JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)

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THE REPUBLIC OF INDONESIA

FEASIBILITY STUDY ON THE WARSAMSON HYDROELECTRIC POWER DEVELOPMENT PROJECT IN THE REPUBLIC OF INDONESIA

FINAL REPORT

SUPPORTING REPORT

VOLUME-I HYDROLOGICAL ANALYSIS

VOLUME-II TOPOGRAPHIC SURVEY

FEBRUARY 1996

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VOLUME - I HYDROLOGICAL ANALYSIS

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CHAPTER 1 OBJECTIVES AND SCOPE OF STUDY

Analysis and estimation of the river flow, flood discharge and sedimentation, as well as other hydrological parameters, at the proposed project site are essential in determining the technically optimum development scale and design conditions for the facilities to be built.

During the feasibility study (F/S), the following works were carried out;

- collection of meteorological data, precipitation data, discharge data and other data which have been taken at the existing observation stations in and around the river basin
- visiting the project site as well as some of the observation stations, to assess a hydrological conditions where they are located
- site survey, undertaken by PLN, to obtain supplementary hydro-meteorological data,
- thorough analysis of the hydrological parameters which were required for the optimization study

The data collection was continued up to the Feasibility-grade Design Stage in which a thorough hydrological analysis was carried out. The analysis covers the estimation of natural river flow, flood discharge, sedimentation and evaporation.

CHAPTER 2 SUMMARY OF AVAILABLE DATA

Hydro-meteorological data such as rainfall, water levels, atmospheric air temperature and so forth were collected during this F/S. However, it is regrettable to say that there are too many missing records at the existing observation stations. It is essential that improvements to the present situation are made so that the data can be collected continuously.

The following is the summary of data obtained at the observation stations including the new stations established during this F/S.

2.1 Rainfall

There are 20 rain-gauging stations in and around the Warsamson river basin including the new station established by PLN during this F/S. All the rainfall data available at present are exhibited in Appendix A.

The rain-gauging stations, WSN-1 ~ WSN-6, were established by PLN and have been operated since 1991. The station at Sorong Jefman was established by BMG, and since 1920 the rainfall has been observed. The other stations, excluding the new station, were installed by other organizations and the registration of data was terminated before 1987.

The operation of the new station was started in 1995. This station is located near WSN-1 for obtaining not only rainfall data but also other meteorological data.

The locations of the above stations and the availability of data are shown in Figs. 2.1, 2.2 and 2.3.

(1) WSN-1 ~ WSN-6

Data taken at WSN-1 ~ WSN-6 could be most useful for the hydrological analysis of the project since these stations are located in and near the Warsamson river basin, and daily rainfall data has been collected. However, there are too many missing records as shown in Figs. 2.2 and 2.3. This was caused by mechanical trouble with recorders, imperfect maintenance and so forth. Due care has to be taken for data collection.

(2) Sorong Jefman

This station is located relatively close to the project area . Rainfall data over a long period of time is available only at this station in the Sorong area although there is a long break in the records from 1942 to 1957. Maximum daily rainfall records up to 1990 were also recorded at this station as shown in Table A.2 of Appendix A.

During this F/S, recent rainfall data was collected from BMG in Jakarta and Sorong Jefman, but only monthly rainfall data was completely recorded.

(3) New station at Malano

Instruments such as an evaporimeter, a barometer, a sunshine recorder, a thermometer, an automatic rain gauge, a wind vane and an anemometer were supplied by JICA and installed by PLN at this station. It's operation began in 1995. In the project area, only this station is collecting meteorological data, and these data will be very useful for the project in the future.

2.2 Discharge Data

Long term discharge data is of vital importance in determining the technically optimum development scale and design conditions for the plant facilities to be built. It is, however, to be regretted that the discharge measurements carried out at the Malano gauging station by Pt. Wiratman & Associates and Pt. Geo Ace under contract with PLN, were only for certain periods which effected the discharge rating curves, but they may be no longer applicable to the present river conditions. By using the instrument supplied by JICA, PLN undertook the discharge measurements at the Malano gauging station (Malano AWLR) to produce a new discharge rating curve.

Appendix D exhibits the results of discharge measurements during this F/S.

2.3 Water Level

Malano AWLR was installed by PLN and started operation in March 1991. It is regrettable to say that water levels also have not been recorded continuously and that data is lacking for large parts of the years as shown in Fig. 2.3.

All data collected are exhibited in Table B.1 of Appendix B. It is of vital importance to maintain the automatic water level recorder properly and collect data continuously.

2.4 Meteorological Data

Meteorological data is available at the meteorological station class II Jefman in the Sorong area, which has been operated by BMG. At this station, data such as wind speed, rainfall, air temperature and humidity have been collected.

In addition, meteorological data has been collected by PLN at the new Malano station since February, 1995.

All the data are exhibited in Appendix C.

2.5 Other Data

(1) Sedimentation

In the project area, no research, except for the study in the Pre-F/S, was carried out on the sedimentation range before the conducting of this F/S. In order to examine the study results in the Pre-F/S Report, the suspended load of the Warsamson river was measured by PLN at the Malano AWLR in the course of this F/S. Data obtained is exhibited in Appendix E.

(2) Tidal level

The discharge point of the proposed hydropower plant will be located downstream of the waterfall, where the water level may be affected by the tidal levels. Therefore, during this F/S, an automatic water level recorder was installed downstream of the waterfall for measuring water levels and clarifying the influence due to the tidal levels. In order to examine the correlation between the tidal levels at Sorong Port and the river estuary, the tidal levels near the estuary were also measured.

The observation records are shown in Appendix F.

(3) Topographic maps

In order to clarify the locations of the existing rain-gauge stations, an area of the river basin and a length of the Warsamson river, topographic maps with scales of 1/ 250,000 and 1/63,300 were used.

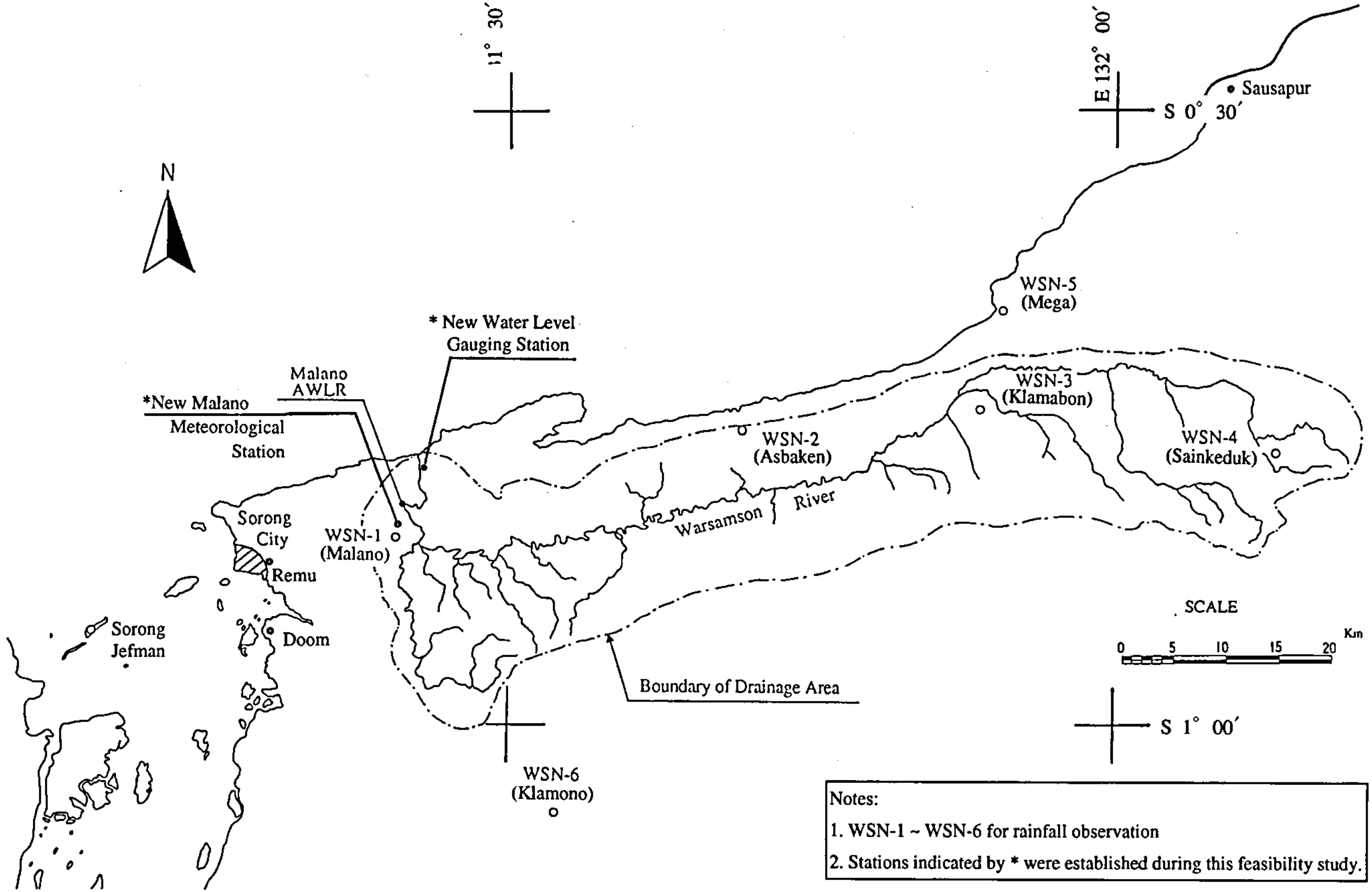


Fig. 2.1 Location Map for Rainfall Gauge and Water Level Gauge Stations

Fig. 2.2 Availability of Annual / Monthly Hydro-meteorological Data

▬ : Complete data
▭ : Incomplete data

Station Name	Station No.	EL (m)	Location	Property
I. Rainfall				
1. Sorong - Jefman	0402/499	2	00°58'S • 131°07'E	BMG
2. Sorong - Remu	0410/499	5	00°53'S • 131°17'E	PU
3. Sorong - Doom	0408/499	10	00°53'S • 131°17'E	Pertanian
4. Klamono	1404/49	40	01°07'S • 131°30'E	Pertamina
5. Sausapur	004/498n	10	00°30'S • 132°05'E	Perkbunan
6. Ayamaru	1604/504t	300	01°17'S • 132°11'E	Pertanian
7. Atinyo	1608/504d	150	01°26'S • 132°23'E	
8. Ayawasi	1648/504e	500	01°11'S • 132°29'E	Katholik
9. Wefiani	16279499a	4		
10. Kebar	0648/499d	350	00°48'S • 133°04'E	
11. Kebare	0204/522	2	00°04'S • 130°59'E	
12. Makbon	0412/506	-	00°45'S • 131°30'E	Pertanian
13. Mega	0414/506	3	00°40'S • 131°53'E	Pertanian
14. Malano	WSN-1	50	01°06'S • 131°21'E	PLN
15. Asbaken	WSN-2	375	00°47'S • 132°07'E	PLN
16. Klamabon	WSN-3	375	00°46'S • 131°00'E	PLN
17. Sainkeduk	WSN-4	150	00°47'S • 132°07'E	PLN
18. Mega	WSN-5	50	00°39'S • 132°07'E	PLN
19. Klamono	WSN-6	50	01°06'S • 131°31'E	PLN
20. New Malano	-	-	-	PLN
II. River Water Level				
1. Malano AWLR		38	01°51'S • 131°24'E	PLN
III. Climate				
1. Sorong Jefman		2	00°56'S • 131°07'E	BMG
2. New Malano			-	PLN

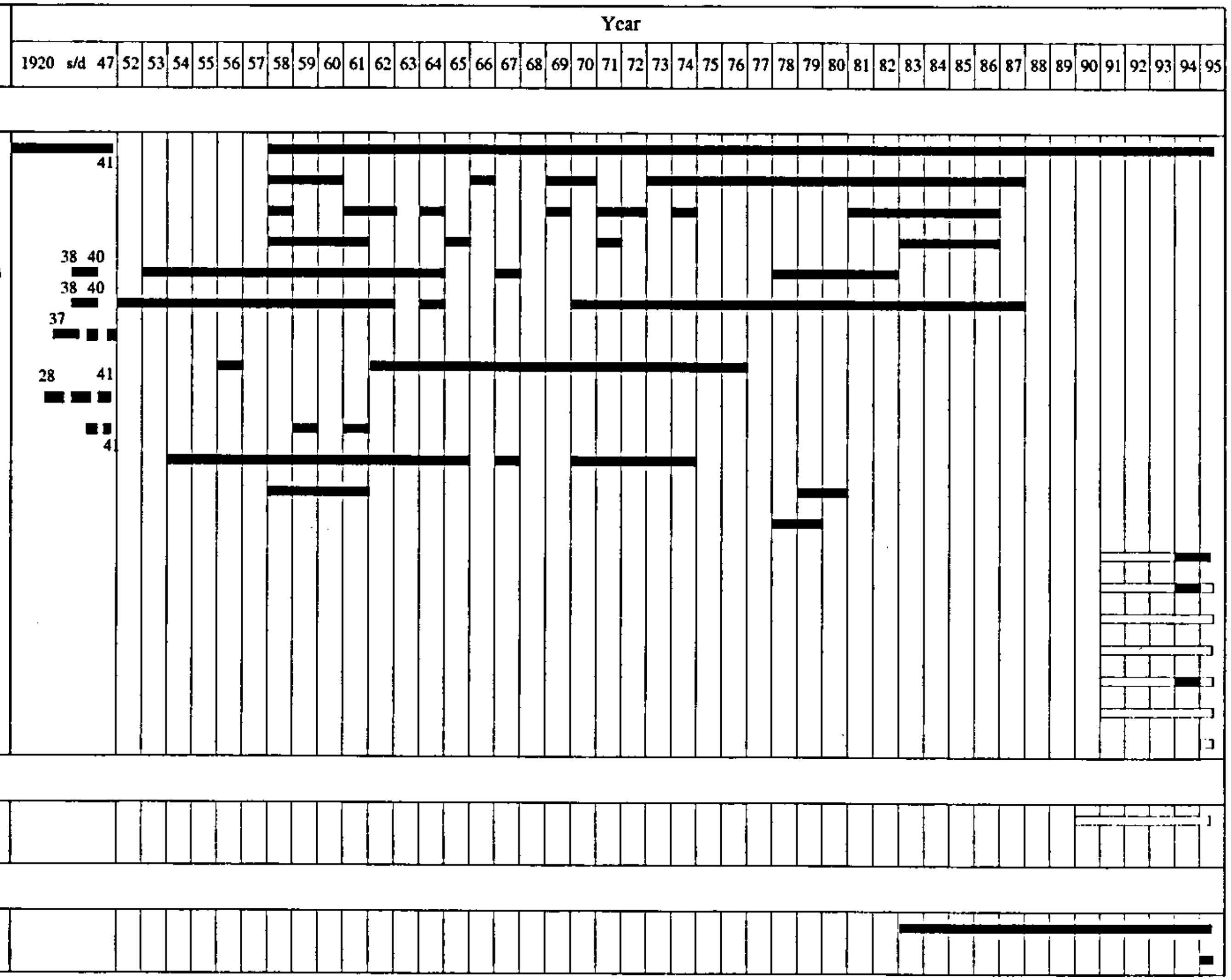
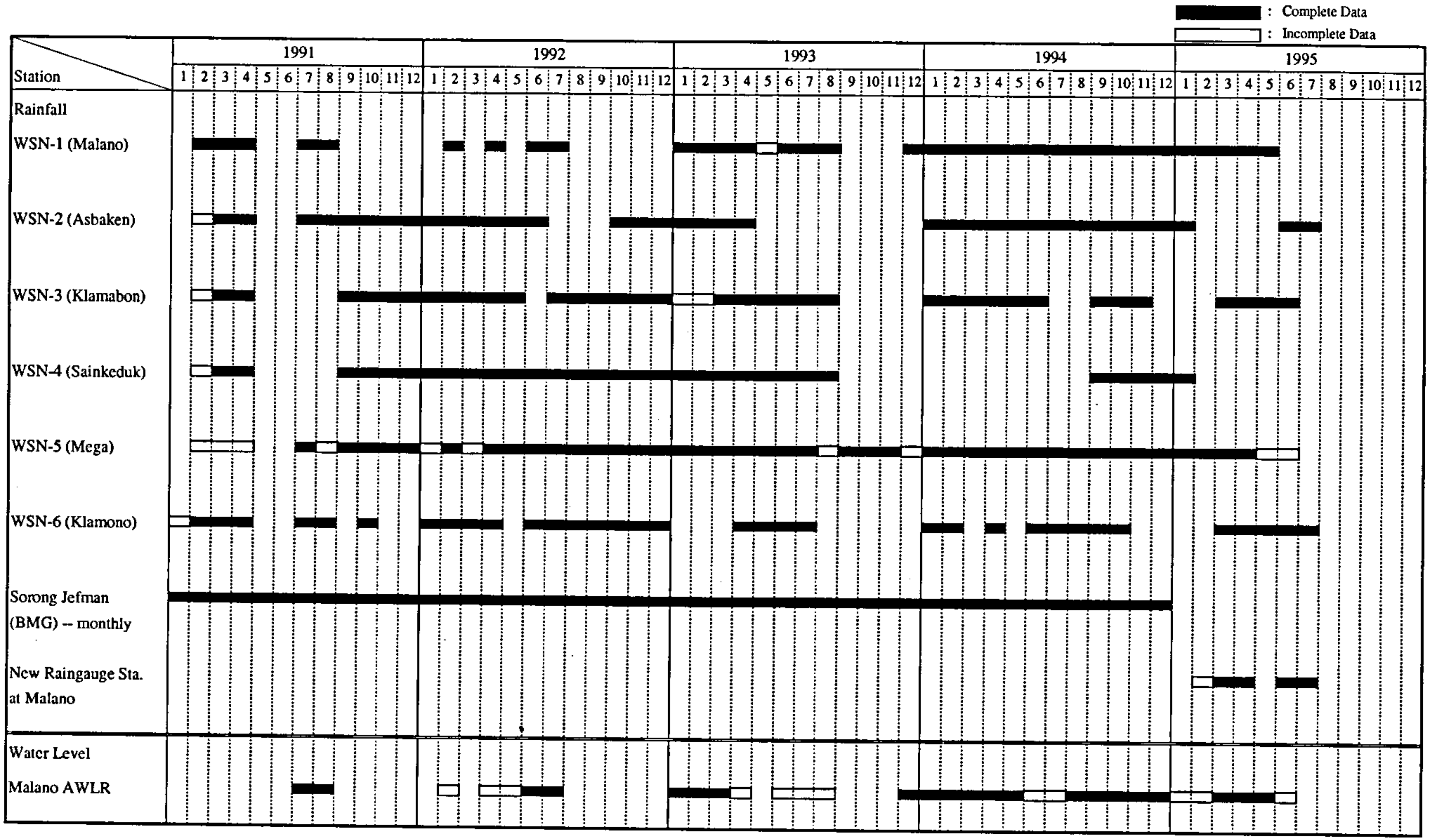


Fig. 2.3 Availability of Daily / Monthly Rainfall and Water Level Data



CHAPTER 3 HYDRO-METEOROLOGICAL CONDITIONS OF RIVER BASIN

The river basin, which is covered by dense forest, is bounded by a mountain range with Mount Sagawawi (673 m) in the south and Mount Mayalon (686 m) in the north. The form of the basin is very narrow (about 15 km wide x 95 km long) and it generally has flat features with many isolated hills. The catchment areas are about 1,460 km^2 at the proposed dam site and about 1,412 km^2 at Malano AWLR.

According to the site reconnaissance, miscellaneous weathered rocks, such as mudstone, tuff, siltstone and so forth, are distributed in the upstream area, and most of the area is covered by residual soil and dense tropical vegetation. It seems that the permeability is low, but water retentivity is high because of the dense vegetation.

The Warsamson river flows from east to west for a total length of about 190 km, including the Sumrem river (about 32 km long) which flows in the most upstream area, and reaches the Pacific Ocean at Dan Pier Strait in the north of Irian Jaya. The slope of the river bed is estimated as about 1/1,500 ~ 1/3,000 except for the Sumrem river and the stretch between the waterfall and the Malano bridge.

According to the meteorological data at Sorong Jefman, the average temperature is about 28 °C and the average humidity is about 81 %. It is said that the climate in this area is influenced by the West and East monsoon, but it rains almost every month and a clear dry season cannot be seen from the rainfall data at the gauging stations (WSN-1 ~ WSN-6 and Jefman).

Annual rainfall at Sorong Jefman varies from 1,793 to 4,098 mm according to Table A.2 of Appendix A. The annual rainfall from 1958 to 1994 and for 5-year moving averages are shown in Fig. 3.1. According to the figure, dry years and wet years come in a cycle of 4 to 6 years, and a long cycle change extending 14 years also exists.

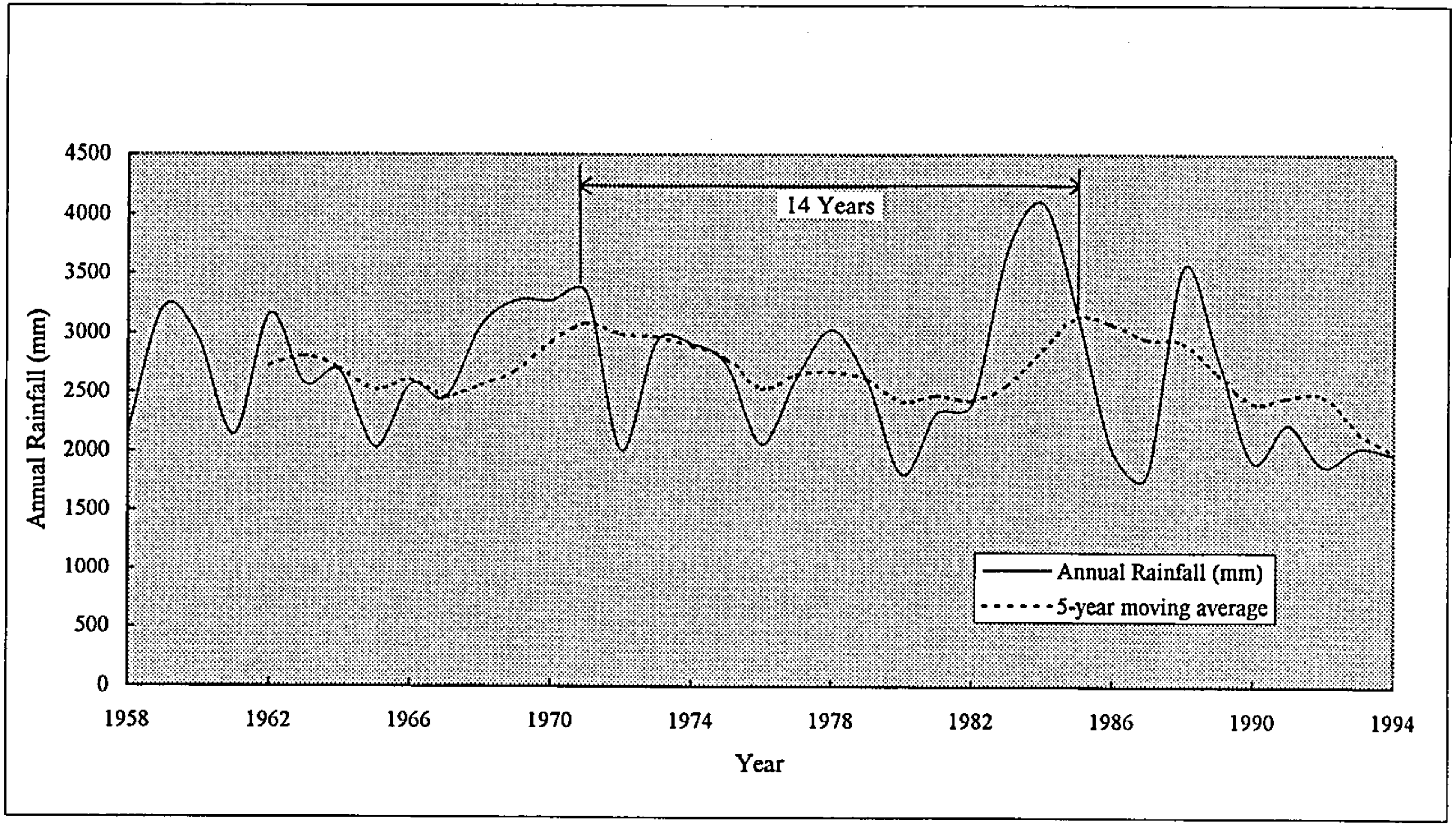


Fig. 3.1 Simple Moving Average of Annual Rainfall at Sorong Jefman

CHAPTER 4 STUDY ON NATURAL RIVER FLOW

4.1 Discharge Rating Curve

By using the results of discharge measurements undertaken by PLN during this F/S (Appendix D), a new rating curve shown in Fig. 4.3 was produced.

First, a discharge rating curve toward the elevation of the water surface (h) was produced by regression analysis as shown in Fig. 4.1 since "h" was recorded during the discharge measurement.

Secondly, the correlation between the elevation of the water surface (h) and reading at the existing Malano AWLR (H) was examined (Fig. 4.2). This work is necessary to estimate the river flow from water level records at Malano AWLR in the past and in the future.

Finally, Fig. 4.3 was obtained by interpolating the h-H relation to the equations of the EL-Q rating curve indicated in Fig. 4.1.

$$Q = 12.294\ H^2 + 35.446\ H + 4.99\ (H < 1.80\ m)$$
$$Q = 1.1013\ H^2 + 96.797H - 69.19\ (H \geq 1.80\ m)$$

Fig. 4.3 compares the rating curves obtained in this F/S and the Pre-F/S completed in 1992. Both curves cross at the middle, but some difference can be seen at low and high water levels. This difference is caused by erosion of the river bed and the river banks, sedimentation and/or errors in the measurement.

Water levels recorded at Malano AWLR were converted to river flows as follows:

River flow up to 1993	: by using the rating curves in the Pre-F/S
River flow from 1994	: by using the rating curves produced in this F/S

The results are exhibited in Appendix B.

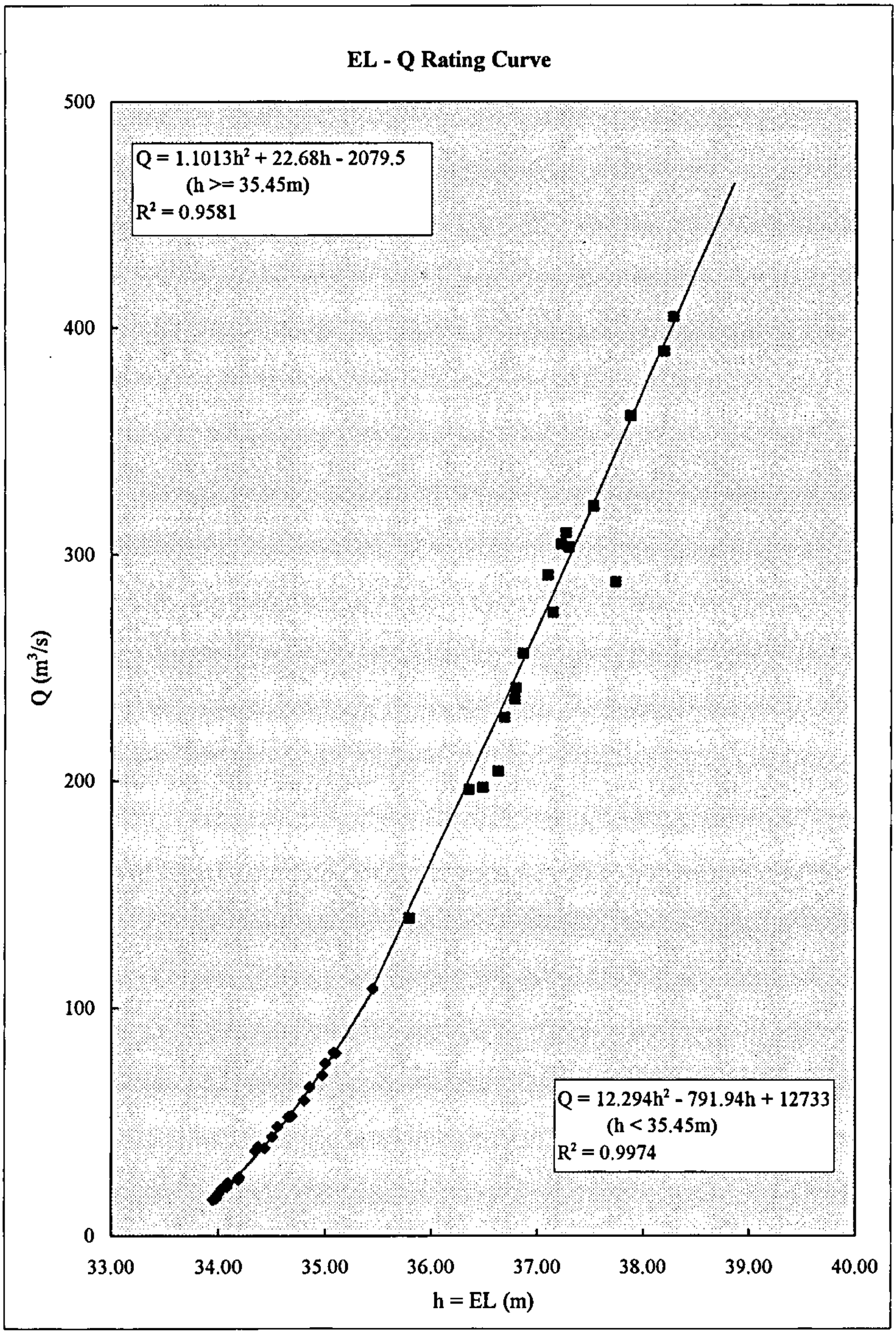


Fig. 4.1 Discharge Rating Curve (EL - Q)

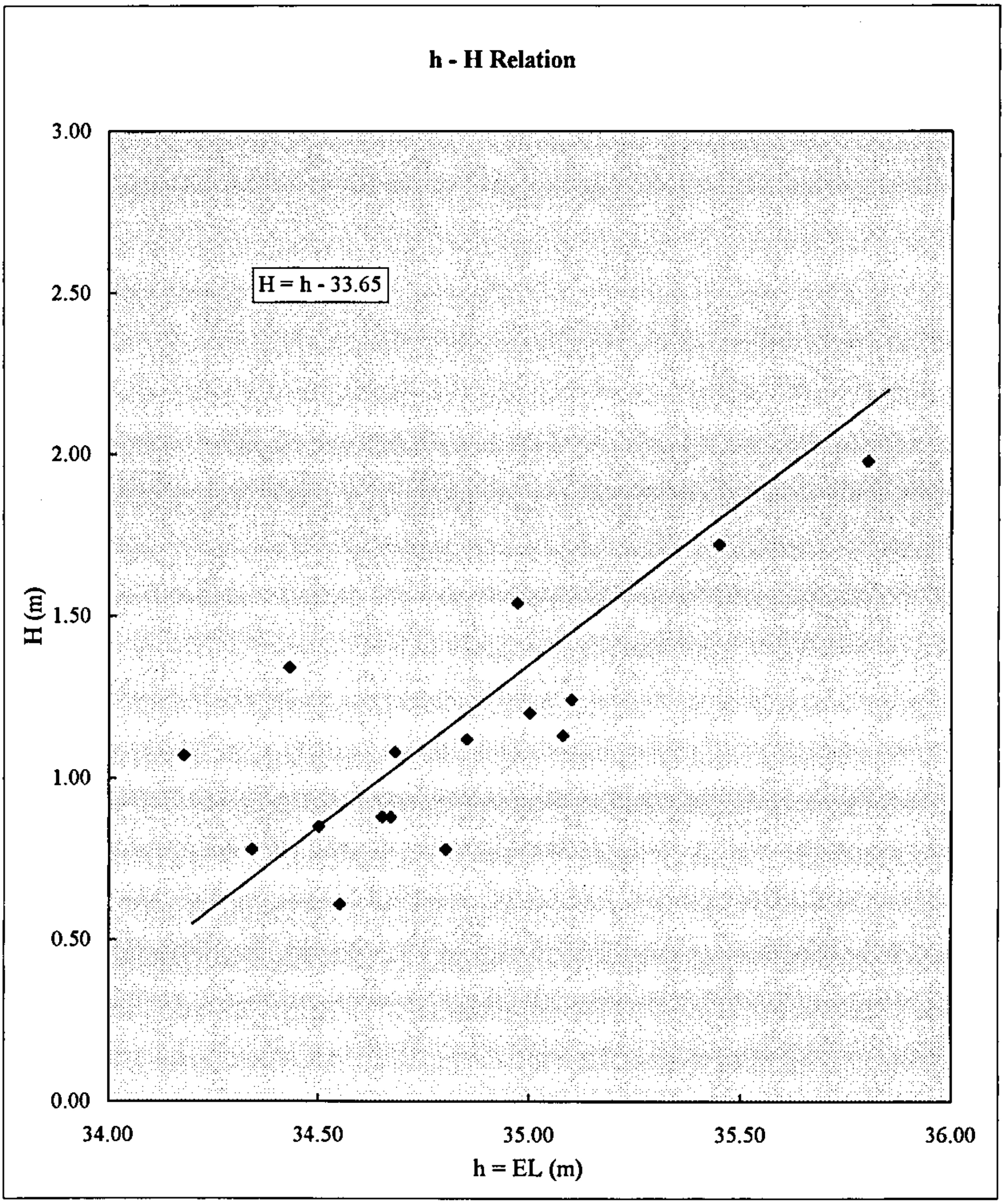


Fig. 4.2 Relation Between EL and H (W.L. recorded at Malano AWLR)

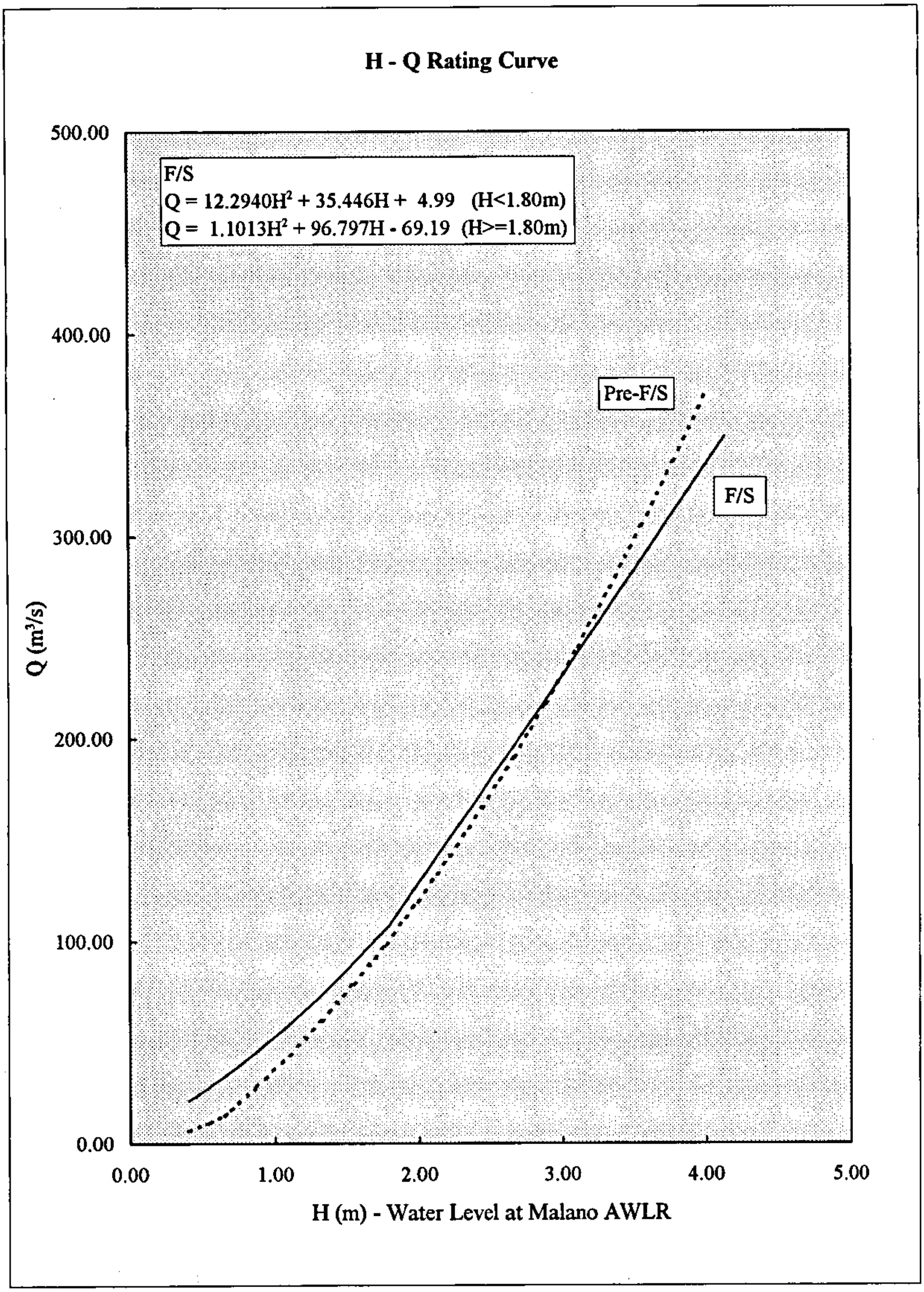


Fig. 4.3 Discharge Rating Curve

4.2 Study on Run-off Coefficient and Estimation of River Flow

The run-off coefficient was estimated based on the rainfall and discharge data obtained, and also by referring to the specific mean discharge used for the planning of other projects in Indonesia.

(1) Estimation of run-off coefficient by using rainfall and discharge data

Table B.1 in Appendix B shows the results of the conversion from the water levels which were observed at Malano AWLR to river flows as mentioned in Section 4.1.

Table A.1 in Appendix A shows the rainfall data observed at WSN-1 ~ WSN-6.

Based on the data shown in the above tables, run-off coefficients were estimated as follows:

1) Monthly rainfall data at WSN-1 ~ WSN-6 were converted to areal rainfall by using Thiessen Polygons (Figs. 4.4 ~ 4.10). Since there is a lack of data, the data for only 19 months were used for these calculations as shown in Table 4.1.

2) Average monthly river flows for the above 19 months were obtained from Table B.1 of Appendix B. The river flow in April 1991 was taken from the Pre-F/S report.

3) It was found, by comparing the areal rainfall and the river flow as shown in Table 4.2, that an average run-off coefficient of approximately 0.58 is obtained.

The above result seems to be reasonable considering the site conditions such as topography, soil cover and soil type. It is, however, necessary to review it by collecting more data in the detailed design stage since there are some problems in the above estimation;

- The volume of data examined is not sufficient.

- Only 6 rain-gauging stations exist in and near the catchment area which has an area of 1,460 km^2. Also ,the cases where monthly rainfall data at all of the stations are available in the same month is for 4 months only. These facts reduce the reliability of the estimated areal rainfall data and run-off coefficient.

- The estimation was made assuming that rainfall in a certain month runs off in the same month, with some losses. However, it is considered that river flow is affected by antecedent rainfalls in the preceding months as well. This effect could not be examined since there was too much missing of data.

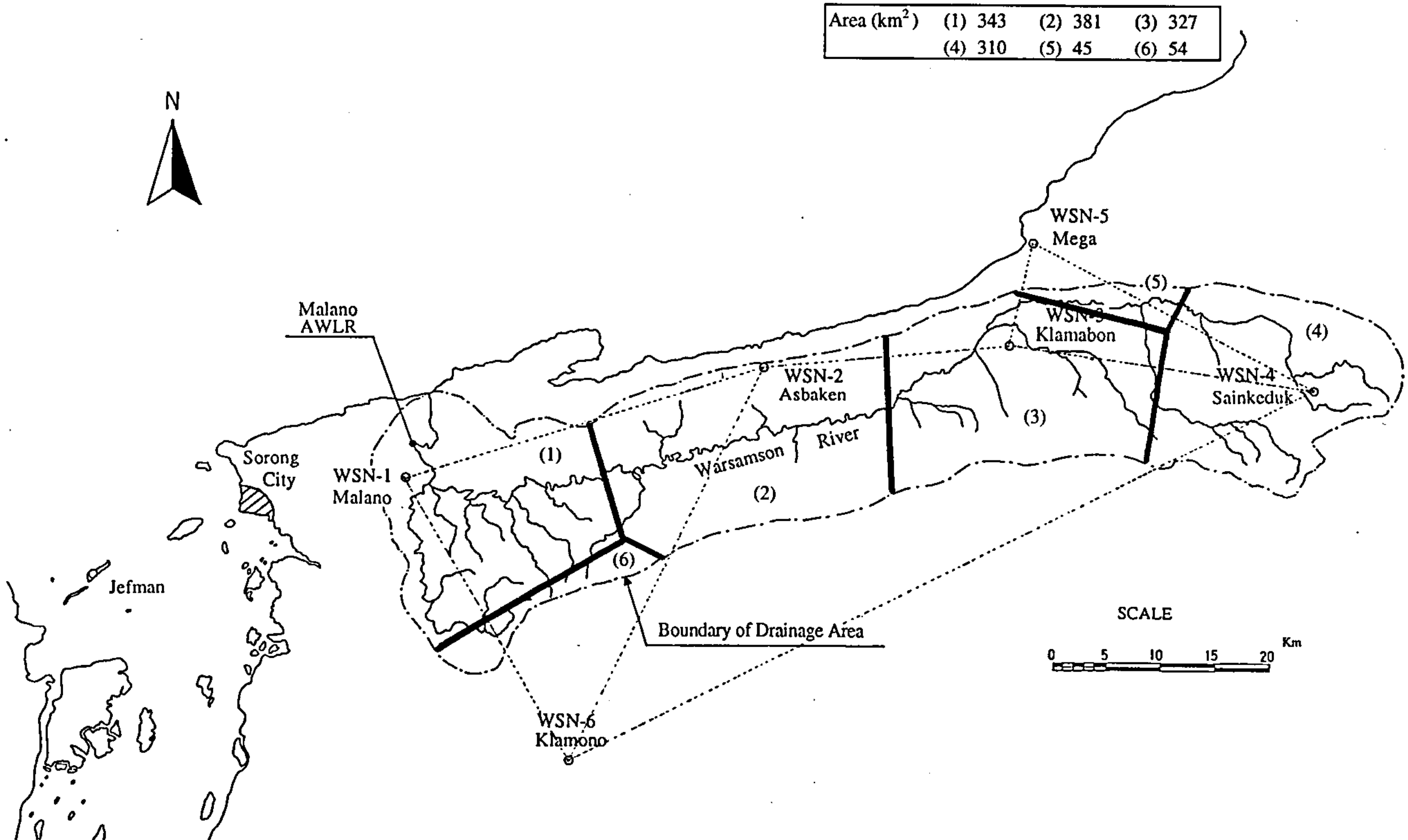


Fig. 4.4 Thiessen Polygon (1)

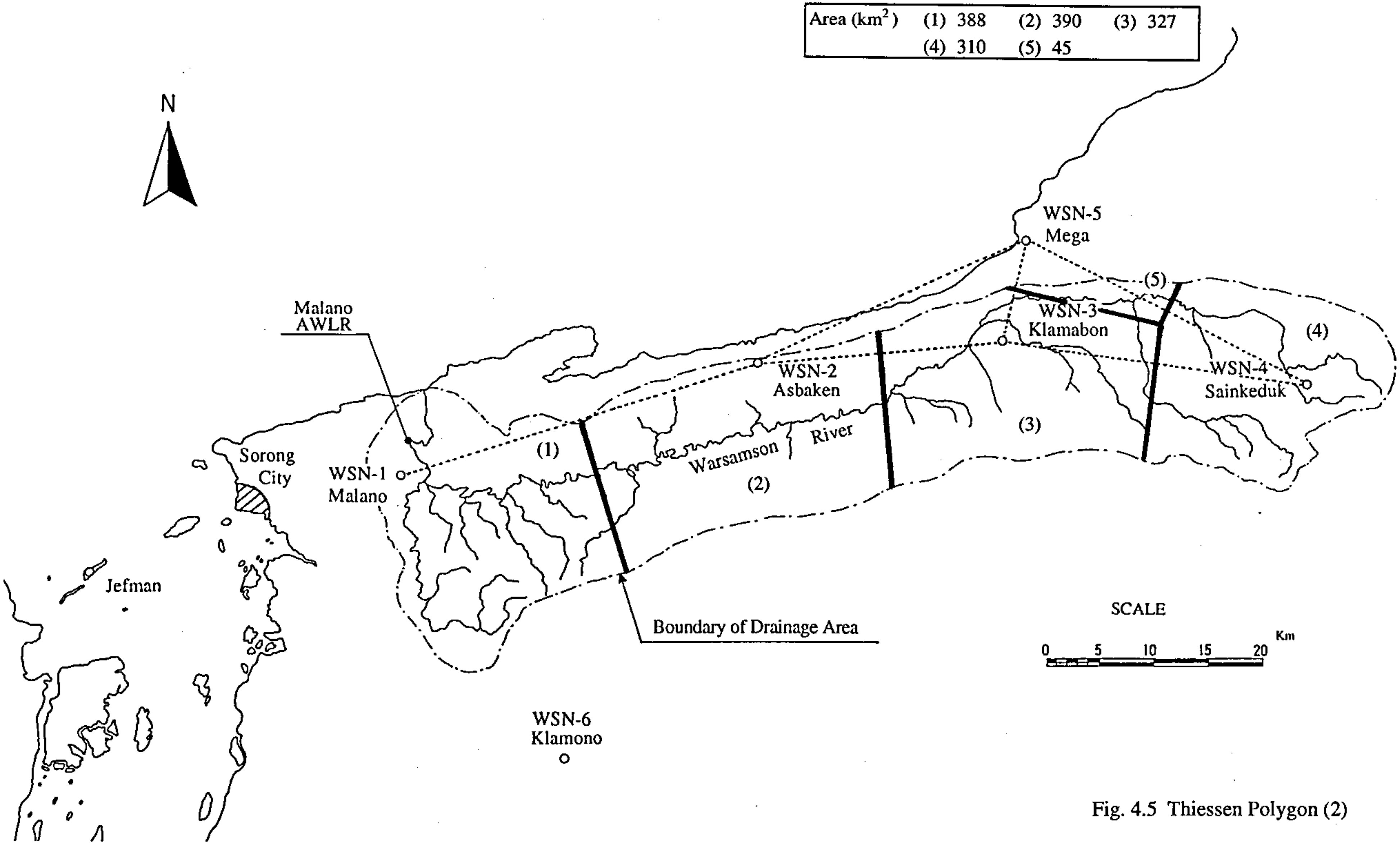


Fig. 4.5 Thiessen Polygon (2)

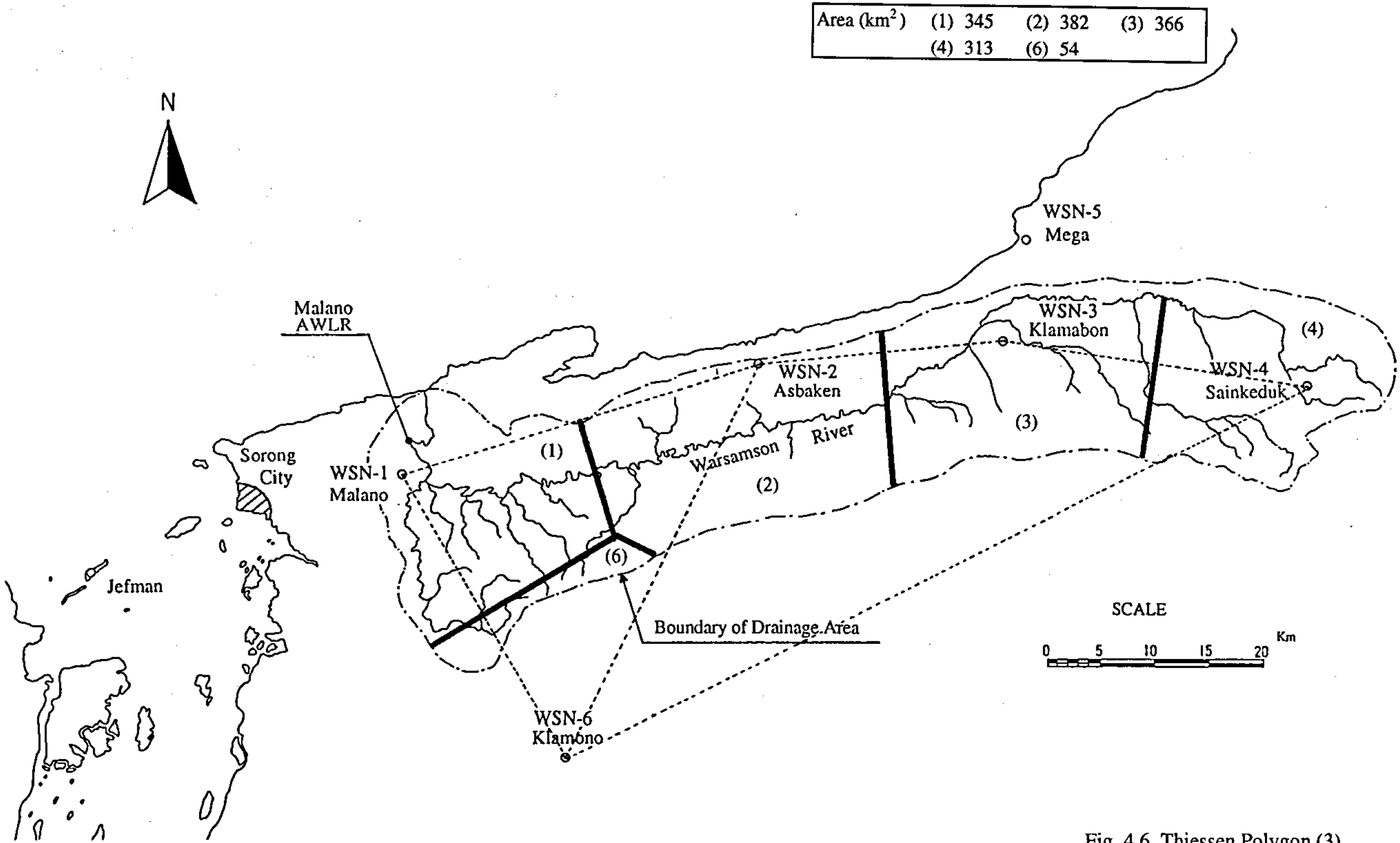


Fig. 4.6 Thiessen Polygon (3)

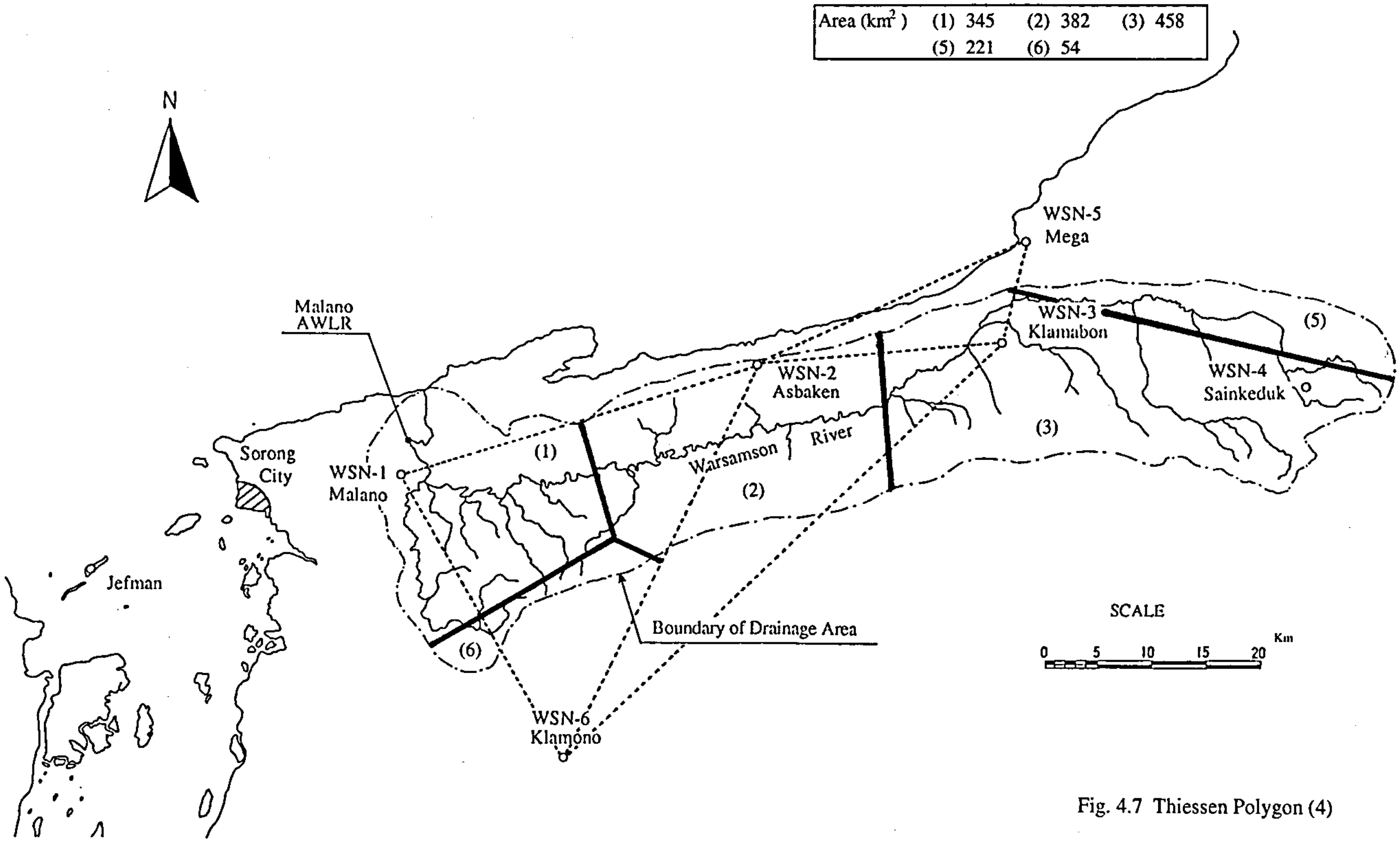


Fig. 4.7 Thiessen Polygon (4)

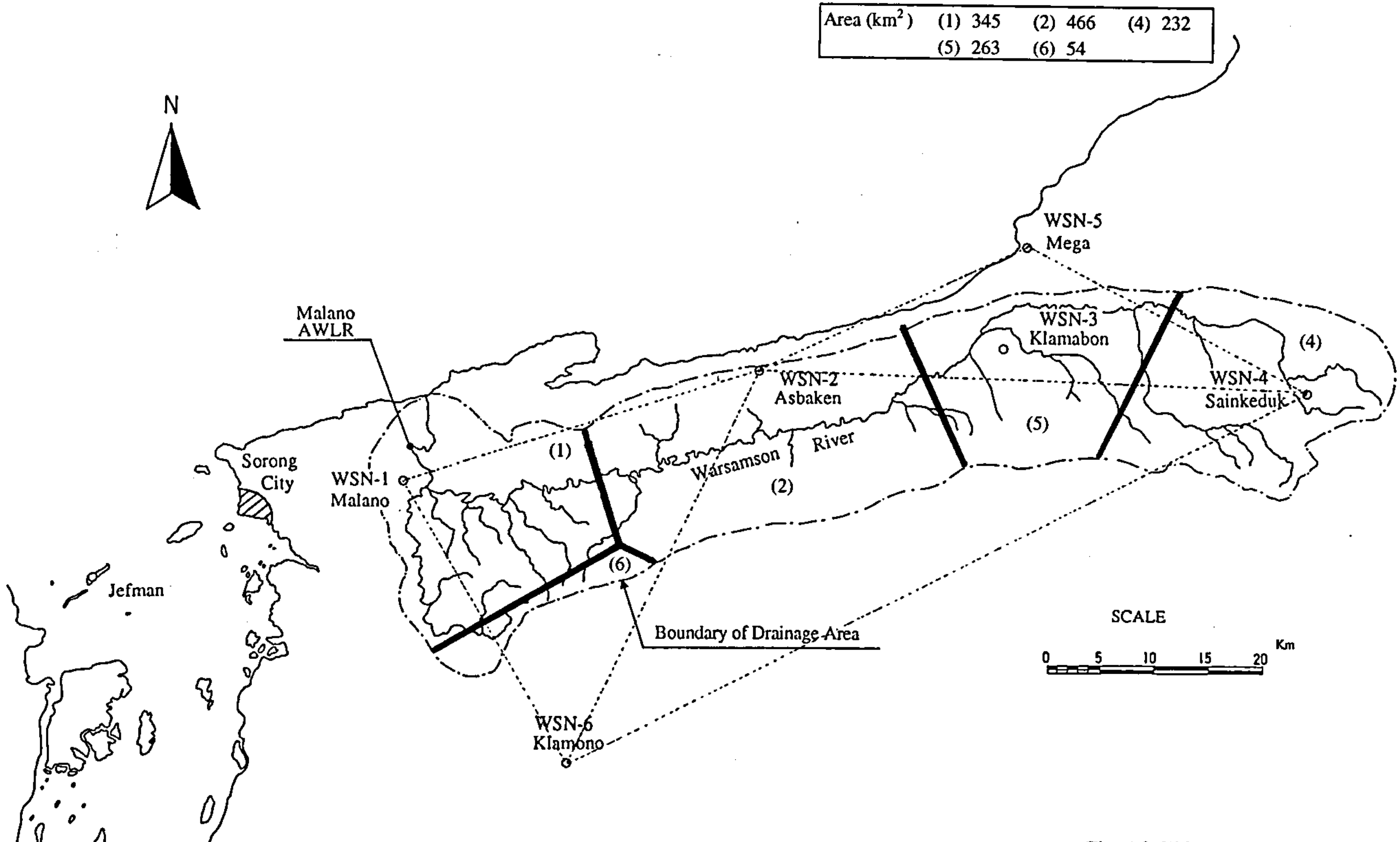


Fig. 4.8 Thiessen Polygon (5)

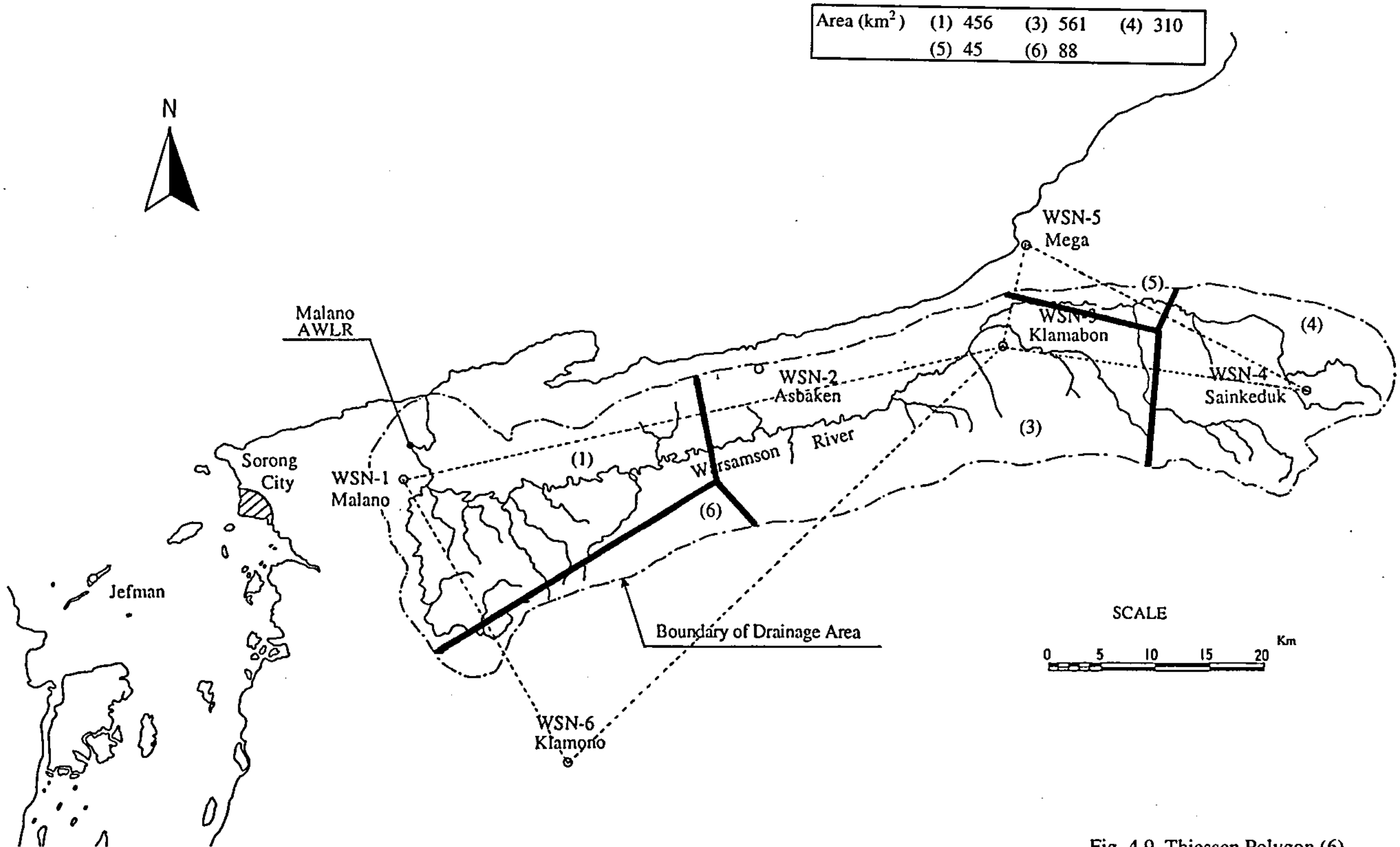


Fig. 4.9 Thiessen Polygon (6)

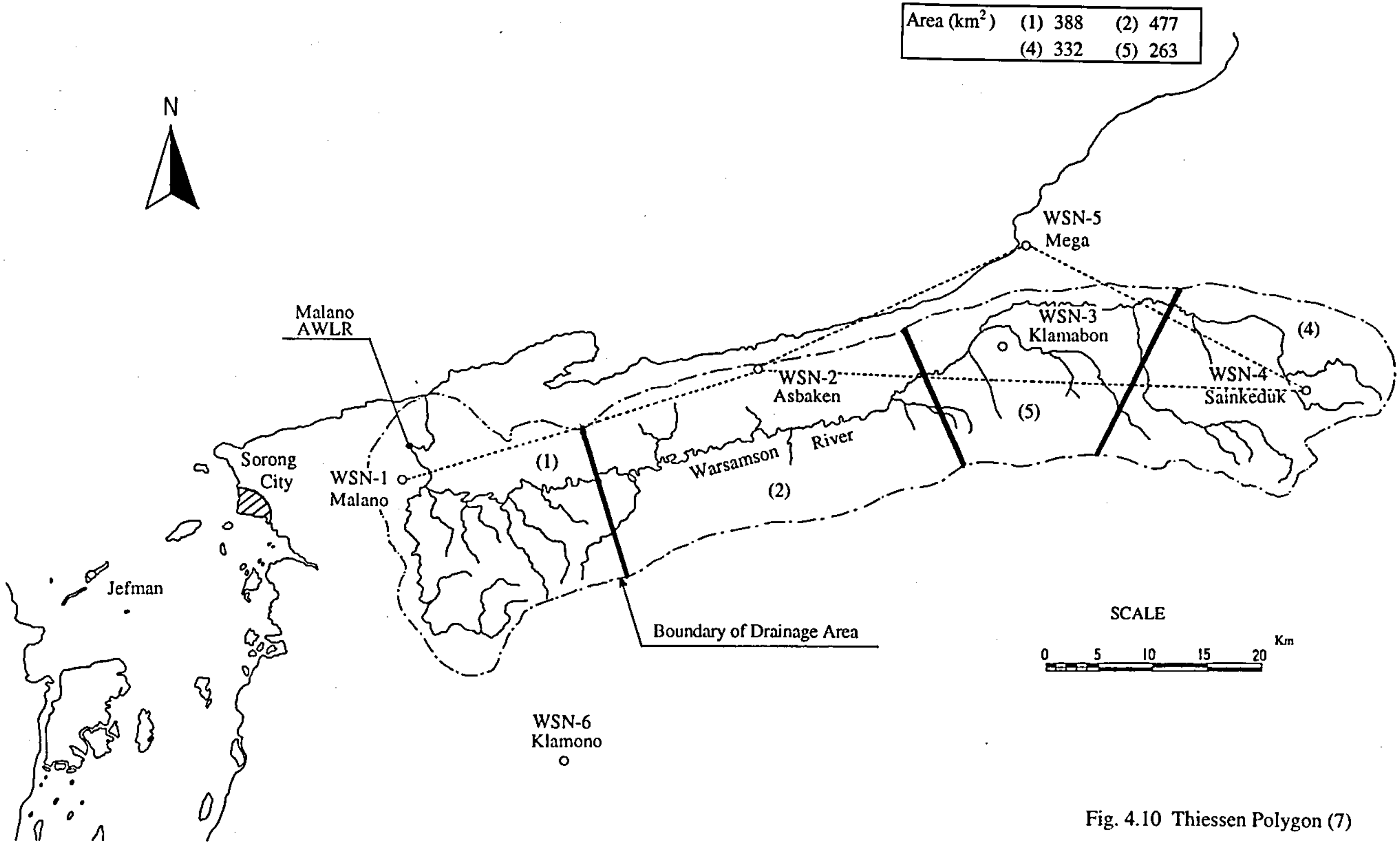


Fig. 4.10 Thiessen Polygon (7)

