

**Table 4-3 Irrigation Benefit at Full Development Stage**

(Unit: million Rp/)

Name of Projects	Without Project Condition					total primary profit	
	irrigated PU area*	rainfed PU area	rainfed non-PU	swamp area	other area		
SILAU/BUNUT	area(ha) profit/ha t.profit	11104 0.721 8,006.0	1000 0.331 331.0	5290 0.331 1,751.0	0 0.0 0.0	1065 0.331 352.5	10,440.5
TAMBUNG TULANG	area(ha) profit/ha t.profit	0 0.331 1,337.2	4040 0.331 1,337.2	0 0.0 0.0	1715 0.0 0.0	0 0.0 0.0	1,337.2
S.EMPAT	area(ha) profit/ha t.profit	0 0.0 0.0	0 0.0 0.0	0 0.0 0.0	2800 0.0 0.0	0 0.0 0.0	
Pd.MAHONDANG	area(ha) profit/ha t.profit	1600 0.721 1,153.6	1120 0.331 370.7	50 0.331 16.6	3438 0.0 0.0	580 0.331 192.0	1,732.9
LEIDONG-ASAHAN	area(ha)** profit/ha t.profit	80 0.721 57.7	13240 0.331 4,382.4	2640 0.331 873.8	29540 0.0 0.0	0 0.0 0.0	5,314.0
KANOPAN LEFT	area(ha) profit/ha t.profit	0 0.331 0.0	1384 0.331 458.1	680 0.331 225.1	2256 0.0 0.0	0 0.0 0.0	683.2
AEK NATAS	area(ha) profit/ha t.profit	0 0.0 0.0	2704 0.331 895.0	0 0.0 0.0	1206 0.0 0.0	280 0.331 92.7	987.7
KUALUH RIGHT	area(ha) profit/ha t.profit	0 0.0 0.0	0 0.0 0.0	2040 0.331 675.2	385 0.0 0.0	0 0.0 0.0	675.2
AEK NAETEK	area(ha) profit/ha t.profit	0 0.0 0.0	2400 0.331 794.4	0 0.0 0.0	1050 0.0 0.0	0 0.0 0.0	794.4
SMALL-SCALE	area(ha) profit/ha t.profit	1664 0.721 1,199.7	1392 0.407 566.5	4590 0.407 1,868.1	0 0.0 0.0	16 0.331 5.3	3,639.7

Name of Projects	With Project Condition			total primary Profit	Irrigation Benefit (Total)	Benefit Per ha (\$/ha)	
	irrigated lowland	new irrigated and small scale system	control drainage				
SILAU/BUNUT	area(ha) profit/ha t.profit	13380 1.092 15,157.0	14710 0.95 13,974.5	0 0.0 0.0	29,131.5	18,691.0	739
TAMBUNG TULANG	area(ha) profit/ha t.profit	0 0.769 0.0	0 0.769 0.0	5755 0.769 4425.595	4,425.6	3,088.4	303
S.EMPAT	area(ha) profit/ha t.profit	0 0.769 0.0	0 0.769 0.0	2800 0.769 2153.2	2,153.2	2,153.2	434
Pd.MAHONDANG	area(ha) profit/ha t.profit	2000 1.092 2184	10370 0.95 9851.5	0 0.0 0.0	12,035.5	10,302.7	941
LEIDONG-ASAHAN	area(ha)** profit/ha t.profit	100 1.092 109.2	33500 0.95 31825	28800 1.9923 57378.24	89,312.4	83,998.5	1,044
KANOPAN LEFT	area(ha) profit/ha t.profit	0 0.769 0.0	0 0.769 0.0	4320 0.769 3322.08	3,322.1	2,638.9	345
AEK NATAS	area(ha) profit/ha t.profit	0 0.95 0.0	8380 0.95 7961	0 0.0 0.0	7,961.0	6,973.3	940
KUALUH RIGHT	area(ha) profit/ha t.profit	0 0.95 0.0	4850 0.95 4607.5	0 0.0 0.0	4,607.5	3,932.3	916
AEK NAETEK	area(ha) profit/ha t.profit	0 0.95 0.0	6900 0.95 6555	0 0.0 0.0	6,555.0	5,760.6	943
SMALL-SCALE	area(ha) profit/ha t.profit	0 0.95 0.0	12,277 0.95 11662.77	0 0.0 0.0	11,662.8	8,023.1	781

\*:Cropping intensity for irrigated lowland is 160 %, other land except swamp 100 %/

