SUPPORTING REPORT

PART-K

SOCIO-ECONOMY AND LAND USE

THE STUDY ON FLOOD CONTROL FOR AMBON AND PASAHARI AREA
IN THE REPUBLIC OF INDONESIA
SUPPORTING REPORT
PART-K

TABLE OF CONTENTS

LIST OF TABLES AND FIGURES

LIST OF TABLES

LIST OF FIGURES

CHAPTER 1 SOCIO-ECONOMY

1.1 Current Social Conditions

Transmigration to Seram Island is concentrated in the Pasahari Area. It is located in the Seram Utara Sub-District of the Central Maluku District. The study area is composed of seven villages (Wailoping, Kobi, Waitonipa, Marasahua, Morokai and Samal) and other new transmigration units outside the villages. Most of the families in the Pasahari Area migrated under the Government's transmigration policy. There were 27 resettlement units as of August 1996.

The Seram Island transmigration was started in the fiscal year 1982/83, and was administrated by the Transmigration Agency. Eight areas were selected as the destinations for transmigration to Seram Island: Samal I (on the right bank of the Samal River), Samal II (on the left bank of the Samal River), Kobi and Lofin, Matakabo, Bote, Musala and Namto, out of which Samal I, Samal II and Kobi are located within the Study Area. According to the Transmigration Agency, total transmigration to Seram Island will number 9,800 households by the time the program is completed; around 7,000 households have already migrated. Each of these households has been provided with two ha of land: one ha for main crops, 3/4 ha for supplemental crops and 1/4 ha for housing. Table-K.1.1 shows the number of households and population in the Study Area, including both transmigrated and local people.

Table-K.1.1 No. of Households and Population in the Study Area (December 1996)

Transmigration Area	Potential Irrigation Area	No. of Households	Population
Samal I	2,217 ha	1,488	5,764
Samal II	2,500 ha	815	3,500
Kobi	2,898 ha	1,779	6,522
TOTAL	7,515 ha	4082	15,786

Source : JICA Study Team

There are currently five resettlement units in Samal I, six units in Samal II and eight units in Kobi. Most of the families originate from East or West Java, where Islam is the only religion. There are also several small groups of native families in the Pasahari Area. Overall, the relationship between the resettlers and native residents has been good; native residents provide seeds to resettlers, who, in turn, transfer rice plantation technology to native residents (rice was not produced in this area before the transmigration). According to interviews with resettlers, more than 100 households went back to Java after the severe dry season in 1988 (all rice fields were rain-fed at that time) and several have already returned to Pasahari. All the resettlers who transmigrated in the 1980s have already been issued land certificates.

Social facilities such as schools, clinics and religious facilities are provided by the Government under the transmigration scheme. No public transport is available yet; bicycles and motorcycles are the major means of transport within the villages, while private trucks/vehicles, although still scarce, are available for transport between or outside the villages.

1.2 Irrigation Scheme

The construction of the Ministry of Public Works' irrigation scheme, which has mainly been financed by the Asian Development Bank, started in the fiscal year 1993/94. It is expected that construction on 1,884 ha in Samal I and 1,411 ha in Kobi (and 281 ha in Lofin) will be completed by the end of the fiscal year 1996/97. Although the construction of the irrigation network in Samal II is envisaged for the fiscal year 1998/99, the designing phase has not yet begun due to budgetary constraints. Financing by the OECF for the uncompleted part of the irrigation network for Samal I and Kobi is currently under consideration. The total construction costs are expected to be Rp 3,250 million for Samal I and Rp 10,550 million for Kobi. Figure-K.1.1 shows the Ministry of Public Works' irrigation scheme in the Pasahari Area.

1.3 Current Agricultural Production

The population is highly dependent on the agricultural sector for employment. With the exception of some small shops and restaurants, no industrial or commercial services exist. However, trading activities are expected to increase in accordance with the increase in agricultural production; food crops are already shipped to Ambon City through Kobisadar Port, which is located close to the mouth of the Samal River. This port is equipped with a relatively large pier that enables loading of agricultural products onto several medium-sized boats at one time. It takes about four days to go by boat from Kobisadar to Ambon.

The following table shows the production volume of major food crops, their planted area and productivity in the Pasahari Area.

Table-K.1.2 Planted Area and Production of Major Food Crops (Fiscal Year 1995/96)

Crops	Planted Area (ha)	Production (ton)	Productivity (ton/ha)
Rice (Wet Land)	649	3,505	5.4
Rice (Dry Land)	1,330	2,128	1.6
Maize	240	480	0.5
Mung Bean	70	70	1.0
Peanut	200	240	1.2
Soybean	1,550	1,550	1.0
Cabbage	9	27	3.0
Cowpea	6	15	2.5
String bean	4	6	1.5

Source: Department of Agriculture, Maluku Province

Before the construction of irrigation canals, rice was used only for consumption by families, while the surplus of other crops, such as maize, cassava or corn, was shipped to Ambon. In 1996, the first harvest of rice on the irrigated area took place, and the surplus was shipped to Ambon that very same year. Rice production is expected to significantly increase, in line with the development of irrigation facilities. Agricultural income is still small, estimated at Rp 2.5 to 3 million per household.

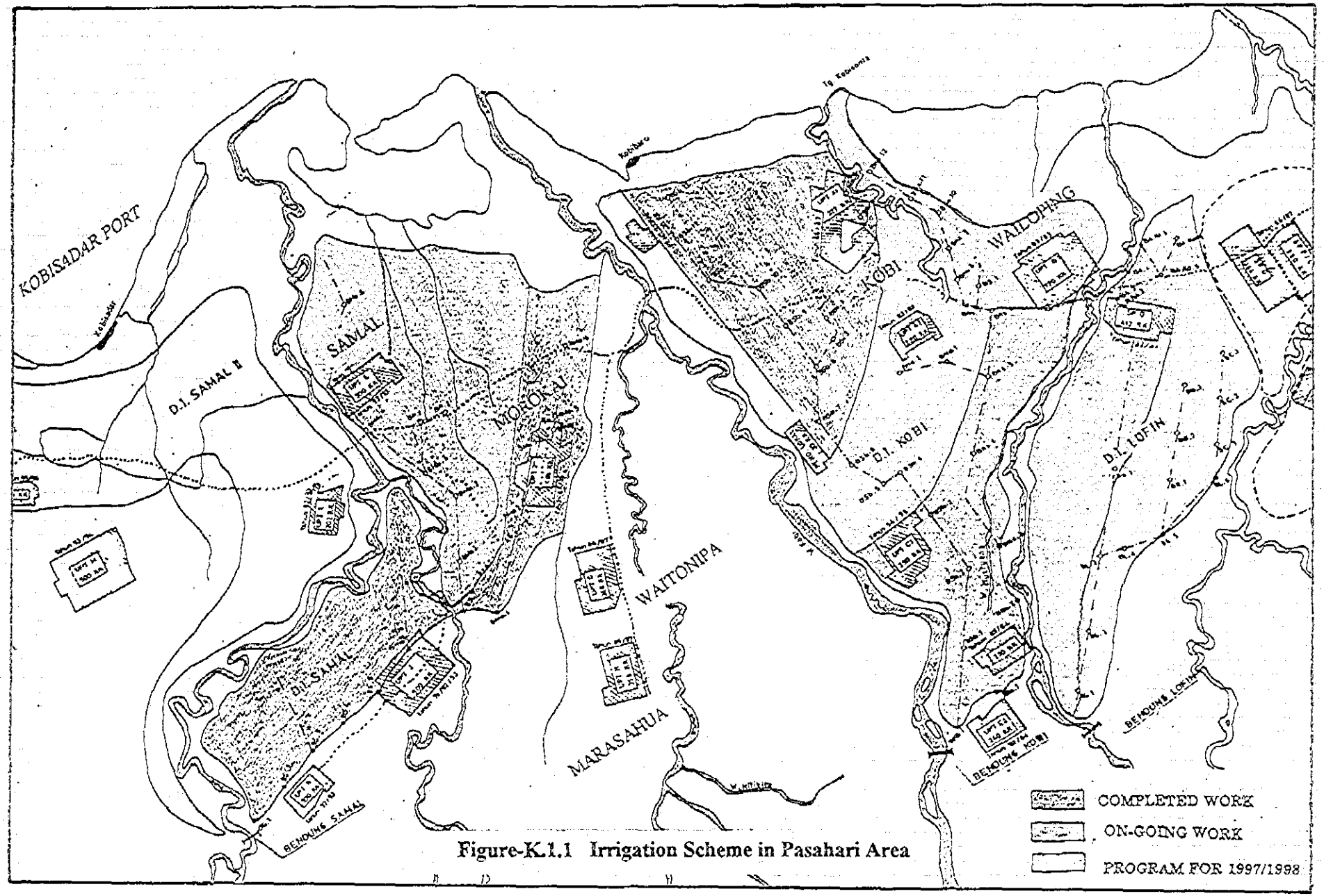


Figure-K.1.1 Irrigation Scheme in Pasahari Area

1.4 Future Socio-economic Conditions

1.4.1 Future Population

The future transmigration schedule to the Study Area is shown in Table-K.1.3. According to the Transmigration Agency, 4,120 people are scheduled to be newly transmigrated by the end of the fiscal year 1998/99. Since no more transmigration is currently planned by the Transmigration Agency in the Pasahari Area, this study used 1.9% as the figure for future population growth rate in this area, which is the same as the national population growth rate. The future population in the Study Area is shown in Table-K.1.4.

Table-K.1.3 Transmigration Plan

Transmigration Area	1997/98			1998/99		
	Area (ha)	No. of Household	* Population	Area (ha)	No. of Household	* Population
Samal I	260	130	520	500	250	1,000
Samal II	500	250	1,000	-	-	-
Kobi	800	400	1,600	-	-	-
TOTAL	1,560	780	3,120	500	250	1,000

Source : Transmigration Agency in Ambon, 1997

* Estimated by JICA Study Team applying the figure 4 person/household.

Table-K.1.4 Future Population in the Study Area

Year	1996	1998	2000	2005	2010	2015	2020	2025	2030
New Transmigration	-	4,120	4,278	4,700	5,164	5,674	6,233	6,849	7,524
Population Existing in 1996	15,786	16,392	17,020	18,700	20,545	22,573	24,800	27,247	29,936
Total	15,786	20,512	21,298	23,400	25,709	28,246	31,034	34,096	37,460

Source : JICA Study Team

1.4.2 Expected Increase in Agricultural Production

It is expected that agricultural production in the Pasahari Area will increase in line with development of irrigation canals. The Seram Irrigation Project of DGWRD anticipates that the future cropping intensity in paddy will be 170% for Samal I (limited water availability will prevent the second cropping in some areas) and 200% for Kobi. Each area is expected to attain a yield of 4.5 ton/ha/harvest by the year 2001. As a result, the anticipated rice production in Samal I and Kobi from 2001 is 16,960 tons/year and 26,082 tons/year, respectively. Although there are no data available regarding water availability in Samal II, cropping intensity in paddy is expected to increase significantly also in this area when the irrigation project is realized. The following table shows the anticipated increase in cropped area and yields in Samal I and Kobi.

Table-K.1.5 Anticipated Increase in Cropped Area and Yields

Year	Samal I			Year	Kobi		
	Net Area	Cropped Area	Yield (ton/ha/harv.)		Net Area	Cropped Area	Yield (ton/ha/harv.)
1997	1,417	2,834	2.67	1997	1,900	3,800	2.96
1998	〃	〃	3.04	1998	〃	〃	3.34
1999	2,217	2,834	3.46	1999	〃	〃	3.73
2000	〃	3,634	3.95	2000	〃	〃	4.11
2001	〃	3,667	4.50	2001	2,898	5,796	4.50
2002	〃	〃	4.50	2002	〃	〃	4.50
2003	〃	〃	4.50	2003	〃	〃	4.50

CHAPTER 2 LAND USE

2.1 Current Land Use

The overall land use situation in Pasahari Area in 1988 is shown in Figure-K.2.1. (This land use map was compiled by the Study Team based on the aero-photographs which were taken in 1988.) The size of each land use category in the flood prone area is shown in Table-K.2.1. The Pasahari area was once covered mainly with forests and grasslands, with mangrove forests along the coast. However, since cultivation is expanding rapidly in line with the transmigration and irrigation schemes, some forest and grasslands have already been turned into farmland.

Table-K.2.1 Current Land Use in Flooded Area as of 1988

Category	Samal River Basin		Kobi River Basin	
	Area (km^2)	Ratio (%)	Area (km^2)	Ratio (%)
Dense Forest	29.4	51.5	30.7	40.3
Less Dense Forest	2.6	4.6	2.6	3.4
Bush	0.3	0.5	1.4	1.8
Mangrove	12.6	22.1	12.4	16.3
Plantation	0.4	0.7	1.9	2.5
Paddy Field	4.6	8.1	11.0	14.4
Pasture	5.4	9.5	10.4	13.6
Crop Field / Orchard	0.0	0.0	0.5	0.7
Marsh	0.2	0.4	0.8	1.0
Housing Settlement	1.5	2.6	4.6	6.0
Total Area	57.0	100.0	76.3	100.0

Source: JICA Study Team

2.2 Future Land Use

The resettlement to the Samal and Kobi areas is scheduled to be finished in the fiscal year 1998/99, while irrigation facilities for Samal I and Kobi will be completed by the end of the fiscal year 1996/97. Except for the Samal II project, no further irrigation projects are yet scheduled.