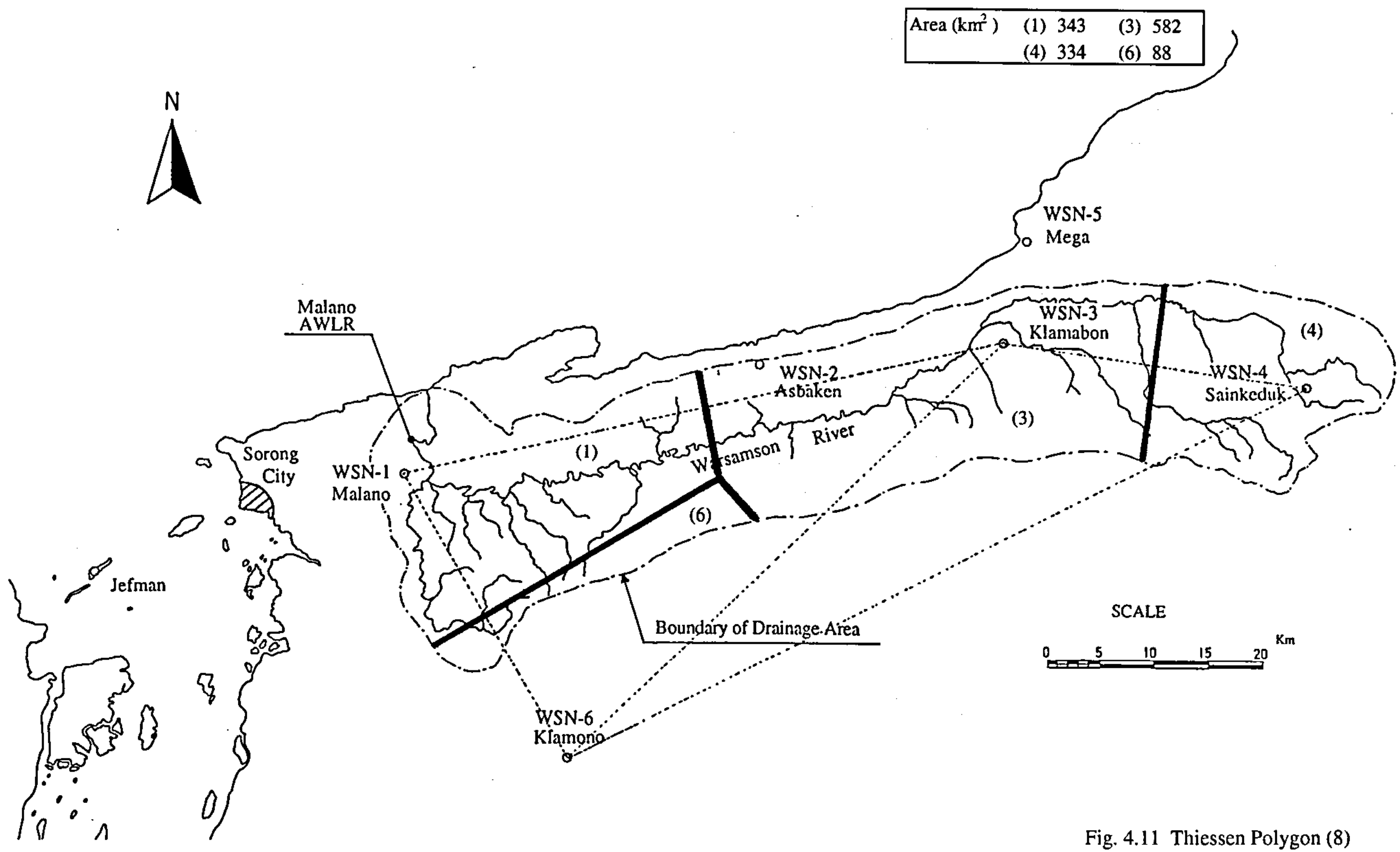


Fig. 4.11 Thiessen Polygon (8)

Table 4.1 Areal Rainfall derived from Thiessen Polygons and Comparison with Monthly Rainfall at Jefman

Month		Thiessen Polygons							Jefman	Ratio
		WSN-1	WSN-2	WSN-3	WSN-4	WSN-5	WSN-6	Total		
1991. 3	Area (km^2)	345.0	382.0	366.0	313.0	x	54.0	1460.0		
	Weight	0.24	0.26	0.25	0.21	x	0.04	1.0		
	Rainfall (mm)	380.0	387.5	455.5	324.5	x	351.5			
	Weighted Rainfall (mm)	89.8	101.4	114.2	69.6	x	13.0	387.9	235.0	0.61
1991. 4	Area (km^2)	345.0	382.0	366.0	313.0	x	54.0	1460.0		
	Weight	0.24	0.26	0.25	0.21	x	0.04	1.0		
	Rainfall (mm)	156.0	248.5	214.0	358.0	x	429.0			
	Weighted Rainfall (mm)	36.9	65.0	53.6	76.7	x	15.9	248.1	156.0	0.63
1992. 2	Area (km^2)	343.0	381.0	327.0	310.0	45.0	54.0	1460.0		
	Weight	0.23	0.26	0.22	0.21	0.03	0.04	1.0		
	Rainfall (mm)	151.0	186.0	227.0	111.0	127.0	248.0			
	Weighted Rainfall (mm)	35.5	48.5	50.8	23.6	3.9	9.2	171.5	50.0	0.29
1992. 4	Area (km^2)	343.0	381.0	327.0	310.0	45.0	54.0	1460.0		
	Weight	0.23	0.26	0.22	0.21	0.03	0.04	1.0		
	Rainfall (mm)	119.5	279.0	292.0	278.0	248.0	142.0			
	Weighted Rainfall (mm)	28.1	72.8	65.4	59.0	7.6	5.3	238.2	100.0	0.42
1992. 6	Area (km^2)	345.0	466.0	x	332.0	263.0	54.0	1460.0		
	Weight	0.24	0.32	x	0.23	0.18	0.04	1.0		
	Rainfall (mm)	266.0	150.0	x	290.0	209.0	510.0			
	Weighted Rainfall (mm)	62.9	47.9	x	65.9	37.6	18.9	233.2	136.0	0.58
1992. 7	Area (km^2)	456.0	x	582.0	334.0	x	88.0	1460.0		
	Weight	0.31	x	0.40	0.23	x	0.06	1.0		
	Rainfall (mm)	109.5	x	444.0	222.0	x	299.0			
	Weighted Rainfall (mm)	34.2	x	177.0	50.8	x	18.0	280.0	191.0	0.68
1993. 1	Area (km^2)	388.0	477.0	x	332.0	263.0	x	1460.0		
	Weight	0.27	0.33	x	0.23	0.18	x	1.0		
	Rainfall (mm)	189.5	148.0	x	238.0	204.0	x			
	Weighted Rainfall (mm)	50.4	48.4	x	54.1	36.7	x	189.6	111.0	0.59
1993. 2	Area (km^2)	388.0	477.0	x	332.0	263.0	x	1460.0		
	Weight	0.27	0.33	x	0.23	0.18	x	1.0		
	Rainfall (mm)	71.0	0.0	x	244.0	187.0	x			
	Weighted Rainfall (mm)	18.9	0.0	x	55.5	33.7	x	108.0	114.0	1.06
1993. 3	Area (km^2)	388.0	390.0	327.0	310.0	45.0	x	1460.0		
	Weight	0.27	0.27	0.22	0.21	0.03	x	1.0		
	Rainfall (mm)	76.5	92.0	202.0	279.0	105.0	x			
	Weighted Rainfall (mm)	20.3	24.6	45.2	59.2	3.2	x	152.6	110.0	0.72
1993. 4	Area (km^2)	343.0	381.0	327.0	310.0	45.0	54.0	1460.0		
	Weight	0.23	0.26	0.22	0.21	0.03	0.04	1.0		
	Rainfall (mm)	140.0	63.0	394.0	460.0	112.0	397.0			
	Weighted Rainfall (mm)	32.9	16.4	88.2	97.7	3.5	14.7	253.4	206.0	0.81
1993. 6	Area (km^2)	456.0	x	561.0	310.0	45.0	88.0	1460.0		
	Weight	0.31	x	0.38	0.21	0.03	0.06	1.0		
	Rainfall (mm)	25.0	x	330.0	500.0	201.0	239.0			
	Weighted Rainfall (mm)	7.8	x	126.8	106.2	6.2	14.4	261.4	136.0	0.52
1993. 7	Area (km^2)	456.0	x	561.0	310.0	45.0	88.0	1460.0		
	Weight	0.31	x	0.38	0.21	0.03	0.06	1.0		
	Rainfall (mm)	124.0	x	572.0	904.0	131.0	496.0			
	Weighted Rainfall (mm)	38.7	x	219.8	191.9	4.0	29.9	484.4	294.0	0.61
1994. 1	Area (km^2)	345.0	382.0	458.0	x	221.0	54.0	1460.0		
	Weight	0.24	0.26	0.31	x	0.15	0.04	1.0		
	Rainfall (mm)	140.5	44.0	182.0	x	169.0	156.0			
	Weighted Rainfall (mm)	33.2	11.5	57.1	x	25.6	5.8	133.2	35.0	0.26
1994. 2	Area (km^2)	345.0	382.0	458.0	x	221.0	54.0	1460.0		
	Weight	0.24	0.26	0.31	x	0.15	0.04	1.0		
	Rainfall (mm)	46.5	7.0	56.0	x	41.0	163.0			
	Weighted Rainfall (mm)	11.0	1.8	17.6	x	6.2	6.0	42.6	161.0	3.78
1994. 4	Area (km^2)	345.0	382.0	458.0	x	221.0	54.0	1460.0		
	Weight	0.24	0.26	0.31	x	0.15	0.04	1.0		
	Rainfall (mm)	368.5	1249.0	343.0	x	168.0	474.0			
	Weighted Rainfall (mm)	87.1	326.8	107.6	x	25.4	17.5	564.4	229.0	0.41
1994. 6	Area (km^2)	345.0	382.0	458.0	x	221.0	54.0	1460.0		
	Weight	0.24	0.26	0.31	x	0.15	0.04	1.0		
	Rainfall (mm)	600.0	263.0	171.0	x	199.0	539.0			
	Weighted Rainfall (mm)	141.8	68.8	53.6	x	30.1	19.9	314.3	326.0	1.04
1994. 10	Area (km^2)	343.0	381.0	327.0	310.0	45.0	54.0	1460.0		
	Weight	0.23	0.26	0.22	0.21	0.03	0.04	1.0		
	Rainfall (mm)	239.5	0.0	212.0	87.0	83.5	357.0			
	Weighted Rainfall (mm)	56.3	0.0	47.5	18.5	2.6	13.2	138.0	191.0	1.38
1994. 11	Area (km^2)	388.0	390.0	327.0	310.0	45.0	x	1460.0		
	Weight	0.27	0.27	0.22	0.21	0.03	x	1.0		
	Rainfall (mm)	126.5	460.0	176.0	492.0	233.5	x			
	Weighted Rainfall (mm)	33.6	122.9	39.4	104.5	7.2	x	307.6	191.0	0.62
1994. 12	Area (km^2)	388.0	477.0	x	332.0	263.0	x	1460.0		
	Weight	0.27	0.33	x	0.23	0.18	x	1.0		
	Rainfall (mm)	48.0	48.0	x	287.0	217.0	x			
	Weighted Rainfall (mm)	12.8	15.7	x	65.3	39.1	x	132.8	72.0	0.54
									Average	0.82

Table 4.2 Study on Run-off Coefficient by comparing discharge and rainfall data

Month	Ave. Monthly Discharge (m3/s)	Run-off (mm)	Monthly Rainfall						Thiessen's Rainfall (mm)	Run-off Coefficient	Remarks
			WSN-1	WSN-2	WSN-3	WSN-4	WSN-5	WSN-6			
1991 Apr.	66.55	122.1	156.0	250.0	214.0	353.0	-	429.0	238.2	0.51	
1992 Jul.	94.00	178.2	109.0	-	444.0	222.0	251.0	299.0	280.0	0.64	
1993 Jan.	67.08	127.2	190.0	148.0	-	238.0	204.0	-	189.6	0.67	
Feb.	40.08	68.6	71.0	0.0	-	244.0	187.0	-	108.0	0.64	
Mar.	42.37	80.3	77.0	92.0	202.0	279.0	105.0	-	152.6	0.53	
1994 Jan.	68.45	129.8	140.5	44.0	182.0	-	169.0	156.0	133.2	0.97	
Feb.	58.11	99.5	46.5	7.0	56.0	-	41.0	163.0	42.6	2.34	rejected
Apr.	111.18	204.0	368.5	1249.0	343.0	-	168.0	474.0	564.4	0.36	
Sep.	26.95	49.5	4.0	0.0	1.0	218.0	2.0	9.0	47.8	1.03	rejected
Oct.	28.87	54.7	239.5	0.0	212.0	87.0	83.5	357.0	138.0	0.40	
Nov.	49.29	90.4	126.5	460.0	176.0	492.0	233.5	-	307.6	0.29	
Dec.	58.79	111.5	48.0	48.0	-	287.0	217.0	-	132.8	0.84	
									Average	0.58	

note : Catchment area at Malano AWLR = 1,412.5 km2

(2) Estimation of run-off coefficient from specific mean discharge

Fig. 4.11 shows the specific mean discharge at various dam sites in Indonesia, on which a regression line is also indicated. For the catchment area of 1,460 km^2, a specific mean discharge is obtained as about 5.0 $m^3/s/100\ km^2$. This can be converted to a run-off depth as follows;

$$5.0\ (m^3/s/100\ km^2)\ x\ 365\ x\ 24\ x\ 3{,}600\ x\ 10^{-5} = 1{,}577\ mm$$

On the other hand, the mean annual rainfall at Sorong Jefman in the period from 1983 to 1994 is 2,591 mm (see Table A.2). Therefore, the run-off coefficient is estimated as;

$$\frac{1{,}577}{2{,}591} \doteqdot 0.61$$

(3) Conclusion

From the studies in (1) and (2), the run-off coefficient is estimated as 0.58 ~ 0.61. However, since the estimation was made by using insufficient data, it is safe to adopt a lower run-off coefficient, 0.5, in this F/S.

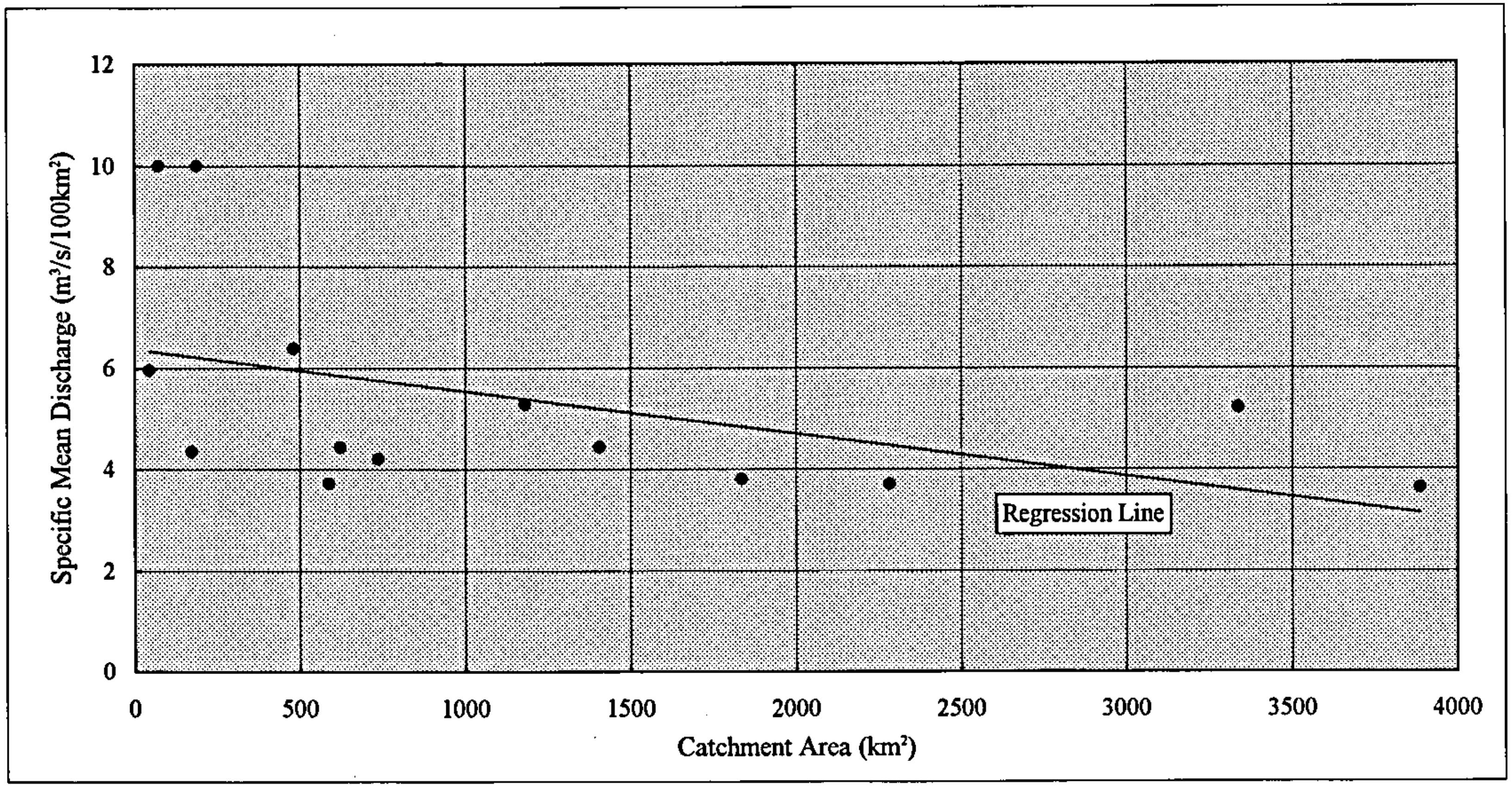


Fig. 4.12 Specific Mean Discharge at Various Dam Sites in Indonesia

4.3 Natural River Flow

Since the rainfall and flow data in the catchment area are insufficient to estimate a long-term river flow, these were derived from the monthly rainfall at Sorong Jefman and the run-off coefficient of 0.5

Before calculating the monthly river flow, the monthly rainfall data at Sorong Jefman was examined by comparing it with those at WSN-1 ~ WSN-6. Table 4.1 shows the results. According to the table, the monthly rainfall at Sorong Jefman is about 82% of the areal rainfall in the catchment area. This does not mean that the monthly rainfall at Sorong Jefman can be increased by 20% for calculating the river flow. However, it can be said, at least, that the river flow derived by the above-mentioned method is on the safe side for the hydropower planning.

Table 4.3 and Fig. 4.12 show the estimated river flow and flow duration curve.

Table 4.3 Estimated Monthly River Flow at Dam Site

(m^3/s)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Average
1920	16	17	23	122	34	144	32	47	71	67	38	12	52
1921	63	64	100	97	75	77	88	65	127	28	71	83	78
1922	40	88	41	87	36	92	96	75	65	54	23	49	62
1923	116	63	62	82	43	48	33	3	36	31	15	65	50
1924	40	98	63	66	108	71	153	81	107	55	89	59	83
1925	53	80	67	52	93	88	71	93	61	5	31	56	62
1926	38	24	37	95	133	92	140	76	182	49	74	59	84
1927	63	30	73	72	111	126	105	33	161	48	69	31	77
1928	30	51	61	68	91	90	69	57	47	16	53	58	58
1929	53	18	84	80	144	132	64	38	66	49	47	34	68
1930	17	47	111	49	56	172	8	7	4	122	43	41	56
1931	66	15	29	81	153	189	121	36	90	43	44	39	76
1932	30	46	63	63	90	57	143	107	53	107	50	71	74
1933	55	65	40	44	61	83	102	99	153	62	32	51	70
1934	83	52	82	70	83	125	128	113	79	135	98	70	94
1935	54	21	57	59	122	137	69	112	48	142	70	50	79
1936	74	77	107	79	83	84	130	55	87	141	21	48	83
1937	66	58	90	70	87	126	102	57	148	97	73	32	84
1938	52	27	70	57	96	63	84	196	112	68	45	100	81
1939	58	55	24	93	86	119	40	25	35	8	61	3	50
1940	58	64	59	60	76	90	13	132	44	13	41	30	57
1941	34	14	37	90	170	11	24	49	52	55	51	47	53
1958	12	27	53	41	50	54	34	132	44	49	46	56	50
1959	56	16	29	91	141	150	117	49	52	72	69	47	74
1960	83	47	27	54	86	63	237	31	54	25	59	49	68
1961	34	62	59	55	39	75	95	31	40	18	41	46	50
1962	113	63	35	108	110	93	41	102	38	74	36	63	73
1963	76	72	50	72	150	68	84	37	9	9	23	65	60
1964	31	83	35	121	62	87	73	40	32	50	46	84	62
1965	76	8	40	85	80	90	6	10	1	36	72	60	47
1966	35	43	38	39	83	73	53	114	62	39	69	62	59
1967	91	45	22	76	109	84	96	28	15	47	36	31	57
1968	36	18	97	29	46	128	95	56	93	68	106	74	71
1969	38	15	112	52	158	68	132	85	28	95	73	45	76
1970	53	38	66	77	159	60	126	96	68	34	56	71	76
1971	58	61	38	54	131	117	80	119	89	93	55	31	77
1972	45	81	37	47	46	144	19	41	29	9	43	26	47
1973	80	33	63	140	97	93	65	100	68	44	23	13	68
1974	14	92	27	106	119	87	70	61	80	57	51	47	67
1975	43	33	37	78	97	88	63	78	97	39	36	68	63
1976	30	63	29	48	88	35	47	53	35	87	48	10	48
1977	33	56	71	79	79	130	38	49	46	60	44	47	61
1978	72	15	144	35	40	91	111	84	82	29	58	74	70
1979	15	28	68	78	56	147	26	19	143	20	70	50	60
1980	41	41	25	66	75	60	29	52	5	44	37	23	41
1981	45	29	62	49	111	32	119	10	84	12	43	49	54
1982	38	35	74	55	91	73	-	-	82	33	25	51	56
1983	68	10	21	52	134	118	114	144	147	122	41	51	86
1984	62	75	59	109	194	105	201	62	162	29	35	42	95
1985	38	105	17	42	149	99	66	79	95	70	66	55	73
1986	26	46	44	40	41	64	63	15	75	59	32	50	46
1987	38	5	60	30	90	42	10	36	16	89	53	25	42
1988	55	38	56	25	91	90	134	191	92	75	65	66	82
1989	34	57	78	86	8	70	85	79	74	107	71	29	65
1990	26	35	35	37	60	38	48	37	68	110	18	19	44
1991	83	31	64	44	158	53	57	9	1	30	3	77	51
1992	4	15	39	28	72	38	52	28	55	117	35	32	43
1993	30	34	30	58	98	38	80	13	88	25	39	31	47
1994	10	49	64	64	92	92	16	37	0	52	54	20	46
Ave.	49	45	56	68	94	89	79	65	69	58	49	48	64

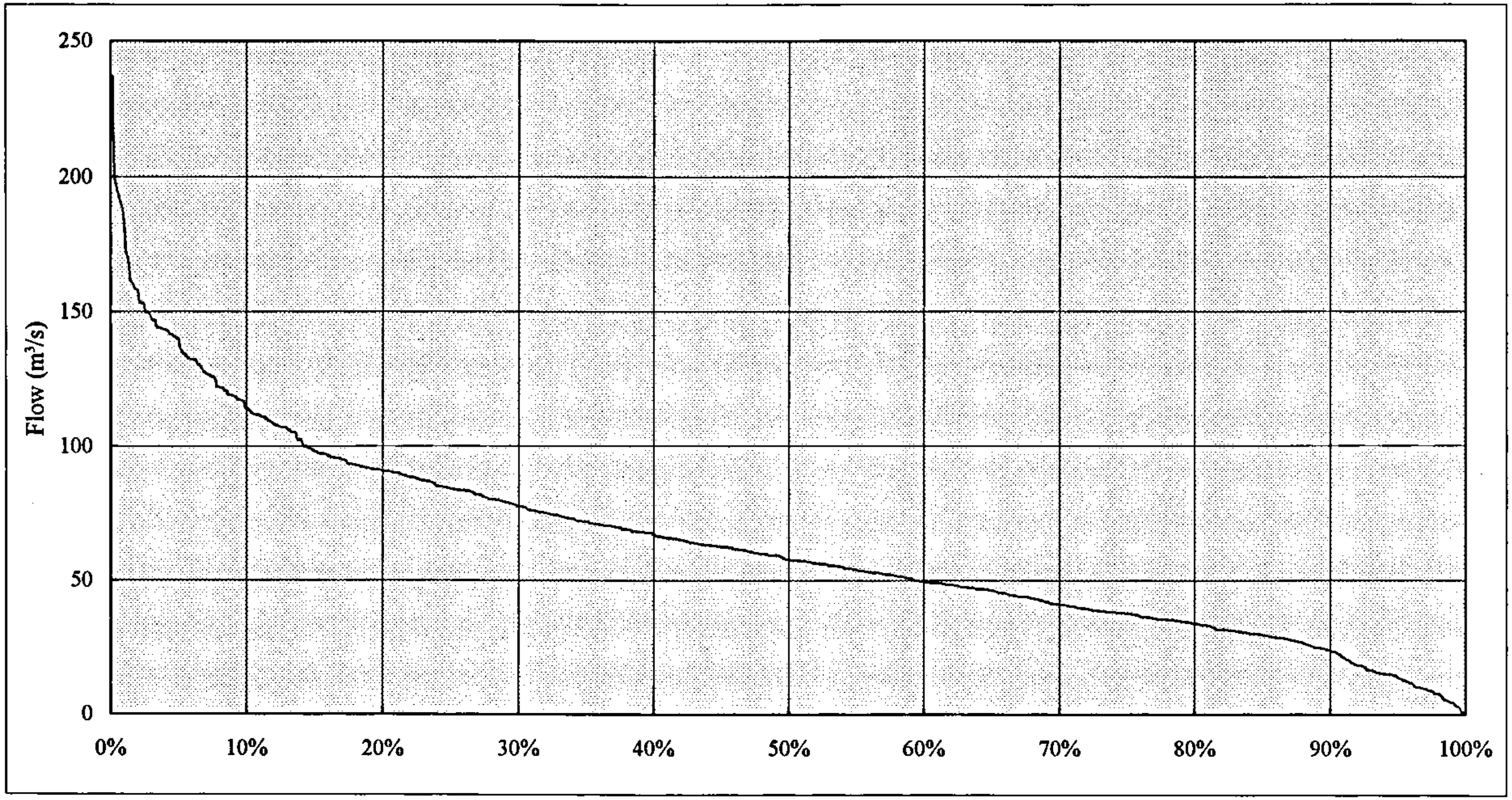


Fig. 4.13 Flow Duration Curve

CHAPTER 5 FLOOD ANALYSIS

There is difficulty in estimating the design flood because of the lack of discharge, flood and rainfall data observed in the project site. One of the methods for estimating the flood discharge is to refer to the specific flood discharge adopted for other projects. However, considering the particular characteristics of the drainage area (for example, Horton's form factor, about 0.045, is quite small), it would not be appropriate to refer to them. It was, therefore, decided to estimate the design flood by applying the triangular hydrograph.

5.1 Probable Rainfall

Rainfall data observed over a long period of time in the drainage area is not available. Instead, the daily rainfall data at Sorong Jefman was used to estimate the probable rainfall since this data is available for a relatively long period and the location of the gauging station is near the project site.

Table A.2 in Appendix A shows the rainfall data at this station, and based on this the frequency analysis was carried out by using the Hazen, Thomas, Gumbel and Iwai methods. Table 5.1 shows the results of the analysis, and the probable rainfall to be used in the subsequent flood analysis is summarized in Table 5.2.

Table 5.1 Results of Frequency Analysis for 24-hr Rainfall

unit (mm)

T (year)	Hazen	Thomas	Gumbel	Iwai
2	119	119	119	120
3	136	137	137	136
5	154	157	157	154
10	176	182	181	175
30	208	218	219	205
50	222	235	236	218
100	241	257	260	235
200	260	279	283	253
300	271	292	296	263
500	285	308	313	275
1000	304	331	336	292

Table 5.2 Probable Rainfall

Return Period (yr)	5	10	100	200	300	1000
Rainfall (mm)	157	182	260	283	296	336

The probable rainfall shown in Table 5.2 is point rainfall. For the flood analysis, the point rainfall needs to be converted into the average rainfall on the drainage area (areal rainfall) and its hourly distribution.

Point rainfall has to be multiplied by a reduction factor to convert it into areal rainfall. For obtaining the reduction factor, rainfall data at several stations in the drainage area is necessary. Since the data in the project area is insufficient for this purpose, the areal rainfall was estimated by using the D.A. formula proposed by Horton.

$P = Po \cdot e^{-a}$

where,

P	:	Areal rainfall (mm)
Po	:	Maximum point rainfall (mm)
a	:	$a = kA^n$
k, n	:	Constants to be determined for each heavy rainfall

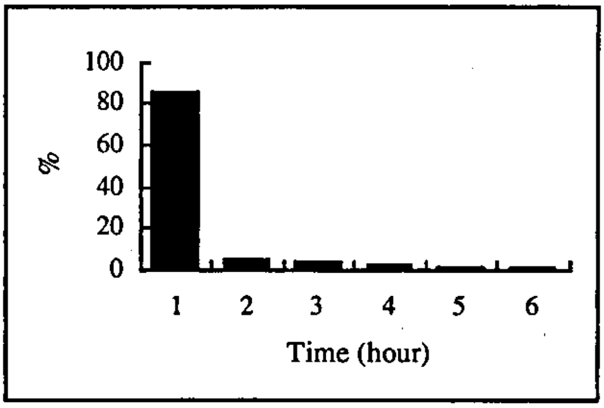
The envelope of P/Po for 24-hr rainfall was found, in his study, when k = 0.1 and n = 0.2. Inserting k = 0.1, n = 0.2 and A = 1,460 km^2, the above formula gives P = 0.65 Po. However, it seems too conservative to use 0.65 for such a wide and slender-shaped drainage area. Therefore, in the table below, P = 0.60 Po is used for deriving areal rainfall from the point rainfall.

Table 5.3 Areal Rainfall

Return Period (yr)	5	10	100	200	300	1000
Areal Rainfall (mm)	94	109	156	170	178	202

5.2 Hyetograph

The rainfall distribution was studied by using 24-hr rainfall data higher than 50 mm obtained at the stations WSN-1 ~ WSN-6, which is summarized in Table 5.4 and Figs. 5.3 and 5.4. It is known, from Fig. 5.4, that there are mainly two types of distribution. No. 1 indicates that heavy rainfall occurs only at the beginning, while No. 6 indicates that it occurs in the middle of a storm. Since storm rainfall data is limited in the project area, two types of design hyetographs (Figs. 5.1 and 5.2) derived from Figs. 5.3 and 5.4 were used for estimating the design flood.



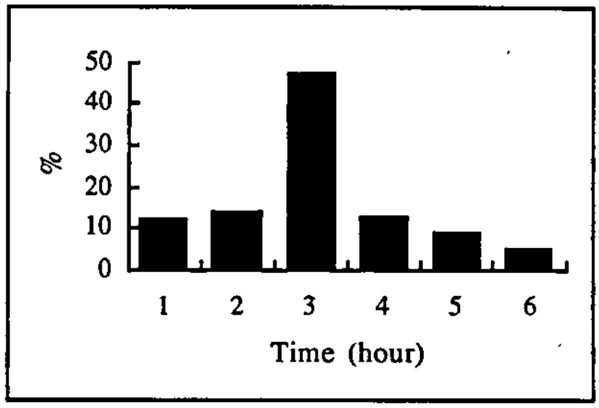


Fig 5.1 Gross Rainfall in % (Case-1)

Fig 5.2 Gross Rainfall in % (Case-2)

5.3 Triangular Hydrograph Analysis

(1) Triangular hydrograph

The concept of the triangular hydrograph and equations, which were obtained empirically by SCS (Soil Conservation Service in U.S.A.) and CHPW (California Highways and Public Works), are shown in Fig. 5.5.

From the available maps including the topographic maps obtained by the aerial photogrammetry, the following figures are obtained:

A = 1,460 km^2 = 563.2 $mile^2$

L = 158 km (98.1 miles) of the Warsamson river
+32 km (19.9 miles) of the Sumrem river

H = 75 m (246 feet) for the Warsamson river
and 700 m (2297 feet) for the Sumrem river

Assuming that D = 1 hr and Q = 1 mm (1/25.4 inch),

Tc = 68.8 hrs, Tp = 41.8 hrs, Tb = 111.6 hrs
q = 256.7 ft^3/s (7.3 m^3/s)

Table 5.4 Hourly Distribution of Rainfall

Time		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	Total
1. Mega (4-9-93)	Rainfall (mm/h)	43	1.5	1.5	1	2	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	50
	Accumulation	43	44.5	46	47	49	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	
	Accum / Total	86	89	92	94	98	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	
	Rain / Total	86	3	3	2	4	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
2. Malano (11-7-91)	Rainfall (mm/h)	3	0	24	10	1.5	2	4	3.5	12	8.5	0.5	0	0	0	0	0	0	0	0	0	0	0	0	0	69
	Accumulation	3	3	27	37	38.5	40.5	44.5	48	60	68.5	69	69	69	69	69	69	69	69	69	69	69	69	69	69	
	Accum / Total	4.3478	4.3478	39.13	53.623	55.797	58.696	64.493	69.565	86.957	99.275	100	100	100	100	100	100	100	100	100	100	100	100	100	100	
	Rain / Total	4.3478	0	34.783	14.493	2.1739	2.8986	5.7971	5.0725	17.391	12.319	0.7246	0	0	0	0	0	0	0	0	0	0	0	0	0	
3. Malano (9-4-94)	Rainfall (mm/h)	0.5	0	0.5	0.5	0.5	0	0.5	0.5	0	35	5	1	3	3	2	2	1	0	0	0	0	0	0	0	55
	Accumulation	0.5	0.5	1	1.5	2	2	2.5	3	3	38	43	44	47	50	52	54	55	55	55	55	55	55	55	55	
	Accum / Total	0.9091	0.9091	1.8182	2.7273	3.6364	3.6364	4.5455	5.4545	5.4545	69.091	78.182	80	85.455	90.909	94.545	98.182	100	100	100	100	100	100	100	100	
	Rain / Total	0.9091	0	0.9091	0.9091	0.9091	0	0.9091	0.9091	0	63.636	9.0909	1.8182	5.4545	5.4545	3.6364	3.6364	1.8182	0	0	0	0	0	0	0	
4. Klamono (13-10-91)	Rainfall (mm/h)	1	0	0	0	52	0	1	0.5	0	0	0	0	0	0	0	0	0	0.5	0	0	0	0	0	0	55
	Accumulation	1	1	1	1	53	53	54	54.5	54.5	54.5	54.5	54.5	54.5	54.5	54.5	54.5	54.5	55	55	55	55	55	55	55	
	Accum / Total	1.8182	1.8182	1.8182	1.8182	96.364	96.364	98.182	99.091	99.091	99.091	99.091	99.091	99.091	99.091	99.091	99.091	99.091	100	100	100	100	100	100	100	
	Rain / Total	1.8182	0	0	0	94.545	0	1.8182	0.9091	0	0	0	0	0	0	0	0	0	0.9091	0	0	0	0	0	0	
5. Klamono (15-7-91)	Rainfall (mm/h)	1	2.5	1.5	0	0	0	0	0	0	1	1	9.5	5	2	19	17	1	0	0	2.5	0	0	3	0	66
	Accumulation	1	3.5	5	5	5	5	5	5	5	6	7	16.5	21.5	23.5	42.5	59.5	60.5	60.5	60.5	63	63	63	66	66	
	Accum / Total	1.5152	5.303	7.5758	7.5758	7.5758	7.5758	7.5758	7.5758	7.5758	9.0909	10.606	25	32.576	35.606	64.394	90.152	91.667	91.667	91.667	95.455	95.455	95.455	100	100	
	Rain / Total	1.5152	3.7879	2.2727	0	0	0	0	0	0	1.5152	1.5152	14.394	7.5758	3.0303	28.788	25.758	1.5152	0	0	3.7879	0	0	4.5455	0	
6. Klamono (1-5-94)	Rainfall (mm/h)	14	0	0	7	8	3	34	7	4	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	78
	Accumulation	14	14	14	21	29	32	66	73	77	78	78	78	78	78	78	78	78	78	78	78	78	78	78	78	
	Accum / Total	17.949	17.949	17.949	26.923	37.179	41.026	84.615	93.59	98.718	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	
	Rain / Total	17.949	0	0	8.9744	10.256	3.8462	43.59	8.9744	5.1282	1.2821	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
7. Klamono (6-6-92)	Rainfall (mm/h)	31	32	1	13	16	3.5	0.5	3.5	2	4	2.5	5.5	1	0.5	0	0	0	0	0	0	0	0	0	0	116
	Accumulation	31	63	64	77	93	96.5	97	100.5	102.5	106.5	109	114.5	115.5	116	116	116	116	116	116	116	116	116	116	116	
	Accum / Total	26.724	54.31	55.172	66.379	80.172	83.19	83.621	86.638	88.362	91.81	93.966	98.707	99.569	100	100	100	100	100	100	100	100	100	100	100	
	Rain / Total	26.724	27.586	0.8621	11.207	13.793	3.0172	0.431	3.0172	1.7241	3.4483	2.1552	4.7414	0.8621	0.431	0	0	0	0	0	0	0	0	0	0	
8. Klamono (11-10-92)	Rainfall (mm/h)	35	25	2	0.5	0.5	1	1	4	4	0.5	0.5	0	0	0	0	0	0	0	0	0	0	0	0	0	74
	Accumulation	35	60	62	62.5	63	64	65	69	73	73.5	74	74	74	74	74	74	74	74	74	74	74	74	74	74	
	Accum / Total	47.297	81.081	83.784	84.459	85.135	86.486	87.838	93.243	98.649	99.324	100	100	100	100	100	100	100	100	100	100	100	100	100	100	
	Rain / Total	47.297	33.784	2.7027	0.6757	0.6757	1.3514	1.3514	5.4054	5.4054	0.6757	0.6757	0	0	0	0	0	0	0	0	0	0	0	0	0	
9. Klamabon (14-3-94)	Rainfall (mm/h)	38	0	2	0.5	0	36.5	0	0	0.5	1	0.5	0	0	0	0	0	0	0	0	0	0	0	0	0	79
	Accumulation	38	38	40	40.5	40.5	77	77	77	77.5	78.5	79	79	79	79	79	79	79	79	79	79	79	79	79	79	
	Accum / Total	48.101	48.101	50.633	51.266	51.266	97.468	97.468	97.468	98.101	99.367	100	100	100	100	100	100	100	100	100	100	100	100	100	100	
	Rain / Total	48.101	0	2.5316	0.6329	0	46.203	0	0	0.6329	1.2658	0.6329	0	0	0	0	0	0	0	0	0	0	0	0	0	
10. Sainkedui (4-4-93)	Rainfall (mm/h)	5	23	1	1	9	18	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	57
	Accumulation	5	28	29	30	39	57	57	57	57	57	57	57	57	57	57	57	57	57	57	57	57	57	57	57	
	Accum / Total	8.7719	49.123	50.877	52.632	68.421	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	
	Rain / Total	8.7719	40.351	1.7544	1.7544	15.789	31.579	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
R/T Ave		24.343	10.851	4.8815	4.0646	14.214	9.0895	5.3897	2.4288	3.0282	8.4142	1.4794	2.0954	1.3892	0.8916	3.2424	2.9394	0.3333	0.0909	0	0.3788	0	0	0.4545	0	
Ave. Accum.		24.343	35.194	40.076	44.14	58.355	67.444	72.834	75.263	78.291	86.705	88.184	90.28	91.669	92.561	95.803	98.742	99.076	99.167	99.167	99.545	99.545	99.545	100	100	69.9

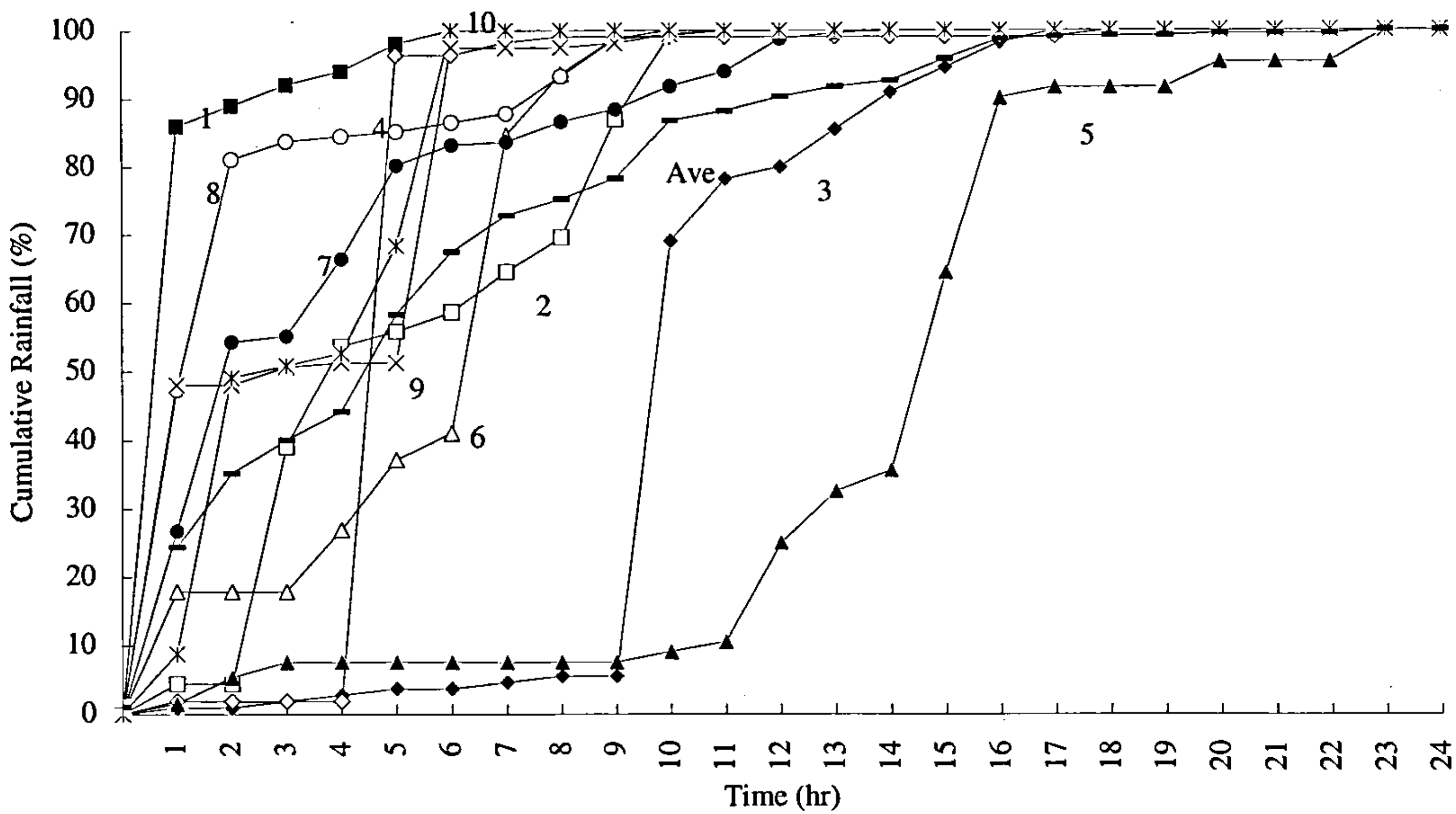


Fig. 5.3 Cumulative Rainfall

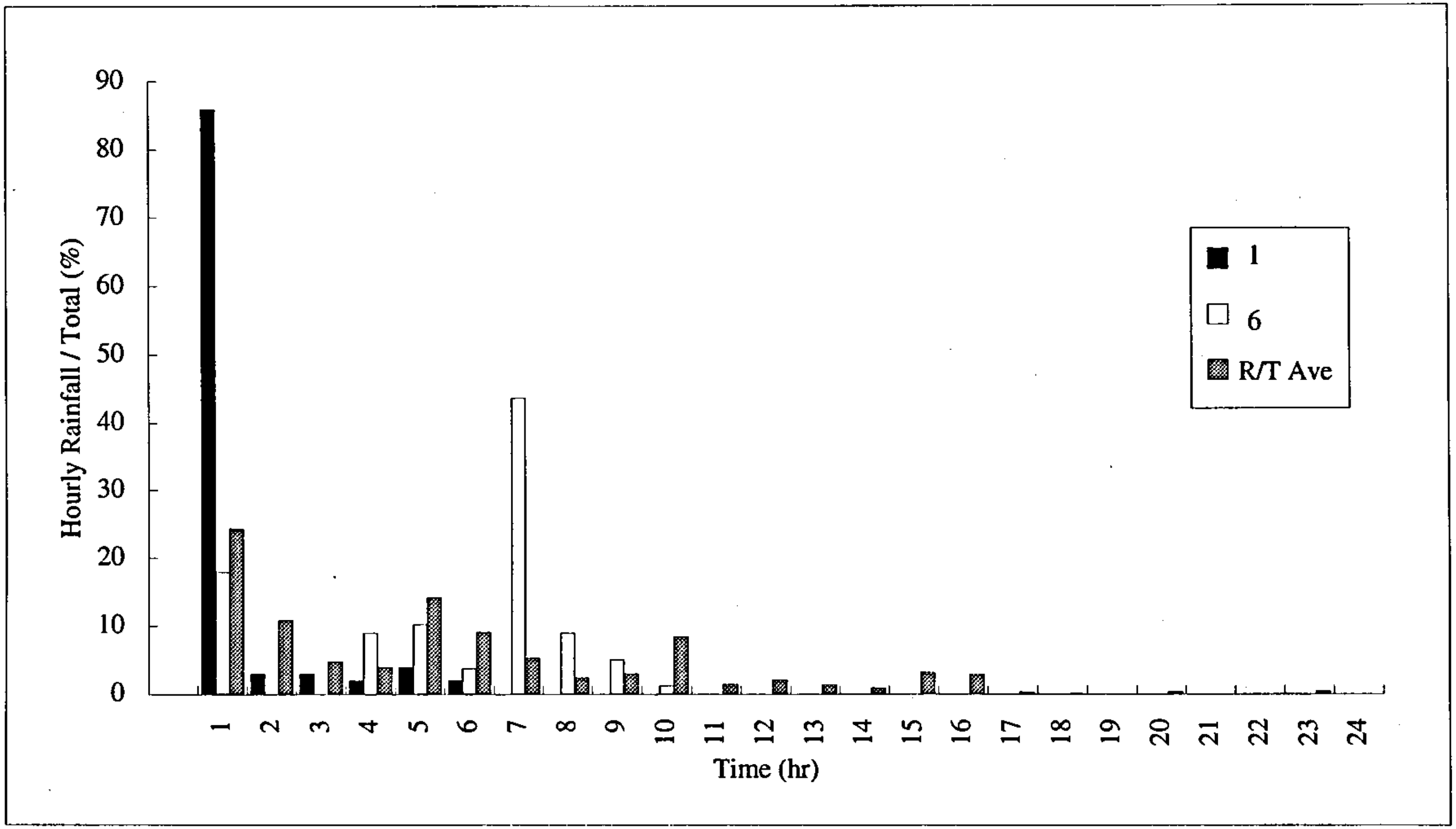
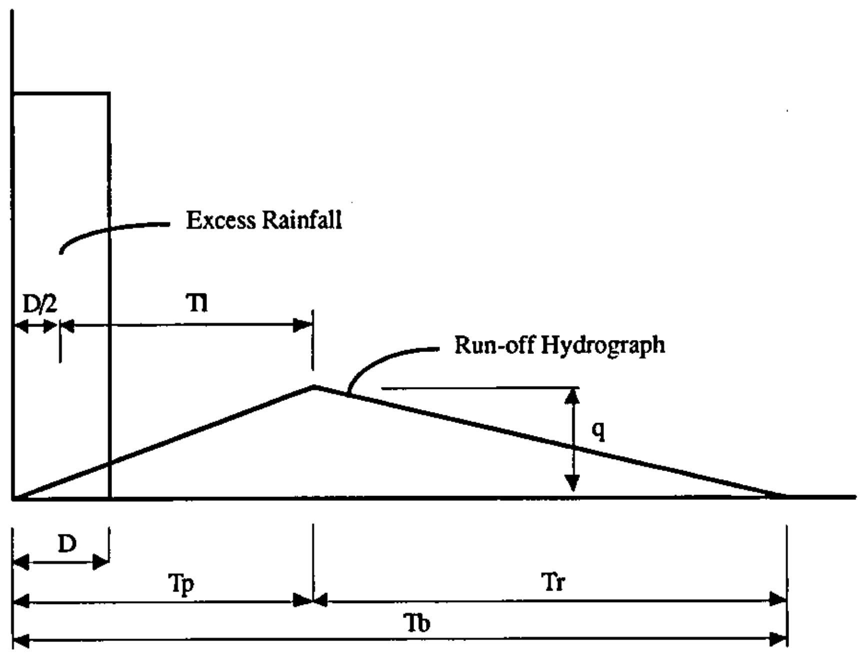


Fig. 5.4 Hourly Distribution of 24hrs Rainfall

However, Tc = 68.8 hrs seems too long since it means that the mean velocity is only 0.77 m/s. It is estimated, from the data shown in the Pre-F/S Report and the discharge measurements during this F/S, that the mean velocity (Vm) during the flood is more than 1.2 m/s. Assuming that Vm = 1.5 m/s, Tc becomes 35.2 hrs and consequently, Tp, Tb and q are obtained as follows:

Tp = 21.6 hrs, Tb = 57.7 hrs, q = 497 ft^3/s (14.1 m^3/s)

The above figures appear more reasonable than the previous ones. Therefore, these were used for the estimation of the design flood.



Q: Total runoff in inches
q: Peak rate (ft ^{3}/s)
D: Rainfall excess period, hours
Tl: Lag, time from center of excess rainfall to time of peak (hours) = 0.6Tc
Tc: Time of concentration - Travel time of water from hydraulically most distant point to point of interest (hours)
Tb: Time base of hydrograph (hours) = 2.67Tp
H: Elevation difference in feet
L: Length of longest watercourse in miles
A: Total area of basin in square miles

$$Tc = \left(\frac{11.9L^3}{H}\right)^{0.385}$$

$$Tp = D/2 + 0.6Tc$$

$$q = \frac{484AQ}{Tp}$$

Fig. 5.5 Concept of Triangular Hydrograph

(2) Design flood

For the basic design of the spillway and diversion, the probable floods with return periods of 200 years for a concrete dam, 1000 years for a fill dam and 5 years for a diversion channel were estimated.

200 year flood

An areal rainfall with a return period of 200 years is 170 mm/day according to the study in Section 5.1. This was converted to hourly rainfall by using Figs. 5.3 and 5.4, and consequently, Figs. 5.6 and 5.7 were obtained. Furthermore, from the rainfall in these figures, the loss caused by infiltration and evapotranspiration was deducted to obtain the effective rainfall which produces run-off.

The SCS's guide provides a means whereby an engineer may obtain an estimation of direct run-off from a given amount of rainfall. For obtaining this it is firstly necessary to examine the hydrologic conditions.

Assumptions:

1) Hydrologic soil group --- "C"

   Soils having slow infiltration rates when thoroughly wetted.

2) Hydrologic condition class of a forest area --- "IV~V"

   Since the drainage area is covered by dense forest and its natural conditions are well preserved, it is assumed that humus is kept in a loose condition with a deep thickness.

From these assumptions, the run-off curve number was estimated as approximately 60.

This is the curve number for the average moisture condition of the drainage area. Since antecedent rainfall is expected prior to the occurrence of the design storm, the curve number should be increased to 78 in accordance with the SCS's guide. The effective rainfall, as referred to in Figs. 5.8 and 5.9, was obtained by using the curve number 78 in Fig. 5.10.

By means of the triangular hydrograph, the flood hydrographs were obtained for the two cases as shown in Figs. 5.11 and 5.12. For the basic design of the spillway, the peak discharge is to be increased by 20%.

Design Flood = 1,740 x 1.2 ≈ 2,100 m^3/s

For other return periods

By the same procedure as mentioned above, the probable flood discharges for various return periods were estimated as summarized in Table 5.5, Figs. 5.13 and 5.14.

Table 5.5 Probable Flood

(m^3/s)

T (year)	5	10	100	200	300	1,000
Case-1	778	944	1,561	1,740	1,849	2,167
Case-2	749	914	1,539	1,703	1,839	2,126

Table 5.6 Design Flood

(m^3/s)

T (year)	5	200	1,000
Design Flood	800	2,100	2,600

(3) Examination of the design flood for the spillway

Fig. 5.15 shows the curves obtained by Creager's equation, on which the design flood with a 200 year return period estimated above is plotted together with the design floods for several dams in Indonesia. Although it can be seen that all of these lie close to the curves for C = 30 and C = 60, the design flood for the Warsamson HEPP lies on the lower side compared with the others. This seems quite reasonable considering the particular characteristics of the drainage area.

The flood analysis was carried out with many assumptions because of insufficient data. For a review or further study on the flood, it is of vital importance to continuously collect hydrological data for a long period of time in the catchment area.

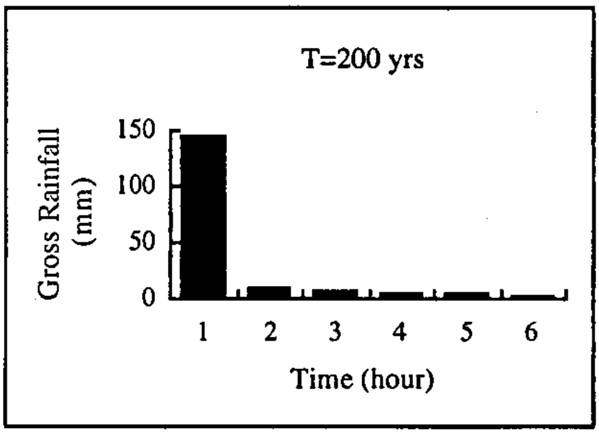


Fig. 5.6 Gross Rainfall (Case-1)

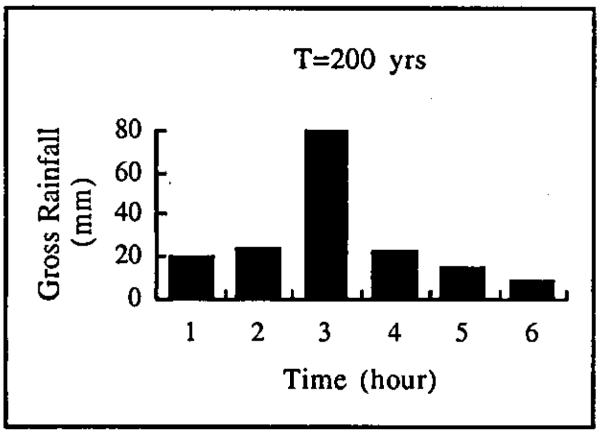


Fig. 5.7 Gross Rainfall (Case-2)

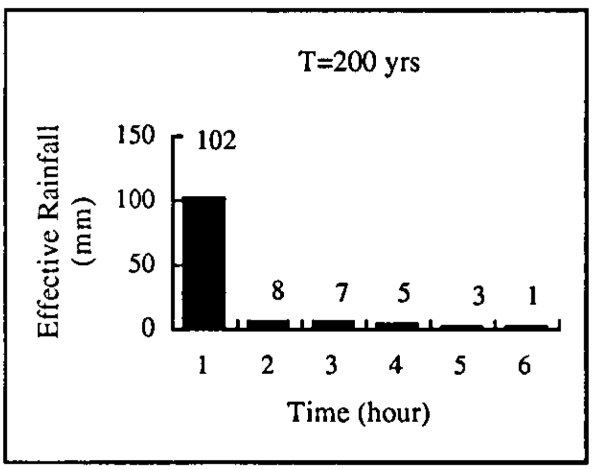


Fig. 5.8 Effective Rainfall (Case-1)

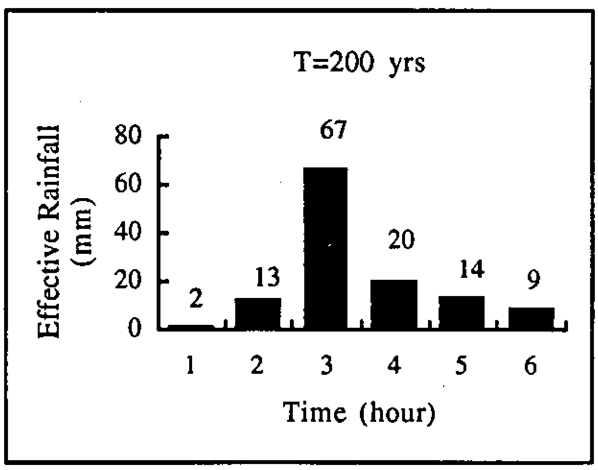


Fig. 5.9 Effective Rainfall (Case-2)

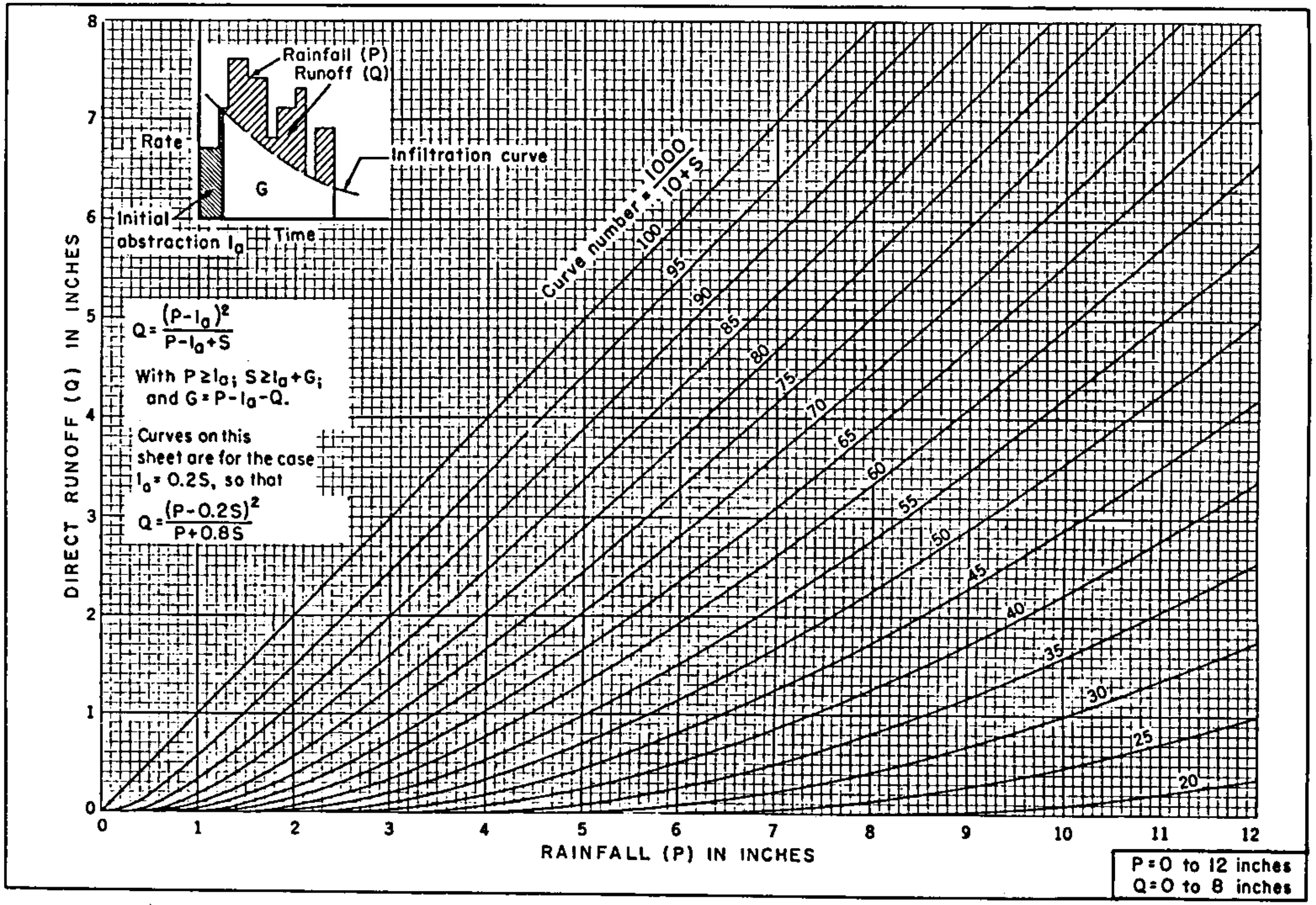


Fig. 5.10 Direct Runoff Curve

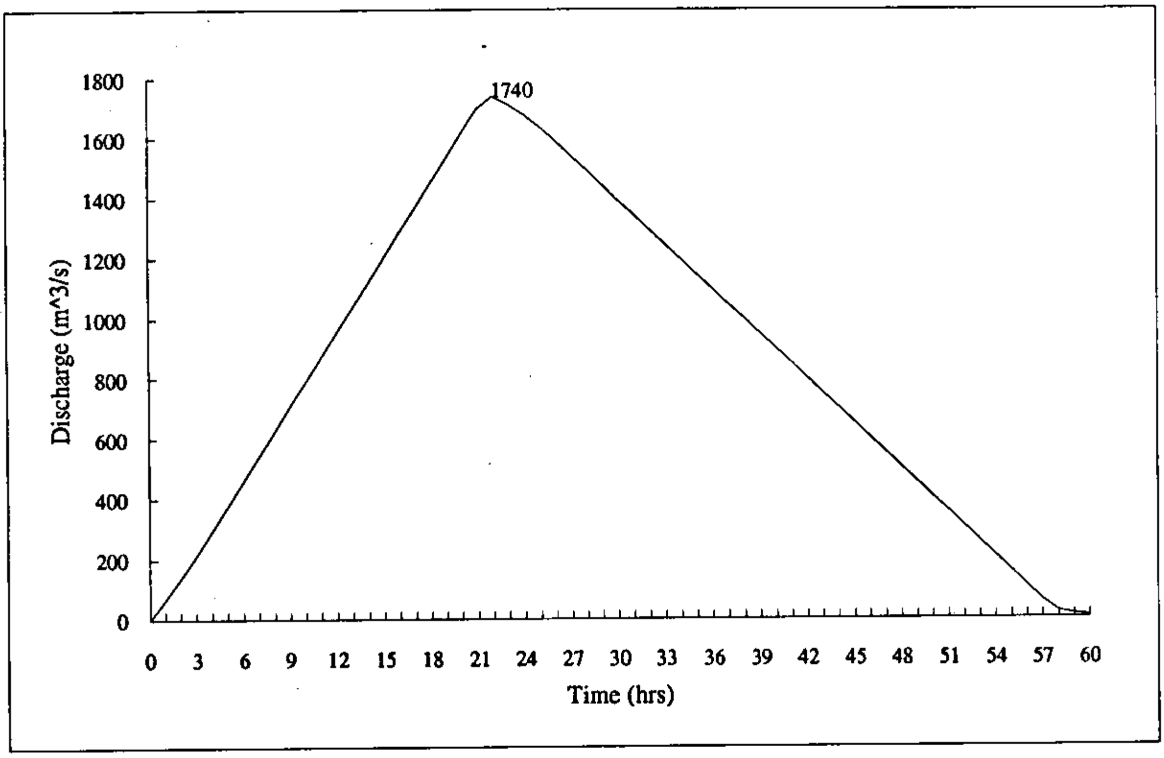


Fig. 5.11 Hydrograph for T=200 yrs (Case-1)

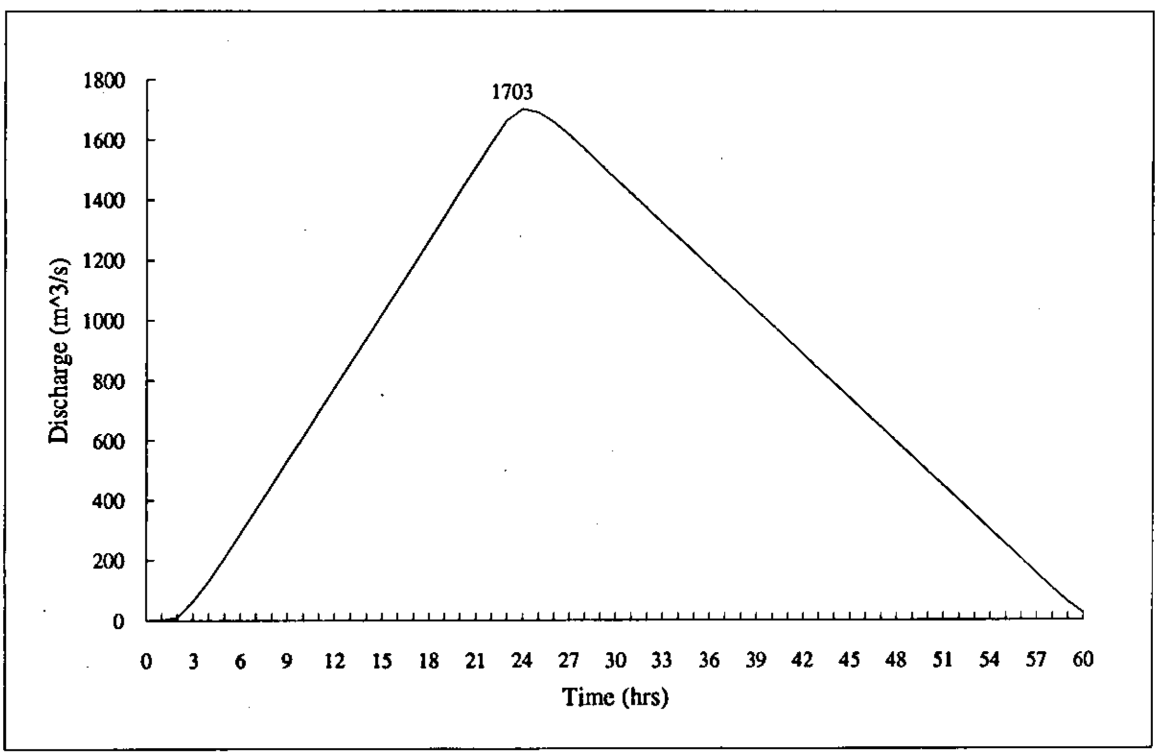


Fig. 5.12 Hydrograph for T=200 yrs (Case-2)

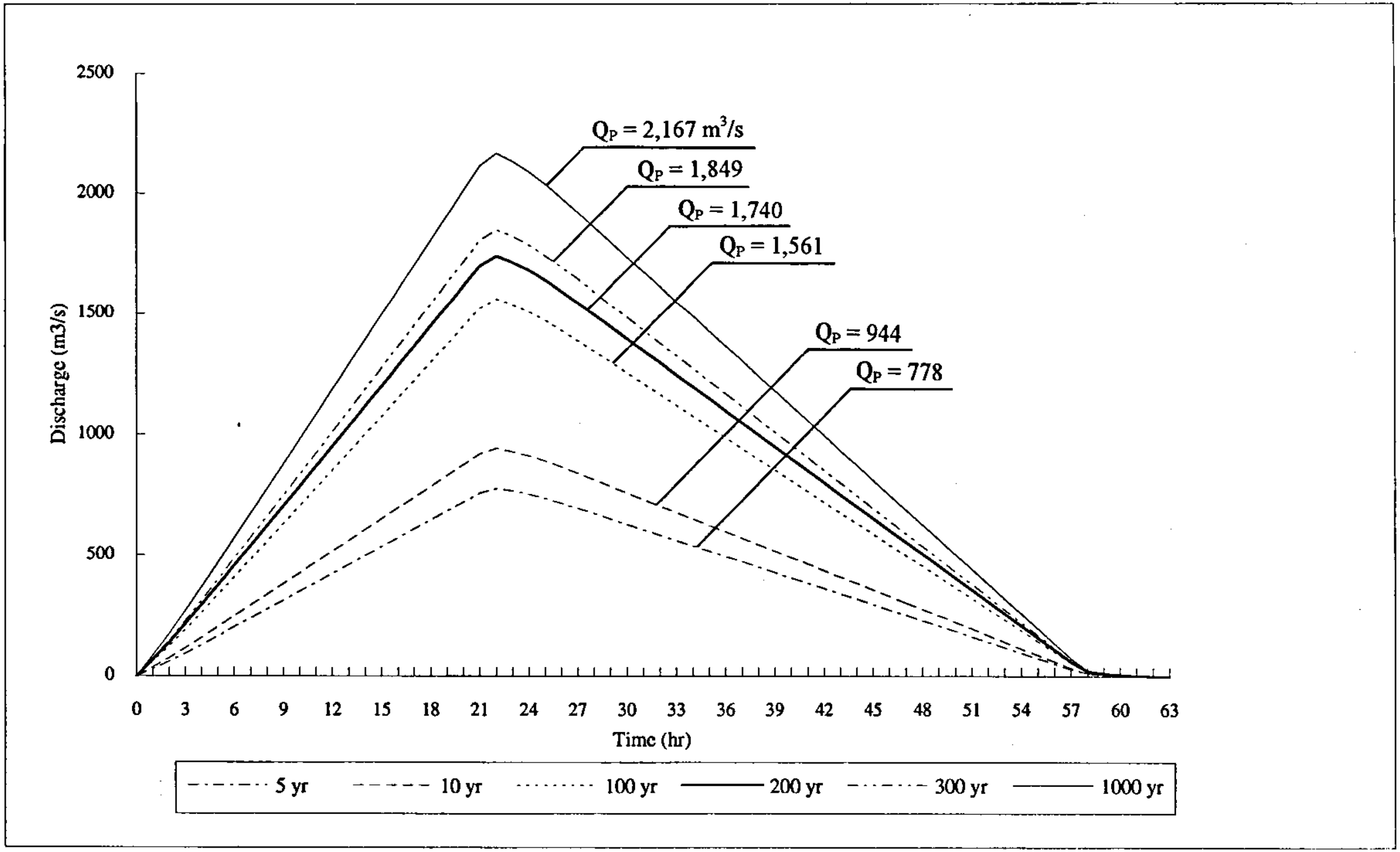


Fig. 5.13 Probable Flood Discharge (Case-1)

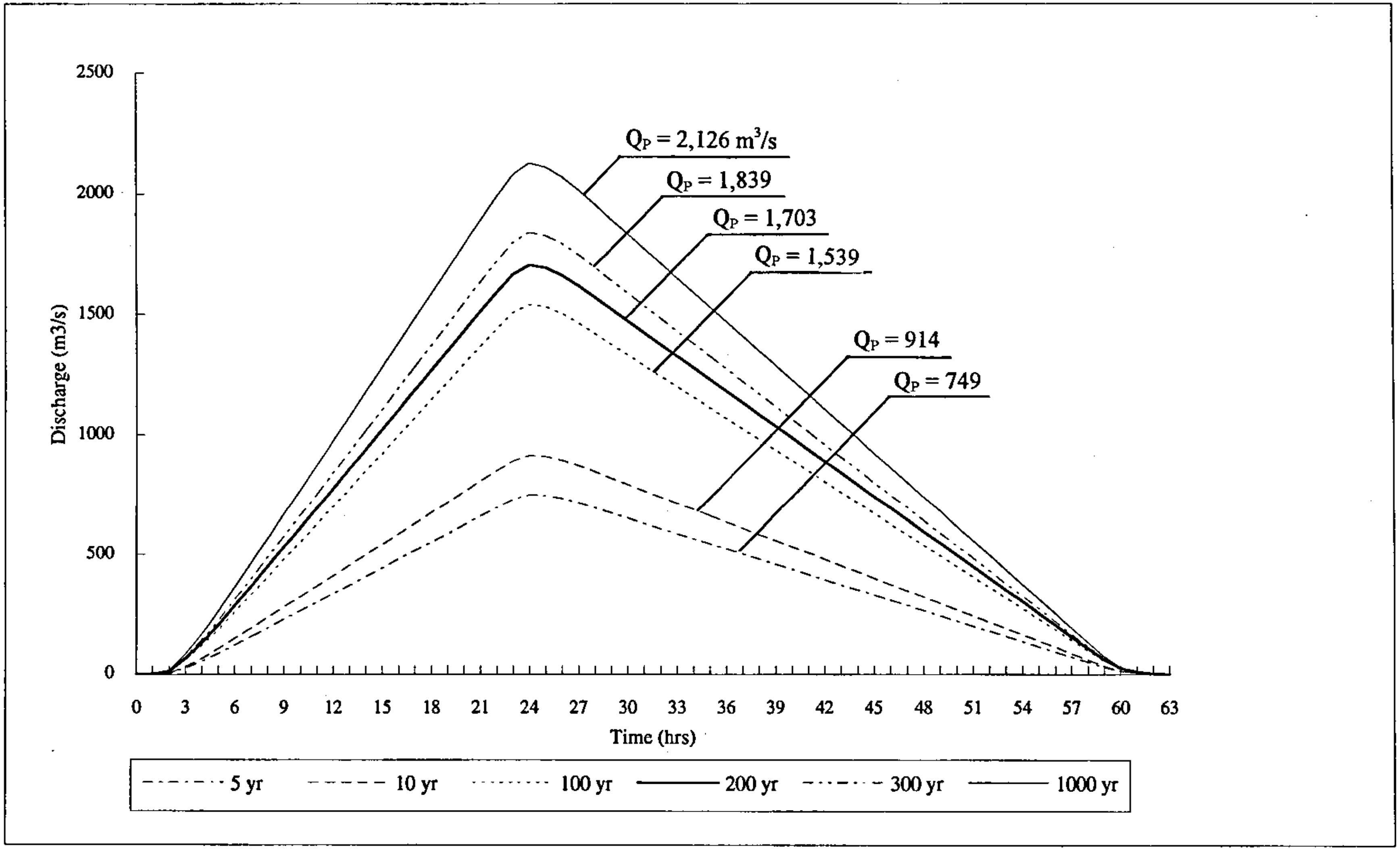


Fig. 5.14 Probable Flood Discharge (Case-2)

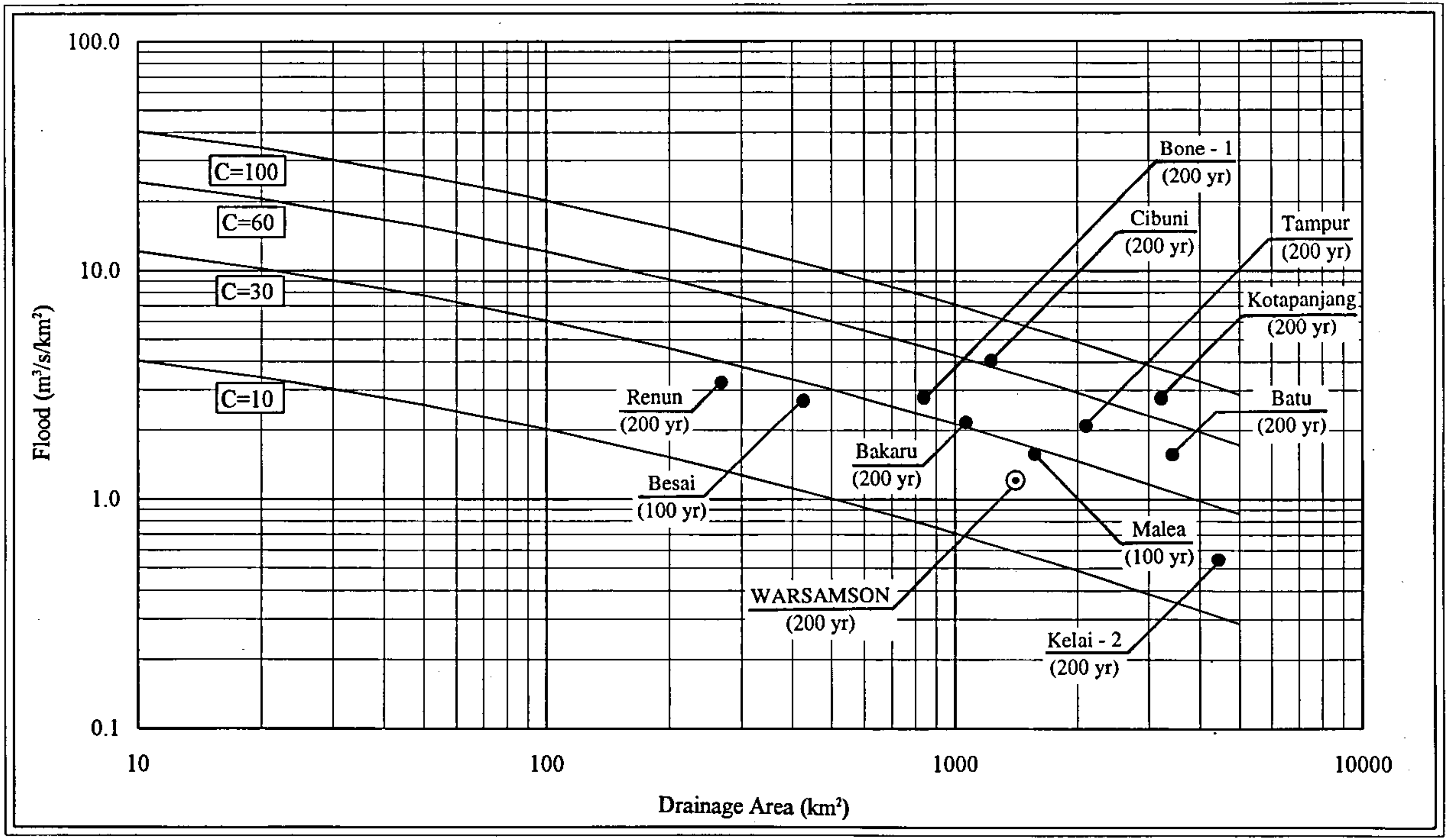


Fig. 5.15 Curves from Creager's Equation

CHAPTER 6 STUDY ON SEDIMENTATION

6.1 Suspended Load

During this F/S, suspended loads were measured at Malano AWLR by PLN, results of which are exhibited in Appendix E. Fig. 6.1 shows the suspended load discharge toward river flow. As can be seen in this figure, points are scattered at random and a good correlation of the two parameters cannot be obtained. It is considered that this was caused by the following reasons;

1) In the catchment area, the downstream and the most upstream areas are very hilly but the middlestream area has relatively flat features. In addition, there are variable geological conditions (surface soil) and land cover (vegetation). Therefore, even if sediment load is measured at the same flow, the amount of sediment load produced by erosion varies depending on where the rain falls.

