	12	30	9	7	.	1	.	10	.	.	.
11	1	.	.	5	.	5	1	.	.	.	.	31
12	10	.	.	24	.	.	11	.	.	.	.	1
13	1	.	.	.	3	23	32	.	.	.	.	15
14	40	1	.	4	25	.	.	.	.	.	.	1
15	.	57	6	.	11	.	.	.	.	.	10	1
16	.	.	.	.	.	.	.	.	10	10	.	2
17	.	12	.	.	72	.	.	.	.	.	.	.
18	.	.	14	.	2	.	.	.	.	30	20	4
19	30	1	.	1	13	.	.	10	.	40	.	2
20	46	64	5	.	.	.	.	.	.	.	.	.
21	11	40	39	23	11	.	.	.	20	.	.	17
22	2	57	1	.	.	15	.	.	.	.	.	51
23	60	.	8	.	5	.	.	.	.	10	.	7
24	7	1	3	.	.	.	.	.	.	8	.	9
25	33	.	.	.	2	4	.	.	.	.	.	.
26	10	15	.	1	.	10	.	.	.	.	.	2
27	2	.	.	.	.	2	.	.	.	.	.	2
28	4	.	6	.	.	.	1	.	.	.	.	54
29	1	.	1	.	.	3	6	.	20	.	10	36
30	14	.	.	40	2	35	.	.	.	.	.	2
31	.	.	.	.	8	.	.	.	.	28	.	12
Total	359	327	211	146	186	125	73	20	180	166	70	396

TABLE H-11
(Continued)

1979 RAINFALL
(mm)

JATIRUNGGO

Day	Jan	Feb	Mar	Apr	May	June	Jul	Aug	Sep	Oct	Nov	Dec
1	11	70	.	2	16	10						
2	9	28	4	18	15	.						
3	1	.	6	12	.	.						
4	7	.	.	143	.	.						
5	18	11	4	14	.	2						
6	2	2	10	28	.	.						
7	.	.	26	11	.	13						
8	8	1	24	8	.	3						
9	16	.	3	3	11	.						
10	.	24	.	.	.	.						
11	2	15	3	21	2	.						
12	25	6	13	4	.	.						
13	36	8	.	24	.	.						
14	10	.	.	21	1	.						
15	63	19	.	.	.	2						
16	.	1	.	28	.	.						
17	6	2	67	12	.	.						
18	4	.	3	10	.	.						
19	.	.	11	2	.	.						
20	17	15	3	2	15	.						
21	7	.	.	1	.	.						
22	.	7	.	15	22	.						
23	.	25	21	1	42	.						
24	.	.	.	.	.	.						
25	8	3	.	4	.	.						
26	10	.	.	.	.	.						
27	.	.	.	16	.	.						
28	.	.	.	.	.	.						
29	3	.	2	6	.	5						
30	.	.	.	.	.	.						
31	10	.	8	.	19	.						
Total	273	237	208	406	143	35						

TABLE H-11
(Continued)

1976 RAINFALL
(mm)

JIMBARAN

Day	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1	2	.	31	12	.	.	.	.	.	.	44	.
2	13	.	8	.	.	.	.	.	.	.	4	.
3	.	.	21	3	.	.	.	.	.	.	.	.
4	2	.	37	2	.	.	.	.	.	5	.	.
5	.	.	.	1	.	.	10	.	.	15	.	.
6	4	5	.	.	46	.	.	.	.	15	.	.
7	1	2	.	.	.	2	.	.	.	.	.	.
8	29	.	4	.	1	4	.	.	.	1	.	2
9	22	20	24	.	.	.	.	.	.	.	.	21
10	30	13	15	.	.	2	.	.	.	.	8	.
11	5	.	.	.	.	9	.	.	.	.	25	8
12	4	.	41	5	.	.	.	.	.	2	.	1
13	.	30	.	.	.	.	.	.	.	20	67	.
14	4	.	8	.	.	.	.	.	.	2	.	.
15	1	.	6	.	.	.	.	.	.	.	20	.
16	1	.	.	.	.	.	.	.	.	2	45	.
17	1	1	7	15	1	.	.	.	.	2	13	.
18	6	45	13	.	.	.	.	.	.	1	13	.
19	1	.	38	52	.	.	.	.	.	.	.	.
20	19	1	4	.	.	.	.	.	.	.	10	42
21	12	.	.	.	.	.	.	.	.	2	30	2
22	10	1	7	.	.	.	.	.	.	1	24	16
23	.	74	1	1	.	.	.	.	.	2	6	.
24	3	8	3	3	.	.	.	11	.	.	25	.
25	6	21	16	2	.	.	.	3	.	.	6	1
26	39	.	.	.	.	.	.	.	.	21	34	1
27	.	.	30	.	1	.	.	6	.	1	1	1
28	2	4	3	1	.	.	.	.	.	2	.	2
29	5	3	14	2	.	.	.	5	.	7	.	2
30	.		2	.	.	.	2	.	.	7	10	4
31	.		6		.	.	.	.	.	42	.	.
Total	222	228	339	99	49	17	12	25	.	150	385	103

TABLE H-11
(Continued)

1977 RAINFALL
(mm)

JIMBARAN

Day	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1	.	9	5	.	.	21	.	.	.	.	.	2
2	10	4	16	5	.	.	.	.	.	.	24	34
3	.	18	4	3	.	11	.	.	.	.	15	3
4	.	22	47	.	.	13	.	.	.	.	.	1
5	9	.	31	9	.	30	.	.	.	.	1	.
6	1	3	19	.	.	30	.	.	.	.	.	5
7	31	.	12	20	6	10	.	.	.	.	.	40
8	13	51	12	5	14	40	.	.	.	.	16	.
9	3	1	.	.	18	26	.	.	.	.	6	3
10	.	2	14	5	3	8	.	.	.	.	.	.
11	.	3	1	10	.	7	.	.	1	.	.	2
12	2	10	10	4	2	.	.	.	1	.	.	2
13	2	38	7	.	.	1	.	.	.	.	.	.
14	1	3	30	.	.	.	.	.	.	.	12	.
15	12	.	7	.	.	.	.	.	.	.	20	.
16	.	.	18	.	.	.	.	.	.	.	1	14
17	1	.	.	13	.	.	.	.	.	.	.	5
18	10	.	2	2	.	1	.	.	.	.	.	.
19	4	.	9	.	.	1	.	.	.	.	.	.
20	.	3	55	12	5	1	.	.	.	.	1	.
21	.	.	2	19	70	.	.	.	.	.	.	1
22	82	.	1	.	1	.	.	.	.	.	.	19
23	2	.	10	45	8	9	.	.	4	.	.	18
24	.	44	33	.	13	.	.	.	.	.	2	4
25	.	15	2	13	31	.	.	.	1	.	1	.
26	45	28	13	7	2	1	.	.	.	.	.	.
27	.	.	7	.	28	.	.	.	.	.	.	2
28	.	.	.	.	52	.	.	.	.	.	.	.
29	2	.	.	3	1	.	.	.	.	.	2	2
30	2	.	.	.	.	.	.	.	.	.	12	35
31	.	.	.	.	.	.	.	.	.	.	.	35
Total	232	254	367	175	254	210	0	0	7	0	113	227

TABLE H-11
(Continued)

1978 RAINFALL
(mm)

JIMBARAN

Day	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1	35	69	4	.	104	.	16	10	.	.	4	.
2	16	5	9	8	.	.	10	.	7	.	.	55
3	.	.	.	.	.	8	6	.	38	122	.	.
4	5	16	18	26	20	11	1	16	.	.	.	.
5	.	12	.	.	.	.	.	4	.	.	.	.
6	22	2	.	.	2	1	6	16	3	.	.	11
7	.	1	6	.	.	1	15	.	.	.	24	5
8	1	7	.	1	.	12	10	.	6	.	.	2
9	27	46	2	1	.	.	.	.	10	.	.	25
10	2	13	10	1	6	.	2	.	12	.	7	1
11	.	23	.	1	1	.	28	.	.	.	.	20
12	9	42	.	2	.	.	22	.	.	.	.	2
13	8	5	.	42	7	27	32	.	.	.	.	.
14	2	1	.	.	24	.	.	.	.	.	.	.
15	2	56	3	3	16	21	.	.	2	.	.	3
16	8	8	.	.	3	1	.	25	.	.	.	18
17	.	7	.	.	.	.	.	.	.	7	.	.
18	.	.	55	.	17	.	.	4	5	10	24	.
19	23	.	.	.	8	.	.	31	.	20	.	.
20	1	56	.	.	.	.	.	1	.	5	.	.
21	25	40	57	2	12	.	.	.	14	20	.	8
22	2	40	3	.	4	16	.	.	.	.	.	10
23	27	.	10	.	1	.	1	.	.	.	.	30
24	19	.	2	.	.	.	.	.	.	.	.	3
25	10	.	.	8	4	13	.	.	.	.	.	.
26	5	12	.	4	.	.	.	.	.	.	.	.
27	5	.	.	.	.	1	.	.	.	.	.	7
28	9	.	.	.	.	.	.	.	1	.	.	67
29	.	.	12	2	.	18	4	.	4	.	.	3
30	.	.	.	.	1	4	.	3	.	.	.	11
31	.	.	.	.	11	.	144	1	.	.	.	19
Total	263	461	191	101	241	134	297	111	102	184	59	300

TABLE H-11
(Continued)

1979 RAINFALL
(mm)

JIMBARAN

Day	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec
1	10	44	1	23	37	16						
2	8	6	2	8	3	.						
3	.	.	.	64	.	.						
4	11	.	1	36	.	2						
5	7	.	53	3	15	3						
6	3	.	20	47	10	.						
7	.	.	36	.	.	23						
8	.	.	28	100	1	3						
9	90	.	6	1	7	.						
10	.	.	.	4	.	2						
11	.	.	3	2	5	.						
12	.	14	6	1	.	.						
13	46	.	.	44	.	.						
14	9	.	.	5	.	.						
15	54	4	.	2	.	3						
16	.	9	.	10	3	.						
17	.	2	.	.	.	.						
18	1	22	.	.	.	.						
19	.	5	.	7	.	.						
20	.	17	3	43	53	.						
21	.	.	.	21	.	.						
22	.	22	1	2	42	.						
23	4	14	7	2	9	.						
24	.	.	.	.	5	.						
25	2	4	.	20	.	.						
26	2	.	.	.	7	.						
27	.	.	2	11	3	.						
28	1	.	1	.	.	.						
29	35	.	.	.	8	.						
30	.	.	.	.	3	.						
31	5	.	19	.	14	.						
Total	288	163	189	456	225	52						

TABLE H-11
(Continued)

1977 RAINFALL
(mm)

JRAGUNG

Day	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1	.	14	.	.	.	.	.	.	.	.	.	50
2	.	.	27	6	.	.	55	.	.	2	.	8
3	3	87	29	.	.	.	.	.	.	3	26	3
4	.	49	17	.	8	13	.	.	.	.	.	3
5	10	.	40	.	.	1	.	.	.	13	36	.
6	1	3	37	.	.	14	.	.	.	.	1	33
7	49	6	20	.	3	12	.	.	.	.	1	15
8	7	19	5	.	17	47	.	.	.	.	23	.
9	1	1	1	30	9	3	.	.	.	.	25	5
10	9	10	13	4	30	2	.	.	.	.	6	.
11	.	2	3	.	.	.	.	.	.	.	.	1
12	3	7	.	6	53	.	.	.	.	1	.	.
13	2	4	3	.	.	.	.	.	.	.	.	.
14	1	3	13	.	4	7	.	.	.	.	.	17
15	15	.	17	.	.	.	.	.	.	.	36	.
16	.	.	35	.	.	.	.	.	.	.	2	.
17	.	.	10	.	.	.	.	.	.	.	.	.
18	21	.	71	30	.	.	.	.	.	.	4	.
19	.	.	17	.	.	.	.	.	.	.	.	1
20	3	13	.	15	.	.	.	.	.	1	5	.
21	2	.	2	.	.	.	.	.	.	.	2	.
22	45	.	11	133	10	22	.	.	1	1	5	9
23	.	.	2	70	.	1	.	.	.	.	2	.
24	1	12	.	11	.	.	.	.	.	.	3	41
25	.	59	.	.	1	.	.	.	.	.	50	.
26	8	24	.	.	11	.	.	.	.	.	.	4
27	.	.	3	.	25	.	.	.	.	.	.	4
28	.	.	.	.	4	.	.	.	.	.	.	24
29	.	.	.	.	31	.	.	.	13	12	19	3
30	10	.	.	.	.	.	.	.	.	.	.	90
31	.		.		.		.	.		.		.
Total	191	313	376	305	206	122	55	0	14	33	246	311

TABLE H-11
(Continued)

1978 RAINFALL
(mm)

JRAGUNG

Day	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1	21	147	.	.	.	.	.	3	.	4	.	20
2	6	15	.	.	.	.	.	14	.	2	.	.
3	.	2	7	43	1	54	1	7	116	16	12	70
4	19	54	.	.	1	4	3	.	.	.	7	10
5	.	4	9	.	65	10	.	3	.	1	8	.
6	1	.	7	.	.	.	8	.	6	.	.	.
7	16	.	.	3	.	.	.	9	22	.	.	20
8	7	4	.	.	.	5	46	.	3	.	12	.
9	4	1	16	.	.	.	.	.	.	.	3	.
10	6	.	.	.	20	.	1	.	34	.	1	.
11	16	3	2	6	.	.	23	.	9	.	3	.
12	10	.	.	33	.	.	18	.	.	.	.	.
13	16	1	3	27	.	1	.	.	.	.	.	.
14	.	10	3	30	67	.	.	.	.	.	.	.
15	1	.	16	.	2	3	.	1	.	33	.	.
16	68	3	17	.	.	1	.	25	.	39	19	.
17	.	.	.	.	.	.	.	.	2	.	.	.
18	1	2	2	.	1	.	.	.	2	20	.	.
19	65	62	.	.	4	.	.	.	.	1	3	10
20	9	28	.	.	.	5	.	1	.	7	.	.
21	6	13	4	21	9	3	.	.	40	13	.	.
22	4	.	10	.	1	.	1	.	5	1	.	.
23	.	3	7	.	3	.	.	.	.	.	.	60
24	.	.	4	.	.	.	.	.	.	.	1	60
25	36	15	.	2	7	.	.	.	.	.	.	.
26	28	.	2	26	4	1	.	.	.	14	.	.
27	10	.	2	.	.	25	.	.	.	.	.	.
28	8	.	2	.	.	.	.	6	.	5	.	.
29	4	.	1	.	4	2	.	4	.	.	.	20
30	48	.	.	1	1	1	.	6	4	.	20	.
31	5	.	.	.	29	.	.	.	.	133	.	.
Total	415	367	114	192	219	115	101	79	243	289	89	270

TABLE H-11
(Continued)

1979 RAINF...
(mm)

JRAGUNG

Day	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1	38	26	.	18	9	.						
2	18	21	1	.	26	.						
3	4	.	1	.	.	.						
4	2	.	.	50	.	.						
5	.	30	.	.	77	62						
6	22	1	4	21	.	.						
7	.	7	85	1	.	26						
8	8	.	27	18	.	1						
9	24	.	29	5	2	.						
10	1	23	7	9	.	.						
11	.	11	7	51	2	.						
12	7	.	17	20	.	.						
13	25	12	3	52	.	.						
14	17	4	.	32	14	.						
15	15	8	3	.	.	1						
16	2	.	.	.	.	.						
17	.	.	62	1	3	.						
18	.	.	.	.	1	.						
19	.	7	.	.	.	.						
20	5	10	2	.	11	.						
21	9	.	.	3	14	.						
22	.	1	.	18	6	.						
23	.	4	.	2	10	.						
24	.	42	1	.	.	.						
25	11	.	.	7	.	.						
26	2	.	.	.	.	.						
27	.	.	.	19	.	.						
28	.	.	3	.	.	.						
29	.	.	9	5	.	.						
30	.	.	.	.	.	.						
31	2	.	28	.	30	.						
Total	212	207	289	332	205	90						

TABLE H-11
(Continued)

1976 RAINFALL
(mm)

KARANGJATI

Day	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1	10	.	51	40	.	.	.	.	.	.	.	.
2	.	.	12	.	.	.	.	.	.	.	3	1
3	.	.	59	16	.	.	.	.	.	.	.	.
4	10	.	20	.	.	.	5	.	.	.	.	.
5	.	.	.	6	.	.	.	.	.	5	.	.
6	.	1	.	4	16	.	.	.	.	10	.	.
7	.	2	.	.	23	.	.	.	.	.	.	1
8	20	2	4	.	22	1	.	.	.	7	.	.
9	30	9	39	.	.	.	.	.	.	.	.	1
10	40	9	29	.	.	2	.	.	.	.	2	.
11	40	.	.	.	.	3	.	.	.	.	2	9
12	10	.	34	.	.	1	.	.	.	6	.	.
13	.	7	9	.	.	.	.	.	.	5	9	.
14	30	35	.	.	.	.	.	.	.	4	.	.
15	.	.	.	3	.	.	.	.	.	.	14	.
16	.	.	18	.	.	.	.	.	.	1	8	.
17	.	1	41	19	.	.	.	.	.	6	34	.
18	10	47	7	.	.	.	.	.	.	.	.	10
19	10	6	15	53	2	.	.	.	.	.	2	.
20	50	.	3	.	.	.	.	.	.	.	3	.
21	62	.	.	.	.	.	.	.	.	9	20	5
22	30	.	1	.	.	.	.	.	.	17	17	.
23	.	106	.	.	.	.	.	.	.	.	1	.
24	4	9	41	10	.	.	.	.	.	.	3	.
25	1	62	2	.	.	.	.	19	2	.	2	.
26	82	.	.	.	.	.	.	.	.	3	9	.
27	.	.	1	.	1	.	.	.	.	3	.	.
28	2	.	6	.	.	.	.	4	1	1	.	10
29	3	17	19	1	.	.	.	.	13	7	.	5
30	5		1	3	.	.	5	.	.	10	9	.
31	3		1	3	.	.	.	.	.	6	.	.
Total	452	313	413	158	64	7	10	23	16	100	138	42

TABLE H-11
(Continued)

1977 RAINFALL
(mm)

KARANGJATI

Day	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1	.	8	11	.	.	.	.	.	.	.	.	22
2	.	17	10	10	.	20	.	.	.	.	6	47
3	.	7	14	.	.	29	.	.	.	.	7	1
4	.	.	57	.	.	3	.	.	.	.	.	12
5	.	5	58	.	.	.	.	.	.	.	.	.
6	1	3	14	.	.	1	.	.	.	.	.	12
7	30	2	31	19	13	15	.	.	.	.	.	3
8	17	48	10	9	7	3	.	.	.	.	.	.
9	6	.	.	4	16	8	.	.	.	.	.	3
10	3	2	26	8	19	1	.	.	.	.	.	.
11	.	.	.	.	.	2	.	.	.	.	.	2
12	1	7	3	5	15	.	.	.	.	.	.	8
13	2	35	5	1	.	.	.	.	.	.	.	5
14	3	5	7	.	1	.	.	.	.	.	3	5
15	10	.	19	.	12	.	.	.	.	.	18	.
16	3	.	1	.	.	1	.	.	.	.	.	1
17	.	.	1	.	.	.	.	.	.	.	.	3
18	15	.	2	31	.	.	.	.	.	.	.	.
19	2	.	41	.	.	10	.	.	.	7	.	.
20	.	13	81	.	.	.	.	.	.	.	4	.
21	.	2	1	80	.	.	.	.	.	.	.	.
22	51	.	.	20	42	.	.	.	2	.	1	15
23	1	.	4	2	10	.	.	.	.	.	.	1
24	.	44	30	27	2	12	.	.	7	1	3	3
25	.	36	10	.	14	.	.	.	.	.	4	.
26	32	27	1	13	25	4	.	.	1	.	.	.
27	6	.	10	.	.	.	.	.	.	.	4	1
28	.	.	1	.	20	1	.	.	.	.	.	.
29	.	.	.	.	56	.	.	.	.	.	.	.
30	13	.	.	.	.	.	.	.	.	.	.	34
31	10	.	.	.	10	.	.	.	.	.	.	48
Total	206	261	448	229	262	110	0	0	10	8	50	226

TABLE H-11
(Continued)

1978 RAINFALL
(mm)

KARANGJATI

Day	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1	63	79	.	.	19	.	.	14	1	.	.	.
2	6	32	.	16	19	.	.	.	3	.	.	70
3	1	1	8	2	.	34	.	2	58	13	.	10
4	11	6	8	.	8	3	2	1	.	.	.	20
5	5	18	15	.	.	.	.	.	.	.	.	20
6	16	.	.	7	6	.	2	25	.	2	10	10
7	.	.	8	1	.	7	2	.	.	.	.	20
8	1	14	.	1	.	9	11	.	12	.	20	30
9	49	12	22	10	.	.	20	.	59	.	.	10
10	2	19	17	10	.	.	3	.	10	.	10	10
11	.	2	.	15	5	.	17	.	.	.	.	.
12	24	13	.	.	.	.	.	.	.	.	.	.
13	10	9	1	1	1	30	.	.	.	.	.	.
14	4	3	1	.	20	.	.	.	.	.	.	30
15	1	22	5	.	27	2	.	.	.	1	.	.
16	14	11	.	.	3	3	.	3	3	17	10	10
17	.	4	.	9	1	11	.	11	.	10	.	.
18	.	.	30	1	6	.	.	.	.	3	.	.
19	24	.	.	.	11	.	.	6	.	5	.	.
20	4	29	25	2	.	.	.	7	.	8	.	.
21	17	52	38	.	14	.	.	.	48	22	20	.
22	5	36	13	.	.	14	.	.	.	.	.	40
23	51	.	7	.	22	.	17	.	.	.	.	.
24	8	1	3	1	.	14	.	.	.	.	.	.
25	20	.	6	2	8	.	.	.	.	.	.	.
26	17	17	.	.	.	1	.	.	.	10	10	75
27	5	.	.	.	.	.	.	.	.	.	.	.
28	8	.	5	19	.	11	.	.	.	.	.	80
29	2	.	1	.	.	.	8	.	37	.	.	80
30	18	.	.	.	1	.	.	.	.	.	.	.
31	7	.	.		20		37	.	.	.	.	70
Total	393	380	213	97	191	139	119	69	231	91	80	585

Table H-11
(Continued)

1979 RAINFALL
(mm)

KARANGJATI

Day	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1	.	120	30	.	.	30						
2	.	.	20	20	20	10						
3	20	.	10	30	10	.						
4	10	.	40	70	.	.						
5	30	10	.	40	.	.						
6	20	20	.	.	10	.						
7	.	.	50	.	.	10						
8	.	.	.	.	.	.						
9	10	30	.	20	.	20						
10	.	.	10	10	.	.						
11	.	.	10	.	.	.						
12	60	.	.	.	10	.						
13	30	.	.	.	.	.						
14	.	20	.	40	.	.						
15	.	10	.	30	10	.						
16	.	.	.	.	.	.						
17	10	20	10	.	.	.						
18	.	.	.	10	.	.						
19	.	.	.	.	.	.						
20	10	10	.	.	.	.						
21	.	.	.	30	.	.						
22	.	.	.	70	.	.						
23	.	.	40	20	10	.						
24	.	40	10	.	.	.						
25	20	10	.	.	.	.						
26	.	20	.	.	.	.						
27	.	.	.	.	.	.						
28	.	.	.	.	.	.						
29	30	.	20	.	.	.						
30	.	.	.	.	.	.						
31	30	.	.	.	10	.						
Total	280	310	250	390	80	70						

TABLE H-11
(Continued)

1976 RAINFALL
(mm)

KLEPU

Day	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1	.	.	28	9	2	.	.	.	.	.	.	.
2	.	.	39	.	.	.	.	.	.	.	.	.
3	.	.	.	.	.	.	.	.	.	.	.	.
4	.	.	.	10	.	.	5	.	.	1	.	.
5	.	.	.	8	.	.	.	.	.	5	.	.
6	.	9	.	12	16	.	.	.	.	7	.	.
7	.	.	.	.	4	.	.	.	.	.	.	.
8	12	20	3	.	1	3	.	.	.	26	.	.
9	48	1	27	.	.	.	.	.	.	.	.	.
10	2	38	31	.	1	.	.	.	.	.	.	.
11	9	.	.	.	.	9	.	.	.	.	.	.
12	.	.	20	.	.	21	.	.	.	21	.	.
13	.	5	5	.	.	.	.	.	.	23	40	.
14	50	15	24	.	.	.	.	.	.	28	.	.
15	.	.	.	5	.	.	.	.	.	.	12	.
16	.	.	.	.	.	.	.	.	.	.	9	.
17	.	.	.	15	.	.	.	.	.	2	19	.
18	.	41	51	.	.	.	.	.	.	2	10	.
19	7	3	13	80	.	.	.	.	.	.	3	.
20	40	.	2	.	.	.	.	.	.	.	6	.
21	41	.	.	.	.	.	.	.	.	7	11	.
22	23	1	7	.	.	.	.	.	.	13	40	.
23	3	85	.	5	.	.	.	.	.	.	.	.
24	7	30	27	7	.	.	.	20	.	.	.	.
25	10	32	.	.	.	.	.	.	3	.	13	.
26	39	.	.	.	.	.	.	1	.	3	57	.
27	.	.	.	.	1	.	.	6	.	5	.	.
28	12	.	.	.	.	.	.	.	.	2	.	.
29	3	2	20	.	.	.	.	12	1	37	.	40
30	.		.	3	.	.	4	.	.	20	.	20
31	.		1		.		.	.		.		10
Total	306	282	298	154	25	33	9	39	4	202	220	70

TABLE H-11
(Continued)

1977 RAINFALL
(mm)

KLEFU

Day	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1	30	60	.	.	.	.	2	.	.	.	.	.
2	.	31	.	.	.	9	.	.	.	.	6	4
3	.	10	.	.	.	6	.	.	.	.	17	4
4	.	1	40	.	.	.	.	.	.	.	.	2
5	.	.	60	1	.	30	.	.	.	.	12	.
6	.	9	.	.	.	.	.	.	.	.	.	19
7	30	20	10	14	14	.	.	.	.	.	.	4
8	.	24	10	4	12	6	.	.	.	.	14	22
9	.	.	24	13	30	43	.	.	.	.	9	3
10	1	3	16	3	.	.	.	.	.	.	.	1
11	.	.	.	.	13	3	.	.	.	.	.	1
12	.	5	.	4	.	.	.	.	1	1	20	5
13	.	18	2	.	1	.	.	.	.	.	.	8
14	2	1	.	.	2	.	.	.	.	.	8	21
15	6	.	13	.	.	.	.	.	.	.	10	2
16	3	.	1	.	.	.	.	.	.	.	14	4
17	.	.	1	.	.	.	.	.	.	.	7	1
18	12	.	43	20	.	.	.	.	.	.	.	.
19	3	.	21	.	.	.	.	.	.	10	.	.
20	1	15	42	.	.	.	.	.	.	.	.	2
21	2	2	.	80	.	.	.	.	.	.	.	.
22	23	30	1	10	25	.	.	.	.	.	2	4
23	.	.	7	2	50	.	.	.	.	.	.	23
24	1	3	21	32	.	17	.	.	11	1	2	2
25	.	30	9	.	30	.	.	.	.	.	1	1
26	27	10	.	.	50	21	.	.	.	.	.	.
27	.	.	.	.	30	.	.	.	1	2	5	3
28	.	.	.	.	.	.	.	.	.	.	5	.
29	.	.	.	.	100	.	.	.	.	.	45	20
30	10	.	.	.	.	.	.	.	.	.	10	19
31	.		.	.	15	.	.	.	.	.	.	45
Total	151	272	321	188	372	135	2	0	13	14	187	220

TABLE H-11
(Continued)