Paddy field has been developed on a alluvial plain of Samal and Kobi by avoiding habitually flooded areas. These areas will be turned into paddy field if flood control facilities are constructed. The area located between the mainstream of Kobi River and Tinupa River (a branch of Kobi River) has a potential to be developed into farmland in the near future. The hilly areas in the upstream of the rivers where people living on hunting reside will remain undeveloped for the time being.

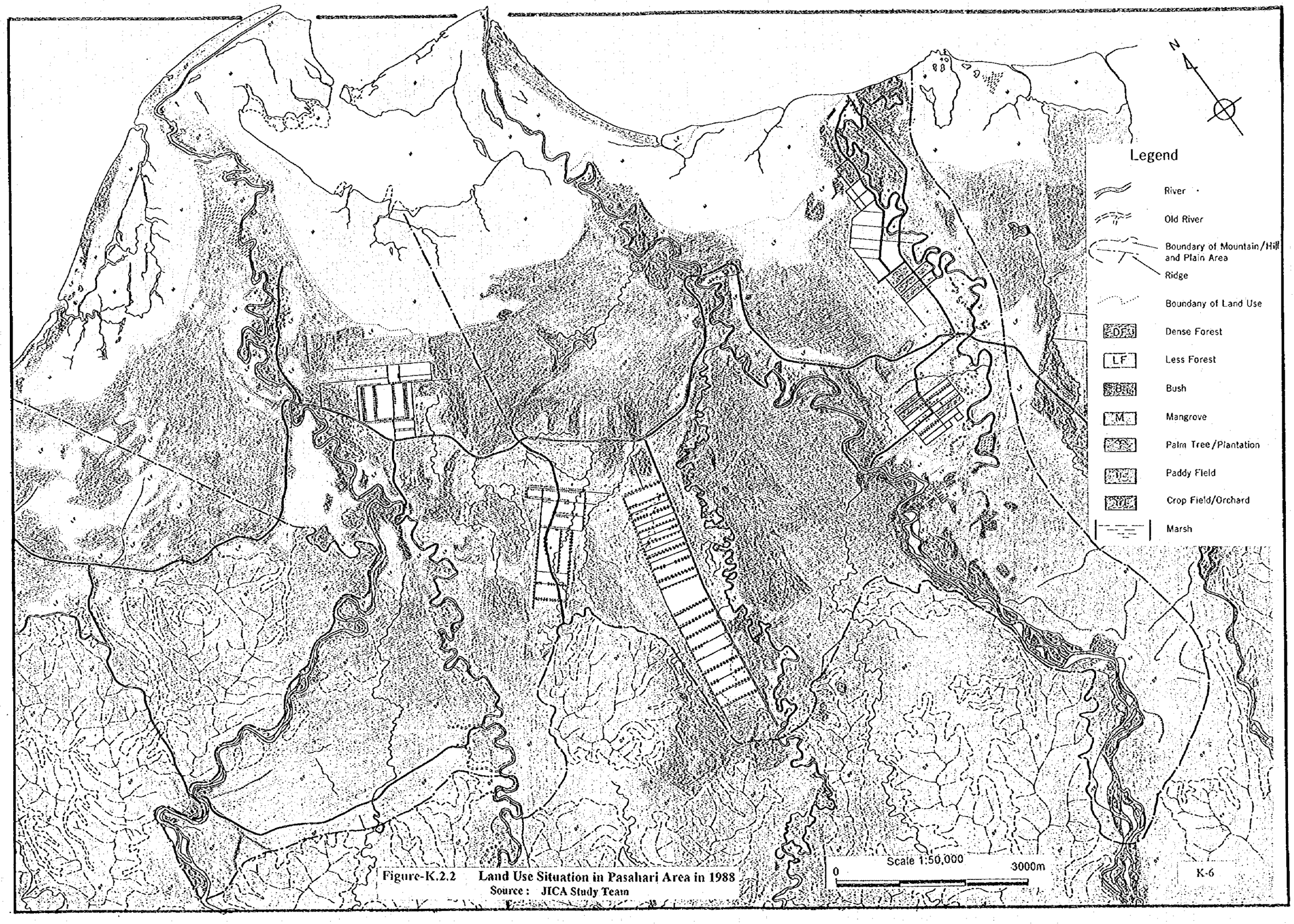


Figure-K.2.2 Land Use Situation in Pasahari Area in 1988
Source : JICA Study Team

SUPPORTING REPORT

PART-L

TOPOGRAPHY AND GEOLOGY

THE STUDY ON FLOOD CONTROL FOR AMBON AND PASAHARI AREA
IN THE REPUBLIC OF INDONESIA
SUPPORTING REPORT
PART-L

TABLE OF CONTENTS

LIST OF TABLES AND FIGURES

LIST OF FIGURES

CHAPTER 1 TOPOGRAPHY AND GEOLOGY OF PASAHARI REGION

1.1 Topography

Vast alluvial lowlands are formed to the north of the center of Ceram Island near the waterfront. The area investigated in the portion of the alluvial lowlands that meet the hilly areas on the mountain side. The Samal River and the Kobi River flow generally north in the hilly areas and in the alluvial plains where the incline is moderate, meander significantly. During floods, the river overflows from the river path and the topography is typical of flood plains(Refer to Figure-L.1.1). Flood plains form through the effects of sedimentation in the river path and from the effects of water that overflows from the river and is often found at the lower reaches of a river where the river bed is formed of nonconsolidated sand or silt. Rivers that meander are eroded on the outer section of the curve and cause sedimentation on the inner section of the curve and thus form flood plains.

B : Backswanp
L : Natural Levee
O : Ox-bow Lake

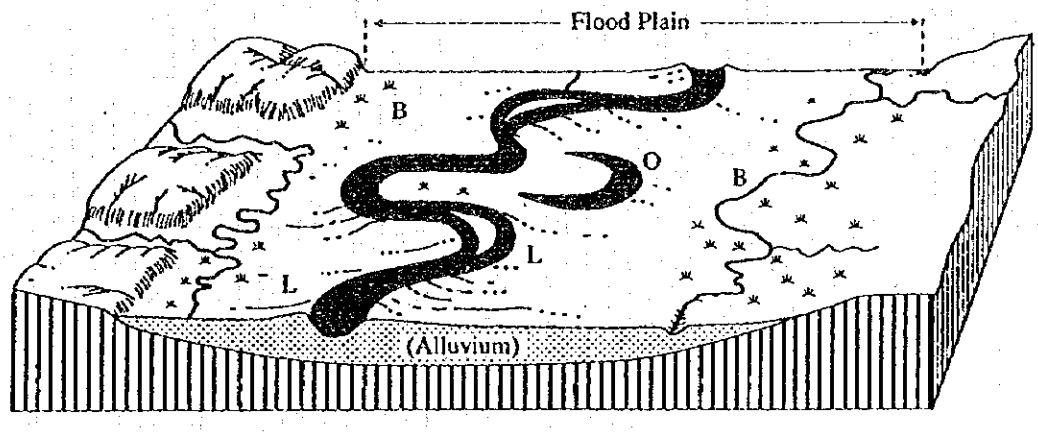


Figure-L.1.1 Schematics of Flood Plain

1.2 Geology

Geology in the vicinity of the Samal River and Kobi River is shown in Figure-L.1.2. The intake of the Samal River is situated at the extreme position where the hilly region formed from sedimentatary rock of the neogene tertiary period changes to the alluvial lowlands. Nonconsolidated conglomerates containing pebbles with diameters of 30 to 50 centimeters are distributed in the river bed in the vicinity. Further downstream, the pebbles become smaller and mostly sand and silt are to be found.

The intake of the Kobi River is positioned in the alluvial lowlands with distribution of nonconsolidated conglomerates containing pebbles with diameters of 5 to 10 centimeters in the vicinity.

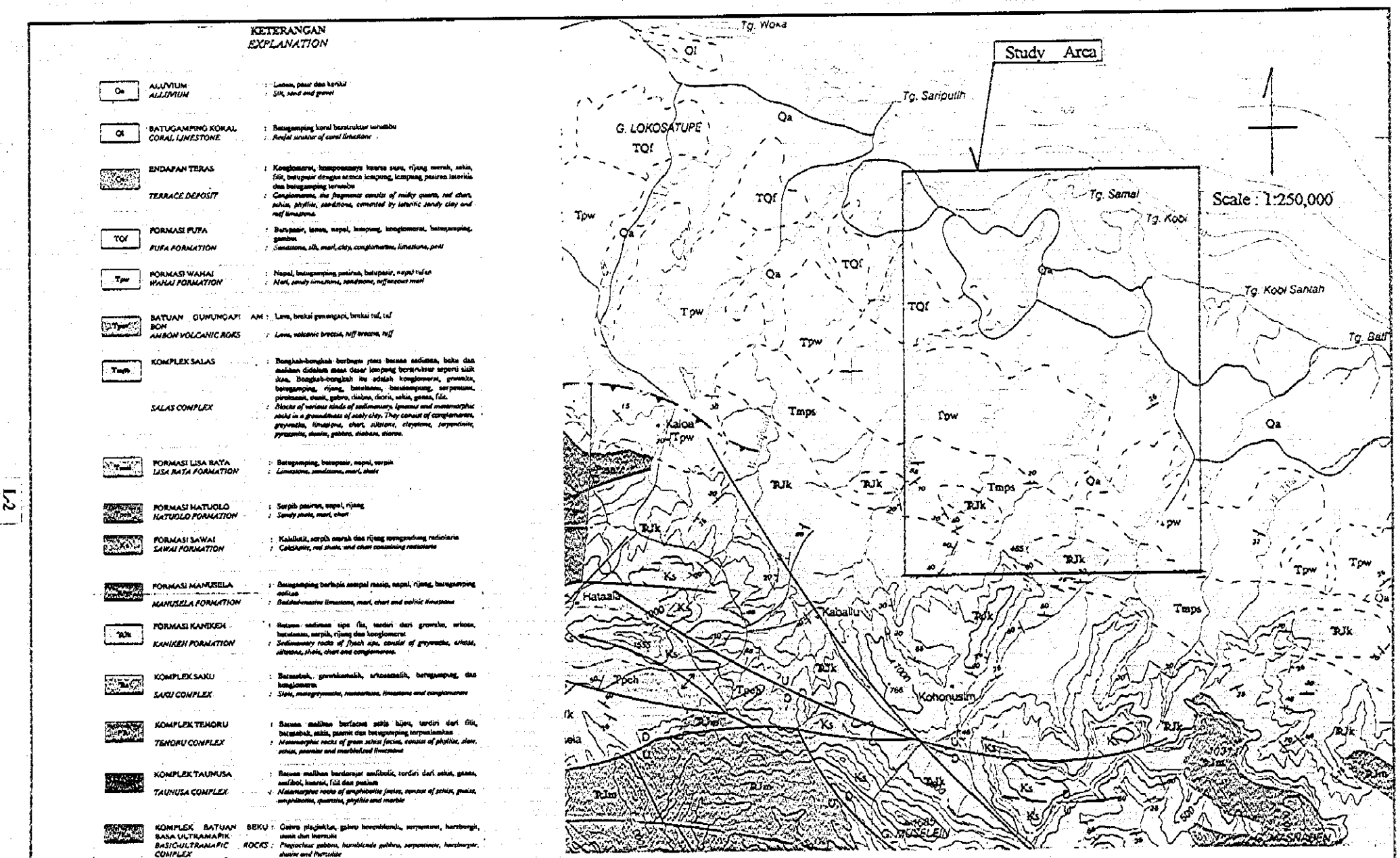


Figure-L.1.2 Geological Map of Pasahari Area

Source : S.Tjokrosapoetro et al.(1993)