2) Extremely high suspended load contents were obtained in a low-flow period from Feb. 3 to Apr. 20, 1995 as seen in Table E.1 of Appendix E. This was probably caused by improper sampling of water, that is to say, samples contained not only suspended load but also a large amount of bed load material.

From the above reasons, after rejecting abnormal and unreliable data, be correlation between suspended load and river flow was re-examined as shown in Table 6.1 and Fig. 6.2. As a result, the following equation was obtained:

$$Qs = 0.000301 \ Q^{2.01}$$

where,

Qs : Suspended load discharge (kg/s)

Q : River flow (m^3/s)

An annual total of suspended load was calculated using the above equation and the estimated monthly river flow shown in Table 4.3.

Table 6.2 shows that the annual average of suspended load is calculated as 54,347 t/year which is equivalent to about 41,805 m^3/year assuming a density of sediment of 1.3 t/m^3. It is considered that this figure is low for the catchment area of 1,460 km^2, and therefore, it is necessary to increase this figure to determine a design sedimentation rate.

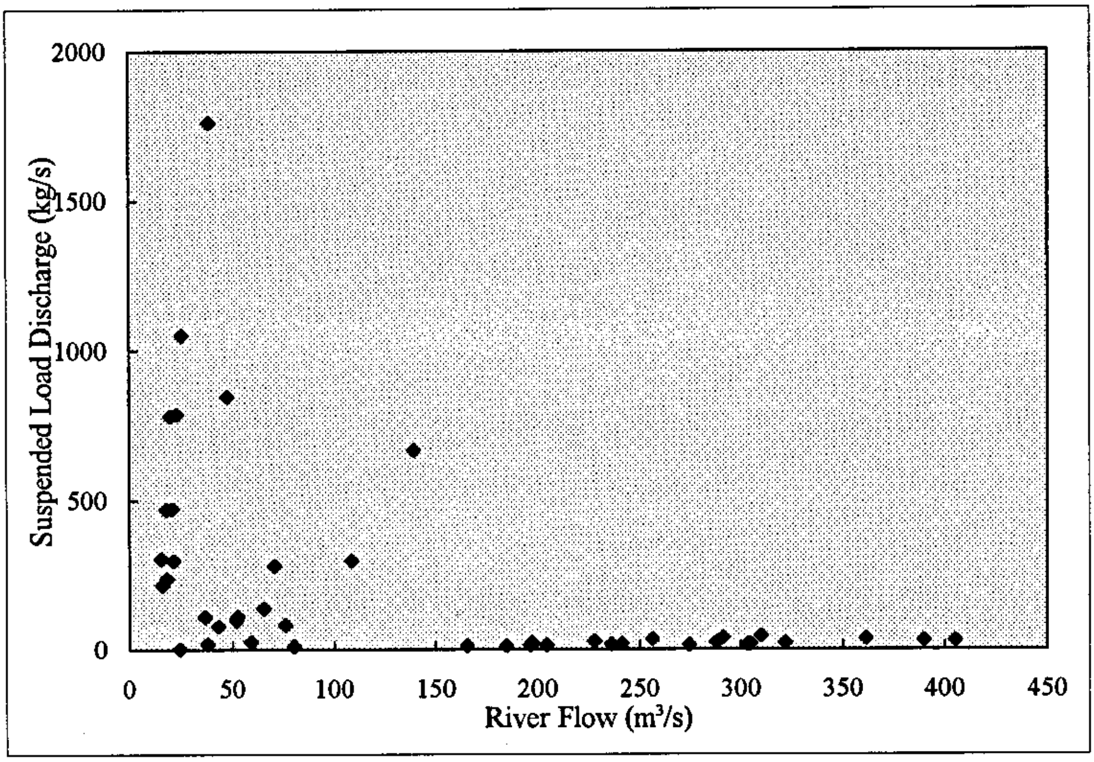


Fig. 6.1 Results of Suspended Load Measurement

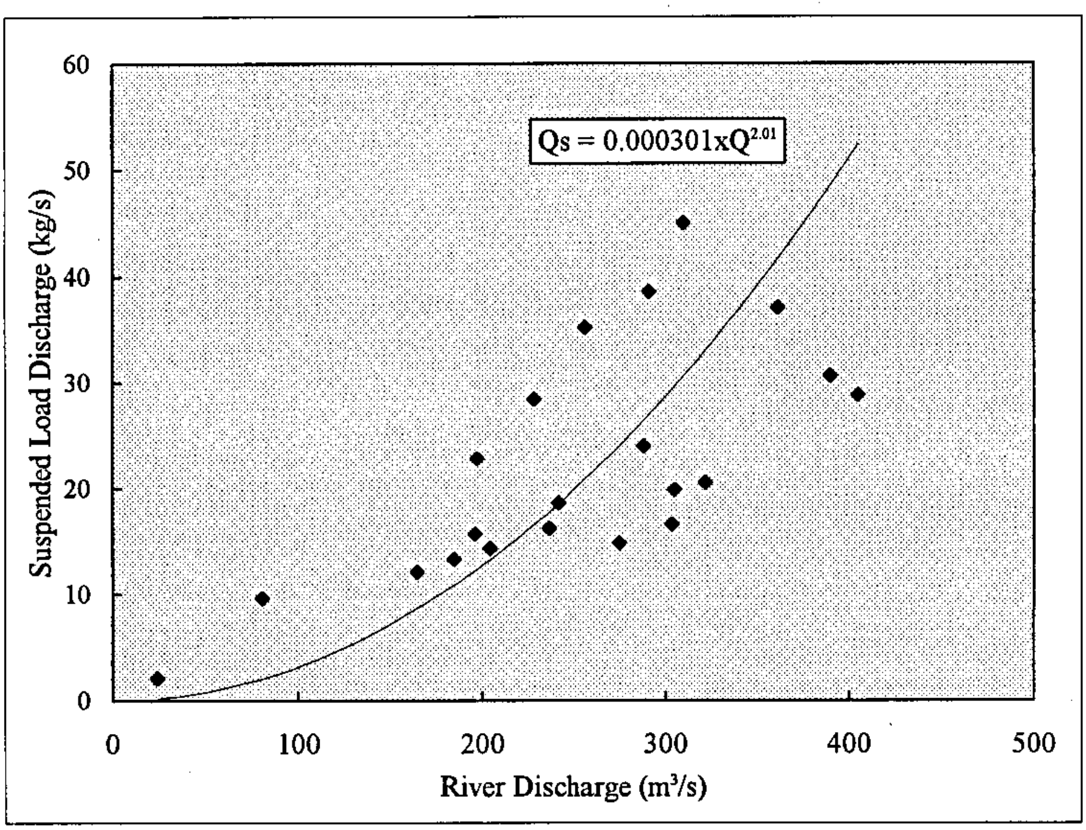


Fig. 6.2 Suspended Load Rating Curve

Table 6.1 Results of Suspended Load Measurement

No.	Date	Time	Position	Measured S.S Contents (mg/l)	Ave. S.S Contents (mg/l)	Flow (m^3/s)	Suspended Load Discharge (kg/s)
1	1-Apr-95	11:45	left middle right	82.0 150.0 30.0	87.3	24.34	2.1
2	10-Apr-95	11:15	left middle right	68.0 180.0 112.0	120.0	80.41	9.6
3	7-Aug-95	15:28	left middle right	86.0 88.0 76.0	83.3	287.97	24.0
4	15-Aug-95	12:00	left middle right	80.0 70.0 70.0	73.3	165.18	12.1
5	16-Aug-95	15:15	left middle right	88.0 84.0 68.0	80.0	196.29	15.7
6	18-Aug-95	17:05	left middle right	60.0 66.0 80.0	68.7	236.25	16.2
7	19-Aug-95	16:05	left middle right	122.0 88.0 98.0	102.7	361.32	37.1
8	21-Aug-95	15:30	left middle right	76.0 108.0 190.0	124.7	228.24	28.5
9	22-Aug-95	10:28	left middle right	80.0 84.0 72.0	78.7	389.73	30.7
10	23-Aug-95	10:00	left middle right	64.0 76.0 92.0	77.3	241.20	18.7
11	24-Aug-95	12:32	left middle right	89.0 226.0 32.0	115.7	197.26	22.8
12	25-Aug-95	11:15	left middle right	64.0 82.0 70.0	72.0	184.66	13.3

13	26-Aug-95	11:05	left middle right	84.0 98.0 14.0	65.3	304.74	19.9
14	27-Aug-95	11:10	left middle right	82.0 36.0 44.0	54.0	274.57	14.8
15	29-Aug-95	12:15	left middle right	82.0 76.0 56.0	71.3	404.91	28.9
16	30-Aug-95	12:30	left middle right	48.0 68.0 76.0	64.0	321.67	20.6
17	31-Aug-95	11:45	left middle right	80.0 78.0 52.0	70.0	204.29	14.3
18	1-Sep-95	14:50	left middle right	52.0 56.0 56.0	54.7	303.47	16.6
19	2-Sep-95	12:10	left middle right	158.0 156.0 84.0	132.7	291.10	38.6
20	3-Sep-95	12:50	left middle right	138.0 150.0 148.0	145.3	309.72	45.0
21	4-Sep-95	11:10	left middle right	132.0 134.0 146.0	137.3	256.44	35.2

Table 6.2 Estimated Suspended Load at Dam Site

(ton)

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
1920	222	237	457	12,230	969	16,916	849	1,884	4,068	3,811	1,170	124	42,937
1921	3,302	3,077	8,446	7,711	4,763	4,817	6,575	3,537	13,153	670	4,068	5,823	65,942
1922	1,306	5,912	1,436	6,219	1,082	6,923	7,723	4,798	3,473	2,419	440	1,973	43,703
1923	11,451	3,048	3,273	5,439	1,552	1,903	923	6	1,034	791	179	3,507	33,107
1924	1,324	7,612	3,302	3,503	9,841	4,134	19,962	5,483	9,364	2,569	6,422	2,910	76,426
1925	2,394	4,902	3,749	2,227	7,244	6,300	4,225	7,373	3,008	18	789	2,646	44,874
1926	1,183	427	1,165	7,443	14,977	6,838	16,689	4,868	27,289	1,995	4,503	2,965	90,343
1927	3,302	686	4,456	4,200	10,347	12,978	9,300	893	21,303	1,906	3,844	806	74,020
1928	763	2,039	3,075	3,780	6,989	6,670	3,967	2,724	1,772	200	2,252	2,777	37,009
1929	2,370	254	5,939	5,215	17,480	14,355	3,448	1,217	3,594	2,017	1,772	954	58,614
1930	229	1,677	10,347	1,971	2,672	24,243	48	35	14	12,555	1,465	1,436	56,692
1931	3,657	177	683	5,364	19,962	29,362	12,330	1,098	6,546	1,572	1,605	1,288	83,644
1932	736	1,639	3,302	3,208	6,822	2,682	17,280	9,643	2,276	9,742	2,016	4,257	63,602
1933	2,493	3,225	1,306	1,564	3,103	5,591	8,868	8,262	19,188	3,187	818	2,202	59,808
1934	5,823	2,017	5,633	4,036	5,861	12,861	13,828	10,709	5,105	15,474	7,801	4,127	93,274
1935	2,419	335	2,698	2,870	12,611	15,290	3,999	10,553	1,881	17,016	3,939	2,109	75,720
1936	4,660	4,695	9,692	5,141	5,861	5,783	14,306	2,493	6,138	16,950	340	1,906	77,967
1937	3,688	2,519	6,905	4,036	6,332	13,095	8,868	2,698	17,931	7,900	4,367	849	79,187
1938	2,225	555	4,127	2,682	7,723	3,266	6,016	32,729	10,173	3,904	1,666	8,446	83,513
1939	2,777	2,261	490	7,009	6,213	11,615	1,324	535	1,018	51	2,980	9	36,282
1940	2,777	3,201	2,883	2,897	4,833	6,670	136	14,792	1,564	148	1,350	763	42,015
1941	969	144	1,165	6,670	24,469	101	479	2,040	2,180	2,544	2,109	1,884	44,754
1958	113	555	2,394	1,332	2,063	2,349	985	14,792	1,564	1,995	1,687	2,646	32,476
1959	2,646	184	723	6,712	16,819	18,484	11,559	2,040	2,180	4,356	3,875	1,884	71,463
1960	5,823	1,703	607	2,399	6,253	3,208	47,877	777	2,374	512	2,870	2,040	76,442
1961	969	2,875	2,965	2,500	1,253	4,572	7,590	820	1,313	277	1,388	1,735	28,257
1962	10,866	3,048	1,049	9,513	10,245	7,095	1,398	8,868	1,187	4,626	1,034	3,331	62,259
1963	4,903	3,953	2,109	4,200	18,977	3,718	5,900	1,115	65	63	440	3,597	49,038
1964	806	5,473	1,017	11,893	3,273	6,179	4,524	1,361	818	2,063	1,751	6,016	45,172
1965	4,833	42	1,361	5,861	5,335	6,587	27	79	1	1,098	4,200	3,047	32,472
1966	1,049	1,408	1,235	1,222	5,746	4,340	2,345	11,024	3,093	1,270	3,875	3,216	39,824
1967	7,031	1,509	395	4,746	9,992	5,706	7,767	632	179	1,841	1,034	820	41,651
1968	1,065	245	7,945	666	1,798	13,330	7,590	2,646	7,061	3,873	9,216	4,660	60,095
1969	1,235	170	10,605	2,227	21,046	3,718	14,731	6,055	614	7,678	4,333	1,673	74,087
1970	2,345	1,109	3,688	4,888	21,561	2,953	13,358	7,723	3,749	938	2,577	4,192	69,081
1971	2,777	2,847	1,183	2,374	14,427	11,232	5,408	11,997	6,504	7,287	2,500	791	69,326
1972	1,694	5,171	1,115	1,772	1,735	17,049	285	1,398	666	67	1,524	547	33,022
1973	5,408	846	3,360	16,066	7,990	7,095	3,597	8,400	3,718	1,653	409	142	58,683
1974	173	6,411	607	9,118	11,997	6,179	4,160	3,159	5,215	2,750	2,109	1,884	53,760
1975	1,552	846	1,115	4,996	7,900	6,300	3,360	5,081	7,711	1,288	1,034	3,873	45,056
1976	763	3,120	683	1,859	6,575	970	1,820	2,321	990	6,373	1,881	89	27,443
1977	908	2,337	4,225	5,032	5,225	13,747	1,217	2,040	1,729	3,020	1,569	1,884	42,933
1978	4,390	177	17,680	1,018	1,306	6,796	10,399	5,900	5,439	709	2,708	4,592	61,114
1979	179	593	3,904	4,996	2,620	17,657	582	311	16,783	347	4,003	2,063	54,039
1980	1,417	1,316	523	3,503	4,729	2,925	723	2,225	20	1,632	1,135	426	20,575
1981	1,714	632	3,187	1,948	10,502	804	11,887	84	5,822	113	1,465	1,973	40,131
1982	1,200	941	4,558	2,424	7,031	4,367	-	-	5,476	893	484	2,202	35,490
1983	3,873	74	376	2,227	15,162	11,450	10,971	17,546	17,657	12,555	1,350	2,155	95,397
1984	3,273	4,484	2,937	9,713	31,912	8,972	34,394	3,216	21,453	683	986	1,494	123,517
1985	1,217	8,412	229	1,426	18,908	8,028	3,627	5,298	7,312	4,063	3,503	2,569	64,593
1986	570	1,634	1,612	1,295	1,417	3,354	3,360	186	4,641	2,965	804	2,086	23,923
1987	1,235	22	3,020	706	6,822	1,426	84	1,082	214	6,657	2,276	512	24,054
1988	2,569	1,139	2,672	495	6,989	6,629	15,287	30,838	6,881	4,729	3,443	3,657	85,328
1989	938	2,466	5,081	6,098	48	3,971	6,095	5,262	4,469	9,692	4,101	683	48,904
1990	558	924	1,001	1,084	3,020	1,152	1,950	1,115	3,718	10,143	269	294	25,229
1991	5,861	742	3,448	1,564	21,266	2,276	2,750	71	1	750	8	5,045	43,781
1992	16	164	1,270	640	4,390	1,187	2,273	644	2,475	11,613	986	849	26,506
1993	763	893	750	2,735	8,171	1,187	5,408	130	6,340	501	1,222	777	28,878
1994	75	1,787	3,418	3,383	7,158	6,881	214	1,165	0	2,273	2,349	320	29,024
										Annual Average			54,347

6.2 Bed Load

Since a measurement of bed load had not been carried out, it was estimated by using the Kalinske-Brown formula. Assuming the river section is rectangular,

$$Q_B = q_B W = 10\ \{u^2/(s-1)\ gd\ \}^2\ udW \tag{6.2.1}$$

where,

Q_B	:	Bed load discharge (m^3/s)
q_B	:	Bed load discharge per unit width ($m^3/s/m$)
u	:	Friction velocity (m/s) $\fallingdotseq \sqrt{gH_m i}$
g	:	Acceleration of gravity = 9.8 (m/s^2)
H_m	:	Water depth (m)
i	:	Energy slope $\fallingdotseq$ River bed slope
s	:	Specific gravity of sediment grain
d	:	Mean grain diameter (m)
W	:	River width (m)

To simplify the formula (6.2.1) and calculate Q_B, the following assumptions were made:

1) i = 1/2,000 (average river bed slope)

2) s = 2.65

3) H_m is equivalent to the water level reading (H) at Malano AWLR. Therefore, H_m can be obtained from the equations of the rating curves shown in Fig. 4.3.

$H_m < 1.80$ m ($Q < 108.6\ m^3/s$)

$Q = 12.294\ H_m^2 + 35.446\ H_m + 4.99$

$$H_m = \frac{-35.446 + \sqrt{1011.0 + 49.176Q}}{24.588} \tag{6.2.2}$$

$H_m \geq 1.80$ m ($Q \geq 108.6\ m^3/s$)

$Q = 1.1013\ H_m^2 + 96.797\ H_m - 69.19$

$$H_m = \frac{-96.797 + \sqrt{9674.5 + 4.405Q}}{2.2026} \tag{6.2.3}$$

4) d can be derived from the study by Shields.

$$\frac{u^2}{(s-1)\ gd} \fallingdotseq 0.05$$

$$u = \sqrt{gH_m i}$$

Therefore, from 1) and 2) above,

$$d = \frac{20\ H_{m}i}{s-1} = 6.06\ H_m \times 10^{-3}\ (m) \qquad (6.2.4)$$

5) W can be obtained from Manning's formula.

$$Q = WH_m \times \frac{1}{n} H_m^{2/3}\, i^{1/2}$$

From 1) and n = 0.035,

$$W = 1.565\ QH_m^{-5/3} \qquad (6.2.5)$$

From 1), 2), 4) and 5) above, the equation (6.2.1) becomes,

$$Q_B = 1.66 \times 10^{-5} \times QH_m^{-1/6} \qquad (6.2.6)$$

Thus, an annual total of bed load can be obtained from the equations (6.2.2), (6.2.3) and (6.2.6) and the estimated monthly river flow shown in Table 4.3.

Table 6.3 shows that the annual average bed load is 32,232 m^3/year. This figure is considered to be on the high side (safe side) since it is known that the Kalinske-Brown formula generally gives a higher solution (in which part of the suspended load is included).

Since the bed load obtained above is a nominal volume of bed load material (particles), it has to be converted to a sediment volume by multiplying by 2 (unit weight of particle/unit weight of sediment = 2.65 /1.3 ≑ 2). Consequently, the annual average of sediment by bed load becomes 64,464 m^3/year.

6.3 Total Sediment Load (Total-Qsd)

From Section 6.1 and 6.2,

Total - Qsd = 41,805 + 64,464
= 106,269 m^3/year

Therefore, Total -Qsd per unit area is obtained as;

Total - Qsd' = 72.8 m^3/km^2/year

Since an excessive sediment load discharge during a flood is not considered in the above estimation, it is necessary to increase the above Total - Qsd'. For the feasibility - grade design, it is recommended to use 100 m^3/km^2/year.

Table 6.3 Estimated Bed Load at Dam Site

(m3)

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
1920	893	880	1,190	4,711	1,621	5,442	1,534	2,142	2,918	2,891	1,720	718	26,659
1921	2,719	2,489	4,075	3,845	3,182	3,138	3,656	2,800	4,866	1,391	2,918	3,469	38,547
1922	1,836	3,296	1,910	3,503	1,696	3,670	3,920	3,192	2,727	2,381	1,149	2,184	31,463
1923	4,659	2,479	2,709	3,306	1,974	2,111	1,588	383	1,634	1,490	805	2,790	25,927
1924	1,846	3,751	2,719	2,737	4,354	2,938	5,963	3,380	4,183	2,443	3,552	2,576	40,442
1925	2,371	3,040	2,871	2,256	3,812	3,523	3,022	3,842	2,564	651	1,460	2,474	31,885
1926	1,761	1,090	1,750	3,787	5,250	3,650	5,509	3,211	6,719	2,194	3,048	2,597	40,566
1927	2,719	1,323	3,092	2,958	4,452	4,837	4,249	1,566	6,025	2,152	2,848	1,501	37,723
1928	1,468	2,131	2,637	2,828	3,754	3,611	2,941	2,504	2,048	858	2,266	2,525	29,572
1929	2,360	885	3,499	3,247	5,623	5,059	2,770	1,782	2,767	2,205	2,048	1,610	33,855
1930	905	1,923	4,452	2,142	2,484	6,378	525	491	575	4,854	1,890	1,910	28,529
1931	2,840	769	1,402	3,286	5,963	6,938	4,815	1,707	3,582	1,984	1,964	1,825	37,077
1932	1,446	1,943	2,719	2,635	3,715	2,442	5,594	4,316	2,277	4,335	2,163	3,032	36,617
1933	2,412	2,539	1,836	1,943	2,648	3,346	4,162	4,036	5,753	2,678	1,482	2,288	35,122
1934	3,469	2,079	3,420	2,908	3,479	4,818	5,067	4,521	3,217	5,327	3,864	2,991	45,161
1935	2,381	988	2,494	2,513	4,864	5,203	2,951	4,492	2,100	5,556	2,878	2,246	38,667
1936	3,152	3,044	4,326	3,227	3,479	3,395	5,145	2,412	3,484	5,547	1,036	2,152	40,398
1937	2,850	2,285	3,734	2,908	3,597	4,857	4,162	2,494	5,584	3,958	3,008	1,534	40,971
1938	2,298	1,213	2,991	2,442	3,920	2,656	3,518	7,412	4,339	2,921	1,995	4,075	39,780
1939	2,525	2,182	1,224	3,689	3,568	4,604	1,846	1,269	1,623	535	2,554	460	26,079
1940	2,525	2,582	2,566	2,523	3,201	3,611	741	5,222	1,943	765	1,826	1,468	28,974
1941	1,621	711	1,750	3,611	6,523	653	1,213	2,215	2,235	2,433	2,204	2,142	27,311
1958	694	1,213	2,371	1,816	2,225	2,308	1,632	5,222	1,943	2,194	2,006	2,474	26,096
1959	2,474	781	1,435	3,621	5,528	5,659	4,678	2,215	2,235	3,062	2,858	2,142	36,688
1960	3,469	1,975	1,336	2,328	3,577	2,635	8,751	1,479	2,318	1,247	2,513	2,215	33,843
1961	1,621	2,418	2,597	2,370	1,804	3,068	3,890	1,512	1,805	974	1,848	2,069	25,974
1962	4,551	2,479	1,675	4,212	4,433	3,709	1,889	4,162	1,730	3,142	1,634	2,729	36,343
1963	3,221	2,771	2,246	2,958	5,831	2,807	3,489	1,718	561	568	1,149	2,820	30,140
1964	1,501	3,252	1,653	4,653	2,709	3,493	3,112	1,868	1,482	2,225	2,037	3,518	31,504
1965	3,201	472	1,868	3,415	3,341	3,591	486	613	136	1,707	2,958	2,627	24,415
1966	1,675	1,786	1,793	1,752	3,449	3,000	2,350	4,580	2,595	1,814	2,858	2,688	30,340
1967	3,764	1,839	1,123	3,118	4,383	3,375	3,929	1,358	805	2,121	1,634	1,512	28,960
1968	1,686	892	3,968	1,361	2,100	4,895	3,890	2,474	3,701	2,911	4,154	3,152	35,184
1969	1,793	758	4,502	2,256	6,104	2,807	5,212	3,528	1,317	3,910	2,998	2,037	37,222
1970	2,350	1,616	2,850	3,158	6,169	2,544	4,990	3,920	2,817	1,599	2,400	3,012	37,425
1971	2,525	2,407	1,761	2,318	5,164	4,536	3,360	4,757	3,572	3,822	2,370	1,490	38,082
1972	2,048	3,173	1,718	2,048	2,069	5,461	986	1,889	1,361	579	1,922	1,280	24,532
1973	3,360	1,443	2,739	5,319	3,978	3,709	2,820	4,065	2,807	2,026	1,116	753	34,136
1974	811	3,413	1,336	4,135	4,757	3,493	3,002	2,668	3,247	2,515	2,204	2,142	33,723
1975	1,974	1,443	1,718	3,187	3,958	3,523	2,739	3,271	3,845	1,825	1,634	2,911	32,028
1976	1,468	2,554	1,402	2,090	3,656	1,590	2,111	2,340	1,604	3,607	2,100	636	25,158
1977	1,577	2,213	3,022	3,197	3,311	4,963	1,782	2,215	2,027	2,617	1,945	2,142	31,012
1978	3,072	769	5,651	1,623	1,836	3,640	4,462	3,489	3,306	1,424	2,452	3,132	34,856
1979	823	1,246	2,921	3,187	2,463	5,546	1,314	1,020	5,423	1,066	2,898	2,225	30,132
1980	1,900	1,771	1,258	2,737	3,172	2,534	1,435	2,298	604	2,016	1,698	1,157	22,578
1981	2,058	1,279	2,678	2,131	4,482	1,471	4,737	624	3,405	694	1,890	2,184	27,634
1982	1,772	1,508	3,122	2,339	3,764	3,008	-	-	3,316	1,566	1,194	2,288	28,652
1983	2,911	559	1,100	2,256	5,279	4,575	4,571	5,632	5,546	4,854	1,826	2,267	41,376
1984	2,709	2,984	2,586	4,251	7,330	4,106	7,574	2,688	6,044	1,402	1,601	1,942	45,218
1985	1,782	3,840	905	1,869	5,822	3,913	2,830	3,331	3,757	2,971	2,737	2,443	36,199
1986	1,302	1,902	2,005	1,794	1,900	2,686	2,739	835	3,088	2,597	1,471	2,236	24,555
1987	1,793	453	2,617	1,394	3,715	1,869	624	1,696	864	3,676	2,277	1,247	22,224
1988	2,443	1,668	2,484	1,206	3,754	3,601	5,298	7,221	3,660	3,172	2,716	2,840	40,062
1989	1,599	2,264	3,271	3,474	525	2,888	3,538	3,321	3,038	4,326	2,928	1,402	32,574
1990	1,291	1,497	1,642	1,666	2,617	1,709	2,173	1,718	2,807	4,413	944	997	23,476
1991	3,479	1,367	2,770	1,943	6,132	2,277	2,515	590	115	1,457	422	3,261	26,327
1992	613	764	1,814	1,339	3,072	1,730	2,319	1,369	2,359	4,688	1,601	1,534	23,203
1993	1,468	1,476	1,457	2,462	4,017	1,730	3,360	729	3,533	1,235	1,752	1,479	24,699
1994	601	1,975	2,759	2,696	3,793	3,660	881	1,750	0	2,319	2,308	1,031	23,774
										Annual Average			32,232

CHAPTER 7 EVAPORATION

Evaporation was measured at the Malano meteorological station established by PLN during this F/S. However, data is available for 3 months only as exhibited in Appendix C. Therefore, it was decided to estimate an evaporation rate based on the Penman-Monteith equation.

$$E_p = F_{p1}A + F_{p2}D \qquad (7.1)$$

where,

E_p	:	evaporation rate from open water (mm/day)
F_{p1}, F_{p2}	:	coefficients obtained hereinbelow
A	:	energy available for evaporation (mm/day)
D	:	average vapor - pressure deficit (kPa)

(1) F_{p1}

$$F_{p1} = \frac{\Delta}{\Delta + \gamma} \qquad (7.2)$$

$$\Delta = \frac{4{,}098 \times 0.6108 \exp\left(\dfrac{17.27T}{237.3 + T}\right)}{(237.3 + T)^2} \text{ (kPa/°C)} \qquad (7.3)$$

where, T is the average atmospheric air temperature in °C shown in Table C.2 of Appendix C.

$$\gamma = 0.0016286 \frac{P}{\lambda} = 0.0672 \text{ kPa/°C} \qquad (7.4)$$

where,

$$P = 103.1 \text{ x } \left(\frac{293 - 0.0065Z}{293}\right)^{5.256} = 102.38 \text{ kPa}$$

(Z = 60 m, elevation of water surface)

$$\lambda = 2.501 - 0.002361Ts = 2.4373 \text{ MJ/kg}$$

(Ts = 27°C, water temperature)

(2) F_{p2}

$$F_{p2} = \frac{\gamma}{\Delta + \gamma} \text{ x } \frac{6.43\,(1 + 0.536\,Ua)}{\lambda} = \frac{0.4624}{\Delta + 0.0672} \qquad (7.5)$$

where, Ua is the average wind speed, assumed as 3.0 m/s based on the wind data in Appendix C.

(3) $A \doteqdot (0.25 + 0.5N)\, So - (0.9N + 0.1)(0.34 - 0.14\sqrt{ed})\, \sigma T^4$ (7.6)

where,

N : cloudiness fraction which is expressed as "Sunshine" in Table C.2 of Appendix C. Since "Sunshine" in the table does not consider rainy days, it shall be decreased by 30%.

So : extraterrestrial radiation, $MJ/m^2/day$
$= 15.392\, dr(\omega s \sin\phi \sin\delta + \cos\phi \cos\delta \sin\omega s)$

dr : relative distance between the earth and the sun
$$= 1 + 0.033 \cos\left(\frac{2\pi}{365} J\right)$$

J : Julian day number

ϕ : latitude of site $\doteqdot 0$

δ : solar declination in radian
$$= 0.4093 \sin\left(\frac{2\pi}{365} J - 1.405\right)$$

ωs : sunset hour angle in radians
$= \arccos(-\tan\phi \tan\delta) = 1.57$

σ : Stefan - Boltzmann constant
$= 4.903 \times 10^{-9}\, MJ/m^2/°K^4/day$

ed : vapor pressure in average conditions

$$\sqrt{ed} = \frac{0.36 - 0.261 \exp(-7.77 \times 10^{-4} T2)}{0.14} \text{ kPa}$$

(4) D

$$D = \frac{0.618}{2}\left\{\exp\left(\frac{17.27\, T\max.}{237.2 + T\max.}\right) + \exp\left(\frac{17.27\, T\min.}{237.2 + T\min.}\right)\right\} \frac{(1 - Rh)}{100} \quad (7.7)$$

where,

Tmax., Tmin. : maximum or minimum atmospheric air temperature in °C which is shown in Table C.2 of Appendix C.

Rh : average relative humidity in decimal fraction which is shown in Table C.2.

From the equations (7.1) ~ (7.7) and Table C.2, an evaporation rate for each month was obtained as shown in Table 7.1.

Table 7.1 Estimation of Evaporation Rate from Open Water

		Jan.	Feb.	Mar.	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
Tmax	(℃)	31.5	31.8	32.0	32.2	32.4	32.4	31.7	32.8	32.5	32.3	33.0	32.0	
Tmin	(℃)	24.4	23.1	24.7	23.7	23.6	24.3	23.7	24.4	23.8	23.7	24.6	24.5	
T (average)	(℃)	28.0	28.1	28.1	28.2	28.2	28.0	27.6	27.6	27.8	28.2	28.3	28.2	
Rh	(%)	81.0	79.6	80.4	80.8	82.2	83.2	82.7	81.8	81.5	79.6	80.2	80.2	
N	(%)	44.2	46.8	45.1	44.6	48.4	45.0	40.9	46.6	43.8	46.7	43.1	43.1	
J (julian day)		15	46	74	105	135	166	196	227	258	288	319	349	
Δ	(kPa/℃)	0.220	0.221	0.221	0.222	0.222	0.220	0.216	0.216	0.218	0.222	0.223	0.222	
Fp1		0.766	0.767	0.767	0.768	0.768	0.766	0.762	0.762	0.764	0.768	0.769	0.768	
Fp2		1.610	1.603	1.603	1.597	1.597	1.610	1.635	1.635	1.622	1.597	1.591	1.597	
δ		-0.373	-0.236	-0.054	0.160	0.325	0.406	0.378	0.245	0.044	-0.163	-0.331	-0.407	
dr		1.032	1.023	1.010	0.992	0.977	0.968	0.968	0.976	0.991	1.008	1.023	1.032	
So	(mm/day)	14.791	15.314	15.518	15.078	14.257	13.691	13.848	14.577	15.240	15.309	14.893	14.585	
√ed		1.558	1.562	1.562	1.566	1.566	1.558	1.540	1.540	1.549	1.566	1.571	1.566	
A	(MJ/m2/day)	6.966	7.412	7.379	7.132	7.014	6.503	6.294	7.041	7.147	7.402	6.932	6.789	
D	(kPa)	0.069	0.068	0.071	0.070	0.071	0.072	0.069	0.073	0.071	0.070	0.073	0.071	
Ep	(mm/day)	5.4	5.8	5.8	5.6	5.5	5.1	4.9	5.5	5.6	5.8	5.4	5.3	Total (mm)
	(mm/month)	168.9	162.2	179.0	167.6	170.5	152.9	152.3	170.1	167.3	179.7	163.4	165.1	1999.0

APPENDIX A

RAINFALL DATA

Table A.1 Annual Rainfall in and around Catchment Area (except WSN-1~6)

(mm)

Year	Rainfall Gauge Station												
	Kebare	Makbon	Kebar	Ayawasi	Weflani	Atinyo	Ayamaru	Sausapor	Sorong Jefman	Sorong Remu	Sorong Doom	Kalmono (Pertamina)	Mega (Pertamina)
1920	-	-	-	-	-	-	-	-	2,244	-	-	-	-
1921	-	-	-	-	-	-	-	-	3,374	-	-	-	-
1922	-	-	-	-	-	-	-	-	2,676	-	-	-	-
1923	-	-	-	-	-	-	-	-	2,148	-	-	-	-
1924	-	-	-	-	-	-	-	-	3,568	-	-	-	-
1925	-	-	-	-	-	-	-	-	2,698	-	-	-	-
1926	-	-	-	-	-	-	-	-	3,608	-	-	-	-
1927	-	-	-	-	-	-	-	-	3,315	-	-	-	-
1928	-	-	-	-	-	-	-	-	2,487	-	-	-	-
1929	-	-	-	-	2,193	-	-	-	2,926	-	-	-	-
1930	-	-	-	-	2,339	-	-	-	2,432	-	-	-	-
1931	-	-	-	-	-	-	-	-	3,275	-	-	-	-
1932	-	-	-	-	-	-	-	-	3,189	-	-	-	-
1933	-	-	-	-	-	-	-	-	3,043	-	-	-	-
1934	-	-	-	-	-	-	-	-	4,040	-	-	-	-
1935	-	-	-	-	2,133	-	-	-	3,404	-	-	-	-
1936	-	-	-	-	-	-	-	-	3,570	-	-	-	-
1937	-	-	-	-	2,895	6,223	-	-	3,624	-	-	-	-
1938	-	-	-	-	-	4,879	5,584	2,710	3,520	-	-	-	-
1939	-	-	-	-	2,041	4,689	4,365	1,758	2,169	-	-	-	-
1940	-	-	1,903	-	2,310	3,943	3,442	2,270	2,449	-	-	-	-
1941	-	-	-	-	2,648	-	-	-	2,302	-	-	-	-
1942	-	-	-	-	-	3,482	-	-	-	-	-	-	-
1943	-	-	-	-	-	4,874	-	-	-	-	-	-	-
1944	-	-	-	-	-	-	-	-	-	-	-	-	-
1945	-	-	-	-	-	7,315	-	-	-	-	-	-	-
1946	-	-	-	-	-	4,578	-	-	-	-	-	-	-
1947	-	-	-	-	-	-	-	-	-	-	-	-	-
1948	-	-	-	-	-	-	-	-	-	-	-	-	-
1949	-	-	-	-	-	-	-	-	-	-	-	-	-
1950	-	-	-	-	-	-	-	-	-	-	-	-	-
1951	-	-	-	-	-	-	-	-	-	-	-	-	-
1952	-	-	-	-	-	-	4,897	-	-	-	-	-	-
1953	-	-	-	-	-	-	4,713	2,408	-	-	-	-	-
1954	2,041	-	-	-	-	-	5,591	3,639	-	-	-	-	-
1955	1,624	-	-	-	-	-	6,209	3,178	-	-	-	-	-
1956	1,422	-	-	5,145	-	-	5,571	3,197	-	-	-	-	-
1957	1,405	-	-	-	-	-	3,944	2,998	-	-	-	-	-
1958	1,118	2,912	-	-	-	-	3,585	2,772	2,160	2,127	2,129	2,950	-
1959	1,862	3,905	2,211	-	-	-	4,504	2,750	3,215	3,056	-	3,680	-
1960	2.048	3,525	-	-	-	-	4,900	2,478	2,953	3,086	-	4,150	-
1961	1,869	3,212	1,712	-	-	-	4,288	3,069	2,139	-	2,280	3,596	-
1962	2,419	-	-	7,110	-	-	5,913	3,361	3,166	-	2,904	-	-
1963	1,980	-	-	5,883	-	-	-	2,867	2,575	-	-	-	-
1964	1,903	-	-	6,799	-	-	2,989	3,339	2,681	-	1,228	-	-
1965	1,142	-	-	4,101	-	-	-	-	2,030	-	-	-	-
1966	-	-	-	4,001	-	-	-	-	2,563	1,482	-	-	-
1967	1,528	-	-	6,160	-	-	-	2,876	2,450	-	-	-	-
1968	-	-	-	5,455	-	-	-	-	3,058	-	-	-	-
1969	-	-	-	5,284	-	-	-	-	3,272	3,165	2,404	-	-
1970	1,389	-	-	5,440	-	-	4,891	-	3,273	3,451	-	2,792	-
1971	1,823	-	-	3,920	-	-	4,988	-	3,338	-	2,918	-	-
1972	1,713	-	-	7,780	-	-	4,054	-	2,013	-	2,580	-	-
1973	4,187	-	-	7,168	-	-	8,096	-	2,931	3,086	-	-	-
1974	2,329	-	-	6,326	-	-	4,567	-	2,909	1,867	2,922	-	-
1975	-	-	-	5,238	-	-	5,464	-	2,730	2,556	-	-	-
1976	-	-	-	5,398	-	-	2,935	-	2,056	2,656	-	-	-
1977	-	-	-	-	-	-	3,541	-	2,626	2,917	-	-	-
1978	-	-	-	-	-	-	4,119	2,901	3,028	1,647	-	-	2,401
1979	-	5,264	-	-	-	-	3,383	2,765	2,583	2,812	-	-	2,580
1980	-	3,158	-	-	-	-	3,652	2,744	1,793	2,428	-	-	-
1981	-	-	-	-	-	-	5,030	2,628	2,327	3,474	3,279	-	-
1982	-	-	-	-	-	-	3,827	1,937	-	1,908	1,458	-	-
1983	-	-	-	-	-	-	8,334	-	3,702	2,968	2,068	3,573	-
1984	-	-	-	-	-	-	5,864	-	4.098	3,741	3,446	3,939	-
1985	-	-	-	-	-	-	6.463	-	3,157	2,767	2,659	3,820	-
1986	-	-	-	-	-	-	3,807	-	2,000	2,616	2,064	3,268	-
1987	-	-	-	-	-	-	5,497	-	1,795	2,116	-	-	-
1988	-	-	-	-	-	-	-	-	3,549	-	-	-	-
1989	-	-	-	-	-	-	-	-	2,795	-	-	-	-
1990	-	-	-	-	-	-	-	-	1,909	-	-	-	-
1991	-	-	-	-	-	-	-	-	2,222	-	-	-	-
1992	-	-	-	-	-	-	-	-	1,870	-	-	-	-
1993	-	-	-	-	-	-	-	-	2,031	-	-	-	-
1994	-	-	-	-	-	-	-	-	1,973	-	-	-	-
Mean	1,877	3,662	1,942	5,700	2,365	4,997	4,818	2,792	2,776	2,663	2,452	3,529	2,490

Source: Pre-F/S Report and data obtained at Sorong Jefman

Table A.2 Monthly Rainfall at Sorong Jefman

(mm)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total	Day Max
1920	60	60	86	434	125	510	117	174	251	247	135	45	2,244	75 (6)
1921	230	211	367	345	276	273	324	238	450	104	251	305	3,374	109 (9)
1922	145	292	152	310	132	327	351	277	232	197	83	178	2,676	112 (9)
1923	427	210	229	290	158	172	122	10	127	113	53	237	2,148	54 (4)
1924	146	337	230	233	396	253	563	296	380	203	315	216	3,568	154 (9)
1925	196	266	245	186	340	312	260	343	216	17	111	206	2,698	117 (5)
1926	138	79	137	339	488	325	515	279	647	179	264	218	3,608	187 (8)
1927	230	100	267	255	406	447	385	120	572	175	244	114	3,315	144 (6)
1928	111	175	222	242	334	321	252	209	166	57	187	211	2,487	104 (5)
1929	195	61	308	284	527	470	235	140	236	180	166	124	2,926	100 (5)
1930	61	156	406	175	207	610	28	24	15	447	151	152	2,432	198 (6)
1931	242	51	105	288	563	671	443	133	318	159	158	144	3,275	123 (5)
1932	109	157	230	223	330	204	524	392	188	394	177	261	3,189	137 (7)
1933	200	216	145	156	223	294	376	363	543	226	113	188	3,043	139 (2)
1934	305	171	300	250	306	445	469	413	281	496	347	257	4,040	117 (8)
1935	197	70	208	211	448	485	253	410	171	520	247	184	3,404	100 (8)
1936	273	265	393	282	306	299	477	200	308	519	73	175	3,570	115 (3)
1937	243	191	332	250	318	449	376	208	525	355	260	117	3,624	138 (10)
1938	189	90	257	204	351	225	310	720	396	250	161	367	3,520	165 (8)
1939	211	181	89	329	315	423	146	93	126	29	215	12	2,169	89 (4)
1940	211	219	215	212	278	321	47	485	156	49	145	111	2,449	104 (6)
1941	125	46	137	321	623	40	88	181	184	202	181	174	2,302	122 (5)
1958	43	90	196	144	182	191	126	485	156	179	162	206	2,160	x
1959	206	52	108	322	517	533	429	181	184	264	245	174	3,215	x
1960	305	160	99	193	316	223	870	112	192	91	211	181	2,953	x
1961	125	204	218	197	142	266	348	115	143	67	147	167	2,139	x
1962	416	210	130	383	404	331	150	376	136	272	127	231	3,166	x
1963	280	239	184	255	549	240	307	134	32	32	83	240	2,575	x
1964	114	286	128	428	229	309	269	148	113	182	165	310	2,681	x
1965	278	25	148	301	292	319	21	36	1	133	255	221	2,030	x
1966	130	143	141	138	303	261	194	419	219	143	245	227	2,563	75 (5)
1967	335	148	80	271	399	297	352	101	53	172	127	115	2,450	109 (7)
1968	131	61	356	102	170	453	348	206	332	249	377	273	3,058	112 (6)
1969	141	50	411	186	578	240	484	311	98	350	259	164	3,272	148 (7)
1970	194	127	243	275	585	214	461	351	241	123	200	259	3,273	225 (7)
1971	211	203	138	192	479	416	294	437	317	341	197	113	3,338	114 (10)
1972	165	268	134	166	167	512	68	150	102	33	154	94	2,013	152 (6)
1973	294	111	232	469	357	331	240	366	240	163	80	48	2,931	80 (3)
1974	53	304	99	375	437	309	258	225	284	210	181	174	2,909	117 (5)
1975	158	111	134	278	355	312	232	285	345	144	127	249	2,730	67 (4)
1976	111	210	105	170	324	123	171	193	121	319	171	38	2,056	106 (8)
1977	121	184	260	279	289	460	140	181	164	220	154	174	2,626	98 (5)
1978	265	51	530	126	145	324	407	307	290	107	205	271	3,028	108 (7)
1979	54	93	250	278	205	521	97	71	508	75	249	182	2,583	123 (9)
1980	151	136	92	233	275	213	108	189	18	162	133	83	1,793	70 (7)
1981	166	96	226	174	409	112	435	37	300	43	151	178	2,327	120 (3)
1982	139	117	270	194	335	260	x	x	291	120	87	188	x	259 (9)
1983	249	33	78	186	491	420	418	528	521	447	145	186	3,702	135 (5)
1984	229	259	217	387	711	372	738	227	574	105	124	155	4,098	130 (4)
1985	140	348	61	149	548	352	241	291	336	255	233	203	3,157	150 (2)
1986	96	154	161	142	151	228	232	55	268	218	112	183	2,000	90 (7)
1987	141	18	220	105	330	149	37	132	58	326	188	91	1,795	80 (10)
1988	203	131	207	88	334	320	493	699	326	275	231	242	3,549	115 (8)
1989	123	189	285	307	28	248	312	290	263	393	252	105	2,795	84 (10)
1990	95	116	127	130	220	134	177	134	240	402	65	69	1,909	112 (9)
1991	306	104	235	156	581	188	210	34	3	110	11	284	2,222	x
1992	16	50	143	100	265	136	191	102	196	430	124	117	1,870	x
1993	111	114	110	206	361	136	294	46	313	90	138	112	2,031	x
1994	35	161	234	229	338	326	59	137	0	191	191	72	1,973	x
Average	179	152	204	240	343	316	291	238	245	213	175	176	2,776	

x : No Data ( ): Month

Sources: -Data obtained at the BMG office in Jefman
-Data exhibited in the Pre-F/S report

Table A.3a Daily Rainfall Data at WSN-1 (Malano) (mm)

Month / Day	1991											
	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul	Aug.	Sep.	Oct.	Nov.	Dec.
1		0.0	0.0	2.0			0.0	0.0				
2		0.5	13.0	10.0			6.0	0.0				
3		3.0	41.0	4.0			9.5	0.0				
4		24.0	0.0	1.0			19.0	1.0				
5		0.5	0.0	1.0			1.0	3.0				
6		5.5	0.0	4.0			1.0	15.5				
7		15.0	0.0	5.0			0.0	9.0				
8		0.5	0.0	0.0			36.0	1.0				
9		0.0	0.0	0.5			0.5	0.0				
10	N.A.	28.5	0.0	0.0	N.A.	N.A.	59.5	11.5	N.A.	N.A.	N.A.	N.A.
11		0.0	0.0	0.0			11.0	8.0				
12		0.0	0.5	15.5			5.0	0.0				
13		0.0	1.5	24.0			0.0	9.0				
14		0.0	11.0	9.0			7.0	1.0				
15		2.5	0.0	2.0			53.0	0.0				
16		1.0	0.0	0.0			0.0	0.0				
17		1.5	0.0	1.5			0.0	0.0				
18		0.0	0.0	0.5			0.0	0.0				
19		0.0	26.0	5.5			0.0	0.0				
20		3.0	10.0	0.0			0.0	0.0				
21		0.0	30.0	3.5			0.0	0.0				
22		1.0	8.0	0.0			0.0	0.0				
23		8.0	0.0	44.0			0.0	1.0				
24		0.0	1.0	0.5			0.0	0.5				
25		0.0	34.5	0.0			48.0	0.0				
26		0.0	1.5	0.0			1.0	0.0				
27		0.0	58.0	21.0			0.5	0.0				
28		0.0	98.0	0.5			0.0	4.0				
29			15.0	0.0			3.0	7.5				
30			29.0	1.0			3.0	1.0				
31			2.0				0.0	0.5				
Monthly total		83.5	380.0	156.0			264.0	73.5				
Day Max.		28.5	98.0	44.0			59.5	60.5				

Table A.3b Daily Rainfall Data at WSN-1 (Malano) (mm)

Month / Day	1992											
	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul	Aug.	Sep.	Oct.	Nov.	Dec.
1		5.0		25.0		17.0	0.0					
2		5.0		11.0		14.0	0.0					
3		32.0		3.0		5.0	3.5					
4		0.0		1.0		3.0	0.0					
5		40.0		0.0		42.0	0.5					
6		0.0		1.0		38.0	0.0					
7		0.0		0.0		2.0	0.0					
8		0.0		0.0		13.0	0.0					
9		0.0		2.0		3.0	0.0					
10	N.A.	0.0	N.A.	2.0	N.A.	9.0	0.0	N.A.	N.A.	N.A.	N.A.	N.A.
11		0.0		0.0		34.0	16.5					
12		0.0		0.0		14.5	15.0					
13		0.0		35.0		23.5	0.0					
14		1.0		0.0		1.5	0.0					
15		46.0		0.0		4.5	0.0					
16		9.0		0.0		22.5	2.5					
17		0.0		0.0		14.5	0.0					
18		0.0		0.0		0.5	0.0					
19		0.0		0.0		0.0	0.0					
20		0.0		0.0		4.5	4.0					
21		0.0		0.0		0.0	0.0					
22		0.0		0.0		0.0	24.0					
23		0.0		1.0		0.0	0.0					
24		0.0		11.0		0.0	0.0					
25		0.0		11.0		0.0	4.5					
26		16.0		3.0		0.0	0.0					
27		1.0		0.0		0.0	2.0					
28		0.0		9.0		0.0	37.0					
29		0.0		5.0		0.0	0.0					
30				0.0		0.0	0.0					
31							0.0					
Monthly total		155.0		120.0		266.0	109.5					
Day Max.		46.0		35.0		42.0	37.0					

Table A.3c Daily Rainfall Data at WSN-1 (Malano) (mm)

Day \ Month	1993											
	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul	Aug.	Sep.	Oct.	Nov.	Dec.
1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0				0.0
2	0.0	0.0	0.0	36.0	0.0	0.0	0.0	0.0				10.0
3	0.0	0.0	0.0	32.0	0.0	0.0	0.0	0.0				5.0
4	0.0	0.0	0.0	0.0	x	0.0	0.0	0.0				0.0
5	0.0	0.0	0.0	1.5	x	0.0	20.0	0.0				28.0
6	0.0	0.0	0.0	0.0	x	0.0	0.0	0.0				0.0
7	0.0	0.0	1.0	0.0	x	0.0	0.0	0.0				0.0
8	0.0	0.0	0.0	0.0	x	0.0	0.0	0.0				0.0
9	0.0	12.5	0.0	0.0	x	0.0	0.0	0.0				0.0
10	0.0	0.0	4.0	0.0	x	0.0	0.0	0.0	N.A.	N.A.	N.A.	0.0
11	0.0	16.0	0.0	0.0	7.0	0.0	0.0	0.0				0.0
12	0.0	0.0	0.0	0.0	2.0	0.0	0.0	0.0				0.0
13	0.0	0.0	9.0	16.0	33.0	0.0	0.0	0.0				0.0
14	40.0	0.0	0.0	22.0	4.0	0.0	4.0	0.0				0.0
15	0.0	2.0	3.5	0.0	29.0	0.0	56.0	0.0				0.0
16	3.5	25.0	30.0	0.0	x	0.0	0.0	0.0				15.0
17	88.0	0.0	0.0	0.0	x	0.0	0.0	0.0				0.0
18	0.0	0.0	0.0	0.0	x	0.0	0.0	0.0				0.0
19	0.0	0.0	6.0	0.0	x	0.0	0.0	0.0				0.0
20	58.0	0.0	11.0	0.0	x	0.0	0.0	0.0				0.0
21	0.0	0.0	0.0	6.0	x	0.0	0.0	0.0				19.0
22	0.0	0.0	0.0	0.0	x	0.0	44.0	0.0				0.0
23	0.0	0.0	0.0	0.0	x	0.0	0.0	0.0				0.0
24	0.0	0.0	0.0	4.0	x	25.0	0.0	5.0				0.5
25	0.0	2.5	0.0	2.0	x	0.0	0.0	7.5				0.0
26	0.0	13.0	4.0	15.0	x	0.0	0.0	3.0				0.5
27	0.0	0.0	0.0	0.0	x	0.0	0.0	5.0				0.0
28	0.0	0.0	0.0	0.0	x	0.0	0.0	4.5				0.5
29	0.0		8.0	5.5	x	0.0	0.0	6.0				0.0
30	0.0		0.0	0.0	x	0.0	0.0	4.5				6.0
31	0.0				x		0.0	0.0				0.0
Monthly total	189.5	71.0	76.5	140.0	75.0	25.0	124.0	35.5				84.5
Day Max.	88.0	25.0	30.0	36.0	33.0	25.0	56.0	7.5				28.0

Table A.3d Daily Rainfall Data at WSN-1 (Malano) (mm)

Day \ Month	1994											
	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul	Aug.	Sep.	Oct.	Nov.	Dec.
1	18.0	0.0	0.0	0.0	2.5	4.5	0.0	0.0	0.0	6.0	0.0	0.0
2	0.0	0.0	0.0	0.0	3.5	7.0	3.5	0.0	0.0	21.5	0.0	0.0
3	0.0	0.0	0.0	0.0	4.5	1.5	11.0	0.0	0.0	5.0	1.5	0.0
4	0.0	0.0	0.0	0.0	48.0	2.5	0.0	0.0	0.0	3.5	0.0	4.0
5	0.0	0.0	5.0	0.0	41.0	56.0	0.0	0.0	0.0	1.5	0.0	18.0
6	19.0	0.0	70.5	2.0	0.0	3.0	0.0	0.0	0.0	1.0	0.0	5.0
7	0.0	0.0	18.0	51.5	0.0	120.0	0.0	0.0	0.0	0.0	0.0	0.0
8	42.0	0.0	1.5	0.0	0.0	172.5	0.0	0.0	0.0	3.5	35.5	0.0
9	10.0	6.0	12.0	55.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
10	0.0	0.0	5.0	0.0	0.0	0.0	0.0	15.0	0.0	21.0	0.0	0.0
11	18.0	1.5	10.5	0.0	0.0	2.0	0.0	0.0	0.0	32.0	1.0	7.5
12	0.0	3.5	7.0	49.0	0.0	107.5	0.0	0.0	0.0	10.5	0.0	0.0
13	0.0	4.0	12.0	0.0	0.0	0.0	0.0	0.0	0.0	25.0	0.0	0.0
14	0.0	30.0	37.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
15	19.0	0.0	0.0	55.0	0.0	10.0	0.0	0.0	0.0	0.0	0.0	0.0
16	0.0	1.5	0.0	3.5	0.0	59.5	0.0	1.5	0.0	0.0	0.0	0.0
17	0.0	0.0	0.0	9.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
18	0.0	0.0	0.0	3.5	5.0	0.0	0.0	0.0	0.0	0.0	0.0	8.0
19	0.0	0.0	8.0	0.0	0.0	2.0	0.0	0.0	0.0	0.0	0.0	5.5
20	10.0	0.0	6.0	0.0	0.0	0.0	0.0	4.5	0.0	0.0	0.0	0.0
21	4.5	0.0	0.0	54.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
22	0.0	0.0	0.0	0.0	0.0	2.0	0.0	0.0	0.0	0.0	0.0	0.0
23	0.0	0.0	0.0	7.5	0.0	3.5	0.0	5.0	0.0	17.5	0.0	0.0
24	0.0	0.0	0.0	0.0	53.0	0.0	0.0	1.0	0.0	8.0	0.0	0.0
25	0.0	0.0	5.0	4.5	1.5	0.0	0.0	0.0	0.0	1.0	0.0	0.0
26	0.0	0.0	0.0	0.0	0.0	0.0	0.0	5.0	0.0	4.0	0.0	0.0
27	0.0	0.0	0.0	3.0	0.0	0.0	0.0	2.0	0.0	17.0	0.0	0.0
28	0.0	0.0	0.0	47.0	0.0	0.0	0.0	0.0	0.0	17.5	19.0	0.0
29	0.0		0.0	0.0	2.5	0.0	0.0	0.0	0.0	0.0	69.0	0.0
30	0.0		0.0	23.5	0.0	46.5	0.0	2.0	4.0	43.5	0.5	0.0
31	0.0		0.0		0.0		0.0	0.0		0.5		0.0
Monthly total	140.5	46.5	197.5	368.5	161.5	600.0	14.5	36.0	4.0	239.5	126.5	48.0
Day Max.	42.0	30.0	70.5	55.0	53.0	172.5	11.0	15.0	4.0	43.5	69.0	18.0

Table A.3e Daily Rainfall Data at WSN-1 (Malano) (mm)