1978 RAINFALL
(mm)

KLEPU

Day	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1	3	70	.	.	26	1	.	10	.	.	10	.
2	20	17	.	.	13	.	1	.	17	.	.	94
3	.	.	71	22	.	10	1	.	40	40	.	10
4	7	23	20	.	31	1	20	.	.	.	.	.
5	19	.	.	.	.	.	.	.	.	10	.	30
6	35	4	.	.	.	.	.	13	.	.	.	10
7	2	.	10	.	.	1	.	.	.	.	4	.
8	2	5	.	.	20	16	.	.	4	.	3	10
9	121	24	10	.	.	.	20	.	36	.	3	.
10	4	13	10	12	.	.	1	.	16	.	.	.
11	.	8	.	4	.	.	10	.	.	.	.	20
12	20	5	.	44	.	.	20	.	.	.	10	10
13	7	.	.	.	.	32	18	.	.	.	.	.
14	90	2	.	.	20	.	.	.	.	.	.	20
15	1	48	.	.	37	.	.	1	.	.	.	.
16	16	40	.	.	4	4	.	8	4	10	.	61
17	.	20	.	.	29	9	.	3	.	2	.	.
18	50	.	75	8	4	.	.	.	.	7	.	.
19	16	.	.	.	10	.	.	4	.	12	.	.
20	14	81	7	.	.	.	.	2	.	.	.	.
21	7	49	83	.	.	.	.	.	24	10	.	20
22	.	73	67	.	.	15	.	.	.	.	.	20
23	89	.	3	.	.	.	2	.	.	.	.	50
24	20	1	.	.	.	.	.	.	.	.	.	.
25	20	.	9	.	.	2	.	.	.	.	.	.
26	.	16	.	1	.	3	.	.	.	10	.	.
27	5	19	.	.	.	1	.	.	.	.	.	.
28	1	.	.	.	.	.	.	.	.	.	.	85
29	.	.	.	.	.	14	.	.	25	.	.	70
30	13	.	.	39	.	17	.	2	.	.	.	10
31	.	.	.	.	.	.	210	.	.	10	.	.
Total	582	518	365	130	194	126	303	43	166	111	30	520

TABLE H-11
(Continued)

1979 RAINFALL
(mm)

KLEPU

Day	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1	50	176	1	18	4	20						
2	44	39	5	26	28	•						
3	2	•	6	63	•	•						
4	64	•	•	212	•	•						
5	22	7	3	5	6	•						
6	•	3	38	39	•	•						
7	•	3	66	3	10	10						
8	10	2	30	6	•	•						
9	38	•	•	1	8	•						
10	•	11	•	•	•	•						
11	24	10	•	18	22	•						
12	54	18	13	2	•	•						
13	114	•	•	17	•	•						
14	6	•	•	3	13	•						
15	81	2	10	•	•	2						
16	•	•	•	33	•	•						
17	2	15	47	2	17	•						
18	6	•	6	•	•	•						
19	•	•	5	44	•	•						
20	32	24	36	•	9	•						
21	8	•	•	•	•	•						
22	•	3	•	21	35	•						
23	•	43	10	•	43	•						
24	•	•	•	•	1	•						
25	•	•	•	•	•	•						
26	5	4	•	•	•	•						
27	•	1	3	11	•	•						
28	•	•	•	•	•	•						
29	14	•	•	•	•	1						
30	•	•	•	•	•	•						
31	7	•	23	•	21	•						
Total	583	361	302	524	217	33						

TABLE H-11
(Continued)

1976 RAINFALL
(mm)

SAMBIROTO

Day	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1	.	.	16	34	.	.	.	.	.	.	2	.
2	10	.	7	.	.	.	.	1	.	.	5	.
3	.	.	37	34	.	.	.	.	.	.	.	.
4	1	.	30	41	9	.	.	.	.	1	.	.
5	.	.	1	19	12	.	.	.	.	9	.	.
6	.	4	.	.	3	.	.	.	.	41	.	.
7	.	3	.	.	.	.	.	.	8	.	.	18
8	32	.	3	7	.	1	.	.	.	41	.	.
9	16	4	52	.	.	.	.	.	.	.	.	.
10	11	5	17	.	10	.	1	.	.	1	17	.
11	8	.	.	.	.	1	.	.	.	.	.	.
12	9	.	45	.	.	.	.	.	.	38	.	.
13	.	4	14	.	.	.	.	.	.	1	31	.
14	29	42	9	16	1	.	.	.	.	46	.	.
15	1	15	6	.	.	.	.	.	.	.	17	.
16	2	.	.	.	.	.	.	.	.	3	33	.
17	.	27	11	.	.	.	.	.	.	31	2	.
18	10	33	82	.	.	.	.	.	.	.	.	.
19	7	.	22	1	.	.	.	.	.	.	7	.
20	65	.	.	.	.	.	.	.	.	.	5	10
21	44	7	.	.	.	.	.	.	.	11	36	10
22	25	.	28	.	.	.	.	.	.	10	19	19
23	4	20	.	4	.	.	.	.	.	.	10	.
24	1	32	4	9	.	.	.	6	.	.	7	1
25	6	48	1	.	.	.	.	.	.	.	11	.
26	14	1	.	.	.	.	.	.	14	2	12	.
27	.	.	.	.	.	.	.	4	.	26	.	.
28	15	.	1	.	.	.	.	.	.	8	.	.
29	1	.	17	.	.	.	.	.	.	88	.	8
30	1	.	2	.	.	.	1	.	.	30	10	12
31	11	.	3	.	.	.	.	.	.	5	.	.
Total	323	245	408	165	35	2	2	11	22	392	224	78

TABLE H-11
(Continued)

1977 RAINFALL
(mm)

SAMBIROTO

Day	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1	10	19	10	5	.	.	10	.	.	.	5	32
2	.	30	5	1	.	26	.	.	.	.	.	19
3	2	20	11	6	.	1	.	.	.	.	65	21
4	.	10	33	.	6	.	.	.	.	.	.	7
5	15		19	.	.	.	.	.	.	.	50	.
6	1	2	12	.	.	57	.	.	.	.	.	30
7	10	3	11	1	.	11	.	.	.	.	.	5
8	15	31	14	15	23	21	.	.	.	.	30	.
9	1	9	1	7	3	22	.	.	.	.	15	3
10	.	10	22	3	2	5	.	.	.	.	2	1
11	.	1	2	9	.	1	.	.	.	.	.	1
12	.	6	.	1	28	.	.	.	.	.	.	.
13	2	8	5	.	2	.	.	.	.	.	.	.
14	1	3	4	.	11	.	.	.	.	.	.	16
15	14	.	68	.	.	.	1	.	.	.	45	1
16	.	.	3	.	.	.	.	.	.	.	.	31
17	.	.	8	.	.	.	.	.	.	.	.	.
18	30	.	7	8	.	.	.	.	.	.	1	.
19	2	.	3	.	.	.	.	.	.	.	.	.
20	1	9	13	4	.	.	.	.	.	.	.	.
21	6	1	1	1	.	.	3	.	.	.	.	.
22	42	.	.	60	.	11	.	.	.	.	5	60
23	.	.	2	42	.	.	.	.	.	.	.	20
24	1	15	2	11	2	2	.	.	.	6	8	10
25	.	20	3	.	1	.	.	.	.	.	11	1
26	7	24	.	.	6	.	.	.	1	.	.	6
27	.	.	.	.	3	.	.	.	.	.	.	.
28	.	.	.	.	2	.	.	.	.	1	.	12
29	.	.	2	.	68	.	.	.	4	52	4	10
30	12	.	.	.	.	.	.	.	.		3	54
31	9	.	.	.	.	.	.	.	.	.	8	83
Total	181	221	261	174	157	157	14	0	5	59	252	423

TABLE H-11
(Continued)

1978 RAINFALL
(mm)

SAMBIROTO

Day	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1	30	72	.	.	34	.	.	12	1	.	.	.
2	8	12	.	.	2	.	5	.	.	5	.	27
3	.	22	.	21	.	24	1	5	95	43	17	15
4	24	.	.	.	26	7	2	14	.	.	.	7
5	.	10	.	.	5	16	.	.	8	.	13	1
6	1	33	.	.	.	.	5	35	21	.	4	7
7	2	.	8	20	.	.	.	.	1	.	53	.
8	.	.	.	.	.	15	7	.	.	.	.	.
9	15	.	8	.	.	.	.	.	72	.	20	2
10	6	4	4	.	16	.	3	.	28	.	2	.
11	1	.	10	20	.	.	3	.	.	.	.	31
12	20	.	.	60	.	.	31	.	.	.	.	.
13	10	.	1	32	5	16	.	.	.	.	.	.
14	2	56	2	44	.	.	.	.	.	.	.	23
15	18	.	15	.	.	3	.	.	.	7	8	2
16	30	.	.	.	.	.	.	3	5	10	.	4
17	30	11	.	.	.	.	.	.	.	.	.	.
18	1	.	1	.	.	.	.	.	.	11	13	2
19	50	.	.	.	24	.	.	.	.	.	.	4
20	67	68	10	.	.	3	.	1	.	2	.	.
21	m	20	21	33	4	1	.	.	38	20	.	8
22	m	20	.	.	.	19	.	.	.	.	.	20
23	m	.	12	.	1	.	3	.	.	.	.	22
24	m	.	1	.	1	.	.	.	.	.	1	5
25	m	.	.	.	.	1	.	.	.	.	.	1
26	m	12	3	7	.	.	.	.	.	16	.	7
27	m	.	1	.	.	3	.	.	.	.	.	.
28	m	.	2	.	.	.	.	.	.	.	.	51
29	m	.	.	.	1	9	.	.	3	2	.	12
30	m	.	.	6	1	1	.	5	.	2	3	8
31	m	.	.	.	15	.	.	.	.	60	.	6
Total	m	340	99	243	135	118	60	75	272	178	134	265

The symbol m indicates that no rainfall measurements were made.

TABLE H-11
(Continued)

1979 RAINFALL
(mm)

SAMBIROTO

Day	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1	16	33	.	6	1	19						
2	13	54	.	8	85	.						
3	5	.	6	6	.	.						
4	.	.	.	27	.	8						
5	24	14	.	.	12	7						
6	6	3	8	20	1	2						
7	.	.	71	.	.	10						
8	9	.	22	9	.	3						
9	17	.	10	6	.	.						
10	.	36	1	4	27	.						
11	.	17	7	44	4	.						
12	22	.	2	68	.	.						
13	48	1	.	50	.	.						
14	10	.	.	43	1	.						
15	60	15	14	.	.	2						
16	.	.	.	2	.	.						
17	.	.	4	5	.	.						
18	.	.	2	.	.	.						
19	.	.	4	3	.	.						
20	.	13	10	.	10	.						
21	13	.	2	.	3	.						
22	.	16	.	5	4	.						
23	.	2	.	2	13	.						
24	.	.	5	.	.	.						
25	17	.	.	10	.	.						
26	6	.	.	.	.	.						
27	.	.	.	10	.	.						
28	.	.	4	.	.	.						
29	.	.	5	.	1	3						
30	.	.	.	.	.	.						
31	15	.	5	.	2	10						
Total	281	204	182	328	164	64						

TABLE H-12

MEAN DAILY FLOW (1972 - 1973)

JRAGUNG RIVER AT BORANGAN BRIDGE (m^3/s)

Day	May	Jun	Jul	Aug	Sep
1	8.42	3.05	0.50	0.08	0.06
2	4.70	2.00	0.50	0.08	0.06
3	2.60	1.20	0.30	0.08	0.06
4	15.69	0.90	0.20	0.08	0.20
5	18.96	1.24	0.10	0.08	0.08
6	17.28	0.40	0.10	0.08	0.08
7	12.24	0.40	0.10	0.06	1.65
8	7.72	1.60	0.40	0.06	3.85
9	10.17	8.77	2.24	0.06	0.70
10	6.40	13.77	0.80	0.06	0.20
11	8.04	4.70	0.30	0.30	0.08
12	15.40	1.86	4.75	0.10	0.44
13	6.40	15.66	18.99	0.20	0.08
14	2.40	6.40	4.28	0.10	0.06
15	2.80	1.35	1.60	0.20	1.09
16	1.80	1.60	0.50	0.50	0.40
17	1.60	1.00	0.30	0.30	0.27
18	9.30	0.90	0.30	0.20	2.48
19	7.62	0.80	0.30	0.08	1.10
20	3.44	0.80	5.50	0.06	7.97
21	2.27	0.80	3.85	0.80	8.90
22	3.93	0.60	1.24	0.08	1.60
23	2.20	0.50	0.30	0.06	9.55
24	2.00	0.30	0.50	0.06	5.91
25	6.37	0.20	0.40	0.06	10.95
26	16.50	0.20	0.30	0.06	5.13
27	8.01	0.20	0.20	0.04	1.20
28	2.80	0.20	0.20	0.04	2.20
29	47.11	0.50	0.20	0.08	1.60
30	13.50	1.40	0.10	0.08	0.90
31	9.42	-	0.10	0.08	-
Average	8.94	2.44	1.60	0.11	2.30

TABLE G-12 (CONTINUED)

MEAN DAILY FLOW (1973-1974)
JRAGUNG RIVER AT BORANGAN BRIDGE (m^3/s)

Day	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1	0.40	3.99	12.80	8.46	18.23	1.60	3.43	0.30	2.40	0.30	0.90	0.06
2	0.30	4.70	6.37	4.70	12.43	12.36	2.60	3.17	1.40	0.20	0.50	0.04
3	0.20	2.20	1.93	2.60	10.79	16.25	2.20	6.28	0.50	0.10	0.80	0.30
4	0.10	1.20	30.61	2.00	10.50	19.07	13.13	5.71	0.08	0.08	0.70	0.10
5	0.20	1.00	12.79	2.00	5.98	25.72	28.70	1.20	0.08	0.06	0.40	0.06
6	0.70	0.80	18.69	2.00	2.80	11.50	15.08	15.08	0.08	0.06	0.40	0.10
7	1.93	1.60	7.90	0.90	2.00	5.55	12.05	4.63	0.08	0.04	0.40	0.50
8	2.82	0.90	6.02	0.50	19.47	28.83	17.59	10.34	0.08	0.04	0.20	3.01
9	2.20	0.90	3.43	0.20	9.90	47.39	18.09	7.64	0.08	0.04	0.10	5.81
10	1.40	1.68	2.44	0.10	4.70	16.87	8.26	5.13	0.08	0.02	0.08	6.30
11	1.40	3.99	12.43	1.10	8.31	13.08	8.34	3.43	0.08	0.06	0.06	7.06
12	0.30	5.59	6.40	7.53	10.40	14.53	5.91	2.20	0.08	2.91	0.60	3.85
13	1.40	5.54	6.57	14.10	9.90	7.19	2.81	3.77	0.08	1.20	0.20	0.90
14	2.17	5.65	4.70	10.20	3.43	15.07	1.40	3.08	0.08	0.20	0.08	0.40
15	0.60	4.50	4.34	28.13	1.60	8.22	2.83	2.05	0.08	1.10	0.06	0.71
16	0.20	19.18	9.01	18.22	1.20	4.28	4.15	2.53	0.08	0.30	0.04	0.78
17	0.08	3.43	6.81	3.43	1.10	3.43	1.40	2.00	3.86	0.20	0.02	0.04
18	0.06	3.82	3.43	5.13	1.00	3.00	1.10	1.40	1.60	0.08	0.02	0.00
19	0.06	4.17	13.10	8.84	2.00	2.80	1.10	0.93	1.00	0.04	0.08	0.00
20	0.30	2.60	5.55	6.40	15.13	3.03	1.00	0.60	0.60	0.02	0.08	7.79
21	0.30	1.00	3.85	3.43	12.42	23.55	0.60	0.50	3.77	0.02	0.06	1.00
22	1.15	0.50	2.20	3.43	4.28	10.66	0.40	0.40	6.68	0.00	0.10	0.80
23	2.20	0.30	1.00	1.60	16.16	16.06	0.81	0.30	2.60	0.00	1.40	0.70
24	0.80	15.14	3.34	1.60	13.92	15.78	0.80	0.20	0.60	0.00	0.40	0.60
25	1.00	15.71	2.60	1.00	3.85	8.90	0.93	0.20	0.50	0.04	1.40	0.60
26	5.05	4.28	2.20	0.90	1.60	3.43	0.06	0.10	0.50	0.06	3.63	0.60
27	9.77	2.80	7.90	0.90	2.80	9.40	0.04	0.10	0.50	0.04	0.90	0.50
28	2.35	15.90	4.28	0.90	1.60	3.88	0.02	0.08	0.40	0.06	0.70	0.50
29	1.30	9.67	2.80	0.90	-	15.11	0.06	0.08	0.40	3.01	0.80	0.50
30	1.00	3.85	1.80	2.89	-	14.10	2.40	0.40	0.30	2.00	1.06	0.40
31	0.90	-	4.05	13.01	-	5.55	-	9.37	-	1.00	0.40	-
Average	1.38	4.41	6.82	5.07	7.41	12.46	5.24	3.01	0.96	0.40	0.53	1.47

TABLE G-12 (CONTINUED)

MEAN DAILY FLOW (1974-1975)

JRAGUNG RIVER AT BORANGAN BRIDGE (m^3/s)

Day	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1	0.30	0.70	0.10	2.00	3.00	3.48	3.85	6.65	0.08	0.36	0	0
2	0.30	3.35	0.02	4.64	4.21	1.20	5.25	2.68	0.06	0.06	0	0.08
3	4.02	5.12	0.00	10.95	1.60	1.20	10.74	1.20	0.04	0	0	0
4	5.92	4.83	0.06	4.06	6.51	0.70	9.88	1.20	0.02	0	0	0
5	3.85	3.16	2.09	28.46	2.20	4.66	5.13	8.39	0.80	0	0	0
6	3.43	2.80	2.65	8.64	1.10	5.58	5.80	7.75	0.20	0	0	0
7	3.69	2.40	3.00	2.00	5.10	15.59	16.52	2.20	0.04	0	0	0
8	3.05	1.80	2.60	1.20	3.41	19.60	3.85	2.32	0.00	0	0	0
9	5.13	1.10	1.20	1.10	5.23	11.22	2.40	3.48	0.00	0	0	9.06
10	1.40	1.20	1.10	4.33	6.65	13.45	1.00	3.14	0.00	0	0	1.54
11	26.75	1.10	1.00	30.41	3.16	11.07	2.01	6.08	0.00	0	0	4.16
12	6.94	0.90	1.20	14.29	2.43	6.40	1.60	5.82	0.00	0	0	0.30
13	4.12	0.08	6.88	2.36	2.54	4.70	5.76	5.58	0.00	0	0	0.08
14	4.17	0.70	3.90	1.10	12.67	4.11	1.38	6.95	0.00	0	0	0.30
15	7.61	1.24	3.81	0.90	8.15	9.44	0.80	5.10	0.00	0	0	6.66
16	14.75	0.80	2.20	1.00	5.55	5.98	0.60	2.58	0.00	0	0	5.01
17	4.70	0.50	0.40	5.00	2.00	4.70	3.35	16.58	0.00	0	0	0.90
18	4.70	0.50	0.30	4.66	1.20	4.70	38.79	7.78	0.00	0	0	0.08
19	1.00	0.79	0.10	1.83	1.60	2.60	34.72	2.13	0.00	0	0	0.50
20	1.10	11.45	0.50	4.20	1.60	1.60	18.61	4.92	0.00	0	0	0.60
21	1.10	6.60	1.90	20.75	1.20	3.65	8.53	2.72	0.00	0	0	0.06
22	4.00	25.70	6.70	10.98	15.60	5.48	8.59	1.60	0.00	0	0	0.08
23	2.89	21.76	2.90	7.65	8.09	2.73	5.13	2.20	0.00	0	0	0.00
24	1.40	13.31	0.90	2.60	2.40	9.18	2.67	7.25	0.00	0	0	0
25	1.40	8.40	2.26	1.40	3.69	8.02	2.20	64.29	0.00	0	0	0.02
26	1.40	7.72	24.01	23.26	1.80	3.43	12.27	6.19	0.00	0	0.06	0
27	1.40	3.17	5.76	14.45	1.47	10.62	15.60	5.41	0.00	0	0	2.83
28	1.10	4.87	3.34	3.83	1.00	3.95	20.48	2.21	0.00	0	0	4.75
29	1.10	0.00	1.40	2.20	-	5.02	11.92	1.00	0.00	0	0.50	1.60
30	0.90	1.80	9.13	9.47	-	3.85	10.40	0.80	1.00	0	0	5.62
31	0.90	-	5.05	6.62	-	3.35	-	0.40	-	0	0	-
Average	4.02	4.62	3.11	7.62	4.11	6.19	8.99	6.34	0.11	0.01	0.02	1.47

TABLE G-12(CONTINUED)

MEAN DAILY FLOW (1975-1976)

JRAGUNG RIVER AT BORANGAN BRIDGE (m^3/s)

Day	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1	12.76	6.02	8.00	12.35	5.30	9.18	10.27	1.63	0.91	0.80	0.97	0.70
2	2.40	6.78	5.44	6.82	4.19	8.80	7.80	1.53	0.80	0.85	0.69	0.65
3	1.60	3.86	1.60	4.35	3.57	11.31	7.82	1.38	0.74	0.85	0.06	0.60
4	8.15	3.83	25.54	2.00	3.23	30.69	15.96	1.88	0.70	0.85	0.06	0.51
5	2.00	2.11	11.17	1.33	3.11	11.43	14.17	1.73	0.65	0.85	0.06	0.44
6	5.98	1.20	1.40	0.94	3.01	6.99	6.05	4.76	0.65	0.85	0.06	0.40
7	2.60	0.80	0.90	0.90	3.10	4.88	5.49	5.70	0.65	0.85	0.06	0.72
8	2.40	0.80	5.63	5.91	3.01	3.93	3.69	3.46	0.65	0.85	0.06	0.75
9	1.80	0.60	2.83	12.18	3.12	19.75	3.12	3.01	0.75	0.80	0.06	0.60
10	1.10	9.36	1.40	12.74	4.57	10.09	2.70	4.63	0.85	0.70	0.06	0.51
11	0.20	3.19	2.60	8.22	3.95	6.95	2.31	1.93	0.85	0.70	0.06	0.44
12	0.50	1.20	2.80	6.53	2.81	26.44	2.22	1.41	1.09	0.74	0.06	0.33
13	5.05	20.21	1.59	4.69	3.27	14.14	2.31	1.27	1.02	0.70	0.06	0.39
14	1.20	8.50	14.61	9.17	8.11	9.76	2.58	1.20	0.91	0.65	0.06	0.36
15	0.70	12.40	9.40	8.42	5.26	10.61	2.84	1.14	0.85	0.65	0.06	0.33
16	0.20	7.40	3.04	5.18	3.68	6.25	2.57	1.08	0.85	0.65	0.06	0.33
17	0.08	5.34	5.91	4.53	6.82	8.09	2.78	1.02	0.85	0.65	0.06	0.33
18	0.06	3.00	1.46	4.05	16.74	41.25	2.94	0.91	0.80	0.65	0.06	0.33
19	0.04	5.29	0.90	4.05	6.88	19.94	16.09	0.85	0.70	0.65	0.06	0.30
20	0.20	4.28	0.50	31.40	5.19	8.99	16.03	0.85	0.70	0.65	0.06	0.41
21	5.36	2.40	0.30	42.47	5.34	4.98	3.13	0.85	0.74	0.65	0.14	0.30
22	1.00	1.80	0.90	29.39	3.94	10.22	2.32	0.85	0.80	0.65	0.08	0.30
23	1.20	1.60	0.50	13.70	19.65	4.83	2.30	0.85	0.85	0.65	0.06	0.33
24	2.60	0.10	0.50	7.70	7.80	8.06	3.90	0.85	0.85	0.65	0.06	0.33
25	1.40	7.08	0.70	6.58	17.07	6.74	3.05	0.85	0.85	0.65	0.14	0.41
26	3.43	6.06	0.50	17.34	11.72	3.82	1.97	0.85	0.91	0.60	0.12	0.44
27	6.90	1.20	0.20	7.84	6.43	5.46	1.63	0.80	0.96	0.56	0.06	0.36
28	6.40	2.28	4.45	6.55	5.10	4.15	1.63	0.74	0.96	0.56	0.06	0.34
29	7.40	7.84	4.02	5.27	4.39	7.68	1.63	0.76	0.91	0.56	0.32	0.24
30	1.60	1.60	4.47	4.98	-	5.57	1.63	1.48	0.80	0.61	0.78	0.21
31	1.20	-	19.07	5.66	-	4.98	-	1.15	-	1.07	0.75	-
Average	2.82	4.60	4.56	9.46	6.22	10.84	5.10	1.66	0.82	0.71	0.17	0.42

TABLE G-12 (CONTINUED)

MEAN DAILY FLOW (1976-1977)

JRAGUNG RIVER AT BORANGAN BRIDGE (m^3/s)

Day	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1	0.21	0.85	0.94	2.21	8.88	2.26	2.30	1.30	4.12	1.75	0.17	0.09
2	0.21	0.75	0.72	2.00	5.42	3.42	2.30	1.13	5.27	0.70	0.17	0.07
3	0.21	0.60	0.64	1.80	13.38	3.41	1.55	1.06	7.85	0.59	0.17	0.07
4	0.21	0.51	0.59	1.70	7.84	21.86	0.67	1.06	7.82	0.59	0.17	0.07
5	0.21	0.40	0.55	1.70	2.68	11.80	0.48	0.99	6.11	0.59	0.17	0.07
6	0.51	0.30	0.53	1.70	1.46	19.61	0.46	0.87	7.83	0.59	0.16	0.07
7	0.72	0.24	1.78	2.10	1.70	6.65	3.36	0.86	7.72	0.59	0.13	0.07
8	0.83	0.19	0.75	2.27	12.75	10.93	6.40	3.04	10.79	0.59	0.12	0.07
9	0.76	0.17	0.72	2.23	7.12	4.09	5.48	4.30	14.25	0.55	0.12	0.07
10	0.49	0.34	0.72	2.10	3.11	6.49	4.25	8.85	7.49	0.50	0.12	0.07
11	0.36	0.37	1.89	1.83	2.54	6.08	3.95	2.93	4.67	0.50	0.12	0.07
12	1.79	0.38	1.31	1.70	2.10	2.63	3.95	4.50	3.81	0.50	0.12	0.07
13	1.48	3.73	0.96	1.60	9.98	2.55	2.43	4.00	2.41	0.43	0.12	0.07
14	2.33	2.22	0.96	1.40	4.16	3.86	0.60	3.85	1.66	0.29	0.12	0.07
15	2.54	1.81	0.96	1.20	2.05	15.39	0.53	3.70	1.35	0.18	0.12	0.07
16	1.69	9.17	0.96	0.98	1.23	8.71	0.51	2.78	1.35	0.13	0.11	0.07
17	2.71	6.98	0.96	0.82	0.84	5.34	0.70	1.41	1.28	0.10	0.10	0.07
18	1.81	4.46	0.91	0.78	0.67	7.59	2.74	0.81	1.07	0.05	0.11	0.07
19	1.48	3.05	0.86	0.78	0.57	12.70	3.01	0.77	0.93	0.03	0.12	0.07
20	1.48	1.90	1.10	0.78	0.57	26.63	1.78	0.68	0.93	0.02	0.12	0.07
21	1.48	22.95	1.13	0.78	0.71	7.80	6.54	0.61	0.93	0.02	0.12	0.07
22	1.74	11.47	1.01	15.52	0.69	3.76	12.91	4.62	1.44	0.02	0.12	0.07
23	1.10	6.76	0.96	3.38	0.62	3.06	15.89	5.22	1.00	0.02	0.13	0.07
24	0.85	7.90	0.91	1.28	5.04	6.30	8.94	1.69	0.94	0.02	0.14	0.07
25	0.85	3.80	0.86	0.72	14.37	6.99	5.23	1.26	0.93	0.02	0.14	0.07
26	0.85	9.74	0.86	0.61	18.88	4.16	2.70	5.08	1.20	0.02	0.14	0.07
27	1.25	6.71	0.86	0.86	5.05	3.40	2.00	3.80	1.62	0.03	0.14	0.07
28	0.75	2.62	0.86	0.78	1.68	2.55	1.42	4.05	1.35	0.05	0.13	0.07
29	6.06	1.88	1.52	0.78	–	2.20	1.40	34.90	1.28	0.10	0.12	0.07
30	7.43	2.03	2.44	0.78	–	2.30	1.40	9.10	1.20	0.15	0.11	0.07
31	1.30	–	1.90	1.50	–	2.30	–	3.37	–	0.17	0.10	–
Average	1.47	3.81	1.07	1.89	4.86	7.32	3.53	3.95	3.69	0.32	0.13	0.07