Geology of the Masohi Quadrangle , Maluku

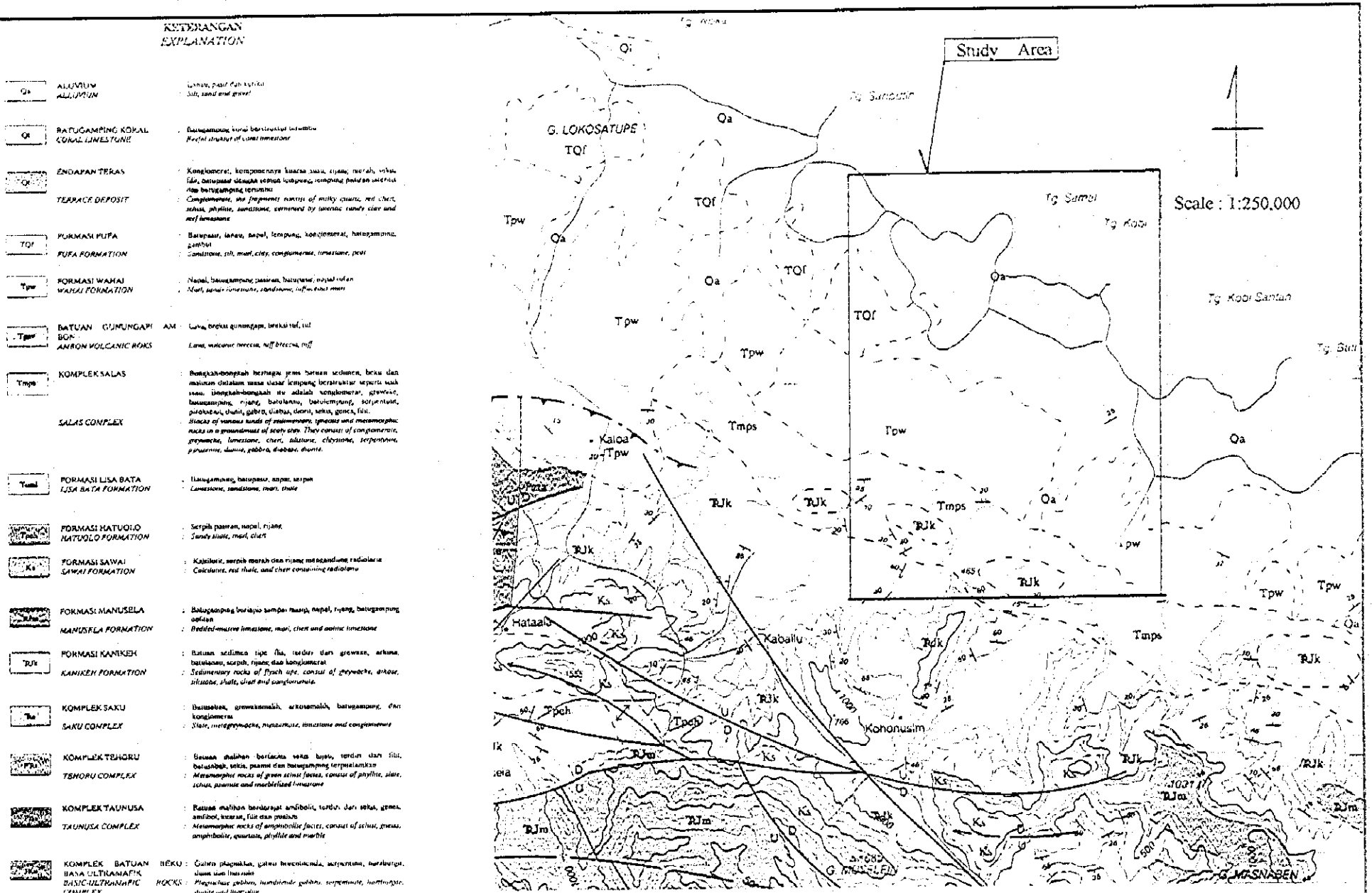


Figure-L.1.2 Geological Map of Pasahari Area

Source : S.Tjokrosapoetro et al.(1993)
Geology of the Masohi Quadrangle , Maluku

SUPPORTING REPORT

PART-M

METEOROLOGY AND HYDROLOGY

THE STUDY ON FLOOD CONTROL FOR AMBON AND PASAHARI AREA
IN THE REPUBLIC OF INDONESIA
SUPPORTING REPORT
PART-M

TABLE OF CONTENTS

LIST OF TABLES AND FIGURES

LIST OF TABLES

LIST OF FIGURES

CHAPTER 1 CLIMATE

The climate in Indonesia can generally be described as marine tropical with high temperatures and much rain. Temperature variation is small and there is a rainy season from October to March and a dry season from April to September. The division of the rainy season and dry season is usually clear in the west region from Sumatra to Bali and in Irian Jaya, but the rainy season is shorter in much of the east region except for Irian Jaya. The weather conditions in the Pasahari Study Area are outlined in Table-M.1.1. The average temperature and humidity are as high as 24.7 °C and 89% respectively, indicating a hot and humid climate. Figure-M.1.1 characterizes the seasonal fluctuation of weather.

Table-M.1.1 Weather Conditions in Pasahari Area (Kobisonta Station)

Month/Year	Rainfall (mm)			Fine Weather Ratio (%)	Relative Humidity (%)	Maximum Temperature (°C)	Minimum Temperature (°C)	Average Temperature (°C)
	Kairatu	Wahai	Kobi-sonta					
January	135	291	231	40	91	27.4	21.7	24.4
February	110	379	191	42	92	27.7	21.8	24.6
March	100	298	261	44	92	28.2	17.3	24.2
April	129	226	165	46	91	27.9	22.2	25.1
May	169	144	125	50	91	27.0	22.0	24.7
June	192	125	33	58	90	26.9	22.3	24.7
July	260	113	46	34	85	26.6	22.1	24.4
August	187	87	22	64	84	26.9	21.7	24.3
September	180	86	31	51	85	27.5	21.9	24.5
October	88	68	38	52	87	27.5	22.6	25.0
November	77	105	82	52	88	27.9	22.6	24.8
December	144	147	197	30	91	27.5	22.5	25.2
Total/Average	1,797	2,077	1,424	47	89	27.1	21.8	24.7

Note: Figures are average values from 7 years (1987-1995) at Kobisonta, from 18 years (1954-1993) at Wahai, from 11 years (1975-1995) at Kairatu.

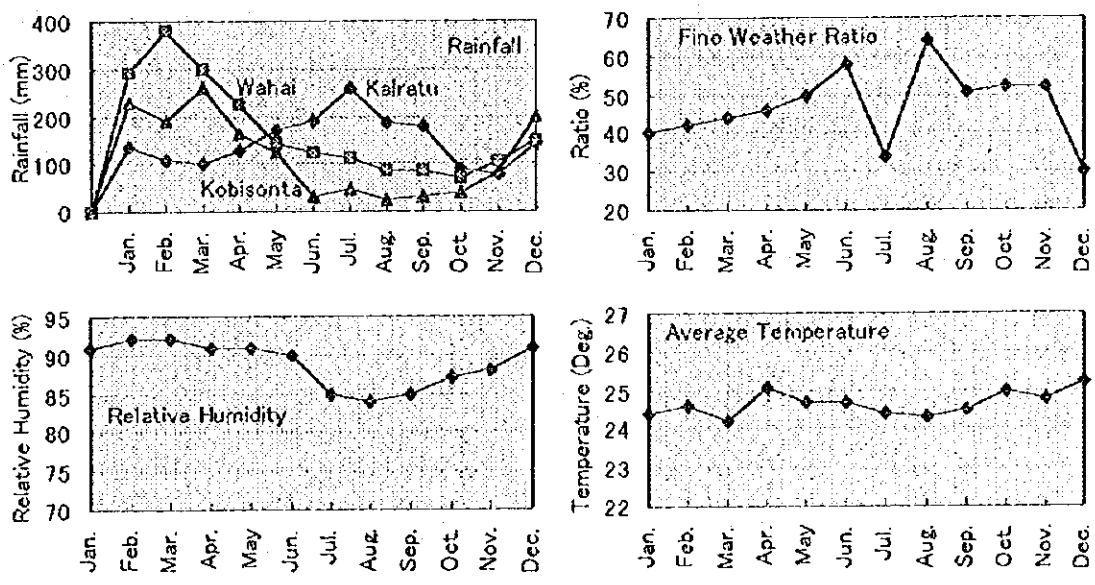


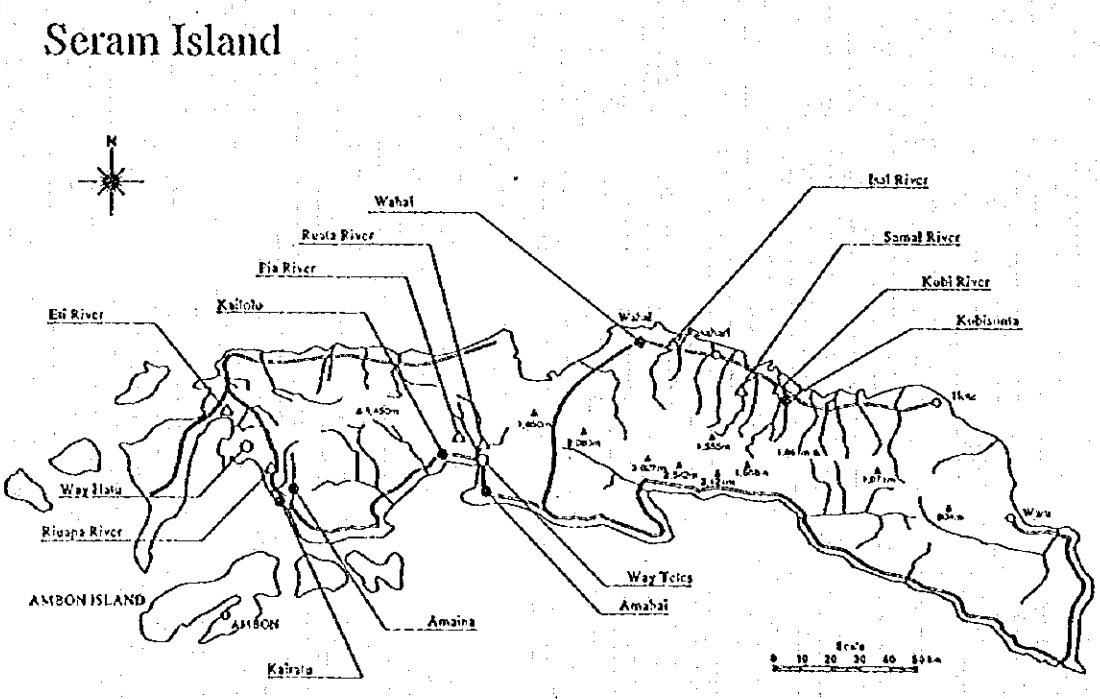
Figure-M.1.1 Seasonal Fluctuation of Weather in Kobisonta Station

CHAPTER 2 NETWORK OF OBSERVATION STATIONS

Table-M.2.1 and M.2.2 outline existing observation stations in Seram Island, including both meteorological (rainfall) stations and hydrological stations. The location of these stations is shown in Figure-M.2.1. There are eight meteorological (rainfall) stations in Seram Island, two of which are located in the vicinity of the Study Area (Wahai and Kobisonta in Pasahari). Of the seven hydrological stations in Seram Island, two stations are located in the Study Area (Samal River and Kobi River).

Table-M.2.3 and M.2.4 show the condition of data recorded by the meteorological and hydrological stations. In Pasahari area, the station at Kobisonta has five years of daily rainfall. Other records are kept at Wahai (14 years) and Kairatu (11 years). Hourly rainfall has only been recorded at Kairatu for 11 years, but this station is on the south side of Seram Island and 160 km away from the Study Area.

As for river water level record, there are not many data available and in the Pasahari area there are only five months' water level records for Samal and Kobi Rivers. Regarding discharge measurement data, there are some data from nine observation surveys for the 2 target rivers in Pasahari area. However, there are no flood data nor H-Q curves available.



Legend

- Meteorological Observation Station
- Rainfall Station
- Water Level Observation Station

Figure-M.2.1 Location of Meteorological and Hydrological Stations

Table-M.2.1 Outline of Meteorological (Rainfall) Stations

Station Name	Elevation (EL.m)	Organization	Observation Item		Type of Rainfall Gauge	Observation Period	
			Rainfall	Others		From	Current Condition
Kobisonta	20	PUSLITBANG	O	O	A, O	1984	Operated*
Amaina	30	PUSLITBANG	O	O	A, O	1978	Operated
Kailolo	17	PUSLITBANG	O	O	O	1983	Operated
Way Hatu	21	PUSLITBANG	O	-	A, O	1981	Operated
Way Tetes	15	PUSLITBANG	O	-	O	1980	Closed
Kairatu	5	BMG	O	O	A, O	1983	Operated
Amahai	10	BMG	O	O	A, O	1983	Operated
Wahai	5	BMG	O	O	O	1953	Operated

Note - PUSLITBANG: Pusat Penelitian dan Pengenabangan Pengairam in Bandung)
- BMG : Departmen Perhubungan, Badan Meteorologi dan Geofisika
- Others : Temperature, Relative Humidity, Sunshine Hours, Wind Speed, etc.
- A : Automatic Rainfall Gauge - O : Ordinary Rainfall Gauge

Table-M.2.2 Outline of Hydrological Stations

Station Name (River Name)	Organization	Type of Gauge	Observation Period	
			From	Current Condition
Samal River	PUSLITBANG	Staff Gauge	1992	Closed
Kobi River	PUSLITBANG	Staff Gauge	1989	Closed
Isal River	PUSLITBANG	Automatic Gauge	1983	Closed
Pia River	PUSLITBANG	Automatic Gauge	1983	Closed
Eti River	PUSLITBANG	Automatic Gauge	1983	Closed
Riuapa River	PUSLITBANG	Automatic Gauge	1983	Operated
Ruata River	PUSLITBANG	Staff Gauge	1983	Closed

Note - PUSLITBANG : Pusat Penelitian dan Pengenabangan Pengairam in Bandung)

Table-M.2.3 Condition of Existing Data at Meteorological Stations

Station Name	Distance from Study Area	Available Period of Existing Data		Suitability as Representative Station
		Daily Rainfall	Hourly Rainfall	
Kobisonta	Inside	7 years	-	O
Wahai	50km	18 years	-	⊙
Kairatu	160km	11 years	8 years	⊙
Amaina	160km	5 years	-	X
Amahai	100km	3 years	-	X
Kailolo	100km	2 years	-	X
Way Hatu	170km	2 years	-	X
Way Tetes	100km	-	-	X

Note - : O Suitable; : ⊙ Less suitable : X Unsuitable

Table-M.2.4 Condition of Existing Data at Hydrological Stations

Station Name	Location	Available Period		H-Q Curve
		Daily Water Level	Peak Discharge of Flood Time	
Samal	O	4 months	-	N.A.
Kobi	O	5 months	-	N.A.
Isal	X	5 months	-	N.A.
Pia	X	1 year	-	N.A.
Eti	X	-	-	N.A.
Riuapa	X	1 year	-	N.A.
Ruata	X	-	-	N.A.