\*\* :including oil palm land of 28800 ha indicated in colum of control drainage

**Table 4-4 Main Features of Proposed Project Works**

Item	Description
<b>1. Location</b>	Noth-east of Kisaran, 150 km from Medan, North Sumatra Province
<b>2. Water resources</b>	Conjunctive use of Silau and Bunut river flows
<b>3. Project Command Area</b>	
(1) Gross area	14,300 ha
(2) Net irrigation area	10,300 ha
<b>4. Agricultural Development Plan</b>	
(1) Cropping pattern	Double crop of paddy per year
(2) Cropping intensity	200%
(3) Annual incremental paddy production	74,000 ton/year
<b>5. Proposed Project Work</b>	
(1) Water resource facilities	
(i) Construction of Silau integrated weir	Rubber tube type movable weir on the Silau river
(ii) Construction of inter-basin diversion canal	Diversion canal from the Silau to the Bunut river (L= 8.3 km)
(iii) Rehabilitation of existing weirs on Bunut river	3 weirs of Serbangan, Panca Arga and Buluru
(2) Rehabilitation and construction of irrigaiton canals	49 canals of 170 km in total (Rehabilitation : 60 km, New construction ; 110 km)
(3) Rehabilitation and construction of drainage canals	48 canals of 180 km in total (Rehabilitation : 82 km, New construction ; 98 km)
(4) Construction of farm road network	354 km in total(New roads)
(5) Construction of Bunut flood dike	Construction of earth dike and dredging of river bed for 34 km
(6) Construction of on-farm facilities	9,510 ha ( area of 790 ha has been developed)
(7) Land reclamation	670 ha from coconuts field to paddy fields in Silau system
(8) Construction of agri-business quarter	70 sites (each has drying yard and building in 2,000 sq-m land)
(9) Procurement of O&M equipment	Operation vehicles, maintenance equipment, etc.
(10) Training program for O&M staff and farmers	Nos. of trainees : Government staff ; 58 , Farmers ; 550
<b>6. Project Cost *</b>	
(1) Construction cost (Rp. million)	100,426 (US\$ 5,500/ha)
(2) Other costs (Rp. million)	31,635
(3) Total (Rp. million)	132,061
<b>7. Project Fund Requirement</b>	
(1) Foreign currency portion (US\$ 1,000)	56,520
(2) Local currency portion (Rp. million)	57,271
(3) Total cost (Rp. million)	157,311
<b>8. Implementation Program</b>	
(1) Implementation period	
(i) Detailed design and pre-construction management	2.5 years
(ii) Construction period	4.5 years
(iii) Total period	7 years
(2) Execution agency	DGWRD, DPU (Project office will be established)
<b>9. Economic Evaluation **</b>	
(1) Economic capital costs (Rp. million)	148,432
(2) Annual economic benefit (Rp. million)	22,901
(3) Economic Internal Rate of Return (%)	13.2 %
(4) Benefit-Cost (B/C) ratio (at 12 % discount rate)	1.10
(5) Benefit minus Cost (B-C) ratio (at 12 % discount rate)	Rp. 9,580 million

Remarks:

1. Conversion rate : US\$ 1.0 = Rp. 1,770

2. Price escalation ratio : Foreign currency ; 3% / year, Local currency ; 8 % /year

\*: The cost does not include a price contingency

\*\* : The economic evaluation is made based on the costs and benefits of the Project and Silau flood control works by DGWRD