TABLE G-12 (CONTINUED)

MEAN DAILY FLOW (1977 - 78)

JRAGUNG RIVER AT BORANGAN BRIDGE (m^3/s)

Day	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1	0.05	0.00	2.37	17.01	50.23	3.16	0.76	5.38	1.37	1.84	7.28	0.17
2	0.05	0.01	5.57	4.05	15.05	3.08	0.86	3.72	0.79	1.43	2.24	0.27
3	0.05	0.74	2.42	1.96	4.99	4.74	3.66	1.59	3.25	0.96	1.51	12.23
4	0.05	0.66	3.99	6.72	3.01	8.36	3.02	3.64	2.75	0.94	1.31	2.58
5	0.05	2.12	1.46	2.60	9.95	3.20	1.50	3.94	1.58	0.85	1.34	1.21
6	0.03	0.06	4.91	4.35	3.62	4.01	1.01	1.43	1.08	0.85	2.16	1.32
7	0.01	0.33	4.40	3.40	2.33	7.32	1.54	0.92	0.85	0.85	3.06	0.96
8	0.01	2.09	1.71	1.91	1.83	3.43	1.01	0.75	1.16	1.90	1.09	1.05
9	0.02	0.84	1.06	9.47	2.78	3.67	0.86	0.60	1.27	2.39	0.66	14.43
10	0.04	0.35	0.88	3.18	4.41	6.58	0.94	0.92	1.03	1.87	0.47	10.69
11	0.06	0.30	0.83	2.25	3.36	3.65	1.31	0.69	0.75	2.80	0.44	4.12
12	0.04	0.21	0.74	2.76	3.41	1.88	13.27	0.65	0.56	8.71	0.36	1.89
13	0.08	0.18	0.71	8.10	2.38	1.56	6.38	0.75	3.20	5.82	0.27	1.02
14	0.09	0.16	1.97	5.60	1.11	1.41	11.53	7.27	2.11	2.81	0.21	0.90
15	0.10	2.14	0.74	3.36	12.38	2.63	2.62	6.94	1.16	1.65	0.19	0.85
16	0.10	0.32	2.42	5.44	4.51	2.18	1.54	3.09	1.41	1.15	0.32	0.90
17	0.10	0.06	1.01	1.92	4.53	1.63	1.16	7.82	1.27	0.90	0.84	0.85
18	0.09	0.06	0.65	1.69	1.93	5.58	0.93	3.13	1.14	0.56	0.37	0.65
19	0.05	0.05	0.50	10.19	1.09	3.50	0.86	4.88	0.96	1.29	0.77	0.56
20	0.06	0.38	0.42	12.85	32.99	4.22	0.95	2.26	0.79	1.63	1.17	0.51
21	0.06	0.08	0.35	4.58	24.88	7.81	1.83	4.47	0.74	0.54	0.55	3.60
22	0.07	0.12	3.19	3.47	28.24	11.97	0.85	2.31	1.26	0.33	0.23	1.94
23	0.05	0.08	1.83	20.49	7.01	5.17	0.82	1.71	1.65	0.33	0.23	0.86
24	0.05	0.06	3.24	4.33	3.96	4.06	0.83	1.56	1.04	0.23	0.23	0.56
25	0.07	0.29	1.41	8.68	3.03	2.19	0.87	1.42	0.74	0.23	0.12	0.40
26	0.06	0.18	0.73	10.53	4.92	1.51	1.10	1.43	1.07	0.30	0.11	0.30
27	0.05	0.03	0.66	5.35	4.00	1.45	0.75	0.90	1.02	0.22	0.07	0.27
28	0.08	0.01	1.98	4.27	4.61	1.56	0.65	0.70	0.90	0.62	0.06	0.24
29	0.18	1.33	1.74	2.62	-	1.32	0.65	0.51	1.63	0.64	0.07	0.29
30	0.08	0.76	13.43	3.82	-	1.09	2.34	0.44	2.49	0.40	0.09	0.68
31	0.05	-	41.20	3.83	-	0.85	-	0.52	-	18.69	0.11	-
Average	0.06	0.48	3.50	5.83	8.81	3.70	2.22	2.46	1.37	2.06	0.90	2.21

TABLE G-12 (CONTINUED)

MEAN DAILY FLOW (1978-79)

RAGUNG RIVER AT BORANGAN BRIDGE (m^3/s)

Day	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1	0.33	2.59	0.13	8.63	28.60	0.75	2.65	1.34				
2	0.24	1.71	7.48	9.87	19.13	0.60	2.85	11.40				
3	15.47	1.09	6.67	4.64	3.55	0.18	2.74	3.81				
4	2.84	1.13	2.22	3.46	1.00	1.03	30.88	1.24				
5	0.94	2.07	1.86	11.60	2.91	1.77	15.95	7.11				
6	0.66	2.00	2.60	3.30	1.79	3.77	35.55	2.92				
7	0.65	6.81	2.96	1.67	1.41	20.22	7.23	1.61				
8	0.65	2.27	4.32	2.63	0.91	11.30	10.53	0.98				
9	0.44	1.79	2.53	12.59	0.62	6.66	7.74	1.46				
10	0.31	1.35	1.50	4.91	9.58	2.93	3.59	1.80				
11	0.21	1.33	1.66	2.25	8.61	1.96	13.24	1.87				
12	0.21	1.02	2.56	13.18	5.39	2.14	15.35	1.02				
13	0.19	0.87	3.45	22.55	3.18	1.63	18.88	0.75				
14	0.14	0.85	3.00	12.49	1.69	1.03	10.67	0.75				
15	0.26	1.01	1.91	36.74	3.53	4.14	3.54	0.67				
16	0.31	0.77	2.62	9.04	2.30	1.07	6.67	0.43				
17	0.23	0.41	2.06	4.50	1.63	6.55	3.06	0.36				
18	0.71	1.06	0.95	2.31	3.55	3.62	1.71	0.33				
19	0.76	1.04	0.85	1.75	1.35	2.01	1.49	0.27				
20	1.30	0.64	0.72	1.79	2.21	2.80	2.81	3.80				
21	4.24	0.38	1.53	5.83	2.33	2.59	3.29	1.47				
22	2.00	0.40	8.62	2.84	2.51	1.24	5.14	6.92				
23	0.78	0.34	8.91	1.48	4.91	0.75	2.40	7.36				
24	0.46	0.31	3.58	1.26	3.28	2.28	1.23	2.22				
25	0.36	0.25	2.49	3.31	1.52	1.22	1.03	0.94				
26	0.75	0.19	1.79	2.15	1.05	0.74	1.76	0.55				
27	0.94	0.14	1.37	2.21	0.96	0.60	1.98	0.51				
28	0.52	0.17	22.64	1.69	0.85	0.56	0.92	0.55				
29	0.36	0.17	14.40	4.47		0.86	1.08	0.60				
30	0.33	0.14	3.33	2.71		0.65	0.85	0.51				
31	12.28		4.33	2.71		0.97		2.06				
Average	1.61	1.14	4.03	6.47	4.23	2.86	7.23	2.18				

TABLE H-13

SUSPENDED SEDIMENT YIELD

JRAGUNG CATCHMENT UPSTREAM FROM BORANGAN BRIDGE

Water Year	Month	Suspended Sediment kg	Water Discharged m^3	Monthly Average Concentration mg/l
1977-78	Nov	16,620,000	1,256,000	13,200
	Dec	386,073,000	9,377,000	41,200
	Jan	175,078,000	15,619,000	11,200
	Feb	513,583,000	21,302,000	24,200
	Mar	33,007,000	9,915,000	3,330
	Apr	56,560,000	5,750,000	9,840
	Total	1,180,921,000	63,219,000	
1978-79	Oct	48,733,000	4,311,000	11,300
	Nov	10,766,000	2,964,000	3,630
	Dec	76,719,000	10,802,000	7,100
	Jan	105,780,000	17,328,000	6,100
	Feb	107,850,000	10,228,000	10,500
	Mar	51,746,000	7,656,000	6,760
	Apr	213,768,000	18,732,000	11,410
	May	48,882,000	5,844,000	8,360
	Total	664,244,000	80,385,000	

TABLE H-14

MONTHLY STREAMFLOW

JRAGUNG RIVER AT THE BORANGAN BRIDGE

(10^6 m^3)

Water Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1972-1973								23.9	6.3	4.3	0.3	6.0	-
1973-1974	3.7	11.4	18.3	13.6	17.9	32.3	13.6	8.1	2.5	1.1	1.4	3.8	127.7
1974-1975	10.8	12.0	8.3	20.4	9.9	16.6	23.3	17.0	0.3	0.0	0.1	3.8	122.5
1975-1976	7.6	11.9	12.2	25.3	15.6	29.0	13.2	4.4	2.1	1.9	0.5	1.1	124.8
1976-1977	3.9	9.9	2.9	5.1	11.8	19.6	9.2	10.6	9.6	0.8	0.4	0.2	84.0
1977-1978	0.2	1.3	9.4	15.6	21.3	9.9	5.8	6.6	3.5	5.5	2.4	5.6	87.2
1978-1979	4.3	3.0	10.8	17.3	10.2	7.7	18.7	5.8					-
Short-term Mean	5.1	8.2	10.3	16.2	14.4	19.2	14.0	10.9	4.0	2.3	0.8	3.4	108.8

TABLE H-15

BASIN RAINFALL AND STREAMFLOW
JRAGUNG RIVER AT BORANGAN BRIDGE

Water Year	Month	Rainfall mm	Percent of Long-term Rainfall	Streamflow 10^6 m^3	Percent of Long-term Streamflow
1977-78	Nov	168	67	1.3	15
	Dec	302	94	9.4	63
	Jan	367	87	15.6	60
	Feb	392	111	21.3	102
	Mar	194	54	9.9	45
	Apr	164	64	5.8	39
	Season	1,587	81	63.3	59
1978-79	Oct	115	97	4.3	116
	Nov	85	34	3.0	34
	Dec	375	116	10.8	72
	Jan	331	78	17.3	66
	Feb	241	68	10.2	49
	Mar	216	60	7.7	34
	Apr	405	158	18.7	127
	May	171	86	5.8	66
	Season	1,979	85	77.8	65

TABLE H-16

LONG-TERM SUSPENDED SEDIMENT LOAD

JRAGUNG RIVER AT BORANGAN BRIDGE

Month	Average Concentration mg/l	Long-term Streamflow 10^6 m^3	Long-term Suspended Sediment metric ton
Oct	11,300	3.71	41,900
Nov	8,420	8.78	73,900
Dec	24,200	14.91	360,800
Jan	8,650	26.14	226,100
Feb	17,400	20.79	361,700
Mar	5,050	22.24	112,300
Apr	10,600	14.71	155,900
May	8,360	10.00	83,600
Remainder	500	8.34	4,200
		129.62	1,420,400

TABLE H-17

ANNUAL FLOW DURATION CURVE

JRAGUNG RIVER AT BORANGAN BRIDGE

Limits %	Interval %	Mid Ordinate %	Discharge m^3/s	Interval x Discharge % m^3/s
0.00-0.02	0.02	0.01	300	6.00
0.02-0.1	0.08	0.06	100	8.00
0.1-0.5	0.4	0.3	50	20.00
0.5-1.5	1.0	1.0	35	35.00
1.5-5.0	3.5	3.25	17	63.00
5-15	10	10	10.5	105.00
15-25	10	20	6.5	65.00
25-35	10	30	4.2	42.00
35-45	10	40	2.8	28.00
45-55	10	50	1.8	18.00
55-65	10	60	1.0	10.00
65-75	10	70	0.57	5.70
75-85	10	80	0.32	3.20
85-95	10	90	0.18	1.80
95-98.5	3.5	96.75	0.12	0.42
98.5-99.5	1.0	99.0	0.11	0.11
99.5-99.9	0.4	99.7	0.105	0.04
99.9-99.98	0.08	99.94	0.102	0.01
99.98-100	0.02	99.99	0.100	0.01
				411.28

Annual Volume of flow = $411.28 \times \frac{3600 \times 24}{100} \times 365.25 = 129.8\ m^3/s.$

TABLE H-18

WATER AND SEDIMENT DISCHARGE

TWICE DAILY METHOD

Year	Month	Volume of Water m^3	Weight of Suspended Sediment kg
1978	Jun	3,294,000	3,000,000
	Jul	3,884,000	5,839,000
	Aug	3,134,000	7,580,000
	Sep	4,[illegible]14,000	14,360,000
	Oct	3,241,000	5,035,000
	Nov	3,447,000	16,122,000
	Dec	11,089,000	76,549,000
1979	Jan	14,490,000	34,417,000
	Feb	9,411,000	123,379,000
	Mar	6,991,000	34,739,000
	Apr	30,275,000	429,624,000
	May	6,341,000	52,397,000
		100,211,000	803,041,000

TABLE H-19

ANNUAL SUSPENDED SEDIMENT
JRAGUNG RIVER AT BORANGAN BRIDGE

1977-1978

Limits %	Interval %	Mid. Ordinate %	Water Discharge m^3/s	Sediment Concentration mg/l	Sediment Load % kg/s
0.00-0.02	0.02	0.01	300	105,000	630.00
0.02-0.1	0.08	0.06	100	68,000	544.00
0.1-0.5	0.4	0.3	50	45,000	900.00
0.5-1.5	1.0	1.0	35	34,000	1,190.00
1.5-5.0	3.5	3.25	17	17,000	1,011.50
5-15	10	10	10.5	9,500	997.50
15-25	10	20	6.5	4,700	305.50
25-35	10	30	4.2	2,100	88.20
35-45	10	40	2.8	900	25.20
45-55	10	50	1.8	300	5.40
55-65	10	60	1.0	10	0.10
65-75	10	70	0.57	10	0.06
75-85	10	80	0.32	10	0.03
85-95	10	90	0.18	10	0.02
95-98.5	3.5	96.75	0.12	10	0.00
98.5-99.5	1.0	99.0	0.11	10	0.00
99.5-99.9	0.4	99.7	0.105	10	0.00
99.9-99.98	0.08	99.94	0.102	10	0.00
99.98-100	0.02	99.99	0.100	10	0.00
					5697.51

Annual suspended sediment load

$$= \frac{5,697.51}{100} \times 3,600 \times 24 \times 365.25 = 1,800 \times 10^6 \text{ kg}$$

$$= 17,800 \text{ t/km}^2$$

TABLE H-20

ANNUAL SUSPENDED SEDIMENT

JRAGUNG RIVER AT BORANGAN BRIDGE

1978 - 1979

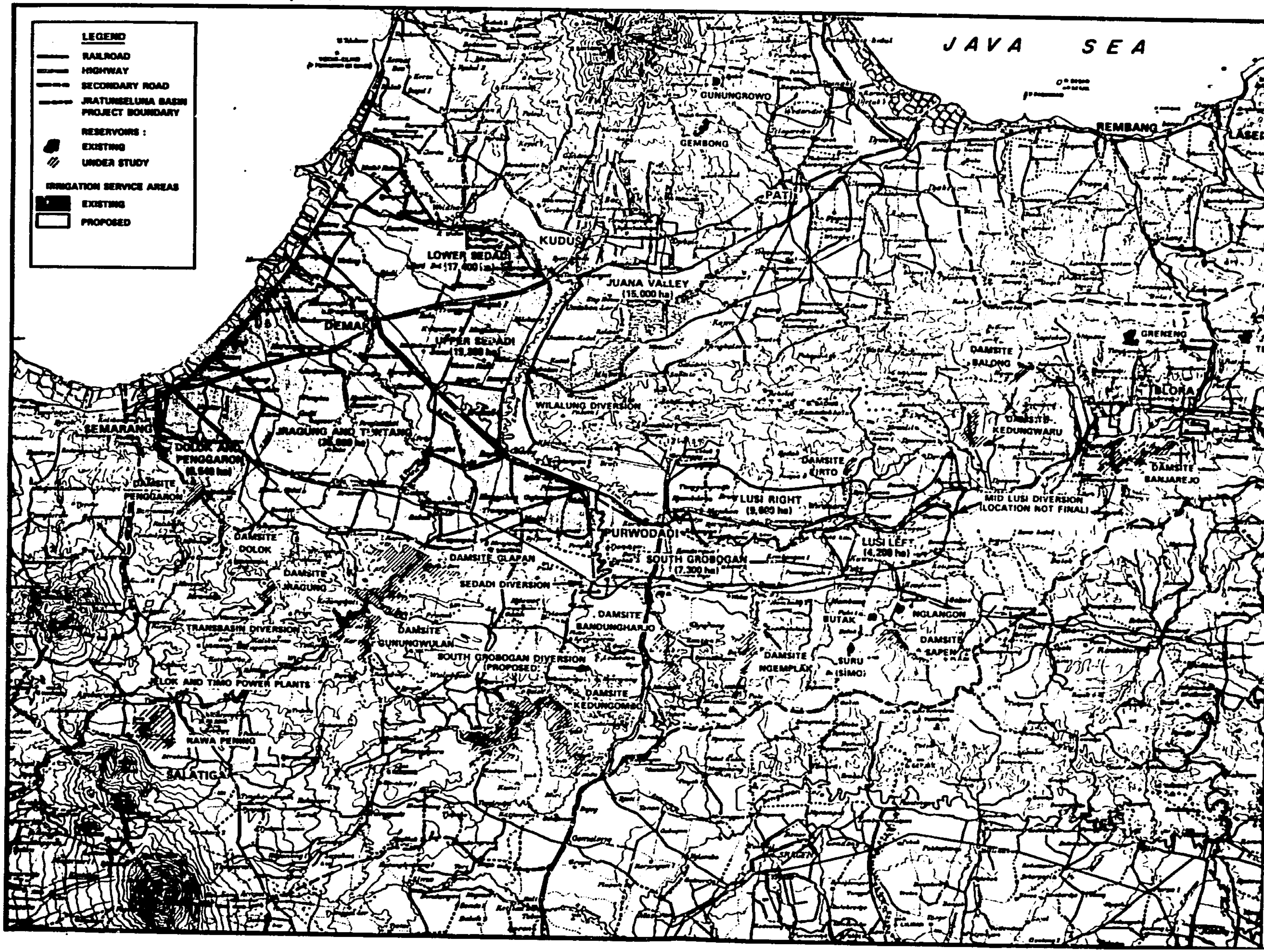
Limits %	Interval %	Mid Ordinate %	Water Discharge m^3/s	Sediment Concentration kg/s	Sediment Load % kg/s
0.00-0.02	0.02	0.01	300	42,000	252.00
0.02-0.1	0.08	0.06	100	27,000	216.00
0.1 -0.5	0.4	0.3	50	19,000	380.00
0.5 -1.5	1.0	1.0	35	15,000	525.00
1.5 -5.0	3.5	3.25	17	8,200	487.90
5-15	10	10	10.5	5,200	546.00
15-25	10	20	6.5	3,000	195.00
25-35	10	30	4.2	1,800	75.60
35-45	10	40	2.8	1,100	27.50
45-55	10	50	1.8	600	10.80
55-65	10	60	1.0	270	2.70
65-75	10	70	0.57	100	0.57
75-85	10	80	0.32	10	0.03
85-95	10	90	0.18	10	0.02
95-98.5	3.5	96.75	0.12	10	0.00
98.5-99.5	1.0	99.0	0.11	10	0.00
99.5-99.9	0.4	99.7	0.105	10	0.00
99.9-99.98	0.08	99.94	0.102	10	0.00
99.98-100	0.02	99.99	0.100	10	0.00
					2718.22

Annual suspended sediment load

$$= \frac{2718.22 \times 3{,}600 \times 24 \times 365.25}{100} = 858 \times 10^6 \text{ kg}$$

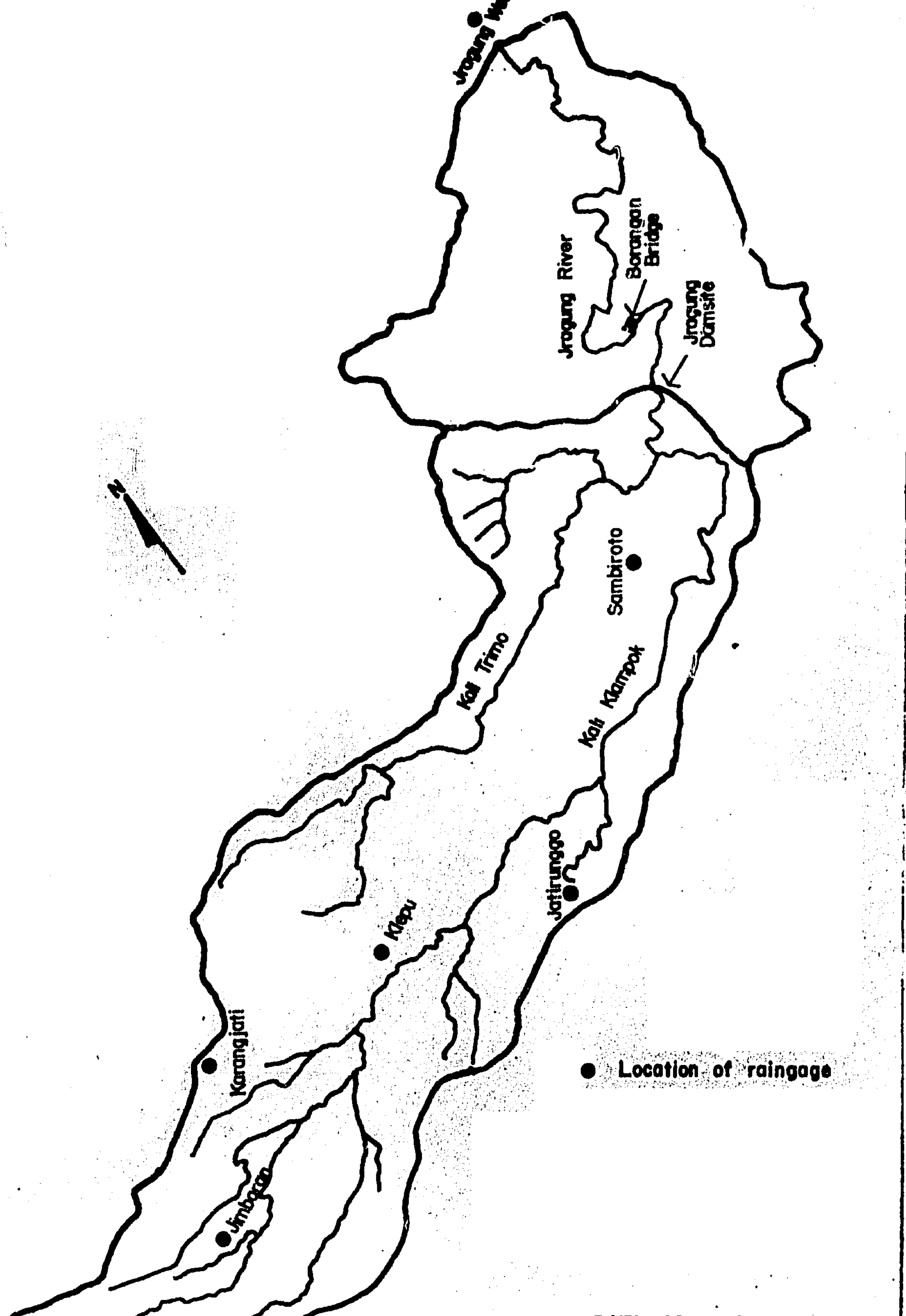
$$= 8{,}500 \text{ t/km}^2.$$

FIGURE II-



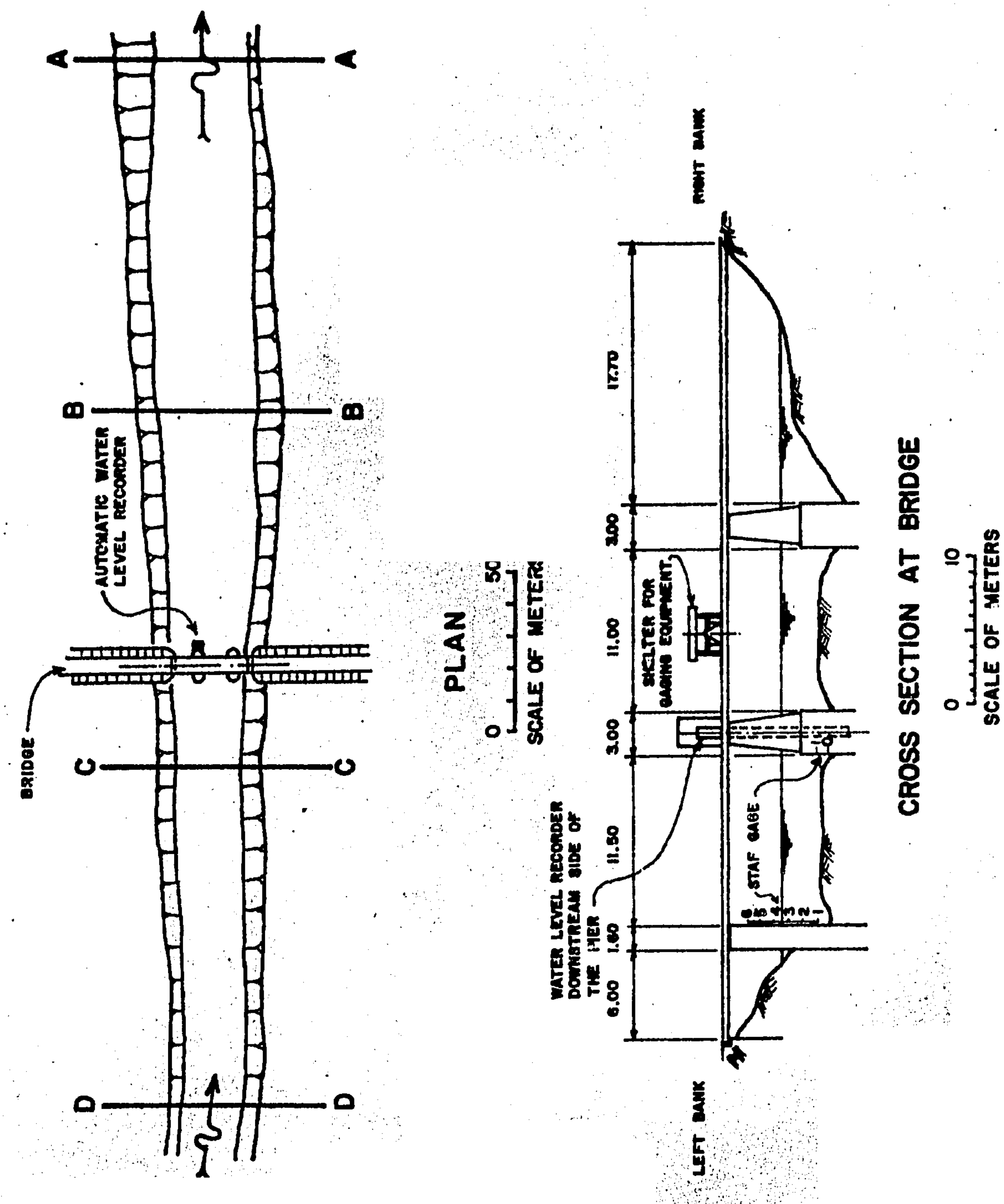
REPUBLIC OF INDONESIA
MINISTRY OF PUBLIC WORKS
DIRECTORATE GENERAL OF WATER RESOURCES DEVELOPMENT
JRATUNSELUNA BASIN DEVELOPMENT PROJECT