Note - : O within Study Area; X: outside Study Area; N.A : not available

CHAPTER 3 INSTALLATION OF OBSERVATION STATIONS AND FLOW MEASUREMENT

3.1 Observation Stations Installed by JICA Study Team

In order to verify meteorological and hydrological data in the target river basins, automatic rainfall recorders, automatic water level recorders and water level staff gauges have been installed as part of this Study. The following hydrometric stations were installed in the Pasahari area by the Study Team :

- Automatic rainfall recorder (ARR) : 1 in Pasahari
- Automatic water level recorder (AWLR) : 1 in Pasahari
- Staff gauges : 2 in Pasahari (1 on each river)

3.2 Location of Observation Stations

The locations of the observation stations installed by the Study Team in the Pasahari area are shown in Figure-M.3.1 and the stations are listed in Table-M.3.1 below. The catchment areas at the location of each staff gauge and for each river basin are also indicated.

Table-M.3.1 List of Installed Observation Stations

Target Area	Item	Station Code	River or Basin	Catchment Area (km²)	
				Station	Total
Pasahari Area	Staff Gauge	S-SM-1	Samal River	260.4	269
		S-KB-1	Kobi River	264.0	272
	AWLR	AW-SM-1	Samal River	260.4	269
	ARR	AR-PH-1	Samal River	-	269

There were originally two existing staff gauges on the Samal and Kobi rivers in the Pasahari target area, but both gauges were washed away during flood flows. Two new staff gauges have been installed at locations agreed with P.U.. The staff gauge for Samal river has been installed next to the main road bridge, and that for Kobi river has been constructed just downstream of the existing irrigation free intake.

The automatic water level recorder (AWLR) for the Pasahari area was also constructed on Samal river, adjacent to the existing road bridge. Installation of the AWLR was recently completed and responsibility handed over to P.U.. A local gauge reader has been appointed to record the daily water level from the staff gauge (3 times per day) and to change the recorder paper (once per week) on the AWLR.

The new automatic rainfall recorder (ARR) for the Pasahari area, AR-PH-1, has been installed at Unit L (Desa Wai Lea), the transmigration unit nearest to Samal river. P.U. has employed a local gauge reader responsible for changing the recorder paper once per week and collection of rainfall data is ongoing. It should be noted, however, that the existing automatic rainfall gauge operated by P.U. at Kobisonta is not functional and it is recommended that this gauge is repaired as soon as possible.

Item	Station Code	River or Basin
Staff Gauge	S-SM-1	Samal River
	S-KB-1	Kobi River
Automatic Water Level Recorder	AW-SM-1	Samal River
Automatic Rainfall Recorder	AR-PH-1	Samal River

Legend : Installed by JICA
- ○ Staff Gauge
- □ Automatic W.L. Recorder
- △ Automatic Rainfall Recorder

Existing
- ▲ Automatic Rainfall Recorder

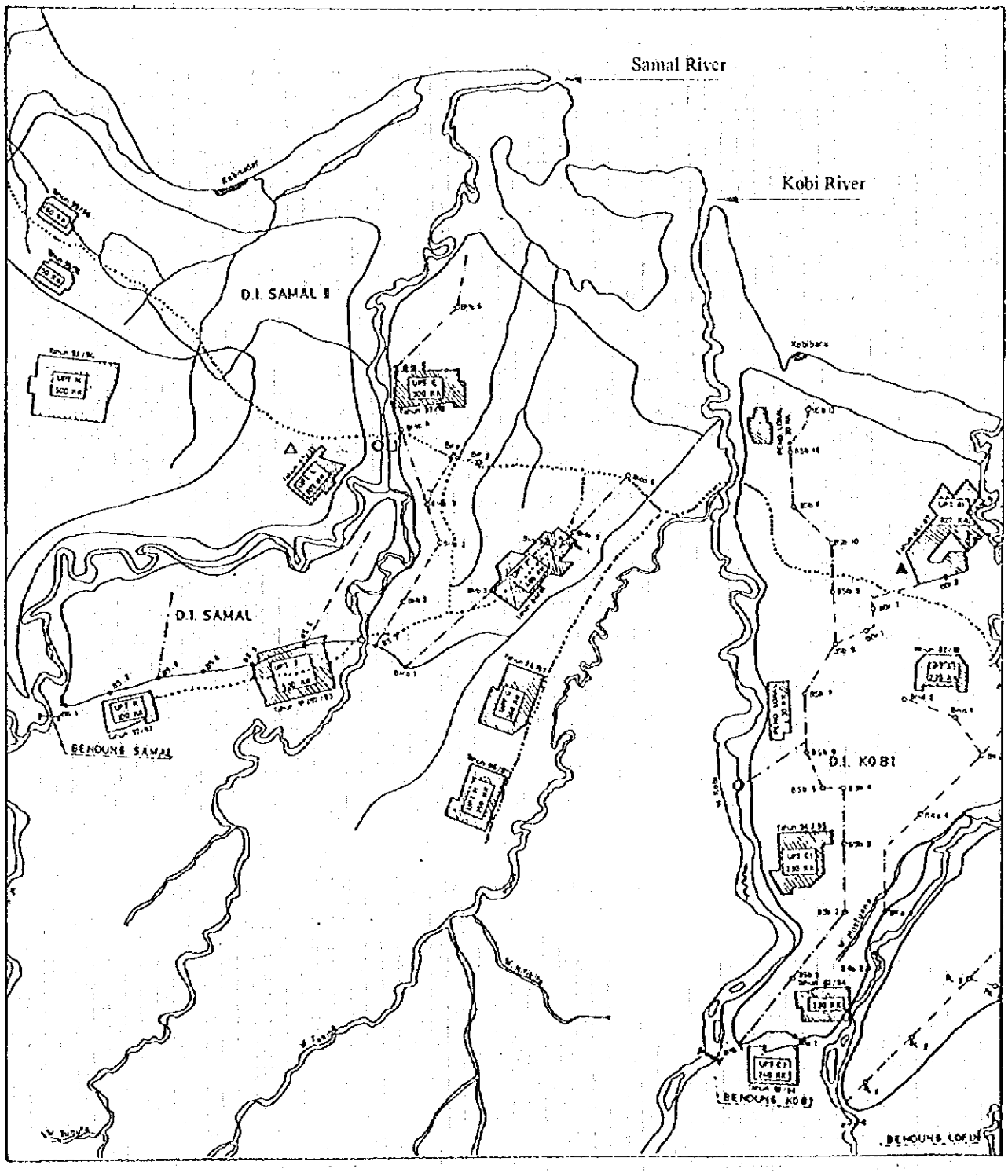


Figure-M.3.1 Location of Hydrometric Stations - Pasahari Area

3.3 Flow Measurement

Discharge measurement was undertaken for Samal and Kobi rivers in the Pasahari area during field trips in December 1996 and January 1997. Technology transfer was undertaken to explain river discharge measurement to Team counterparts and staff of the P.U. Hydrological Section who assisted in the river gauging activities.

The "velocity-area" method was again used to assess the discharge for the Pasahari area rivers. Flow velocity was measured with a current meter at a number of positions across the river width and multiplied by the cross sectional area to give the total discharge. However, because of the depth of the rivers and the high river flows encountered during the rainy season in North Seram, it was necessary to undertake flow measurement from bridges or boats in addition to the wading method employed in Ambon. The results of the river discharge measurement in the Pasahari area are presented in Table-M.3.2.

Discharge was measured a total of four times for Samal river at the location of the new staff gauge installed by the JICA Study Team. The December field trip coincided with the occurrence of floods in the Pasahari area and it was possible to measure the discharge in Samal river three times as the water level receded after the flood. The highest discharge of nearly 57 m^3/sec was measured using a current meter from the Samal road bridge. Discharge on two subsequent days was estimated using the float method. The time taken for a surface float to travel a known distance was measured - the average flow velocity is assumed to be equal to 0.7 times the measured surface velocity. During the January field trip, river levels were lower and discharge was measured from a canoe using a current meter.

For Kobi river, discharge was measured a total of five times at two locations. The first location was close to Seti Bakti village, upstream from the Kobi road bridge, corresponding to the former location of a staff gauge washed away during flooding. Discharge was measured using a current meter at this point three times - twice from a canoe during high flows in December 1996 and once using the wading method in January 1997. The second location was the position chosen for the installation of the new staff gauge provided by the JICA Study Team downstream of the existing irrigation free intake. The float method was used in December 1996 to estimate the discharge at this point; however, it was not possible to accurately check either the water depth or the river width because of the high flood flow. Discharge was measured using a current meter and the wading method during lower flows in January 1997.

Table-M.3.2 Results of Discharge Measurement in Pasahari Area

River	Date	Width (m)	No. of Verticals	Section Area (m^2)	Water Level (m)	Average Vel. (m/s)	Discharge Q (m^3/s)
SAMAL	1996/12/17	30.0	15	83.00	4.40	0.69	56.88
(Road Bridge)	1996/12/18	28.0	Float	66.50	3.80	0.63	42.20
	1996/12/19	26.0	Float	49.70	3.15	0.50	24.88
	1997/1/9	24.0	15	29.25	2.19	0.34	9.97
KOBI	1996/12/18	24.5	11	43.09	2.65	0.92	39.71
(Seti Bakti)	1996/12/19	23.0	10	20.81	1.80	0.85	17.73
	1997/1/10	20.8	15	12.88	1.41	0.57	7.32
KOBI	1996/12/18	20.0	Float	20.00	1.50	1.13	22.60
(Free Intake)	1997/1/10	17.4	17	9.12	0.90	0.57	5.23

CHAPTER 4 RAINFALL ANALYSIS

4.1 Representative Rainfall Stations and Basin Rainfall

4.1.1 Representative Rainfall Stations

In Pasahari area, since the station at Kobisonta is within the Study Area and possesses seven years of daily rainfall data, it can be taken as a representative station for both of the target river basins. However, the station at Kairatu is the only station to provide hourly rainfall data in Seram, but is 160 km from Kobisonta and located on the opposite side of the island where the rainy season and dry season are reversed. However, a comparison of the data from Kairatu and Kobisonta shows the similarity of the two stations in terms of probable daily rainfall (Table-M.4.1 and Figure-M.4.1). This indicates that although the seasonal rainfall characteristics differ greatly between Kairatu and Kobisonta, their hourly rainfalls may not be so different from each other since their daily rainfalls are roughly equal. Therefore, the daily rainfall in Pasahari area is estimated by using the data from Kobisonta and the hourly rainfall in the Pasahari Area are estimated by using the data from Kairatu. For the above mentioned reasons, the representative rainfall observation stations in the Pasahari Area are chosen as shown in Table-M.4.2.

Table-M.4.1 Comparison of Probable Daily Rainfall

Item			Seram			Ambon
			Kobisonta	Kairatu	Wahai	Pattimura
Mean Annual Rainfall [mm/year]			1400 (1.0)	1800 (1.3)	2100 (1.5)	3000 (2.1)
Maximum Daily Rainfall [mm/day]			145.8 [11 years]	155.8 [11 years]	225 [25 years]	455 [50 years]
Probable Daily Rainfall [mm/day]	Return Period (year)	5	122.9 (1.00)	129.4 (1.05)	152.2 (1.24)	259.5 (2.11)
		10	140.7 (1.00)	146.9 (1.04)	171.3 (1.22)	321.9 (2.29)
		20	158.5 (1.00)	164.4 (1.04)	190.4 (1.20)	384.6 (2.43)
		30	169.0 (1.00)	174.7 (1.03)	201.5 (1.19)	421.9 (2.50)
		50	182.1 (1.00)	187.6 (1.03)	215.6 (1.18)	469.9 (2.58)
		100	199.9 (1.00)	205.1 (1.03)	234.7 (1.17)	537.0 (2.69)
		200	217.7 (1.00)	222.7 (1.02)	253.8 (1.17)	606.7 (2.79)

Note : Values in ( ) are ratios to Kobisonta data.