Day \ Month	1995											
	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul	Aug.	Sep.	Oct.	Nov.	Dec.
1	0.0	0.5	24.0	0.0	31.5							
2	0.0	0.5	1.0	0.0	7.5							
3	0.0	6.0	0.0	0.0	58.5							
4	0.0	0.0	4.5	19.5	8.0							
5	10.0	0.0	1.5	21.0	0.0							
6	0.0	0.0	1.0	0.0	17.0							
7	0.0	3.0	0.0	0.0	0.0							
8	0.0	32.5	0.0	0.0	6.0							
9	13.0	0.0	10.5	17.0	12.0							
10	5.0	12.0	3.0	28.0	8.5							
11	0.0	0.0	1.0	1.0	0.0							
12	2.5	0.0	6.0	0.0	23.0							
13	0.0	0.0	0.0	0.0	24.5							
14	0.0	0.0	0.0	0.0	0.0							
15	5.5	0.0	1.0	0.0	51.5							
16	8.5	22.5	0.0	0.0	0.0							
17	0.0	0.0	34.5	7.5	7.5							
18	20.5	0.0	0.0	0.5	0.0							
19	0.0	0.0	3.5	0.0	17.0							
20	0.0	6.5	0.0	0.0	2.5							
21	0.0	0.0	3.5	0.0	4.0							
22	0.0	7.0	12.0	0.0	0.0							
23	24.0	0.0	1.5	0.0	0.0							
24	5.5	1.5	0.5	37.5	0.0							
25	6.0	0.0	0.5	7.5	0.0							
26	0.0	0.0	11.0	14.0	0.0							
27	0.0	26.0	1.5	0.0	0.0							
28	2.5	0.0	0.0	10.0	0.0							
29	0.0		28.5	0.0	0.0							
30	0.0		0.0	0.5	0.0							
31	5.0		0.0		0.0							
Monthly total	108.0	118.0	150.5	164.0	279.0							
Day Max.	24.0	32.5	34.5	37.5	58.5							

Table A.4a Daily Rainfall Data at WSN-2 (Asbaken) (mm)

Day \ Month	1991											
	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul	Aug.	Sep.	Oct.	Nov.	Dec.
1		x	12.5	3.0			78.0	0.0	0.0	0.0	0.0	0.0
2		x	19.0	11.0			0.0	0.0	5.0	0.0	0.0	0.0
3		x	36.0	0.5			0.0	0.0	18.0	0.0	0.0	0.0
4		x	0.0	4.0			56.0	0.0	0.0	0.0	0.0	7.0
5		x	1.5	31.5			0.0	0.0	0.0	0.0	0.0	0.0
6		x	0.0	2.0			0.0	0.0	0.0	0.0	0.0	12.0
7		x	1.0	0.0			0.0	0.0	0.0	0.0	0.0	20.0
8		x	1.5	30.0			0.0	25.0	0.0	0.0	0.0	16.0
9		x	0.0	0.0			0.0	0.0	0.0	0.0	0.0	6.0
10	N.A.	x	1.5	0.0	N.A.	N.A.	4.0	0.0	0.0	0.0	0.0	11.0
11		x	0.0	0.0			0.0	0.0	0.0	10.0	0.0	4.0
12		x	0.0	0.0			0.0	3.0	0.0	27.0	0.0	42.0
13		x	0.5	10.0			1.0	0.0	0.0	0.0	0.0	68.0
14		x	50.5	38.0			24.0	0.0	0.0	75.0	0.0	9.0
15		x	18.5	1.0			9.0	0.0	0.0	63.0	0.0	5.0
16		x	0.0	0.0			0.0	0.0	0.0	29.0	0.0	6.0
17		x	0.0	1.0			0.0	0.0	0.0	0.0	0.0	22.0
18		x	22.5	23.5			0.0	0.0	0.0	0.0	0.0	10.0
19		x	0.0	0.0			0.0	0.0	0.0	0.0	0.0	12.0
20		x	36.5	7.0			0.0	0.0	0.0	0.0	0.0	10.0
21		21.5	6.0	21.0			0.0	0.0	6.0	0.0	0.0	11.0
22		75.0	3.0	0.0			0.0	0.0	0.0	0.0	0.0	11.0
23		13.0	4.5	10.5			0.0	0.0	0.0	0.0	0.0	26.0
24		30.0	1.5	18.0			0.0	0.0	0.0	0.0	0.0	26.0
25		7.5	23.0	1.0			1.0	0.0	0.0	0.0	32.0	37.0
26		4.0	28.0	0.0			9.0	0.0	0.0	0.0	0.0	57.0
27		3.5	44.5	12.0			0.0	0.0	0.0	0.0	20.0	48.0
28		3.5	59.0	0.0			0.0	0.0	0.0	2.0	0.0	7.0
29			7.5	0.0			23.0	0.0	0.0	0.0	0.0	4.0
30			8.0	23.5			0.0	0.0	0.0	0.0	0.0	0.0
31			0.0				0.0	0.0		0.0		6.0
Monthly total		158.0	386.5	248.5			205.0	28.0	29.0	206.0	52.0	493.0
Day Max.		75.0	59.0	38.0			78.0	25.0	18.0	75.0	32.0	68.0

Table A.4b Daily Rainfall Data at WSN-2 (Asbaken) (mm)

Day \ Month	1992											
	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul	Aug.	Sep.	Oct.	Nov.	Dec.
1	23.0	0.0	0.0	14.0	0.0	5.0				0.0	0.0	0.0
2	0.0	23.0	2.0	16.0	0.0	25.0				0.0	0.0	8.0
3	14.0	0.0	22.0	18.0	0.0	0.0				0.0	0.0	0.0
4	6.0	0.0	30.0	32.0	0.0	0.0				0.0	0.0	10.0
5	6.0	0.0	0.0	19.0	0.0	0.0				0.0	0.0	8.0
6	3.0	59.0	0.0	0.0	0.0	20.0				0.0	0.0	40.0
7	1.0	0.0	0.0	0.0	20.0	0.0				27.0	0.0	60.0
8	0.0	0.0	0.0	0.0	20.0	0.0				21.0	0.0	0.0
9	3.0	0.0	14.0	0.0	30.0	0.0				0.0	0.0	0.0
10	0.0	0.0	0.0	19.0	0.0	0.0	N.A.	N.A.	N.A.	0.0	0.0	14.0
11	0.0	0.0	0.0	17.0	0.0	0.0				20.0	0.0	0.0
12	0.0	0.0	4.0	14.0	0.0	25.0				0.0	15.0	0.0
13	0.0	55.0	0.0	10.0	0.0	5.0				15.0	0.0	6.0
14	0.0	0.0	0.0	18.0	0.0	0.0				25.0	20.0	0.0
15	0.0	0.0	0.0	0.0	0.0	15.0				0.0	0.0	0.0
16	0.0	47.0	0.0	0.0	0.0	0.0				0.0	0.0	0.0
17	0.0	0.0	0.0	6.0	0.0	20.0				0.0	0.0	20.0
18	0.0	0.0	5.0	14.0	0.0	10.0				10.0	0.0	30.0
19	0.0	0.0	0.0	18.0	0.0	0.0				0.0	10.0	6.0
20	0.0	0.0	0.0	20.0	0.0	15.0				0.0	0.0	0.0
21	0.0	0.0	0.0	0.0	0.0	10.0				0.0	0.0	50.0
22	0.0	0.0	0.0	0.0	0.0	0.0				0.0	0.0	105.0
23	0.0	0.0	0.0	0.0	33.0	0.0				0.0	0.0	9.0
24	8.0	0.0	0.0	0.0	0.0	0.0				0.0	0.0	50.0
25	0.0	0.0	5.0	0.0	13.0	0.0				0.0	0.0	40.0
26	0.0	0.0	0.0	5.0	0.0	0.0				0.0	0.0	40.0
27	0.0	0.0	0.0	0.0	0.0	0.0				0.0	0.0	10.0
28	0.0	0.0	5.0	10.0	0.0	0.0				0.0	0.0	0.0
29	0.0	2.0	5.0	19.0	0.0	0.0				0.0	0.0	0.0
30	0.0		0.0	27.0	0.0	0.0				0.0	0.0	0.0
31	0.0		0.0		0.0					0.0		0.0
Monthly total	64.0	186.0	92.0	296.0	116.0	150.0				118.0	45.0	506.0
Day Max.	23.0	59.0	30.0	32.0	33.0	25.0				27.0	20.0	105.0

Table A.4c Daily Rainfall Data at WSN-2 (Asbaken) (mm)

Month / Day	1993											
	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul	Aug.	Sep.	Oct.	Nov.	Dec.
1	0.0	0.0	0.0	0.0								
2	0.0	0.0	2.0	0.0								
3	0.0	0.0	22.0	0.0								
4	0.0	0.0	30.0	0.0								
5	0.0	0.0	0.0	0.0								
6	0.0	0.0	0.0	0.0								
7	0.0	0.0	0.0	0.0								
8	0.0	0.0	0.0	0.0								
9	0.0	0.0	14.0	0.0								
10	0.0	0.0	0.0	0.0	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.
11	0.0	0.0	0.0	0.0								
12	0.0	0.0	4.0	0.0								
13	0.0	0.0	0.0	0.0								
14	0.0	0.0	0.0	3.0								
15	0.0	0.0	0.0	20.0								
16	0.0	0.0	0.0	5.0								
17	0.0	0.0	0.0	0.0								
18	0.0	0.0	5.0	0.0								
19	4.0	0.0	0.0	0.0								
20	6.0	0.0	0.0	0.0								
21	20.0	0.0	0.0	20.0								
22	45.0	0.0	0.0	15.0								
23	60.0	0.0	0.0	0.0								
24	5.0	0.0	0.0	0.0								
25	8.0	0.0	5.0	0.0								
26	0.0	0.0	0.0	0.0								
27	0.0	0.0	0.0	0.0								
28	0.0	0.0	5.0	0.0								
29	0.0		5.0	0.0								
30	0.0		0.0	0.0								
31	0.0		0.0									
Monthly total	148.0	0.0	92.0	63.0								
Day Max.	60.0	0.0	30.0	20.0								

Table A.4d Daily Rainfall Data at WSN-2 (Asbaken) (mm)

Day \ Month	1994											
	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul	Aug.	Sep.	Oct.	Nov.	Dec.
1	0.0	0.0	0.0	0.0	10.0	10.0	0.0	0.0	0.0	0.0	0.0	0.0
2	0.0	0.0	0.0	0.0	18.0	15.0	0.0	0.0	0.0	0.0	0.0	0.0
3	0.0	0.0	0.0	54.0	40.0	2.0	0.0	0.0	0.0	0.0	0.0	0.0
4	0.0	0.0	30.0	60.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
5	0.0	0.0	24.0	42.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
6	5.0	0.0	0.0	5.0	6.0	9.0	0.0	0.0	0.0	0.0	11.0	0.0
7	10.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	19.0	0.0
8	0.0	0.0	10.0	0.0	0.0	0.0	0.0	5.0	0.0	0.0	0.0	0.0
9	0.0	0.0	16.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
10	0.0	0.0	5.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	41.0	0.0
11	0.0	0.0	0.0	20.0	76.0	18.0	0.0	0.0	0.0	0.0	8.0	0.0
12	0.0	0.0	0.0	29.0	43.0	18.0	0.0	0.0	0.0	0.0	0.0	0.0
13	4.0	0.0	0.0	85.0	0.0	7.0	0.0	0.0	0.0	0.0	0.0	0.0
14	0.0	0.0	8.0	91.0	0.0	16.0	0.0	0.0	0.0	0.0	0.0	12.0
15	15.0	0.0	40.0	40.0	0.0	0.0	0.0	0.0	0.0	0.0	3.0	31.0
16	10.0	0.0	21.0	14.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
17	0.0	0.0	11.0	0.0	0.0	24.0	0.0	0.0	0.0	0.0	13.0	0.0
18	0.0	0.0	0.0	0.0	15.0	33.0	0.0	0.0	0.0	0.0	24.0	5.0
19	0.0	0.0	0.0	0.0	14.0	51.0	0.0	0.0	0.0	0.0	0.0	0.0
20	0.0	0.0	0.0	0.0	0.0	60.0	0.0	0.0	0.0	0.0	0.0	0.0
21	0.0	4.0	8.0	120.0	0.0	0.0	0.0	0.0	0.0	0.0	8.0	0.0
22	0.0	3.0	23.0	110.0	0.0	0.0	0.0	0.0	0.0	0.0	60.0	0.0
23	0.0	0.0	48.0	74.0	0.0	0.0	0.0	0.0	0.0	0.0	32.0	0.0
24	0.0	0.0	15.0	99.0	7.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
25	0.0	0.0	0.0	40.0	0.0	0.0	0.0	0.0	0.0	0.0	11.0	0.0
26	0.0	0.0	0.0	124.0	13.0	0.0	0.0	0.0	0.0	0.0	230.0	0.0
27	0.0	0.0	0.0	64.0	18.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
28	0.0	0.0	0.0	33.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
29	0.0		0.0	40.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
30	0.0		0.0	35.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
31	0.0		0.0		0.0		0.0	0.0		0.0		0.0
Monthly total	44.0	7.0	259.0	1179.0	260.0	263.0	0.0	5.0	0.0	0.0	460.0	48.0
Day Max.	15.0	4.0	48.0	124.0	76.0	60.0	0.0	5.0	0.0	0.0	230.0	31.0

Table A.4e Daily Rainfall Data at WSN-2 (Asbaken) (mm)

Day \ Month	1995											
	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul	Aug.	Sep.	Oct.	Nov.	Dec.
1	6.0					30.0	8.0					
2	12.0					18.0	10.0					
3	0.0					15.0	18.0					
4	0.0					30.0	19.0					
5	0.0					44.0	30.0					
6	0.0					31.0	50.0					
7	0.0					20.0	48.0					
8	0.0					40.0	80.0					
9	0.0					5.0	61.0					
10	0.0					6.0	42.0					
11	41.0					0.0	37.0					
12	0.0					0.0	41.0					
13	0.0					0.0	42.0					
14	0.0					0.0	0.0					
15	11.0					12.0	0.0					
16	18.0					18.0	0.0					
17	60.0					6.0	0.0					
18	78.0					13.0	0.0					
19	5.0					10.0	0.0					
20	0.0					13.0	0.0					
21	16.0					22.0	0.0					
22	17.0					20.0	16.0					
23	0.0					5.0	20.0					
24	81.0					11.0	36.0					
25	10.0					13.0	40.0					
26	4.0					0.0	33.0					
27	0.0					0.0	21.0					
28	0.0					0.0	15.0					
29	0.0					30.0	11.0					
30	0.0					16.0	16.0					
31	0.0						10.0					
Monthly total	359.0					428.0	704.0					
Day Max.	81.0					44.0	80.0					

Table A.5a Daily Rainfall Data at WSN-3 (Klamabon) (mm)

Day \ Month	1991											
	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul	Aug.	Sep.	Oct.	Nov.	Dec.
1		x	2.0	6.0					0.0	0.0	0.0	0.0
2		x	16.0	3.5					17.0	0.0	0.0	0.0
3		x	34.0	0.0					5.0	0.0	0.0	2.0
4		x	0.0	0.0					0.0	0.0	0.0	0.0
5		x	0.0	31.5					0.0	0.0	0.0	0.0
6		x	0.0	0.0					10.0	0.0	0.0	2.0
7		x	0.0	23.0					15.0	0.0	0.0	0.0
8		x	14.0	7.5					15.0	0.0	0.0	36.0
9		x	2.0	0.0					11.0	0.0	0.0	6.0
10	N.A.	x	13.0	0.0	N.A.	N.A.	N.A.	N.A.	16.0	9.0	0.0	0.0
11		x	0.0	9.5					7.0	69.0	9.0	60.0
12		x	17.0	0.0					0.0	5.0	0.0	11.0
13		0.0	6.0	4.0					4.0	57.0	0.0	53.0
14		0.0	5.5	5.0					9.0	46.0	0.0	0.0
15		75.5	78.5	3.0					10.0	62.0	0.0	3.0
16		0.0	141.0	0.0					8.0	0.0	4.0	0.0
17		0.0	0.0	3.5					5.0	29.0	0.0	2.0
18		0.0	0.0	7.5					0.0	3.0	0.0	19.0
19		8.0	8.0	0.0					0.0	0.0	24.0	0.0
20		14.5	8.0	0.0					0.0	0.0	0.0	0.0
21		0.0	22.5	3.0					0.0	0.0	0.0	8.0
22		20.0	3.0	0.0					0.0	0.0	0.0	3.0
23		53.0	25.5	14.0					20.0	0.0	0.0	0.0
24		2.0	0.5	5.0					17.0	0.0	0.0	30.0
25		0.0	24.0	10.5					0.0	0.0	46.0	3.0
26		0.0	12.0	0.0					0.0	0.0	0.0	62.0
27		25.0	8.0	3.5					5.0	0.0	3.0	24.0
28		0.0	5.0	5.0					39.0	0.0	92.0	0.0
29			0.0	2.0					0.0	0.0	0.0	14.0
30			9.0	67.0					20.0	0.0	0.0	3.0
31			1.0						28.0	0.0		11.0
Monthly total		198.0	455.5	214.0					261.0	280.0	178.0	352.0
Day Max.		75.5	141.0	67.0					39.0	69.0	92.0	62.0

Table A.5b Daily Rainfall Data at WSN-3 (Klamabon) (mm)

Day \ Month	1992											
	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul	Aug.	Sep.	Oct.	Nov.	Dec.
1	0.0	23.0	0.0	0.0	0.0		0.0	28.0	0.0	7.0	0.0	0.0
2	0.0	0.0	0.0	8.0	17.0		0.0	0.0	0.0	1.0	0.0	49.0
3	12.0	0.0	7.0	0.0	5.0		0.0	0.0	40.0	26.0	0.0	34.0
4	1.0	0.0	42.0	88.0	0.0		0.0	29.0	0.0	6.0	0.0	0.0
5	2.0	2.0	5.0	26.0	0.0		10.0	0.0	12.0	0.0	0.0	0.0
6	3.0	87.0	0.0	6.0	10.0		0.0	55.0	0.0	3.0	0.0	33.0
7	0.0	0.0	0.0	0.0	15.0		0.0	47.0	7.0	4.0	5.0	0.0
8	0.0	0.0	0.0	0.0	15.0		23.0	54.0	0.0	8.0	0.0	0.0
9	0.0	0.0	0.0	0.0	11.0		7.0	0.0	20.0	48.0	0.0	12.0
10	0.0	0.0	0.0	0.0	16.0	N.A.	0.0	0.0	0.0	11.0	11.0	0.0
11	2.0	0.0	11.0	12.0	7.0		55.0	17.0	0.0	0.0	4.0	2.0
12	0.0	0.0	0.0	28.0	0.0		25.0	0.0	20.0	0.0	28.0	0.0
13	0.0	0.0	0.0	39.0	4.0		0.0	6.0	5.0	18.0	0.0	0.0
14	2.0	0.0	0.0	10.0	9.0		0.0	0.0	6.0	0.0	23.0	0.0
15	42.0	0.0	0.0	9.0	10.0		0.0	0.0	9.0	0.0	9.0	6.0
16	7.0	0.0	0.0	13.0	8.0		0.0	4.0	2.0	16.0	0.0	0.0
17	0.0	115.0	0.0	8.0	5.0		0.0	18.0	8.0	1.0	0.0	34.0
18	0.0	0.0	0.0	0.0	0.0		5.0	4.0	4.0	0.0	0.0	10.0
19	3.0	0.0	9.0	0.0	0.0		83.0	0.0	7.0	2.0	0.0	54.0
20	0.0	0.0	1.0	0.0	0.0		0.0	27.0	0.0	0.0	25.0	4.0
21	17.0	0.0	3.0	0.0	0.0		0.0	0.0	4.0	2.0	1.0	0.0
22	0.0	0.0	6.0	0.0	0.0		8.0	36.0	0.0	1.0	0.0	0.0
23	0.0	0.0	0.0	0.0	20.0		0.0	0.0	0.0	0.0	0.0	7.0
24	40.0	0.0	0.0	5.0	17.0		3.0	0.0	0.0	0.0	x	0.0
25	8.0	0.0	0.0	5.0	0.0		0.0	9.0	0.0	0.0	x	0.0
26	0.0	0.0	0.0	12.0	0.0		39.0	2.0	0.0	0.0	0.0	0.0
27	0.0	0.0	0.0	0.0	5.0		50.0	3.0	0.0	1.0	0.0	0.0
28	0.0	0.0	0.0	11.0	39.0		29.0	21.0	37.0	0.0	0.0	0.0
29	2.0	0.0	0.0	0.0	0.0		1.0	0.0	5.0	6.0	0.0	0.0
30	0.0		7.0	12.0	20.0		54.0	37.0	7.0	0.0	0.0	10.0
31	0.0		0.0		28.0		52.0	0.0		0.0		0.0
Monthly total	141.0	227.0	91.0	292.0	261.0		444.0	397.0	193.0	161.0	106.0	255.0
Day Max.	42.0	115.0	42.0	88.0	39.0		83.0	55.0	40.0	48.0	28.0	54.0

Table A.5c Daily Rainfall Data at WSN-3 (Klamabon) (mm)

Day \ Month	1993											
	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul	Aug.	Sep.	Oct.	Nov.	Dec.
1	0.0	x	0.0	7.0	0.0	20.0	5.0	0.0				
2	0.0	x	0.0	40.0	7.0	38.0	30.0	0.0				
3	0.0	x	0.0	8.0	3.0	4.0	51.0	0.0				
4	0.0	x	2.0	0.0	0.0	16.0	156.0	0.0				
5	x	x	0.0	0.0	7.0	40.0	0.0	0.0				
6	x	x	0.0	20.0	0.0	56.0	0.0	0.0				
7	x	x	12.0	12.0	0.0	19.0	20.0	0.0				
8	x	x	0.0	1.0	2.0	43.0	5.0	0.0				
9	x	x	30.0	5.0	0.0	39.0	8.0	0.0				
10	x	x	5.0	99.0	9.0	0.0	1.0	0.0	N.A.	N.A.	N.A.	N.A.
11	x	0.0	1.0	26.0	8.0	0.0	15.0	0.0				
12	x	20.0	0.0	8.0	22.0	0.0	31.0	0.0				
13	x	0.0	36.0	0.0	10.0	0.0	7.0	2.0				
14	x	0.0	0.0	0.0	0.0	0.0	0.0	2.0				
15	x	59.0	6.0	1.0	0.0	0.0	0.0	0.0				
16	x	33.0	8.0	0.0	0.0	0.0	0.0	0.0				
17	x	3.0	42.0	2.0	0.0	0.0	0.0	0.0				
18	x	8.0	2.0	0.0	0.0	0.0	53.0	0.0				
19	x	12.0	10.0	8.0	0.0	16.0	9.0	0.0				
20	x	0.0	0.0	4.0	23.0	32.0	0.0	13.0				
21	x	0.0	3.0	16.0	0.0	0.0	2.0	0.0				
22	x	0.0	0.0	14.0	0.0	0.0	0.0	0.0				
23	x	0.0	0.0	0.0	0.0	0.0	0.0	0.0				
24	x	1.0	0.0	85.0	3.0	1.0	18.0	0.0				
25	x	4.0	15.0	0.0	0.0	0.0	0.0	0.0				
26	x	9.0	0.0	22.0	25.0	1.0	24.0	18.0				
27	x	0.0	12.0	0.0	0.0	0.0	12.0	4.0				
28	x	4.0	2.0	2.0	0.0	2.0	24.0	12.0				
29	x		4.0	0.0	0.0	3.0	44.0	0.0				
30	x		12.0	14.0	12.0	0.0	42.0	0.0				
31	x		0.0		43.0		15.0	27.0				
Monthly total	0.0	153.0	202.0	394.0	174.0	330.0	572.0	78.0				
Day Max.	0.0	59.0	42.0	99.0	43.0	56.0	156.0	27.0				

Table A.5d Daily Rainfall Data at WSN-3 (Klamabon) (mm)

Day \ Month	1994											
	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul	Aug.	Sep.	Oct.	Nov.	Dec.
1	35.0	0.0	0.0	2.0	0.0	8.0			0.0	0.0	2.0	
2	25.0	0.0	0.0	0.0	0.0	0.0			0.0	43.0	1.0	
3	0.0	4.0	73.0	10.0	16.0	32.0			0.0	17.0	0.0	
4	0.0	8.0	0.0	0.0	0.0	0.0			0.0	0.0	2.0	
5	13.0	0.0	4.0	12.0	34.0	0.0			0.0	0.0	23.0	
6	5.0	2.0	76.0	0.0	0.0	16.0			0.0	0.0	33.0	
7	0.0	2.0	4.0	1.0	12.0	11.0			0.0	0.0	0.0	
8	0.0	2.0	5.0	0.0	0.0	0.0			0.0	4.0	0.0	
9	0.0	5.0	48.0	11.0	0.0	0.0			0.0	1.0	0.0	
10	2.0	0.0	14.0	0.0	10.0	2.0	N.A.	N.A.	0.0	0.0	3.0	N.A.
11	3.0	10.0	27.0	0.0	0.0	18.0			0.0	0.0	18.0	
12	0.0	0.0	1.0	4.0	0.0	7.0			0.0	3.0	0.0	
13	58.0	2.0	14.0	2.0	0.0	9.0			0.0	0.0	10.0	
14	0.0	4.0	80.0	7.0	0.0	4.0			0.0	6.0	34.0	
15	0.0	0.0	9.0	40.0	0.0	2.0			0.0	0.0	7.0	
16	0.0	0.0	3.0	0.0	3.0	0.0			0.0	0.0	1.0	
17	0.0	0.0	17.0	0.0	10.0	0.0			0.0	0.0	2.0	
18	0.0	0.0	0.0	42.0	0.0	0.0			0.0	8.0	14.0	
19	5.0	9.0	0.0	1.0	6.0	25.0			0.0	0.0	0.0	
20	14.0	0.0	0.0	1.0	1.0	13.0			0.0	0.0	0.0	
21	11.0	7.0	0.0	1.0	2.0	11.0			0.0	0.0	0.0	
22	0.0	0.0	18.0	6.0	0.0	5.0			0.0	0.0	8.0	
23	0.0	1.0	0.0	57.0	5.0	0.0			0.0	0.0	0.0	
24	0.0	0.0	0.0	22.0	2.0	0.0			0.0	30.0	1.0	
25	0.0	0.0	41.0	0.0	0.0	0.0			0.0	11.0	1.0	
26	0.0	0.0	2.0	13.0	30.0	0.0			0.0	21.0	0.0	
27	0.0	0.0	15.0	35.0	3.0	0.0			0.0	27.0	0.0	
28	0.0	0.0	3.0	45.0	12.0	0.0			0.0	1.0	3.0	
29	2.0		2.0	7.0	1.0	8.0			0.0	23.0	10.0	
30	9.0		20.0	21.0	46.0	0.0			1.0	8.0	3.0	
31	0.0		7.0		0.0					9.0		
Monthly total	182.0	56.0	483.0	340.0	193.0	171.0			1.0	212.0	176.0	
Day Max.	58.0	10.0	80.0	57.0	46.0	32.0			1.0	43.0	34.0	

Table A.5e Daily Rainfall Data at WSN-3 (Klamabon) (mm)

Day \ Month	1995											
	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul	Aug.	Sep.	Oct.	Nov.	Dec.
1			0.0	0.0	0.0	5.0						
2			0.0	0.0	1.0	2.0						
3			0.0	17.0	21.0	3.0						
4			60.0	0.0	0.0	0.0						
5			5.0	0.0	0.0	9.0						
6			0.0	4.0	24.0	0.0						
7			7.0	5.0	8.0	10.0						
8			0.0	0.0	20.0	3.0						
9			5.0	0.0	4.0	7.0						
10	N.A.	N.A.	2.0	8.0	7.0	5.0						
11			0.0	0.0	21.0	0.0						
12			0.0	15.0	5.0	0.0						
13			0.0	25.0	0.0	4.0						
14			0.0	7.0	0.0	8.0						
15			0.0	12.0	0.0	12.0						
16			0.0	5.0	0.0	13.0						
17			26.0	0.0	4.0	7.0						
18			37.0	0.0	2.0	0.0						
19			2.0	3.0	0.0	0.0						
20			1.0	0.0	0.0	0.0						
21			7.0	4.0	6.0	0.0						
22			6.0	0.0	6.0	3.0						
23			48.0	17.0	0.0	5.0						
24			3.0	35.0	8.0	9.0						
25			0.0	53.0	2.0	11.0						
26			3.0	5.0	0.0	17.0						
27			6.0	3.0	3.0	23.0						
28			8.0	0.0	0.0	30.0						
29			0.0	4.0	26.0	32.0						
30			0.0	0.0	28.0	7.0						
31			5.0		15.0							
Monthly total			231.0	222.0	211.0	225.0						
Day Max.			60.0	53.0	28.0	32.0						

Table A.6a Daily Rainfall Data at WSN-4 (Sainkeduk) (mm)

Month / Day	1991											
	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul	Aug.	Sep.	Oct.	Nov.	Dec.
1		x	0.0	56.0					0.0	0.0	0.0	0.0
2		x	10.5	10.0					0.0	0.0	0.0	0.0
3		x	0.0	3.0					3.0	0.0	0.0	0.0
4		x	0.0	0.0					0.0	0.0	0.0	4.5
5		x	0.0	30.5					0.0	0.0	0.0	0.0
6		x	0.0	0.5					0.0	0.0	0.0	1.5
7		x	0.0	2.5					0.0	0.0	0.0	0.0
8		x	3.5	3.5					0.0	0.0	0.0	5.5
9		x	0.5	1.5					0.0	0.0	0.0	13.5
10	N.A.	x	36.0	0.0	N.A.	N.A.	N.A.	N.A.	0.0	0.0	0.0	23.0
11		x	0.0	27.0					0.0	0.0	7.5	0.0
12		x	11.0	0.0					0.0	0.0	0.0	14.0
13		x	4.0	1.0					0.0	0.0	0.0	39.0
14		x	3.5	10.5					0.0	0.0	0.0	0.0
15		x	38.0	0.0					0.0	0.0	4.5	2.0
16		0.0	38.5	0.0					0.0	0.0	36.5	0.0
17		0.0	0.0	52.5					0.0	0.0	0.0	3.0
18		0.0	0.0	28.0					0.0	0.0	1.0	11.0
19		0.0	12.5	0.5					2.5	0.0	2.5	0.0
20		8.5	7.5	0.0					0.0	0.0	0.0	0.0
21		0.0	15.5	41.5					4.5	0.0	0.0	11.0
22		9.0	15.5	0.0					29.0	0.0	0.0	1.5
23		25.0	34.5	5.5					0.0	0.0	0.0	15.0
24		1.0	8.0	12.0					0.0	0.0	0.0	15.0
25		0.0	18.0	27.5					0.0	0.0	24.0	26.5
26		0.0	28.5	0.0					10.5	0.0	0.0	25.0
27		1.5	5.5	12.5					0.0	0.0	0.0	35.0
28		5.0	4.5	30.5					0.0	0.0	0.0	0.0
29			0.0	0.0					0.0	0.0	9.5	4.0
30			8.5	1.5					0.0	0.0	0.0	2.0
31			20.5							0.0		0.0
Monthly total		50.0	324.5	358.0					49.5	0.0	85.5	252.0
Day Max.		25.0	38.5	56.0					29.0	0.0	36.5	39.0

Table A.6b Daily Rainfall Data at WSN-4 (Sainkeduk) (mm)

Day \ Month	1992											
	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul	Aug.	Sep.	Oct.	Nov.	Dec.
1	0.0	20.0	0.0	43.0	100.0	6.0	5.0	2.0	20.0	30.0	0.0	0.0
2	0.0	3.0	0.0	48.0	15.0	10.0	5.0	2.0	10.0	40.0	0.0	0.0
3	0.0	0.0	0.0	25.0	10.0	46.0	8.0	4.0	4.0	32.0	0.0	12.0
4	14.0	0.0	5.0	25.0	16.0	10.0	12.0	0.0	6.0	24.0	0.0	16.0
5	0.0	4.0	4.0	21.0	19.0	10.0	10.0	0.0	8.0	37.0	0.0	6.0
6	1.0	25.0	5.0	0.0	24.0	10.0	5.0	0.0	12.0	25.0	8.0	12.0
7	0.0	13.0	0.0	0.0	43.0	10.0	5.0	0.0	5.0	15.0	20.0	0.0
8	0.0	0.0	0.0	0.0	25.0	10.0	5.0	9.0	12.0	10.0	20.0	0.0
9	0.0	0.0	0.0	0.0	48.0	10.0	2.0	0.0	9.0	24.0	20.0	0.0
10	0.0	0.0	8.0	8.0	3.0	10.0	5.0	0.0	21.0	45.0	40.0	0.0
11	0.0	0.0	0.0	9.0	9.0	10.0	5.0	0.0	10.0	27.0	13.0	0.0
12	0.0	0.0	0.0	0.0	35.0	10.0	6.0	12.0	13.0	8.0	32.0	0.0
13	0.0	0.0	10.0	3.0	0.0	8.0	5.0	10.0	18.0	15.0	0.0	20.0
14	0.0	0.0	0.0	0.0	7.0	29.0	3.0	0.0	43.0	24.0	15.0	0.0
15	40.5	4.0	0.0	0.0	1.0	1.0	3.0	6.0	13.0	12.0	0.0	19.0
16	15.0	6.0	0.0	0.0	0.0	0.0	0.0	21.0	7.0	38.0	10.0	31.0
17	0.0	36.0	0.0	0.0	31.0	32.0	3.0	8.0	16.0	22.0	10.0	12.0
18	0.0	0.0	0.0	0.0	0.0	4.0	16.0	7.0	30.0	18.0	15.0	10.0
19	0.0	0.0	0.0	0.0	0.0	26.0	16.0	4.0	11.0	1.0	13.0	13.0
20	2.0	0.0	8.0	15.0	0.0	26.0	6.0	3.0	17.0	14.0	9.0	12.0
21	0.0	0.0	0.0	2.0	0.0	4.0	5.0	2.0	13.0	14.0	31.0	20.0
22	0.0	0.0	0.0	0.0	53.0	4.0	5.0	3.0	0.0	27.0	16.0	4.0
23	0.0	0.0	30.0	0.0	5.0	4.0	5.0	15.0	0.0	0.0	17.0	0.0
24	0.0	0.0	0.0	0.0	0.0	0.0	10.0	20.0	0.0	0.0	9.0	0.0
25	0.0	0.0	0.0	2.0	0.0	0.0	9.0	12.0	0.0	0.0	0.0	4.0
26	0.0	0.0	0.0	15.0	0.0	0.0	6.0	10.0	16.0	10.0	0.0	0.0
27	0.0	0.0	6.0	13.0	5.0	0.0	5.0	8.0	30.0	12.0	0.0	0.0
28	18.0	0.0	0.0	18.0	15.0	0.0	13.0	30.0	30.0	16.0	6.0	4.0
29	40.0	0.0	0.0	13.0	5.0	0.0	32.0	24.0	10.0	24.0	0.0	0.0
30	0.0		0.0	18.0	5.0	0.0	3.0	25.0	9.0	0.0	0.0	0.0
31	13.0		0.0		0.0		4.0	0.0		0.0		12.0
Monthly total	143.5	111.0	76.0	278.0	474.0	290.0	222.0	237.0	393.0	564.0	304.0	207.0
Day Max.	40.5	36.0	30.0	48.0	100.0	46.0	32.0	30.0	43.0	45.0	40.0	31.0

Table A.6c Daily Rainfall Data at WSN-4 (Sainkeduk) (mm)

Day \ Month	1993											
	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul	Aug.	Sep.	Oct.	Nov.	Dec.
1	0.0	0.0	0.0	15.0	4.0	40.0	40.0	0.0				
2	0.0	0.0	0.0	0.0	0.0	10.0	50.0	0.0				
3	0.0	0.0	22.0	0.0	12.0	16.0	50.0	0.0				
4	0.0	0.0	13.0	0.0	0.0	20.0	38.0	0.0				
5	0.0	0.0	10.0	0.0	0.0	8.0	12.0	0.0				
6	0.0	24.0	0.0	0.0	12.0	6.0	10.0	0.0				
7	0.0	21.0	7.0	12.0	6.0	12.0	9.0	0.0				
8	8.0	12.0	0.0	18.0	10.0	5.0	6.0	0.0				
9	4.0	21.0	9.0	14.0	11.0	13.0	14.0	0.0				
10	2.0	7.0	19.0	16.0	9.0	15.0	20.0	0.0	N.A.	N.A.	N.A.	N.A.
11	10.0	14.0	12.0	53.0	8.0	10.0	36.0	0.0				
12	16.0	0.0	27.0	65.0	0.0	12.0	8.0	0.0				
13	0.0	0.0	16.0	42.0	20.0	4.0	13.0	15.0				
14	0.0	0.0	0.0	4.0	36.0	11.0	15.0	0.0				
15	0.0	0.0	0.0	4.0	4.0	18.0	16.0	0.0				
16	15.0	0.0	0.0	17.0	64.0	20.0	31.0	0.0				
17	15.0	6.0	0.0	17.0	1.0	35.0	22.0	0.0				
18	41.0	26.0	12.0	15.0	17.0	10.0	23.0	0.0				
19	12.0	20.0	16.0	12.0	11.0	16.0	45.0	0.0				
20	10.0	7.0	10.0	18.0	0.0	22.0	25.0	0.0				
21	16.0	7.0	10.0	22.0	2.0	31.0	50.0	0.0				
22	10.0	10.0	11.0	10.0	15.0	10.0	45.0	0.0				
23	18.0	10.0	27.0	5.0	0.0	11.0	30.0	0.0				
24	10.0	12.0	16.0	10.0	42.0	9.0	105.0	32.0				
25	10.0	11.0	9.0	8.0	15.0	6.0	50.0	15.0				
26	18.0	6.0	0.0	15.0	33.0	5.0	51.0	22.0				
27	4.0	20.0	10.0	16.0	20.0	10.0	28.0	30.0				
28	0.0	10.0	12.0	15.0	1.0	15.0	53.0	33.0				
29	8.0		0.0	31.0	35.0	50.0	30.0	72.0				
30	0.0		4.0	6.0	25.0	40.0	31.0	28.0				
31	11.0		7.0		12.0		61.0	10.0				
Monthly total	238.0	244.0	279.0	460.0	425.0	490.0	1017.0	257.0				
Day Max.	41.0	26.0	27.0	65.0	64.0	50.0	105.0	72.0				

Table A.6d Daily Rainfall Data at WSN-4 (Sainkeduk) (mm)

Day \ Month	1994											
	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul	Aug.	Sep.	Oct.	Nov.	Dec.
1									0.0	20.0	94.0	0.0
2									0.0	2.0	32.0	2.0
3									0.0	3.0	32.0	0.0
4									0.0	0.0	16.0	24.0
5									0.0	16.0	48.0	26.0
6									0.0	0.0	36.0	9.0
7									0.0	0.0	32.0	8.0
8									0.0	0.0	16.0	16.0
9									0.0	0.0	16.0	4.0
10	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	0.0	0.0	8.0	8.0
11									0.0	0.0	18.0	16.0
12									0.0	0.0	22.0	16.0
13									17.0	0.0	4.0	16.0
14									20.0	0.0	18.0	8.0
15									14.0	16.0	4.0	16.0
16									11.0	4.0	8.0	16.0
17									0.0	2.0	10.0	16.0
18									0.0	3.0	14.0	0.0
19									15.0	1.0	8.0	0.0
20									10.0	9.0	4.0	0.0
21									0.0	0.0	4.0	16.0
22									0.0	0.0	0.0	8.0
23									0.0	0.0	8.0	8.0
24									0.0	2.0	16.0	8.0
25									25.0	7.0	4.0	6.0
26									30.0	0.0	2.0	2.0
27									15.0	0.0	16.0	0.0
28									18.0	0.0	2.0	0.0
29									24.0	2.0	0.0	6.0
30									19.0	0.0	0.0	16.0
31										0.0		16.0
Monthly total									218.0	87.0	492.0	287.0
Day Max.									30.0	20.0	94.0	26.0

Table A.6e Daily Rainfall Data at WSN-4 (Sainkeduk) (mm)

Day \ Month	1995											
	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul	Aug.	Sep.	Oct.	Nov.	Dec.
1	0.0											
2	2.0											
3	0.0											
4	24.0											
5	26.0											
6	16.0											
7	16.0											
8	10.0											
9	16.0											
10	16.0											
11	5.0											
12	16.0											
13	16.0											
14	16.0											
15	16.0											
16	33.0											
17	7.0											
18	5.0											
19	13.0											
20	0.0											
21	0.0											
22	0.0											
23	3.0											
24	4.0											
25	2.0											
26	0.0											
27	8.0											
28	8.0											
29	16.0											
30	4.0											
31	17.0											
Monthly total	315.0											
Day Max.	33.0											

Table A.7a Daily Rainfall Data at WSN-5 (Mega) (mm)

Day \ Month	1991											
	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul	Aug.	Sep.	Oct.	Nov.	Dec.
1		x	1.0	1.0			10.0	x	0.0	0.0	0.0	0.0
2		x	15.0	4.0			25.0	x	0.0	0.0	0.0	0.0
3		x	45.0	x			5.0	x	0.0	0.0	0.0	7.0
4		x	0.0	x			10.0	x	0.0	0.0	0.0	7.0
5		x	1.5	x			0.0	x	0.0	0.0	0.0	3.0
6		x	2.0	x			0.0	10.0	0.0	0.0	0.0	0.0
7		x	1.5	x			0.0	5.0	0.0	0.0	0.0	0.0
8		x	3.0	18.0			0.0	x	0.0	0.0	0.0	10.0
9		0.0	0.0	1.0			6.0	2.0	0.0	0.0	0.0	0.0
10	N.A.	12.5	5.5	36.5	N.A.	N.A.	0.0	x	0.0	0.0	0.0	57.0
11		0.0	0.0	10.5			25.0	3.0	0.0	50.0	0.0	0.0
12		0.0	5.0	17.0			0.0	x	0.0	0.0	0.0	110.0
13		0.0	0.5	0.0			2.0	x	0.0	33.0	0.0	60.0
14		0.0	35.0	30.0			2.0	x	0.0	150.0	0.0	0.0
15		37.0	8.0	0.0			4.0	x	0.0	22.0	0.0	0.0
16		0.0	12.0	x			0.0	x	0.0	19.0	5.0	0.0
17		0.0	0.0	x			0.0	x	0.0	0.0	0.0	0.0
18		0.0	5.5	x			0.0	x	0.0	0.0	0.0	0.0
19		0.0	98.5	x			0.0	x	0.0	0.0	0.0	0.0
20		3.0	10.0	x			0.0	x	0.0	0.0	0.0	0.0
21		5.0	1.5	x			0.0	x	14.0	0.0	0.0	0.0
22		42.0	2.0	0.0			0.0	x	15.0	0.0	0.0	0.0
23		24.5	13.0	2.0			0.0	x	0.0	0.0	0.0	0.0
24		5.0	6.5	1.0			0.0	x	0.0	0.0	0.0	24.0
25		0.0	12.0	1.0			2.0	x	0.0	0.0	0.0	0.0
26		0.0	x	0.0			5.0	0.0	3.0	0.0	0.0	0.0
27		0.0	x	3.0			2.0	x	0.0	0.0	0.0	40.0
28		0.0	x	1.5			0.0	2.0	0.0	0.0	0.0	0.0
29			x	0.0			0.0	x	0.0	0.0	0.0	0.0
30			x	0.0			0.0	3.0	0.0	0.0	0.0	25.0
31			x				4.0	x		0.0		15.0
Monthly total		129.0	284.0	126.5			102.0	25.0	32.0	274.0	5.0	358.0
Day Max.		42.0	98.5	36.5			25.0	10.0	15.0	150.0	5.0	110.0

Table A.7b Daily Rainfall Data at WSN-5 (Mega) (mm)

Day \ Month	1992											
Day	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul	Aug.	Sep.	Oct.	Nov.	Dec.
1	0.0	5.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.0	6.0	5.0
2	0.0	5.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	6.0	8.0
3	0.0	0.0	7.0	0.0	0.0	0.0	1.0	0.0	3.0	1.0	0.0	0.0
4	2.0	0.0	13.0	49.0	0.0	66.0	1.0	0.0	16.0	12.0	1.0	0.0
5	6.0	0.0	15.0	0.0	0.0	0.0	0.5	0.0	0.0	0.0	0.0	0.0
6	4.0	10.0	0.0	10.0	3.0	0.0	0.0	0.0	9.0	0.0	0.0	0.0
7	0.0	0.0	0.0	0.0	0.0	3.0	0.0	0.0	0.0	5.0	0.0	0.0
8	0.0	0.0	0.0	0.0	34.0	25.0	0.0	5.0	0.0	30.0	0.0	0.0
9	0.0	0.0	0.0	5.0	0.0	0.0	0.0	0.0	0.0	80.0	0.0	3.0
10	0.0	0.0	0.0	5.0	3.0	5.0	0.0	1.0	3.0	0.0	0.0	0.0
11	2.0	0.0	0.0	0.0	40.0	35.0	0.0	4.0	0.0	3.0	0.0	41.0
12	0.0	0.0	0.0	0.0	13.0	20.0	0.0	2.0	0.0	0.0	0.0	0.0
13	35.0	0.0	0.0	8.0	0.0	0.0	80.0	0.0	0.0	0.0	0.0	0.0
14	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.0	0.0	35.0	10.0
15	15.0	0.0	0.0	3.0	0.0	15.0	20.0	0.0	15.0	0.0	0.0	19.0
16	5.0	10.0	0.0	56.0	0.0	0.0	4.0	0.0	0.0	6.0	0.0	0.0
17	2.0	97.0	0.0	44.0	0.0	5.0	20.0	41.0	0.0	3.0	25.0	3.0
18	2.0	0.0	0.0	40.0	4.0	12.0	20.0	3.0	23.0	0.0	0.0	6.0
19	x	0.0	10.0	0.0	0.0	0.0	20.0	0.0	0.0	18.0	15.0	40.0
20	x	0.0	0.0	9.0	0.0	18.0	25.0	4.0	0.0	2.0	0.0	9.0
21	x	0.0	0.0	0.0	0.0	5.0	0.0	0.0	1.0	0.0	0.0	0.0
22	0.0	0.0	4.0	15.0	0.0	0.0	0.0	60.0	0.0	2.0	4.0	0.0
23	2.0	0.0	0.0	0.0	5.0	0.0	0.0	0.0	0.0	0.0	0.0	26.0
24	25.0	0.0	x	0.0	0.0	0.0	0.0	0.0	0.0	12.0	0.0	1.0
25	25.0	0.0	x	4.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
26	0.0	0.0	x	0.0	0.0	0.0	24.0	2.0	0.0	0.0	8.0	0.0
27	0.0	0.0	x	0.0	0.0	0.0	35.0	6.0	0.0	2.0	2.0	0.0
28	3.0	0.0	x	0.0	24.0	0.0	0.0	20.0	0.0	17.0	0.0	0.0
29	0.0	0.0	x	0.0	0.0	0.0	0.0	0.0	3.0	8.0	0.0	0.0
30	0.0		x	0.0	0.0	0.0	11.0	17.0	4.0	1.0	0.0	6.0
31	0.0		x		15.0		27.0	2.0		0.0		0.0
Monthly total	128.0	127.0	49.0	248.0	141.0	209.0	288.5	167.0	80.0	205.0	102.0	177.0
Day Max.	35.0	97.0	15.0	56.0	40.0	66.0	80.0	60.0	23.0	80.0	35.0	41.0

Table A.7c Daily Rainfall Data at WSN-5 (Mega) (mm)

Day \ Month	1993											
	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul	Aug.	Sep.	Oct.	Nov.	Dec.
1	0.0	0.0	0.0	0.0	0.0	9.0	0.0	0.0	2.0	10.0	0.0	0.0
2	19.0	2.0	0.0	10.0	0.0	22.0	31.0	0.0	40.0	0.0	0.0	0.0
3	0.0	0.0	0.0	5.0	0.0	12.0	13.0	0.0	6.0	0.0	0.0	17.0
4	0.0	0.0	0.0	9.0	2.0	13.5	17.5	0.0	51.0	0.0	0.0	0.0
5	0.0	0.0	0.0	6.0	2.0	5.0	14.5	0.0	3.0	0.0	0.0	1.0
6	26.0	38.0	15.0	7.0	2.0	28.0	0.0	0.0	9.0	0.0	2.0	51.0
7	0.0	0.0	8.0	4.0	0.0	8.0	0.0	0.0	20.0	0.0	4.0	0.0
8	18.0	10.0	0.0	0.0	0.0	29.5	0.0	0.0	1.0	0.0	8.0	1.0
9	3.0	20.0	20.0	2.0	0.0	0.0	0.0	0.0	8.0	2.0	1.0	1.0
10	11.0	5.0	4.0	1.0	0.0	7.0	0.0	0.0	3.0	0.0	0.0	0.0
11	11.0	1.0	0.0	0.0	1.0	0.0	0.0	0.0	2.0	0.0	3.0	7.0
12	15.0	12.0	0.0	20.0	0.0	3.5	4.0	0.0	8.0	0.0	0.0	3.0
13	0.0	0.0	19.0	0.0	1.0	0.0	4.0	0.0	0.0	29.0	12.0	2.0
14	0.0	0.0	2.0	1.0	8.0	0.5	0.0	4.5	20.0	1.0	0.0	1.0
15	4.0	0.0	0.0	3.0	1.0	9.0	0.0	0.0	34.0	0.0	6.0	0.0
16	4.0	10.0	8.0	0.0	0.0	0.0	0.0	0.0	6.0	19.0	2.0	0.0
17	0.0	2.0	3.0	2.0	0.0	0.0	0.5	x	13.0	x	0.0	4.0
18	0.0	3.0	2.0	0.0	0.0	0.0	0.5	x	6.0	0.0	8.0	4.0
19	0.0	27.0	0.0	0.0	6.0	1.0	0.5	x	0.0	0.0	0.0	11.0
20	0.0	8.0	0.0	4.0	52.0	0.0	0.0	x	0.0	0.0	7.0	10.0
21	0.0	0.0	6.0	0.0	0.0	0.0	0.0	x	0.0	0.0	0.0	14.0
22	2.0	0.0	0.0	6.0	0.0	0.0	0.0	x	0.0	0.0	0.0	2.0
23	27.0	1.0	10.0	5.0	0.0	0.0	0.0	x	7.0	0.0	0.0	8.0
24	11.0	7.0	0.0	7.0	2.0	2.5	4.0	3.0	2.0	0.0	0.0	1.0
25	43.0	3.0	0.0	0.0	4.0	0.0	0.0	0.5	0.0	0.0	0.0	0.0
26	10.0	38.0	4.0	10.0	5.0	1.0	2.0	0.5	x	2.0	0.0	0.0
27	0.0	0.0	0.0	0.0	6.0	12.0	5.5	0.5	x	0.0	0.0	12.0
28	0.0	0.0	0.0	10.0	23.0	1.0	10.0	23.0	18.0	0.0	1.0	0.0
29	0.0		4.0	0.0	11.0	0.0	9.0	15.0	3.0	0.0	6.0	10.0
30	0.0		0.0	0.0	0.0	0.0	0.0	x	33.0	0.0	0.0	19.0
31	0.0		0.0		0.0		6.0	x		2.0		26.0
Monthly total	204.0	187.0	105.0	112.0	126.0	164.5	122.0	47.0	295.0	65.0	60.0	205.0
Day Max.	43.0	38.0	20.0	20.0	52.0	29.5	31.0	23.0	51.0	29.0	12.0	51.0

Table A.7d Daily Rainfall Data at WSN-5 (Mega) (mm)

Day \ Month	1994											
	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul	Aug.	Sep.	Oct.	Nov.	Dec.
1	18.0	0.0	0.0	0.0	0.0	3.0	5.0	0.0	0.0	9.0	1.0	7.0
2	4.0	4.0	6.0	0.0	22.0	6.0	4.0	0.0	0.0	4.0	0.5	1.0
3	0.0	9.0	0.0	0.0	0.0	3.0	12.0	11.0	0.0	0.0	63.0	2.0
4	1.0	2.0	1.0	0.0	15.0	11.0	0.0	1.0	0.0	0.0	5.5	24.0
5	1.0	4.0	44.0	0.0	8.0	7.0	0.0	9.0	0.0	5.5	9.5	26.0
6	6.0	3.0	8.0	0.0	1.0	6.0	0.0	2.0	0.0	0.0	0.0	0.0
7	0.0	3.0	0.0	0.0	2.0	1.0	11.0	2.0	0.0	0.0	0.0	0.0
8	0.0	3.0	10.0	0.0	4.0	1.0	0.0	6.0	0.0	0.5	0.0	0.0
9	1.0	1.0	34.0	0.0	0.0	39.0	5.5	0.0	0.0	0.0	1.5	11.0
10	0.0	1.0	41.0	0.0	0.0	3.0	2.5	3.0	0.0	0.5	5.0	1.5
11	14.0	9.0	1.0	0.0	0.0	0.0	1.0	1.0	0.0	3.5	5.0	10.0
12	45.0	2.0	2.0	14.0	0.0	34.0	0.0	1.0	0.0	1.0	28.0	0.0
13	0.0	0.0	30.0	32.0	0.0	0.0	0.0	0.0	0.0	8.5	1.0	26.0
14	14.0	0.0	9.0	3.0	0.0	0.0	0.0	0.0	0.0	0.5	1.0	40.0
15	1.0	0.0	2.0	3.0	0.0	5.0	0.0	0.0	0.0	0.0	11.0	19.0
16	0.0	0.0	12.0	0.0	2.0	4.0	4.5	0.0	0.0	0.0	1.0	11.0
17	0.0	0.0	5.0	7.0	23.0	0.0	0.0	0.0	0.0	0.0	10.0	1.0
18	0.0	0.0	22.0	3.0	0.0	0.0	0.0	0.0	0.0	0.0	0.5	4.0
19	35.0	0.0	0.0	2.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	11.0
20	8.0	0.0	3.0	27.0	0.0	10.0	0.0	2.0	0.0	0.0	9.0	10.5
21	0.0	0.0	0.0	1.0	0.0	19.0	0.0	0.5	0.0	0.0	0.0	0.5
22	1.0	0.0	1.0	3.0	0.0	4.0	0.0	0.0	0.0	0.0	17.0	0.0
23	0.0	0.0	0.0	0.0	5.0	2.0	0.0	0.0	0.0	1.0	24.0	0.0
24	0.0	0.0	4.0	7.0	0.0	14.0	0.0	0.0	0.0	15.0	0.5	2.0
25	0.0	0.0	43.0	1.0	3.0	4.0	0.0	0.0	0.0	11.0	3.0	0.5
26	1.0	0.0	17.0	6.0	4.0	2.0	0.0	0.0	0.0	1.0	0.0	0.0
27	1.0	0.0	1.0	14.0	9.0	0.0	0.0	1.0	0.0	0.0	4.0	0.0
28	3.0	0.0	0.0	28.0	0.0	0.0	0.0	0.0	0.0	0.0	12.0	1.0
29	15.0		0.0	18.0	10.0	14.0	2.5	0.0	2.0	9.5	4.0	0.5
30	0.0		23.0	0.0	3.0	7.0	1.0	0.0	0.0	11.0	15.5	0.5
31	0.0		2.0		4.0		0.5	0.0		2.0		7.0
Monthly total	169.0	41.0	321.0	169.0	115.0	199.0	49.5	39.5	2.0	83.5	233.5	217.0
Day Max.	45.0	9.0	44.0	32.0	23.0	39.0	12.0	11.0	2.0	15.0	63.0	40.0

Table A.7e Daily Rainfall Data at WSN-5 (Mega) (mm)

Day \ Month	1995											
	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul	Aug.	Sep.	Oct.	Nov.	Dec.
1	4.0	0.5	0.0	0.5	0.9	0.0						
2	0.0	0.0	0.0	5.9	15.9	0.0						
3	0.0	0.5	0.3	0.3	0.0	0.0						
4	43.0	50.5	21.5	13.2	4.7	0.0						
5	4.0	0.0	21.1	1.5	0.3	0.0						
6	5.0	25.0	0.0	2.4	0.8	0.0						
7	3.0	22.5	4.0	0.3	0.2	4.5						
8	0.5	0.0	4.6	0.3	0.0	1.1						
9	2.0	16.5	9.6	0.0	0.3	0.7						
10	21.0	0.0	0.0	1.4	0.1	0.0						
11	30.0	0.0	0.0	0.0	0.7	0.0						
12	0.0	0.0	1.0	0.2	0.0	0.0						
13	0.0	0.0	0.0	0.0	0.0	15.2						
14	38.0	0.0	0.0	11.1	9.6	1.8						
15	67.0	0.0	0.0	5.3	0.0	0.5						
16	0.0	8.0	2.9	0.0	3.0	1.3						
17	6.5	0.0	9.9	0.0	0.0	16.2						
18	3.5	0.0	0.3	0.0	0.5	3.1						
19	28.0	0.0	0.2	0.0	1.5	0.1						
20	7.0	2.0	0.0	1.0	1.4	17.9						
21	15.0	8.5	0.0	1.0	0.0	5.0						
22	3.0	42.0	23.1	0.0	0.0	32.0						
23	7.5	0.0	1.9	0.0	0.0	3.9						
24	36.0	0.0	0.0	14.0	0.0	0.8						
25	2.0	1.0	0.2	1.2	0.0	0.0						
26	2.5	5.0	2.5	0.6	0.5	12.0						
27	1.0	1.0	13.5	0.2	0.1	1.1						
28	1.0	2.0	0.2	0.0	0.0	0.8						
29	0.5		0.0	0.0	0.0	0.1						
30	0.0		1.1	0.0	0.0	7.4						
31	0.5		0.0		0.0							
Monthly total	331.5	185.0	117.9	60.4	40.5	125.5						
Day Max.	67.0	50.5	23.1	14.0	15.9	32.0						
			(A)	(A)	(A)	(A)						

(A) : Rainfall data measured by an automatic raingauge

Table A.8a Daily Rainfall Data at WSN-6 (Klamono) (mm)

Day \ Month	1991											
	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul	Aug.	Sep.	Oct.	Nov.	Dec.
1	x	0.0	1.5	13.5			16.0	0.0		0.0		
2	x	0.0	4.0	73.0			3.0	0.0		0.0		
3	x	0.0	40.5	3.5			5.0	0.0		0.0		
4	x	25.0	0.0	35.0			2.0	0.0		0.0		
5	x	0.0	0.0	7.0			28.0	7.0		0.0		
6	x	9.0	0.0	0.0			4.0	3.0		0.0		
7	x	0.0	0.0	0.0			19.0	2.0		0.0		
8	x	9.0	0.0	2.0			0.0	1.0		0.0		
9	x	0.0	0.0	0.0			2.0	2.0		19.0		
10	x	11.0	0.0	0.5	N.A.	N.A.	20.0	0.0	N.A.	16.0	N.A.	N.A.
11	x	4.0	0.0	0.0			1.0	5.0		18.0		
12	x	0.0	0.0	0.0			0.0	1.0		0.0		
13	x	0.0	13.5	6.5			16.0	0.0		58.0		
14	x	0.0	17.5	14.0			12.0	3.0		56.0		
15	x	36.0	0.5	0.0			50.0	6.0		29.0		
16	x	0.0	5.0	0.0			7.0	5.0		0.0		
17	x	0.0	0.0	14.0			0.0	0.0		3.0		
18	x	0.0	0.0	22.0			0.0	0.0		0.0		
19	x	0.0	14.0	0.5			0.0	0.0		0.0		
20	x	0.0	2.0	1.5			0.0	0.0		0.0		
21	x	0.0	2.5	21.0			0.0	0.0		0.0		
22	x	0.0	27.5	0.0			0.0	0.0		0.0		
23	x	14.0	34.0	91.0			0.0	0.0		0.0		
24	x	0.0	48.5	19.0			0.0	0.0		0.0		
25	18.0	0.0	26.0	39.0			0.0	0.0		0.0		
26	3.0	7.0	26.5	1.5			37.0	0.0		0.0		
27	0.0	0.0	3.5	26.0			0.0	0.0		0.0		
28	0.0	0.0	11.5	5.5			0.0	0.0		0.0		
29	0.0		16.0	20.0			0.0	10.0		0.0		
30	0.0		7.0	13.0			25.0	0.0		5.0		
31	0.0		50.0				0.0	3.0		15.0		
Monthly total	21.0	115.0	351.5	429.0			247.0	48.0		219.0		
Day Max.	18.0	36.0	50.0	91.0			50.0	10.0		58.0		

Table A.8b Daily Rainfall Data at WSN-6 (Klamono) (mm)

Month / Day	1992											
	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul	Aug.	Sep.	Oct.	Nov.	Dec.
1	0.0	0.0	0.0	14.0		3.0	0.0	3.0	0.0	0.0	0.0	0.0
2	0.0	0.0	3.0	3.0		1.0	0.0	10.0	1.0	17.0	0.0	4.0
3	0.0	2.0	3.0	31.0		9.0	7.0	0.0	15.0	4.0	0.0	2.0
4	0.0	6.0	17.0	43.0		96.0	3.0	0.0	4.0	7.0	0.0	6.0
5	12.0	66.0	0.0	0.0		1.0	1.0	0.0	50.0	0.0	0.0	5.0
6	0.0	40.0	0.0	0.0		142.0	1.0	13.0	0.0	5.0	0.0	14.0
7	0.0	0.0	0.0	0.0		4.0	0.0	0.0	0.0	0.0	1.5	0.0
8	2.0	0.0	0.0	0.0		7.0	2.0	0.0	0.0	12.0	0.0	0.0
9	0.0	0.0	0.0	0.0		11.0	0.0	2.0	1.0	26.0	3.5	18.0
10	0.0	0.0	0.0	0.0	N.A.	6.0	0.0	4.0	0.0	0.0	4.0	3.0
11	0.0	0.0	0.0	0.0		74.0	0.0	1.0	1.0	74.0	0.0	0.0
12	0.0	0.0	5.0	0.0		26.0	5.0	65.0	9.0	0.0	0.0	11.0
13	2.0	0.0	0.0	0.0		1.0	19.0	0.0	4.0	0.0	1.0	13.0
14	0.0	0.0	0.0	0.0		8.0	0.0	0.0	6.0	0.0	0.5	16.0
15	0.0	42.0	35.0	0.0		50.0	2.0	0.0	0.0	4.0	3.0	2.0
16	0.0	56.0	0.0	5.0		4.0	54.0	5.0	0.0	5.0	0.0	0.0
17	0.0	36.0	0.0	7.0		36.0	1.0	37.0	1.0	13.0	0.0	0.0
18	1.0	0.0	11.0	0.0		0.0	35.0	4.0	0.0	0.0	5.0	0.0
19	0.0	0.0	2.0	0.0		19.0	3.0	0.0	0.0	2.0	30.0	2.0
20	0.0	0.0	37.0	0.0		2.0	11.0	8.0	1.0	2.0	1.5	2.0
21	0.0	0.0	0.0	0.0		10.0	12.0	0.0	1.0	2.0	1.0	0.0
22	0.0	0.0	14.0	13.0		0.0	33.0	0.0	38.0	2.0	27.5	14.0
23	0.0	0.0	0.0	0.0		0.0	6.0	4.0	25.0	4.0	0.0	10.0
24	9.0	0.0	0.0	2.0		0.0	0.0	0.0	0.0	0.0	9.5	1.0
25	5.0	0.0	0.0	3.0		0.0	8.0	1.0	0.0	0.0	0.0	1.0
26	7.0	0.0	0.0	0.0		0.0	2.0	0.0	0.0	0.0	12.5	0.0
27	0.0	0.0	0.0	11.0		0.0	14.0	2.0	2.0	0.0	9.0	0.0
28	0.0	0.0	0.0	0.0		0.0	29.0	39.0	8.0	0.0	1.0	1.0
29	9.0	0.0	2.0	3.0		0.0	1.0	1.0	37.0	5.0	0.0	0.0
30	0.0		10.0	7.0		0.0	50.0	2.0	0.0	2.0	0.0	0.0
31	36.0		3.0				0.0	0.0		0.0		0.0
Monthly total	83.0	248.0	142.0	142.0		510.0	299.0	201.0	204.0	186.0	110.5	125.0
Day Max.	36.0	66.0	37.0	43.0		142.0	54.0	65.0	50.0	74.0	30.0	18.0

Table A.8c Daily Rainfall Data at WSN-6 (Klamono) (mm)

Day \ Month	1993											
	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul	Aug.	Sep.	Oct.	Nov.	Dec.
1				7.0	0.0	0.0	0.0					
2				40.0	7.0	104.0	69.0					
3				8.0	3.0	2.0	24.0					
4				0.0	0.0	2.0	23.0					
5				0.0	7.0	0.0	8.0					
6				20.0	0.0	80.0	0.0					
7				12.0	0.0	4.0	6.0					
8				1.0	2.0	2.0	0.0					
9				5.0	0.0	2.0	4.0					
10	N.A.	N.A.	N.A.	99.0	9.0	0.0	0.0	N.A.	N.A.	N.A.	N.A.	N.A.
11				26.0	8.0	12.0	12.0					
12				8.0	22.0	4.0	13.0					
13				0.0	10.0	0.0	4.0					
14				0.0	0.0	0.0	2.0					
15				4.0	0.0	0.0	0.0					
16				0.0	0.0	0.0	0.0					
17				2.0	0.0	0.0	25.0					
18				0.0	0.0	0.0	64.0					
19				8.0	0.0	14.0	0.0					
20				4.0	23.0	0.0	29.0					
21				16.0	0.0	0.0	0.0					
22				14.0	0.0	0.0	0.0					
23				0.0	0.0	0.0	6.0					
24				85.0	3.0	0.0	0.0					
25				0.0	0.0	0.0	1.0					
26				22.0	25.0	0.0	89.0					
27				0.0	0.0	13.0	14.0					
28				2.0	0.0	0.0	0.0					
29				0.0	0.0	0.0	14.0					
30				14.0	12.0	0.0	85.0					
31					43.0		4.0					
Monthly total				397.0	174.0	239.0	496.0					
Day Max.				99.0	43.0	104.0	89.0					

Table A.8d Daily Rainfall Data at WSN-6 (Klamono) (mm)

Day \ Month	1994											
	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul	Aug.	Sep.	Oct.	Nov.	Dec.
1	3.0	0.0		7.0		23.0	6.0	0.0	8.0	0.0		
2	0.0	0.0		0.0		24.0	26.0	5.0	0.0	0.0		
3	0.0	12.0		0.0		11.0	10.0	0.0	1.0	0.0		
4	0.0	4.0		6.0		23.0	5.0	3.0	0.0	0.0		
5	4.0	0.0		13.0		98.0	4.0	0.0	0.0	78.0		
6	1.0	28.0		3.0		34.0	1.0	0.0	0.0	0.0		
7	42.0	36.0		5.0		0.0	7.0	0.0	0.0	0.0		
8	2.0	15.0		45.0		42.0	0.0	4.0	0.0	81.0		
9	7.0	45.0		2.0		16.0	0.0	0.0	0.0	2.0		
10	2.0	9.0	N.A.	1.0	N.A.	8.0	5.0	2.0	0.0	7.0	N.A.	N.A.
11	4.0	5.0		1.0		13.0	19.0	6.0	0.0	0.0		
12	1.0	6.0		7.0		6.0	0.0	2.0	0.0	6.0		
13	4.0	1.0		10.0		21.0	0.0	6.0	0.0	33.0		
14	37.0	2.0		4.0		4.0	0.0	25.0	0.0	16.0		
15	16.0	0.0		40.0		50.0	0.0	14.0	0.0	2.0		
16	4.0	0.0		23.0		0.0	0.0	6.0	0.0	0.0		
17	3.0	0.0		7.0		1.0	3.0	0.0	0.0	0.0		
18	0.0	0.0		23.0		1.0	0.0	2.0	0.0	0.0		
19	0.0	0.0		12.0		63.0	0.0	3.0	0.0	0.0		
20	0.0	0.0		0.0		4.0	0.0	4.0	0.0	0.0		
21	11.0	0.0		5.0		5.0	1.0	2.0	0.0	0.0		
22	0.0	0.0		4.0		9.0	2.0	1.0	0.0	0.0		
23	15.0	0.0		12.0		2.0	0.0	5.0	0.0	4.0		
24	0.0	0.0		4.0		28.0	0.0	2.0	0.0	0.0		
25	0.0	0.0		16.0		13.0	0.0	0.0	0.0	17.0		
26	0.0	0.0		0.0		5.0	0.0	2.0	0.0	0.0		
27	0.0	0.0		16.0		7.0	0.0	6.0	0.0	8.0		
28	0.0	0.0		73.0		10.0	5.0	0.0	0.0	71.0		
29	0.0			30.0		15.0	2.0	1.0	0.0	4.0		
30	0.0			21.0		3.0	1.0	9.0	0.0	8.0		
31	0.0						6.0	2.0		20.0		
Monthly total	156.0	163.0		390.0		539.0	103.0	112.0	9.0	357.0		
Day Max.	42.0	45.0		73.0		98.0	26.0	25.0	8.0	81.0		