JRATUNSELUNA BASIN
UPDATED DEVELOPMENT PLAN
LOCATION MAP



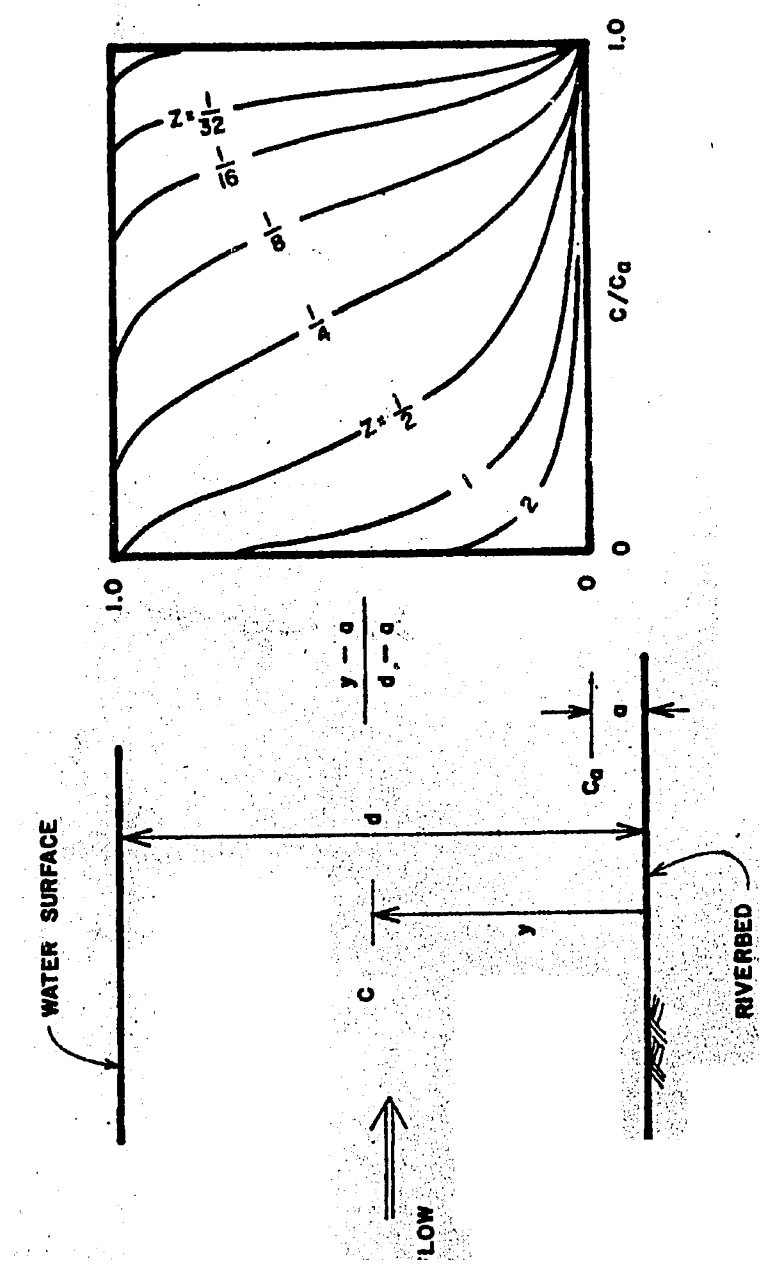
JRATUNSELUNA BASIN

JRAGUNG WATERSHED LOCATION MAP



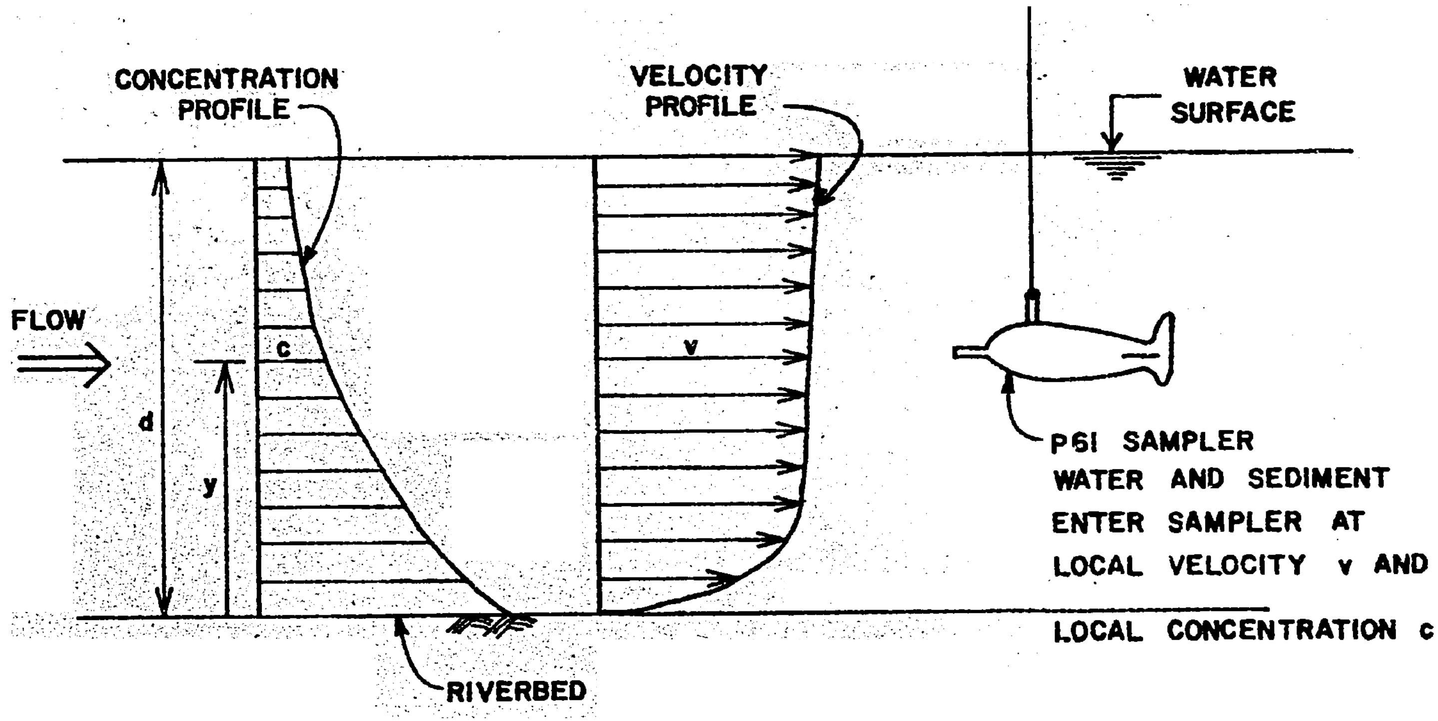
JRATUNSELUNA BASIN

JRAGUNG RIVER
AT THE
BORANGAN BRIDGE



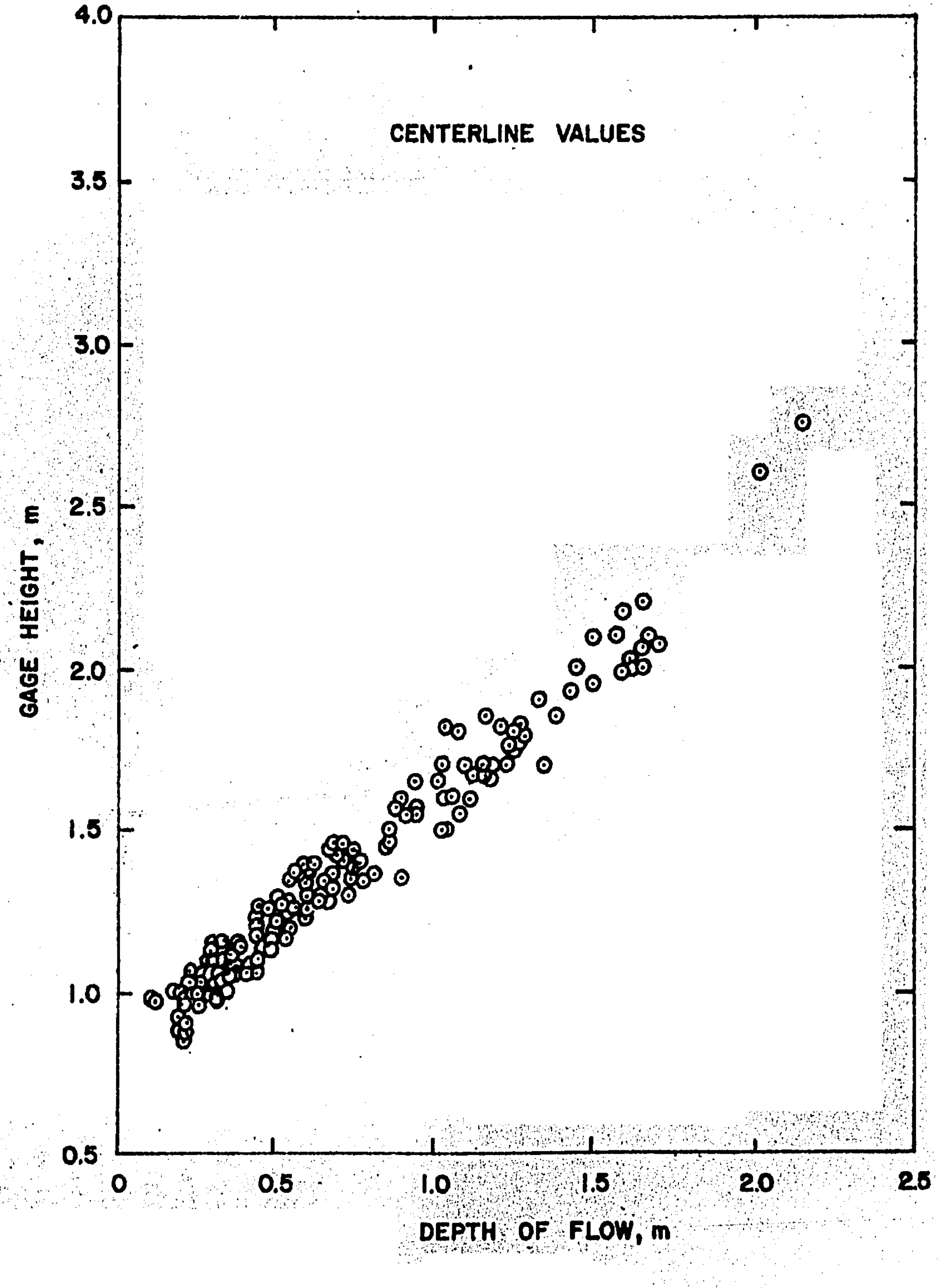
JRATUNSELUNA BASIN

VARIATION OF SEDIMENT CONCENTRATION WITH DEPTH



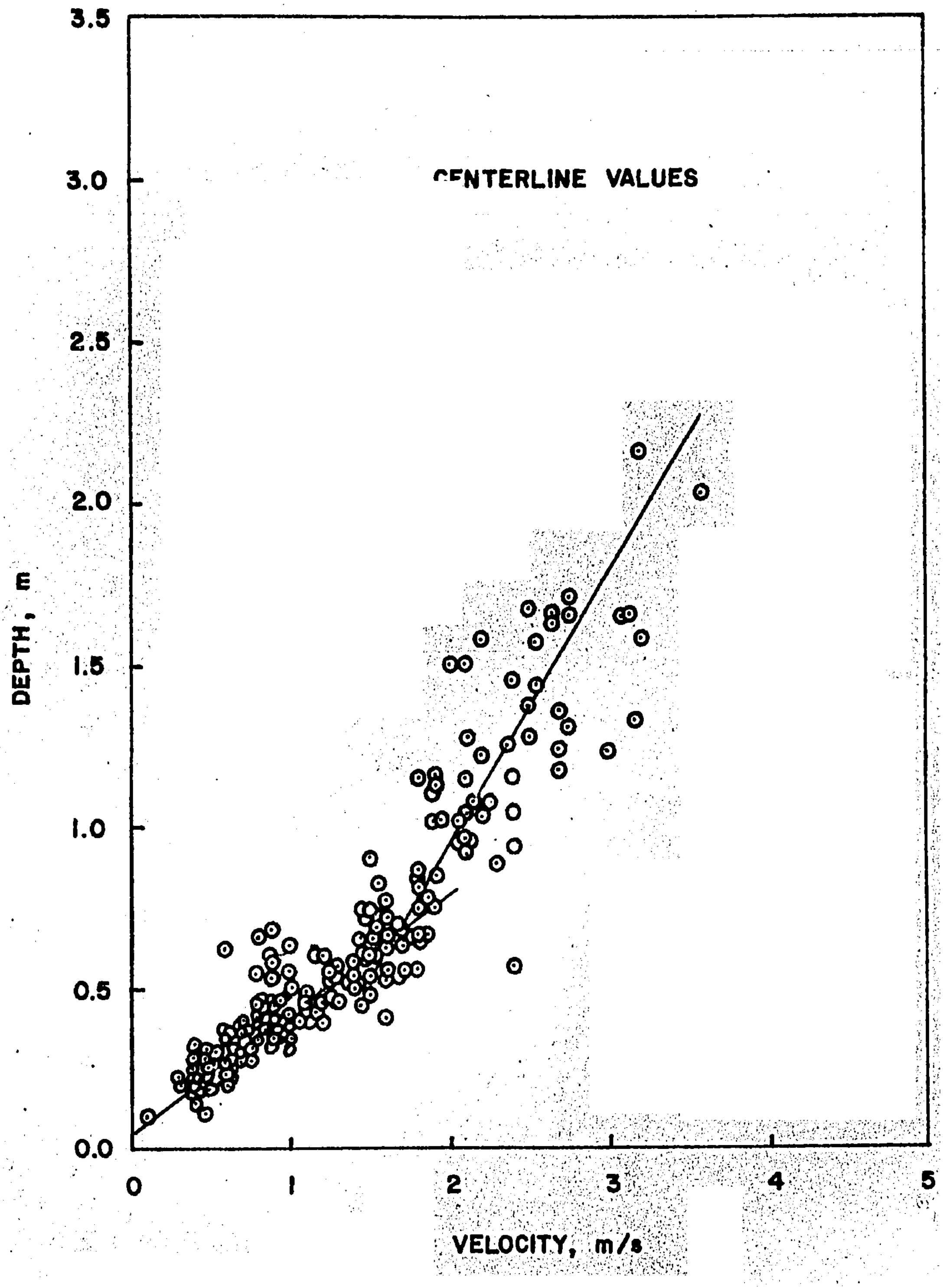
JRATUNSELUNA BASIN

SAMPLING SUSPENDED SEDIMENT WITH P61



JRATUNSELUNA BASIN

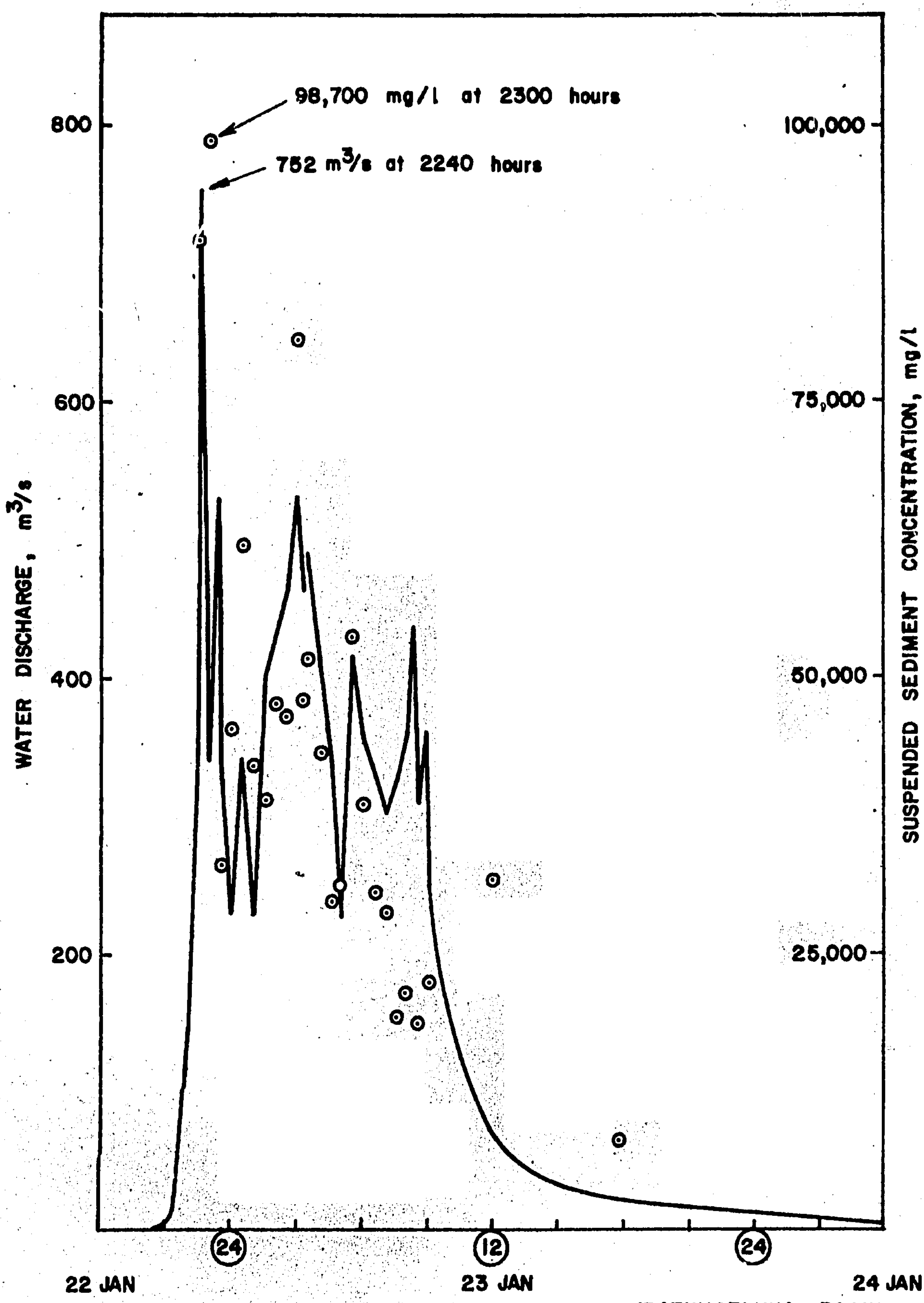
JRAGUNG RIVER
DEPTH OF FLOW



JRATUNSELUNA BASIN

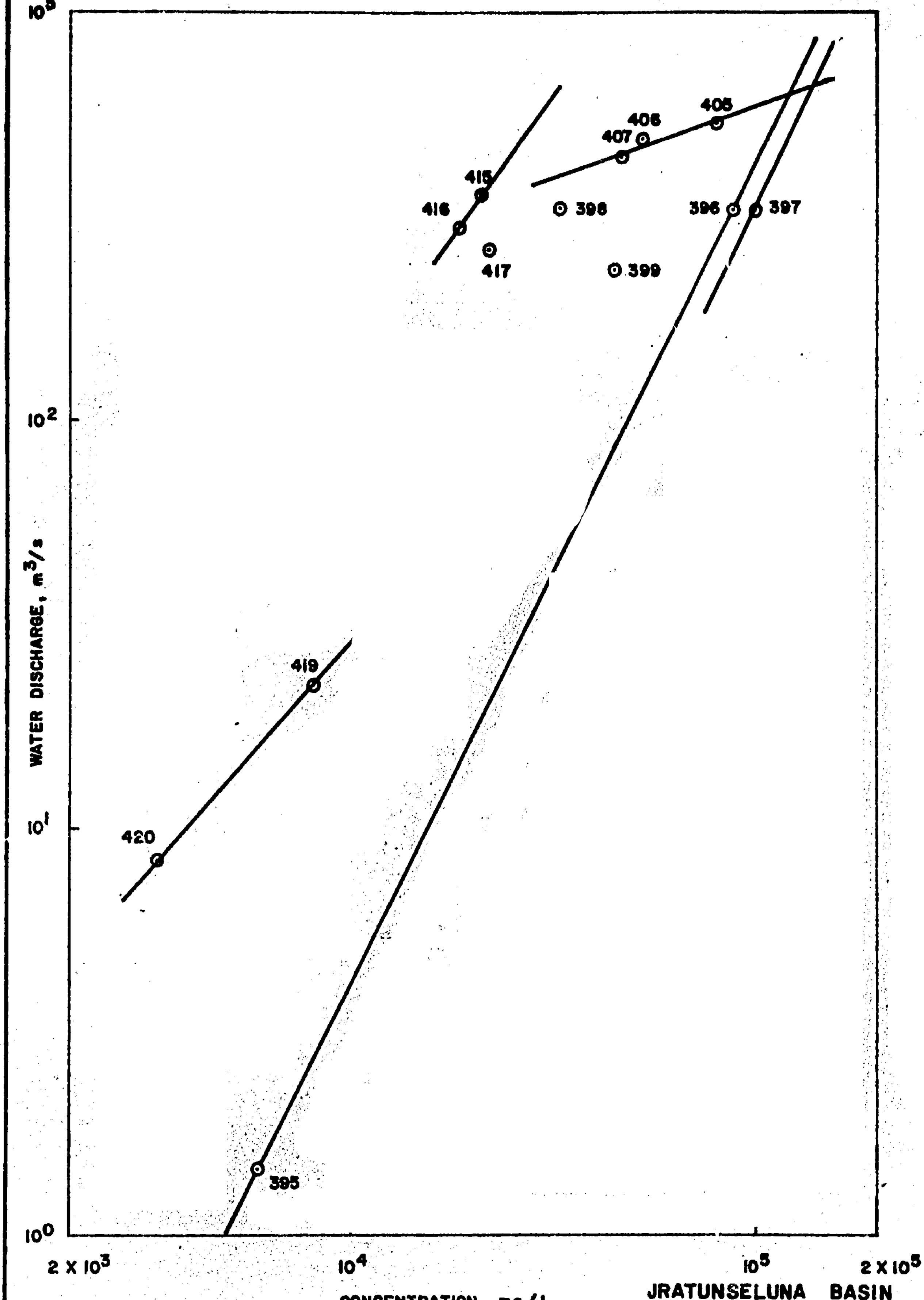
JRAGUNG RIVER
DEPTH AND VELOCITY
OF FLOW

FIGURE H - 7



JRATUNSELUNA BASIN

JRAGUNG RIVER
FLOOD OF 22 JANUARY 1980

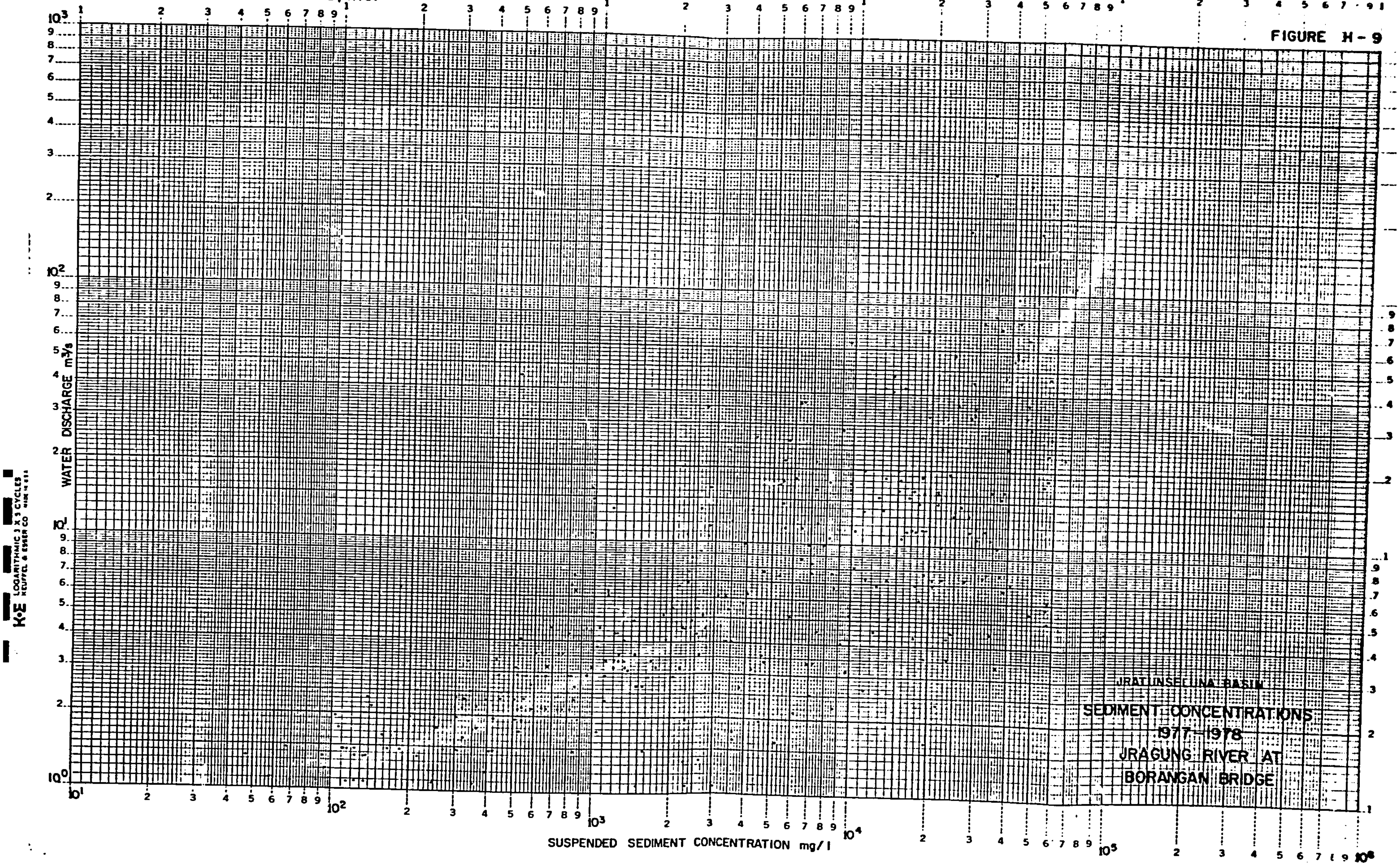


JRATUNSELUNA BASIN

JRAGUNG RIVER
GRAPH FOR INTERPOLATION

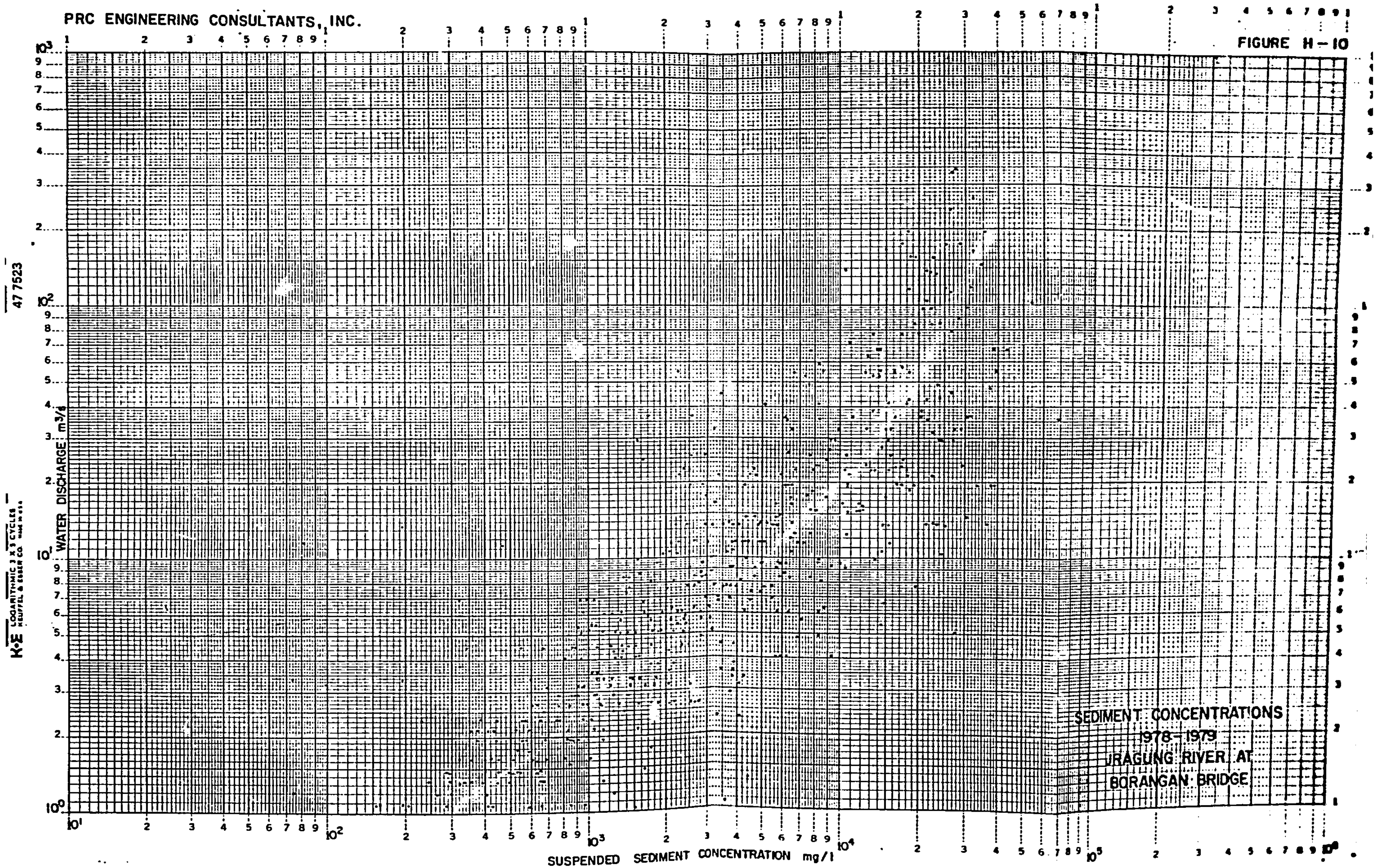
PRC ENGINEERING CONSULTANTS, INC.