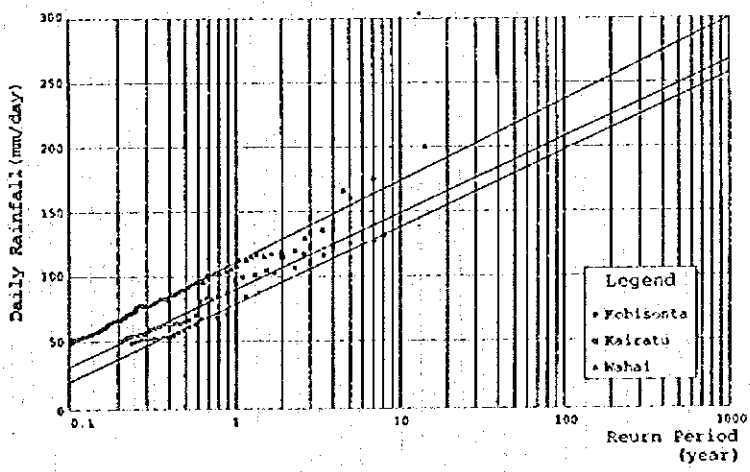


Figure-M.4.1 Comparison of Probable Daily Rainfall [Seram]

Table-M.4.2 Representative Rainfall Stations

Item	Daily Rainfall	Hourly Rainfall	Rainfall Intensity
Station	Kobisonta	Kairatu	Kobisonta, Kairatu

4.1.2 Basin Mean Rainfall

The rainfall data to be used in the discharge analysis need to be set with attention paid to the basin characteristics of each target river. In Pasahari area, the representative rainfall stations of Kobisonta and Kairatu are at low altitude (El. 2m and 20m, respectively). However, because the basins of the two target rivers cover a wide area of approximately 250 km^2 and reach an altitude about 1,000 m in the upstream mountainous area, it is necessary to take into account the altitude difference. Manusela rainfall station is located in the mountainous area, and mean annual rainfall data is available. From the locations of Kobisonta and Manusela in the river basin, it is decided that the basin mean rainfall can be taken as the arithmetic average of the data from the two stations, i.e. 1.5 times the mean annual rainfall recorded at Kobisonta.

Table-M.4.3 Calculation of the Mean Annual Rainfall in Pasahari Area

Item	Altitude (m)	Mean Annual Rainfall (mm/year)	Ratio
Kobisonta Station	EL. 20 m	1,424 [1987-1995]	1.0
Manusela Station	EL.730 m	2,868 [observed period unknown]	2.0
Pasahari Area river basin mean rainfall	-	2,146 [=(1,424+2,868)/2]	1.5

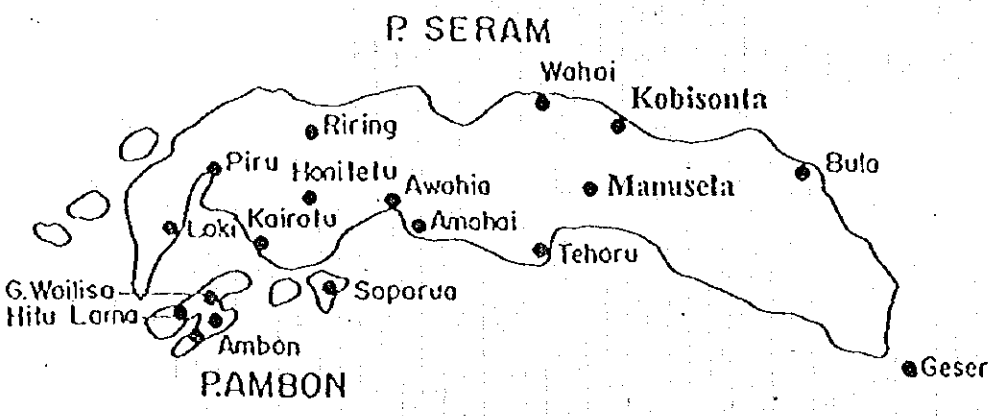


Figure-M.4.2 Location of Manusela Rainfall Station in Pasahari Area

4.2 Probability Analysis

4.2.1 Probable Daily Rainfall

Since daily rainfall data are only available for seven years at Kobisonta station, the non annual probability method should be applied as probability analysis using the daily rainfall data more than 50 mm/day during available observation term (7 years) as shown in Table-M.4.4. Table-M.4.5 and Figure-M.4.3 show the probable daily rainfall calculated based on the above daily rainfall data.

Table-M.4.4 Daily Rainfall Data Used in Probability Analysis [Kobisonta: r>50mm/day]

No.	Date	Daily Rainfall (mm/day)	No.	Date	Daily Rainfall (mm/day)
1	09-Jan-87	50.8	15	03-Apr-92	108.9
2	06-Feb-87	70.0	16	28-May-92	86.8
3	08-Mar-87	51.3	17	09-Jan-93	117.8
4	01-Mar-90	53.7	18	07-Feb-93	129.5
5	02-Apr-90	55.8	19	11-Mar-93	55.7
6	09-Dec-90	61.6	20	10-Dec-93	52.0
7	29-Dec-90	53.1	21	25-Dec-93	59.6
8	26-Jan-91	73.1	22	06-Dec-94	57.8
9	04-Feb-91	70.8	23	27-Jan-95	54.2
10	18-Feb-91	63.6	24	19-Feb-95	72.5
11	26-Jul-91	50.7	25	19-Mar-95	70.3
1	05-Feb-92	50.3	26	30-Mar-95	90.7
13	05-Mar-92	102.8	27	26-Apr-95	50.5
14	23-Mar-92	65.2	28	17-Dec-95	59.0

Table-M.4.5 Probable Daily Rainfall [Pasahari Area - Kobisonta]

Return Period	year	2	3	5	10	20	30	50	100	200
Probable Daily Rainfall	mm	99.3	109.8	122.9	140.7	158.5	169.0	182.1	199.9	217.7

Note : Calculated by Non Annual Probability Method
(Non Annual Daily Rainfall Data more than 50mm/day for 7 years)

Pasahari Area [Kobisonta]

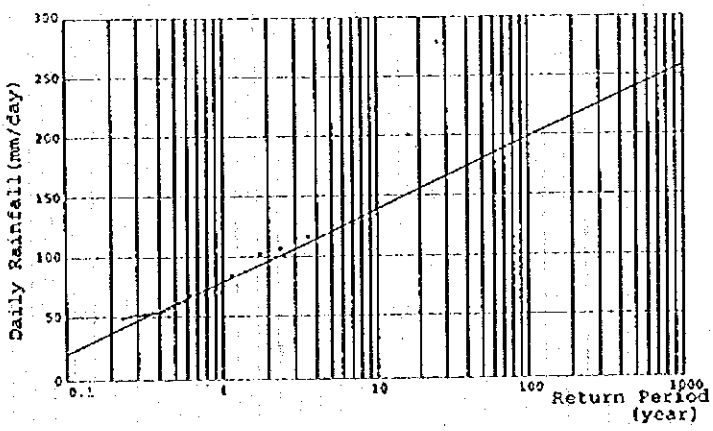


Figure-M.4.3 Probable Daily Rainfall

4.2.2 Probable Hourly Rainfall

Since hourly rainfall data are only available for eight years at Kairatu station, the non annual probability method should be applied as probability analysis using the hourly rainfall data more than 30 mm/hour during available observation term (8 years) as shown in Table-M.4.6. Table-M.4.7 and Figure-M.4.4 show the probable hourly rainfall calculated based on the above hourly rainfall data.

Table-M.4.6 Hourly Rainfall Data Used in Probability Analysis [Kairatu: r>30mm/hour]

No.	Date	Hourly Rainfall (mm/hour)
1	1988/1/25 14:00	36.6
2	1988/1/27 19:00	33.0
3	1988/2/16 18:00	41.5
4	1988/9/24 18:00	35.9
5	1989/7/27 13:00	39.2
6	1989/9/28 15:00	42.2
7	1989/12/12 17:00	36.2
8	1990/2/8 17:00	35.0
9	1990/2/17 19:00	39.6
10	1991/5/2 16:00	43.0
11	1991/9/25 2:00	43.8
12	1991/12/25 16:00	44.8
13	1993/11/1 20:00	38.1
14	1994/8/8 17:00	33.1
15	1995/1/22 18:00	47.0
16	1995/4/15 20:00	34.8

Table-M.4.7 Probable Hourly Rainfall [Pasahari Area - Kairatu]

Return Period	year	2	3	5	10	20	30	50	100	200
Probable Hourly Rainfall	mm	41.8	43.9	46.6	50.3	54.0	56.1	58.8	62.5	66.2

Note : Calculated by Non Annual Probability Method
(Non Annual Hourly Rainfall Data more than 30 mm/hour for 8 years)

Pasahari Area
[Kairatu]

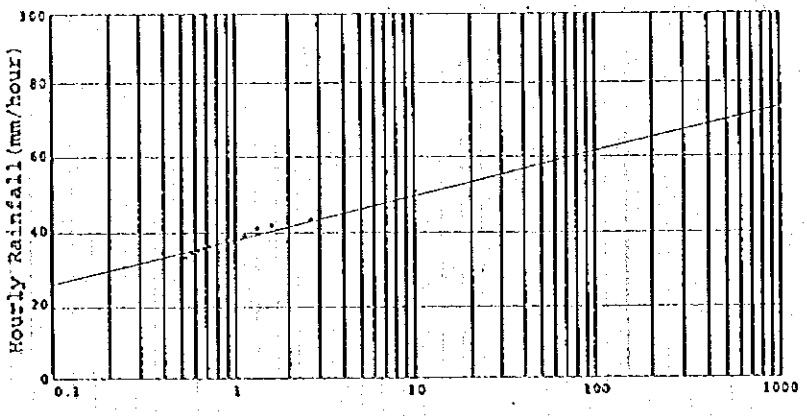


Figure-M.4.4 Probable Hourly Rainfall

4.2.3 Rainfall Intensity Curve

The rainfall intensity curves are calculated by the Talbot Formula using the probable daily rainfall and probable hourly rainfall for Ambon and Pasahari areas. Coefficients "a" and "b" in the Talbot Formula are calculated by the specific coefficient method. The calculation results are shown in Table-M.4.9 and Figure-M.4.5.

4.3 Flood Rainfall

4.3.1 Flood Daily Rainfall

The flood daily rainfall levels in the Study Area are shown in Table-M.4.8. The maximum daily rainfall recorded in Pasahari is 145.8 mm/day (January 27, 1988). Taking into account an occurrence probability of 1/10, the corresponding daily rainfall in Pasahari is 145.8 mm/day (probability 1/11~1/10).

Table-M.4.8 Flood Daily Rainfall in Pasahari

Rank	Pasahari [Kobisonta Station]		Reference [Wahai Station]	
	Date	Daily Rainfall (mm/day)	Date	Daily Rainfall (mm/day)
1	1988/Jan/27	145.8	1970/Feb/09	200
2	1993/Feb/07	129.5	1970/Feb/02	174
3	1993/Jan/09	117.8	1973/Feb/19	164
4	1992/Apr/03	108.9	1978/Feb/19	135
5	1986/Apr/16	104.0	1975/Feb/10	128
6	1992/Mar/05	102.8	1969/Mar/14	118
7	1989/Jul/16	101.9	1960/Jan/18	116
8	1986/Mar/27	94.2	1977/Mar/07	116
9	1989/Feb/13	93.1	1969/Apr/09	115
10	1986/Jan/29	90.8	1969/Feb/01	114

Note : Kobisonta - 11 years [1985-1995], Wahai - 14 years [1959-1993]

Table-M.4.9 Rainfall Intensity [Kairatu]

Return Period (year)		2	5	10	15	20	25	30	50	70	100	200
Rn(24)		106.2	129.4	146.9	157.1	164.4	170.1	174.7	187.6	196.0	205.1	222.7
Rn(1)		41.8	46.6	50.3	52.5	54.0	55.2	56.1	58.8	60.6	62.5	66.2
b		1.7	2.0	2.2	2.3	2.3	2.4	2.4	2.5	2.6	2.6	2.7
a		113.8	140.2	160.3	172.0	180.4	187.0	192.4	207.3	217.1	227.7	248.2
In=a/(t+b)	0.2	59.2	63.5	67.2	69.5	71.0	72.3	73.2	76.1	78.0	80.1	84.2
[mm/hr]	0.5	51.2	55.9	59.7	62.0	63.5	64.8	65.7	68.5	70.4	72.4	76.4
t(hour)	1	41.8	46.6	50.3	52.5	54.0	55.2	56.1	58.8	60.6	62.5	66.2
	2	30.6	35.0	38.3	40.2	41.6	42.6	43.4	45.8	47.4	49.0	52.3
	4	19.9	23.3	25.9	27.4	28.5	29.3	29.9	31.8	33.0	34.3	36.8
	6	14.7	17.5	19.6	20.8	21.6	22.3	22.8	24.3	25.3	26.3	28.4
	8	11.7	14.0	15.7	16.7	17.4	18.0	18.4	19.7	20.5	21.4	23.1
	10	9.7	11.7	13.2	14.0	14.6	15.1	15.5	16.6	17.3	18.0	19.5
	12	8.3	10.0	11.3	12.0	12.6	13.0	13.3	14.3	14.9	15.5	16.8
	14	7.2	8.8	9.9	10.6	11.0	11.4	11.7	12.5	13.1	13.7	14.8
	16	6.4	7.8	8.8	9.4	9.8	10.2	10.4	11.2	11.7	12.2	13.2
	18	5.8	7.0	7.9	8.5	8.9	9.2	9.4	10.1	10.5	11.0	12.0
	20	5.2	6.4	7.2	7.7	8.1	8.4	8.6	9.2	9.6	10.1	10.9
	22	4.8	5.8	6.6	7.1	7.4	7.7	7.9	8.5	8.8	9.2	10.0
	24	4.4	5.4	6.1	6.5	6.9	7.1	7.3	7.8	8.2	8.5	9.3

(Remark) This is calculated from Talbot formula using daily raifall and hourly rainfall.