Table A.8e Daily Rainfall Data at WSN-6 (Klamono) (mm)

Day \ Month	1995											
	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul	Aug.	Sep.	Oct.	Nov.	Dec.
1			0.0	9.0	0.0	0.1	35.3					
2			0.0	20.0	17.4	0.1	14.7					
3			0.0	10.0	44.0	0.7	38.7					
4			0.0	3.0	2.0	4.3	3.5					
5			0.0	1.5	0.0	0.2	39.1					
6			0.0	0.0	0.5	3.3	18.8					
7			3.0	0.0	2.3	13.7	0.6					
8			16.0	0.0	0.1	3.9	25.1					
9			2.0	2.0	6.1	29.7	2.2					
10	N.A.	N.A.	0.0	3.0	1.6	0.7	40.9					
11			6.0	0.5	0.1	18.3	0.2					
12			0.0	0.0	0.2	6.7	7.8					
13			0.0	0.5	17.7	20.5	1.1					
14			0.0	1.0	0.3	33.5	0.5					
15			0.0	9.0	1.5	0.2	0.4					
16			7.0	7.0	0.2	0.5	0.3					
17			7.0	7.0	15.2	13.4	0.2					
18			0.0	0.0	8.8	2.8	20.9					
19			8.0	0.0	12.2	1.3	0.2					
20			14.0	0.0	0.0	5.3	16.5					
21			2.0	0.0	0.1	17.6	19.6					
22			2.0	4.0	0.1	0.2	0.8					
23			27.0	0.0	0.0	0.1	2.7					
24			7.0	0.0	34.9	15.6	14.0					
25			7.0	15.0	0.3	0.7	0.6					
26			3.0	17.0	0.6	3.5	6.9					
27			10.0	15.0	0.1	11.6	32.3					
28			2.0	1.0	0.0	4.3	16.8					
29			2.0	15.0	0.1	0.2	16.0					
30			2.0	0.0	0.0	37.7	6.4					
31			2.0		0.1		0.0					
Monthly total			129.0	140.5	166.5	250.7	383.1					
Day Max.			27.0	20.0	44.0 (A)	37.7 (A)	40.9 (A)					

Table A.9 Daily Rainfall Data at the New Gauging Station (mm)

Day \ Month	1995											
	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul	Aug.	Sep.	Oct.	Nov.	Dec.
1		x	1.6	0.0		0.0	34.6					
2		x	0.0	2.1		0.0	2.5					
3		x	0.0	0.8		0.8	47.6					
4		0.9	0.0	3.1		0.0	10.5					
5		0.0	20.0	24.9		0.0	37.3					
6		14.3	0.9	23.9		8.8	15.3					
7		18.3	0.0	0.0		1.4	5.3					
8		0.0	0.0	0.0		15.4	20.0					
9		13.9	28.7	0.0		9.6	6.6					
10	N.A.	1.6	5.7	25.8	N.A.	75.5	30.6					
11		0.8	1.7	0.0		10.6	5.8					
12		0.0	1.5	0.0		1.2	0.8					
13		0.0	0.0	0.0		1.5	39.1					
14		0.3	0.0	0.0		72.7	11.9					
15		0.0	2.5	0.0		29.6	0.0					
16		0.0	1.3	0.0		0.0	1.1					
17		0.7	21.3	5.6		6.6	2.8					
18		1.0	0.9	5.3		3.2	22.5					
19		2.3	0.9	0.5		4.1	18.2					
20		1.7	3.0	0.0		0.0	56.7					
21		3.2	23.7	0.0		20.6	17.5					
22		1.4	1.0	0.0		16.2	4.8					
23		0.6	1.3	5.2		19.4	21.9					
24		1.1	2.9	58.6		34.4	5.1					
25		0.6	0.0	74.5		41.8	27.1					
26		11.2	40.0	4.4		0.0	21.2					
27		30.5	15.0	10.3		42.4	26.3					
28		39.4	0.0	0.0		11.4	21.7					
29			3.4	0.0		3.4	61.2					
30			0.0	0.0		0.0	26.7					
31			0.0				2.8					
Monthly total		143.8	177.3	245.0		430.6	605.5					
Day Max.		39.4	40.0	74.5		75.5	61.2					
		(A)		(A)		(A)	(A)					

(A) : Rainfall data measured by an automatic raingauge

APPENDIX B

WATER LEVEL AT MALANO AWLR

Table B.1 Water Level and Calculated Discharge at Malano AWLR (1/5)

Year : 1991 (m3/s)

Date	Jan		Feb		Mar		Apr		May		Jun		Jul		Aug		Sep		Oct		Nov		Dec	
	H (m)	Q	H (m)	Q	H (m)	Q	H (m)	Q	H (m)	Q	H (m)	Q	H (m)	Q	H (m)	Q	H (m)	Q	H (m)	Q	H (m)	Q	H (m)	Q
1													1.60	83.53	0.91	30.39	0.67	14.97						
2													1.60	83.53	0.82	24.42	0.66	14.36						
3													1.59	82.67	0.77	21.20	-							
4													1.92	112.61	0.74	19.30	-							
5													2.65	189.46	0.72	18.05	-							
6													1.98	118.38	0.73	18.67	-							
7													1.74	95.91	1.10	43.72	-							
8													1.66	88.77	1.22	52.65	-							
9													1.56	80.10	0.99	35.88	-							
10	N.A.		N.A.		N.A.		N.A.		N.A.		N.A.		1.82	103.22	0.93	31.75	-		N.A.		N.A.		N.A.	
11													1.48	73.35	1.26	55.72	-							
12													1.68	90.54	1.03	38.70	-							
13													1.68	90.54	0.98	35.19	-							
14													2.00	120.32	1.17	48.88	-							
15													3.32	272.85	1.26	55.72	-							
16													2.06	126.22	1.23	53.41	-							
17													1.58	81.81	1.18	49.63	-							
18													1.40	66.79	1.11	44.45	-							
19													1.22	52.65	0.98	35.19	-							
20													1.10	43.72	0.84	25.73	-							
21													1.00	36.58	0.74	19.30	-							
22													0.90	29.72	0.70	16.81	-							
23													0.94	32.43	0.68	15.58	-							
24													0.81	23.77	0.68	15.58	-							
25													0.82	24.42	0.66	14.36	-							
26													1.78	99.54	0.66	14.36	-							
27													1.44	70.05	0.65	13.75	-							
28													1.11	44.45	0.69	16.19	-							
29													0.91	30.39	0.80	23.13	-							
30													0.86	27.05	0.69	16.19	-							
31													0.99	35.88	0.66	14.36								
Average														81.01		29.62		14.66						

Notes : 1) (-) No data

2) Discharge was calculated by using the rating curve shown in the Pre-F/S Report

$H \geq 0.65$ m : Q = 13.713 H^2 + 42.599 H - 19.73

$H \leq 0.65$ m : Q = 23.362 (H + 0.123)^2

Table B.1 Water Level and Calculated Discharge at Malano AWLR (2/5)

Year : 1992 (m3/s)

Date	Jan		Feb		Mar		Apr		May		Jun		Jul		Aug		Sep		Oct		Nov		Dec	
	H (m)	Q	H (m)	Q	H (m)	Q	H (m)	Q	H (m)	Q	H (m)	Q	H (m)	Q	H (m)	Q	H (m)	Q	H (m)	Q	H (m)	Q	H (m)	Q
1			-		0.48	8.49	0.92	31.07	2.08	128.20	2.95	225.27	1.04	39.40										
2			-		0.47	8.22	1.12	45.18	2.96	226.51	2.55	178.07	1.00	36.58										
3			0.64	13.60	-		1.92	112.61	2.48	170.26	2.72	197.59	0.97	34.49										
4			0.73	18.67	-		2.62	186.01	2.17	137.28	2.85	213.06	0.96	33.80										
5			0.69	16.19	-		2.44	165.85	-		-		0.94	32.43										
6			1.32	60.39	-		2.29	149.73	-		-		0.93	31.75										
7			1.54	78.39	-		-		-		-		0.92	31.07										
8			1.26	55.72	-		-		-		-		0.91	30.39										
9			0.98	35.19	-		-		-		2.90	219.13	0.90	29.72										
10	N.A.		0.96	33.80	-		-		-		3.09	242.83	0.89	29.05	N.A.		N.A.		N.A.		N.A.		N.A.	
11			0.63	13.25	-		-		-		3.96	364.00	0.94	32.43										
12			0.58	11.55	-		-		-		3.69	324.18	1.01	37.28										
13			0.55	10.58	-		-		-		4.19	399.51	1.10	43.72										
14			0.52	9.66	-		2.44	165.85	-		4.18	397.93	1.19	50.38										
15			0.53	9.96	-		2.41	162.58	-		4.03	374.66	1.45	70.87										
16			1.10	43.72	-		2.22	142.42	-		3.70	325.62	1.76	97.72										
17			2.46	168.05	-		2.02	122.27	-		4.61	468.08	1.96	116.44										
18			2.50	172.47	-		1.88	108.82	-		3.77	335.77	4.60	466.39										
19			1.89	109.77	-		1.72	94.11	-		3.36	278.22	2.33	153.97										
20			1.46	71.70	-		1.50	75.02	-		2.94	224.04	1.90	110.71										
21			0.97	34.49	-		0.99	35.88	-		2.57	180.32	1.76	97.72										
22			0.71	17.43	-		0.83	25.07	-		2.56	179.19	1.71	93.21										
23			0.62	12.90	-		0.88	28.38	-		2.50	172.47	1.68	90.54										
24			0.56	10.90	-		1.16	48.14	-		2.42	163.67	1.63	86.14										
25			0.54	10.27	-		1.12	45.18	-		2.31	151.85	1.57	80.95										
26			0.54	10.27	-		1.14	46.65	-		2.18	138.31	1.59	82.67										
27			0.52	9.66	-		1.42	68.41	-		2.00	120.32	2.23	143.46										
28			0.49	8.78	-		1.95	115.48	-		1.64	87.01	2.43	164.76										
29			0.48	8.49	-		2.16	136.26	-		1.27	56.49	2.32	152.91										
30					0.96	33.80	2.14	134.23	-		1.10	43.72	2.73	198.77										
31					0.87	27.71			-				2.86	214.27										
Average				39.11		19.56		97.62		165.56		233.13		94.00										

Notes :
1) (-) No data
2) Discharge was calculated by using the rating curve shown in the Pre-F/S Report

$H \geq 0.65$ m : $Q = 13.713 H^2 + 42.599 H - 19.73$

$H \leq 0.65$ m : $Q = 23.362 (H + 0.123)^2$

Table B.1 Water Level and Calculated Discharge at Malano AWLR (3/5)

Year : 1993

(m3/s)

Date	Jan		Feb		Mar		Apr		May		Jun		Jul		Aug		Sep		Oct		Nov		Dec	
	H (m)	Q	H (m)	Q	H (m)	Q	H (m)	Q	H (m)	Q	H (m)	Q	H (m)	Q	H (m)	Q	H (m)	Q	H (m)	Q	H (m)	Q	H (m)	Q
1	0.76	20.57	1.46	71.70	0.99	35.88	1.15	47.39	-		-		4.56	459.66	-						-		1.07	41.55
2	0.76	20.57	1.22	52.65	0.98	35.19	1.58	81.81	-		1.04	39.40	2.53	175.82	2.43	164.76					-		1.07	41.55
3	0.64	13.60	1.34	61.98	0.93	31.75	1.58	81.81	1.48	73.35	0.98	35.19	2.10	130.20	2.38	159.33					-		1.05	40.12
4	0.48	8.49	1.25	54.95	0.91	30.39	1.68	90.54	1.36	63.57	1.24	54.18	2.30	150.79	2.31	151.85					-		1.04	39.40
5	0.43	7.14	1.29	58.04	0.91	30.39	1.41	67.60	1.33	61.18	1.17	48.88	2.75	201.12	2.25	145.54					-		1.02	37.99
6	0.40	6.39	1.24	54.18	0.90	29.72	1.52	76.70	1.73	95.01	1.63	86.14	2.56	179.19	2.13	133.22					-		1.02	37.99
7	0.37	5.68	1.09	43.00	1.00	36.58	1.76	97.72	1.52	76.70	-		2.32	152.91	1.80	101.38					-		1.01	37.28
8	0.36	5.45	0.96	33.80	1.13	45.92	1.72	94.11	1.65	87.89	-		2.60	183.73	1.62	85.27					-		1.01	37.28
9	0.37	5.68	0.95	33.12	1.10	43.72	1.57	80.95	1.65	87.89	-		2.96	226.51	1.46	71.70					-		1.00	36.58
10	0.32	4.58	1.22	52.65	1.15	47.39	2.15	135.25	1.75	96.81	-		3.02	233.99	1.40	66.79	N.A.		N.A.		-		0.98	35.19
11	0.27	3.61	1.15	47.39	1.01	37.28	3.07	240.29	2.94	224.04	-		2.72	197.59	1.36	63.57					-		0.98	35.19
12	0.24	3.08	1.06	40.83	0.93	31.75	2.65	189.46	2.27	147.63	-		2.20	140.36	1.34	61.98					-		0.96	33.80
13	0.23	2.91	0.95	33.12	1.30	58.82	2.25	145.54	1.69	91.43	-		2.03	123.26	1.32	60.39					-		0.93	31.75
14	0.35	5.23	1.14	46.65	1.21	51.89	2.45	166.95	1.65	87.89	-		1.98	118.38	1.31	59.61					-		0.92	31.07
15	1.29	58.04	0.91	30.39	1.14	46.65	2.03	123.26	1.64	87.01	2.70	195.26	1.96	116.44	1.30	58.82					-		0.91	30.39
16	1.42	68.41	0.99	35.88	1.22	52.65	2.20	140.36	1.69	91.43	2.24	144.50	1.87	107.88	1.28	57.26					-		0.89	29.05
17	1.70	92.32	1.05	40.12	1.42	68.41	1.64	87.01	2.48	170.26	1.82	103.22	1.79	100.46	1.27	56.49					-		0.88	28.38
18	1.64	87.01	1.01	37.28	1.45	70.87	1.71	93.21	1.68	90.54	1.92	112.61	1.71	93.21	1.25	54.95					-		0.86	27.05
19	1.69	91.43	1.00	36.58	1.26	55.72	1.51	75.86	1.29	58.04	1.40	66.79	1.96	116.44	1.22	52.65					-		0.84	25.73
20	2.04	124.24	1.06	40.83	1.16	48.14	-		1.35	62.77	1.26	55.72	1.85	106.01	1.20	51.14					-		0.82	24.42
21	2.34	155.04	1.08	42.27	1.10	43.72	-		1.19	50.38	1.10	43.72	1.65	87.89	1.17	48.88					-		0.80	23.13
22	2.43	164.76	0.69	16.19	1.00	36.58	-		1.14	46.65	1.05	40.12	1.53	77.55	1.15	47.39					-		0.80	23.13
23	2.52	174.70	0.61	12.55	0.91	30.39	-		1.18	49.63	1.02	37.99	1.54	78.39	1.12	45.18					1.26	55.72	0.80	23.13
24	2.58	181.45	0.57	11.22	0.92	31.07	-		1.49	74.19	1.01	37.28	1.73	95.01	-						1.22	52.65	0.80	23.13
25	2.61	184.87	0.71	17.43	1.02	37.99	-		-		1.01	37.28	2.02	122.27	-						1.19	50.38	0.80	23.13
26	2.02	122.27	1.32	60.39	1.25	54.95	-		-		1.04	39.40	-		-						1.16	48.14	0.80	23.13
27	1.59	82.67	0.97	34.49	1.11	44.45	-		-		1.33	61.18	-		-						1.14	46.65	0.80	23.13
28	1.52	76.70	0.79	22.48	1.06	40.83	-		-		1.09	43.00	-		-						1.13	45.92	0.87	27.71
29	1.85	106.01	-	-	1.04	39.40	-		-		2.59	182.59	-		-						1.11	44.45	1.13	45.92
30	1.85	106.01	-	-	0.96	33.80	-		-		5.60	648.86	-		-						1.09	43.00	1.28	57.26
31	1.68	90.54	-	-	0.92	31.07			-				-		-								1.38	65.17
Average		67.08		40.08		42.37		111.36		89.74		100.63		151.00		81.73						48.36		33.54

Notes :
1) (-) No data
2) Discharge was calculated by using the rating curve shown in the Pre-F/S Report

$H \geq 0.65$ m : $Q = 13.713 H^2 + 42.599 H - 19.73$

$H \leq 0.65$ m : $Q = 23.362 (H + 0.123)^2$

Table B.1 Water Level and Calculated Discharge at Malano AWLR (4/5)

Year : 1994 (m3/s)

Date	Jan		Feb		Mar		Apr		May		Jun		Jul		Aug		Sep		Oct		Nov		Dec	
	H (m)	Q	H (m)	Q	H (m)	Q	H (m)	Q	H (m)	Q	H (m)	Q	H (m)	Q	H (m)	Q	H (m)	Q	H (m)	Q	H (m)	Q	H (m)	Q
1	1.54	88.73	0.83	42.88	0.65	33.22	1.82	110.63	4.18	354.66	3.17	248.72	-		1.28	70.50	0.70	35.83	0.45	23.43	1.05	55.76	0.64	32.71
2	1.53	88.00	0.81	41.77	0.64	32.71	1.64	96.19	3.11	242.50	2.94	224.91	-		-		0.68	34.78	0.44	22.97	1.07	56.99	0.63	32.20
3	1.44	81.53	0.79	40.67	0.63	32.20	1.52	87.27	3.57	290.41	3.37	269.52	-		1.28	70.50	0.70	35.83	0.45	23.43	1.04	55.15	0.85	44.00
4	1.42	80.11	0.77	39.57	0.61	31.19	1.46	82.95	3.13	244.57	2.75	205.33	2.26	155.20	1.26	69.17	0.66	33.74	0.47	24.37	0.99	52.13	1.12	60.11
5	1.30	71.85	0.76	39.03	0.61	31.19	1.91	119.71	3.78	312.44	3.83	317.70	2.19	148.08	1.24	67.85	0.55	28.20	0.47	24.37	0.96	50.35	1.51	86.55
6	1.20	65.23	0.76	39.03	1.99	127.80	1.88	116.68	3.26	258.07	3.15	246.65	1.90	118.70	1.23	67.19	0.53	27.23	0.47	24.37	1.03	54.54	1.32	73.20
7	1.23	67.19	1.30	71.85	2.18	147.06	1.76	105.46	3.25	257.03	3.36	268.48	1.84	112.65	1.22	66.53	0.52	26.75	0.47	24.37	1.40	78.71	1.31	72.52
8	1.23	67.19	2.45	174.57	1.70	100.78	1.62	94.68	2.64	194.03	4.13	349.37	1.82	110.63	1.20	65.23	0.52	26.75	0.47	24.37	1.28	70.50	1.31	72.52
9	1.48	84.38	2.13	141.98	1.62	94.68	1.43	80.82	2.48	177.64	4.49	387.63	1.78	107.04	1.24	67.85	0.52	26.75	0.47	24.37	1.16	62.65	1.31	72.52
10	1.40	78.71	1.78	107.04	1.54	88.73	1.26	69.17	2.31	160.29	3.33	265.36	1.68	99.24	1.18	63.93	0.52	26.75	0.47	24.37	-		1.29	71.17
11	1.22	66.53	1.41	79.41	2.04	132.86	1.17	63.29	2.05	133.87	2.84	214.60	1.59	92.43	1.16	62.65	0.52	26.75	0.47	24.37	1.02	53.94	1.28	70.50
12	1.25	68.51	1.36	75.94	2.37	166.40	1.08	57.61	2.05	133.87	2.87	217.69	1.56	90.20	1.16	62.65	0.52	26.75	0.47	24.37	1.01	53.33	1.28	70.50
13	1.52	87.27	1.30	71.85	2.40	169.47	1.00	52.73	2.03	131.85	3.42	274.74	1.56	90.20	1.14	61.38	0.52	26.75	0.47	24.37	0.98	51.53	1.25	68.51
14	1.53	88.00	1.26	69.17	2.73	203.27	1.06	56.38	2.01	129.82	2.80	210.48	1.56	90.20	1.13	60.74	0.52	26.75	0.47	24.37	0.96	50.35	1.25	68.51
15	1.47	83.66	1.17	63.29	3.19	250.80	1.88	116.68	1.96	124.76	2.39	168.45	1.57	90.94	1.12	60.11	0.52	26.75	0.47	24.37	0.96	50.35	1.25	68.51
16	1.43	80.82	1.09	58.23	2.01	129.82	1.62	94.68	1.86	114.66	3.27	259.11	1.80	108.63	1.10	58.86	0.51	26.27	0.46	23.90	0.96	50.35	1.26	69.17
17	1.41	79.41	1.02	53.94	1.91	119.71	1.57	90.94	1.76	105.46	2.61	190.95	1.70	100.78	1.08	57.61	0.50	25.79	0.47	24.37	0.99	52.13	1.22	66.53
18	1.37	76.63	0.96	50.35	2.33	162.33	1.73	103.11	1.69	100.01	-		1.54	88.73	1.08	57.61	0.48	24.84	0.48	24.84	1.00	52.73	1.20	65.23
19	1.31	72.52	0.92	48.01	2.07	135.90	1.69	100.01	1.84	112.65	-		1.66	97.71	1.04	55.15	0.48	24.84	0.48	24.84	0.99	52.13	1.21	65.88
20	1.24	67.85	0.89	46.28	1.94	122.74	1.62	94.68	2.03	131.85	-		1.61	93.93	1.04	55.15	0.48	24.84	0.48	24.84	0.94	49.17	1.20	65.23
21	1.18	63.93	0.88	45.70	2.08	136.91	1.63	95.43	1.97	125.77	-		1.54	88.73	1.02	53.94	0.48	24.84	0.48	24.84	0.89	46.28	1.18	63.93
22	1.14	61.38	0.62	31.69	2.22	151.13	1.58	91.69	1.88	116.68	-		1.51	86.55	0.95	49.76	0.48	24.84	0.48	24.84	0.87	45.13	1.14	61.38
23	1.09	58.23	0.55	28.20	1.72	102.33	1.94	122.74	1.81	109.62	-		1.47	83.66	0.93	48.59	0.48	24.84	0.53	27.23	0.86	44.57	1.11	59.48
24	1.06	56.38	0.58	29.68	1.44	81.53	2.09	137.93	1.72	102.33	-		1.42	80.11	0.92	48.01	0.48	24.84	0.73	37.42	0.78	40.12	1.04	55.15
25	1.02	53.94	0.74	37.95	1.28	70.50	1.98	126.79	2.07	135.90	-		1.22	66.53	0.92	48.01	0.48	24.84	0.78	40.12	0.69	35.30	0.98	51.53
26	0.98	51.53	0.76	39.03	1.22	66.53	1.94	122.74	2.49	178.66	-		1.11	59.48	0.92	48.01	0.47	24.37	0.78	40.12	0.66	33.74	0.92	48.01
27	0.94	49.17	0.51	26.27	1.55	89.47	2.12	140.97	2.20	149.09	-		1.08	57.61	0.92	48.01	0.47	24.37	0.71	36.35	0.61	31.19	0.85	44.00
28	0.92	48.01	0.66	33.74	1.57	90.94	3.79	313.49	2.00	128.81	-		1.08	57.61	0.92	48.01	0.47	24.37	0.74	37.95	0.68	34.78	0.77	39.57
29	0.89	46.28			1.55	89.47	2.59	188.90	1.95	123.75	-		1.09	58.23	0.81	41.77	0.47	24.37	0.80	41.21	0.67	34.26	0.70	35.83
30	0.87	45.13			1.98	126.79	2.71	201.22	2.37	166.40	-		1.19	64.58	0.72	36.88	0.46	23.90	0.81	41.77	0.61	31.19	0.65	33.22
31	0.85	44.00			2.20	149.09			2.33	162.33			-		0.72	36.88			1.09	58.23			0.67	34.26
Average		68.45		58.11		111.86		111.18		168.06		254.10		92.53		56.95		26.95		28.87		49.29		58.79

Notes : 1) (-) No data

2) Discharge was calculated by using the rating curve obtained in this F/S

$H \geq 1.80$ m : Q = 1.1013 H^2 + 96.797 H - 69.19

$H \leq 1.80$ m : Q = 12.294 H^2 + 35.446 H + 4.99

Table B.1 Water Level and Calculated Discharge at Malano AWLR (5/5)

Year : 1995 (m3/s)

Date	Jan		Feb		Mar		Apr		May		Jun		Jul		Aug		Sep		Oct		Nov		Dec	
	H (m)	Q	H (m)	Q	H (m)	Q	H (m)	Q	H (m)	Q	H (m)	Q	H (m)	Q	H (m)	Q	H (m)	Q	H (m)	Q	H (m)	Q	H (m)	Q
1	0.62	31.69	-		0.84	43.44	1.06	56.38	1.44	81.53	0.67	34.26	3.98	333.51	4.45	383.37								
2	0.59	30.18	-		0.84	43.44	0.95	49.76	1.33	73.88	0.65	33.22	2.88	218.72	4.76	416.52								
3	0.59	30.18	-		0.76	39.03	0.86	44.57	1.24	67.85	0.64	32.71	2.75	205.33	4.50	388.70								
4	0.58	29.68	-		0.69	35.30	0.78	40.12	1.22	66.53	0.62	31.69	2.60	189.93	4.38	375.91								
5	0.59	30.18	-		0.62	31.69	0.87	45.13	1.20	65.23	0.60	30.68	4.51	389.77	4.73	413.30								
6	0.59	30.18	-		0.60	30.68	1.23	67.19	1.20	65.23	0.60	30.68	3.37	269.52	4.32	369.53								
7	0.71	36.35	-		0.61	31.19	1.20	65.23	1.17	63.29	0.60	30.68	2.18	147.06	4.12	348.31								
8	0.80	41.21	-		0.62	31.69	1.17	63.29	1.16	62.65	1.73	103.11	2.39	168.45	4.47	385.50								
9	0.82	42.32	-		1.57	90.94	1.13	60.74	1.10	58.86	2.54	183.78	2.57	186.85	4.73	413.30								
10	0.95	49.76	-		3.03	234.22	1.13	60.74	1.28	70.50	2.17	146.05	4.51	389.77	4.68	407.94								
11	1.73	103.11	-		2.14	143.00	1.12	60.11	1.75	104.67	1.75	104.67	3.58	291.46	4.28	365.28								
12	1.78	107.04	-		1.59	92.43	1.07	56.99	1.57	90.94	2.27	156.21	2.97	228.01	3.21	252.88								
13	1.72	102.33	-		1.34	74.56	0.99	52.13	2.46	175.60	3.17	248.72	2.88	218.72	2.44	173.55								
14	1.52	87.27	-		1.13	60.74	0.96	50.35	2.82	212.54	4.41	379.10	2.52	181.73	2.04	132.86								
15	1.46	82.95	-		0.99	52.13	0.92	48.01	2.05	133.87	4.31	368.46	2.39	168.45										
16	1.40	78.71	-		0.88	45.70	0.90	46.85	3.06	237.32	2.88	218.72	2.24	153.16										
17	1.40	78.71	-		0.80	41.21	0.89	46.28	2.13	141.98	2.81	211.51	2.21	150.11										
18	1.40	78.71	-		0.79	40.67	0.88	45.70	1.74	103.89	2.57	186.85	2.23	152.14										
19	1.40	78.71	-		0.88	45.70	0.88	45.70	1.72	102.33	2.43	172.53	4.04	339.84										
20	1.41	79.41	-		0.86	44.57	0.85	44.00	1.68	99.24	2.28	157.23	4.40	378.04										
21	1.41	79.41	-		0.83	42.88	0.84	43.44	1.64	96.19	2.36	165.38	3.98	333.51										
22	1.30	71.85	-		0.84	43.44	0.80	41.21	1.62	94.68	2.90	220.78	2.76	206.36										
23	1.31	72.52	-		0.95	49.76	0.80	41.21	1.56	90.20	3.17	248.72	3.41	273.69										
24	2.82	212.54	-		1.29	71.17	0.79	40.67	1.46	82.95	3.68	301.94	3.45	277.87										
25	2.94	224.91	-		1.25	68.51	1.46	82.95	1.30	71.85	3.95	330.34	3.80	314.54										
26	1.87	115.67	-		1.26	69.17	2.54	183.78	1.09	58.23	3.29	261.19	2.26	155.20										
27	1.72	100.56	-		1.79	107.83	2.08	136.91	0.95	49.76	3.51	284.14	4.51	389.77										
28	1.68	96.54	0.68	34.78	1.69	100.01	1.68	99.24	0.86	44.57	3.25	257.03	3.75	309.29										
29	-				1.52	87.27	1.61	93.93	0.79	40.67	2.91	221.82	3.11	242.50										
30	-				1.32	73.20	1.57	90.94	0.76	39.03	3.00	231.11	3.34	266.40										
31	-				1.18	63.93			-				3.64	297.74										
Average		78.67		34.78		65.47		63.45		91.53		179.44		252.50		344.78								

Notes :
1) (-) No data
2) Discharge was calculated by using the rating curve obtained in this F/S

H ≥ 1.80 m : Q = 1.1013 H^2 + 96.797 H - 69.19

H ≤ 1.80 m : Q = 12.294 H^2 + 35.446 H + 4.99

APPENDIX C

METEOROLOGICAL DATA

Table C.1 Meteorological Data at Sorong Jefman (1/2)

YEAR		1983												1984											
		1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12
Atomospheric Temperature (℃)	(max.)	30.8	31.5	32.0	31.0	31.8	30.4	30.5	30.2	30.9	31.0	31.0	32.0	31.1	30.1	30.6	31.1	31.1	30.9	30.4	29.9	30.6	30.2	31.6	30.8
	(min.)	24.4	23.1	24.7	23.7	23.6	25.0	24.9	24.8	24.5	24.7	25.3	25.1	25.0	25.0	25.1	25.5	24.9	24.9	24.3	24.5	24.5	23.7	26.4	25.0
	(Ave.)	27.7	27.9	28.4	27.3	27.6	27.5	26.8	27.6	27.0	27.1	27.5	27.0	27.4	27.0	27.3	27.7	27.2	27.5	26.5	26.7	26.8	27.5	28.0	28.0
Sunshine	(%)	-	-	-	-	-	-	-	-	-	-	-	-	66	59	51	65	60	61	48	55	61	62	57	54
Average Relative Humidity	(%)	83	82	82	83	87	86	87	87	87	85	83	84	81	83	82	83	86	84	89	82	82	82	81	80
Number of Rainy Days	(day)	17	5	10	15	21	19	25	24	20	18	15	18	19	19	24	22	25	22	25	13	23	10	9	13
Wind Direction		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Wind Speed	(knots) (max.)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	(min.)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

YEAR		1985												1986											
		1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12
Atomospheric Temperature (℃)	(max.)	30.7	30.6	31.5	31.5	30.0	30.7	29.4	30.6	31.4	31.6	31.3	30.6	30.6	30.6	30.6	31.1	32.4	31.5	31.7	32.8	32.5	32.0	31.5	31.3
	(min.)	26.4	25.7	25.6	24.7	24.3	25.1	23.7	24.5	24.5	24.2	25.3	25.3	25.7	25.2	25.2	25.5	25.4	25.1	25.1	25.4	25.1	25.3	25.1	25.6
	(Ave.)	27.5	27.5	28.2	27.8	27.4	27.0	26.5	26.5	26.6	27.9	27.2	28.1	28.2	27.9	27.9	28.3	28.9	28.3	28.4	29.1	28.8	28.6	28.3	28.4
Sunshine	(%)	46	46	62	58	78	51	44	48	57	81	50	48	55	61	49	60	76	60	63	75	80	67	63	75
Average Relative Humidity	(%)	81	80	75	78	82	86	79	84	83	75	78	80	81	75	80	78	77	80	79	80	77	80	81	76
Number of Rainy Days	(day)	16	14	9	13	25	18	22	21	22	16	18	22	13	13	25	13	17	13	14	7	9	22	21	14
Wind Direction		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Wind Speed	(knots) (max.)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	(min.)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

YEAR		1987												1988											
		1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12
Atomospheric Temperature (℃)	(max.)	30.4	31.0	30.3	31.5	31.5	30.4	30.1	30.6	31.1	31.9	30.0	31.4	31.2	31.1	31.0	32.2	32.1	31.2	30.2	30.9	31.1	31.2	31.6	31.0
	(min.)	24.5	25.8	25.2	25.4	25.4	25.5	25.0	24.7	25.3	25.4	25.1	25.7	25.2	25.3	26.0	25.7	25.7	24.9	24.6	24.9	24.9	25.1	25.4	25.0
	(Ave.)	27.4	28.1	27.7	28.4	28.4	27.9	27.9	28.1	28.4	28.9	29.4	29.3	29.2	28.6	28.5	28.8	28.3	28.3	27.8	27.3	28.3	28.6	29.1	27.7
Sunshine	(%)	60	62	77	·72	74	71	77	74	53	77	80	61	65	88	62	67	69	69	65	76	72	58	60	62
Average Relative Humidity	(%)	82	79	78	81	81	82	80	83	80	79	82	79	77	81	81	78	81	82	82	78	82	82	79	82
Number of Rainy Days	(day)	14	6	16	14	17	6	5	12	6	13	14	6	12	12	14	14	19	15	22	24	20	17	18	18
Wind Direction		-	-	-	-	-	-	-	-	-	-	-	-	S	N	N	N-S	S	SE-S	SE	S-SE	N-S	S-N	N	S-N
Wind Speed	(knots) (max.)	-	-	-	-	-	-	-	-	-	-	-	-	18	15	15	16	12	20	15	12	11	12	15	12
	(min.)	-	-	-	-	-	-	-	-	-	-	-	-	4	5	5	6	4	6	5	4	4	6	5	7

Table C.1 Meteorological Data at Sorong Jefman (2/2)

YEAR		1989												1990											
		1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12
Atomospheric Temperature (℃)	(max.)	30.7	29.6	30.5	31.3	31.3	30.3	31.6	30.5	31.9	31.4	31.2	31.4	30.8	31.8	31.9	31.4	31.5	30.6	30.7	30.8	32.1	32.3	31.6	31.7
	(min.)	25.5	25.0	24.9	25.2	25.7	24.3	24.6	24.9	25.0	25.0	25.6	25.4	25.4	25.7	25.8	25.8	25.8	25.4	25.0	25.0	25.0	24.9	25.5	25.9
	(Ave.)	28.6	28.2	27.7	28.7	28.5	28.5	28.4	26.5	28.6	28.2	28.7	28.1	27.9	28.5	28.6	28.6	28.7	28.1	28.1	27.4	28.0	29.0	28.3	29.3
Sunshine	(%)	-	-	-	-	-	-	50	54	52	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Average Relative Humidity	(%)	87	80	80	81	80	83	81	80	81	78	81	82	82	77	81	82	82	82	85	83	82	80	77	79
Number of Rainy Days	(day)	15	17	16	16	11	17	18	14	23	16	18	12	17	13	17	15	14	17	18	14	14	15	11	10
Wind Direction		W	W	W	SW	SW	SW	S-SE	S-SE	S-SE	S-SE	S-SE	S-N	N-W	N	N	N-S	N-S	N-SE	S	S	SE-S	S	S	N
Wind Speed	(knots) (max.)	7	7	8	7	8	7	7	10	7	7	6	5	12	15	15	15	18	30	18	20	25	20	17	20
	(min.)	4	3	5	3	4	3	4	5	3	3	4	3	8	9	7	7	8	11	11	12	10	10	8	9

YEAR		1991												1992											
		1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12
Atomospheric Temperature (℃)	(max.)	30.8	31.1	30.8	31.0	31.8	31.9	31.0	30.9	31.0	31.4	33.0	31.8	31.5	31.7	31.1	31.8	32.1	31.2	30.3	31.5	32.0	31.7	31.7	31.0
	(min.)	25.4	25.7	25.3	25.4	24.9	25.1	24.9	25.1	23.8	24.5	25.3	24.5	25.0	25.5	25.2	25.7	25.4	25.2	24.7	24.9	24.0	24.8	25.1	25.3
	(Ave.)	28.1	28.5	28.1	28.2	28.4	28.5	27.9	28.0	27.4	28.0	29.0	28.1	28.0	28.4	28.3	28.1	28.5	28.2	28.0	28.4	27.8	28.0	27.2	27.6
Sunshine	(%)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	53	63	77	57	65	64
Average Relative Humidity	(%)	79	82	80	80	81	83	82	79	80	80	81	82	80	79	81	80	79	82	82	80	80	78	81	82
Number of Rainy Days	(day)	17	8	17	15	21	14	14	9	2	10	1	16	4	6	11	12	16	14	16	11	11	10	13	11
Wind Direction		N	N	N	S-SE	S-SE	S-SE	S	SE-N	S-SE	S-N	SE-N	N-W	N	N-NE	N-NE	N-NW	S-SE	S-SE	S-SE	S-SE	S-SE	S-SE	S-W	N
Wind Speed	(knots) (max.)	15	18	18	10	15	15	24	25	30	15	12	10	25	25	20	18	12	32	22	17	15	15	12	12
	(min.)	8	5	5	3	4	9	7	6	12	8	6	6	9	14	10	8	7	12	11	7	9	8	7	7

YEAR		1993												1994											
		1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12
Atomospheric Temperature (℃)	(max.)	30.9	31.1	31.4	31.3	31.9	32.4	31.0	31.9	31.0	32.3	30.4	30.9	31.4	31.5	30.7	31.3	30.6	29.4	-	29.1	31.1			
	(min.)	25.4	25.3	25.3	25.1	24.3	24.7	24.8	24.6	24.6	25.3	24.6	25.1	25.9	25.6	25.3	25.4	25.6	24.3	24.9	24.4	24.7			
	(Ave.)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-			
Sunshine	(%)	80	80	71	58	75	78	60	88	49	65	56	67	70	72	79	66	52	60	66	-	-			
Average Relative Humidity	(%)	78	78	82	82	84	82	81	80	83	77	78	76	81	79	83	84	86	86	85	85	81			
Number of Rainy Days	(day)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-			
Wind Direction		N	N	N	N	N-SE	S-SE	S	S-SE	S-SW	N-S	N-S	N-S	N-S	N-NW	M-SW	N-S	S-SW	S-SW	S-SW	S-SW	S-SW			
Wind Speed	(knots) (max.)	15	15	17	11	17	18	15	25	16	15	8	15	20	18	15	15	25	25	25	25	25			
	(min.)	4	5	5	0	5	0	4	3	0	5	5	5	5	5	3	3	3	3	8	3	2			

Table C.2 Monthly Average of Meteorological Data at Sorong Jefman

Item	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
Max. Temperature (℃)	31.5	31.8	32.0	32.2	32.4	32.4	31.7	32.8	32.5	32.3	33.0	32.0
Min. Temperature (℃)	24.4	23.1	24.7	23.7	23.6	24.3	23.7	24.4	23.8	23.7	24.6	24.5
Average Temperature (℃)	28.0	28.1	28.1	28.2	28.2	28.0	27.6	27.6	27.8	28.2	28.3	28.2
Average Sunshine (%)	63.1	66.9	64.4	63.7	69.1	64.3	58.4	66.6	62.6	66.7	61.6	61.6
Average Humidity (%)	81.0	79.6	80.4	80.8	82.2	83.2	82.7	81.8	81.5	79.6	80.2	80.2
Average Rainy Days (day)	14.4	11.3	15.9	14.9	18.6	15.5	17.9	14.9	15.0	14.7	13.8	14.0
Max. Wind Speed (knots)	25.0	25.0	17.0	18.0	25.0	32.0	25.0	25.0	30.0	20.0	17.0	20.0
Min. Wind Speed (knots)	4.0	3.0	3.0	3.0	3.0	3.0	4.0	3.0	2.0	3.0	4.0	3.0

Source: BMG Meteorological Station Class II, Jefman, Sorong

Table C.3 Atmospheric Temperature at New Malano Station (1995)

Unit : ℃

Date	Feburuary			March			April			May			June			July			August			September		
	Mean	Max.	Min.	Mean	Max.	Min.	Mean	Max.	Min.	Mean	Max.	Min.	Mean	Max.	Min.	Mean	Max.	Min.	Mean	Max.	Min.	Mean	Max.	Min.
1	-	-	-	26.8	30.1	24.0	27.3	31.5	24.0	26.2	31.5	23.6	28.2	32.5	25.0	25.7	31.0	23.0	25.2	30.0	23.0	24.2	28.4	22.8
2	-	-	-	26.9	30.8	23.5	25.4	32.2	24.0	26.3	30.5	23.2	27.6	33.0	23.5	25.8	31.5	23.0	24.2	28.2	22.9	25.6	30.6	22.0
3	26.1	26.5	25.9	27.0	31.8	23.5	27.3	31.2	24.0	26.9	31.0	24.0	27.5	33.0	24.0	25.8	30.6	23.0	25.0	30.0	22.9	25.0	28.2	23.2
4	25.6	27.5	24.1	25.1	26.8	24.0	27.5	32.5	24.1	21.1	30.0	24.0	27.6	33.0	23.0	25.9	30.0	23.5	25.7	30.0	22.9	25.0	28.8	23.0
5	26.3	31.0	24.0	26.0	31.0	23.2	25.8	30.0	24.0	26.4	29.0	23.5	26.9	32.0	24.0	25.4	31.0	23.0	25.6	30.0	23.6	24.1	28.0	22.2
6	26.6	32.0	23.4	26.1	29.0	23.2	26.7	31.6	23.5	26.0	29.0	24.5	26.2	31.5	24.8	25.6	31.2	23.0	25.9	31.2	23.1	25.0	29.0	22.5
7	26.3	32.0	23.2	26.4	30.2	23.1	27.0	32.0	24.0	26.1	31.0	24.0	26.6	31.0	24.4	25.5	29.0	22.5	26.0	31.2	22.1	24.9	28.8	22.5
8	26.3	31.0	23.5	27.0	29.0	25.0	27.5	33.5	23.7	28.1	32.0	25.0	26.0	30.4	23.5	25.6	30.5	23.2	26.0	30.0	23.2	25.8	30.5	22.0
9	25.6	31.0	22.8	25.1	27.0	23.5	26.3	31.0	24.0	27.2	32.5	24.8	24.4	31.8	23.0	25.2	29.0	23.0	25.4	30.0	23.0	25.5	31.0	22.0
10	25.9	30.5	23.5	25.8	29.0	24.0	24.3	28.1	23.0	27.3	31.0	24.8	25.4	30.8	22.0	24.9	29.0	22.0	25.4	31.0	22.5	26.0	30.5	23.4
11	27.3	31.9	23.5	27.1	31.0	24.5	27.0	32.0	22.9	27.6	32.5	23.9	26.4	31.0	23.0	25.0	27.4	23.0	25.9	30.8	23.0	25.3	29.0	22.3
12	27.6	32.0	24.2	26.6	30.8	24.0	25.8	28.5	24.0	26.9	31.5	24.2	26.8	31.0	23.5	25.4	30.0	23.1	25.4	29.0	23.0	23.7	24.8	23.7
13	27.0	32.4	23.2	27.4	31.8	24.2	26.8	31.5	23.5	27.2	31.0	25.0	26.2	30.4	24.0	25.0	28.0	22.2	25.2	29.0	22.5			
14	27.1	31.9	23.0	27.2	32.5	23.0	27.2	32.8	23.2	26.3	30.8	24.0	25.6	30.0	23.5	24.8	29.0	22.2	24.6	27.0	22.2			
15	27.3	32.5	23.7	27.0	31.5	25.0	27.5	32.4	24.0	26.8	32.0	23.0	25.9	30.0	23.0	24.3	27.0	22.0	25.7	29.3	22.1			
16	26.7	32.0	24.0	25.6	30.2	24.0	27.6	32.9	23.9	27.2	32.0	24.0	25.5	29.8	23.0	25.5	30.8	22.0	26.0	31.0	22.9			
17	26.7	31.5	23.5	26.5	31.9	24.0	27.0	31.0	23.8	26.7	31.0	24.0	25.3	30.0	23.0	25.3	31.2	22.0	25.4	29.5	23.0			
18	26.7	31.5	23.0	27.0	31.0	23.6	26.6	31.8	23.1	27.0	32.6	23.2	26.0	31.0	23.0	25.6	30.0	23.0	25.5	30.5	23.0			
19	27.4	32.0	24.0	26.8	31.0	24.0	26.6	31.0	23.0	25.8	31.0	23.5	27.1	31.0	24.0	25.8	30.0	22.9	25.6	30.0	23.2			
20	27.7	32.0	25.0	26.8	32.5	23.8	27.2	31.9	23.0	25.6	29.9	22.2	26.2	30.0	24.8	25.6	30.2	22.8	25.8	29.7	24.0			
21	27.2	32.0	24.0	26.7	33.0	23.8	26.4	32.0	23.8	26.3	31.2	22.8	25.8	30.0	23.8	25.3	30.0	22.4	25.4	29.0	24.0			
22	26.1	30.0	24.0	36.5	31.0	23.7	27.0	32.8	22.5	26.3	31.2	22.5	26.1	30.5	23.8	25.3	30.8	22.0	25.4	29.0	23.0			
23	26.3	32.0	23.5	26.2	31.0	23.7	27.6	33.8	23.0	26.8	32.2	22.6	25.7	29.8	23.2	24.4	29.0	22.8	25.2	29.0	23.1			
24	25.8	32.0	22.0	26.8	31.0	23.9	25.9	30.0	23.2	27.1	32.5	23.0	25.4	31.0	23.0	25.4	30.0	22.0	25.1	29.0	23.1			
25	26.4	31.0	23.0	27.2	32.5	23.5	25.9	30.8	23.9	27.3	32.1	24.0	24.7	28.0	22.8	25.5	29.7	22.9	25.5	30.0	23.0			
26	26.8	30.2	24.0	26.8	31.0	23.8	25.7	31.0	23.2	26.2	29.9	24.0	24.3	29.0	23.0	25.1	30.0	22.9	24.1	28.0	22.2			
27	26.7	31.0	23.5	26.7	31.5	24.0	26.5	31.8	23.0	26.9	32.0	23.0	24.4	27.0	23.0	25.2	30.0	22.3	25.5	30.0	22.1			
28	26.7	30.8	23.5	27.2	32.0	24.1	26.4	31.5	23.9	27.5	33.2	23.0	24.9	29.0	23.0	26.5	30.0	24.1	26.2	31.0	23.0			
29				27.0	31.5	23.8	26.9	33.0	23.2	27.1	32.8	23.5	27.2	30.0	22.5	25.8	30.0	22.8	26.0	30.5	23.0			
30				26.8	30.5	24.1	27.6	32.2	24.0	27.0	31.0	23.5	25.3	29.5	23.2	26.0	30.0	23.0	26.1	30.2	22.6			
31				26.4	31.0	23.5				26.9	32.8	23.0				25.4	30.8	23.0	26.3	30.3	24.0			
Ave.	26.61	-	-	26.91	-	-	26.67	-	-	26.57	-	-	26.0	-	-	25.4	-	-	25.4	-	-	25.1	-	-
Max.	-	32.4	-	-	33.0	-	-	33.8	-	-	32.8	-	-	33.0	-	-	31.5	-	-	31.2	-	-	31.0	-
Min.	-	-	22.0	-	-	23.1	-	-	22.5	-	-	22.2	-	-	22.0	-	-	22.0	-	-	22.1	-	-	22.0

Table C.4 Humidity at New Malano Station (1995)

Unit : %

Date	Feburuary			March			April			May			June			July			August			September		
	Mean	Max.	Min.	Mean	Max.	Min.	Mean	Max.	Min.	Mean	Max.	Min.	Mean	Max.	Min.	Mean	Max.	Min.	Mean	Max.	Min.	Mean	Max.	Min.
1	-	-	-	85.5	98	67	84.8	98	60	89.5	98	65	84.3	97	60	88.3	98	62	90.8	97	70	93.0	97	74
2	-	-	-	85.2	99	63	88.5	98	59	87.3	98	65	84.4	98	59	87.9	97	65	90.6	97	70	88.5	97	72
3	92.2	95	90	83.4	99	57	84.3	99	62	88.3	97	70	84.0	97	60	89.9	98	65	91.8	98	70	92.0	96	75
4	92.0	98	78	94.6	99	83	83.6	98	52	92.1	97	75	82.3	97	54	88.4	97	65	87.4	97	65	90.8	96	76
5	88.8	99	64	87.0	99	63	90.5	97	68	90.3	97	75	93.0	97	64	89.0	97	67	89.1	96	65	91.8	96	75
6	87.0	99	55	88.0	98	71	83.8	97	54	92.6	97	76	87.2	97	64	88.9	97	64	87.6	97	66	89.5	96	73
7	90.8	100	62	85.7	99	66	84.2	98	54	88.4	97	69	90.2	97	70	91.9	98	76	86.7	97	60	89.9	96	75
8	91.2	100	69	85.0	98	72	84.0	98	54	83.9	96	62	90.7	97	70	89.8	97	70	88.4	97	66	85.1	97	60
9	91.6	100	65	94.9	99	86	89.4	97	62	88.5	97	63	89.6	97	65	91.8	98	80	89.6	96	70	89.2	97	65
10	91.5	100	72	90.7	99	72	90.8	97	74	89.6	97	66	89.0	98	70	90.1	97	70	88.8	97	65	88.7	97	67
11	84.8	99	64	85.6	98	62	88.4	99	58	86.3	99	66	88.8	98	70	91.2	97	80	87.7	97	66	87.5	96	64
12	80.7	99	56	86.6	99	68	90.0	98	72	91.3	98	65	89.1	98	70	88.9	97	66	89.7	96	75	95.4	97	91
13	83.8	98	61	82.8	97	61	83.5	98	55	89.1	97	74	90.3	98	70	87.2	97	74	88.7	97	67			
14	83.5	100	60	81.4	99	47	82.1	98	53	88.1	97	64	90.7	97	65	90.4	98	70	89.9	97	74			
15	83.6	99	53	85.9	98	60	83.1	98	54	84.4	97	55	88.3	97	65	90.4	97	75	86.3	96	70			
16	87.2	98	60	87.8	98	59	82.7	98	55	86.3	98	65	92.0	98	73	86.5	97	60	87.0	97	65			
17	87.7	99	59	89.7	98	60	88.3	98	66	86.3	97	64	89.2	98	70	87.1	98	60	88.0	96	70			
18	86.3	99	60	87.5	98	68	89.2	98	62	85.2	97	56	88.7	98	65	88.8	97	65	88.2	96	65			
19	82.8	98	57	87.7	98	65	86.3	98	60	88.5	97	61	86.2	97	68	88.5	97	65	88.4	97	71			
20	82.2	98	55	83.3	98	50	82.8	99	55	89.7	97	72	89.7	97	70	89.4	96	70	89.4	97	65			
21	87.2	98	60	84.9	97	46	88.3	98	55	86.2	98	64	91.5	97	70	90.4	96	68	91.5	96	72			
22	90.8	99	67	86.7	98	62	81.3	98	55	83.4	97	56	89.3	97	70	88.2	98	60	88.6	96	70			
23	86.1	99	58	89.6	98	62	83.5	98	52	82.3	97	55	89.8	97	70	91.0	96	77	90.5	97	72			
24	85.9	99	52	86.7	97	60	91.4	98	75	85.7	98	62	89.6	97	61	89.4	97	65	91.6	97	75			
25	85.8	98	65	83.6	98	58	90.5	97	63	85.8	98	60	91.3	97	78	89.1	97	70	89.9	97	70			
26	86.3	98	63	87.1	98	64	91.4	98	60	90.5	97	73	92.4	98	70	90.1	97	60	93.3	98	76			
27	87.5	99	65	87.1	99	62	86.8	97	62	83.8	97	46	92.6	97	80	88.5	97	65	89.4	97	70			
28	87.0	99	66	84.9	98	55	87.2	97	62	81.8	98	54	90.5	97	75	88.6	97	62	87.7	97	63			
29				85.2	98	62	82.2	97	47	84.9	98	62	89.1	97	67	86.6	97	65	88.0	96	65			
30				86.0	98	66	84.0	97	59	86.9	97	62	90.0	97	70	87.1	98	65	87.4	98	70			
31				87.6	98	62				84.0	99	55				88.0	97	62	88.7	96	68			
Ave.	87.1	-	-	86.7	-	-	86.2	-	-	87.1	-	-	89.1	-	-	89.1	-	-	89.1	-	-	89.6	-	-
Max.	-	100	-	-	99	-	-	99	-	-	99	-	-	98	-	-	98	-	-	98	-	-	97	-
Min.	-	-	52	-	-	46	-	-	47	-	-	46	-	-	54	-	-	60	-	-	63	-	-	60

Table C.5 Barometric Pressure at New Malano Station (1995)

Unit : hPa

Date	Feburuary			March			April			May			June			July			August		
	Mean	Max.	Min.	Mean	Max.	Min.	Mean	Max.	Min.	Mean	Max.	Min.	Mean	Max.	Min.	Mean	Max.	Min.	Mean	Max.	Min.
1	-	-	-	997.0	998.3	996.0	997.6	998.9	996.8	997.7	999.1	996.5	997.4	998.6	996.0	998.2	999.2	996.2	997.9	999.8	996.0
2	-	-	-	997.3	998.8	995.9	998.4	999.5	997.7	998.6	1000.8	997.0	997.4	998.4	996.0	998.3	999.0	996.8	997.1	998.0	995.8
3	999.6	999.7	999.5	996.2	997.5	995.0	998.5	999.9	997.0	997.6	999.2	995.1	997.7	999.6	996.9	997.6	998.6	996.0	996.5	997.8	994.8
4	999.3	1001.0	998.0	996.7	998.0	995.1	998.2	999.0	996.3	996.4	997.8	994.8	997.9	999.0	996.0	997.4	998.8	995.3	997.3	998.2	996.0
5	999.3	1000.5	997.8	997.4	998.8	996.1	998.8	999.8	997.4	996.6	998.0	995.1	997.5	998.8	995.7	996.7	997.8	995.0	998.4	999.9	996.9
6	999.8	1001.0	998.1	998.0	999.0	997.0	998.0	999.9	996.0	997.3	998.6	996.2	998.1	999.0	997.0	996.9	998.1	995.0	998.7	1000.0	996.9
7	999.8	1001.0	998.0	998.7	1000.0	997.8	997.4	998.8	995.9	997.3	998.9	996.0	998.1	999.4	997.0	997.1	998.9	996.0	998.0	999.0	995.9
8	999.1	1000.0	997.1	998.3	999.6	996.8	998.2	999.9	996.9	997.1	998.3	995.0	998.6	999.9	997.3	998.6	999.1	997.1	998.8	1000.0	997.0
9	998.8	1000.0	997.0	998.9	1000.8	997.0	999.4	1001.2	998.0	996.9	998.0	995.0	998.6	1000.0	997.6	999.1	1000.2	997.0	999.9	1001.0	998.4
10	998.9	999.8	997.7	999.3	1001.0	998.0	1000.6	1002.0	998.9	996.9	998.1	995.3	998.4	999.8	997.0	998.9	1000.0	997.0	1000.6	1001.5	998.9
11	998.8	1000.0	997.8	999.6	1001.2	998.0	1000.3	1002.3	998.8	997.6	999.2	996.0	997.1	999.1	995.2	998.8	1000.0	997.5	1000.8	1002.0	999.5
12	999.0	1000.0	998.0	999.0	1000.0	997.0	1000.1	1001.8	998.2	998.3	999.1	997.0	997.8	999.0	996.0	998.6	1000.0	997.0	999.4	1001.0	997.9
13	998.3	1000.0	997.0	999.4	1001.0	997.8	999.7	1001.2	998.0	998.5	1000.4	996.8	998.1	999.1	996.6	998.7	1000.0	997.0	999.1	1000.0	998.0
14	998.4	1000.0	997.0	1000.1	1001.3	999.0	999.7	1000.9	997.9	999.3	4001.0	998.0	998.4	999.7	996.7	998.3	999.1	997.0	999.6	1000.2	998.2
15	998.9	1000.0	997.4	1000.0	1001.8	998.3	999.2	1000.2	997.2	999.5	1001.1	998.0	998.3	1000.0	996.1	998.5	1000.0	997.9	999.2	1000.0	997.0
16	999.4	1000.8	998.0	999.7	1001.0	997.5	998.8	1000.0	997.2	1000.7	1001.5	999.8	997.7	998.5	996.4	998.5	1000.0	997.1	999.2	1001.1	997.7
17	999.5	1001.0	997.9	1000.1	1002.8	998.0	998.4	999.8	996.1	1001.1	1002.9	1000.0	998.1	999.1	997.2	999.1	1000.9	997.9	998.9	1000.0	997.2
18	999.4	1000.0	997.2	1000.5	1002.1	998.5	998.5	1000.0	996.9	1000.7	1002.1	999.1	999.4	1000.1	998.1	998.5	1000.8	997.9	999.3	1000.3	998.0
19	999.0	1000.0	997.5	1000.4	1001.5	998.9	998.5	1000.0	997.1	1001.0	1001.0	1000.0	1000.0	1001.1	999.0	999.0	1000.0	997.2	999.5	1000.0	998.0
20	998.6	1000.0	997.0	1000.1	1002.6	997.9	997.7	999.0	995.7	999.7	1001.0	998.0	1000.1	1001.2	998.3	999.2	1000.0	997.5	998.7	1000.0	997.0
21	998.0	999.0	996.5	999.4	100.9	997.8	997.6	999.5	995.7	998.8	1000.0	997.0	999.4	1000.6	997.2	999.0	1000.0	997.5			
22	999.0	1001.0	997.7	998.3	999.9	996.9	997.5	999.0	995.3	999.2	1000.5	997.9	999.7	1000.8	997.4	999.4	1001.0	997.8			
23	999.1	1000.2	997.0	998.3	1000.0	996.9	997.9	999.2	996.0	999.8	1001.7	998.1	999.1	1000.2	997.3	1000.3	1001.0	999.0			
24	998.6	1000.0	996.6	998.4	1000.1	996.9	998.2	1000.0	996.0	999.1	1001.0	997.0	999.2	1000.0	997.9	998.8	1000.5	996.6			
25	998.1	999.0	996.5	997.9	999.8	996.1	998.7	1000.0	997.0	998.7	1000.5	997.0	999.4	1001.0	998.1	998.2	999.9	996.5			
26	997.6	999.0	996.0	996.1	1000.0	995.0	998.9	1000.7	997.8	999.5	1001.0	998.5	999.2	1000.0	998.0	998.2	999.5	997.0			
27	997.0	999.0	995.0	997.1	998.8	995.0	999.1	1000.3	997.8	999.8	1001.2	998.0	998.9	999.9	998.0	998.8	1000.0	997.0			
28	997.0	998.0	995.0	997.5	998.8	995.2	998.3	999.2	996.8	998.6	1000.0	996.5	998.9	1000.0	998.0	998.3	1000.5	996.9			
29				996.8	998.8	995.2	997.9	999.0	996.8	997.4	998.8	996.0	998.3	999.3	997.0	997.8	999.3	995.8			
30				997.1	998.4	995.2	997.5	998.9	996.2	998.0	999.5	996.3	998.8	1000.0	997.0	998.0	999.0	996.4			
31				997.4	998.8	996.0				996.9	998.4	996.1				998.7	1000.0	997.5			
Ave.	998.8	-	-	998.4	-	-	998.6	-	-	998.5	-	-	998.5	-	-	998.4	-	-	998.8	-	-
Max.	-	1001.0	-	-	1002.8	-	-	1002.3	-	-	1002.9	-	-	1001.2	-	-	1001.0	-	-	1002.0	-
Min.	-	-	995.0	-	-	995.0	-	-	995.3	-	-	994.8	-	-	995.2	-	-	995.0	-	-	994.8

Table C.6 Wind Speed and Direction at New Malano Station (1995)

Unit : M/S

Date	Feburuary				March				April				May				July				August			
	Mean	Max.	Min.	Direc.	Mean	Max.	Min.	Direc.	Mean	Max.	Min.	Direc.	Mean	Max.	Min.	Direc.	Mean	Max.	Min.	Direc.	Mean	Max.	Min.	Direc.
1	-	-	-	-	1.10	2.5	0.0	-	1.05	2.0	0.5	-	2.05	2.5	2.0	W	-	-	-	-	1.60	2.0	1.5	-
2	-	-	-	-	0.78	2.2	0.0	-	0.93	2.0	0.5	-	2.04	2.5	2.0	SE	-	-	-	-	0.85	1.5	0.2	-
3	-	-	-	-	0.54	2.5	0.0	-	1.34	2.0	0.5	-	1.91	2.0	1.5	S-SW	-	-	-	-	0.30	1.0	0.0	-
4	-	-	-	-	0.40	1.5	0.0	-	0.91	2.0	0.5	-	1.65	2.0	1.2	NE-E	-	-	-	-	0.43	2.0	0.0	-
5	-	-	-	-	0.50	1.5	0.0	-	0.80	2.0	0.5	-	1.58	1.9	1.2	NE	-	-	-	-	0.36	1.0	0.0	-
6	-	-	-	-	0.89	2.0	0.0	-	0.83	2.0	0.2	-	1.86	2.0	1.6	N-NW	-	-	-	-	0.49	1.8	0.2	-
7	-	-	-	-	0.98	2.0	0.5	-	0.62	1.0	0.5	-	1.96	2.2	1.9	NW	-	-	-	-	0.45	1.5	0.2	-
8	-	-	-	-	1.15	2.0	0.5	-	0.64	2.0	0.0	-	1.91	2.3	1.5	SE-E	-	-	-	-	0.62	1.8	0.2	-
9	-	-	-	-	0.50	0.5	0.5	-	0.50	0.5	0.5	-	1.80	2.0	1.3	E	-	-	-	-	0.30	0.8	0.0	-
10	1.25	2.0	0.5	-	0.73	2.0	0.5	-	0.33	0.5	0.5	-	1.70	2.0	1.3	N	-	-	-	-	0.48	2.0	0.0	-
11	1.24	2.2	0.5	-	0.85	2.0	0.0	-	1.08	2.0	0.0	N-NW	2.14	3.6	1.5	NW	-	-	-	-	0.50	2.8	0.2	-
12	1.08	2.0	0.5	-	1.27	2.5	0.5	-	1.63	2.5	1.5	SE	1.96	3.0	1.3	S	-	-	-	-	0.45	1.8	0.2	-
13	0.73	2.0	0.3	-	1.33	2.0	0.0	-	1.76	2.1	1.4	SE-E	1.94	2.0	1.5	NW	-	-	-	-	0.65	2.5	0.2	-
14	0.94	0.3	2.0	-	1.73	2.2	1.5	-	1.87	2.2	1.5	SE	1.87	2.3	1.5	N-NW	-	-	-	-	0.45	1.8	0.2	-
15	0.70	2.0	0.2	-	1.64	2.0	1.0	-	1.47	2.1	1.0	SE-E	1.31	1.4	1.3	-	-	-	-	-	0.68	1.8	0.2	-
16	0.39	0.5	0.1	-	1.60	2.0	1.0	-	1.60	2.3	1.0	SE	-	-	-	-	-	-	-	-	0.56	1.8	0.4	-
17	0.69	2.0	0.0	-	1.65	2.0	1.5	-	1.63	1.9	1.0	SE-E	-	-	-	-	-	-	-	-	0.57	2.2	0.2	-
18	0.93	2.2	0.5	-	1.67	2.0	1.5	-	1.83	2.2	1.5	E	-	-	-	-	-	-	-	-	0.68	2.0	0.2	-
19	0.95	2.0	0.5	-	1.72	2.5	1.5	-	1.78	2.1	1.2	SE-E	-	-	-	-	-	-	-	-	0.51	1.0	0.2	-
20	1.13	2.2	0.5	-	1.43	2.0	1.0	-	1.50	1.5	1.5	SW-W	-	-	-	-	-	-	-	-	0.44	1.0	0.2	-
21	0.98	2.0	0.5	-	1.39	2.0	1.0	-	1.74	2.0	1.5	NW-W	-	-	-	-	-	-	-	-	0.30	0.5	0.0	-
22	0.31	0.5	0.0	-	1.05	2.0	1.0	-	1.65	2.0	1.5	N-NW	-	-	-	-	-	-	-	-	0.41	1.6	0.0	-
23	0.45	1.5	0.0	-	0.85	2.0	0.0	-	1.74	2.0	1.0	N	-	-	-	-	-	-	-	-	0.30	1.8	0.0	-
24	0.51	1.0	0.3	-	0.97	2.0	0.5	-	2.00	2.0	2.0	E	-	-	-	-	-	-	-	-	0.19	1.0	0.0	-
25	1.03	2.0	0.3	-	1.01	2.5	0.0	-	2.08	3.0	2.0	N-NW	-	-	-	-	-	-	-	-	0.26	0.8	0.0	-
26	0.60	1.5	0.5	-	0.77	2.0	0.5	-	1.98	2.5	1.5	E	-	-	-	-	1.62	2.2	1.0	-	0.33	2.4	0.2	-
27	0.88	2.2	0.0	-	0.79	2.0	0.5	-	2.05	3.0	1.3	NW	-	-	-	-	1.50	2.0	1.0	-	0.33	1.8	0.0	-
28	1.20	2.5	0.5	-	0.59	1.5	0.0	-	2.15	2.5	2.0	N	-	-	-	-	1.36	2.0	1.0	-	0.48	2.2	0.2	-
29					0.65	1.0	0.5	-	2.10	2.5	2.0	N	-	-	-	-	1.55	2.0	1.0		0.35	0.8	0.2	
30					1.10	2.0	0.5	-	2.02	2.2	2.0	NE	-	-	-	-	1.46	2.0	1.0		0.23	0.5	0.2	
31					0.79	1.8	0.5	-					-	-	-	-	1.63	2.0	1.5					
Avc.	0.84	-	-		1.05	-	-		1.45	-	-		1.85	-	-		1.52	-	-		0.48	-	-	
Max.	-	2.5	-		-	2.5	-		-	3.0	-		-	3.6	-		-	2.0	-		-	2.8	-	
Min.	-	-	0.0		-	-	0.0		-	-	0.0		-	-	1.2		-	-	1.5		-	-	0.0	

Table C.7 Pan Evapolation at New Malano Station (1995)