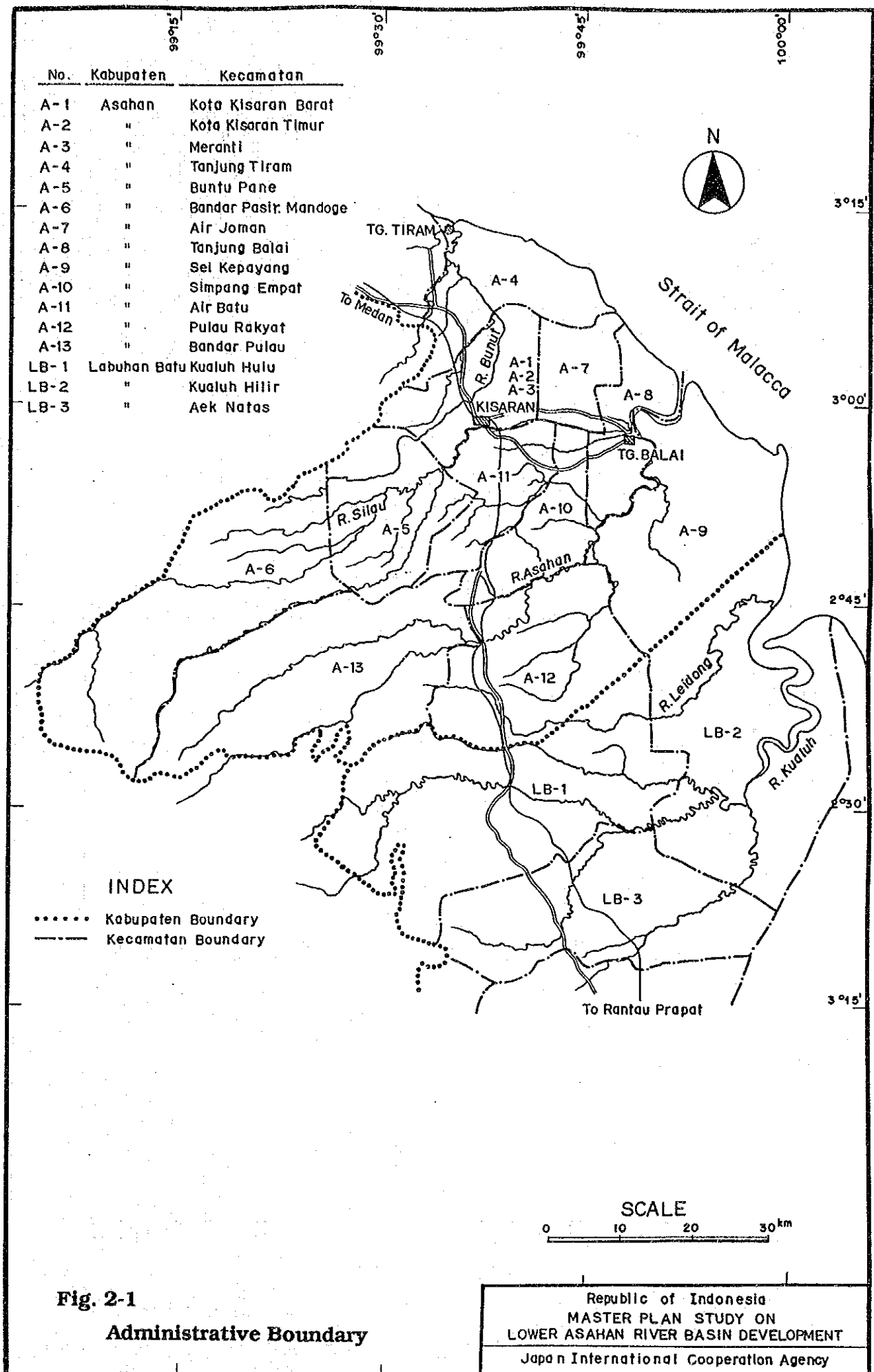
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# **Figures**