FIGURE H-9

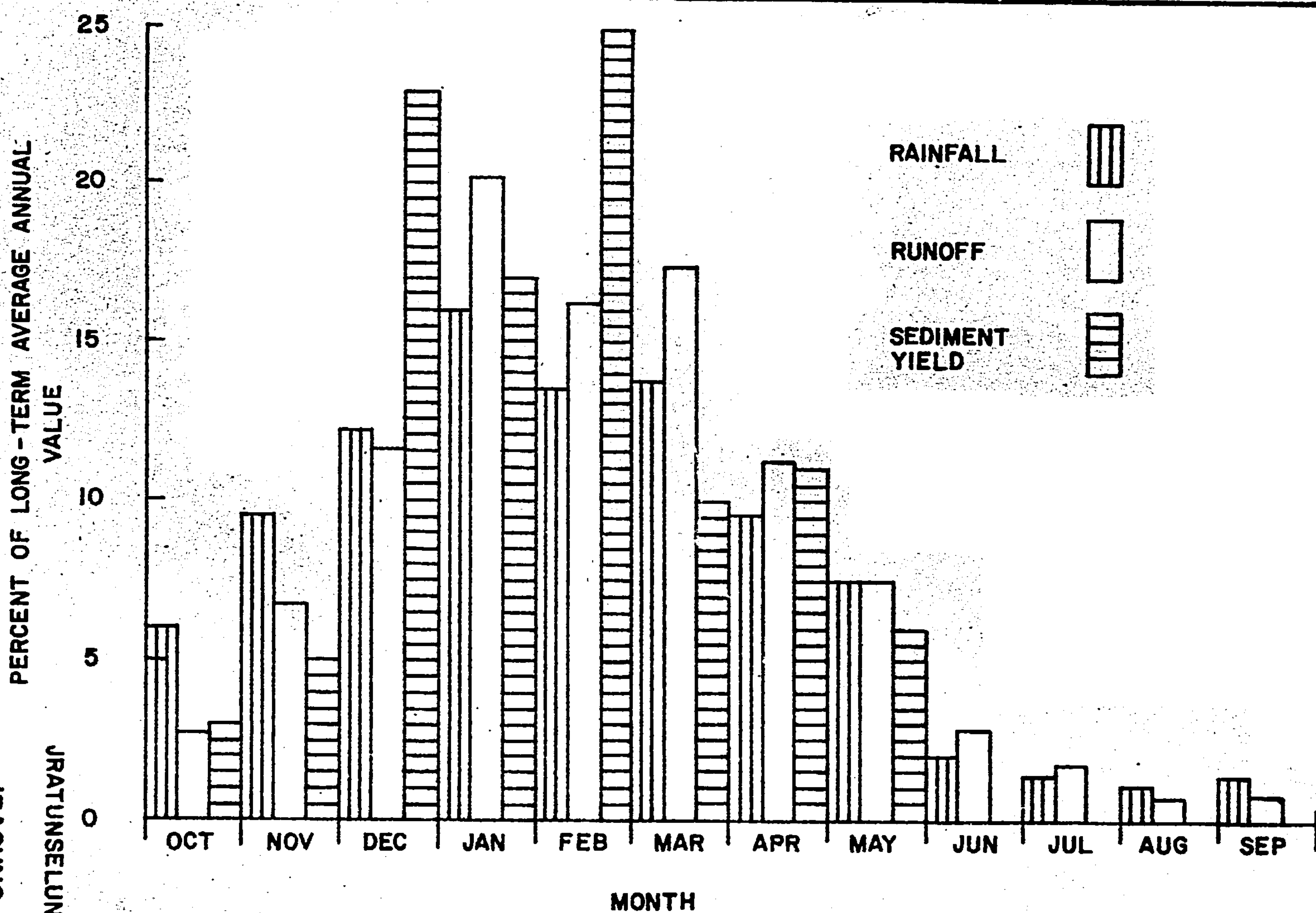


PRC ENGINEERING CONSULTANTS, INC.

FIGURE H-10



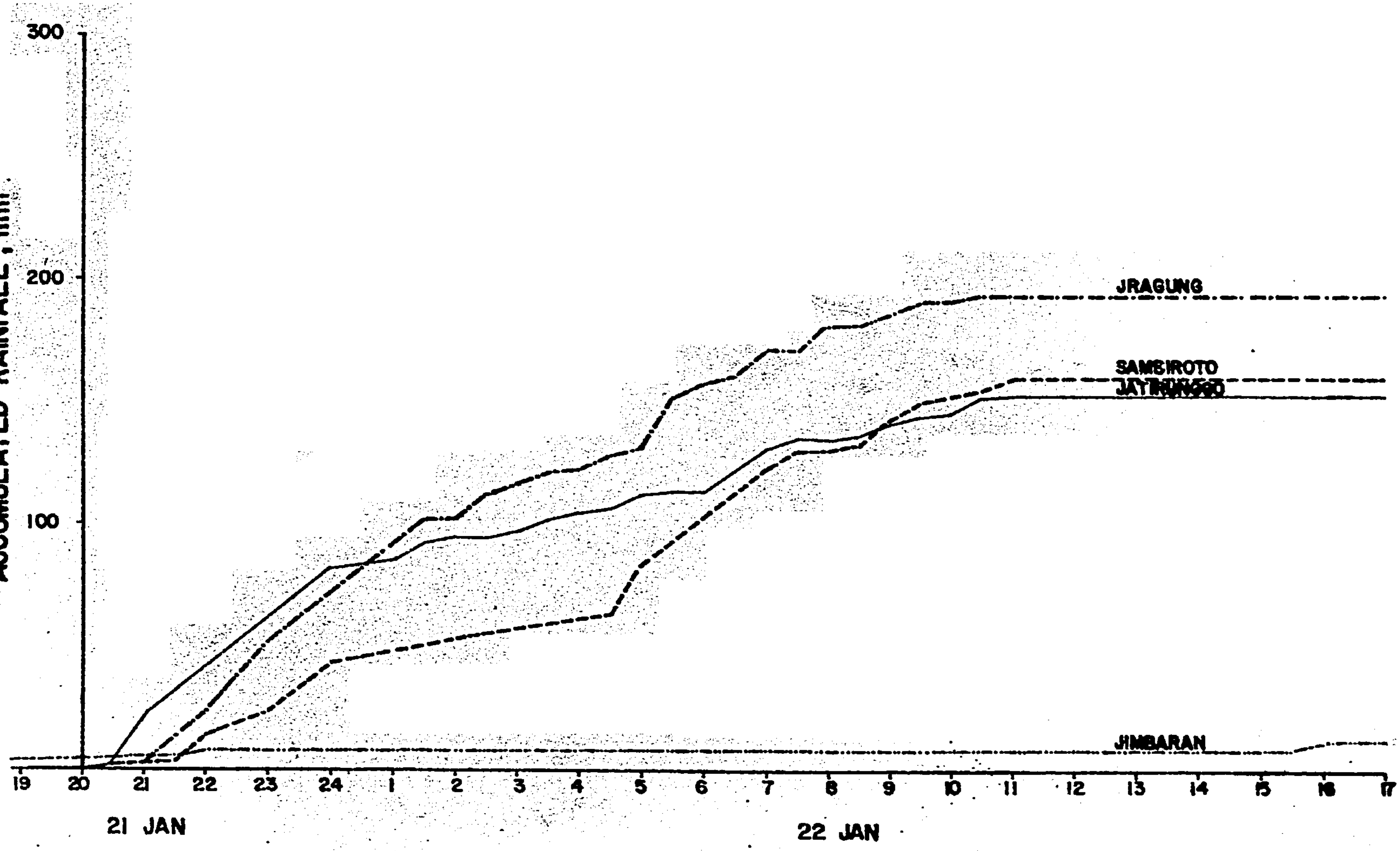
PRC ENGINEERING CONSULTANTS, INC.



JRATUNSELUNA BASIN
JRAGUNG RIVER
MONTHLY DISTRIBUTIONS

FIGURE H - 11

JRATUNSELUNA BASIN
JRAGUNG WATERSHED
RAINFALL INTENSITY
21,22 JANUARY 1980



PRC ENGINEERING CONSULTANTS, INC.

FIGURE H-12

LIST OF REFERENCES

The following publications were reviewed during the course of the Jragung River sedimentation studies.

A1 American Society of Civil Engineers, "Sedimentation Engineering", Manuals and Reports on Engineering Practice No. 54, Vito A. Vanoni, editor, New York 1975.

A2 Afiat, M, Angdi A., Atmakusuma S, Notosugondo, H, Purbo-Hadiwidjojo, M, and Soedigno, "The Water Resources of Indonesia, Their Potentials and Their Utilization at Present, " paper presented at International Conference on Water for Peace, Washington, D.C. May 23-31; 1967.

A3 Ayers, R.S. & Westcot, D.W., "Water Quality for Agriculture," FAO Irrigation and Drainage Paper No. 29, Rome, 1976.

B2 Bols, P.L. "The Iso-erodent Map of Java and Madura", Belgian Technical Assistance Project, ATA 105, Soil Research Institute, Bogor, Indonesia, p. 38, 1978.

B3 Brune, G.M. "Trap Efficiency of Reservoirs". Trans. Amer. Geophy. Union, Vol. 34, pp. 407-418, 1953.

C1 Churchill, M.A., discussion of "Analysis and Use of Reservoir Sedimentation Data," by L.C. Gottschalk, Proceeding of the Federal Interagency Sedimentation Conference, Denver, Colorado, pp. 139-140, 1947.

C2 Coster C., "Bovengrondse afstroming in erosic op Java", Tectone XXXI, p. 458, 1938.

C3 Caughran, G.W., "Comments and Suggestions Concerning Erosion Experimental Basin at Waspada". UNDP, OTC/SF Project Ins-27, March 1972.

D1 Dames, T.W.G., "The Soils of East Central Java, with a Soil map 1:250,000", Nr 141, Contributions of the General Agricultural Research Station, Bogor, Java, January, 1955.

D2 Dijk, J.W. Van & Vogelzang, W.L.M., "The Influence of Improper Soil Management on Erosion Velocity in the Tjiloetoeng Basin", (Residency of Cheribon, West Java) Medelingen van het Algemeen Proefstation voor de Landbouw, No. 71, 1948.

D3 Dijk, J.W. Van & Ehrencron, V.K.R., "The Different Rate of Erosion within Two Adjacent Basins in Java", Medelingen van het Algemeen Proefstation voor de Landbouw, No. 48, 1949.

E1 Engineering Consultants, Inc.," Jragung Dam Multi-Purposed Irrigation, Flood Control, Hydro-Electric and Municipal and Industrial Water Supply Project, Upgraded Feasibility Study, Appendix II, Hydrology," prepared for Republic of Indonesia, Ministry of Public Works and Electric Power, Directorate General of Water Resources Development, Directorate of Irrigation, Jakarta, September 1976.

E2 Engineering Consultants, Inc., "Jragung Dam Project, Final Design Report, Part I, Text," prepared for the Directorate General of Water Resources and Development, Ministry of Public Works, Republic of Indonesia, April 1979.

E3 Engineering Consultants, Inc., "Citanduy Basin Feasibility Report," prepared for Directorate of Rivers, Directorate General of Water Resources and Development, Ministry of Public Works, Republic of Indonesia, November 1974.

E4 Engineering Consultants, Inc., "Upgraded Feasibility Study for Jragung Dam," for Ministry of Public Works and Electric Power, Directorate General of Water Resources Development, Republic of Indonesia, 1976.

E5 Engineering Consultants Inc., "Jragung Dam Project, Upstream Watershed Management, Jragung River," prepared for Republic of Indonesia, Directorate of Irrigation/Prosida, Directorate General of Water Resources Development, Ministry of Public Works, 1979.

G1 Geological Survey of Indonesia, "Geological Map of Java and Madura, Sheet Central Java," Second edition, Directorate General of Mines, Ministry of Mines, 1977.

G2 Goeltenboth, F., "The Rawa Pening Lake-Background Information, Facts and Problems," Proc. of the First Seminar in Aquatic Biology and Aquatic Management of the Rawa Pening Lake, Satya Wacana Christian University, Salatiga, Central Java, November 20-21, 1978.

G3 Gottschalk, L.C., "Reservoir Sedimentation", Section 17-I, Handbook of Applied Hydrology, Editor, Ven Te Chow, McGraw-Hill Book Co, 1964.

G4 Guy, H.P., "Laboratory Theory and Methods for Sediment Analysis", United States Geological Survey Techniques of Water Resources Investigations, Book 5, Chapter C1, Washington D.C., 1969

H1 Hershfield, D.M., "Method for Estimating Probable Maximum Rainfall," Journal of American Waterworks Assoc., vol. 57, pp. 965-972, August 1965.

H2 Hollerwoger, F., "The Accelerated Growth of River Deltas in Java." The Indon. Journal of Geography, Vol. 4, No. 7, June 1964.

H3 Hunting Technical Services & Sir M. McDonald, "Kali Progo Basin Study. Supporting Report: Vol. A. Climate and Hydrology," prepared for Ministry of Public Works and Electric Power, Directorate General of Water Resources Development, Republic of Indonesia, 1971.

H4 Haan, J.H. De. "Silt Transportation of Rivers in Java", United Nations Econ. Comm. for Asia and Far East, Proc. of Regional Techn. Conf. on Flood Control in Asia and the Far East, Flood Cont. Ser No. 3, Bangkok, pp. 179-184, 1952.

H5 Hershfield, D.M., "Estimating the Probable Maximum Precipitation," ASCE Hyd. Div. September 1961.

I1 Iswandi Haryanto, "The Seasonal Variation of the Water and Sediment Distribution to the Rawa Pening Lake," Journal of Satya Wacana Research, Vol. Serie 3, Salatiga, Central Java, 1978.

I2 The Institute of Meteorology and Geophysics, "Rain Observations in Indonesia," Department of Communications, Yearbooks 1879 to 1975, Jakarta.

J1 Jratunseluna Project, "Tranchekaart Volgens Opn 1926 Rawa Pening," 1:10,000 scale map prepared for Proyek Rehabilitasi Irigasi Semarang - Kudus, 29 December 1970.

J2 Jratunseluna Project, "Rawa Pening Scale 1:10,000 map", prepared by the Topographical Department, 1976.

J3 Japan International Cooperation Agency, "Study for Making Master Plan For Land Erosion and Volcanic Debris Control in the Area of Mt. Merapi," Progress Report prepared for Republic of Indonesia, March 1979.

K1 Kaul, F.J., "Notes on Design Floods for Reservoir Spillway in Indonesia," Inst. of Hydr. Eng., Bandung, Seminar on rainfall - runoff relations and design floods in Indonesia, 1974.

K2 Klein, H.A., "Oceans and Continents in Motion," J.B. Lippincott Company, New York, 191 pp, 1972.

L1 Lane, E.W., "The Importance of Fluvial Morphology in Hydraulic Engineering," ASCE Proc., Vol. 81, No. 745, 1955.

M1 Meijerink, A. M. J., "A Hydrological Reconnaissance Survey of the Serayu River Basin, Central Java," ITC Journal 4, 1977.

N1 NEDECO, "Jratunseluna Basin Development Plan, Central Java, Glapan Dam, Irrigation, Flood Control and Hydro-Power Project Feasibility Study, Vol. 2, Appendices I - IX, Part B, Tables, Annexes and Figures", prepared for Republic of Indonesia, Ministry of Public Works and Electric Power, Directorate General of Water Resources Development, Jakarta, July 1975.

N2 NEDECO, "Jragung Dam Flood Control and Irrigation Project Feasibility Study," prepared for Directorate General of Water Resources Development, Ministry of Public Works and Electric Power, Republic of Indonesia, August 1973.

N3 NEDECO, "Ngrambat Dam Irrigation, Flood Control and Hydro-Power Project Feasibility Study, Vol. 3 Supporting Data, Jratunseluna Basin Development Plan Central Java," prepared for the Directorate General of Water Resources Development, Ministry of Public Works and Electric Power, Republic of Indonesia, Jakarta, June 1975.

N4 NEDECO, "Jratunseluna Basin Development Project, Prefeasibility Study, Rawa Pening," prepared for the Directorate General of Water Resources Development, Ministry of Public Works and Power, Republic of Indonesia, February 1972.

N5 NEDECO, "Jratunseluna Basin Development Plan, River Morphology", Supporting Report VII, prepared for the Directorate General of Water Resources Development, Ministry of Public Works and Electric Power, Republic of Indonesia, July 1973.

N6 NEDECO, "Sedeku - Prosida Semarang - Demak - Kudus Irrigation Rehabilitation Project, Quarterly Report No. 3," prepared for the Directorate General of Water Resources Development, Ministry of Public Works, Republic of Indonesia, October 1948.

N7 National Irrigation Administration and Engineering Consultants, Inc., "Draft Feasibility Report, Magat Watershed Management Project", Main Report and Appendices, Republic of the Philippines, Manila, November 1978.

N8 National Irrigation Administration and Engineering Consultants, Inc., "Draft Feasibility Report, Pantabangan Watershed Management Project", Main Report and Appendices, Republic of the Philippines, Manila, November 1978.

N9 NEDECO-SMEC, "Cirebon-Cimanuk Feasibility Study; Part 8: Cimanuk Irrigation Storage Project," Feasibility Report (Vol. 3 - Appendices I to VIII), prepared for Ministry of Public Works and Electric Power, Directorate General of Water Resources Development, Republic of Indonesia, 1973.

N10 NEDECO, "Serang Flood Diversion Feasibility Study," prepared for Ministry of Public Works and Electric Power, Directorate General of Water Resources Development, Republic of Indonesia, 1976.

N11 NEDECO, "Ngrambat Dam Feasibility Study," Prepared for Ministry of Public Works and Electric Power, Directorate General of Water Resources Development, Republic of Indonesia, 1975.

N12 NEDECO, "Computation of Irrigation Water Requirements for Wet Sawah Paddy," prepared for Ministry of Public Works and Electric Power, Directorate General of Water Resources Development, Republic of Indonesia, Irrigation Rehabilitation Project, Series - B, 1973.

N13 NEDECO, "Jratunseluna Basin Development Plan Central Java, Galapan Dam Irrigation, Flood Control and Hydro-Power Project, Feasibility Study Volume 3: Supporting Data", prepared for Republic of Indonesia, Ministry of Public Works and Electric Power, Directorate General of Water Resources Development, October 1975.

P1 PRC Engineering Consultants Inc., "Tuntang/Jragung Rivers Basins Integrated Development Plan Special Report II, Geology", prepared for the Republic of Indonesia, Ministry of Public Works, Directorate General of Water Resources Development, November 1979.

P2 PRC Engineering Consultants Inc., "Tuntang/Jragung Rivers Basins Integrated Development Plan Appendix A (Part I), Hydrology", prepared for the Republic of Indonesia, Ministry of Public Works, Directorate General of Water Resources Development, November 1979.

P3 PRC Engineering Consultants Inc., "Tuntang/Jragung Rivers Basins Integrated Development Plan Appendix F (Part I), Erosion and Soil Conservation", prepared for the Republic of Indonesia, Ministry of Public Works, Directorate General of Water Resources Development, November 1979.

P4 PRC Engineering Consultants Inc., "Tuntang/Jragung Rivers Basins Integrated Development Plan Appendix G, Social and Environmental Assessment", prepared for the Republic of Indonesia, Ministry of Public Works, Directorate General of Water Resources Development, November 1979.

P5 PRC Engineering Consultants Inc., "Tuntang/Jragung Rivers Basins Integrated Development Plan Interim Report," prepared for the Republic of Indonesia, Ministry of Public Works, Directorate General of Water Resources Development, August 1979.

R1 Rutten, L.M.R., "Over Denudatie Snelheid op Java", Versl: Wis en Natuurk. Afd. Kon. Academie van Wetenschappen, Amsterdam, XXVI, page 921-930, 1917.

R2 Rutten, L.M.R., "De Geologie van Ned. Indie," W.P. van Stockum & Zoon, Den Haag, 218 pp, 1932.

R3 Rutten, L. "Le Paysage des Indes Orientales et Occidentales" Proceedings of the 15th International Geographical Congress, vol. 1, pp 58-77, Amsterdam, 1938.

S1 Snowy Mountains Engineering Corporation, "Definite Scheme Report, Volume 4, Water Investigations. The Improvement and Development of the Serang River and Irrigation Project, Central Java, " prepared for Republic of Indonesia, Ministry of Public Works, Directorate General of Water Resources Development, Jakarta, September, 1978.

S2 Snowy Mountains Engineering Corporation, "Cimanuk Project, Jatigede Dam and Power Facility, Report on Hydrology," Vol. 1 prepared for the Ministry of Public Works and Electric Power, Directorate General of Water Resources Development, Republic of Indonesia, May, 1977.

S3 Schumm, S.A., "The Fluvial System", John Wiley & Sons, New York, 1977.

S4 Snowy Mountains Engineering Corporation et Al, "Serayu River Basin Study Feasibility Report," prepared for Ministry of Public Works and Electric Power, Directorate General of Water Resources Development, Republic of Indonesia, 1974.

S5 Snowy Mountains Engineering Corporation, "Feasibility of a Hydro-electric Power Facility at Jatigede," Prepared for Ministry of Public Works and Electric Power, Directorate General of Water Resources Development, Republic of Indonesia, 1977.

S6 Snowy Mountains Engineering Corporation et Al. "Improvement and Development of the Kali Serang and Irrigation Project - Inception Report," prepared for Ministry of Public Works and Electric Power, Directorate General of Water Resources Development, Republic of Indonesia, 1977.

S7 Snowy Mountains Engineering Corporation et Al, "South Grobogan Irrigation Project - Feasibility Report," prepared for Ministry of Public Works and Electric Power, Directorate General of Water Resources Development, Republic of Indonesia, 1978.

S8 Sbihi, M and Buning, R.A., "Practical Applications of Systems Analysis in Reservoir Sizing," Water Power and Dam Construction, October 1976.

S9 Snowy Mountains Engineering Corporation, et Al, "Draft of Definite Scheme Report, Volume 1, Summary, the Improvement and Development of the Serang River and Irrigation Project, Central Java," prepared for Republic of Indonesia, Ministry of Public Works Directorate General of Water Resources Development, February 1979.

T1 Thaden, R.E., Harli Sumadirdja and Richards, P.W., "Geological Map of the Magelang and Semarang Quadrangles, Java," Geological Survey of Indonesia, Directorate General of Mines, Ministry of Mines, Jakarta, 1975.

T2 Tudor Engineering Company, "Technical Evaluation of Feasibility Studies for Jragung Dam and Ngrambat Dam," prepared for U.S. Agency for International Development, Department of State, May 1974.

V1 von Bemmelen, R.W., "The Geology of Indonesia," vol. 1 A, General Geology of Indonesia and Adjacent Archipelagoes, 2 nd edition, Martinus Nijhoff, the Hague, 1970.

V2 Vlugter, H., "Sediment Transportation by Running Water and the Design of Stable Channels in Alluvial Soils." Bouw En Water Bouwkunde, 18, De Ingenieur, Jrg 74, NR 36 7-9-1962.

LECTURE NOTES

by

Dr. M.A. STEVENS

INTRODUCTION

General

The Davis Model is a geological interpretation of the erosion and sedimentation processes. The model is one of rapid uplift of the land masses followed by slower erosion of its surface.

Some maximum rates of uplift in the world are:

Himalayan Mountains	5	mm/year
California Mountains	8	mm/year
Great Lakes, USA	15	mm/year
New Zealand Mountains	7	mm/year
Java	?	

The uplift in the Himalayans is a result of the Indian plate crushing into the plate to the north.

The uplift of the Great Lakes is mainly due to rebound caused by the removal of the ice covering the area during the last continental glaciation.

Water and gravity are the principal agents of erosion. Consequently, erosion in the the tropics is generally greater than in other areas. Here are some examples of denudation rates.

United States, average	0.03	mm/year
Iowa, loess	13	mm/year
Java pristine	0.5	mm/year
New Guinea, earthquake	115	mm

Some Relations

The amount of runoff from pristine watersheds in the tropics depends mostly on the amount of rainfall. The relation for Java is shown in Figure 1. Where the annual rainfall is very low, there is no runoff. Where rainfall is greater runoff is also greater.

For the Jragung catchment, the annual rainfall is approximately 2700 mm and the runoff 1300 mm

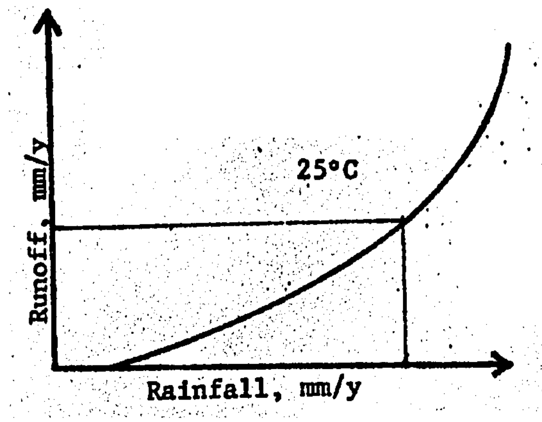


Figure 1: Runoff from rainfall for pristine watersheds

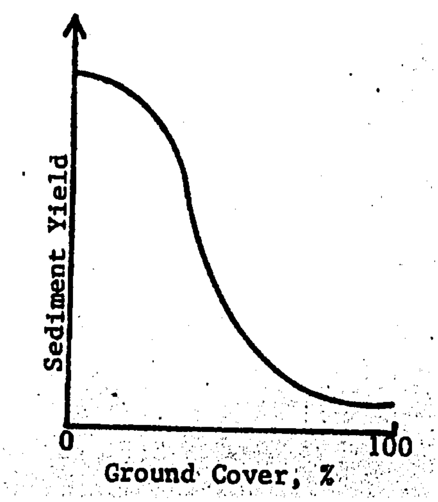


Figure 2: The relation between Sediment yield and ground cover.