-;Talbot Formula

In=a/(t+b) [mm/hr] ,t: Rainfall Duration(hour), a, b: Constant

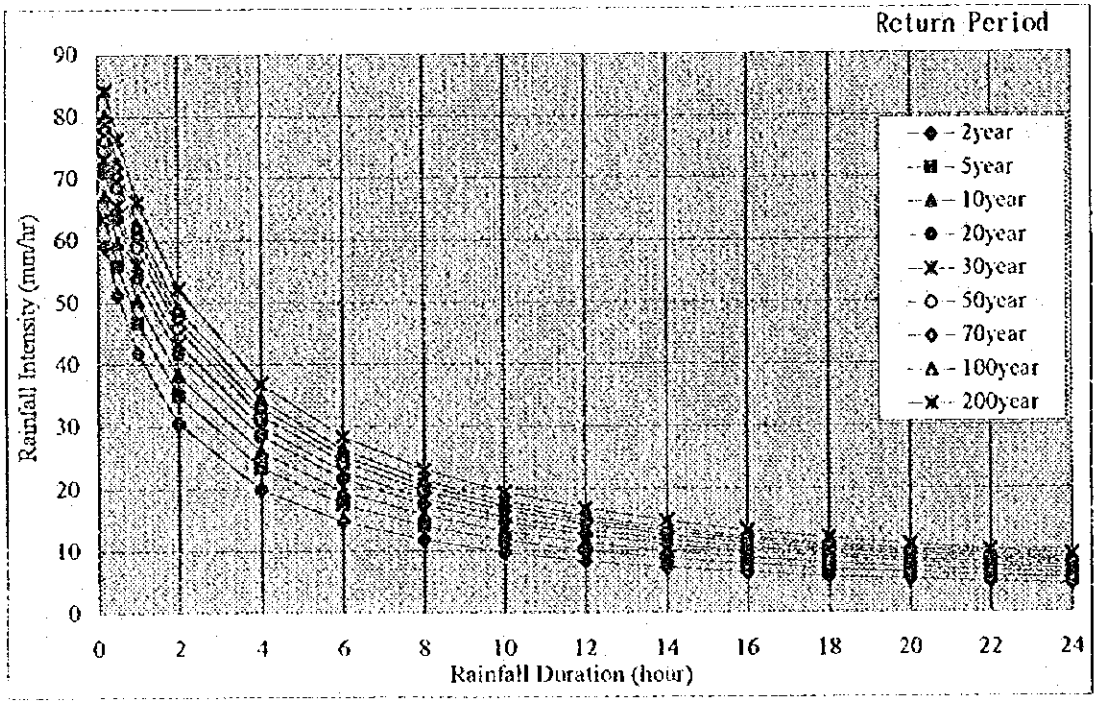


Figure-M.4.5 Rainfall Intensity Curve [Kairatu]

SUPPORTING REPORT

PART-N

FLOOD CONTROL PLAN AND DESIGN

THE STUDY ON FLOOD CONTROL FOR AMBON AND PASAHARI AREA
IN THE REPUBLIC OF INDONESIA
SUPPORTING REPORT
PART-N

TABLE OF CONTENTS

LIST OF TABLES AND FIGURES

LIST OF TABLES

LIST OF FIGURES

CHAPTER 1 DISCHARGE SYSTEMS FOR FLOOD WATER

1.1 River Systems

The Study area in the Pasahari area of Seram includes the two river basins of Samal and Kobi rivers, and their tributaries Musi and Tinupa. The catchment areas and main river lengths have been measured by the Study Team using the revised 1:100,000 scale topographical map. The results are given in Table-N.1.1 and the longitudinal profiles of the two rivers are shown in Figure-N.1.1 below. The basin boundaries are shown in Figure-N.1.2.

Table-N.1.1 Study River Basins - Pasahari Area

River Name	Catchment Area (km^2)	Length of Main River (km)
Samal River	268.9	56.8
Kobi River	271.8	50.6

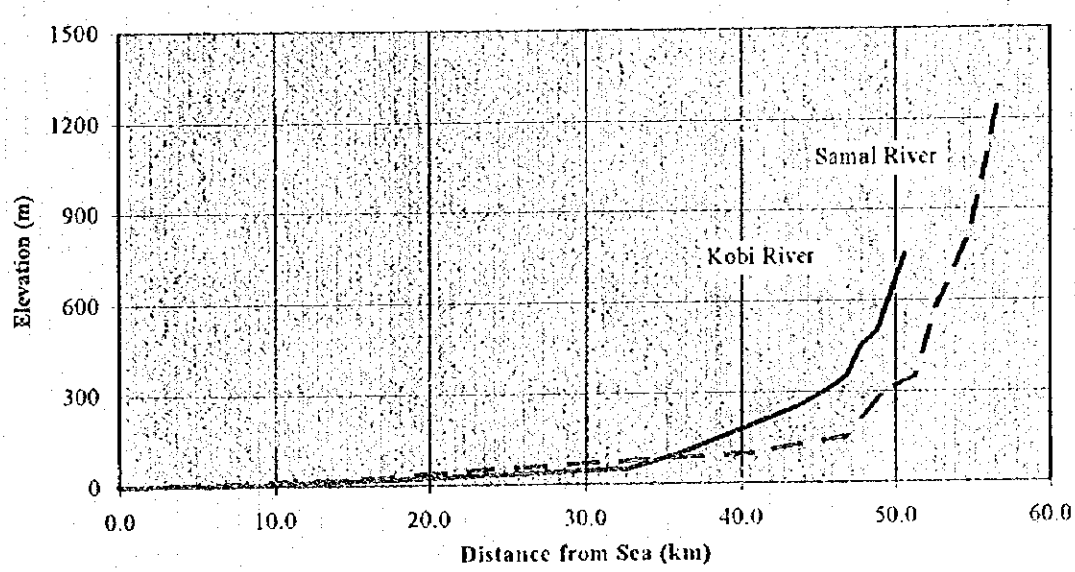


Figure-N.1.1 Longitudinal Profiles of Samal and Kobi Rivers

As part of this Study, longitudinal and cross sectional river surveys were carried out for Samal and Kobi rivers, and for their tributaries, Musi and Tinupa. The survey levelling routes for the Pasahari rivers are shown in Figure-N.1.3. Longitudinal profiles for the four rivers, prepared using the ground level data along the levelling survey routes, are presented in Figure-N.1.4. The downstream slope of Samal and Kobi rivers across the alluvial plain is very gentle, in particular the first 10 km from the river mouth, and consequently the river course meanders considerably.

The map in Figure-N.1.3 was prepared from the 1988 aerophotographs reduced to a scale of 1:50,000. From this map the actual river course distances were measured. The meandering nature of the rivers across the gently sloping alluvial plain is clearly indicated by the fact that the river course distances are more than 50% longer than the 'straight line' survey route distances for both Samal and Kobi. A comparison of the survey route and river course distances is given in Table-N.1.2 for the four rivers.