Unit : mm

Date	Feburuary	March	April	May	June	July	August
1	-	2.9	2.5	-	-	-	-
2	-	2.0	-	1.1	-	-	-
3	-	2.4	2.1	-	-	-	-
4	-	2.5	-	-	1.5	-	-
5	-	1.7	-	-	2.8	-	2.1
6	-	2.0	1.2	-	-	-	-
7	-	1.4	-	-	1.2	-	-
8	-	1.4	1.3	1.6	-	-	-
9	-	-	-	-	-	-	2.7
10	-	-	-	1.0	-	-	-
11	-	2.2	1.7	2.0	-	-	-
12	-	1.8	1.4	-	-	-	-
13	-	1.8	1.1	0.9	-	-	2.0
14	2.4	2.8	2.0	-	-	-	-
15	3.4	1.5	1.6	1.9	-	-	1.0
16	1.2	-	2.4	1.7	1.2	-	-
17	2.3	-	1.2	2.3	-	-	-
18	2.7	1.4	3.1	1.7	-	-	-
19	2.9	2.8	1.2	-	-	-	0.5
20	2.7	-	1.8	-	1.4	-	1.6
21	1.5	1.7	1.6	0.6	-	-	-
22	0.3	0.7	1.9	1.4	-	-	-
23	1.7	1.2	1.7	2.2	-	-	-
24	2.6	-	-	1.2	-	-	-
25	0.7	-	-	-	-	-	-
26	1.3	-	-	-	-	-	-
27	3.3	-	-	-	-	-	-
28	1.4	1.3	1.8	-	-	-	-
29		1.4	2.1	-	-	-	-
30		1.9	1.6	-	-	-	-
31		-		-		-	-
Ave.	2.0	1.3	1.2	0.6	0.3	0.0	0.3
Max.	3.4	2.9	3.1	2.3	2.8	0.0	2.7
Min.	0.3	0.0	0.0	0.0	0.0	0.0	0.0

- Rainy Day

Table C.8 Sunshine Radiation at New Malano Station (1995)

Unit : %

Date	Feburuary	March	April
1	-	83.3	58.3
2	-	70.8	62.5
3	-	75.0	58.3
4	33.3	70.8	78.3
5	-	70.8	50.0
6	-	58.3	83.3
7	41.7	58.3	66.7
8	41.7	70.8	62.7
9	50.0	-	54.2
10	66.7	33.3	62.5
11	83.3	50.0	
12	83.3	16.7	
13	66.7	45.8	
14	66.7	50.0	
15	41.7	20.8	
16	66.7	NA	
17	50.5	NA	
18	70.8	NA	
19	79.2	NA	
20	79.2	NA	
21	58.3	NA	
22	58.3	NA	
23	66.7	NA	
24	58.3	62.5	
25	66.7	79.2	
26	79.2	58.3	
27	70.8	70.8	
28	75.0	70.8	
29		62.5	
30		70.8	
31		58.3	
Ave.	63.3	59.4	63.7
Max.	83.3	83.3	83.3
Min.	33.3	16.7	50.0

NA : Not available

APPENDIX D

RESULTS OF DISCHARGE MEASUREMENT

Table D.1 Results of Discharge Measurement

No	Date	Water Level in Elevation (m)	Water Level Reading at Malano AWLR (m)	Discharge (m^3/s)	Mean Velocity (m/s)
1	3-Feb-95	34.19		25.53	0.508
2	11-Feb-95	34.37		38.93	0.662
3	14-Feb-95	34.08		21.11	0.470
4	15-Feb-95	34.04		20.49	0.485
5	16-Feb-95	34.00		18.09	0.438
6	17-Feb-95	33.98		16.28	0.403
7	18-Feb-95	34.03		20.08	0.470
8	21-Feb-95	34.00		18.00	0.436
9	22-Feb-95	33.95		15.56	0.401
10	23-Feb-95	34.09		22.84	0.500
11	7-Mar-95	34.55	0.61	47.69	0.712
12	27-Mar-95	35.80	1.98	139.44	1.082
13	28-Mar-95	35.45	1.72	108.49	0.978
14	29-Mar-95	34.97	1.54	70.46	0.800
15	30-Mar-95	34.43	1.34	38.21	0.615
16	1-Apr-95	34.18	1.07	24.34	0.488
17	4-Apr-95	34.34	0.78	36.88	0.646
18	5-Apr-95	34.80	0.78	59.39	0.744
19	6-Apr-95	35.10	1.24	80.17	0.849
20	7-Apr-95	35.00	1.20	75.70	0.841
21	10-Apr-95	35.08	1.13	80.41	0.825
22	11-Apr-95	34.85	1.12	65.32	0.794
23	12-Apr-95	34.68	1.08	52.62	0.710
24	17-Apr-95	34.65	0.88	52.07	0.713
25	18-Apr-95	34.67	0.88	52.14	0.709
26	20-Apr-95	34.50	0.85	43.21	0.660
27	7-Aug-95	37.74		287.97	1.185
28	15-Aug-95	35.92		165.18	1.145
29	16-Aug-95	36.36		196.29	1.178
30	18-Aug-95	36.79		236.25	1.229
31	19-Aug-95	37.88		361.32	1.426
32	21-Aug-95	36.69		228.24	1.217
33	22-Aug-95	38.19		389.73	1.438
34	23-Aug-95	36.80		241.20	1.251
35	24-Aug-95	36.49		197.26	1.122
36	25-Aug-95	36.28		184.66	1.141
37	26-Aug-95	37.23		304.74	1.408
38	27-Aug-95	37.15		274.57	1.299
39	29-Aug-95	38.28		404.91	1.467
40	30-Aug-95	37.53		321.67	1.381
41	31-Aug-95	36.63		204.29	1.105
42	1-Sep-95	37.30		303.47	1.378
43	2-Sep-95	37.10		291.10	1.391
44	3-Sep-95	37.27		309.72	1.417
45	4-Sep-95	36.87		256.44	1.303

APPENDIX E

RESULTS OF SUSPENDED LOAD MEASUREMENT

Table E.1 Results of Suspended Load Measurement

No.	Date	Time	Position	Measured S.S Contents (mg/l)	Ave. S.S Contents (mg/l)	Flow (m^3/s)	Suspended Load Discharge (kg/s)
1	3-Feb-95	17:00	left middle right	168.0 15,756.0 107,580.0	41,168.0	25.53	1,051.0
2	11-Feb-95	12:00	left middle right	30,008.0 26,944.0 78,720.0	45,224.0	38.93	1,760.6
3	14-Feb-95	12:00	left middle right	6,220.0 13,244.0 23,040.0	14,168.0	21.11	299.1
4	15-Feb-95	9:30	left middle right	26,808.0 1,042.0 41,270.0	23,040.0	20.49	472.0
5	16-Feb-95	16:30	left middle right	27,620.0 2,986.0 9,060.0	13,222.0	18.09	239.2
6	17-Feb-95	17:40	left middle right	10,488.0 26,730.0 3,070.0	13,429.3	16.28	218.7
7	18-Feb-95	9:05	left middle right	138.0 94,220.0 22,408.0	38,922.0	20.08	781.7
8	21-Feb-95	16:58	left middle right	19,876.0 53,480.0 4,960.0	26,105.3	18.00	470.0
9	22-Feb-95	12:56	left middle right	9,284.0 41,790.0 7,590.0	19,554.7	15.56	304.3
10	23-Feb-95	10:55	left middle right	216.0 100,240.0 2,940.0	34,465.3	22.84	787.2
11	7-Mar-95	10:18	left middle right	152.0 41,630.0 11,560.0	17,780.7	47.69	847.9
12	27-Mar-95	13:05	left middle right	48.0 48.0 14,248.0	4,781.3	139.44	666.7

Table E.1 Results of Suspended Load Measurement

No.	Date	Time	Position	Measured S.S Contents (mg/l)	Ave. S.S Contents (mg/l)	Flow (m^3/s)	Suspended Load Discharge (kg/s)
13	28-Mar-95	11:00	left middle right	16.0 8,060.0 170.0	2,748.7	108.49	298.2
14	29-Mar-95	11:15	left middle right	64.0 11,782.0 160.0	4,002.0	70.46	282.0
15	30-Mar-95	10:40	left middle right	88.0 1,332.0 100.0	506.7	38.21	19.4
16	1-Apr-95	11:45	left middle right	82.0 150.0 30.0	87.3	24.34	2.1
17	4-Apr-95	12:15	left middle right	2,392.0 6,370.0 190.0	2,984.0	36.88	110.1
18	5-Apr-95	10:25	left middle right	700.0 320.0 280.0	433.3	59.39	25.7
19	6-Apr-95	10:20	left middle right	170.0 50.0 280.0	166.7	80.19	13.4
20	7-Apr-95	10:00	left middle right	3,180.0 60.0 30.0	1,090.0	75.70	82.5
21	10-Apr-95	11:15	left middle right	68.0 180.0 112.0	120.0	80.41	9.6
22	11-Apr-95	12:10	left middle right	28.0 6,210.0 140.0	2,126.0	65.32	138.9
23	12-Apr-95	11:55	left middle right	100.0 210.0 6,196.0	2,168.7	52.62	114.1
24	17-Apr-95	11:15	left middle right	155.0 216.0 5,290.0	1,887.0	52.07	98.3

Table E.1 Results of Suspended Load Measurement

No.	Date	Time	Position	Measured S.S Contents (mg/l)	Ave. S.S Contents (mg/l)	Flow (m^3/s)	Suspended Load Discharge (kg/s)
25	18-Apr-95	12:10	left middle right	156.0 217.0 5,586.0	1,986.3	52.14	103.6
26	20-Apr-95	11:55	left middle right	160.0 215.0 5,176.0	1,850.3	43.21	80.0
27	7-Aug-95	15:28	left middle right	86.0 88.0 76.0	83.3	287.97	24.0
28	15-Aug-95	12:00	left middle right	80.0 70.0 70.0	73.3	165.18	12.1
29	16-Aug-95	15:15	left middle right	88.0 84.0 68.0	80.0	196.29	15.7
30	18-Aug-95	17:05	left middle right	60.0 66.0 80.0	68.7	236.25	16.2
31	19-Aug-95	16:05	left middle right	122.0 88.0 98.0	102.7	361.32	37.1
32	21-Aug-95	15:30	left middle right	76.0 108.0 190.0	124.7	228.24	28.5
33	22-Aug-95	10:28	left middle right	80.0 84.0 72.0	78.7	389.73	30.7
34	23-Aug-95	10:00	left middle right	64.0 76.0 92.0	77.3	241.20	18.7
35	24-Aug-95	12:32	left middle right	89.0 226.0 32.0	115.7	197.26	22.8
36	25-Aug-95	11:15	left middle right	64.0 82.0 70.0	72.0	184.66	13.3

Table E.1 Results of Suspended Load Measurement

No.	Date	Time	Position	Measured S.S Contents (mg/l)	Ave. S.S Contents (mg/l)	Flow (m^3/s)	Suspended Load Discharge (kg/s)
37	26-Aug-95	11:05	left middle right	84.0 98.0 14.0	65.3	304.74	19.9
38	27-Aug-95	11:10	left middle right	82.0 36.0 44.0	54.0	274.57	14.8
39	29-Aug-95	12:15	left middle right	82.0 76.0 56.0	71.3	404.91	28.9
40	30-Aug-95	12:30	left middle right	48.0 68.0 76.0	64.0	321.67	20.6
41	31-Aug-95	11:45	left middle right	80.0 78.0 52.0	70.0	204.29	14.3
42	1-Sep-95	14:50	left middle right	52.0 56.0 56.0	54.7	303.47	16.6
43	2-Sep-95	12:10	left middle right	158.0 156.0 84.0	132.7	291.10	38.6
44	3-Sep-95	12:50	left middle right	138.0 150.0 148.0	145.3	309.72	45.0
45	4-Sep-95	11:10	left middle right	132.0 134.0 146.0	137.3	256.44	35.2

APPENDIX F

TIDE LEVEL

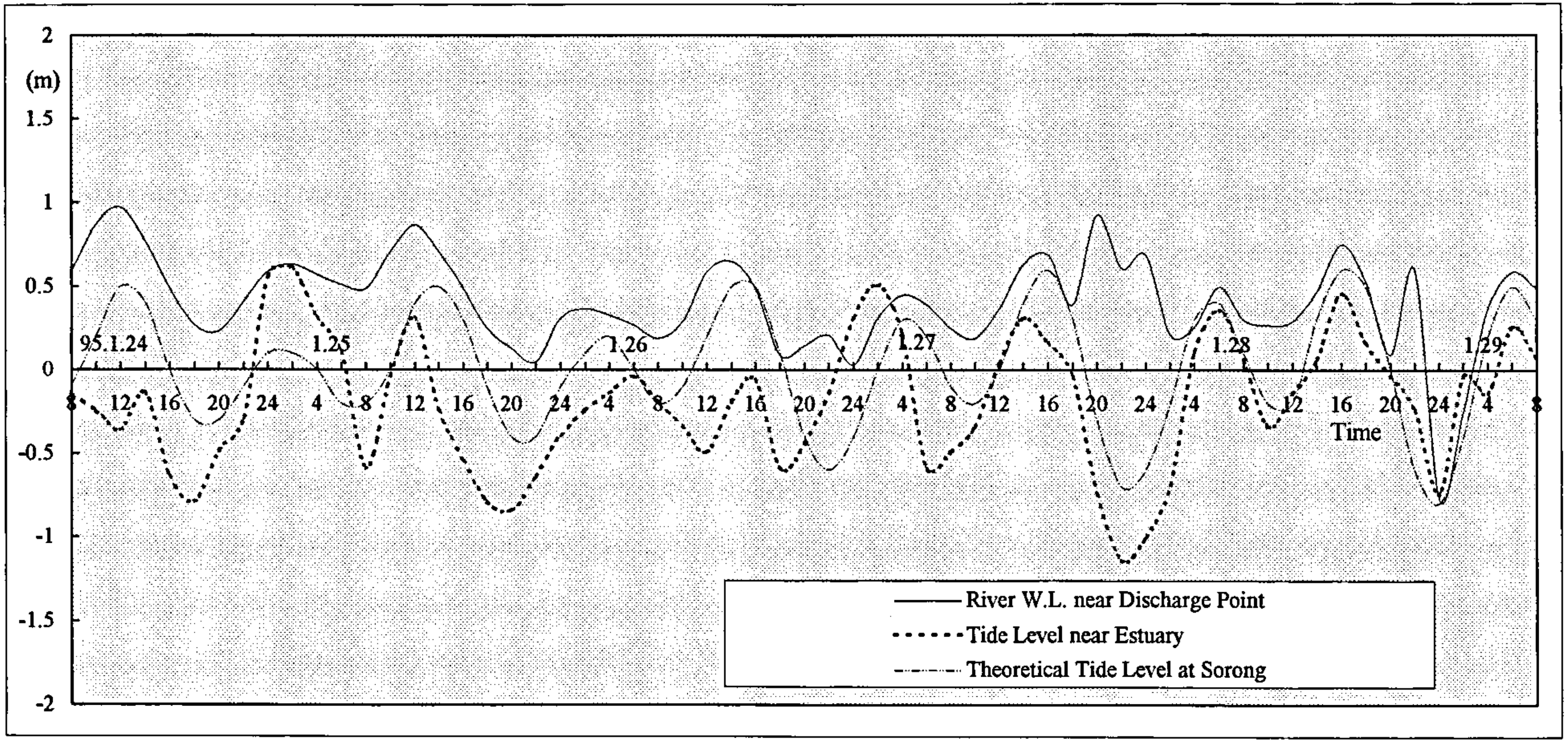


Fig F.1 Results of Water Level Measurement (1/3)

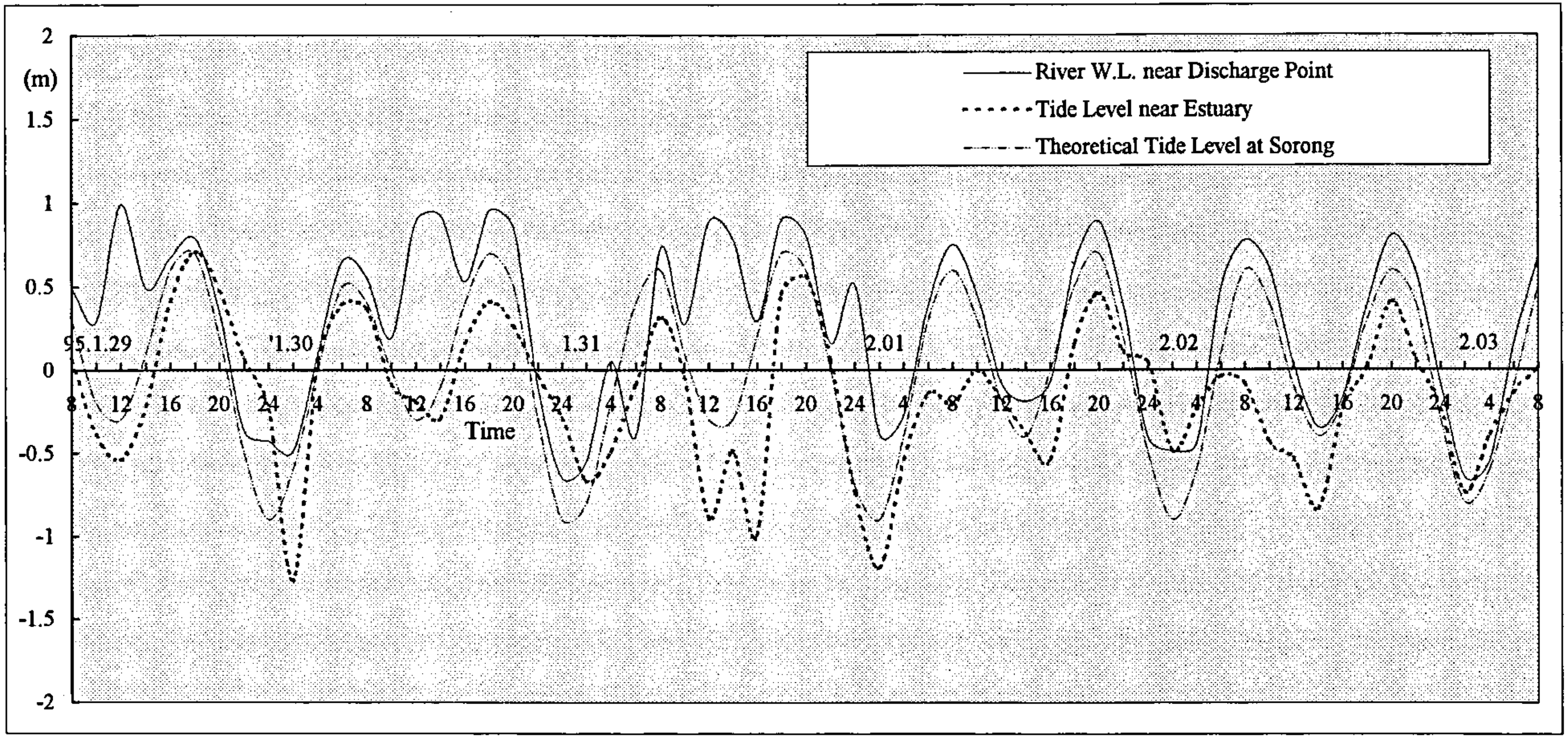


Fig F.1 Results of Water Level Measurement (2/3)

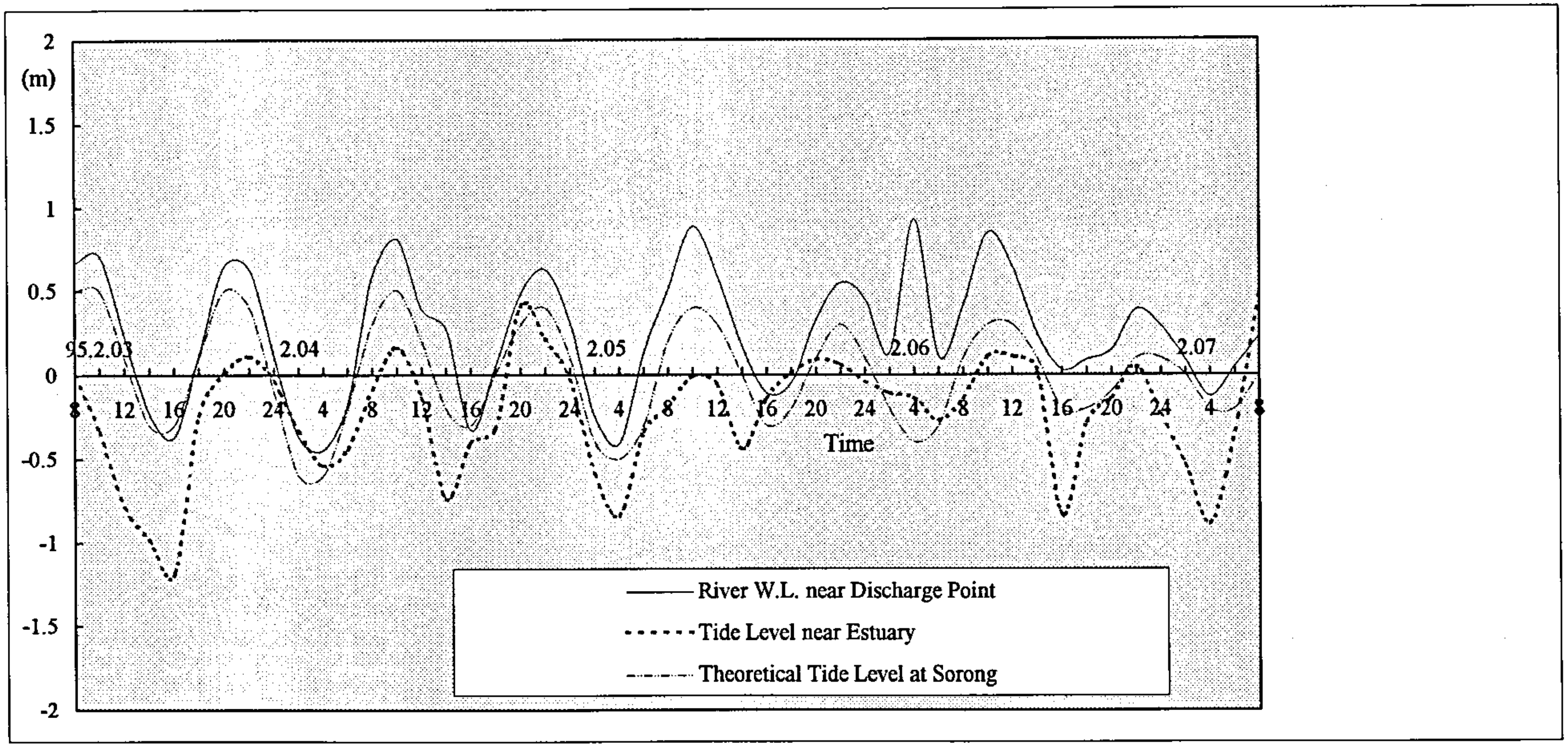


Fig F.1 Results of Water Level Measurement (3/3)

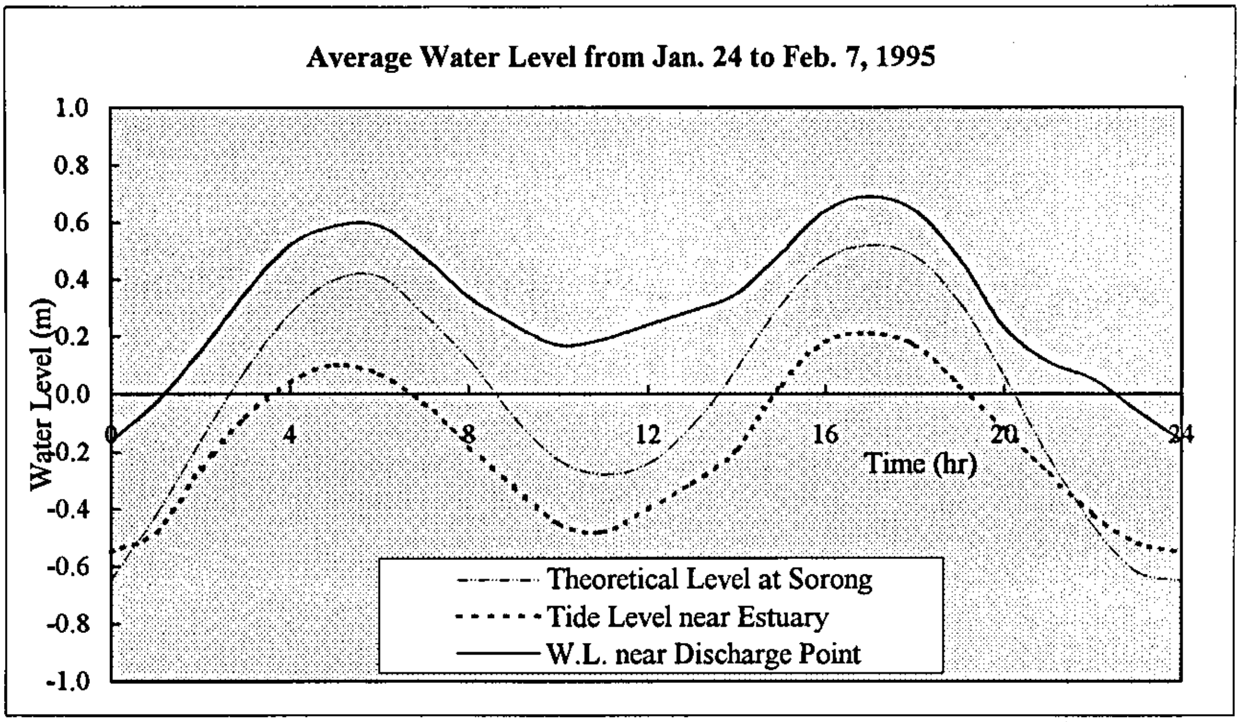


Fig. F.2 Average Water Level

VOLUME - II TOPOGRAPHIC SURVEY

Table of Contents

CHAPTER 1 PLANNING AND PREPARATION

In accordance with the Scope of Wok agreed upon between PT. PLN (PERSERO) and JICA, the JICA Study Team prepared the technical specifications for Aerial Photography and Topographic Survey and made contract with PT. AEROKARTO INDONESIA to coduct survey activities.

In accordance with the Cntract Document, PT. AEROKARTO INDONESIA prepared work plan, time schedule, personnels, instruments, distribution of Bench Mark, survey control network plan, flight plan and permission letters needed for implementation of the work.

Security Clearance for Aerial Photography was obtained from Pussurta ABRI No.SC-065/P/SPA/XII/93 dated on January 21,1994.

CHAPTER 2 MONUMENTATION

16 monuments, which were established in the planning and preparation work for the project, were installed with the type and size as shown in appendix 2.1.

All concrete monuments were described and documented with sketches and photographs providing detailed information about monuments such as coordinates, locations, access etc.

For description and location of concrete monuments, see Appendix 2.2.

CHAPTER 3 AERIAL PHOTOGRAPHY

3.1. General

The aerial photography of the Warsamson Hydroelectric Power Development project was carried out using Wild RC.20 camera by kinematic GPS method.
As reference point,SP.74 (Located at Biak island) was used :

Latitude	:	1° 10' 04.12100" S
Longitude	:	136° 05' 23.63200" E
Elevation	:	124.410 m

The benefit of Kinematic GPS are as follows :

- Especially in the Warsamson area which are covered with dense forest, Kinematic GPS will minimize the need of ground control point and will minimize tree cuting.
- Every Principle point of photograph has coordinates.
- Coordinates of every photo can be obtained immediately after post processing is completed.
- Aerial triangulation activity can be commenced as soon as diapositive is ready.
- A sub meter accuracy can be obtained.

3.2. Aerial Photography

a. Instrument Preparation

Instrument preparation activity consists of instrument setting and testing of GPS instrument which are used on the ground and in an aircraft.
Instrument setting in an aircraft is rather complex because it requires antenna setting, interconection between GPS receiver, camera and computer which must be integrated each other.

There are 5 (five) main elements to be set in an aircraft :

1. GPS antenna which is installed at 1.78 meters in front of a camera.
2. GPS receiver Trimble 4000 SSE.
3. Toshiba Laptop Computer.
4. Aerial camera WILD RC-20 FMC.
5. External clock (Rubidium).

b. Observation Method

Observation was done by a differential method, where one of receivers was installed on the reference point and the other one in the aircraft, and positions of GPS satellites were simultanously observed.

Using TOPAS software post processing, relative position between the reference point and antenna position on the aircraft was obtained. Center point position of photograph was obtained from aerial triangulation using PAT-B GPS software.

c. Observation Procedure

Before implementing the observation, preparation was done :

- Preparation of sky plot, satellite window, satellite availability before observation.
- Time planning and observation according to sky plot, satellite window, satellite avaibality and weather condition.

Observation was done simultanously, on the reference point and in the aircraft :

- Recording data 1 PPS GPS in the aircraft and 3 seconds data at the reference point.
- Sending GPS time signal from the receiver to the aircraft (after converted in computer) to print on every frame of film.
- Sending exposure signal from the camera to the GPS receiver.
- Recording (down loading) observation datas into diskete for post processing.

3.3. Post Processing

To obtain position of observation points, data 1 PPS from the aircraft and 3 seconds data from the reference point were proceed.

Coordinates of every center point of photograph was obtained after the following correction :

a. Differential Correction.

Differential correction is carried out in two stages and its basic concept is as follows :

1. According to a reference point position, an error of carrier phase is computed using 3 seconds data. This error is known as "differential correction".
2. Using differential correction from the reference point, to proceed datas from aircraft which have identical error.

As we know there are lot of errors in carrier phase data :

- Tropospheric error.
- Ionospheric error.

- Clock error.
- Multy path error.

According to the reference point position, errors are computed and corrected to antenna position on the aircraft.

b. Clock Correction (Clock error)

As we know, satellite uses an atomic clock and GPS receiver uses oscilator quartz which have different accuracy.

To avoid delay caused by accuracy of oscilator quartz, precise external clock (Rubium, Cesium) was installed which was used in the post processing.

c. Offset Correction

Position of antenna and center camera does not coincide, so center position of camera must be computed and corrected.

d. Position of Center of Photograph Computation

Position of antenna was corrected by correction factor, which was computed formerly.

Center position of camera was computed using aerial triangulation bundle adjustment method. PAT-B GPS software was used for adjusment.

3.4. Coordinate Transformation

From bundle adjusment computation it was obtained geographic coordinate in WGS '84. Coordinate of photo center in ID '74 was transformed from WGS '84 using DMA (Defence Mapping Agency) formula (according to Bakosurtanal's letter dated on October 28,1991) :

$$\begin{matrix} X \\ Y \\ Z \end{matrix}_{(ID\ '74)} = \begin{matrix} dX \\ dY \\ dZ \end{matrix} + (scale) \begin{matrix} 1 & -Rz & Ry \\ Rz & 1 & -Rx \\ -Ry & Rx & 1 \end{matrix} \begin{matrix} X \\ Y \\ Z \end{matrix}_{(WGS\ '84)}$$

Transformation parameter used are :

dX = - 2.691 m

dY = + 14.757 m

dZ = - 4.727 m

Rx = 0"

Ry = 0"

Rz = + 0.814"

K = + 0.600 PPM (S = 1 + K)

Aerial Triangulation was computed in cartesian coordinate system. Formula for the tranformation from geographic coordinate system to cartesian coordinate system are :

$X = (r + h)\ \text{Cos Lat} . \text{Cos Lon}$

$Y = (r + h)\ \text{Cos Lat} . \text{Sin Lon}$

$Z = (r - h)\ \text{Sin Lat}$

$$r = \frac{a}{(1 - e2.\text{Sin } 2\text{Lat})2}$$

3.5. Printing and Editing

a. Processing Film.

Processing of film is a very importand process, due to this step will determine quality of paper print and diapositive film. This step was supervised by a laboratorium supervisor.

b. Annotation.

Every photograph have to be annotated to simplify in finding photograph in the next future. Annotation consist of :

- Roll number of film
- Time of exposure
- Date of exposure
- Project owner
- Location of survey area
- Scale of photograph
- Number of flight line
- Number of photograph every flight line

c. Flight Line Map

Flight line map was made to make easy and fast in finding photograph.

Flight line map was made at scale of 1 : 100.000. Number of photograph and number of flight line were included in that map.d. Printing Paper and Diapositive.

Two sets of aerial photograph were printed in double weight paper and one set diapositive printed in film material.

3.6. Personnel and Equipment

<u>Personnels</u>

1. Ir.Indra Ranadireksa	: Photography Engineer
2. Ir. Kurniawati	: Coordinator
3. Capt. Martono	: Pilot
4. Evi Sufina	: Mechanic
5. Rochadi Pramugari	: Navigator
6. Endang Kusmana	: Camera Operator
7. Sugiyo	: Laboratory Technician
8. Rachmat Suryana	: Laboratory Technician
9. Saidi	: Laboratory Technician
10. Budi Riyanto	: Annotator
11. Rasmanto	: Draftsman
12. Peltu Sudiarto	: Security Officer

<u>Equipments</u>

1. Aircraft Taurus King Air Reg. No. PK - VKY
2. Aerial Camera Wild RC - 20 No. 13123
3. Trimvec Kinematic GPS
4. PAT-B GPS Software
5. Rewind processor
6. Developing machine
7. Rinsing machine
8. Contact printer Aerotopograph KG - 30
9. Dryer
10. Dark room facilities
11. Annotation table
12. Drafting table
13. Drafting equipment
14. Camera reproduction
15. Vehicle.

CHAPTER 4 FIELD VERIFICATION

Field verification was executed using 4 times enlarged aerial photograph at scale of 1 : 2,500 map and 2 times at scale of 1 : 10,000 map.

All objects on the photographs were verified according to the map symbol. Uninterpretable objects were also notated including bridges, roads, rivers, vegetations etc.

All necessary data such as name of villages, Kecamatan, Kabupaten, and its boundary were identified and plotted on the 4 times and 2 times enlarged photograph.

CHAPTER 5 CONTROL POINT SURVEY

5.1. General

Control point survey by GPS observation in Warsamson Hydroelectric Power Development Project is to obtain coordinates of control points which have been established in the survey area. The coordinates will be used to produce topographic map at scale of 1 : 10,000 and 1 : 2,500.

Distribution of control points are selected on requirement of aerial triangulation, 12 control points were distributed for mapping at scale of 1 : 10,000 in 200 square km area and 4 control points were distributed for mapping at scale of 1 : 2,500.

GPS observation network were tied to Doppler Station N.6007/SP5 in Sorong. Coordinate of N.6007/SP5 was obtained from Bakosurtanal.

The coordinates which were obtained from GPS observation are in WGS '84 ellipsoid reference which then transformed to ID '74 as a national ellipsoid reference.

Instruments which were used in this work were GPS receivers Leica System 200 survey type and SKI software version 1.08 from Leica for data processing.

GPS observation have been executed from January 15, 1994 to February 15, 1994 and data processing executed from February 20, 1994 to March 3, 1994.

5.2. GPS Observation

a. Preparation.

Before implementing GPS observation, selecting the control points have to be done in order to fulfill the requirement of aerial triangulation.

Permission letter from Pussurta ABRI was needed for field survey work. Permission Letter was obtained from Pussurta ABRI no. SC-040/D/SPA/XII/93 dated on January 13, 1994.

b. GPS Observation.

Before observation of GPS satellites, almanac collection was done in survey area to obtain the best time for satellite observation according to GDOP and PDOP. Almanac of GPS satellite was made using latitude and longitude argument.

Satellite observation were executed on 16 control points :

W.01, W.02, W.03, W.04, W.05, W.06, W.07, W.08, W.09, W.10, W.11, W.12, W.13, W.14, W.15, W.16

and 8 Spot Elevation Survey :

SPOT.A, SPOT.B, SPOT.C, SPOT.D, SPOT.E, SPOT.F, SPOT.G, SPOT.H and tied to Doppler Station N.6007/SP5 which it coordinates was given by Bakosurtanal. Satelitte observation was executed using two GPS receiver Leica system 200 which using dual frequencies for 1 hour and were tied to N.6007/SP5 for 1.5 hours. Cut off angle satellite observation was 15 degrees and observation record rate was 15 seconds. Satellite observations were using differential carrier phase static method.

5.3. Data Processing

Data processing was carried out using SKI software version 1.08 from Leica.

a. Base Line Computation.

Preliminary computation was base line computation. The coordinates of every control points, the length of the base line and the accuracy of measurement were obtained from the base line computation.

b. Network Adjustment.

SKI software version 1.08 from Leica was used for network adjustment. This package program computed network control point in cartesian coordinate with least square adjustment. N.6007/SP5 which has Geodetic and UTM grid coordinates in WGS '84 was used as reference point with its coordinates are as follow :

Geodetic coordinate :

Latitude = 0° 52' 30.644370" S

Longitude = 131° 15' 12.873080" E

Elevation = 141.390 m (above ellipsoid reference)

UTM Grid coordinate :

Northing = 750,802.593 m

Southing = 9,903,190.983 m

Elevation = 65.924 m (according to Sorong peil)

c. Datum Transformation.

The result of coordinates from network adjustment were transformed from WGS '84 to ID '74 using transformation parameter :

dX = - 2.691 m

dY = + 14.757 m

dZ = - 4.727 m

Rx = 0"

Ry = 0"

Rz = + 0.814"

K = + 0.600 PPM (S = 1 + K)

The final result of geodetic coordinate and UTM grid are on ID '74 reference ellipsoid. (See Appendix 5.1)

Accuracy of GPS Observation.

No.	Point Number	Latitude (meter)	Longitude (meter)
1.	W.01	0.01072	0.01934
2.	W.02	0.01407	0.02235
3.	W.03	0.00892	0.01736
4.	W.04	0.01465	0.02282
5.	W.05	0.00675	0.01073
6.	W.06	0.00459	0.00661
7.	W.07	0.01566	0.02349
8.	W.08	0.02347	0.10192
9.	W.09	0.02315	0.10175
10.	W.10	0.00388	0.00437
11.	W.11	0.02962	0.18020
12.	W.12	0.00848	0.00985
13.	W.13	0.00467	0.00529
14.	W.14	0.00939	0.01131
15.	W.15	0.01155	0.01315
16.	W.16	0.02296	0.10166
17.	SPOT.A	0.00401	0.00589
18.	SPOT.B	0.00760	0.01466
19.	SPOT.C	0.00759	0.01661
20.	SPOT.D	0.01280	0.02106
21.	SPOT.E	0.01335	0.02155
22.	SPOT.F	0.00765	0.01570
23.	SPOT.G	0.03825	0.15605
24.	SPOT.H	0.02277	0.10162

5.4. Personnel and Equipment :

Personnels :

1. Ir. Mohamad Soleh	: Coordinator/Surveyor
2. Ir. Judi	: Surveyor
3. Noerqamar Aroeppala	: Assistant Surveyor
4. Abdul Gafur	: Assistant Surveyor

Equipments :

1. 2 (two) sets of GPS receiver Leica system 200 survey type consist of :
   Sensor Wild SR299 No : 100506, 100533.
   Controller Wild CR233 No : 93183, 93181.

2. Radio Comunication Kenwood	: 2 sets
3. Note Book Computers USA COM	: 2 sets
4. Generator set Honda	: 2 sets
5. SKI Software	: 2 sets

CHAPTER 6 LEVELLING

6.1. General

Vertical control points in the Warsamson Hydroelectric Power Development Project were required for aerial triangulation computation. The aerial triangulation result will be used to prepare topographic maps at scale of 1 : 2,500 and 1 : 10,000.
Total measurement length of direct levelling was 160.103 km and was tied to Sorong peil BM PLB at the Sorong harbour and BM KTJ in Pertamina estate. Map of levelling route, see Appendix 6.1

6.2. Personnel and Equipment

Personnels :

1. Suparmanto	: Surveyor
2. Suwandi	: Surveyor
3. Widodo	: Surveyor
4. Abdul Gafur	: Supervisor

Equipments :

1. TOPCON ATS 3	: 2 set (Instr. No. C.102 and E.041).
2. WILD NAK 1	: 1 set (Instr. No. 472740).

6.3. Observation

Vertical control point survey was carried out using direct levelling observation and was tied to BM KTJ which has elevation 2.504 m above mean sea level. Bench mark ABT.2 which was proposed in pre feasibility study report was not used, the bench mark does not exist any more because of bridge construction.
Levelling observation was carried out using double standing observation, first observation reads all three thread and second observation only middle.

6.4. Computation

Different elevetion was computed from observation 1 and observation 2.
Mean different elevation was obtained from :
d h = 1/2 (Obs.1 + Obs.2).

where,

d h : mean different elevation

Obs.1 : different elevation from observation 1

Obs.2 : different elevation from observation 2

6.5. Accuracy

Discrepancy of levelling observation : +/- 50 mm $\sqrt{S}$ where S is the length in kilometer of a single run.

Point	S (km)	Height Difference I (m)	Height Difference II (m)	Error (mm)	Tolerance (mm)	Remarks
BM KTJ T. Mariat	31.9	178.675	178.645	30	282	OK
DP. 6 W.04	24.2	11.393	11.402	9	245	OK
DP. 16 W.08	18.7	146.166	146.152	14	216	OK
SPOT. C SPOT. F	2.2	20.849	20.854	5	74	OK
W.03 SPOT. D	5.4	-31.891	- 31.929	38	116	OK
HP.1 W.10	5.2	- 64.678	- 64.666	12	114	OK
HP.2 W.14	2.0	- 40.885	- 40.881	4	70	OK
HP.3 W. 12	2.2	24.403	24.395	8	74	OK
HP.4 SPOT. G	5.6	- 11.406	- 11.402	4	119	OK
HP. 5 W. 11	6.1	- 62.704	- 62.694	10	124	OK
HP. 6 SPOT. H	3.4	- 27.921	- 27.928	7	92	OK
HP. 7 W. 15	1.1	28.948	28.950	2	52	OK
HP. 8 W. 16	4.7	- 5.304	- 5.296	8	107	OK
HP. 9 W. 09	4.7	3.866	3.860	6	109	OK

CHAPTER 7 AERIAL TRIANGULATION

7.1. General

The Implication and purpose of Aerial Triangulation work is to obtain the coordinates (X,Y,Z) of the aerial photo points. The coordinates were required for the orientation process of each stereo model on the plotting instrument to produce topographic map at scale of 1 : 10,000 and 1 : 2,500.

Ground control points resulted from field measurement (GPS survey and levelling survey) were used as reference points.

7.2. Aerial Triangulation and Block Adjusment

The sequence of works to be carried out as follows :

a. Data Collection

All necessary datas were collected and prepared such as :

- Flight index
- Control points coordinate and description
- Calibration report of the aerial camera etc.

b. Planning

Preparation of aerial triangulation was carried out as follows :

- Selecting of the aerial photos.

  Total model of the aerial photos were 204 models.

- Control Point Selection

  14 horizontal control points and 11 vertical control points were selected as control for the aerial triangulation processing.

c. Preparation

Stages of preparation were carried out as follows :

- Point selection and numbering

  Pass points and tie points were selected within the triple overlap area with the Circle notation on the index model.

Numbering system was carried out as follows :

Model number <u>141</u> <u>12</u> <u>0</u>

1 2 3

where,

1	= Course number
2	= Photo number
3	= Principle point

- The horizontal and vertical control points were annotated on the index models as a square (□), and vertical control points were annotated as triangle (   ).

The point selection and the numbering were carried out on the 1 : 20,000 and 1 : 10,000 scale of the aerial photographs by using a mirror stereoscope.

d. Point Transfer

The selected points and control points on one diapositive film were marked. The points were transfered to adjacent diapositive film by using Wild PUG.4 instrument, and this activity was carried out until the last photos.

e. Index Model

The index model at scale of 1 : 100.000 was produced.

All point numbers were plotted, to show the relationship between each points in the index model.

f. Measurement of Coordinates

Photo coordinates were observed and measured using a stereo comparator Zeiss Stecometer equipped with digitizer. All points including fiducial mark were measured.

g. Adjustment

The final step of the aerial triangulation is the block adjustment using PAT-B.

Accuracy of the aerial triangulation block adjusment result are as follows :

Standard Deviation of Terrain Points in Units of Terrain System

Element	Point Number	Standard Deviation Value		
		Minimum	Maximum	Mean
X	100	0.113		
Y	100	0.112		
Z	100	0.232		
X	150082		2.927	
Y	150082		2.987	
Z	150081		6.226	
X				0.519
Y				0.517
Z				1.301

7.3. Personnel and Equipment

Personnels :

1. Ir.Kurniawati : Photogrammetric Engineer
2. Djudju Sardju : Coordinator
3. Prawito Sumargono : Op. for point selection
4. Sudirman BE : Op. for point selection
5. Maryono : Op. for point transfer
6. Rubin Subagja S. : Op. for point transfer
7. Harry Wibowo : Op. for measuring model coordinate
8. Mudjianto SE. : Op. for measuring model coordinate
9. N.Q. Aroeppala : Computer Analyst.

Equipments :

1. Stereoscope : 2 unit
2. Point transfer Wild PUG-4 : 1 unit
3. Stereo Comparator Zeiss Stecometer : 1 unit
4. Computer : 1 unit
5. PAT-B : 1 unit
6. Vehicle : 1 unit

CHAPTER 8 PLOTTING AND EDITING

8.1. General

The implication and purpose of stereo plotting and edit-ing work is to draw details and contour lines using aerial photo diapositives. The photo diapositives were placed on the plate holders of the stereo plotter instrument.

8.2. Plotting and Editing

The sequence of the work was carried out as follows :

a. Data Collection

All necessary datas were collected and prepared for stereo plotting such as :

- Model index of aerial triangulation.
- Print out of aerial triangulation adjustment
- Vertical Control points and description on two times enlarged aerial photographs.
- Field Identification Results on two times enlarged aerial photographs.

b. Preparation.

Preparation of Stereo Plotting was carried out as follows :

- Control Sheets.

Control sheets were produced on polyester base material. Coordinates from block adjusment computation were plotted on control sheets.

Total Control sheets of the stereo plotting were 9 sheets for topographic map at scale of 1 : 10,000 and 12 sheets for topographic map at scale of 1 : 2,500.

- Models

Total models of the stereo plotting were 70 Models for topographic map at scale of 1 : 10,000 and 21 Models for topographic map at scale of 1 : 2,500.

c. Plotting and Editing

Plotting manuscript at scale of 1 : 10,000 were carried out using aerial photos at scale of 1 : 20,000, and plotting manuscript at scale of 1 : 2,500 were carried out using aerial photos at scale of 1 : 10,000. Second order precision stereo plotter were used in stereo plotting work.

The sequence of the stereo plotting work are as follows :

1. Inner Orientation
2. Relative Orientation

3. Absolute Orientation

4. Plotting of Details, Spot heights, Vegetation boundaries and Contour lines.

Contour Interval for intermediate contour lines are 5 m for map at scale 1 : 10,000 and 2 m for map at scale 1 : 2,500.

Editing work was carried out on the plotting manuscript by compiling the result of field identification, such as : Symbols, Annotation etc.

d. Result

The final result of plotting and editing works were manuscript map :

- 9 sheets manuscript map at scale of 1 : 10,000.
- 12 sheets manuscript map at scale of 1 : 2,500.

8.3. Personnel and Equipment

Personnels :

1. Ir. Kurniawati	: Photogrammetric Engineer
2. Djudju Sardju	: Coordinator
3. Prawito Sumargono	: Stereo Plotter Operator
4. Harry Wibowo	: Stereo Plotter Operator
5. N.Q. Areoppala	: Stereo Plotter Operator
6. Rochadi P.	: Stereo Plotter Operator
7. Mudjianto SE.	: Stereo Plotter Operator
8. Sri suhartini	: Stereo Plotter Operator
9. Mardius	: Computer Operator
10. Triono	: Computer Operator
11. Ir. Mohamad Soleh	: Editor
12. Ir. Judi	: Editor

Equipment :

1. Computer	: 2 units
2. Roland Plotter	: 1 unit
3. Plotter Wild A-8	: 2 units
4. Plotter Wild AG-1	: 1 unit
5. Drafting table	: 3 units

CHAPTER 9 FAIR DRAWING

9.1. General

The implication and purpose of Fair Drawing work is to draw details using symbols and contour lines from manuscript map and other additional datas to provide a true and informative map. Tracing method was used for the drawing.

9.2. Fair Drawing

The sequence of the work was carried out as follows :

a. Data Collection.

All necessary datas were collected and prepared for fair drawing such as :

- Manuscript map.
- Vertical Control points and description on two times enlarged aerial photographs.
- Field Identification Results on two times enlarged aerial photographs.

b. Preparation.

Preparation of Fair Drawing were carried out as follows :

- Drawing Sheets.

Total 25 sheets were prepared which consist of :

11 sheets map at scale of 1 : 10,000 and

14 sheets map at scale of 1 : 2,500.

Polyester base material drawing sheets size are A1 (55 cm x 80 cm).

Numbering system is as follows (sample for map at scale of 1 : 10,000) :

Sheet number : 11 - 1

where, 11 = Total of sheets.

1 = Sheet number.

- Legend, Symbol.

Legend, symbol and annotation which were used for the map should be approved by the Engineer.

c. Fair Drawing.

Tracing method fair drawing was carried out using drawing pen and black ink from manuscript map at scale of 1 : 10,000 and 1 : 2,500.

Fair drawing works are as follows :

1. Drawing details
2. Spot heights and Contour lines
3. Symbols and annotations. On the map, symbols must be matched to legend.
4. Vegetation boundaries.

Contour Interval for intermediate contour lines are 5 m for map at scale of 1 : 10,000 and 2 m for map at scale of 1 : 2,500.
Other additional information and contour lines were adjusted by the field work.

d. Results.

The final results of the fair drawing are :
- 11 sheets of Topographic maps at scale of 1 : 10,000.
- 14 sheets of Topographic maps at scale of 1: 2,500.

9.3. Personnel and Equipment

Personnels :

1. Ir. Indra Ranadireksa	: Cartographic Engineer
2. Eka Ch. Ruslan	: Coordinator
3. Tulus Satmoko	: Editor
4. Ir. Umar Senoaji	: Editor
5. Budi Riyanto	: Draftsman
6. Rasmanto	: Draftsman
7. Ahmad Fauzi	: Draftsman
8. Ade Sutisna	: Draftsman
10. Hartini	: Draftsman
11. Triono	: Computer Operator
12. Mardius	: Computer Operator

Equipments :

1. Computer	: 2 unit
2. Roland Plotter	: 1 unit
3. Drafting table	: 9 unit
4. Drafting tools	: 9 unit

CHAPTER 10 RIVER LONGITUDINAL PROFILING

10.1. General

Work of river longitudinal profiling in the Warsamson Hydroelectric Power Development Project consist of :

- Setting of PVC for Spot Elevation Survey.
- Setting of wooden pegs for 30 - 200 m interval.
- Traversing and Longitudinal profiling.

10.2. Longitudinal Profiling

Longitudinal profiling has been carried out for 23.6 km along the rivers of : Warsamson, Klalin and Klasmigik.

Traverse survey using Total Station instrument was carried out to obtain coordinate. Longitudinal profiling along the rivers was carried out using automatic level instrument.

Accuracy of traverse survey obtained :

Route No.	Name	Initial Point	Terminal Point	Total Length (Km)	Accuracy	Tolerance 1 : 7,000
I	Jalur R	Spot. D	W.03	5.1	1 : 30,956	Ok
II	Jalur L	R.1	R'	2.3	1 : 20,676	Ok
III	Jalur C	PB.1	Spot. C	4.9	1 : 14,083	Ok
IV	Jalur F	Spot. C	Spot. F	5.5	1 : 10,135	Ok
V	S. Klalin	-	-	2.0	Open Trav.	-
VI	S. Klasmigik	-	-	6.1	Open Trav.	-
Total Distance = 23.6 Km.						

Note : Route I and II used only for Topographical Survey.

Two Longitudinal profiles along S.Klalin and two along S.Klasmigik were drawn at scale of 1 : 5,000 for horizontal and at scale of 1 : 100 for vertical while three longitudinal profiles along S.Warsamson were drawn at scale of 1 : 10,000 for horizontal and 1 : 200 for vertical. Total number of sheets are 7.

10.3. Personnel and Equipment

Personnels :

1. Rosikin : Surveyor
2. Suwandi : Surveyor

3. Suparmanto	: Surveyor
4. Warsito	: Surveyor
5. Widodo	: Surveyor
6. Suyono	: Surveyor

Equipments :

1. Total Station TOPCON	: 1 unit
2. Theodolite Wild T.0	: 4 unit
3. Automatic level Wild NA.2	: 1 unit

CHAPTER 11 RIVER CROSS SECTION

11.1. General

Measurement of River cross section was carried out along S.Warsamson, confluence of S.Klasaman, S.Klasuwuk and S.Klasway.

Cross section were drawn at scale of 1 : 200 for horizontal and 1 : 100 for vertical.

11.2. River Cross Section

River cross section were carried out in 15 places of S.Warsamson and in every confluence of S.Klasaman, S.Klasawuk and S.Klasway.

Total 18 cross section were drawn in 15 sheets cross section map.

11.3. Personnel and Equipment

<u>Personnels :</u>

1. Rosikin	: Warsito
2. Suwandi	: Widodo
3. Suparmanto	: Suyono

<u>Equipments :</u>

1. Total Station TOPCON	: 1 unit
2. Theodolite Wild T.0	: 4 units
3. Automatic level Wild NA.2	: 1 unit

CHAPTER 12 TOPOGRAPHIC SURVEY

12.1. General

Topographic survey were carried out at the proposed main structure site. Topographic survey was measured for mapping at scale of 1 : 500 with 1 meter interval contour.

12.2. Topographic Survey

Topographic survey were carried out at water fall of S.Warsamson.
Secondary traverse for topographic survey were tied to Route I and Route II which consist of 43 loops. Minimum accuracy obtained in this work is 1/ 3,500.
Traverse network for topographic survey for map at scale of 1 : 500 are Route I and Route II. From the secondary traverse detail points were measured by tacheometric method. Total area which were mapped are 0.6 square km. 10 sheets of the maps were drawn at scale of 1 : 500.

12.3. Personnel and Equipment

<u>Personnels :</u>

1. Rosikin	: Surveyor
2. Suwandi	: Surveyor
3. Suparmanto	: Surveyor
4. Warsito	: Surveyor
5. Widodo	: Surveyor
6. Suyono	: Surveyor

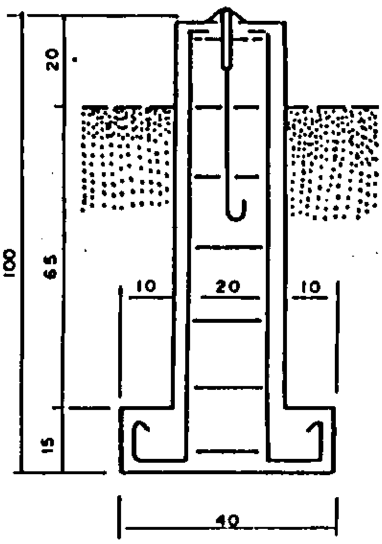
<u>Equipments :</u>

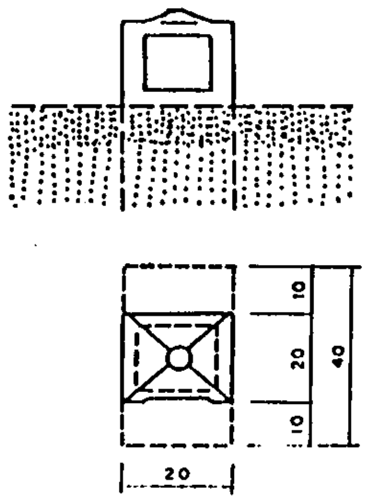
1. Total Station TOPCON	: 1 unit
2. Theodolite Wil T.0	: 4 units
3. Automatic level Wild NA.2	: 1 unit

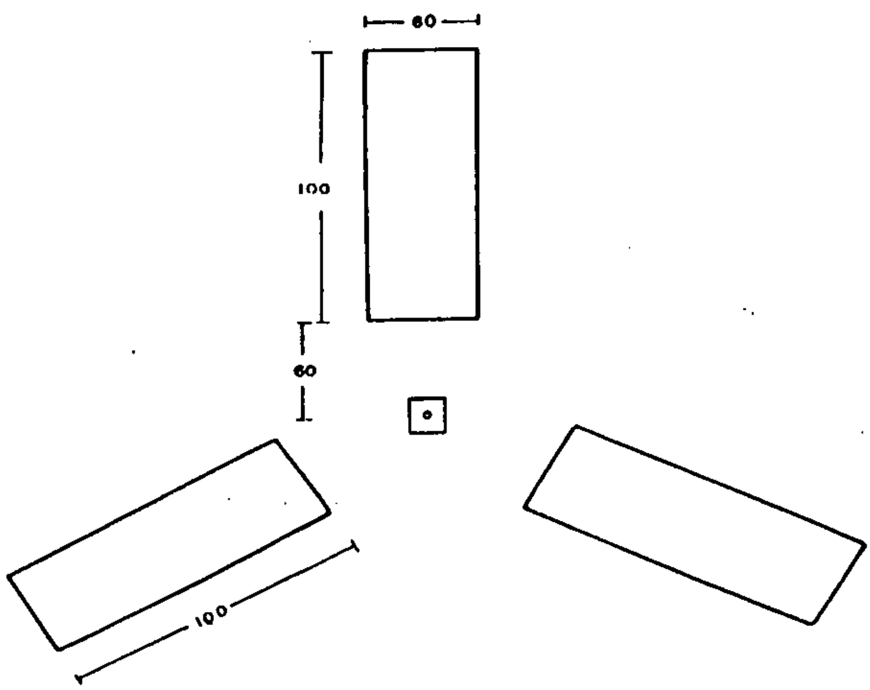
APPENDIX 2.1

TYPE AND SIZE OF MONUMENT

TYPE AND SIZE OF MONUMENT







APPENDIX 2.2

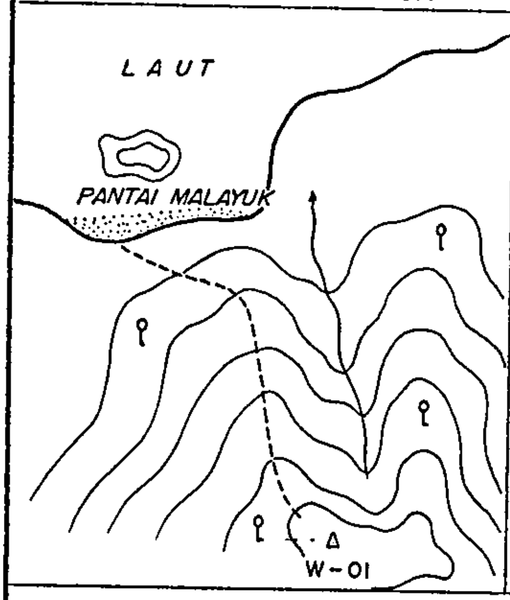
DESCRIPTION OF BENCH MARK

DESCRIPTION OF BENCH MARK AND PREMARK

STATION NO.	PLN. W – 01	SURVEYOR	Suparmanto
DESA	Batu Lobang	CHECKED BY	
KECAMATAN	Makbon	SET UP DATE	05–01–1994
KABUPATEN	Sorong	HEIGHT OF BENCHMARK	± 30 cm
PROVINCE	Irian Jaya	HEIGHT OF PREMARK	cm
ZONE NO.	52		

	COORDINATE OF STATION		
UTM COORDINATE	N (m)	E (m)	H (m)
BENCHMARK	9912043.270	763493.337	
PREMARK			
PRICKING POINT			

SKETCH – MAP OF STATION



DETAIL MAP OF STATION

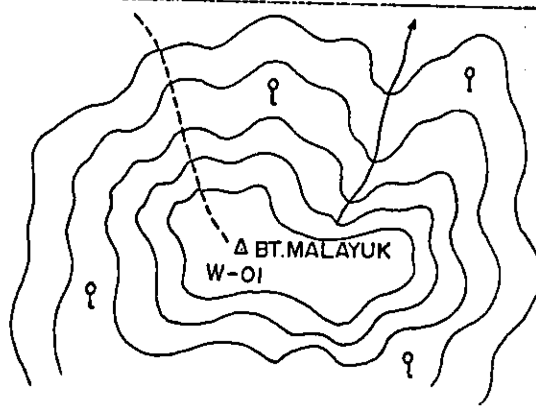


PHOTO OF STATION

REMARKS

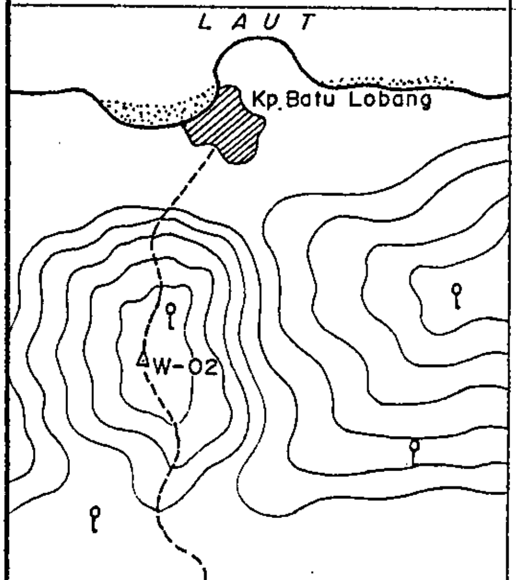
PLN. W – 01 terletak dibukit Malayuk, dapat di – tempuh melalui laut, dari desa Batu Lobang menuju ke pantai Malaguk naik perahu ± 3/4 jam dilanjutkan jalan kaki mengikuti jalan setapak menuju bukit Malayuk ± 1½ jam.

DESCRIPTION OF BENCH MARK AND PREMARK

STATION NO.	PLN. W - 02	SURVEYOR	Suparmanto
DESA	Batu Lobang	CHECKED BY	
KECAMATAN	Makbon	SET UP DATE	05-01-1994
KABUPATEN	Sorong	HEIGHT OF BENCHMARK	± 30 cm
PROVINCE	Irian Jaya	HEIGHT OF PREMARK	cm

ZONE NO. 52	COORDINATE OF STATION		
UTM COORDINATE	N (m)	E (m)	H (m)
BENCHMARK	9912929.911	769126.261	
PREMARK			
PRICKING POINT			

SKETCH-MAP OF STATION



DETAIL MAP OF STATION

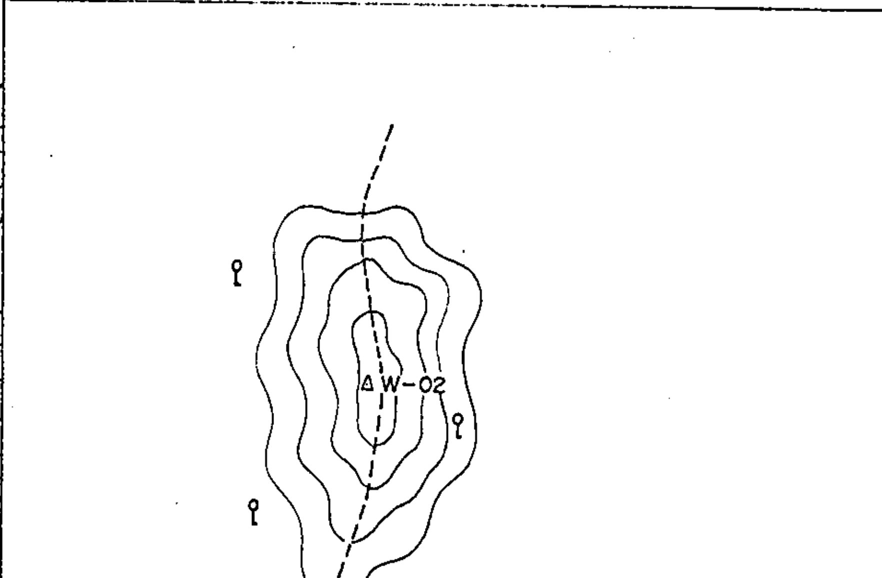
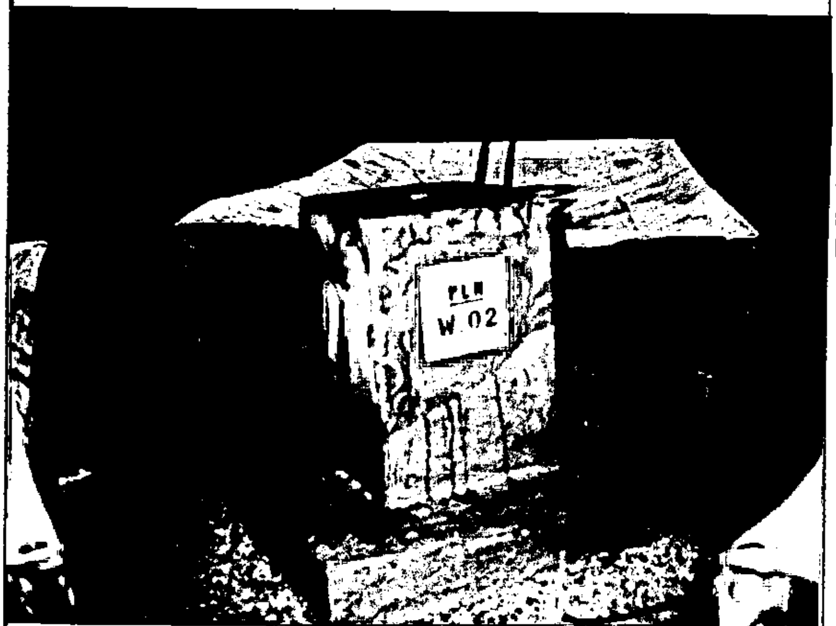


PHOTO OF STATION



REMARKS

PLN. W-02 terletak diatas bukit dipinggir jalan setapak antara proyek pembibitan coklat ke-arah desa Batu Lobang.
PLN. W-02 dapat ditempuh dengan mobil me-ngikuti jalan Sorong - Makbon, berhenti di-proyek pembibitan coklat lalu berjalan kaki me-ngikuti jalan setapak.
Dari pembibitan coklat, ± 1 ½ jam.