Ground cover is the rocks, leaves, twigs, plants moss and other organic materials covering the surface of the soil. If the entire surface is well covered, the erosion is small. When there is little or no ground cover, the erosion is very large. The relation is shown in Figure 3.

Rainwater causes most of the erosion in the tropics. Also rain results in a lush growth of vegetation creating ground cover which prevents erosion. Thus there is as unique value of precipitation which results in the maximum erosion as shown in Figure 3.

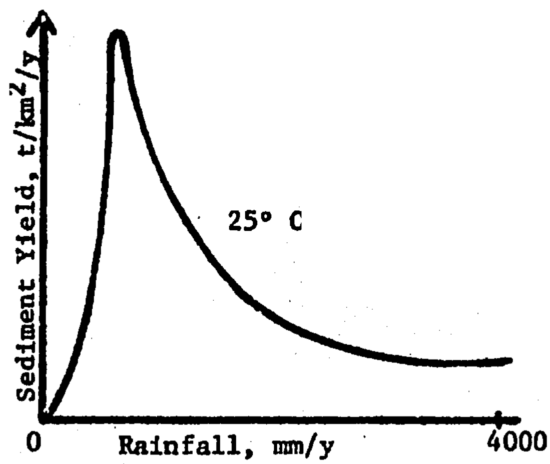


Figure 3: The optimum rainfall to produce maximum erosion.

Under pristine conditions the sediment yield for Java may have been as low as 500 to 2,000 t/km^2/y (metric tons per square kilometer per year).

Topography has a profound effect on erosion. Because gravity forces acting to move rock and soil are greater on slopes than on flat land, steep sloping basins have more erosion than flatter basins. A commonly used number to represent topography is the relief-to-length ratio illustrated in Figure 4.

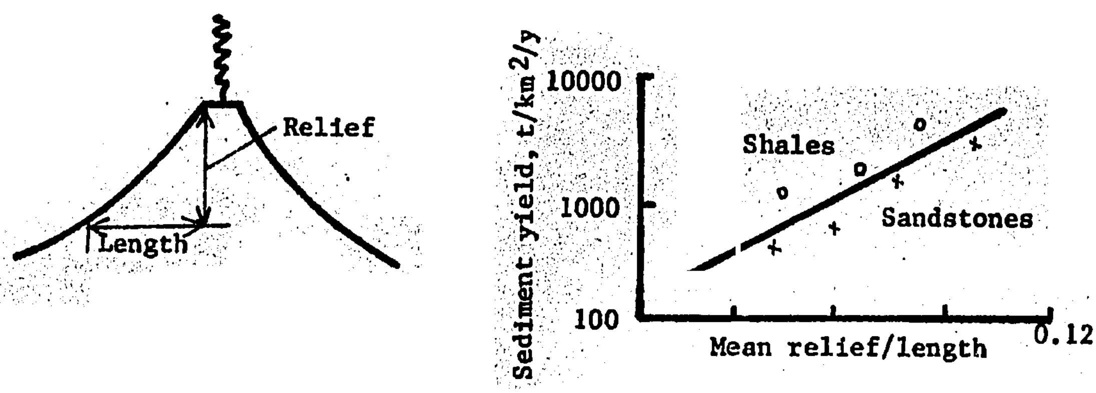


Figure 4: Effect of relief on the sediment yield.

Not all the sediment eroded from a catchment leaves that catchment. Some is deposited in the flatter areas, some is caught in paddies or in ditches. Also, the flatter parts of a catchment produce less erosion than the steeper part. Hence, sediment yield decreases as we go downstream in a catchment.

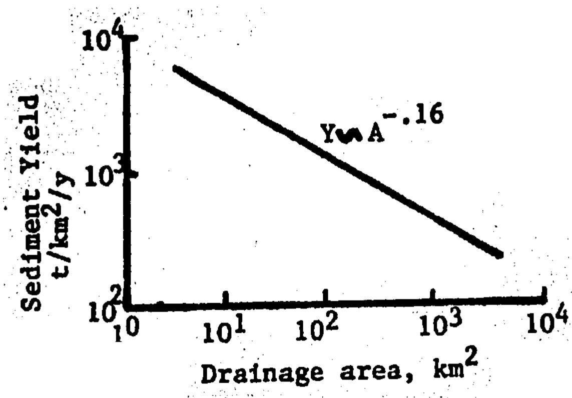


Figure 5: Sediment yield from various sizes of catchments

The lithology of the basin can be an important factor in erosion. When the rock is extremely durable, the rate of erosion is governed by the weathering of the rock and not rainfall. However, in Java weathering appears to be faster than erosion (up 'till now) so there are deep soils and very little exposed rock. Reports by Rutten in 1917 indicate soils derived from volcanic rock are the least erodible. Rutten's values are given below and represent the amount of sediment and dissolved chemicals removed from the catchments in Java.

Region	Total Yield $t/km^2/y$
Volcanic	250 - 1,500
Main volcanics	800 - 2,000
Mixed	750 - 7,500
Sedimentary	4,000 - 12,500

Corresponding values for the catchments under land-use condition currently existing in Java are larger now.

Some Definitions

The development of the vocabulary used to talk about erosion and sedimentation has taken some time. Disagreement still exists as to the meaning of some words and the processes these words are meant to describe. Herein, the latest definitions published by the American Society of Civil Engineers are employed.

Erosion is the loosening or dissolving and removal of earthly or rock materials from any part of the earth's surface. Erosion is often differentiated according to the eroding agent (wind, water, rain-splash) and the type of source (sheet, gully, rill, etc.)

Sediment is the particulate matter of mineral composition derived from the soil or rock by erosion.

Sheet erosion is the wearing away of a thin layer of land surface. This is interpreted to include rill erosion unless otherwise specified. Sheet erosion is the principal mode of erosion in the upland agricultural area of the Jragung catchment.

Rill erosion is the removal of soil by small concentrations of flowing water, with the formation of channels that are small enough to be smoothed completely by normal mechanical cultivation methods. Rill erosion is very common in the upland agricultural areas of Java and along road cuts.

__Soil loss__ is the quantity of soil actually removed by erosion from small tests areas. In large areas, most of which is eroded is not removed from the area. Watersheds in U.S.A. are large so the soil loss can not be estimated accurately.

__Gully__ is the removal of soil by concentrations of flowing water sufficient to cause the formation of channels that cannot be smoothed completely by normal mechanical cultivation methods. Gully erosion is very common in the teak plantations in the Jragung catchment.

__Sediment delivery ratio__ is a measure of the diminution of eroded sediments, by deposition, as they move from the point of erosion to any designated downstream location. This is also expressed as a percentage of the eroded material that reaches a given measuring point. In the pilot watersheds, the sediment delivery rates are almost unity.

__Sediment yield__ is the total sediment outflow from a watershed or drainage basin, measurable at a cross section of reference in a specified period of time. The latest estimate of sediment yield for the Jragung damsite is 16,000 $t/km^2/y$.

__Rate of erosion__ is the rate at which soil is eroded from a given area. This is usually expressed in volume or weight units per unit of area and time. When the areas involved are small, the rate of erosion, soil loss and sediment yield are equivalent.

Sediment Yield

Except for small plots, a few hundred square meters in size, we are not able to determine any values other than the sediment yield. That is, such factors as the soil erosion are unknown. One can place a peg in the ground and record how fast the soil is removed from around the peg, but this cannot be done for a watershed. It is too expensive.

The sediment yield can be measured at the streamgaging stations. Also, sedimentation rates in reservoirs and in deltas at the sea can be measured by surveying.

Possibly the best estimate of sediment yield made in Java is that for the Cimanuk delta. The growth of the delta has been measured over a period of years. This growth indicates that the sediment yield is at least 4,600 $t/km^2/y$. In parts of the upper watershed, the yield is as large as 12,000 $t/km^2/y$.

In Jratunseluna Basin, SMEC's current estimate of the sediment yield at the Kedungombo damsite is 2,410 $t/km^2/y$.

The latest estimate of sediment yield for the Jragung damsite is 16,000 $t/km^2/y$.

Possibly the worst erosion in Java is in a portion of the Serayu basin. The estimate of sediment yield for one small subbasin is greater than 30,000 $t/km^2/y$.

It is best to use units of $t/km^2/y$ to report sediment yield, because the dry unit weight of the residual soils in the catchment are not known - and they may vary greatly from place to place. For example, SMEC has measured the sediment yield for the Kedungombo damsite on the Serang River. The average is 2,410 $t/km^2/y$. If we assume the dry unit weight of soil is 1.5 t/m^3, this yield is equivalent to an average of 1.6 mm over the entire catchment. However, if the dry unit weight of soil is only 1.0 t/m^3, the average would be 2.4 mm

Properties of Soils

Soil erosion occurs when the impact or pressure forces caused by wind, rain or flowing water exceeds those forces holding the soil particles in their matrix. For granular particles like sand, gravity is the principal force holding the particle in its rest position. With loams and clays, the forces resisting erosion are mainly the result of ionic attractions between particles. The erodibility of these fine soils can change depending on the moisture content or can be modified by adding chemicals. For example, there are volcanic soils in Indonesia which do not erode when wet. But if the soil is dried, the forces within the soil are destroyed and there is very little resistance to erosion.

The erodibility of tropical soil has been studied to some extent in Hawaii and more recently in Java. The erodibility of some tropical soils has been related to structural and hydrologic parameters which can be readily measured. One significant finding was that there are major erosional differences between residual and volcanic ash soils in the tropics.

The indication is that base saturation, certain particle size parameters, the amorphous constituent, aggregate stability and suspension percentage are most strongly correlated with erodibility. These parameters are different than those proposed for the U.S. mainland.

For the tropical soils tested in Hawaii, bulk density, percentage of organic matter, structural permeability, and crystalline mineral classes were the least correlated with erodibility.

For residual soils, the hydrologic parameters (infiltration rate and permeability) are among the five most necessary parameters for predicting erodibility. For volcanic ash soils, the mean weight, diameter of aggregate, clay percent, and the change in pH were the most important.

Properties of Sediment

Once the soil particles are eroded, they become sediment. The properties of importance are those that affect how the particles are transported by the fluid - either air or water. These properties are size, shape, specific weight and surface charge.

Size and volume are interchangable; size is the common term used in sedimentation work. The size ranges for sediment follow.

Size Classification
(After ASCE Sedimentation Manual)

Class Name	Size Range mm
Clay	0.00024 - 0.004
Silt	0.004 - 0.062
Sand	0.062 - 2.00
Gravel	2.00 - 64
Cobbles	64 - 256
Boulders	256 - 4,096

The size for silts and clays are determined by hydrometers; sands and gravels are most commonly sieved and cobbles and boulders are measured individually.

Size can be determined by dropping the sediment in still water and measuring the fall velocity. The effects of particle size, area, specific weight, fluid density and viscosity determine the fall velocity. The sedimentation diameter is the diameter of a sphere of the same specific weight and the same terminal settling velocity as the given particle in the same sedimentation fluid.

Shape determines the amount of hydrodynamic drag and lift which can be developed on the particle to keep it in suspension or moving along the bed of the channel. Disk-shaped particles like clay and silt have larger hydrodynamic drag and lift coefficients than spherical particles like sand. It is then easier for the fluid to move silt and clay particles.

The specific weight of the particles is a measure of the gravitional force acting on the particle. Sediment with a large specific weight is more difficult to move than light sediment. Some common specific weights are given below.

Approximate Specific Weight

Mineral	Specific Gravity
Magnetic	5.2
Feldspar	2.6
Quartz	2.65
Chert	2.65
Carbonate particles	2.85

Surface charge has an important effect on the settlement properties of clay. If the particles are attracted to each other, they group together to form an aggregate which settles much faster than the individual particles.

When the sediment is transported to a reservoir and then deposited, the specific weight of the sediment deposit is an important consideration. The specific weight is defined as the dry unit weight of the sedimentary material within a unit volume. The common units are kg/m^3 or t/m^3.

Deposited clays have the smallest specific weight. Initially, the deposit of clay is often no more than 300 kg/m^3. In time, the clay deposit consolidates and the specific weight increases. Silt deposits have slightly larger specific weights than consolidated clay deposits. Deposits of sand have a specific weight of approximately 1,600 kg/m^3 and do not consolidate.

The specific weight of a mixture of particles is determined by adding the fraction contributed by each size. For example, for the mixture of clay, silt, sand and gravels which will be deposited in the Jragung, the average specific weight was computed as 1,000 kg/m^3.

The estimate PRC/ECI uses for the dry unit weight of sediment deposited in the reservoirs in the Jratunseluna Basin is 1,000 kg/m^3. This is the value obtained in investigations of the Cimanuk delta in the Java Sea. The dry unit weight of the soil deposited in the Demak plain has been measured in many studies. Values reported by NEDECO in 1978 [N6] ranged from 860 kg/m^3 to 1,460 kg/m^3. The average is approximately 1,200 kg/m^3. The samples of soil were taken in 33 borings at depths of 1, 3 and 5 m. In other studies in the same area, the values range from 800 to 1,300 kg/m^3.

Samples of alluvial soil were taken up to a depth of 25 m in the floodplain of the Citanduy and Ciseel Rivers at the proposed cross-connection in 1978 and 1979. The general classification of the soil is organic clay. The soil contains shells as well indicating a marine origin.

The average dry unit weight of the samples were as follows.

Classification	No. of Samples	Dry Unit Weight t/m^3
More than 50% clay	26	0.89
More than 50% silt	7	0.91
More than 50% sand	1	1.13
Others	11	0.96

The average dry weight for all 49 samples tested was 0.93 t/m^3.

THE CHANGING LANDSCAPE

General

A pictorial view of the landscape is shown in Figure 6. Parts of the landscape are being eroded and deposition is occuring in other areas.

In general erosion occurs in one or more of these areas:

1. Sheet and rill erosion on bare and cropped soils in the upland area.
2. Degradation in minor drainageways
3. Gully erosion in the uplands
4. Floodplain scour which is very uncommon in Java.
5. Streambed degradation, which is slight in the uplands and non-existent in the low areas of the Jratunseluna basin.
6. Riverbend scour
7. Landslides

Deposition of sediment also occurs in the catchments in areas where the velocity of the water decreases. Commonly these areas have deposition:

8. In areas where the overland flow passes through grass or depressions and where there are decreases in slope.
9. On the floor or floodplain of the valleys
10. On point bars
11. On portions of the streambed.

What evidence of erosion is there in the Jragung catchment? Here is what one can find by roaming around in the basin and in the area downstream in the service area:

Bare soil over large areas

Upland crops with drainage down the slope

Soil pedestals

Trees and plants with roots exposed

Gullies in the teak forests

Large slides and slumps into the river

Riverbend erosion

River gets smaller as one goes downstream on the plains

Sediment deposited on the crest of the Jragung Weir

Irrigation canals with offtakes on the river are heavily sedimented

Water is extremely dirty looking during floods

After every flood there are new deposits of silt and clay on the floodplain, sometimes 10 cm thick.

The extent that the land resource has been destroyed is reflected in the fact that the top horizons of the normal productive soil are missing in many parts of the watersheds. It is these top horizons that provide much of the plant nutrients and a reservoir of water for plant growth.

Figures from around the world indicate that the total wastage of soil is worse than ever and that little progress has been made in stopping the exploitation of this resource. Two reasons may account for the lack of progress. First, the restriction necessary to prevent soil exploitation are socially and politically unacceptable to people and to government when such exploitation is adding to the immediate prosperity of individuals and the nation. Secondly, in a hungry world it is difficult to restrict growing badly needed food even if its production now means the reduction of long-term productivity.

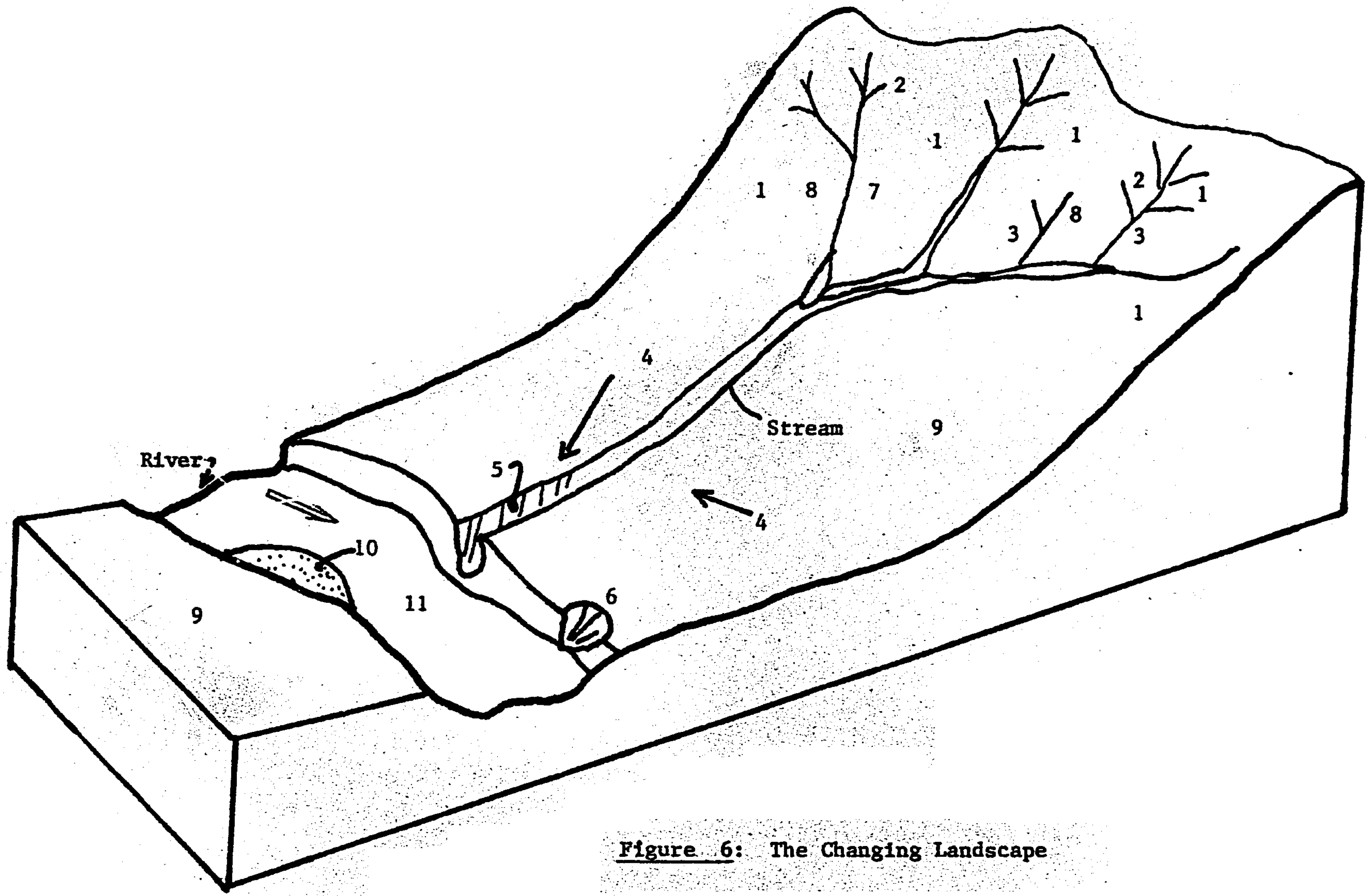


Figure 6: The Changing Landscape

In looking for solutions to erosion problems, we must be concerned with the political as well as the economical and technical feasibility. Herein, the physical processes of erosion and sedimentation are described.

Sheet and Rill Erosion

The universal soil loss equation was developed by the U.S. Department of Agriculture with experimental data collected from cultivated plots. The purpose of the research was to develop a method of predicting soil loss from agricultural land under various cropping patterns and conservation management program. In general, the equation can be used to predict yield from small fields but not from larger watersheds. The equation is applicable only for sheet and rill erosion.

The universal soil-loss equation is presented in the form

$$A = R\,K\,L\,S\,C\,P$$

in which

- A = average soil loss, t/ha
- R = rainfall erosivity factor, tm/ha
- K = soil erodibility factor, t/ha/unit of R
- L = slope length factor
- S = slope gradient factor
- C = crop management factor
- P = erosion control practice factor

The rainfall erosivity factor is a number indicating the impact power of the rain and the erosive power of moving water. The expression for this factor is

$$R = \frac{EI_{30}}{1000}$$

in which E = kinetic energy of the storm rainfall, tm/ha

I_{30} = maximum 30-minute intensity during the storm, mm/h

The component of E occuring during a fraction of the storm.

$$e = p\,(12.1 + 8.9 \log i)$$

in which p = amount of storm rainfall in time Δt, mm

i = intensity of rainfall in time Δt, mm/h

Then for the storm

$$E = \Sigma e$$

and

$$P = \Sigma p$$

the summation being for all increments of time Δt comprising one storm. Here P is the total storm rainfall in mm.

Researchers in Indonesia have shown that, when averaged for many storms,

$$E = 24.7\,P$$

and

$$I_{30} = \frac{13.7\,P}{P + 100}$$

These two equations were developed from rainfall records for the tropical storms experienced in that country. Then, for each storm

$$R = \frac{0.34\,P^2}{P + 100}$$

For the month, use

$$R = 0.11\,P_m^{1.21}\,D^{-0.47}\,(P_{max})^{0.53}$$

Here
- R = rainfall erosivity for the month, tm/ha
- P_m = average monthly rainfall, mm
- D = number of days with rain
- P_{max} = maximum daily rainfall, mm

Annual values of the erosivity factor R in Indonesia range from approximately 1,900 tm/ha to 8,000 tm/ha.

Under field conditions, the distribution of erosive rainstorms within the year in relation to seasonal vegetative cover and crop residue effects is very important. High intensity rain when there is little foliage produces much more erosion than when the crops have maximum foliage.

The soil erodibility factor K is a measure of the rate at which a soil erodes under standard conditions of slope and cultivation. The factor is the rate of soil loss from a hectare of land 22.1 m long with a 9 percent slope under conditions of continuous cultivated fallow when the rainfall erosivity factor is unity.

Values of K are determined from plot studies on various soils. In the Pacific, K values have been obtained in Hawaii and Indonesia. In Java, soils derived from volcanic rock have K values approximately 10 times less than those derived from marine sediments. As shown below, typical values are 0.03 and 0.3 t/ha/unit of R.

Soil	Erodibility t/ha/unit of R
Lathosol	0.034 - 0.104
Grumosol	0.204
Mediterranean	0.140 - 0.260

Values of K obtained in Hawaii range from 0.2 to 1.1 t/ha/unit of R. In the mainland states, K varies from 0.04 to 1.6 t/ha/unit of R.

The slope length factor is the ratio of soil loss from a specific length of slope to that with a length of 22.1 m. The slope length is the distance from the point where overland flow begins to the point where the slope decreases to the extent that deposition begins or to where runoff enters a well-defined channel which is part of the drainage network.

The L factor is given by the expression

$$L = \left(\frac{a}{22.1}\right)^m$$

in which a = length of slope, m

m = 0.5 if the slope is greater than 5%

m = 0.4 if the slope is 4%

m = 0.3 if the slope is 3% or less

The slope gradient factor is the ratio of soil loss from a specific percent slope to that on a 9 percent gradient. The expression for this factor is

$$S = \frac{430 \sin^2 \theta + 30 \sin \theta + 0.43}{6.57}$$

in which

θ = slope angle, degrees

The crop management factor is the ratio of soil loss from land cropped under specified conditions to the corresponding loss from tilled continuous fallow. In physical terms it describes the effect of vegetation in protecting the soil from erosion. Continuous fallow is land that has been tilled and kept free of vegetation for a period of at least three years or until prior crop residues have decomposed.

As there are many combinations of crop and soil management, the crop management factor is quite variable. Crop residue can be removed, left on the surface, or plowed under. Seedbeds can be left rough with much available surface capacity for rainfall, or they can be left smooth. Different combinations of these variables have different effects on soil loss.

The effectiveness of crop residue depends on the amount of residue kept on the surface. The canopy protection of crops depends on the type of vegetation and varies greatly in different months or seasons. Therefore, the overall erosion-reduction effectiveness of a crop depends largely on how much of the erosive rainfall occurs during the periods when the crop and crop residues provide the most protection.

Some typical crop management factors are:

Crop	C Value
Bare, continuously fallow, up and downhill cultivation	1.00
Upland rice at 0.2 x 0.3 m followed by groundnuts	0.45
Upland rice followed by fallow	0.71
Sorghum at 0.2 x 0.5 m	0.30
Sorghum at 0.3 x 0.6 m	0.61
Cassava	0.51
Peanuts	0.4 to 0.8
Palm trees, coffee, cocoa with cover crop	0.1 to 0.3
Forests, dense shrubs, high mulch crops	0.001
Savannah, prairie in good condition	0.01

The erosion control practice factor is the ratio of soil loss from a plot with specified conservation practice to the soil loss occurring from up and down hill tillage operations when other conditions remain constant.

Terraces are effective mechanical practices used to reduce soil loss. Typical P values for terraces in Java range between 0.03 and 0.05 for the benched type and 0.10 to 0.50 for the broad-based type. Terraces in shallow soils sometimes have P values greater than 1.0

The primary value of the universal soil loss equation is in comparing different crop and conservation practices. We can use the equation to predict how much soil can be saved. The two factors which can be manipulated are the crop management factor and the erosion control practice factor.

The factor C is by far the most important manipulative factor. In fact, as long as the vegetal cover is uninterrupted, whether it is forest, bush, savannah, and pasture land, or a simple mulch, erosion and runoff are small despite the erosivity of the rainfall, slope steepness, and soil instability. Studies have shown that when the soil is totally denuded in the tropics, erosion becomes catastrophic; soil losses are multiplied by 100 to 1,000 and the flow by 20 to 50. Under cultivation, erosion is intermediate and varies to a large degree according to the type of crop, the rapidity with which it covers the soil and the cultural techniques put into use to encourage its growth. Density and earliness of planting, cultivation of the soil, appropriate fertilizers, and return of plant residues play a predominant role.

Control of erosion by crop management is just "good farming". The costs are low and benefits are high. We should strive to reduce the soil loss from agricultural land to no more than 5,000 $t/km^2/y$ in the hilly tropics.

Many erosion control practices cost very little. Row crop cultivation and contour cultivation are two inexpensive methods. Mechanical measures such as bench terraces are very effective but expensive.

Other Erosion

The Universal Soil-Loss Equation is valid for small plots having only sheet and rill erosion. The other types of erosion are determined in the following manner.

Erosion in minor channels: Surveys are used to determine the amount of this erosion.

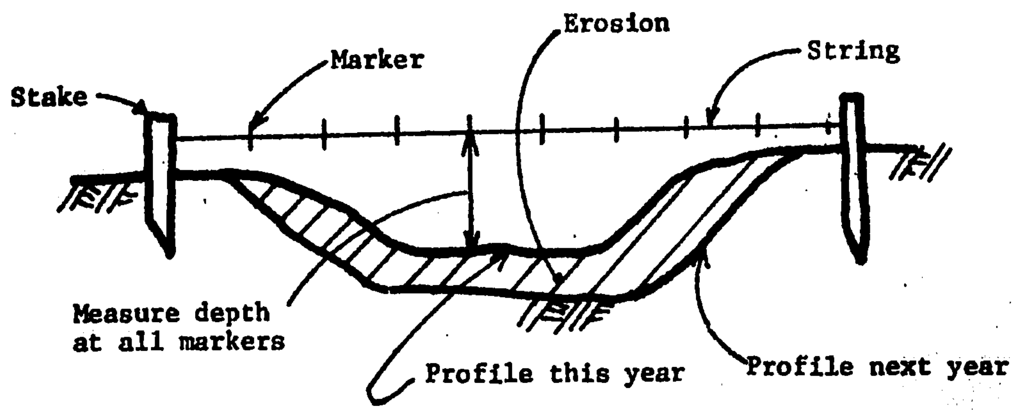


Figure 7: Cross-section of a minor channel.

Gullies: Gully erosion must be measured also. Gullies are major incisions into the landscape and are characterized by a vertical headcut. The movement of such a headcut up a minor channel is shown in Figure 8.