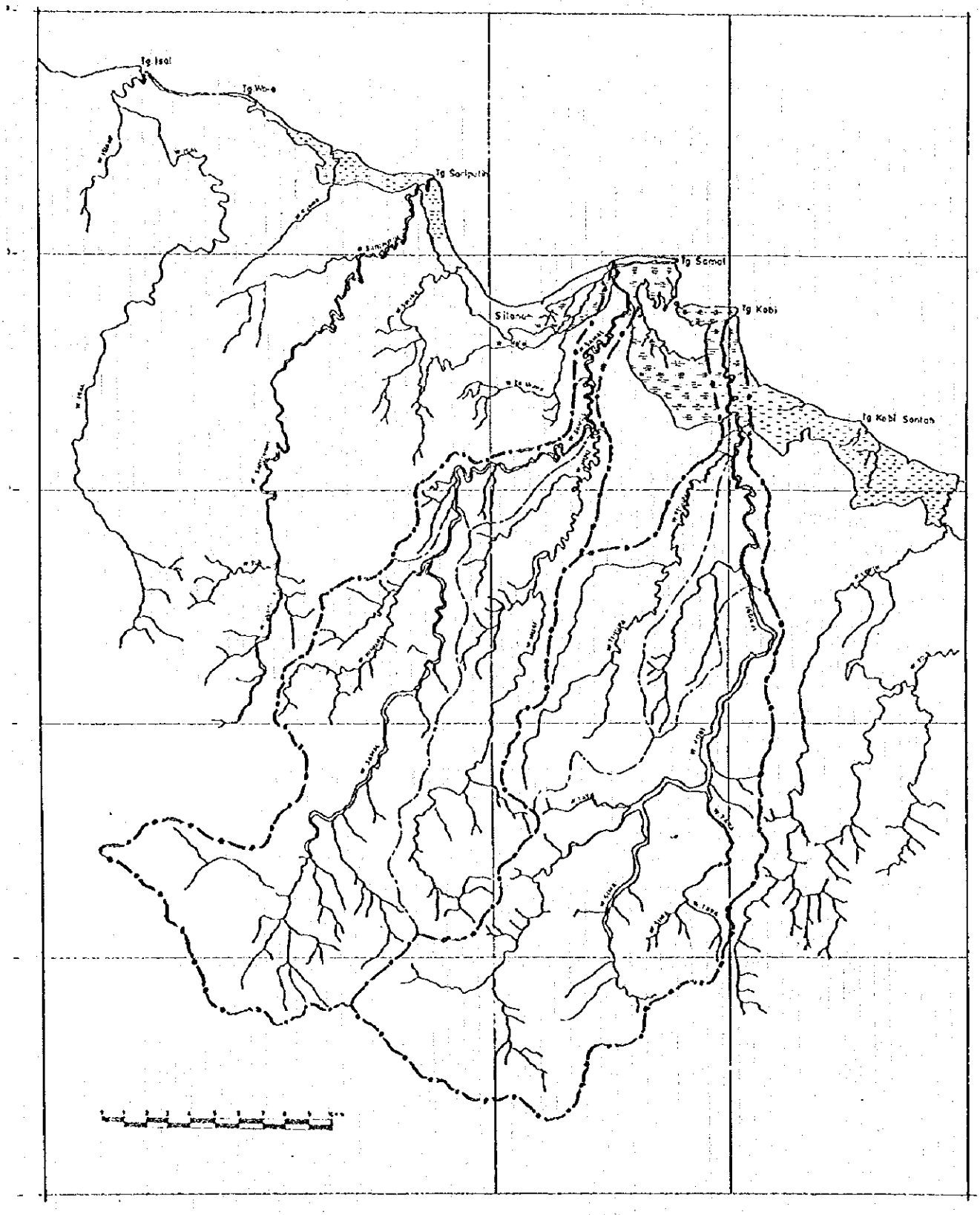


Figure-N.1.2 Basin Boundaries of Samal and Kobi Rivers

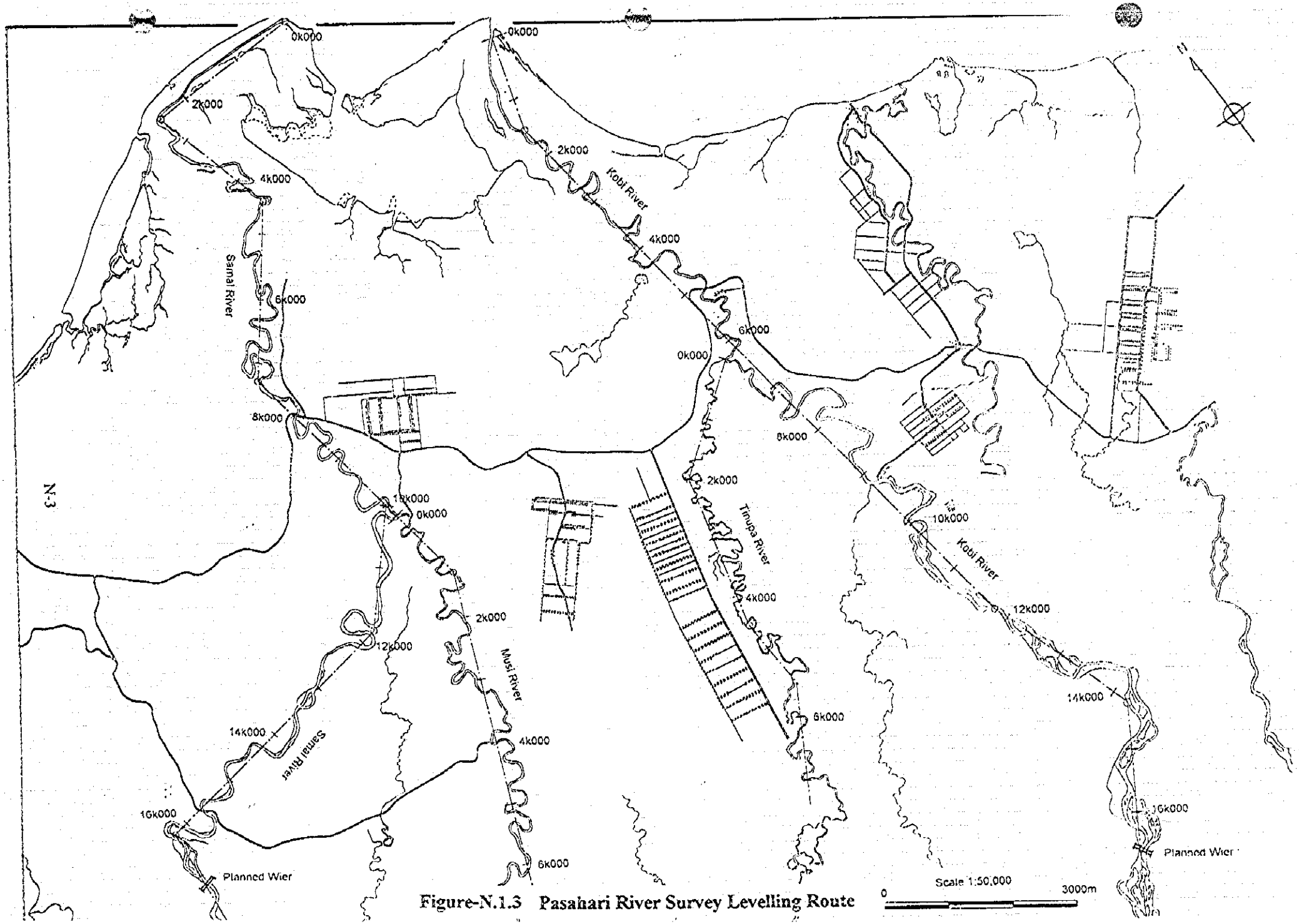


Figure-N.1.3 Pasahari River Survey Levelling Route

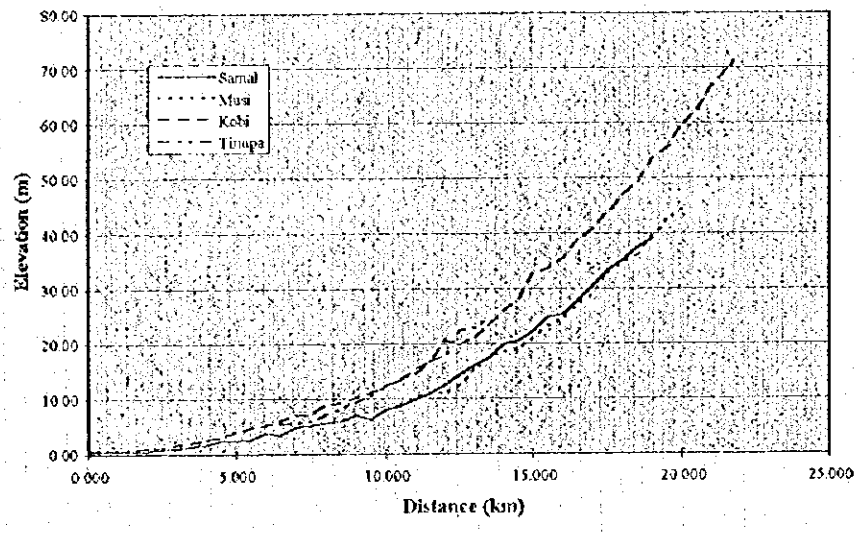


Figure-N.1.4 Longitudinal Profiles along Survey Routes

Table-N.1.2 Comparison of Survey Route and River Course Distances

River	Survey Route Distance (km)	River Course Distance (km)
Samal River	19.0	30.9
Musi River	9.0	16.9
Kobi River	21.5	34.4
Tinupa River	7.0	15.7

1.2 Current Discharge Capacity of Rivers

Longitudinal and cross sectional river surveys for Samal and Kobi rivers, and their tributaries Musi and Tinupa, were carried out in the Pasahari area during Phase I of this Study. The results of these surveys were used to assess the current discharge capacity of the rivers. The river cross sections were surveyed every 500 m over a length of 19 km for Samal, 22 km for Kobi, 9 km for Musi and 7 km for Tinupa. This cross section data was compiled and the uniform flow calculation method was used to obtain stage discharge (H / Q) curves for every cross section over a range of flows up to a maximum of 800 m^3/sec (400 m^3/sec for Musi & Tinupa). The discharge capacity at each section was then estimated by comparing the left and right bank heights to the calculated stage discharge curves.

Based on this analysis, the discharge capacity of each river is summarized in Table-N.1.3 and shown in more detail in Table-N.1.4. The summary table gives the average and extreme values of minimum discharge capacity. Figure-N.1.5 shows the variation in river width and calculated discharge capacity at each cross section of the target rivers in the Pasahari area.

Table-N.1.3 Summary Result of Discharge Capacity

	Discharge Capacity (m^3/sec) - Uniform Flow	
River Name	Average Minimum	Extreme Minimum
Samal River	100 - 150	81
Musi River	100 - 150	66
Kobi River	100 - 150	84
Tinupa River	100 - 150	72

Table-N.1.4(1) Discharge Capacity - Samal River

SAMAL RIVER					UNIFORM FLOW	
Section No.	Marker (km)	Distance (km)	Bank Height (m)		Capacity (m3/sec)	
			Left	Right	Left	Right
Sam01+	0.000	0.000	0.66	0.16	157	118
Sam02+	0.500	0.500	0.22	0.66	120	140
Sam03+	1.000	1.010	0.58	0.28	120	109
Sam04+	1.500	1.542	0.59	0.25	129	113
Sam05+	2.000	2.057	0.60	0.72	81	86
Sam06+	2.500	2.565	0.92	0.69	176	163
Sam07+	3.000	3.414	1.00	1.28	144	160
Sam08+	3.500	3.949	1.40	1.19	177	166
Sam09+	4.000	4.599	1.56	1.44	226	217
Sam10+	4.000	5.068	1.79	1.53	179	146
Sam11+	4.000	5.324	1.94	2.02	204	208
Sam12+	4.500	5.942	2.54	2.14	226	200
Sam13+	5.000	6.679	2.62	2.58	246	246
Sam14+	5.500	7.575	1.76	2.78	137	189
Sam15+	6.000	8.534	3.56	4.00	287	325
Sam16+	6.500	9.568	3.71	4.09	365	400
Sam17+	7.000	10.587	4.35	4.10	365	350
Sam18+	7.000	11.338	4.49	4.17	310	290
Sam19+	7.000	11.549	5.00	4.97	265	265
Sam20+	7.500	12.234	5.11	5.32	720	730
Sam21+	8.000	12.884	5.77	5.75	800	800
Sam22+	8.500	13.883	5.00	6.64	420	680
Sam23+	9.000	14.912	7.23	5.96	485	330
Sam24+	9.500	15.596	7.63	6.24	535	340
Sam25+	10.000	16.559	8.14	6.68	465	280
Sam26+	10.500	17.652	8.11	8.89	440	660
Sam27+	11.000	18.130	9.98	8.58	640	265
Sam28+	11.500	18.705	10.33	10.13	350	290
Sam29+	12.000	20.770	13.39	12.71	650	445
Sam30+	12.500	21.488	13.82	14.29	230	320
Sam31+	13.000	22.068	15.77	15.42	430	330
Sam32+	13.500	22.600	17.76	17.20	800	690
Sam33+	14.000	23.255	19.15	18.33	640	390
Sam34+	14.500	24.099	21.30	21.27	500	500
Sam35+	15.000	24.705	22.00	21.69	350	305
Sam36+	15.500	25.397	22.34	22.63	150	200
Sam37+	16.000	26.359	25.94	26.02	700	720
Sam38+	16.500	27.583	28.00	28.12	300	330
Sam39+	17.000	28.398	29.74	29.34	300	180
Sam40+	17.500	28.802	32.17	32.99	310	545
Sam41+	18.000	29.491	35.19	34.94	800	800
Sam42+	18.500	30.276	35.96	37.23	475	800
Sam43+	19.000	30.896	38.81	38.39	430	300

Table-N.1.4(2) Discharge Capacity - Kobi River

KOBI RIVER					UNIFORM FLOW	
Section No.	Marker (km)	Distance (km)	Bank Height (m)		Capacity (m3/sec)	
			Left	Right	Left	Right
Kob01+	0.000	0.000	0.26	-0.16	54	40
Kob02+	0.500	0.550	0.32	0.32	66	66
Kob03+	1.000	1.065	0.70	0.36	92	77
Kob04+	1.500	1.685	0.75	0.65	85	82
Kob05+	2.000	2.339	0.75	0.98	76	83
Kob06+	2.500	3.129	0.87	1.05	113	124
Kob07+	3.000	4.043	1.53	1.58	154	155
Kob08+	3.000	4.323	1.52	1.82	126	142
Kob09+	3.000	4.608	1.86	1.62	130	120
Kob10+	3.500	5.194	2.08	1.84	117	110
Kob11+	4.000	6.516	2.55	2.76	150	156
Kob12+	4.500	7.594	3.21	3.55	139	152
Kob13+	5.000	8.312	3.66	4.01	108	121
Kob14+	5.125	8.564	3.94	4.15	192	200
Kob15+	5.500	9.192	4.54	4.68	400	408
Kob16+	6.000	10.248	5.54	5.33	265	256
Kob17+	6.500	11.222	5.43	6.16	600	770
Kob18+	7.000	11.888	6.38	6.45	630	650
Kob19+	7.500	12.740	7.45	7.06	490	440
Kob20+	7.500	13.176	7.98	7.82	386	374
Kob21+	7.500	13.642	7.46	7.87	365	410
Kob22+	8.000	14.309	9.04	9.01	650	650
Kob23+	8.000	15.059	8.76	9.19	320	370
Kob24+	8.500	15.874	9.74	9.61	515	500
Kob25+	9.000	17.152	10.35	9.80	440	350
Kob26+	9.500	18.015	10.67	9.92	600	440
Kob27+	10.000	19.214	12.27	12.19	525	485
Kob28+	10.500	20.054	13.83	13.07	800	480
Kob29+	11.000	20.635	15.57	15.86	800	800
Kob30+	11.500	21.302	16.71	16.96	800	800
Kob31+	12.000	22.032	22.61	20.60	800	800
Kob32+	12.500	22.633	30.66	20.98	800	600
Kob33+	13.000	23.367	20.76	21.34	135	320
Kob34+	13.500	24.098	23.20	24.12	82	370
Kob35+	14.000	24.703	26.14	27.01	600	800
Kob36+	14.500	25.381	28.26	29.28	425	800
Kob37+	15.000	26.218	31.34	30.71	660	385
Kob38+	15.500	26.788	33.24	33.22	385	385
Kob39+	16.000	27.366	35.95	35.37	277	83
Kob40+	16.500	27.930	38.03	38.32	166	275
Kob41+	17.000	28.550	44.75	41.00	800	345
Kob42+	17.500	29.200	43.93	43.68	480	350
Kob43+	18.000	29.850	45.91	46.24	220	354
Kob44+	18.500	30.500	48.73	49.73	80	457
Kob45+	19.000	31.150	53.37	52.88	575	337
Kob46+	19.500	31.800	54.59	55.80	200	380
Kob47+	20.000	32.450	59.03	59.68	400	770
Kob48+	20.500	33.100	62.66	69.04	575	800
Kob49+	21.000	33.750	66.37	65.65	246	200
Kob50+	21.500	34.400	68.54	69.21	130	380

Table-N.1.4(3) Discharge Capacity - Musi River

MUSI RIVER					UNIFORM FLOW	
Section No.	Marker (km)	Distance (km)	Bank Height (m)		Capacity (m3/sec)	
			Left	Right	Left	Right
Mus01+	0.000	0.000	6.32	6.32	220	220
Mus02+	0.500	1.160	9.95	8.29	320	150
Mus03+	1.000	1.964	11.20	10.05	400	250
Mus04+	1.500	2.717	10.94	11.26	280	325
Mus05+	2.000	4.139	11.59	12.38	124	185
Mus06+	2.500	4.862	15.50	15.22	142	125
Mus07+	3.000	6.641	17.65	17.24	150	120
Mus08+	3.440	7.254	20.05	20.30	400	400
Mus09+	3.500	7.661	17.92	18.43	100	144
Mus10+	4.000	8.275	20.19	21.35	100	175
Mus11+	4.500	9.342	21.48	22.09	150	234
Mus12+	5.000	10.520	23.55	23.44	165	144
Mus13+	5.500	11.818	26.86	26.85	400	400
Mus14+	6.000	12.394	29.24	28.65	400	325
Mus15+	6.500	13.680	32.28	32.76	218	330
Mus16+	7.000	14.455	34.10	33.91	207	178
Mus17+	7.500	14.969	36.32	34.90	335	84
Mus18+	8.000	15.623	39.51	39.35	230	193
Mus19+	8.500	16.212	41.53	41.38	131	111
Mus20+	9.000	16.878	44.12	44.35	57	89