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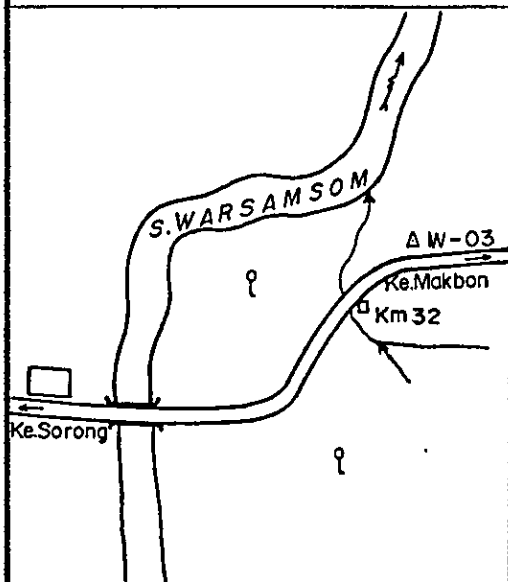
DESCRIPTION OF BENCH MARK AND PREMARK

STATION NO.	PLN. W – 03	SURVEYOR	Suparmanto
DESA	Batu Lobang	CHECKED BY	
KECAMATAN	Makbon	SET UP DATE	04-01-1994
KABUPATEN	Sorong	HEIGHT OF BENCHMARK	± 30 cm
PROVINCE	Irian Jaya	HEIGHT OF PREMARK	cm

ZONE NO. 52	COORDINATE OF STATION		
UTM COORDINATE	N (m)	E (m)	H (m)
BENCHMARK	9910447.042	767970.708	36.146
PREMARK			
PRICKING POINT			

SKETCH-MAP OF STATION



DETAIL MAP OF STATION

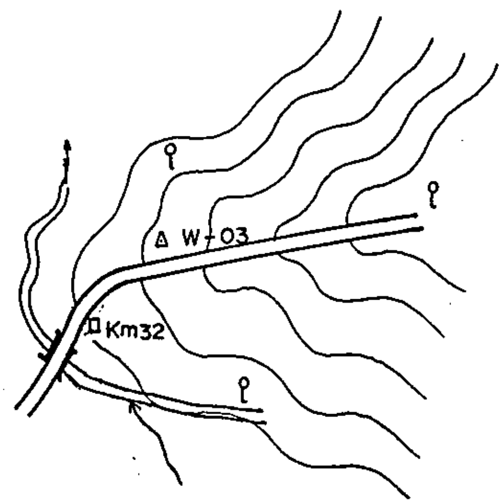


PHOTO OF STATION

REMARKS

PLN. W-03 terletak dipinggir jalan Sorong – Makbon, sebelah kiri jalan.
Dapat ditempuh dengan mobil dari Sorong ± 2 jam.

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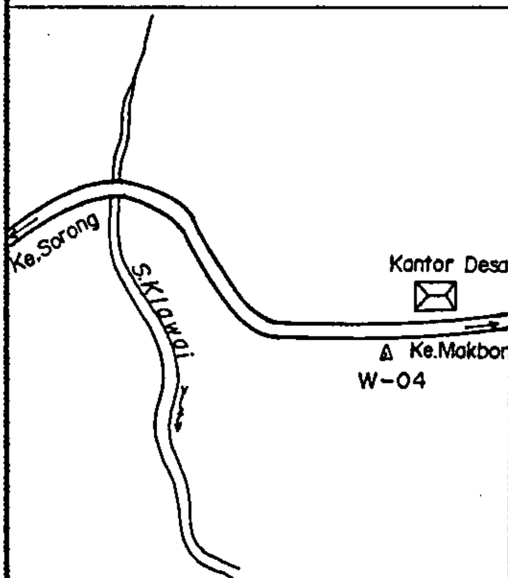
DESCRIPTION OF BENCH MARK AND PREMARK

STATION NO.	PLN. W – 04	SURVEYOR	Suparmanto
DESA	Batu Lobang	CHECKED BY	
KECAMATAN	Makbon	SET UP DATE	04-01-1994
KABUPATEN	Sorong	HEIGHT OF BENCHMARK	± 30 cm
PROVINCE	Irian Jaya	HEIGHT OF PREMARK	cm
ZONE NO.	52		

COORDINATE OF STATION			
UTM COORDINATE	N (m)	E (m)	H (m)
BENCHMARK	9912200.031	772243.397	17.267
PREMARK			
PRICKING POINT			

SKETCH-MAP OF STATION



DETAIL MAP OF STATION

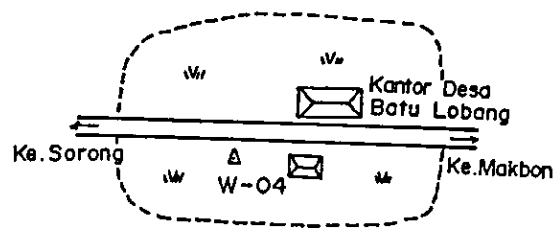


PHOTO OF STATION

REMARKS

PLN. W-04 terletak dipinggir sebelah kanan jalan Sorong – Makbon.
Dapat ditempuh dengan mobil, turun di kantor desa Baru Batu Lobang.
Dari kota Sorong menuju lokasi, ± 2½ jam.

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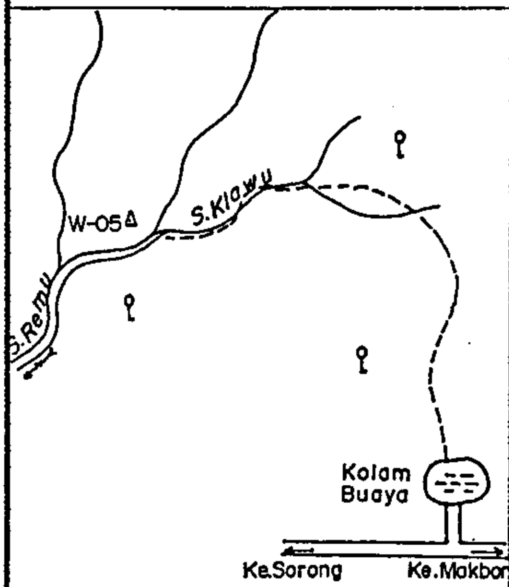
DESCRIPTION OF BENCH MARK AND PREMARK

STATION NO.	PLN. W – 05	SURVEYOR	Widodo
DESA	Malanu, Dukuh Malanu	CHECKED BY	
KECAMATAN	Sorong	SET UP DATE	08–01–1994
KABUPATEN	Sorong	HEIGHT OF BENCHMARK	± 30 cm
PROVINCE	Irian Jaya	HEIGHT OF PREMARK	cm

ZONE NO. 52	COORDINATE OF STATION		
UTM COORDINATE	N (m)	E (m)	H (m)
BENCHMARK	9906920.231	759652.299	
PREMARK			
PRICKING POINT			

SKETCH – MAP OF STATION



DETAIL MAP OF STATION

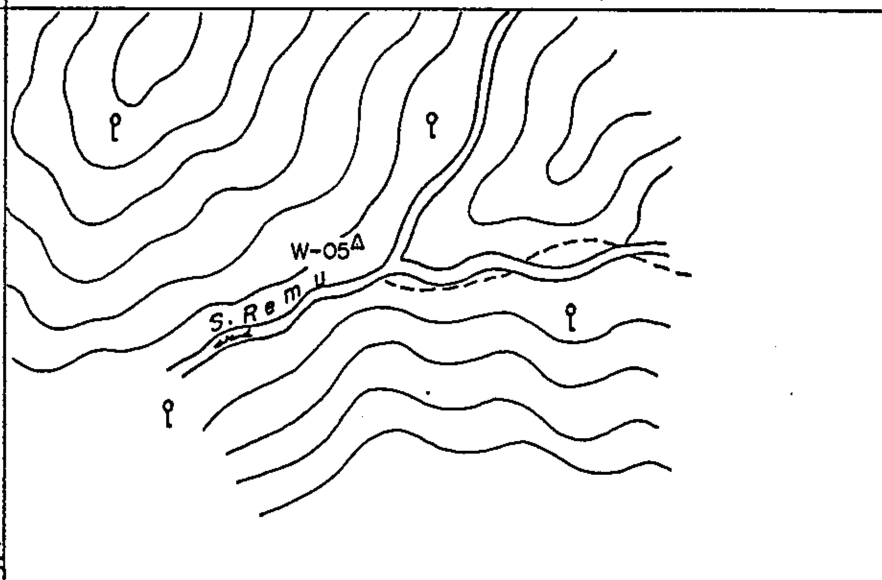


PHOTO OF STATION

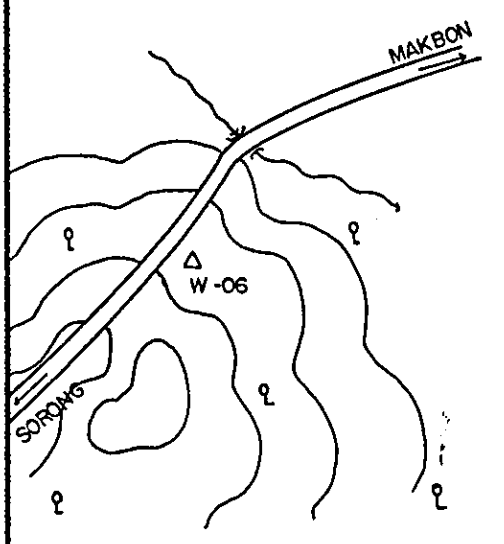
REMARKS

PLN. W–05 dipasang dimuara sungai Klawu ± 20 M. Dapat ditempuh dengan mobil melalui jalan Menuri menuju Kolam Buaya, dilanjutkan dengan berjalan kaki melalui jalan setapak ± 3½ jam.

DESCRIPTION OF BENCH MARK AND PREMARK

STATION NO.	PLN. W – 06		SURVEYOR	Suparmanto
DESA	Malanu		CHECKED BY	
KECAMATAN	Sorong		SET UP DATE	04–01–1994
KABUPATEN	Sorong		HEIGHT OF BENCHMARK	± 30 cm
PROVINCE	Irian Jaya		HEIGHT OF PREMARK	cm
ZONE NO.	52	COORDINATE OF STATION		
UTM COORDINATE	N (m)	E (m)	H (m)	
BENCHMARK	9904633.617	763547.284	95.478	
PREMARK				
PRICKING POINT				

SKETCH–MAP OF STATION



DETAIL MAP OF STATION

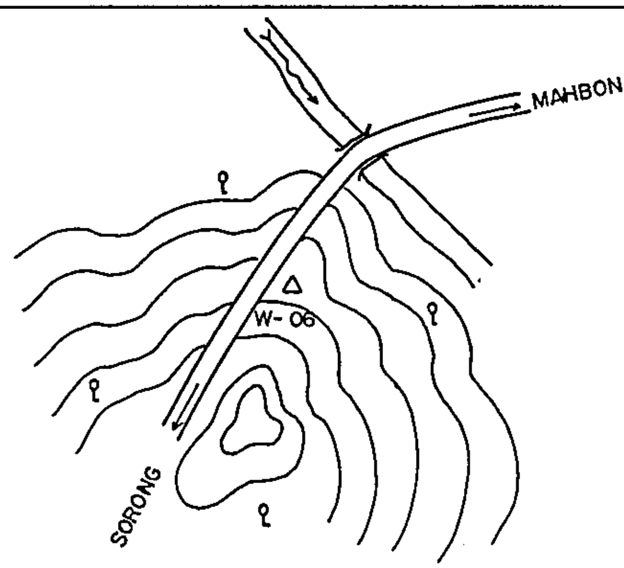


PHOTO OF STATION

REMARKS

PLN. W–06 terletak dipinggir jalan Sorong – Makbon, disebelah kanan jalan Km. , dapat ditempuh dengan mobil dari kota Sorong ± 1 jam.

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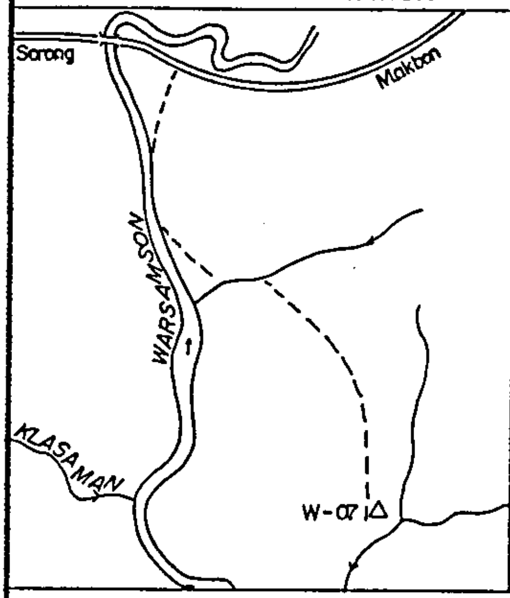
DESCRIPTION OF BENCH MARK AND PREMARK

STATION NO.	PLN. W – 07	SURVEYOR	Widodo
DESA	Batu Lobang, Dukuh Batu Lobang	CHECKED BY	
KECAMATAN	Makbon	SET UP DATE	07–01–1994
KABUPATEN	Sorong	HEIGHT OF BENCHMARK	± 30 cm
PROVINCE	Irian Jaya	HEIGHT OF PREMARK	cm

ZONE NO. 52	COORDINATE OF STATION		
UTM COORDINATE	N (m)	E (m)	H (m)
BENCHMARK	9906399.900	769550.663	
PREMARK			
PRICKING POINT			

SKETCH–MAP OF STATION



DETAIL MAP OF STATION

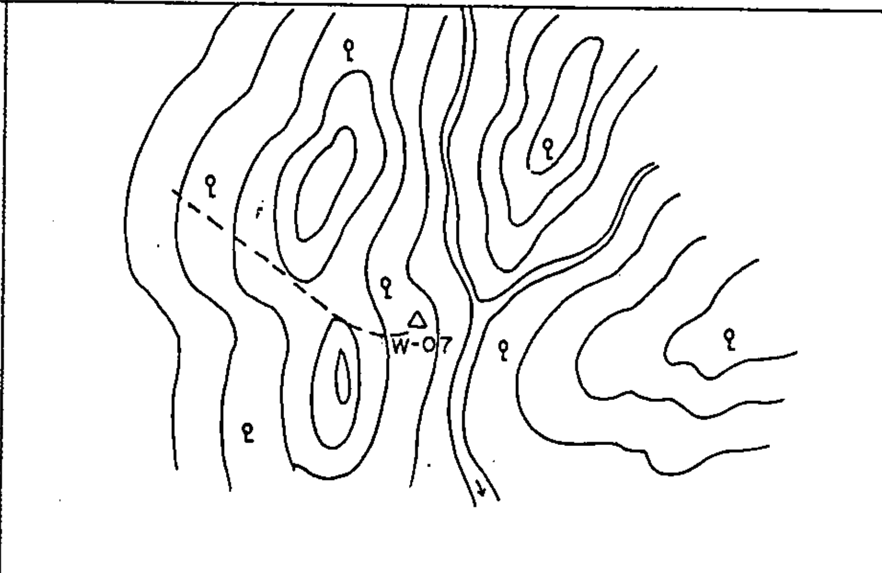


PHOTO OF STATION

REMARKS

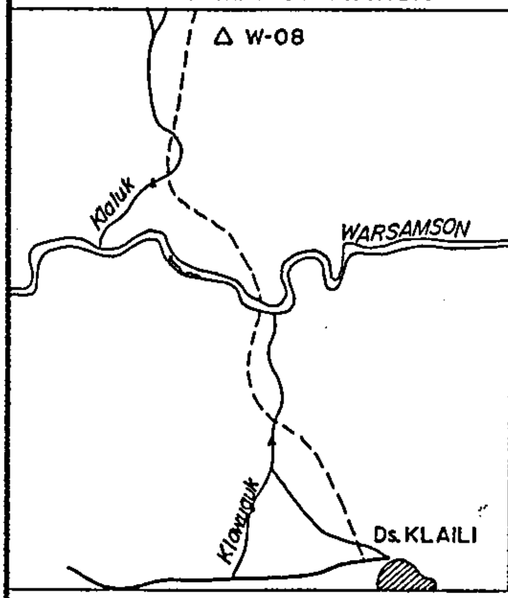
PLN. W–07 dipasang dimuara sungai ± 30 M. Dapat ditempuh dengan mobil melalui jalan Sorong – Makbon.
Berhenti di jembatan Warsamson, ± 200 M masuk kekanan mengikuti jalan setapak ± 2 jam.

DESCRIPTION OF BENCH MARK AND PREMARK

STATION NO.	PLN. W – 08	SURVEYOR	Suwadi
DESA	Klaili	CHECKED BY	
KECAMATAN	Makbon	SET UP DATE	04–01–1994
KABUPATEN	Sorong	HEIGHT OF BENCHMARK	± 30 cm
PROVINCE	Irian Jaya	HEIGHT OF PREMARK	cm
ZONE NO.	52		

COORDINATE OF STATION			
UTM CCORDINATE	N (m)	E (m)	H (m)
BENCHMARK	9910309.225	785393.698	181.623
PREMARK			
PRICKING POINT			

SKETCH–MAP OF STATION



DETAIL MAP OF STATION

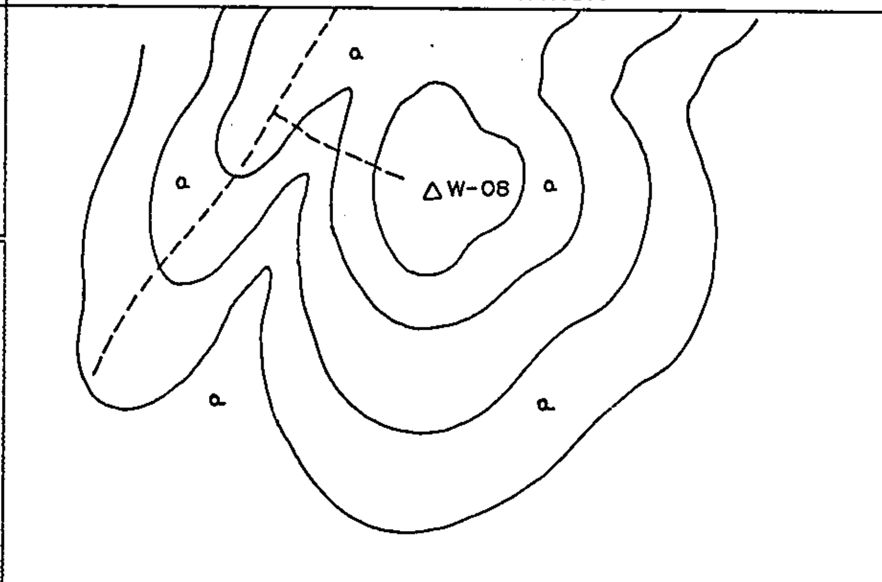


PHOTO OF STATION

REMARKS

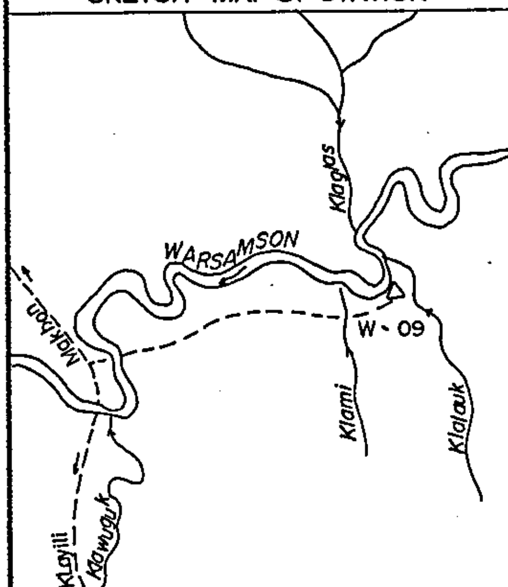
PLN. W–08 dipasang dibukit kecil sebelah kanan jalan Klaili ke Makbon, dari jalan setapak ± 50 M. Dapat ditempuh dari Klaili mengikuti jalan setapak ke Makbon dengan menyeberangi sungai Warsamson.
Dari Klaili sampai sungai Warsamson memerlukan waktu ± 4 jam berjalan kaki.
Dari sungai Warsamson ke PLN. W–08, ditempuh dengan jalan kaki, ± 2½ jam.

DESCRIPTION OF BENCH MARK AND PREMARK

STATION NO.	PLN. W – 09	SURVEYOR	Suwadi
DESA	Klaili	CHECKED BY	
KECAMATAN	Makbon	SET UP DATE	05–01–1994
KABUPATEN	Sorong	HEIGHT OF BENCHMARK	± 30 cm
PROVINCE	Irian Jaya	HEIGHT OF PREMARK	cm

ZONE NO. 52	COORDINATE OF STATION		
UTM COORDINATE	N (m)	E (m)	H (m)
BENCHMARK	9906711.631	789343.141	57.664
PREMARK			
PRICKING POINT			

SKETCH–MAP OF STATION



DETAIL MAP OF STATION

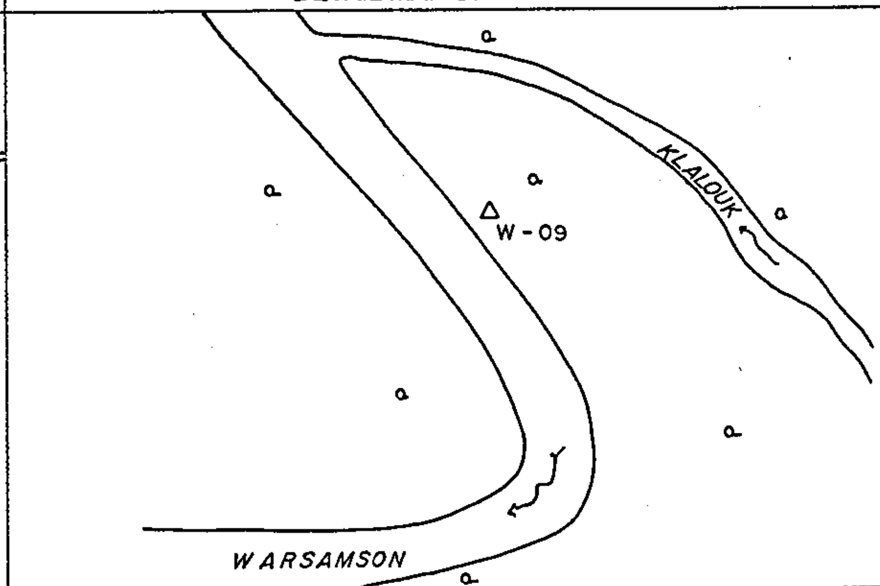
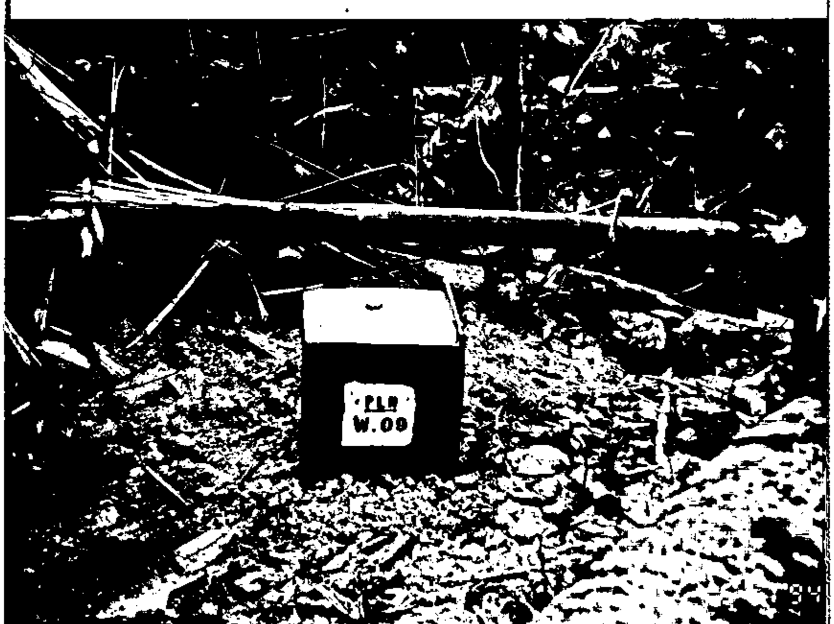


PHOTO OF STATION



REMARKS

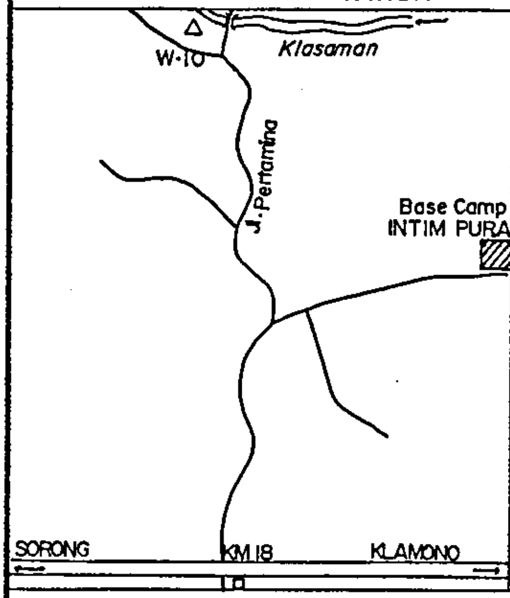
PLN. W–09 dipasang ditepi sungai Warsamson dekat dengan muara Klalouk ± 75 meter. Untuk menuju ke PLN. W–09 melalui desa Klaili mengikuti jalan Klaili – Makbon melalui muara Kla Wuguk. Dari muara menyeberang sungai Warsamson ± 300 M. kekanan meng– ikuti jalan rintisan dan menyeberang sungai Warsamson lagi mengikuti rintisan sampai ke PLN. W–09. Perjalanan dari desa Klaili sampai sungai Warsamson, ± 4 jam. Dari tepi sungai Warsamson sampai ke PLN. W–09 ± 1$^3/_4$ jam.

DESCRIPTION OF BENCH MARK AND PREMARK

STATION NO.	PLN. W – 10	SURVEYOR	Suparmanto
DESA	Klasaman	CHECKED BY	
KECAMATAN	Sorong	SET UP DATE	31 – 12 – 1993
KABUPATEN	Sorong	HEIGHT OF BENCHMARK	± 30 cm
PROVINCE	Irian Jaya	HEIGHT OF PREMARK	cm
ZONE NO.	52		

	COORDINATE OF STATION		
UTM CCORDINATE	N (m)	E (m)	H (m)
BENCHMARK	9898037.920	766537.491	77.033
PREMARK			
PRICKING POINT			

SKETCH – MAP OF STATION



DETAIL MAP OF STATION

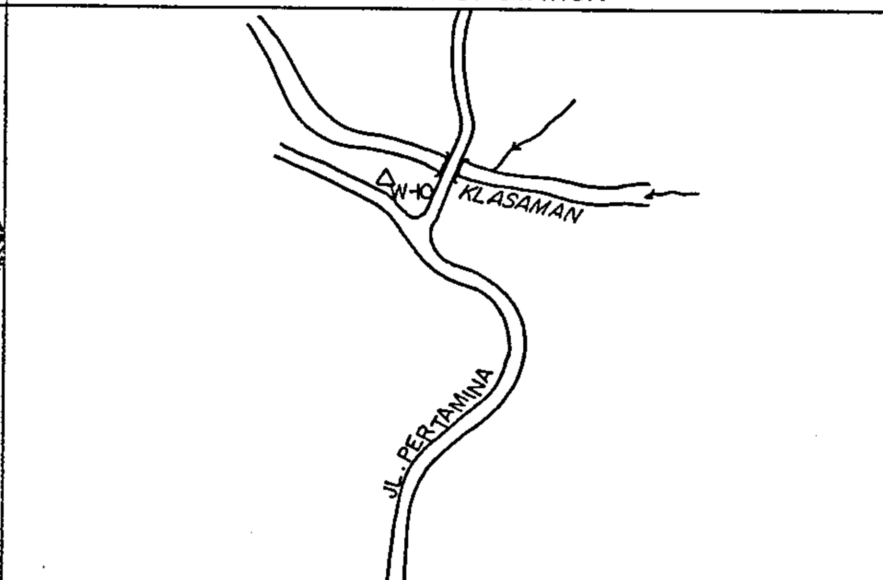


PHOTO OF STATION

REMARKS

PLN. W– 10 terletak disimpang tiga jalan, dekat jembatan besi, dapat ditempuh dengan mobil mengikuti jalan Pertamina masuk dari Km. 18 jalan raya Sorong – Klamono, belok kekiri mengikuti jalan PT. Intimpura ± 7 Km.

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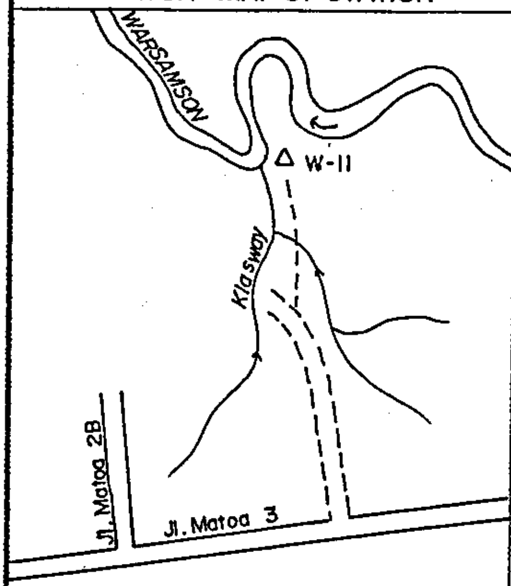
DESCRIPTION OF BENCH MARK AND PREMARK

STATION NO.	PLN. W – 11	SURVEYOR	Widodo
DESA	Klaili	CHECKED BY	
KECAMATAN	Makbon	SET UP DATE	06 – 01 – 1994
KABUPATEN	Sorong	HEIGHT OF BENCHMARK	± 30 cm
PROVINCE	Irian Jaya	HEIGHT OF PREMARK	cm

ZONE NO. 52	COORDINATE OF STATION		
UTM CCORDINATE	N (m)	E (m)	H (m)
BENCHMARK	9904703.669	778000.428	51.116
PREMARK			
PRICKING POINT			

SKETCH – MAP OF STATION



DETAIL MAP OF STATION

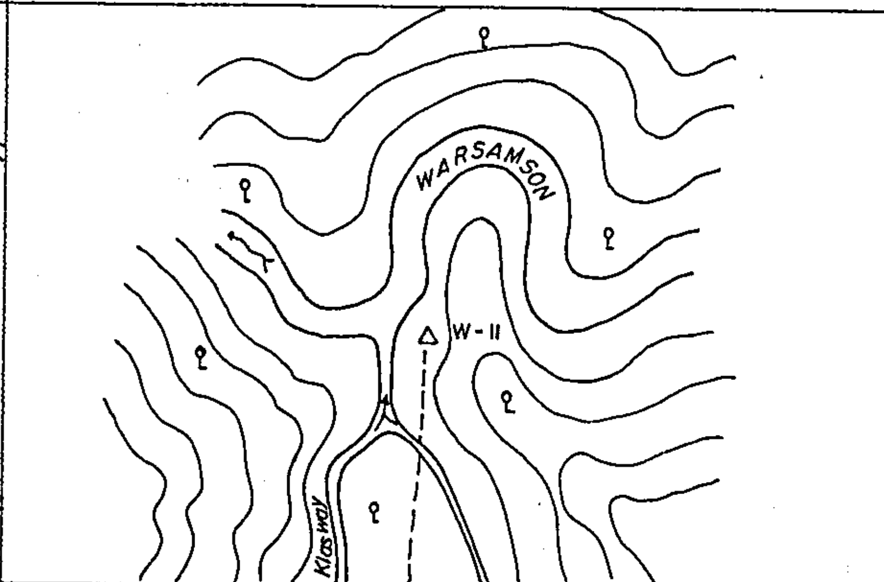
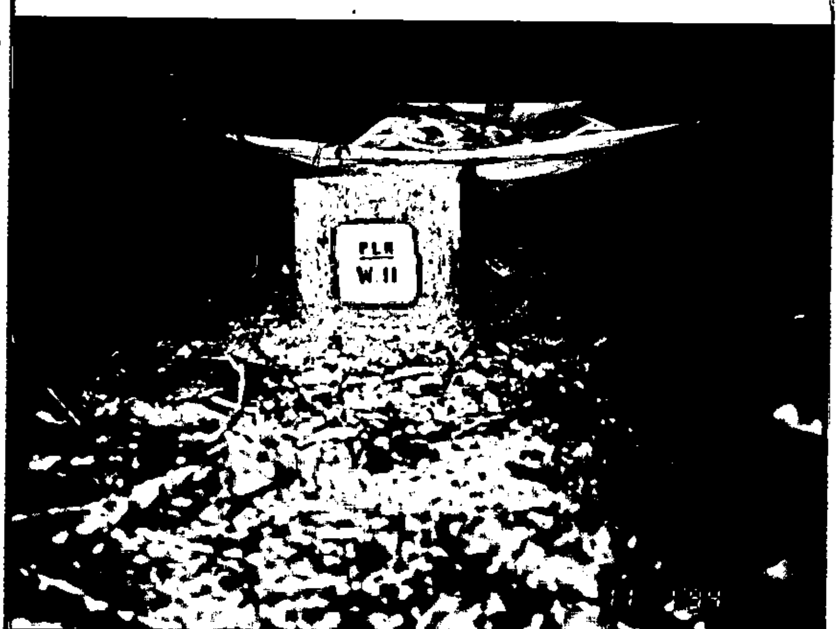


PHOTO OF STATION



REMARKS

PLN. W – 11 dipasang dimuara sungai Kla Suat ± 60 M., dapat ditempuh dengan mobil melalui jalan Matoa 3 belok kiri dari pertigaan doser yang pertama, mengikuti jalan doser dengan jalan kaki ± 30 menit memotong kearah muara sungai Kla Sway ± 1 jam berjalan kaki. Lokasi dalam areal HPH Pt. Intimpura.

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DESCRIPTION OF BENCH MARK AND PREMARK

STATION NO.	PLN. W – 12	SURVEYOR	Suparmanto
DESA	Klasaman	CHECKED BY	
KECAMATAN	Sorong	SET UP DATE	02–01–1994
KABUPATEN	Sorong	HEIGHT OF BENCHMARK	± 30 cm
PROVINCE	Irian Jaya	HEIGHT OF PREMARK	cm

ZONE NO.	52	COORDINATE OF STATION	
UTM CCORDINATE	N (m)	E (m)	H (m)
BENCHMARK	9897675.807	772796.178	172.561
PREMARK			
PRICKING POINT			

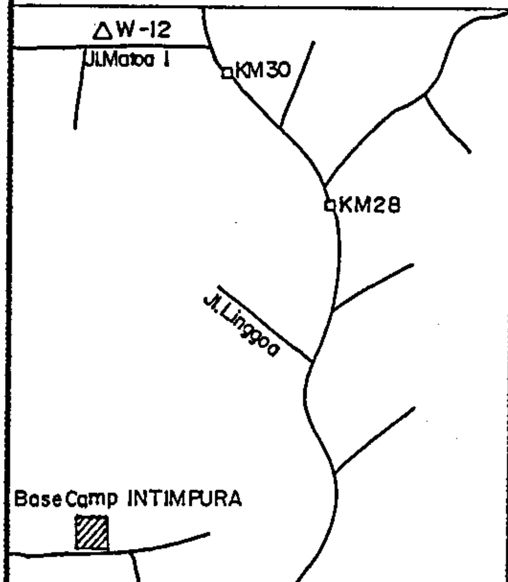
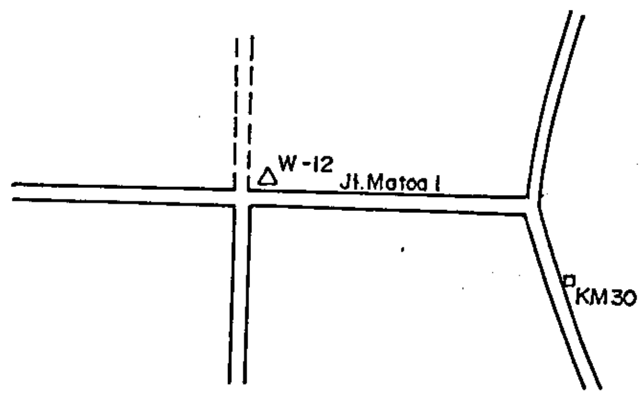
SKETCH–MAP OF STATION	DETAIL MAP OF STATION
	

PHOTO OF STATION

REMARKS

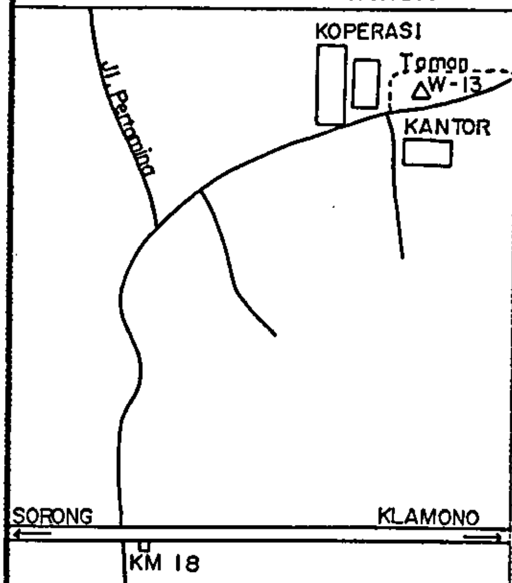
PLN. W–12 terletak di Jl. Matoa 1, simpang empat jalan. Dapat ditempuh dengan mobil dari Base Camp Intimpura.
Berada dalam lokasi HPH Pt. Intimpura.

DESCRIPTION OF BENCH MARK AND PREMARK

STATION NO.	PLN. W – 13	SURVEYOR	Suparmanto
DESA	Klasaman	CHECKED BY	
KECAMATAN	Sorong	SET UP DATE	31–12–1993
KABUPATEN	Sorong	HEIGHT OF BENCHMARK	± 30 cm
PROVINCE	Irian Jaya	HEIGHT OF PREMARK	cm

ZONE NO.	52	COORDINATE OF STATION	
UTM COORDINATE	N (m)	E (m)	H (m)
BENCHMARK	9894586.301	767282.409	93.489
PREMARK			
PRICKING POINT			

SKETCH – MAP OF STATION



DETAIL MAP OF STATION

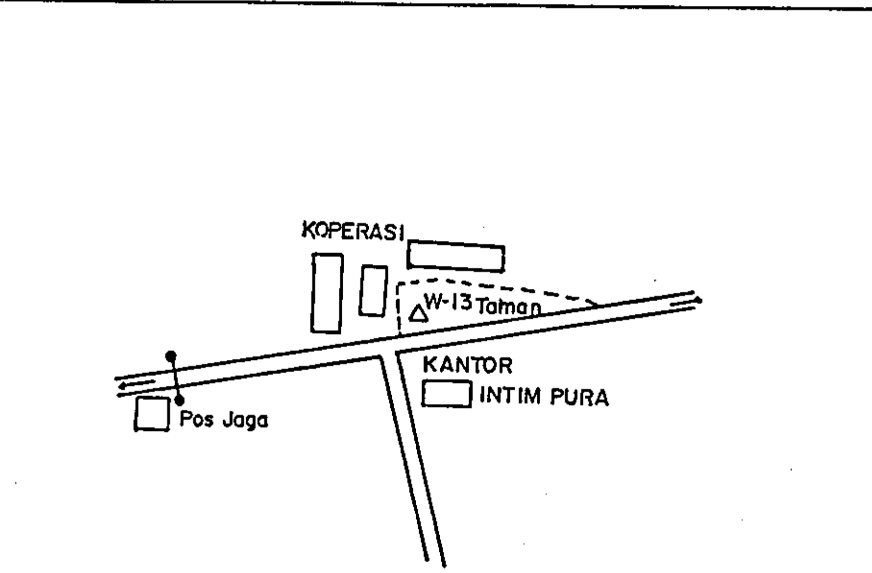


PHOTO OF STATION

REMARKS

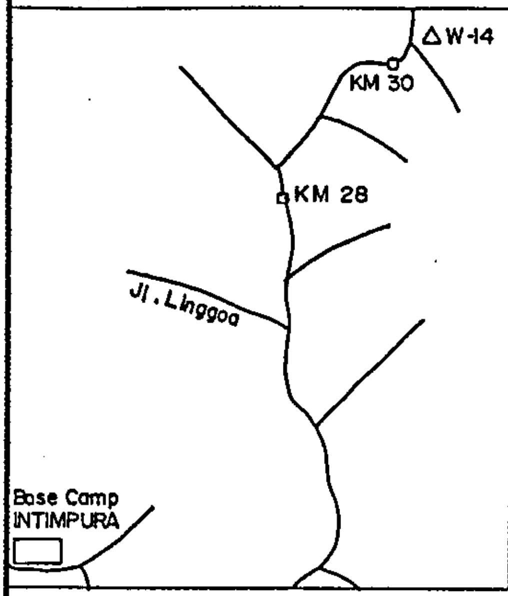
PLN. W–13 terletak di Base Camp Pt. Intimpura didalam taman disamping Koperasi.
Dapat ditempuh dengan mobil melalui jalan raya Sorong – Klamono, pada Km. 18 belok kiri mengikuti jalan Intimpura ± 7,5 Km.

DESCRIPTION OF BENCH MARK AND PREMARK

STATION NO.	PLN. W – 14	SURVEYOR	Suparmanto
DESA	Aimas	CHECKED BY	
KECAMATAN	Sorong	SET UP DATE	31–12–1993
KABUPATEN	Sorong	HEIGHT OF BENCHMARK	± 30. cm
PROVINCE	Irian Jaya	HEIGHT OF PREMARK	cm

ZONE NO. 52	COORDINATE OF STATION		
UTM COORDINATE	N (m)	E (m)	H (m)
BENCHMARK	9895929.122	776898.104	176.449
PREMARK			
PRICKING POINT			

SKETCH–MAP OF STATION



DETAIL MAP OF STATION

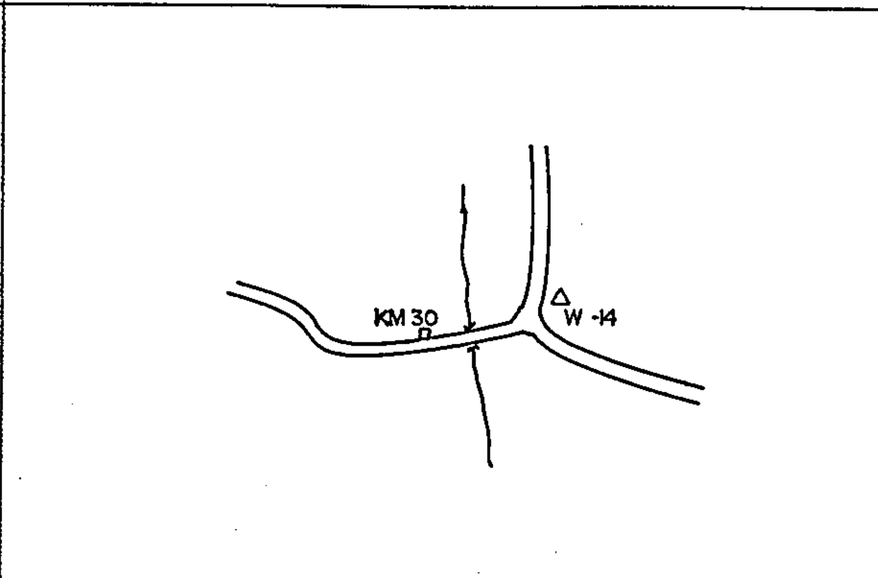


PHOTO OF STATION

REMARKS

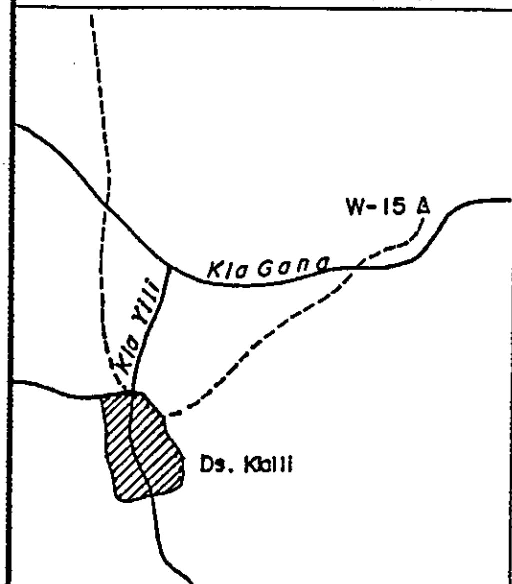
PLN. W–14 terletak disimpang tiga Km. 30 di kawasan HPH Pt. Intimpura.
Dapat ditempuh dengan mobil dari Base Camp Intimpura ± 10 Km. kearah jalan yang menuju ke kampung Klaili.
Lokasi dalam areal HPH Pt. Intimpura, ± 1½ jam dari Sorong.

DESCRIPTION OF BENCH MARK AND PREMARK

STATION NO.	PLN. W – 15	SURVEYOR	Suwadi
DESA	Klaili	CHECKED BY	
KECAMATAN	Makbon	SET UP DATE	30–12–1994
KABUPATEN	Sorong	HEIGHT OF BENCHMARK	± 30 cm
PROVINCE	Irian Jaya	HEIGHT OF PREMARK	cm

ZONE NO.	52		
	COORDINATE OF STATION		
UTM COORDINATE	N (m)	E (m)	H (m)
BENCHMARK	9898402.073	786301.245	128.533
PREMARK			
PRICKING POINT			

SKETCH–MAP OF STATION



DETAIL MAP OF STATION

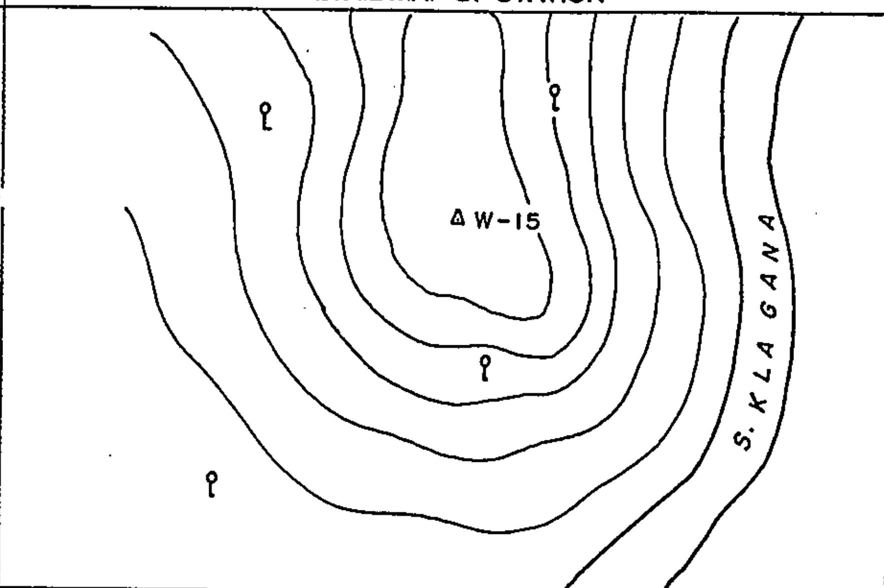


PHOTO OF STATION

REMARKS

PLN. W–15 dipasang ditepi sungai Kla Gona, dari tepi sungai ± 50 M.
Dapat ditempuh dengan mobil melewati jalan HPH Pt. Intimpura, menuju desa Klaili.
Dari desa Klaili, diujung sekolah SD mengikuti jalan setapak menyeberang sungai Kla Gona.
Dari sungai Kla Gona ± 300 M memotong ke-kiri menuju bukit kecil.
Perjalanan dari desa Klaili ± 45 menit.

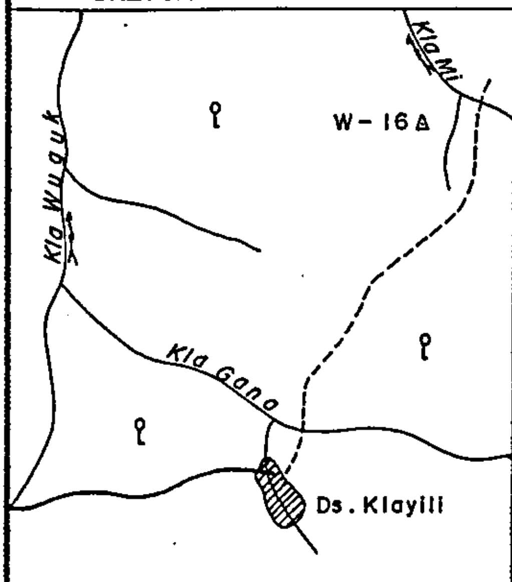
PT. Aerokarto Indonesia

DESCRIPTION OF BENCH MARK AND PREMARK

STATION NO.	PLN. W – 16	SURVEYOR	Suwadi
DESA	Klaili	CHECKED BY	
KECAMATAN	Makbon	SET UP DATE	02–01–1994
KABUPATEN	Sorong	HEIGHT OF BENCHMARK	± 30 cm
PROVINCE	Irian Jaya	HEIGHT OF PREMARK	cm

ZONE NO. 52	COORDINATE OF STATION		
UTM COORDINATE	N (m)	E (m)	H (m)
BENCHMARK	9902153.455	789108.581	79.663
PREMARK			
PRICKING POINT			

SKETCH–MAP OF STATION



DETAIL MAP OF STATION

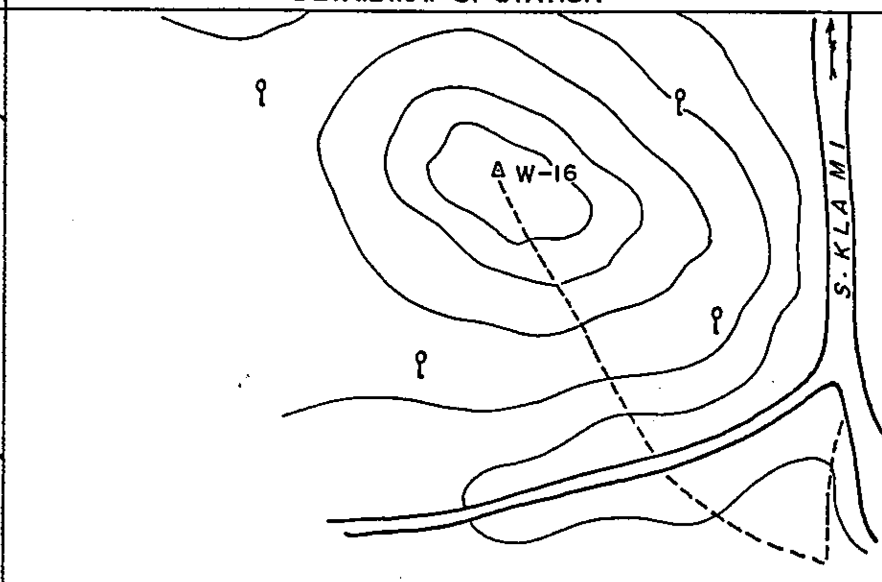


PHOTO OF STATION

REMARKS

PLN. W–16 dipasang dibukit kecil dekat sungai Kla Mi. Dapat ditempuh melalui jalan setapak dari Klaili ke arah Kla Mi.
± 75 M sebelum menyeberang Kla Mi memotong kekiri menyeberangi sungai kecil lalu keatas bukit kecil ± 100 M.
Perjalanan dari desa Klaili ke PLN. W–16 dapat ditempuh ± 2½ jam.

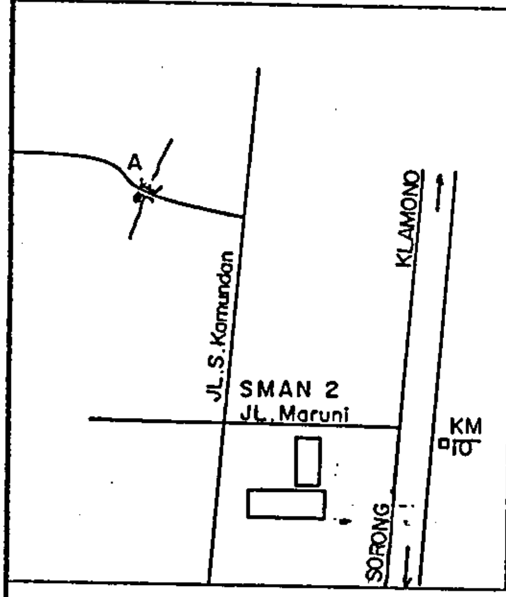
PT. Aerokarto Indonesia

DESCRIPTION OF BENCH MARK AND PREMARK

STATION NO.	Spot – A	SURVEYOR	A. Golhur
DESA	Malano, Dukuh Klawafunkopi	CHECKED BY	
KECAMATAN	Sorong	SET UP DATE	26–12–1993
KABUPATEN	Sorong	HEIGHT OF BENCHMARK	0 cm
PROVINCE	Irian Jaya	HEIGHT OF PREMARK	cm
ZONE NO.	52		

COORDINATE OF STATION			
UTM CCORDINATE	N (m)	E (m)	H (m)
BENCHMARK			
PREMARK			
SPOT GPS POINT	9903770 .590	763292 .357	106 .219

SKETCH–MAP OF STATION



DETAIL MAP OF STATION

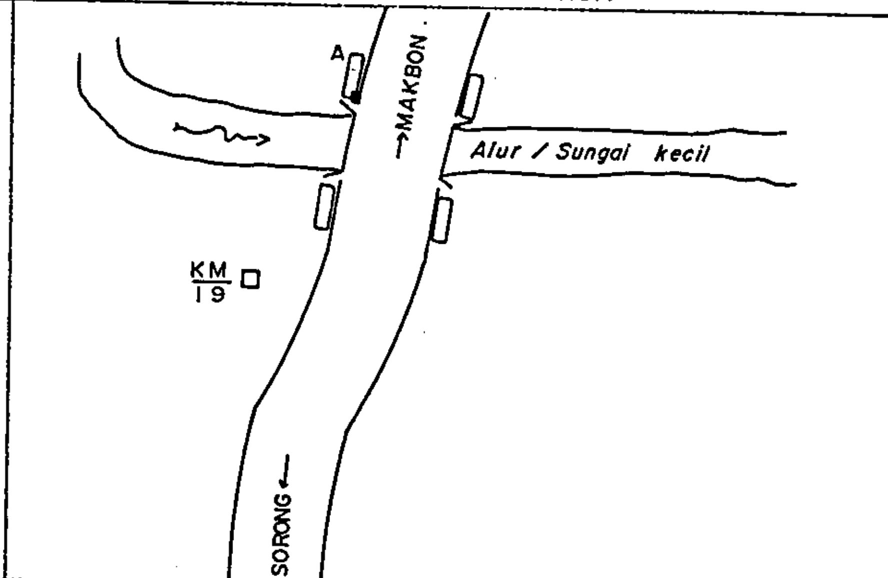


PHOTO OF STATION

REMARKS

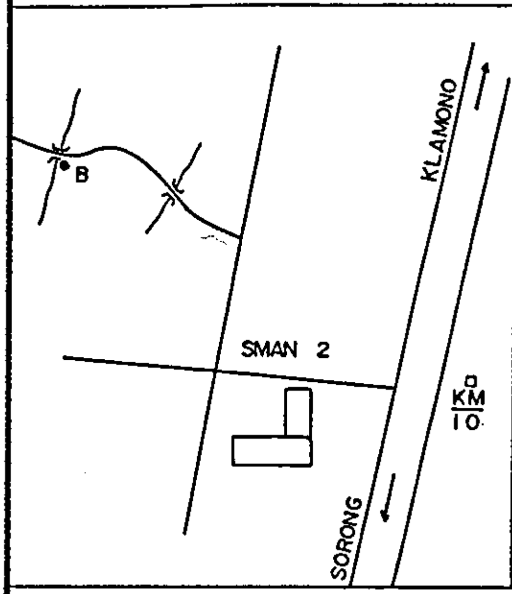
Spot A dipasang pada tepi jembatan sungai (alur) kecil. Disebelah kiri jembatan, arah ke Desa Makbon pada Km. 19 Sorong.
Untuk menuju Spot A, masuk dari jalan baru Propinsi yaitu jalan Sorong – Makbon, dapat ditempuh dengan kendaraan.

DESCRIPTION OF BENCH MARK AND PREMARK

STATION NO.	Spot – B	SURVEYOR	A. Gofhur
DESA	Malano, Dukuh Klawafunkopi	CHECKED BY	
KECAMATAN	Sorong	SET UP DATE	26–12–1993
KABUPATEN	Sorong	HEIGHT OF BENCHMARK	0 cm
PROVINCE	Irian Jaya	HEIGHT OF PREMARK	cm

ZONE NO. 52	COORDINATE OF STATION		
UTM COORDINATE	N (m)	E (m)	H (m)
BENCHMARK			
PREMARK			
SPOT GPS POINT	9905527 .503	764139 .375	71 .308

SKETCH – MAP OF STATION



DETAIL MAP OF STATION

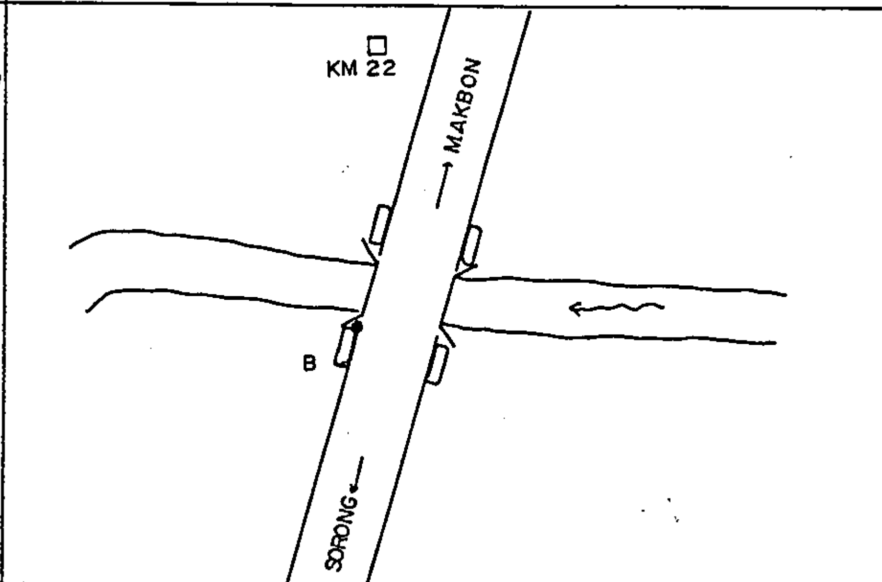
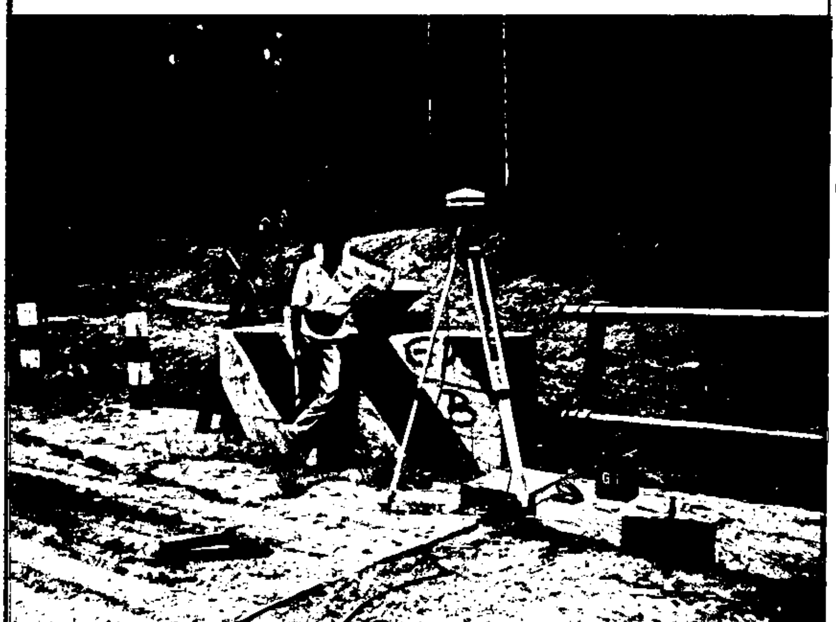


PHOTO OF STATION



REMARKS

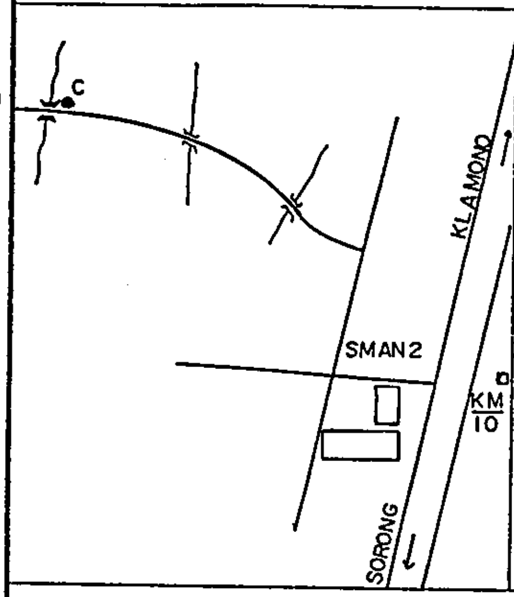
Spot B dipasang pada tepi jembatan sungai disebelah kiri, arah ke Desa Makbon, pada Km. 22 Sorong.
Untuk menuju Spot B masuk dari jalan baru Propinsi, yaitu jalan tembus Sorong – Makbon, dapat ditempuh dengan kendaraan.

DESCRIPTION OF BENCH MARK AND PREMARK

STATION NO.	Spot – C	SURVEYOR	A. Gofhur
DESA	Batu Lobang, Dukuh Klasowo	CHECKED BY	
KECAMATAN	Makbon	SET UP DATE	26–12–1993
KABUPATEN	Sorong	HEIGHT OF BENCHMARK	± 0,5 cm
PROVINCE	Irian Jaya	HEIGHT OF PREMARK	cm
ZONE NO.	52		

	COORDINATE OF STATION		
UTM COORDINATE	N (m)	E (m)	H (m)
BENCHMARK			
PREMARK			
SPOT GPS POINT	9908795 .803	765734 .200	42 .568

SKETCH–MAP OF STATION



DETAIL MAP OF STATION

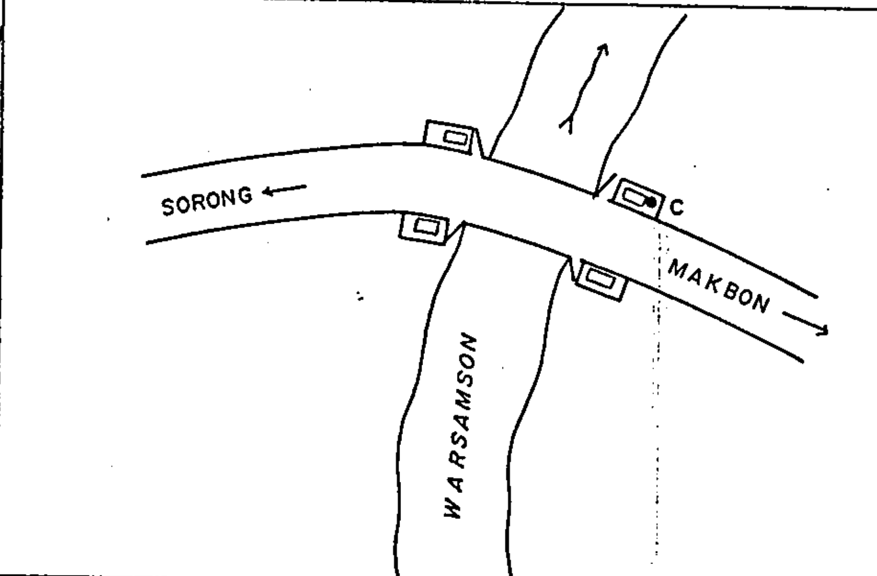


PHOTO OF STATION

REMARKS

Spot C dipasang pada tepi jembatan S. Warsamson disebelah kiri, arah ke Desa Makbon pada Km. 27 Sorong.
Untuk menuju ke Spot C, masuk dari jalan baru Propinsi, yaitu jalan tembus Sorong – Makbon. Dapat ditempuh dengan kendaraan.

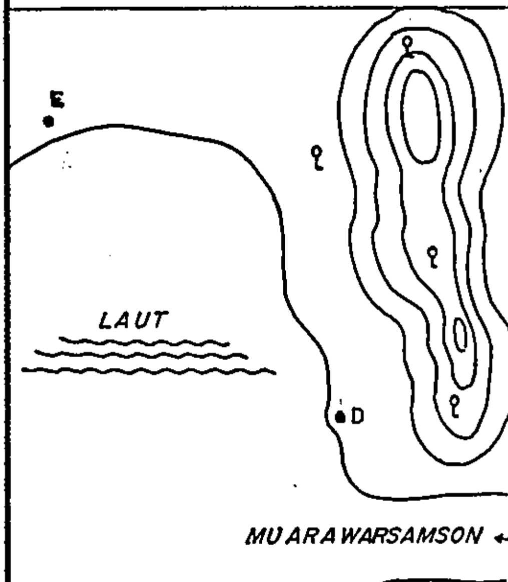
PT. Aerokarto Indonesia

DESCRIPTION OF BENCH MARK AND PREMARK

STATION NO.	Spot – D	SURVEYOR	A. Gofhur
DESA	Batu Lobang	CHECKED BY	
KECAMATAN	Makbon	SET UP DATE	05–01–1994
KABUPATEN	Sorong	HEIGHT OF BENCHMARK	± 30 cm
PROVINCE	Irian Jaya	HEIGHT OF PREMARK	cm

ZONE NO. 52	COORDINATE OF STATION		
UTM COORDINATE	N (m)	E (m)	H (m)
BENCHMARK			
PREMARK			
SPOT GPS POINT	9914287 .846	767274 .250	4 .237

SKETCH–MAP OF STATION



DETAIL MAP OF STATION

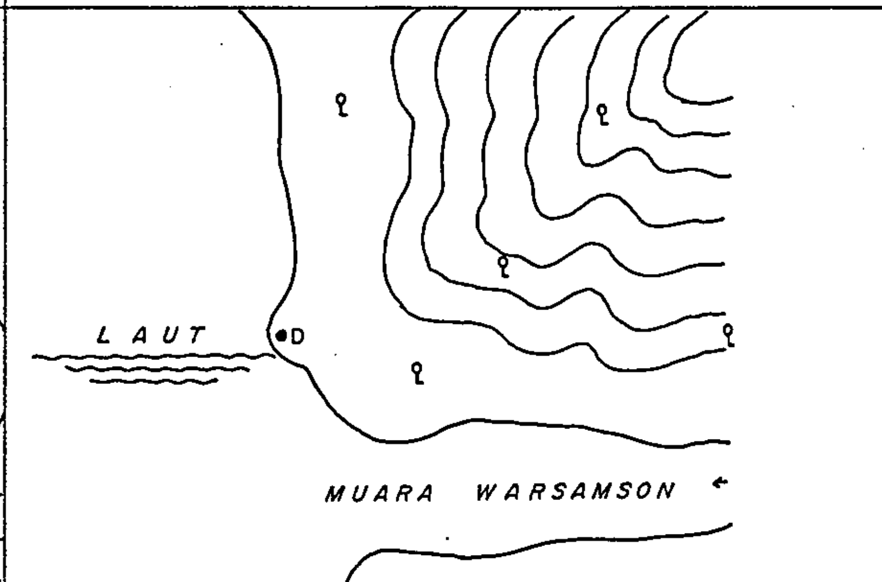


PHOTO OF STATION

REMARKS

Spot D dipasang dimuka muara S. Warsamson sebelah kiri, ± 400 M dari muara.
Untuk menuju Spot D, dapat ditempuh dengan motor boat dari Sorong ke Batu Lobang ± 2 jam, dilanjutkan dengan berjalan kaki dari desa Batu Lobang ke muara S. Warsamson ± 2 jam.