Floodplain Scour: Floodplain scour is very difficult and expensive to measure. In Jratunseluna Basin, floodplain scour is not important as deposition normally occurs; there is so much sediment in the floodwater.

Riverbed Degradation: Riverbed degradation is the slow removal of bed material along a reach of river created by increased sediment transport due to a general increase in velocity. Riverbed degradation differs from local scour which is caused by increased turbulence in the flow.

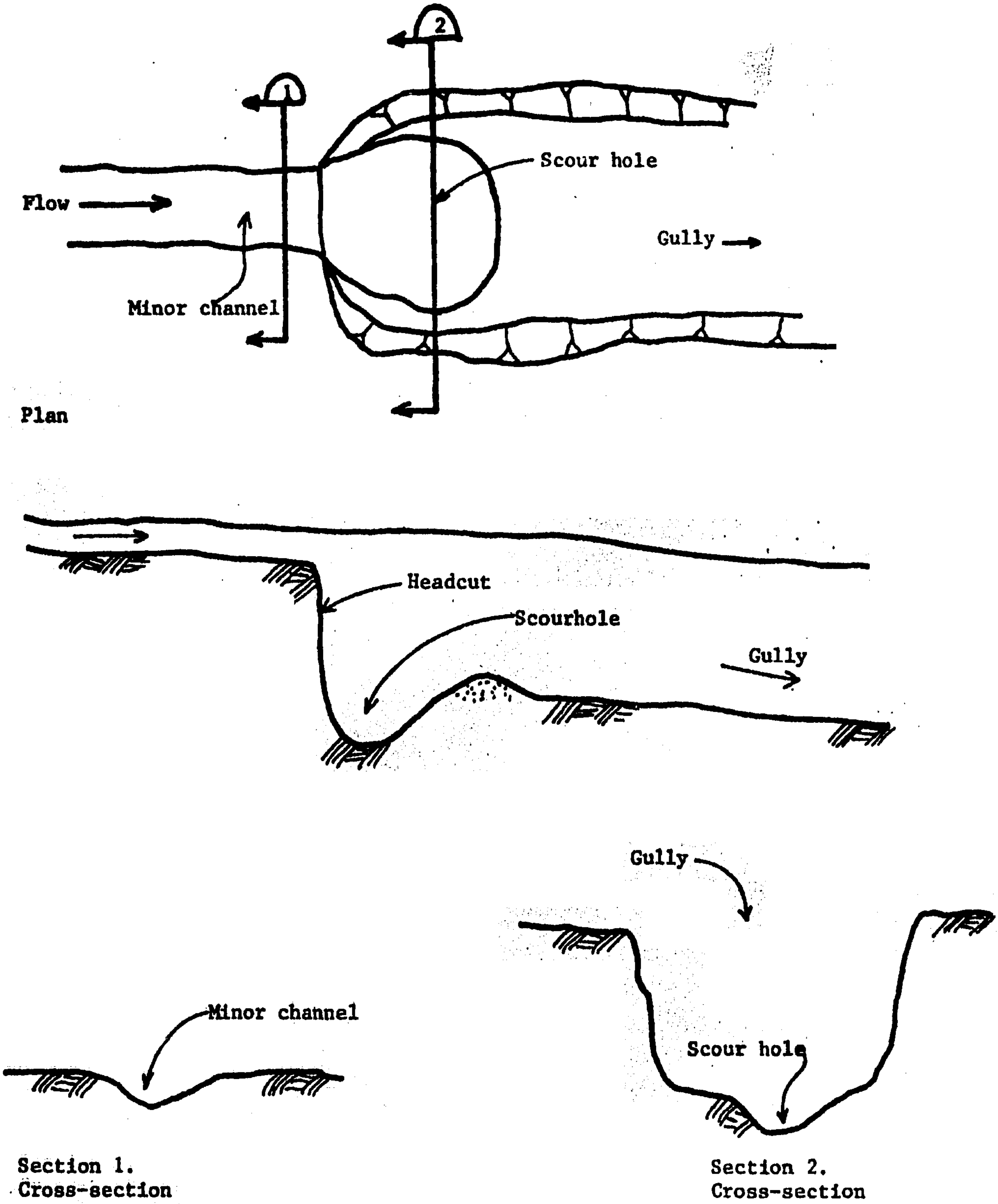


Figure 8: The Geometry of a Gully and Headcut.

One way is to determine the degradation in a reach of river by surveying cross sections of the reach in a sequence of years as shown in Figure 9 below.

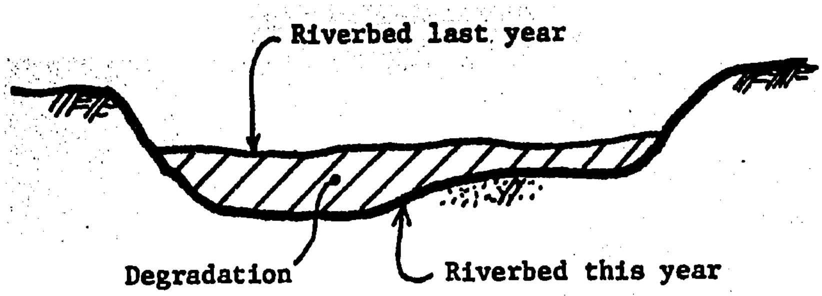


Figure 9: Cross-section of a River Showing Degradation.

Many cross sections are needed to prove that the river is degrading. One or two is not enough. The cross sections must be taken in the same spot each year and the survey must be made during the dry season.

Another way to determine degradation is to use the data collected at the streamgaging station. When each discharge is measured, measurements of stage, G (often called gage height), top width, T and cross-sectional area A are also made. See Figure 10.

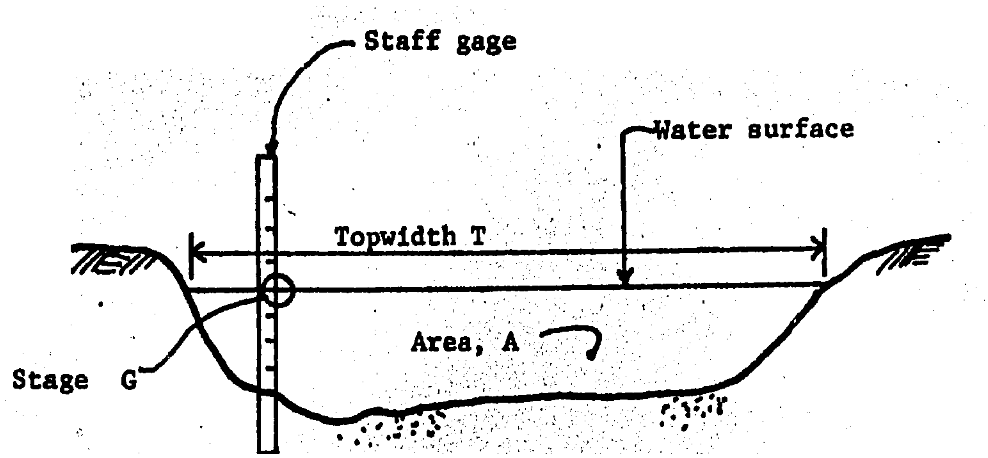


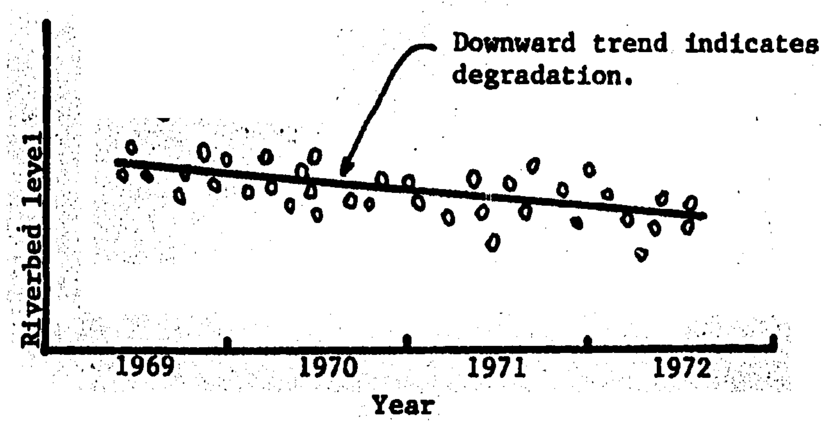
Figure 10: Cross Section at a Streamgaging Station

We define the riverbed level at the gaging station as

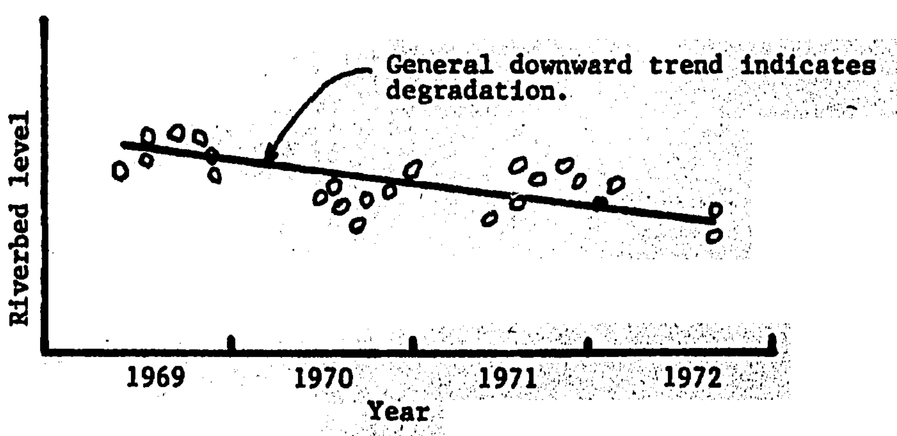
$$\text{Riverbed Level} = \text{Stage} - \text{Average depth}$$
$$= G - \bar{y}$$

in which $\bar{y} = \frac{A}{T}$

Now the riverbed level is plotted versus the time when each discharge measurement was made. Two examples of degradation determined this way are shown below.



a. Many measurements



b. A few measurements

<u>Figure 11</u>: Riverbed Degradation at a Cross-section.

Riverbank Erosion: Riverbank erosion rates are usually obtained by using aerial photographs taken in different years to measure how fast the bankline is moving laterally. The units used to report the erosion are m/y (meters of erosion per year) or ha/km/y (hectares per kilometer of riverbank per year).

The plan view of a river reach is shown in Figure 12. The location of the riverbank at year 1 and n years later are indicated. Let

A_1 = surface area eroded in bend 1 in (n-1) years, ha

L_1 = length of eroding bankline in bend 1, km

Then the apparent erosion along the left bank in bend 1 is

$$E_1 = \frac{A_1}{L_1\ (n-1)}$$

Landslides: The common way is to measure the surface area and volume of the slide and try to determine a relation between the two. The surface area and cross sections through a slide are shown in Figure 13 along with a plot of surface area versus volume of slide.

Slides are very common when severe rainstorms or earthquakes occur. Typhoons create many slides in Taiwan and the Philippines.

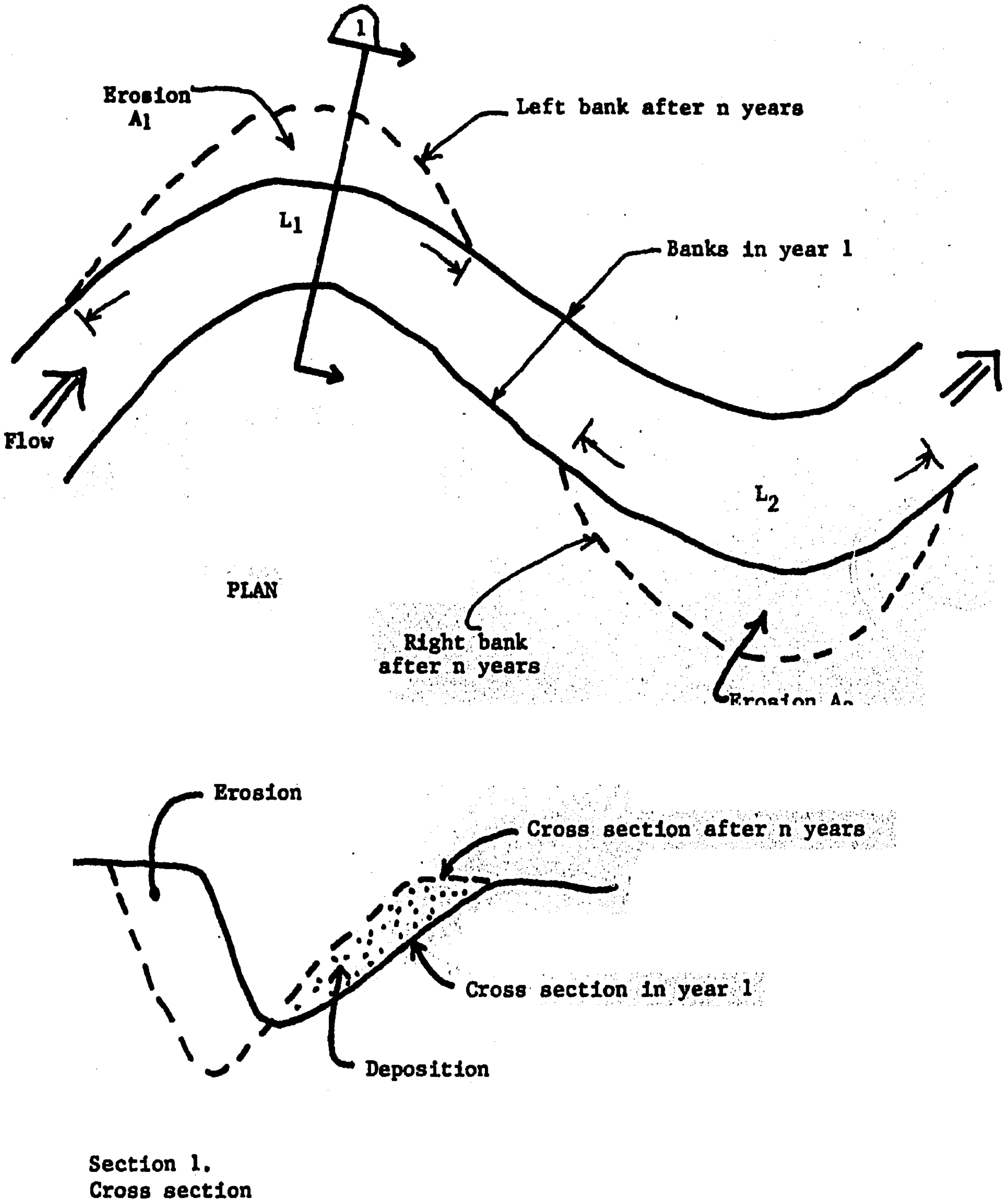


Figure 12: Riverbank Erosion

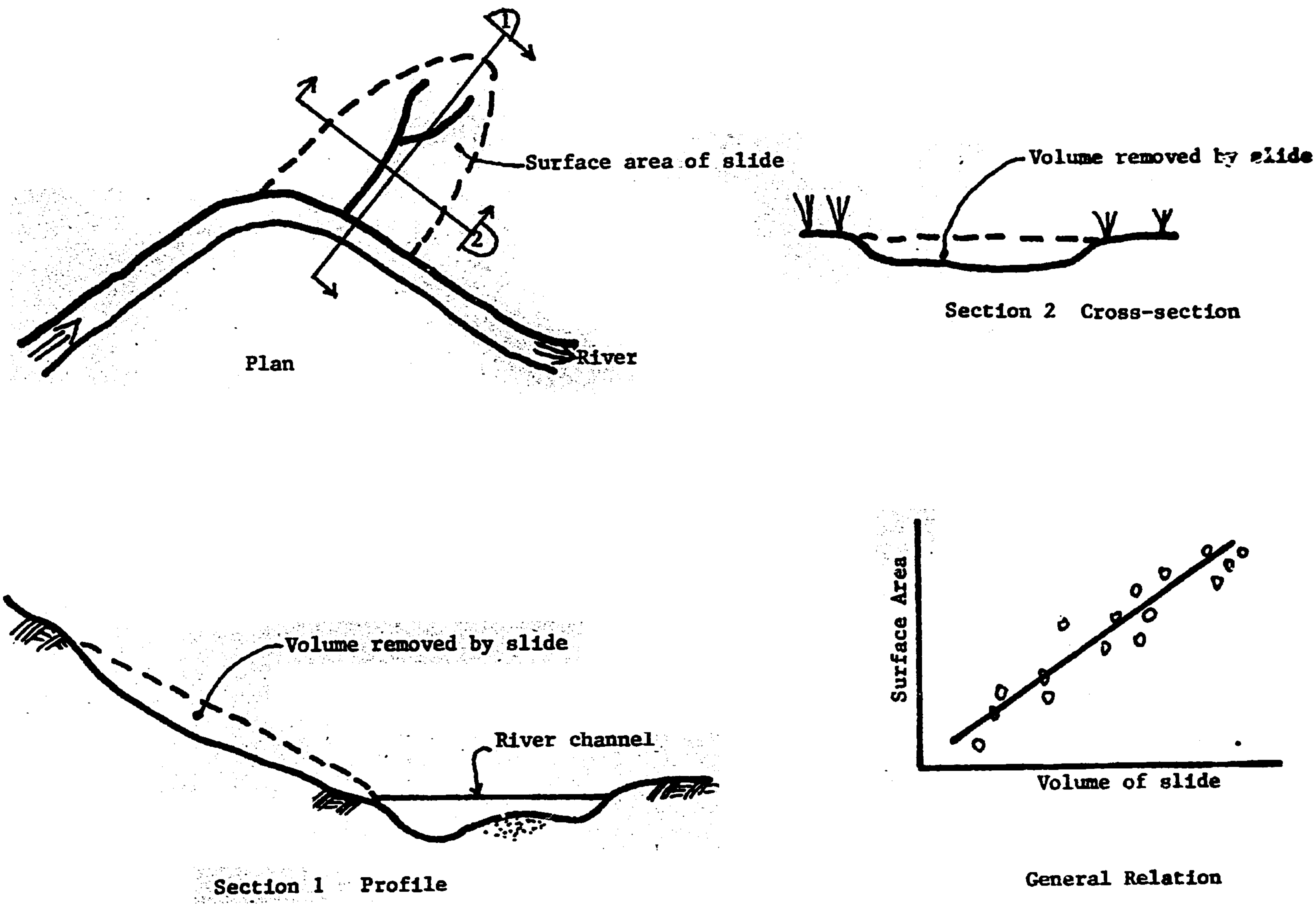


Figure 13: Erosion by Sliding

Deposition

Upland Areas: Deposition in upland areas where sheet and rill erosion occur is very difficult and expensive to measure. The deposition occurs where the velocity decreases due either to obstacles or a flattening in gradient.

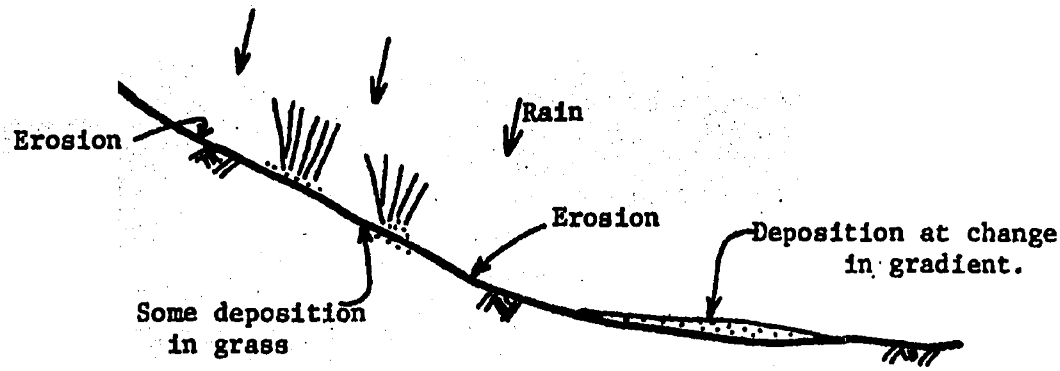


Figure 14: Deposition in Upland Areas

Erosion is less and deposition is greater as we go downstream in most watersheds.

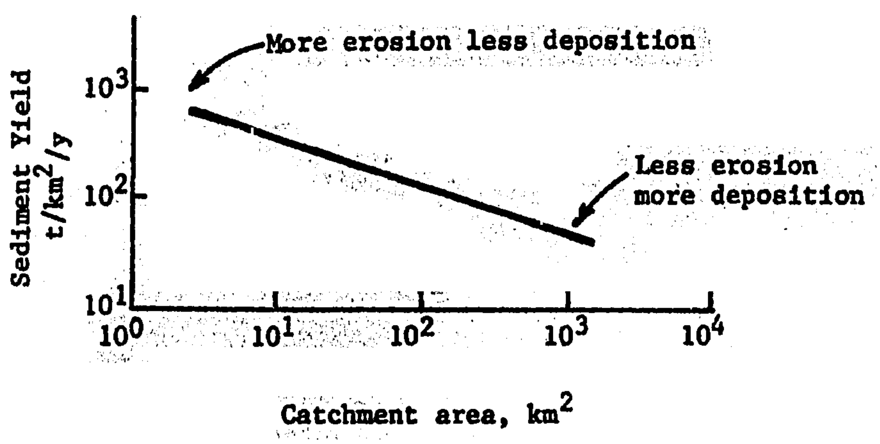


Figure 15: Sediment Yield Versus Catchment area.

Valley or Floodplain Deposition: This deposition occurs when sediment-laden rivers overflow their banks. The deposits of sediment between the levees of the Tuntang River are illustrated in Figure 16.

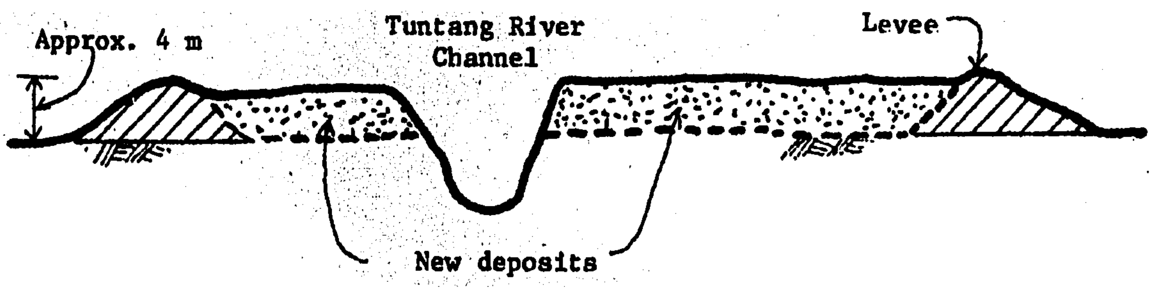


Figure 16: Cross Section of the Tuntang River

The downstream 50 km reach of the Tuntang River is leveed to the Java Sea. Constructed many years ago, the river and its levees were surveyed again by the Jratunseluna Project in June 1972. The surveys show that the floodplain between the levees is nearly filled with sediment. The indication is that the riverbed has not yet aggraded. The distance between the levees varies from a minimum of approximately 150 m to a maximum of slightly more than 1 km.

The elevations of the floodplain inside and outside the levees in 1972 is shown in Figure 17 along with the average riverbed level. The deposits in the floodplain inside the levees ranged linearly from 4 m deep at the Semarang to Surabaya road at Gubug (km 45) to almost nil at the Java Sea. The bankfull depth was approximately

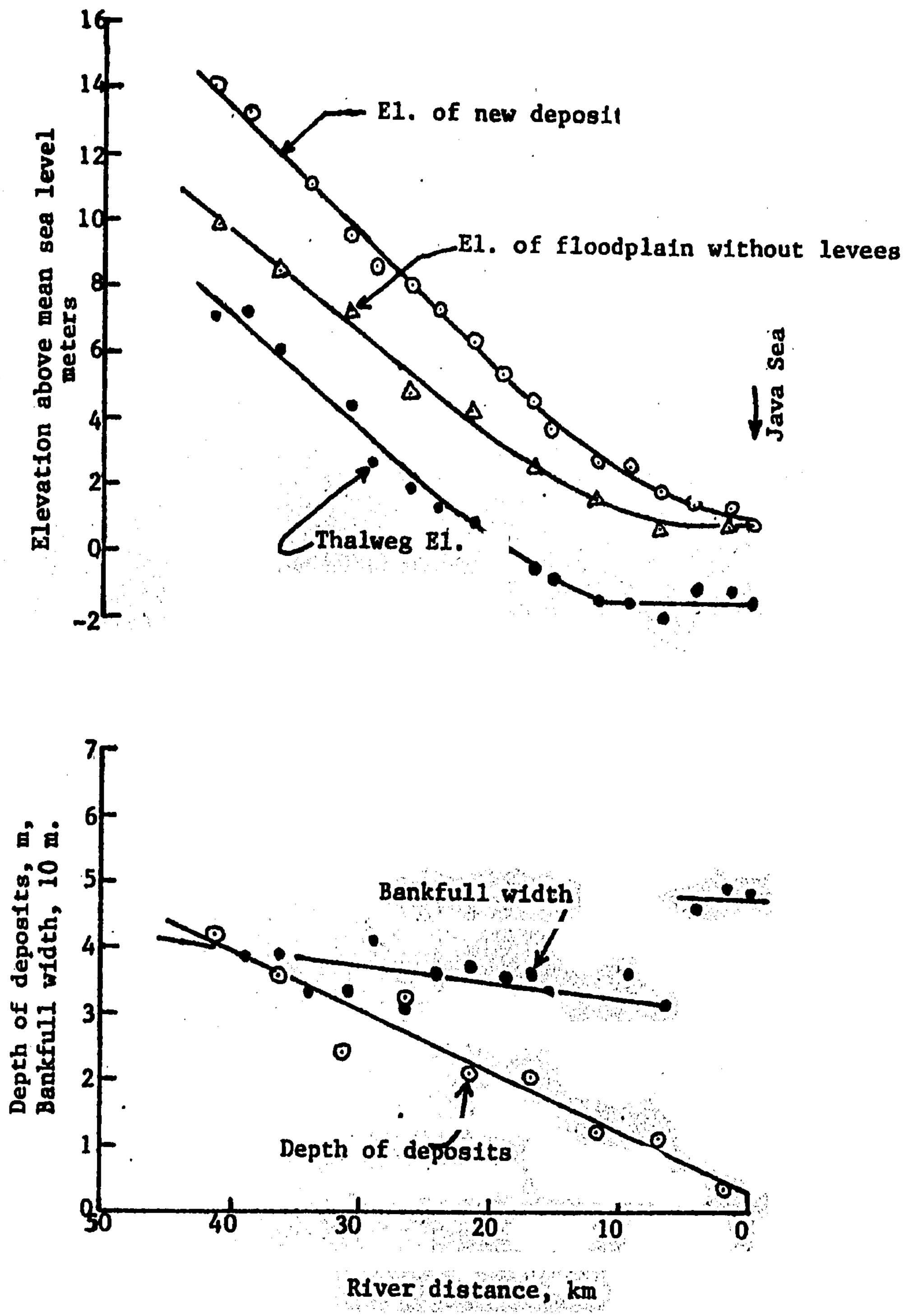


Figure 17: Morphology of the Lower Tuntang River

6 m at the road and 2 m at the sea.

As the new deposits on the floodplain are primarily clay and sometimes up to 15 cm deep in unleveed areas, one can measure the depth of deposit with a ruler. A cross-section of a new floodplain deposit along the Citanduy River is shown in Figure 18.