Table-N.1.4(4) Discharge Capacity - Tinupa River

TINUPA RIVER					UNIFORM FLOW	
Section No.	Marker (km)	Distance (km)	Bank Height (m)		Capacity (m3/sec)	
			Left	Right	Left	Right
Tin01+	0.000	0.000	4.90	5.16	124	136
Tin02+	0.500	0.704	5.74	5.57	188	178
Tin03+	1.000	1.517	6.25	6.31	102	104
Tin04+	1.500	2.324	6.82	7.30	169	205
Tin05+	2.000	3.019	8.25	7.83	117	100
Tin06+	2.500	4.710	8.32	8.92	72	89
Tin07+	3.000	6.438	10.26	9.91	136	117
Tin08+	3.500	8.011	11.35	10.18	144	86
Tin09+	4.000	9.379	12.14	13.47	146	250
Tin10+	4.500	10.009	14.00	14.59	206	260
Tin11+	5.000	10.815	15.97	16.78	162	244
Tin12+	5.500	12.787	17.48	18.25	250	400
Tin13+	6.000	13.857	20.06	19.05	238	143
Tin14+	6.500	14.577	22.04	23.48	400	400
Tin15+	7.000	15.743	23.59	24.42	112	188

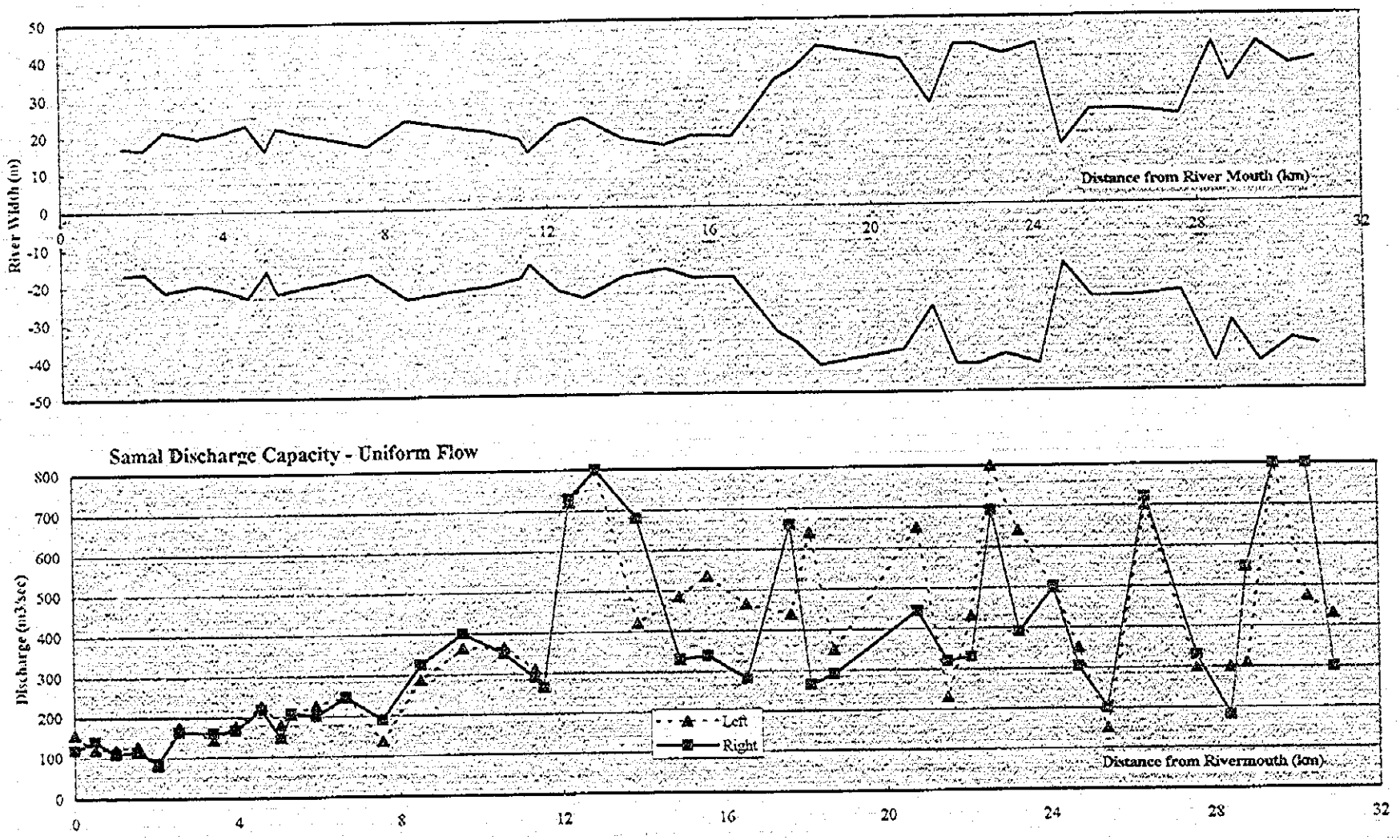


Figure-N.1.5(1) River Width and Discharge Capacity - Samal River

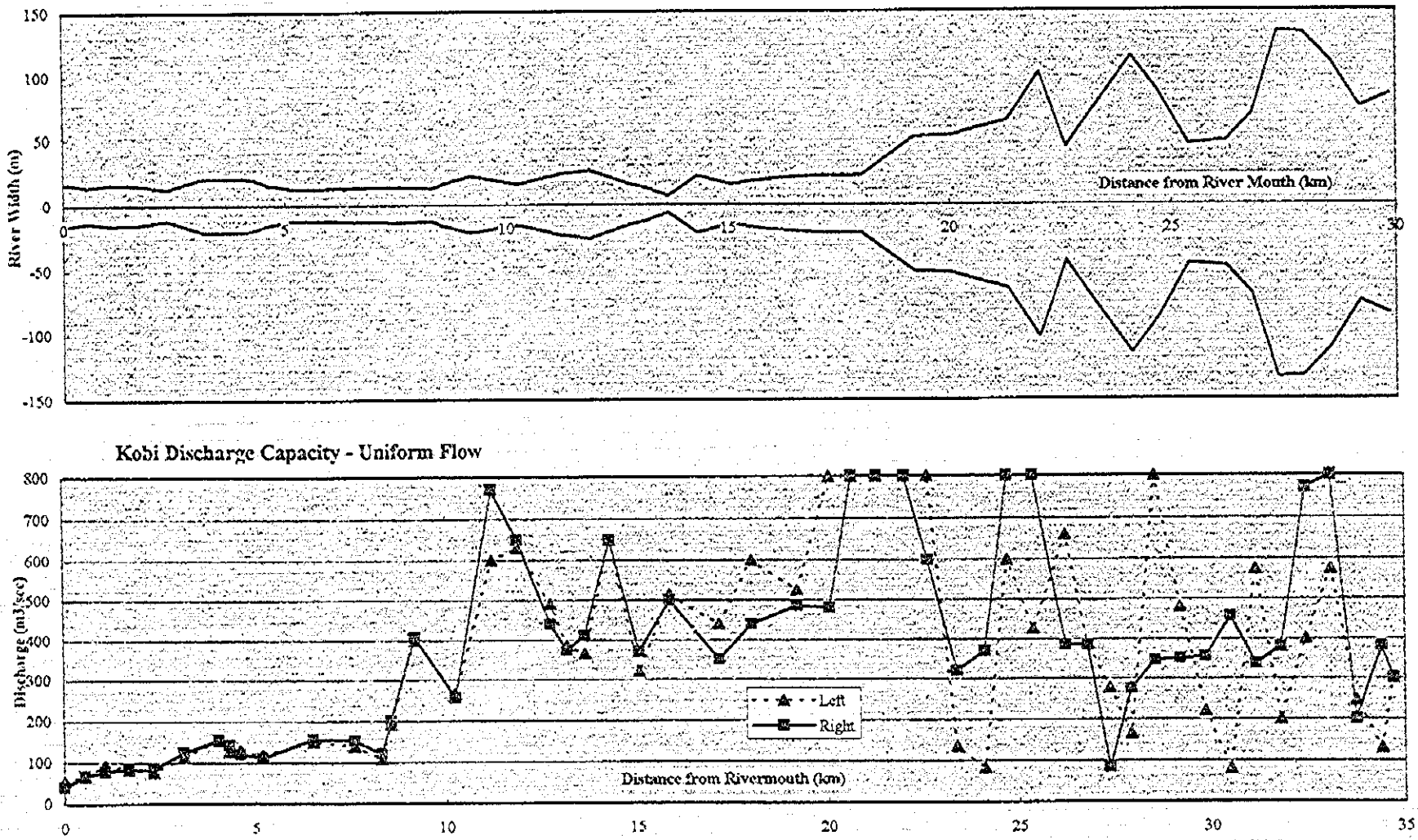


Figure-N.1.5(2) River Width and Discharge Capacity - Kobi River

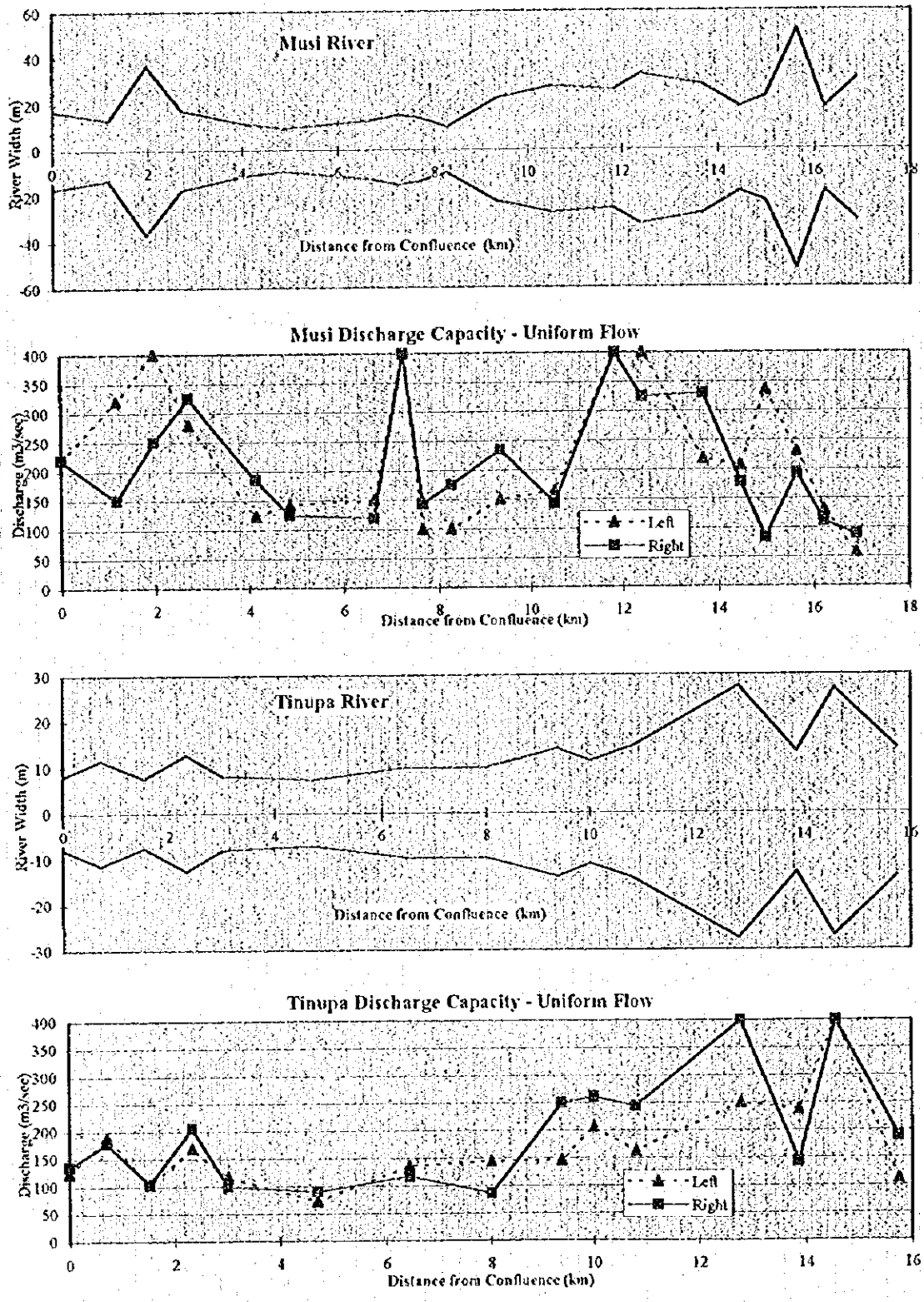


Figure-N.1.5(3) River Width and Discharge Capacity - Musi and Tinupa Rivers