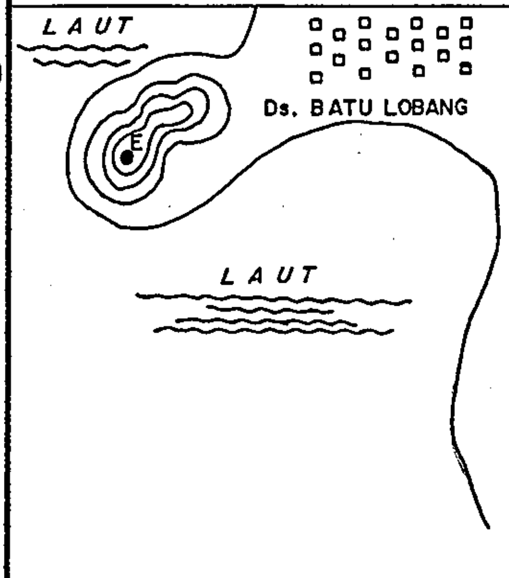
PT. Aerokarto Indonesia

DESCRIPTION OF BENCH MARK AND PREMARK

STATION NO.	Spot – E	SURVEYOR	A. Gofhur
DESA	Batu Lobang	CHECKED BY	
KECAMATAN	Makbon	SET UP DATE	04-01-1994
KABUPATEN	Sorong	HEIGHT OF BENCHMARK	± 30 cm
PROVINCE	Irian Jaya	HEIGHT OF PREMARK	cm
ZONE NO.	52	COORDINATE OF STATION	

UTM COORDINATE	N (m)	E (m)	H (m)
BENCHMARK			
PREMARK			
SPOT GPS POINT	9915378 .500	768359 .216	

SKETCH-MAP OF STATION



DETAIL MAP OF STATION

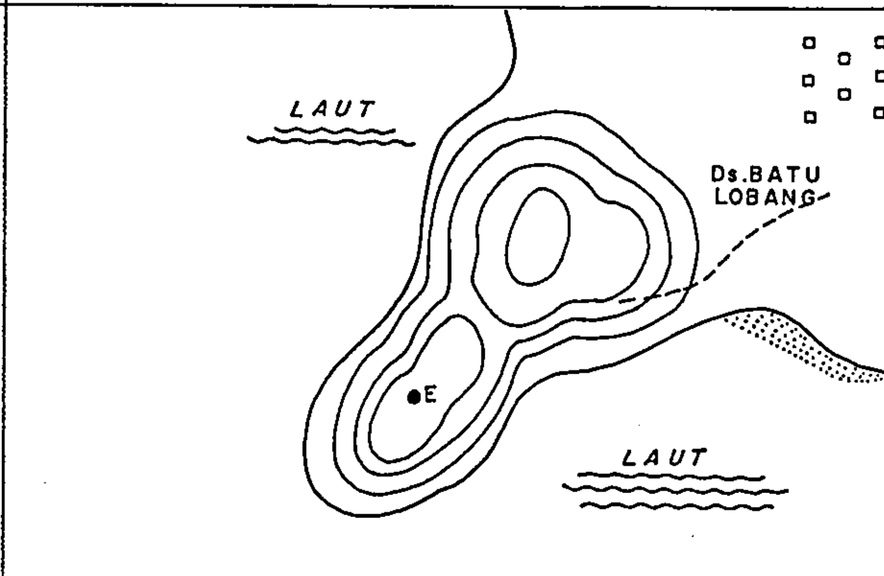


PHOTO OF STATION

REMARKS

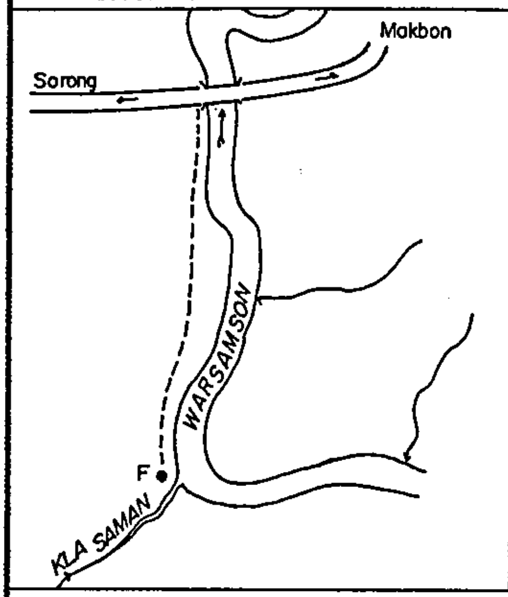
Spot E dipasang diatas bukit di desa Batu – Lobang. Dari desa Batu Lobang ± 250 M. Untuk menuju Spot E, dapat ditempuh dengan motor boat dari Sorong ke desa Batu Lobang ± 2 jam.

DESCRIPTION OF BENCH MARK AND PREMARK

STATION NO.	Spot – F	SURVEYOR	Agus
DESA	Malano	CHECKED BY	
KECAMATAN	Sorong	SET UP DATE	07-01-1994
KABUPATEN	Sorong	HEIGHT OF BENCHMARK	± 30 cm
PROVINCE	Irian Jaya	HEIGHT OF PREMARK	cm

ZONE NO. 52	COORDINATE OF STATION		
UTM COORDINATE	N (m)	E (m)	H (m)
BENCHMARK			
PREMARK			
SPOT GPS POINT	9904903.652	766803.086	42.051 GPS

SKETCH-MAP OF STATION



DETAIL MAP OF STATION

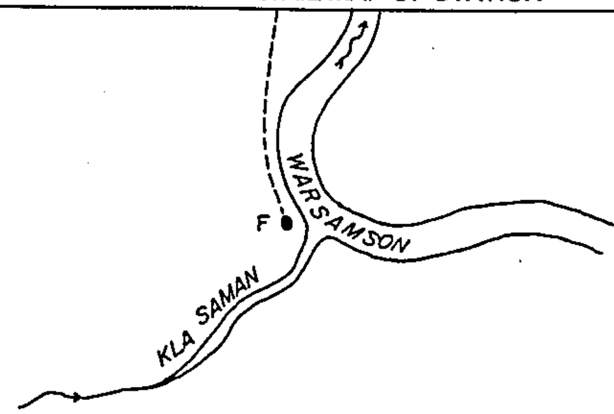
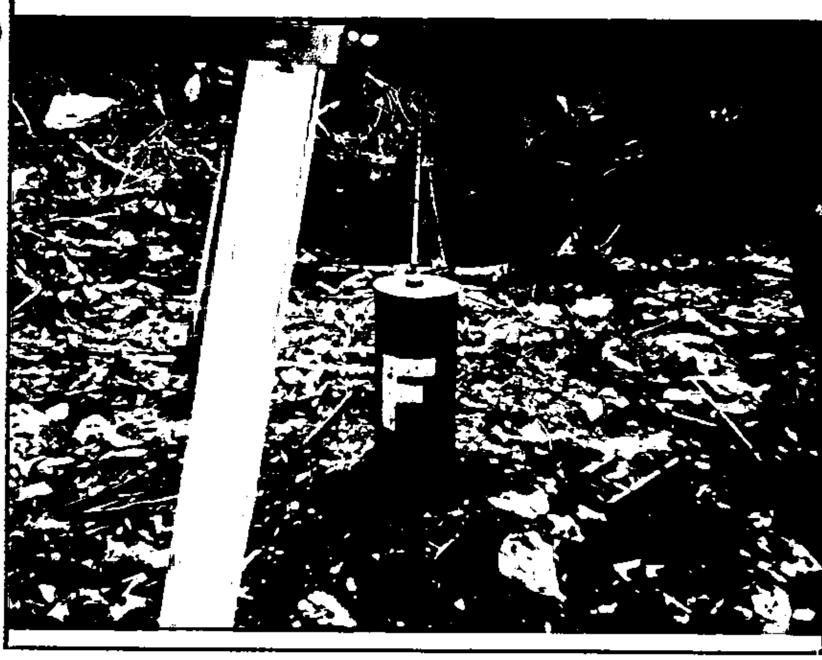


PHOTO OF STATION



REMARKS

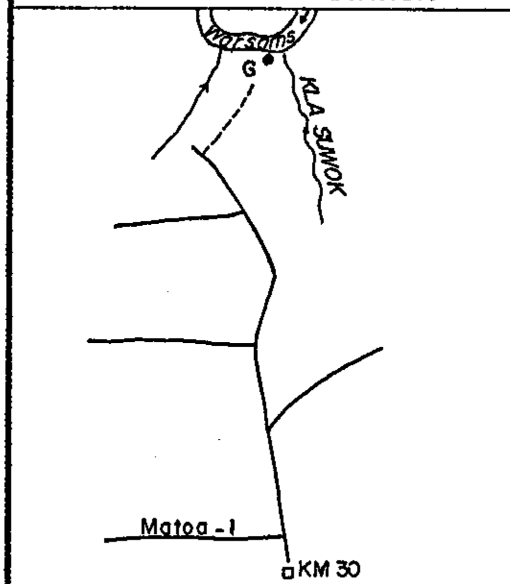
Spot F terletak dimuara S. Klasaman, dapat ditempuh dengan mobil ke jembatan Warsamson dilanjutkan dengan berjalan kaki menyusuri jalan setapak dipinggir S. Warsamson ± 2 jam.

DESCRIPTION OF BENCH MARK AND PREMARK

STATION NO.	Spot – G	SURVEYOR	A. Gofhur
DESA	Klaili	CHECKED BY	
KECAMATAN	Makbon	SET UP DATE	02–01–1994
KABUPATEN	Sorong	HEIGHT OF BENCHMARK	± 30 cm
PROVINCE	Irian Jaya	HEIGHT OF PREMARK	cm

ZONE NO. 52	COORDINATE OF STATION		
UTM CCORDINATE	N (m)	E (m)	H (m)
BENCHMARK			
PREMARK			
SPOT GPS POINT	9903419 .594	773971 .154	72 .664

SKETCH–MAP OF STATION



DETAIL MAP OF STATION

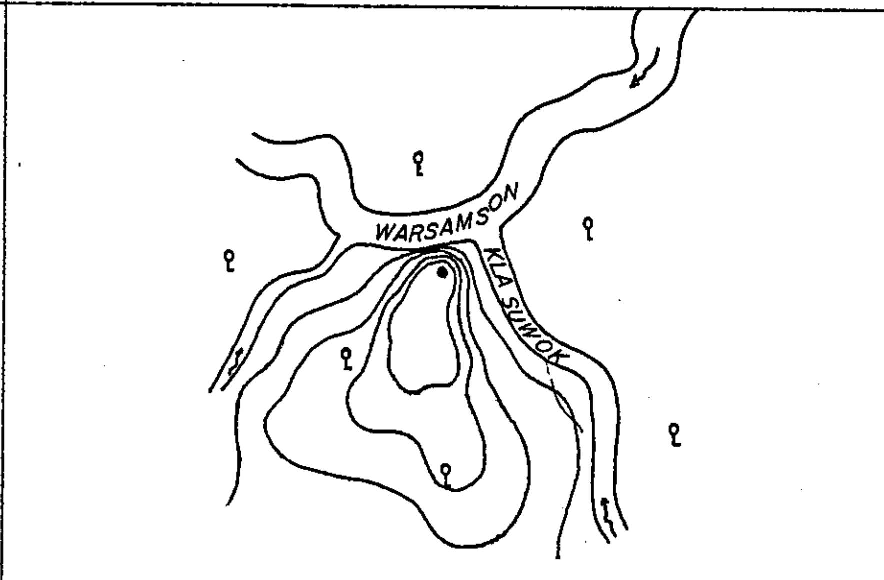


PHOTO OF STATION

REMARKS

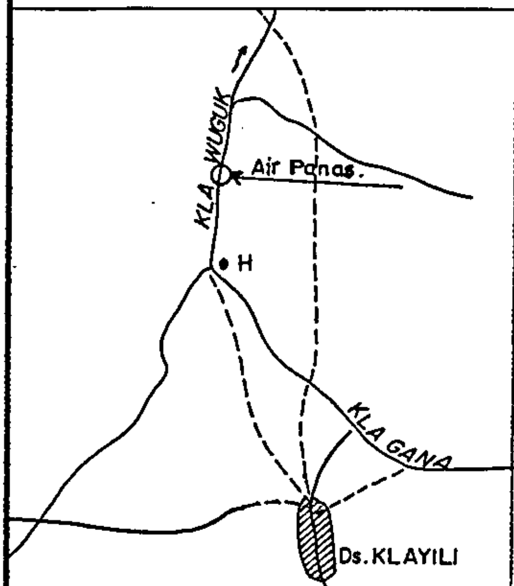
Spot G terletak dimuara S. Klasuwak, dapat di–tempuh dengan mobil dari Base Camp PT. Intimpura ±13 Km dan dilanjutkan jalan kaki mengikuti jalan setapak menuju ke muara Kla–suwak, ± 2 jam.

DESCRIPTION OF BENCH MARK AND PREMARK

STATION NO.	Spot – H	SURVEYOR	Suwadi
DESA	Klaili	CHECKED BY	
KECAMATAN	Makbon	SET UP DATE	31–12–1993
KABUPATEN	Sorong	HEIGHT OF BENCHMARK	± 30 cm
PROVINCE	Irian Jaya	HEIGHT OF PREMARK	cm
ZONE NO.	52		

COORDINATE OF STATION			
UTM COORDINATE	N (m)	E (m)	H (m)
BENCHMARK			
PREMARK			
SPOT GPS POINT	9900465 .269	784386 .257	70 .277

SKETCH – MAP OF STATION



DETAIL MAP OF STATION

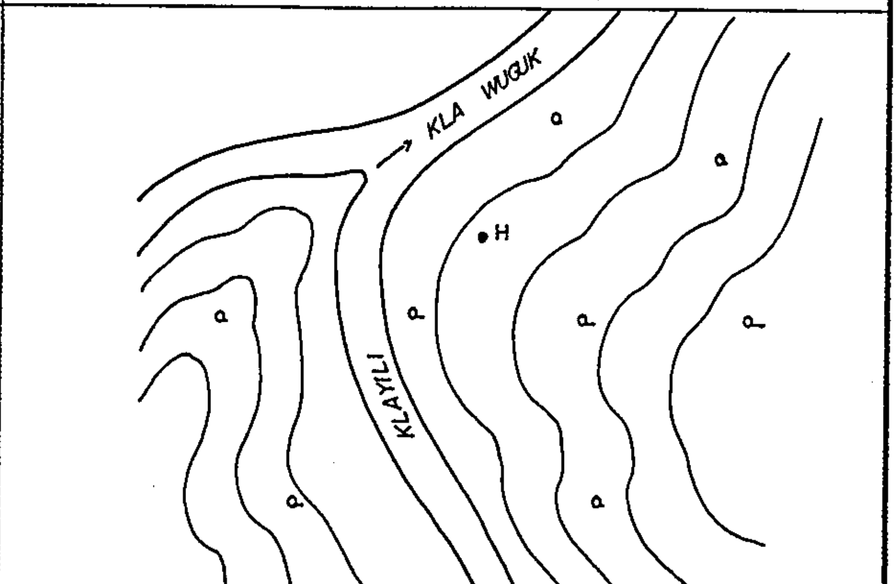


PHOTO OF STATION

REMARKS

Spot H dipasang didekat muara S. Klaili dan S. Klawuguk, yaitu disebelah timur muara ± 20 M. Dapat ditempuh dengan jalan kaki meng– ikuti jalan setapak dari desa Klaili kolam tem– pat mancing, baru mengikuti tepi sungai ke– arah muara ± 200 M.
Perjalanan dari desa Klaili ke Spot H ± 1½ jam.

PT. Aerokarto Indonesia

APPENDIX 3.1.

FLIGHT INDEX FOR SCALE 1 : 10,000

PETA JALUR PEMOTRETAN UDARA

U

SKALA 1 : 100.000

0 1 2 4 6 8 10Km

KETERANGAN

Lokasi	:	SORONG (S.Warsamson)
Proyek	:	Pemotretan Udara Skala 1 : 10.000 Untuk Proyek PLN - JICA
Skala Foto	:	1 : 10.000
Jenis Film	:	PANCHROMATIC B/W KODAK XX, 2405
Jenis Camera	:	Wild RC-20 (f=153.00 mm)
Dipotret oleh	:	PT. AEROKARTO INDONESIA

APPENDIX 3.2

FLIGHT INDEX FOR SCALE 1 : 20,000

PETA JALUR PEMOTRETAN UDARA

U

SKALA 1 : 100.000

0 1 2 4 6 8 10Km

KETERANGAN

Lokasi	:	SORONG (S. Warsamson)
Proyek	:	Pemotretan Udara Skala 1 : 20.000 Untuk Proyek PLN - JICA
Skala Foto	:	1 : 20.000
Jenis Film	:	PANCHROMATIC B/W KODAK XX, 2405
Jenis Camera	:	Wild RC-20 (f=153.00 mm)
Dipotret oleh	:	PT. AEROKARTO INDONESIA

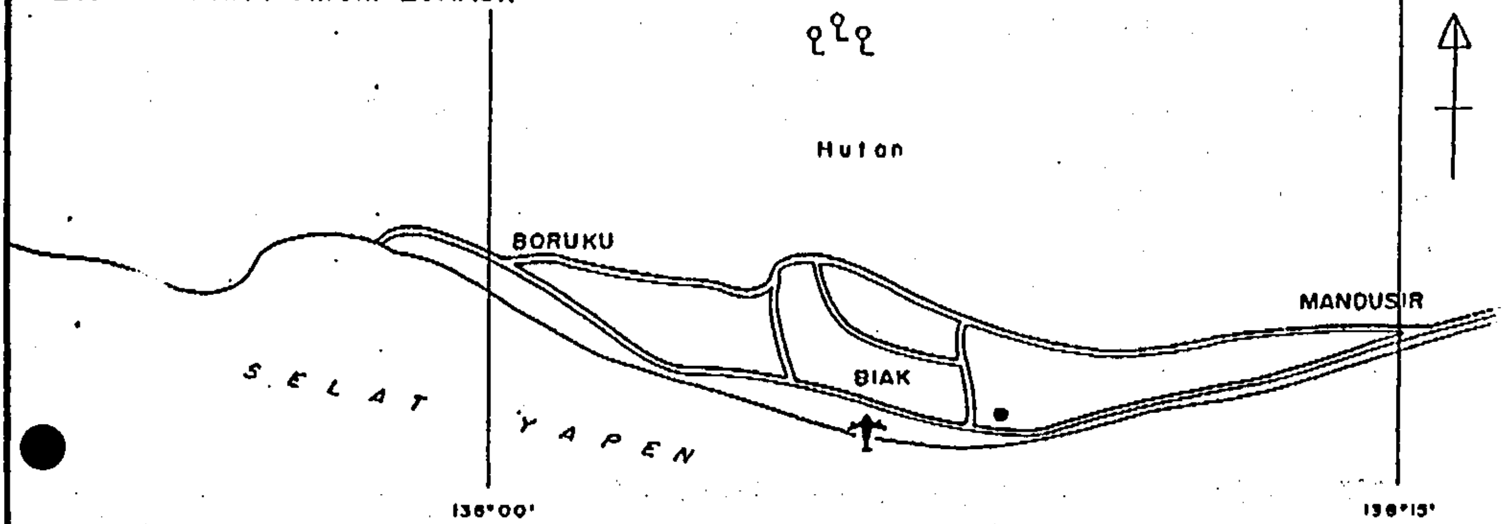
APPENDIX 3.3

DESCRIPTION OF REFERENCE POINT FOR KINEMATIC GPS

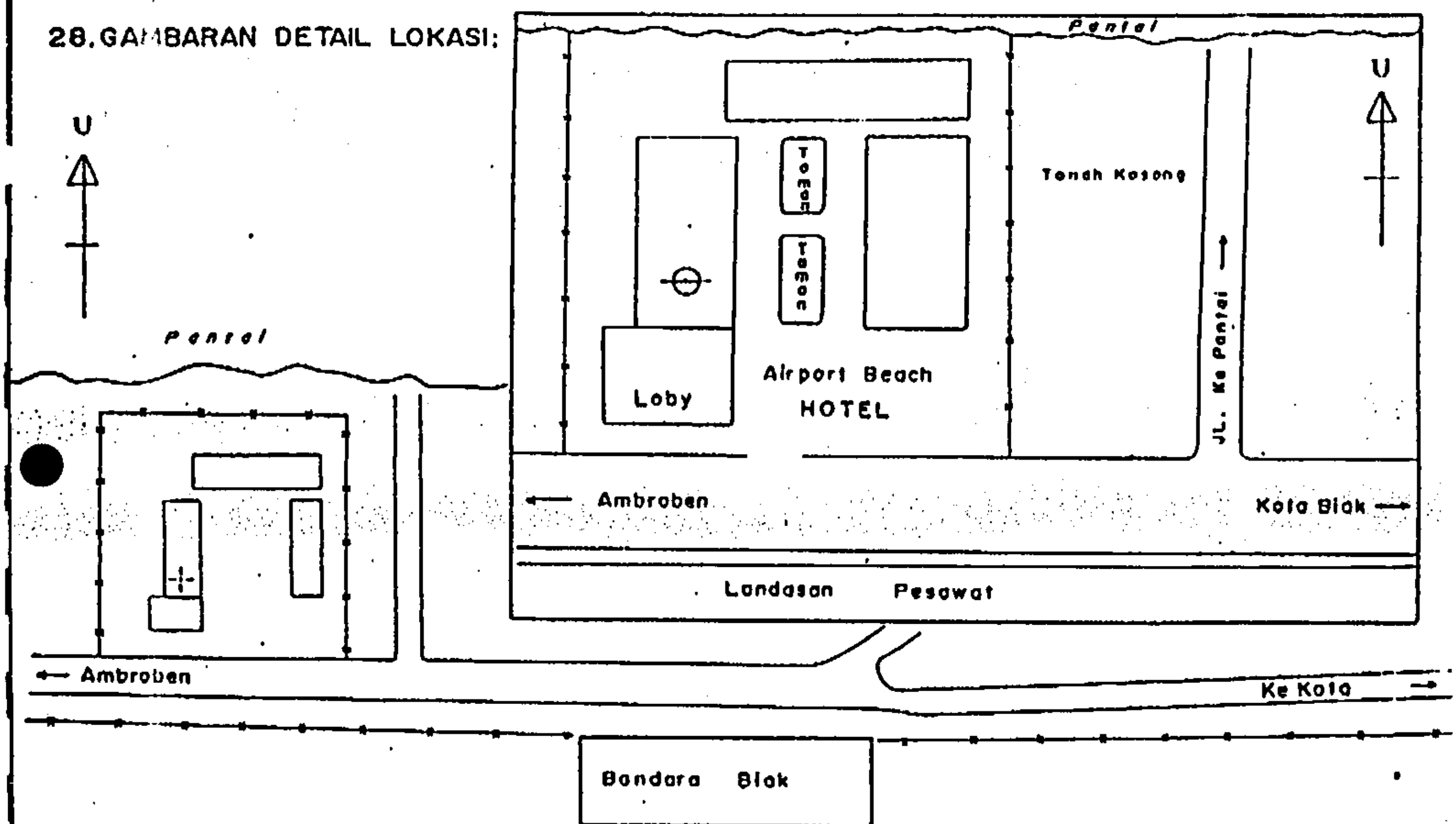
BADAN KOORDINASI SURVEY DAN PEMETAAN NASIONAL (BAKOSURTANAL)
DESKRIPSI TITIK TINGGI

STASIUN
BIAK

27. GAMBARAN UMUM LOKASI:



28. GAMBARAN DETAIL LOKASI:



Lapangan Terbang KAISEPU BIAK

TRIMVEC GPS RELATIVE POSITIONING SOLUTION SUMMARY: VERSION 92.030MBP

OPTIMUM SOLUTION OUTPUT FILE: MBP0330.opt

```
Start date/time: 1994/ 2/ 2      6:53:60.     day of year  33    tow    284040.
Stop  date/time: 1994/ 2/ 2      8:36:15.     day of year  33    tow    290175.
```

STATION INFORMATION

Sta	ID	Ant (m)	Latitude	Longitude	Hgt (m)
1	SP74	0.665	1:10'04.12100"S	136:05'23.63200"E	124.410
2	BIAK	1.549	1:11'33.96237"S	136:06'27.77393"E	88.385

Origin of station 1 coordinates : User input

COMPUTED VECTOR INFORMATION

Station From	To	Slope Distance (m)	Normal Section Azimuth (dms)	Vertical Angle (dms)	Fixed Quality	RDOP
1	2	3398.342	144 17 56.50	-000 37 21.02	4.25	0.0600

ALL VECTORS (dx, dy and dz between ECEF Coordinates)

	From	To	dx(m)	dy(m)	dz(m)	dist(m)	dh(m)
FIX	1	2	-1308.148	-1493.227	-2758.215	3398.342	-36.025

L1 solution
Measurements used: 274   Rejected: 8   RMS (cycles)   0.025

```
WGS84 coordinates (input)
latitude   (d,m,s): S 1 11 33.9623          x-coordinate(m): -4595443.577
longitude  (d,m,s): E136  6 27.7739         y-coordinate(m): 4421102.503
longitude  (d,m,s): W223 53 32.2261         z-coordinate(m): -131881.886
ellipsoid height(m): 88.3850
```

another transformation ? (Y/N)

APPENDIX 5.1

GEODETIC AND UTM COORDINATE IN ID '74

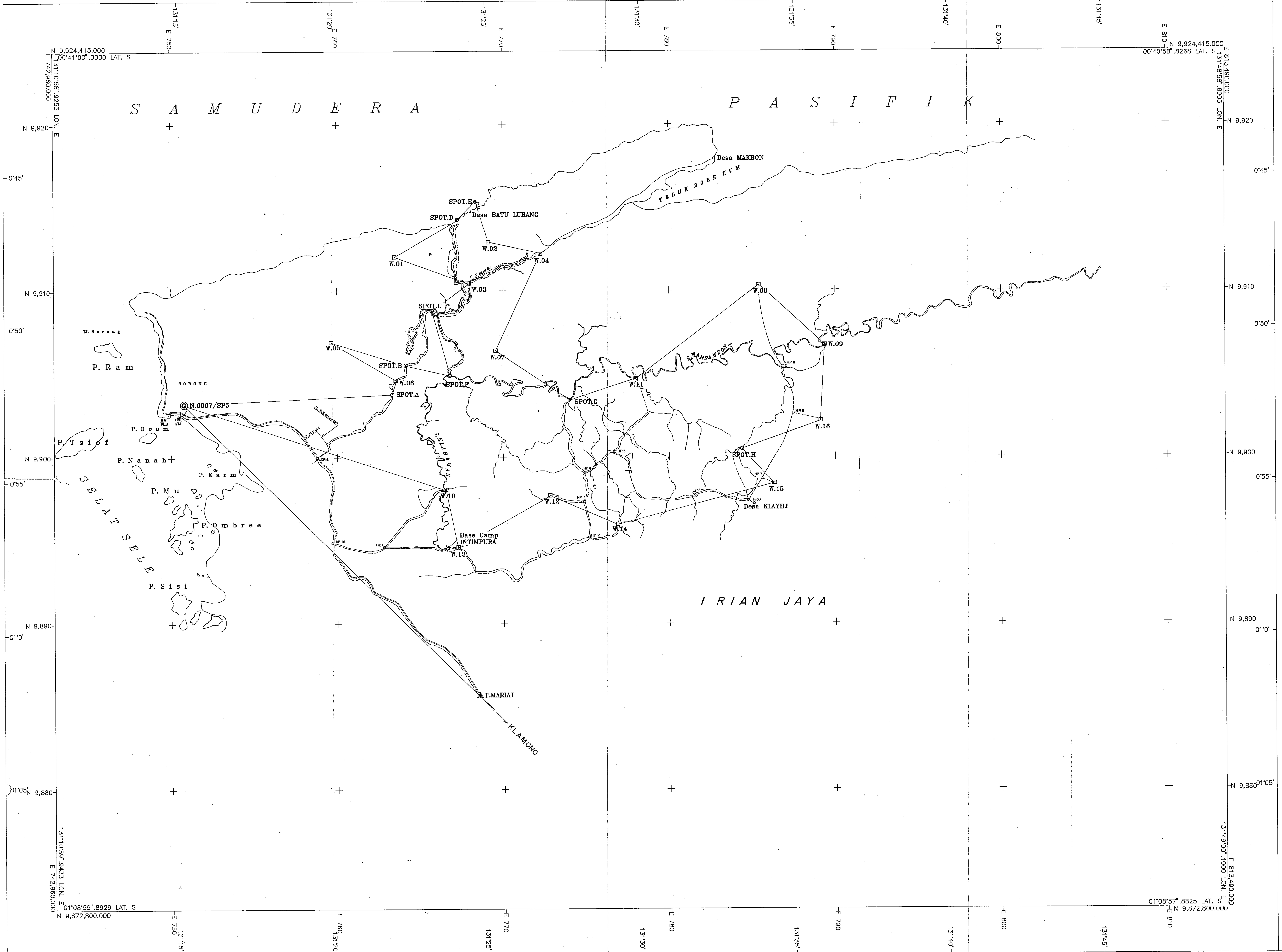
FINAL RESULT
GOEDETIC AND UTM COORDINATE IN ID '74

POINT ID	LATITUDE ° ' ''	LONGITUDE ° ' ''	EASTING (METER)	NORTHING (METER)	ELLIPSOID HEIGHT (METER)	MEAN SEA LEVEL (METER)
N.6007/SP.5	0 52 30.484873 S	131 15 11.809801 E	750770.613	9903195.577	135.0122	65.924
SPOT.A	0 52 11.521678 S	131 21 56.619315 E	763292.357	9903770.590	175.4542	106.219
SPOT.B	0 51 14.330856 S	131 22 23.966338 E	764139.375	9905527.503	140.6619	71.308
SPOT.C	0 49 27.942737 S	131 23 15.458737 E	765734.200	9908795.803	111.8788	42.568
SPOT.D	0 46 29.194036 S	131 24 5.140106 E	767274.250	9914287.846	73.3456	4.237
SPOT.E	0 45 53.682857 S	131 24 40.193206 E	768359.216	9915378.500	103.9480	-
SPOT.F	0 51 34.578076 S	131 23 50.090138 E	766803.086	9904903.652	111.3999	42.051
SPOT.G	0 52 22.720677 S	131 27 41.839936 E	773971.154	9903419.594	142.0436	72.664
SPOT.H	0 53 58.620979 S	131 33 18.570847 E	784386.257	9900465.269	139.8071	70.277
W.01	0 47 42.306675 S	131 22 2.955983 E	763493.337	9912043.270	440.5935	-
W.02	0 47 13.348256 S	131 25 5.034047 E	769126.261	9912929.911	258.9286	-
W.03	0 48 34.165572 S	131 24 27.726280 E	767970.708	9910447.042	105.4277	36.416
W.04	0 47 37.039582 S	131 26 45.812070 E	772243.397	9912200.031	86.5970	17.267
W.05	0 50 29.096803 S	131 19 58.879759 E	759652.299	9906920.231	138.0100	-
W.06	0 51 43.431714 S	131 22 4.843200 E	763547.284	9904633.617	164.7633	95.478
W.07	0 50 45.832418 S	131 25 18.880571 E	769550.663	9906399.900	140.5221	-
W.08	0 48 38.302046 S	131 35 50.922342 E	785393.698	9910309.225	250.8584	181.623
W.09	0 50 35.272855 S	131 33 58.653682 E	789343.141	9906711.631	127.0826	57.664
W.10	0 55 18.004726 S	131 23 41.648464 E	766537.491	9898037.920	145.9417	77.033
W.11	0 51 40.851653 S	131 29 52.060442 E	778000.428	9904703.669	120.5015	51.116
W.12	0 55 29.649308 S	131 27 3.982401 E	772796.178	9897675.807	241.8427	172.561
W.13	0 57 10.308663 S	131 24 5.806582 E	767282.409	9894586.301	162.5095	93.489
W.14	0 56 26.392166 S	131 29 16.621662 E	776898.104	9898929.122	245.7648	176.449
W.15	0 55 5.707576 S	131 34 20.517556 E	786301.245	9898402.073	198.1395	128.533
W.16	0 53 3.584829 S	131 35 51.172958 E	789108.581	9902153.455	149.2650	79.663
T. MARIAT	1 02 1.494810 S	131 24 45.987847 E	768518.802	9885637.166	250.3837	181.161

APPENDIX 6.1.

MAP OF STATIC GPS NETWORK

TRAVERSING AND LEVELLING ROUTE



KEY MAP

NOTES

INDEX SHEET

LEGEND

- EXISTING DOPPLER STATION
- EXISTING TRIANGULATION STATION
- GPS POINT
- SPOT GPS POINT
- GPS NETWORK
- TRAVERSING ROUTE
- LEVELLING ROUTE

N

SKALA / SCALE 1 : 100.000

0 1 2 4 6 8 10 KM

P. T. PLN (PERSERO)

THE FEASIBILITY STUDY ON THE WARSAMSON HYDROELECTRIC POWER DEVELOPMENT PROJECT IN SORONG, IRIAN JAYA

INDEX MAP OF SURVEY WORKS

CHECKED BY :	SCALE	SHEET NUMBER :
APPROVED BY :	1 : 100.000	TOTAL SHEETS :

PT. AEROKARTO INDONESIA

JICA JAPAN INTERNATIONAL COOPERATION AGENCY

APPENDIX 6.2.

FINAL COORDINATE AND ELEVATION OF GPS SURVEY

PT. AEROKARTO IND.

FINAL COORDINATES AND ELEVATION
GPS SURVEY
OF WARSAMSON HEPDP

STA.	E	N	H	REMARKS
N 6007/SP.5	750,770.613	9,903,195.577	65.924	MASTER STATION
W.01	763,493.337	9,912,043.270	372.860	*1
W.02	769,126.261	9,912,929.911	189.800	*2
W.03	767,970.708	9,910,447.042	36.146	
W.04	772,243.397	9,912,200.031	17.267	
W.05	759,652.299	9,906,920.231	72.340	*3
W.06	763,547.284	9,904,633.617	95.478	
W.07	769,550.663	9,906,399.900	–	
W.08	785,393.698	9,910,309.225	181.623	
W.09	789,343.141	9,906,711.631	57.664	
W.10	766,537.491	9,898,037.920	77.033	
W.11	778,000.428	9,904,703.669	51.116	
W.12	772,796.178	9,897,675.807	172.561	
W.13	767,282.409	9,894,586.301	93.489	
W.14	776,898.104	9,895,929.122	176.449	
W.15	786,301.245	9,898,402.073	128.533	
W.16	789,108.581	9,902,153.455	79.663	
SPOT–A	763,292.357	9,903,770.590	106.219	
SPOT–B	764,139.375	9,905,527.503	71.308	
SPOT–C	765,734.200	9,908,795.803	42.568	
SPOT–D	767,274.250	9,914,287.846	4.237	
SPOT–E	768,359.216	9,915,378.500	35.120	*4
SPOT–F	766,803.086	9,904,903.652	42.051	
SPOT–G	773,971.154	9,903,419.594	72.664	
SPOT–H	784,386.257	9,900,465.269	70.277	
T. MARIAT	768,518.802	9,885,637.166	181.161	
BM/KTJ	–	–	2.504	

NOTES

1) REFERENCE ELLIPSOID : ID74 (GRS 67)
2) PROJECTION SYSTEM : UTM – ZONE52
3) ELEVATION : SORONG PEIL – MEAN SEA LEVEL OF SORONG BAY
4) *1 ~ *3 : ELEVATION BY "BLOCK ADJUSTMENT WITH BOUNDLES" IN AERIAL TRIANGULATION
5) *4 : ELEVATION BY EDM

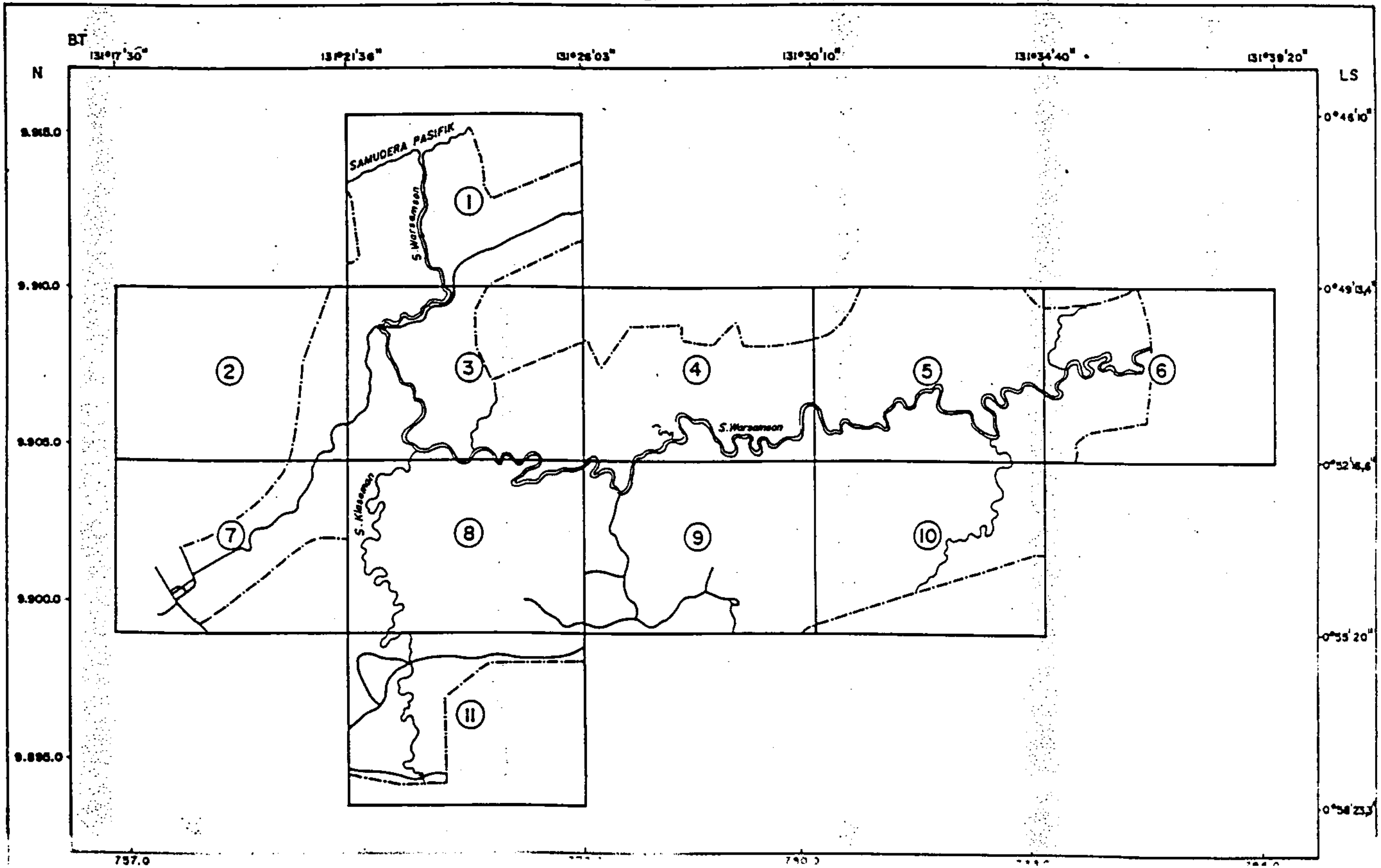
APPENDIX 9.1

INDEX SHEET FOR MAP OF SCALE 1 : 10,000

SHEET INDEX

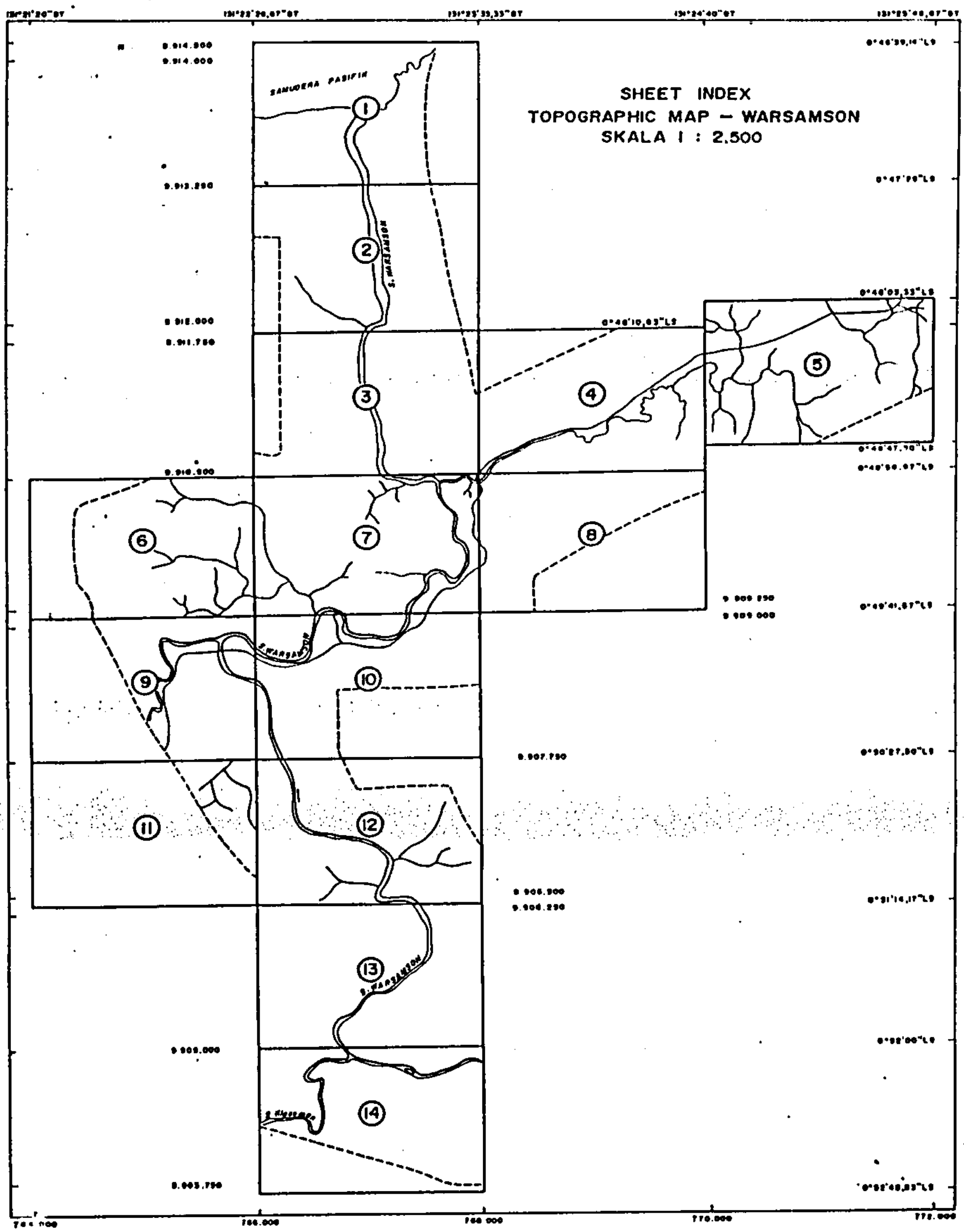
TOPOGRAPHIC MAP-WARSAMSON

SKALA 1:10.000



APPENDIX 9.2

INDEX SHEET FOR MAP OF SCALE 1 : 2,500


SHEET INDEX
TOPOGRAPHIC MAP – WARSAMSON
SKALA 1 : 2.500
SAMUDERA PASIFIK
S. WARSAMSON
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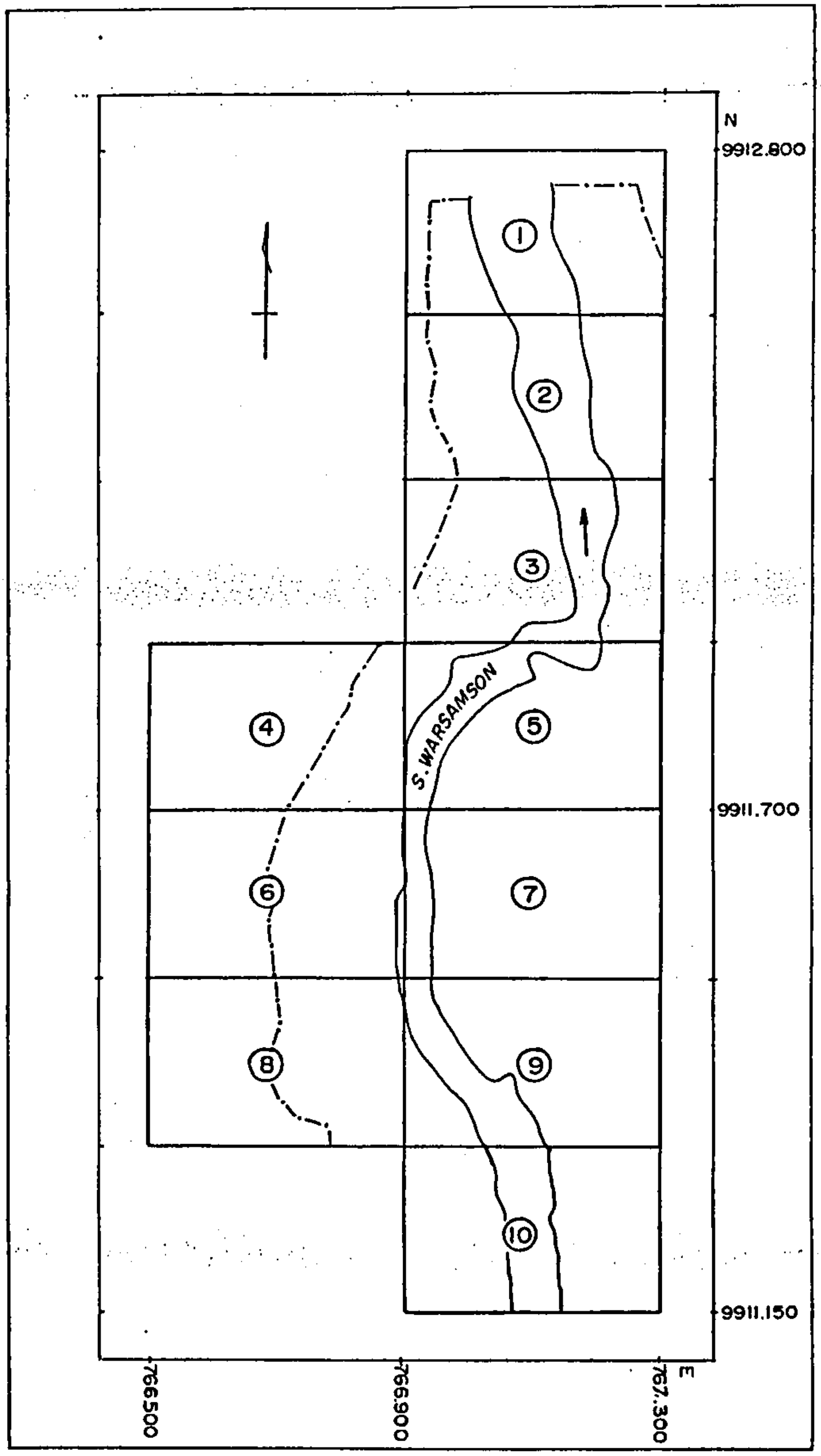
APPENDIX 9.3

INDEX SHEET FOR MAP OF SCALE 1 : 500

SHEET INDEX

TOPOGRAPHIC MAP WARSAMSON

SCALE 1:500



APPENDIX 11.1

FINAL COORDINATE AND ELEVATION OF MAIN TRAVERSE ROUTE

PT. AEROKARTO INDONESIA

WARSAMSON PROJECT **ROUTE : R**

NO.	E	N	H	REMARKS
SPOT-E	768,359.216	9,915,378.500	35.12	PVC
SPOT-D	767,274.250	9,914,287.846	4.237	PVC
AC.1	766,960.203	9,913,952.908	5.90	PVC
1	766,987.491	9,913,853.630	0.83	
2	766,974.487	9,913,817.184	2.00	
3	766,959.616	9,913,788.114	15.36	
4	766,941.081	9,913,744.940	1.65	
5	766,929.767	9,913,673.367	1.82	
6	766,941.542	9,913,600.451	3.81	
7	766,977.238	9,913,540.246	7.51	
8	766,989.031	9,913,471.541	4.93	
9	767,002.401	9,913,445.955	1.78	
10	767,012.367	9,913,429.578	6.88	
11	767,034.315	9,913,390.947	15.53	
12	767,042.623	9,913,367.653	12.21	
13	767,051.055	9,913,305.986	0.85	
14	767,076.126	9,913,246.204	2.57	
15	767,063.884	9,913,187.450	9.69	
16	767,030.512	9,913,138.836	0.75	
17	767,027.788	9,913,099.735	0.96	
D.10	767,036.418	9,913,071.654	3.49	
18	767,035.629	9,913,042.983	5.52	
19	767,037.198	9,912,993.394	2.73	
20	767,042.720	9,912,962.349	0.76	
21	767,055.877	9,912,933.237	2.08	
22	767,064.169	9,912,880.875	0.95	
23	767,081.296	9,912,833.289	1.25	
24	767,106.812	9,912,790.872	2.49	
R.1	767,112.066	9,912,717.774	3.45	
R.2	767,143.928	9,912,693.236	12.12	
R.3	767,159.025	9,912,659.951	37.57	
D.8	767,158.635	9,912,649.966	42.61	
R.4	767,159.273	9,912,604.820	22.94	
D.7	767,159.529	9,912,580.912	8.57	
R.5	767,156.756	9,912,533.108	3.68	
R.6	767,166.516	9,912,479.561	7.05	
R.7	767,191.034	9,912,383.076	17.13	
R.8	767,182.188	9,912,356.578	5.29	
R.9	767,179.463	9,912,337.512	5.14	
AC.2	767,180.059	9,912,286.737	4.53	PVC

PT. AEROKARTO INDONESIA

WARSAMSON PROJECT **ROUTE : R**

NO.	E	N	H	REMARKS
R.7	767,191.034	9,912,383.076	17.13	
R.8	767,182.188	9,912,356.578	5.29	
R.9	767,179.463	9,912,337.512	5.14	
AC.2	767,180.059	9,912,286.737	4.53	PVC
PLN.10	767,212.272	9,912,268.121	9.11	CONCRETE
R.10	767,226.602	9,912,216.791	8.21	
R.11	767,218.447	9,912,159.751	6.15	
R.12	767,211.261	9,912,123.600	8.22	
AC.3	767,207.782	9,912,102.438	5.98	PVC
R.13	767,209.029	9,912,087.999	9.16	
R.14	767,220.609	9,912,025.468	15.66	
R.15	767,211.206	9,911,988.817	19.33	
D.6	767,179.446	9,911,934.087	6.88	
R.16	767,188.492	9,911,878.819	22.93	
R.17	767,210.613	9,911,852.055	43.20	
R.18	767,227.191	9,911,767.770	60.15	
R.19	767,232.785	9,911,706.531	71.82	
D.5	767,237.487	9,911,680.416	74.88	
R.20	767,193.300	9,911,627.954	126.25	
R.21	767,184.672	9,911,603.995	141.20	
R.22	767,169.865	9,911,582.829	153.85	
D.4	767,147.008	9,911,563.077	153.66	
R.23	767,146.226	9,911,511.418	149.18	
R.24	767,144.984	9,911,457.897	142.83	
R.25	767,147.489	9,911,417.937	132.55	
R.26	767,155.630	9,911,378.980	133.83	
R.27	767,151.332	9,911,360.544	134.51	
R.28	767,147.844	9,911,330.793	126.62	
R.29	767,142.801	9,911,296.001	113.03	
R.30	767,151.349	9,911,253.164	90.03	
D.3	767,127.336	9,911,245.440	83.07	
R.31	767,111.957	9,911,242.311	75.53	
R.32	767,058.008	9,911,234.933	41.05	
R.33	767,083.645	9,911,168.333	35.88	
R.34	767,107.207	9,911,114.961	37.77	
AC.4	767,116.160	9,911,076.024	42.11	PVC

NO.	E	N	H	REMARKS
R.44	767,113.454	9,910,661.000	36.69	
R.45	767,116.743	9,910,605.001	39.10	
R.46	767,115.194	9,910,548.981	37.46	
R.47	767,133.529	9,910,502.108	38.69	
R.48	767,148.910	9,910,456.548	38.82	
R.49	767,202.755	9,910,426.743	40.05	
R.50	767,244.645	9,910,420.408	35.71	
R.51	767,325.134	9,910,448.930	36.61	
R.52	767,369.699	9,910,475.168	37.44	
R.53	767,433.261	9,910,493.623	37.58	
R.54	767,498.831	9,910,500.080	39.02	
PB.1	767,533.750	9,910,500.601	37.31	CONCRETE
R.55	767,594.362	9,910,494.765	35.31	
R.56	767,641.403	9,910,477.115	36.78	
R.57	767,681.913	9,910,491.490	36.86	
R.58	767,739.952	9,910,510.236	31.51	
R.59	767,796.245	9,910,492.034	34.57	
R.60	767,843.851	9,910,465.915	37.96	
R.61	767,907.064	9,910,455.691	39.03	
W.03	767,970.708	9,910,447.042	36.146	CONCRETE

PT. AEROKARTO INDONESIA

WARSAMSON PROJECT **ROUTE : L**

NO.	E	N	H	REMARKS
R2	767,143.928	9,912,693.236	12.12	
R1	767,112.066	9,912,717.774	3.45	
L1	767,020.033	9,912,712.193	1.66	
L2	767,024.080	9,912,664.835	3.00	
L3	767,047.487	9,912,600.265	3.15	
PB.10	767,062.333	9,912,570.713	2.95	CONCRETE
L4	767,048.872	9,912,516.901	17.52	
L5	767,025.779	9,912,435.469	32.99	
L6	767,020.581	9,912,377.279	45.48	
L7	767,002.085	9,912,351.667	62.05	
L8	766,992.661	9,912,302.142	84.17	
L9	766,981.709	9,912,267.399	104.51	
L10	766,966.878	9,912,214.832	130.11	
L11	766,962.997	9,912,197.233	130.78	
L12	766,938.482	9,912,107.702	141.13	
L13	766,938.491	9,912,085.019	138.48	
L14	766,931.687	9,912,071.829	134.01	
L15	766,927.294	9,912,065.107	128.34	
L16	766,919.304	9,912,039.451	101.21	
L17	766,918.160	9,912,026.135	87.30	
L18	766,900.971	9,911,981.914	51.92	
L19	766,914.925	9,911,950.646	59.52	
L20	766,928.681	9,911,922.278	60.54	
L21	766,898.128	9,911,886.587	63.99	
L22	766,876.992	9,911,856.810	67.72	
L23	766,852.145	9,911,822.152	70.83	
L24	766,836.536	9,911,760.447	81.45	
L25	766,823.045	9,911,701.959	88.99	
L26	766,822.822	9,911,667.717	102.66	
L27	766,819.144	9,911,609.858	95.89	
L28	766,820.634	9,911,551.793	83.77	
L29	766,812.130	9,911,492.266	89.15	
L30	766,814.224	9,911,480.513	92.43	
L31	766,814.619	9,911,435.438	84.08	
L32	766,810.558	9,911,364.665	99.05	
L33	766,815.137	9,911,315.764	117.08	
L34	766,814.536	9,911,290.933	121.66	

PT. AEROKARTO INDONESIA

WARSAMSON PROJECT ROUTE : L

NO.	E	N	H	REMARKS
L35	766,817.648	9,911,268.046	103.14	
L36	766,836.860	9,911,236.325	73.07	
L37	766,862.715	9,911,204.397	61.02	
L38	766,929.806	9,911,163.637	85.68	
L39	766,978.683	9,911,166.137	65.98	
L40	767,018.888	9,911,148.412	45.30	
L41	767,045.368	9,911,106.388	37.44	
L42	767,071.183	9,910,999.158	44.83	
L43	767,071.376	9,910,931.377	48.12	
L44	767,064.976	9,910,870.383	48.83	
L45	767,075.236	9,910,842.916	46.69	
L46	767,070.235	9,910,790.543	42.02	
L46'	767,122.131	9,910,772.132	34.06	
R42	767,128.830	9,910,776.943	38.05	
R41	767,133.661	9,910,831.218	37.06	

PT. AEROKARTO INDONESIA

WARSAMSON PROJECT **ROUTE : C**

POINTS	E	N	H	REMARKS
R54	767,498.831	9,910,500.080	39.02	
PB.1	767,533.750	9,910,500.601	37.31	CONCRETE
C.1	767,558.938	9,910,463.153	35.58	
C.2	767,568.592	9,910,405.814	34.57	
C.3	767,562.181	9,910,396.301	34.71	
C.4	767,572.842	9,910,373.224	34.18	
C.5	767,567.065	9,910,347.629	34.63	
C.6	767,573.029	9,910,302.375	39.97	
C.7	767,556.956	9,910,260.751	34.01	
C.8	767,557.658	9,910,214.379	35.49	
C.9	767,595.256	9,910,130.652	35.17	
C.10	767,646.649	9,910,079.297	35.63	
C.11	767,674.449	9,910,041.888	36.43	
C.12	767,713.629	9,909,998.741	36.89	
C.13	767,723.686	9,909,969.089	38.38	
C.14	767,739.161	9,909,931.633	38.84	
C.15	767,756.850	9,909,859.914	37.67	
C.16	767,793.906	9,909,845.593	39.62	
C.17	767,831.320	9,909,840.185	38.86	
C.18	767,899.282	9,909,818.493	36.71	
C.19	768,001.718	9,909,588.458	39.62	
C.20	767,972.966	9,909,515.478	39.31	
C.21	767,699.767	9,909,423.408	36.87	
C.22	767,655.431	9,909,439.010	42.94	
C.23	767,640.460	9,909,480.598	36.54	
C.24	767,617.870	9,909,521.030	36.96	
C.25	767,613.680	9,909,577.286	36.87	
C.26	767,586.884	9,909,581.375	36.98	
C.27	767,561.805	9,909,569.102	36.90	
C.28	767,529.045	9,909,540.951	37.39	
C.29	767,503.198	9,909,511.182	37.89	
C.30	767,489.635	9,909,495.818	37.07	
C.31	767,474.440	9,909,462.978	37.61	
C.32	767,456.931	9,909,378.566	37.81	
C.33	767,462.373	9,909,329.008	38.89	
C.34	767,455.278	9,909,308.280	39.43	
C.35	767,434.839	9,909,265.858	37.33	
C.36	767,414.397	9,909,232.368	38.20	
C.37	767,401.522	9,909,188.314	38.93	
C.38	767,403.936	9,909,154.852	39.51	

POINTS	E	N	H	REMARKS
C.39	767,411.013	9,909,104.758	38.22	
C.40	767,415.690	9,908,994.616	39.38	
C.41	767,157.842	9,908,802.416	36.52	
C.42	767,119.456	9,908,808.898	38.05	
C.43	767,091.631	9,908,826.233	38.49	
C.44	767,032.149	9,908,840.644	39.96	
C.45	767,003.008	9,908,841.071	38.86	
C.46	766,988.693	9,908,836.415	38.85	
C.47	766,962.576	9,908,828.936	38.10	
C.48	766,932.006	9,908,822.961	38.35	
C.49	766,908.113	9,908,830.578	37.51	
C.50	766,856.421	9,908,843.842	38.10	
C.51	766,824.794	9,908,865.340	38.21	
C.52	766,788.805	9,908,907.598	38.51	
C.53	766,784.196	9,908,948.712	37.60	
C.54	766,774.194	9,908,993.676	38.14	
C.55	766,775.982	9,909,044.491	38.39	
C.56	766,777.883	9,909,096.638	38.22	
C.57	766,730.017	9,909,163.481	38.47	
C.58	766,697.563	9,909,194.178	38.13	
C.59	766,652.687	9,909,167.779	37.92	
C.60	766,645.805	9,909,135.233	38.35	
C.61	766,615.283	9,909,082.010	38.35	
C.62	766,594.997	9,909,040.020	37.92	
C.63	766,589.882	9,908,996.809	38.56	
C.64	766,599.474	9,908,978.830	40.24	
C.65	766,602.317	9,908,958.485	50.14	
C.66	766,585.869	9,908,926.510	41.82	
C.67	766,569.681	9,908,888.203	45.87	
C.68	766,573.828	9,908,847.767	42.49	
C.69	766,563.253	9,908,784.048	41.97	
C.70	766,555.676	9,908,773.627	37.63	
C.71	766,350.797	9,908,652.731	36.59	
C.72	766,331.856	9,908,645.677	38.81	
C.73	766,299.133	9,908,656.478	38.58	
C.74	766,257.920	9,908,655.694	39.65	
C.75	766,209.327	9,908,674.578	39.04	
C.76	765,988.225	9,908,789.899	36.72	
C.77	765,972.675	9,908,808.030	38.11	
C.78	765,951.280	9,908,856.821	38.66	

WARSAMSON PROJECT **ROUTE : C**

POINTS	E	N	H	REMARKS
C.79	765,922.569	9,908,892.713	38.64	
C.80	765,875.556	9,908,909.908	39.02	
C.81	765,841.584	9,908,910.098	39.24	
C.82	765,776.564	9,908,888.953	38.72	
C.83	765,752.393	9,908,867.345	39.33	
SPOT-C	765,734.200	9,908,795.803	42.568	CONCRETE

PT. AEROKARTO INDONESIA

WARSAMSON PROJECT ROUTE : F

NO.	E	N	H	REMARKS
F.1	765,763.321	9,908,693.905	39.85	
F.2	765,755.132	9,908,621.016	38.95	
F.3	765,770.501	9,908,597.285	38.93	
F.4	765,801.690	9,908,576.984	39.44	
F.5	765,832.596	9,908,566.733	39.55	
F.6	765,858.581	9,908,546.490	38.97	
F.7	765,892.518	9,908,539.618	40.81	
F.8	765,947.664	9,908,513.763	42.21	
F.9	765,993.436	9,908,496.587	40.36	
F.10	766,139.114	9,908,353.090	38.96	
F.11	766,151.974	9,908,313.239	40.64	
F.12	766,161.124	9,908,278.389	39.99	
F.13	766,170.150	9,908,195.265	40.33	
F.14	766,159.885	9,908,142.733	40.11	
F.15	766,148.159	9,908,101.969	38.62	
F.16	766,155.885	9,908,035.094	39.30	
F.17	766,180.945	9,907,947.871	40.30	
F.18	766,188.689	9,907,920.397	39.46	
F.19	766,227.933	9,907,826.901	39.40	
F.20	766,252.050	9,907,774.881	39.80	
F.21	766,273.531	9,907,711.093	39.60	
F.22	766,293.097	9,907,694.087	41.98	
F.23	766,299.774	9,907,645.969	39.41	
F.24	766,315.889	9,907,593.395	41.44	
F.25	766,317.034	9,907,563.935	40.31	
F.26	766,331.122	9,907,538.049	39.29	
F.27	766,353.395	9,907,487.341	39.78	
F.28	766,361.086	9,907,463.339	42.14	
F.29	766,366.919	9,907,423.893	41.28	
F.30	766,399.311	9,907,368.484	43.36	
F.31	766,400.498	9,907,348.916	40.89	
F.32	766,422.570	9,907,297.346	43.13	
F.33	766,440.275	9,907,254.161	39.74	
F.34	766,467.227	9,907,198.011	39.41	
F.35	766,502.759	9,907,152.694	39.66	
F.36	766,537.893	9,907,130.523	39.18	
F.37	766,578.225	9,907,118.959	40.93	
F.38	766,618.101	9,907,093.713	39.92	
F.39	766,654.839	9,907,074.317	39.58	

PT. AEROKARTO INDONESIA

WARSAMSON PROJECT ROUTE : F

NO.	E	N	H	REMARKS
F.40	766,719.544	9,907,059.744	39.35	
F.41	766,796.404	9,907,046.606	39.82	
F.42	766,842.524	9,907,036.371	40.71	
F.43	766,959.813	9,907,022.524	40.80	
F.44	767,004.927	9,907,000.844	40.35	
F.45	767,038.742	9,906,963.204	39.51	
F.46	767,062.894	9,906,946.165	44.80	
F.47	767,115.163	9,906,910.584	40.21	
F.48	767,151.660	9,906,892.118	40.07	
F.49	767,197.818	9,906,670.375	39.35	
F.50	767,201.736	9,906,639.724	40.97	
F.51	767,166.095	9,906,561.541	40.72	
F.52	767,117.560	9,906,474.006	42.09	
F.53	767,164.278	9,906,456.266	42.81	
F.54	767,207.879	9,906,448.230	41.99	
F.55	767,241.061	9,906,450.080	44.16	
F.56	767,303.887	9,906,450.066	43.30	
F.57	767,329.856	9,906,455.390	46.49	
F.58	767,387.196	9,906,438.193	48.20	
F.59	767,581.742	9,906,081.856	39.93	
F.60	767,603.857	9,906,045.861	42.66	
F.61	767,604.372	9,906,008.041	42.80	
F.62	767,615.051	9,905,974.455	41.40	
F.63	767,615.684	9,905,908.752	40.26	
F.64	767,588.489	9,905,876.352	42.07	
F.65	767,583.901	9,905,838.000	41.23	
F.66	767,565.011	9,905,791.941	41.69	
F.67	767,519.201	9,905,774.766	41.32	
F.68	767,485.642	9,905,753.098	40.65	
F.69	767,437.558	9,905,739.162	40.71	
F.70	767,407.342	9,905,688.259	41.11	
F.71	767,319.509	9,905,632.931	41.76	
F.72	767,260.506	9,905,579.550	44.99	
F.73	767,222.132	9,905,564.008	41.86	
F.74	767,188.403	9,905,532.438	42.15	
F.75	767,086.656	9,905,527.406	43.09	
F.76	767,035.632	9,905,514.034	48.28	
F.77	766,992.697	9,905,486.507	47.59	
F.78	766,963.673	9,905,459.676	43.28	

WARSAMSON PROJECT ROUTE : F

NO.	E	N	H	REMARKS
F.79	766,944.377	9,905,437.586	46.19	
F.80	766,913.218	9,905,404.129	40.99	
F.81	766,881.742	9,905,353.516	41.28	
F.82	766,873.560	9,905,318.240	42.76	
F.83	766,846.794	9,905,290.846	41.94	
F.84	766,820.544	9,905,270.464	40.60	
F.85	766,781.139	9,905,251.171	40.56	
F.86	766,720.028	9,905,222.565	42.15	
F.87	766,721.036	9,905,148.962	43.37	
F.88	766,754.660	9,905,099.055	46.66	
F.89	766,786.025	9,905,075.426	44.10	
F.90	766,803.756	9,905,048.804	44.34	
SPOT-F	766,803.086	9,904,903.652	42.051	PVC

APPENDIX 11.2

PERMANENT AZIMUTH AND DISTANCE FOR FOLLOWING SURVEY

Permanent Azimuth and Distance
For Following Survey

Point Number	Easting (meter)	Northing (meter)	Elevation (meter)	Azimuth (D M S)	Distance (meter)
Spot E	768,359.216	9,915,378.500	35.120		
				224 51 00.74	1,538.401
Spot D	767,274.250	9,914,287.846	4.237		
				223 09 22.57	459.139
AC.1	766,960.203	9,913,952.908	5.900		
AC.2	767,180.059	9,912,286.737	4.530		
				120 01 25.54	37.205
PLN.10	767,212.272	9,912,268.121	9.109		
Spot C	765,734.200	9,908,795.803	42.568		
				271 51 52.96	84.912
AB.1	765,649.333	9,908,798.566	42.848		