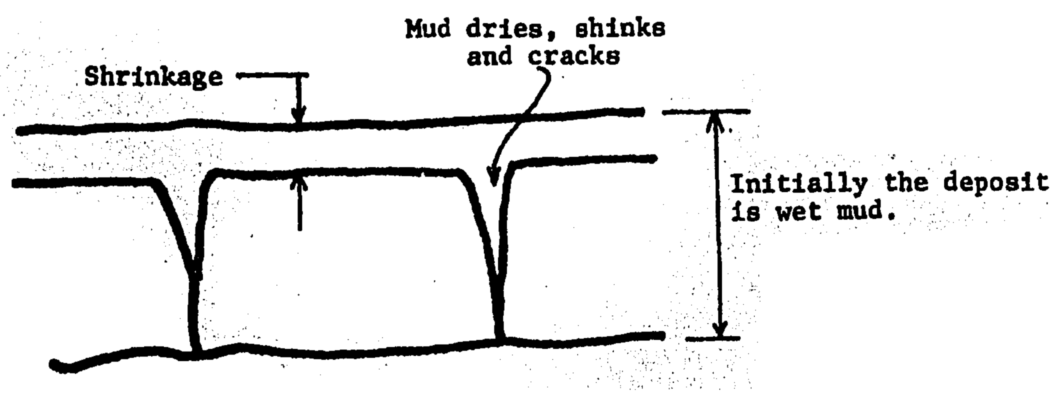


Figure 18: New Clay Deposits on the Floodplain

Point-bar Deposition: As a river moves laterally, bed material and suspended load are deposited on the point bars. The amount of deposition can be measured using the same cross sections as those used to measure riverbank erosion. An example is shown in Figure 19.

Riverbed Aggradation: Aggradation is the general raising of the riverbed over a reach of river. Aggradation is the opposite of degradation and can be measured in the same way. Surveying many cross sections in sequent years is the most common, or one can study the data collected at the streamgaging stations. An upward trend in the plot of riverbed level (G - A/7) versus time is evidence of aggradation.

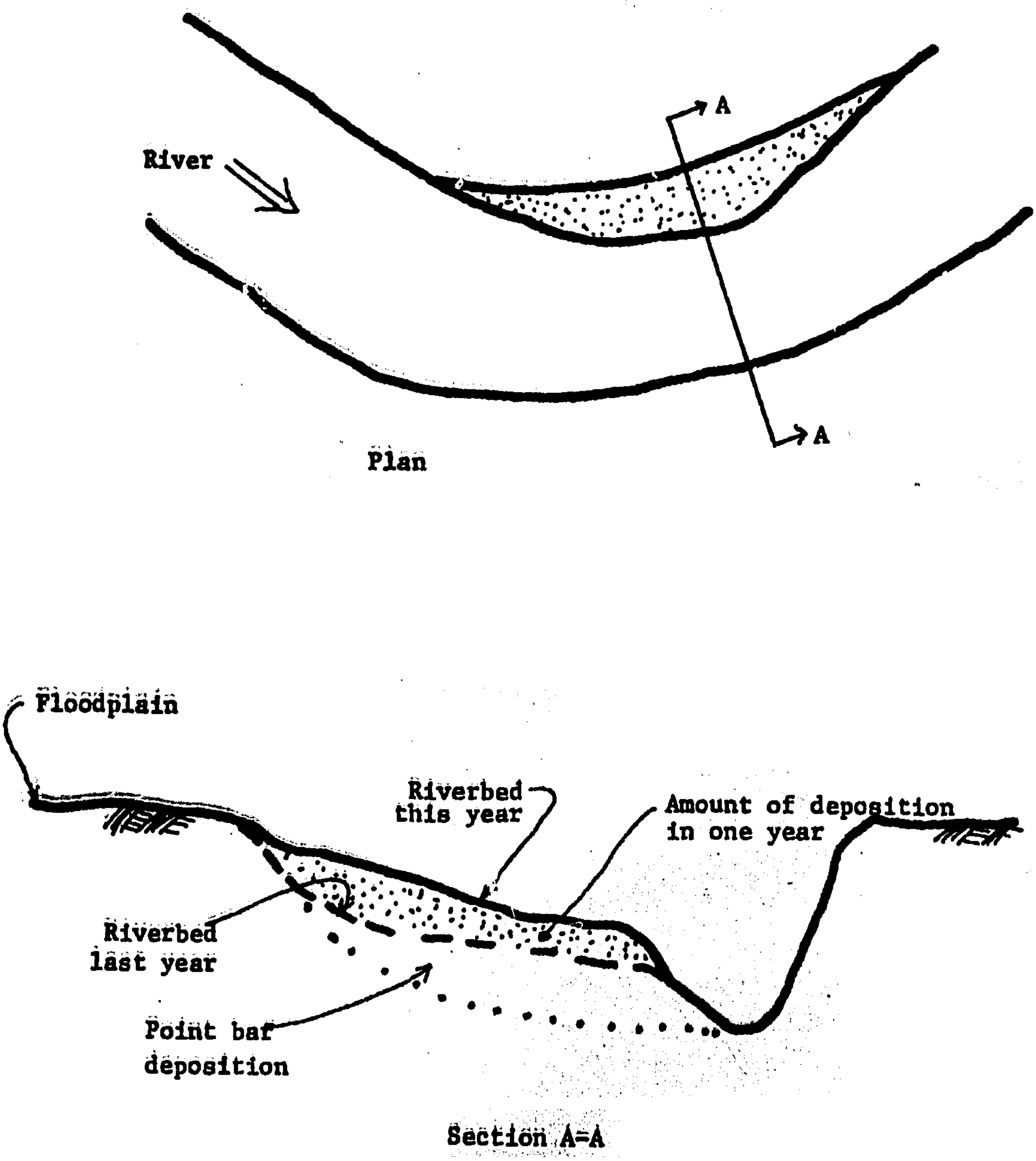


Figure 19: Point Bar Deposition

Delta Formation: The sediment which is carried to the sea may be moved offshore onto shelfs or into bars. Some can be carried along the shoreline and be deposited.

Sometimes the deposits are at the mouth of the river and form a delta.

Along the south coast of Java, the wave action is incessant, the tidal range is 2 m, the surf is 2 to 3 m high and the longshore currents are very strong. There are no deltas.

Along the north coast of Java, the waves are low, the tides are but a fraction of a meter and the sea is shallow. Here deltas form.

In 1948 the Cimanuk River changed courses and cut its current main channel to the sea. From aerial photographs and ocean soundings made in 1969, the amount of material deposited in the delta in the 22-year period from 1948 to 1969 was determined. [See SMEC Report on Cimanuk Project of May 1977]. This amount of deposit is equivalent to an average sediment yield of approximately 4,500 $t/km^2/y$.

Reservoirs: Sediment is deposited in reservoirs in the same manner as in other locations. Where the velocity of the water is decreased, some of the sediment load is deposited.

Records of measurements of reservoir deposition in Java are scarce, difficult to obtain and are often questionable in terms of accuracy.

The information made available to us indicates that the sedimentation rate in the Cacaban reservoir has been large

In 1956, the capacity of the Cacaban reservoir was approximately 90×10^6 m^3. The surface area of the water at full supply level was approximately 9 km^2. The catchment area upstream from the dam is 66 km^2 according to the 1:50,000 scale topographic map made in the period between 1910 and 1920. Another old source indicates the catchment area is 80 km^2.

The reservoir was resurveyed in 1972 and the volume found to be 71×10^6 m^3. The volume of sediment deposited in the 17 year period was 19×10^6 m^3 or approximately 1.1×10^6 m^3/y.

Assuming the catchment area is 80 km^2 and that only 71 km^2 contributes sediment, the average sediment yield must have been at least 15,500 t/km^2/y. The dry unit weight of the sediment in the reservoir is assumed to be 1.0 t/m^3.

Mat Kayu is another reservoir built in 1930. At that time, the capacity was 53.5×10^6 m^3 and the surface area was 8 km^2 at full supply level. The catchment area upstream from the dam is 62 km^2 according to the old topographic maps. In 1972, the volume of water storage had been reduced to 14×10^6 m^3. The volume of deposits which had accummulated in 42 years of operation was 39.5×10^6 m^3 or 0.94×10^6 m^3/y. The sediment yield is then at least 17,400 t/km^2/y for the catchment supply sediment.

SEDIMENT TRANSPORT

Some Definitions

Sediment particles are held in suspension in flowing water by the turbulence in the flow. These particles are called Suspended Sediment.

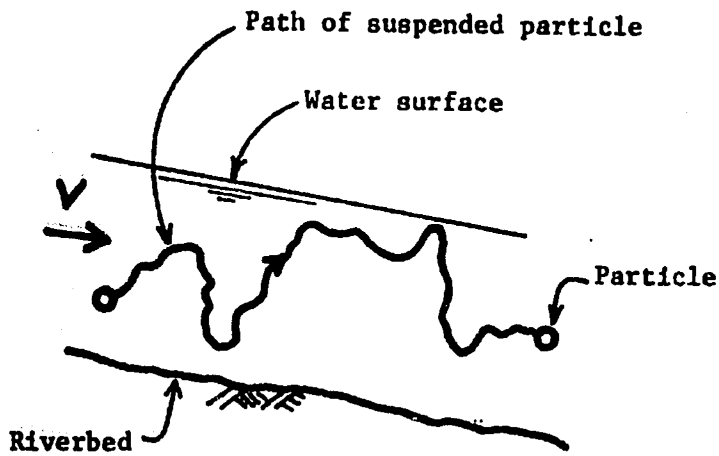


Figure 20: Suspended Sediment

Those particles of sediment which are rolled or bounced along the bed of the river are called Bed Load

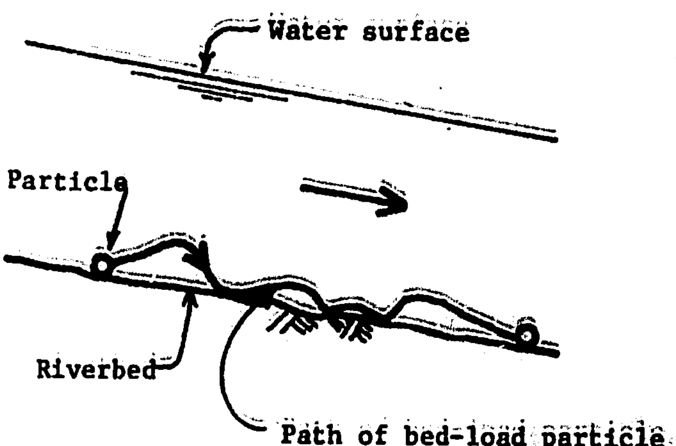


Figure 21: Bed Load

The suspended load can be divided into two parts. First, there is the <u>wash load</u> - suspended sediment particles not found in appreciable quantities on the bed of the river. Wash load is usually silt and clay but if the velocity of the river is very fast, sand can be wash load.

Second, there is bed-material in suspension. These are particles of the same sizes as those found on the bed but they are moving along in suspension. This load is called the <u>suspended bed-material load</u>.

To judge whether the suspended sediment in a river at any location is wash load or not, we use the relationship between the Rouse number, the concentration and depth in the flow.

The Rouse number is

$$Z = \frac{W}{\beta k V_*}$$

Here
- W = fall velocity of the sediment particle, m/s
- β = a coefficient
- k = von Kaiman universal coefficient
  = 0.4
- V_* = the shear velocity

The term V_* has units of velocity and is merely a way of writing $\sqrt{\tau/\rho}$; i.e.

$$V_* = \sqrt{\frac{\tau}{\rho}}$$

Here
- τ = mean or average bed shear stress.
- ρ = density of water

For convenience, we have defined one portion of the average shear stress as

$$\tau' = \rho \frac{f V^2}{8}$$

in which τ' = shear stress on a flat riverbed

f = Darcy's friction factor

V = average velocity of the flow in the river.

Let us assume $\tau = \tau'$

Then $V_* = \sqrt{\frac{f}{8}} \; V$

Now when the fall velocity is low (small particles like silt and clay) and the stream velocity V is large, Z is small.

When the fall velocity W is large (large particles like gravel) and the stream velocity is low, Z is large.

The concentration (representing the mass of particles) of sediment in suspension varies with the Rouse number of the particles in suspension, and distance above the bed of the river. The relation is shown in Figure 22.

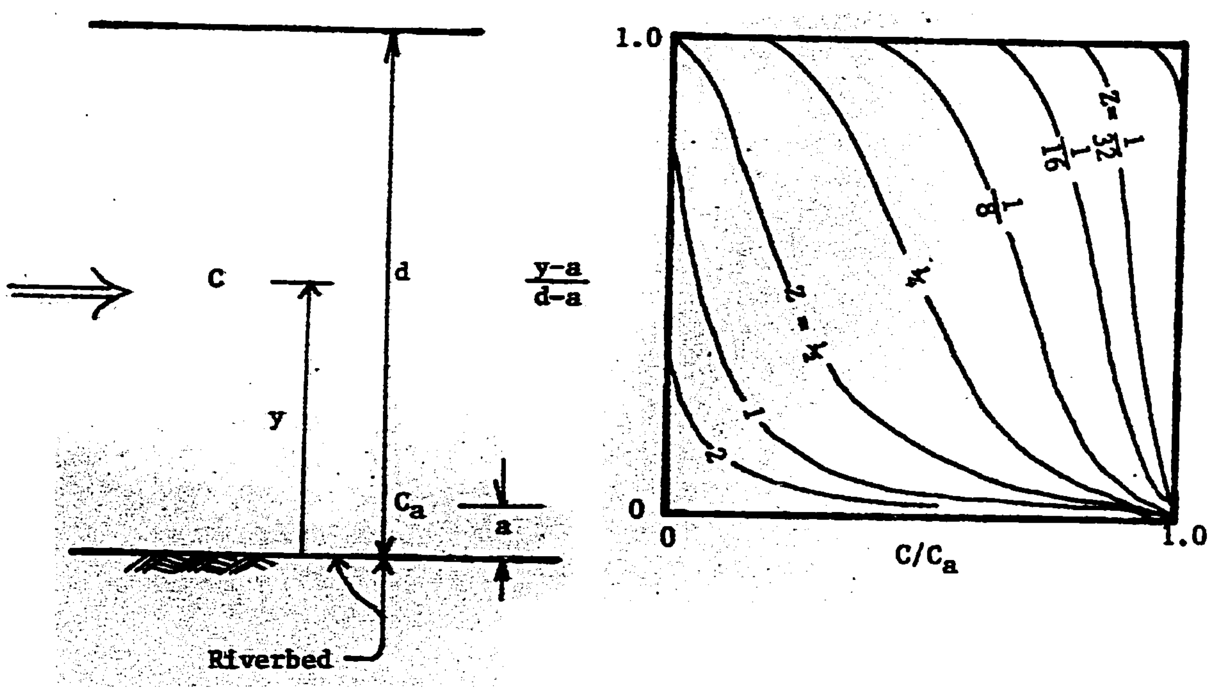


Figure 22: Variation of Concentration of Suspended Sediment C with depth y and Rouse Number.

Here C = the concentration of sediment at a level y above the bed

C_a = the concentration of sediment a distance $a = 0.05\,d$ above the bed

d = the total depth of flow

The units of concentration are

$$\frac{\text{Weight of Sediment}}{\text{Weight of Water + sediment}} \cong \frac{\text{Weight of Sediment}}{\text{Volume of water + sediment}} = \frac{mg}{l}$$

That is, milligrams of sediment per liter of water and sediment.

<u>Bed-material Load</u> consists of all the particles carried in suspension or rolled along the bed which are found in appreciable quantities on the river bed.

Bed-material load consists of all the bed-load and that portion of the suspended sediment load which is not wash load.

<u>Measuring Suspended Sediment</u>

If Z is very small, that is the sediment is very fine and the velocity is large, the suspended sediment concentration does not vary with depth. Then, grab samples taken at the surface are a good way to measure the suspended sediment.

If one does not know what the value of Z is, then the depth integrated sample is best. We take depth integrated samples at the Tuntang gaging station.

In the beginning, depth integrated samples were obtained with a P-61 sediment sampler at the Borangan Bridge on the Jragung River.

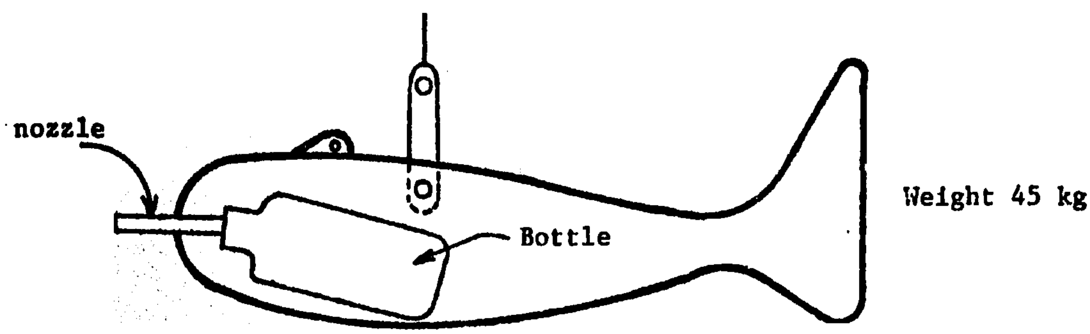


Figure 23: USP61 Sampler

Depth integrated samples were taken from the upstream side of the bridge at the center of the river. Because the suspended sediment is almost all wash load now, it has been assumed that concentration does not vary across the river. Now we are taking grab samples at the center of the bridge. Samples are taken continuously on the rising limb of the hydrograph and at decreasing periods of time throughout the recession.

Most of the samples are collected at night. The entire river and work platform at the bridge is flooded with light produced by at 10-kva generator.

The measured concentrations are plotted on the automatic water recorder chart. An example is shown in Figure 24. Where there are missing data during a flood, the concentrations are plotted against water discharge and the appropriate interpretation is made.

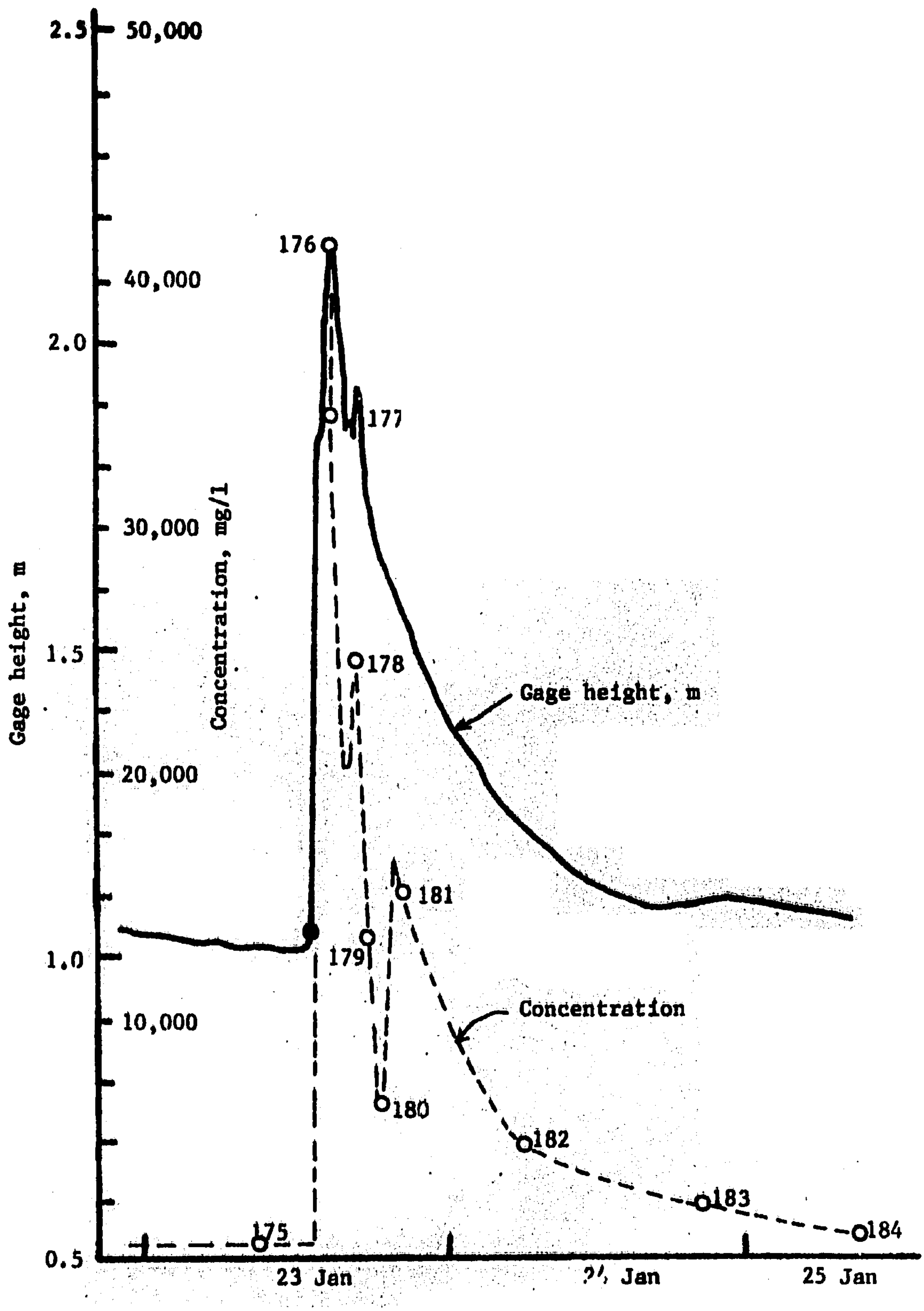


Figure 24: Gage Heights and Concentrations

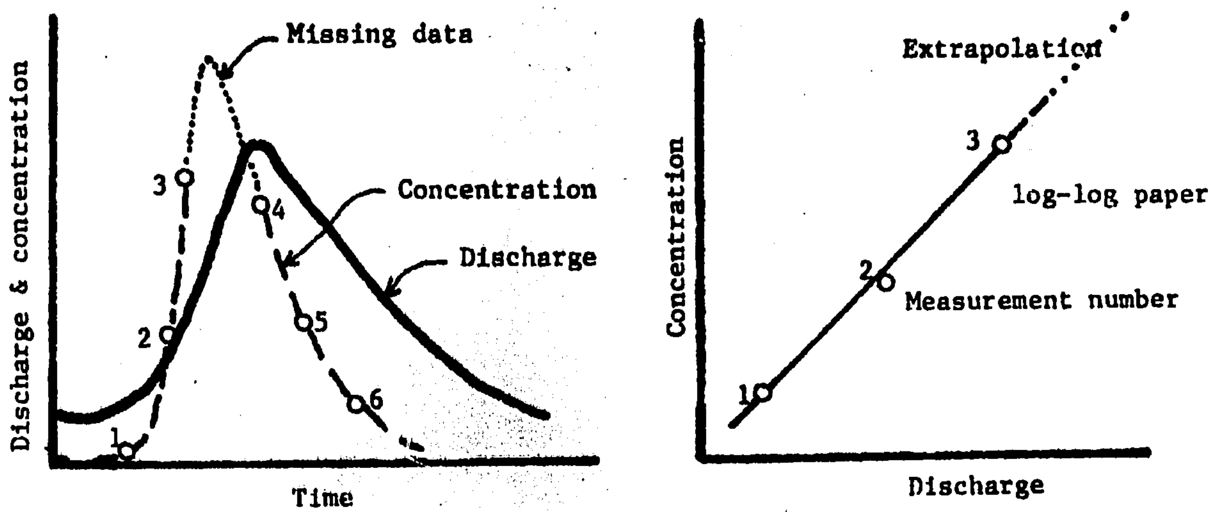


Figure 25: Estimating Missing Data

The calculations for the storm occurring on 1 February 1979 are shown in Table 1. The time periods are chosen so that a linear approximation is appropriate. That is

$$W = \frac{Q_{s1} + Q_{s2}}{2} \Delta t$$

Here W = is the weight of sediment discharged in time Δt

Q_{s1} = suspended sediment discharge at the beginning of the time step Δt

Q_{s2} = suspended sediment discharge at the end of the time step Δt

The suspended sediment load is computed using the expression

$$Q_s = 0.001\ CQ$$

in which Q_s = suspended sediment discharge at any instant of time, kg/s

C = concentration of suspended sediment, mg/l

Q = water discharge, m^3/s

Also

$$V = \frac{Q_1 + Q_2}{2} \Delta t$$

Here V = volume of water discharged in time period Δt

Q_1 = water discharge at the beginning of the time period Δt

Q_2 = water discharge at the end of the time period Δt

During the 1 February 1979 storm, the maximum measured suspended concentration was 68,600 mg/l. The flood peak was 197 m^3/s.

The total sediment discharged between 0800 hours on 1 February and 0800 hours on 2 February was 75,800,000 kg. The volume of water passing the station was 2,450,000 m^3.

The average concentration for the storm was

$$\bar{\bar{C}} = \frac{75,800,000}{2,450,000} \times 1,000 = 30,900\ mg/l$$

which is very, very dirty.

A summary of the monthly suspended sediment load measured at the bridge during the 1977-78 and 1978-79 wet seasons are given in Table 2.

TABLE 1

SUSPENDED SEDIMENT CALCULATIONS

JRAGUNG RIVER AT BORANGAN BRIDGE

Date	Hour	Gage height m	Water discharge m^3/s	Sediment concentration mg/l	Sediment discharge kg/s	Time increment min	Sediment discharge kg	Accumulated sediment kg	Water discharged m^3	Accumulated water m^3
1 Feb 1979	0200	0.98	1.95	1,100	2.15					
						460	50,091		47,395	
	1540	0.95	1.48	1,000	1.48			50,091		47,395
						180	15,194		15,993	
	1840	0.95	1.48	900	1.33			65,285		63,389
						60	7,249		7,516	
	1940	1.02	2.69	1,000	2.69			72,535		70,905
						15	1,088,747		17,077	
	1955	1.68	35.26	68,550	2,416.74			1,161,283		87,983
						10	2,359,212		41,991	
	2005	2.30	104.72	52,020	5,447.30			3,520,495		129,974
						13	5,017,108		98,438	
	2018	2.57	147.69	50,220	7,417.08			8,537,604		228,413
						12	5,214,787		123,971	
	2030	2.83	196.67	35,940	7,068.44			13,752,392		352,384
						10	4,076,174		117,396	
	2040	2.82	194.65	33,490	6,518.81			17,828,567		469,781
						80	24,526,835		773,423	
	2200	2.45	127.61	29,000	3,700.70			42,355,402		1,243,205
						60	10,510,037		383,649	
	2300	2.16	85.53	25,000	2,138.21			52,865,439		1,626,855
						75	6,751,234		283,020	
2 Feb 1979	0015	1.74	40.26	21,420	862.34			59,616,674		1,909,875
						75	2,825,287		156,138	
	0130	1.60	29.14	13,500	393.34			62,441,961		2,066,014
						98	1,524,060		147,762	
	0308	1.48	21.12	5,920	125.05			63,966,021		2,213,776
						202	1,027,571		198,628	
	0630	1.30	11.65	3,820	44.52			64,993,592		2,412,405
						90	206,203		58,342	
	0800	1.26	9.95	3,200	31.85			65,199,795		2,470,747

TABLE 2

SUSPENDED SEDIMENT YIELD

JRAGUNG CATCHMENT UPSTREAM FROM BORANGAN BRIDGE

Water Year	Month	Suspended Sediment kg	Water Discharged m^3	Monthly Average Concentration mg/1
1977-78	Nov	16,620,000	1,256,000	13,200
	Dec	386,073,000	9,377,000	41,200
	Jan	175,078,000	15,619,000	11,200
	Feb	513,583,000	21,302,000	24,200
	Mar	33,007,000	9,915,000	3,330
	Apr	56,560,000	5,750,000	9,840
	Total	1,180,921,000	63,219,000	
1978-79	Oct	48,733,000	4,311,000	11,300
	Nov	10,766,000	2,964,000	3,630
	Dec	76,719,000	10,802,000	7,100
	Jan	105,780,000	17,328,000	6,100
	Feb	107,850,000	10,228,000	10,500
	Mar	51,746,000	7,656,000	6,760
	Apr	213,768,000	18,732,000	11,410
	May	48,882,000	5,844,000	8,360
	Total	664,244,000	80,385,000	

Detailed information on the Jragung River sediment sampling program, calculations and other relevant information are given in Sections H-1 thru H-5 of this Appendix. This document is used as the lecture notes for the remainder of this series on erosion and sedimentation.