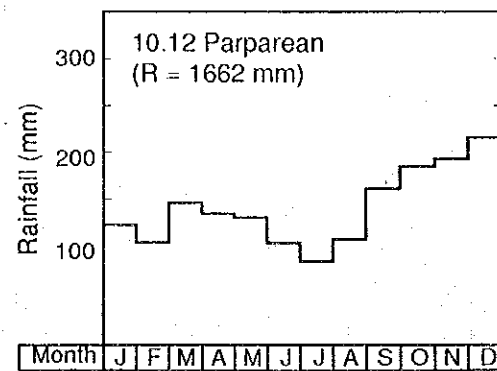
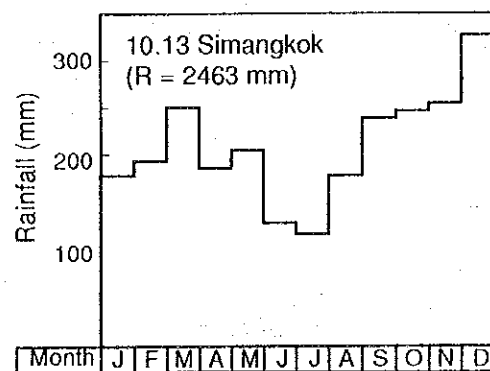
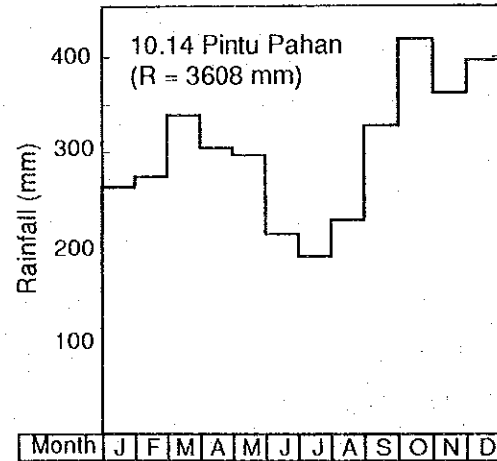
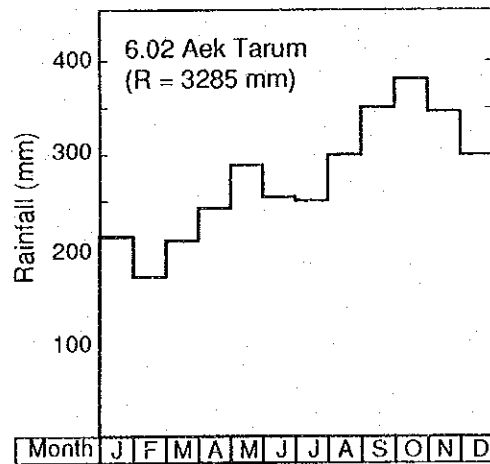
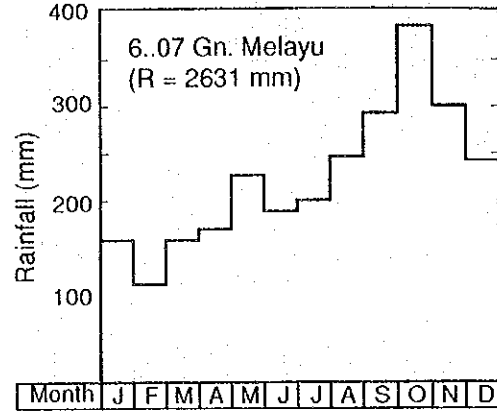
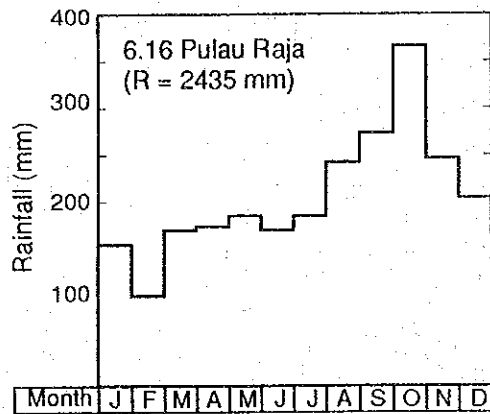
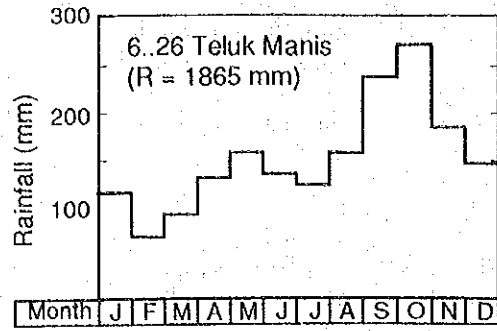
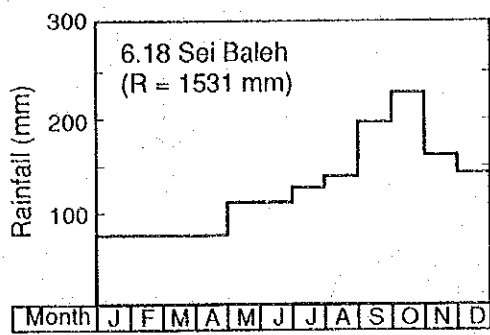
No.	Kabupaten	Kecamatan
A-1	Asahan	Kota Kisaran Barat
A-2	"	Kota Kisaran Timur
A-3	"	Meranti
A-4	"	Tanjung Tiram
A-5	"	Buntu Pane
A-6	"	Bandar Pasir Mandoge
A-7	"	Air Joman
A-8	"	Tanjung Balai
A-9	"	Sel Kepayang
A-10	"	Simpang Empat
A-11	"	Air Batu
A-12	"	Pulau Rakyat
A-13	"	Bandar Pulau
LB-1	Labuhan Batu	Kualuh Hulu
LB-2	"	Kualuh Hilir
LB-3	"	Aek Natas

**INDEX**  
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 ————— Kecamatan Boundary

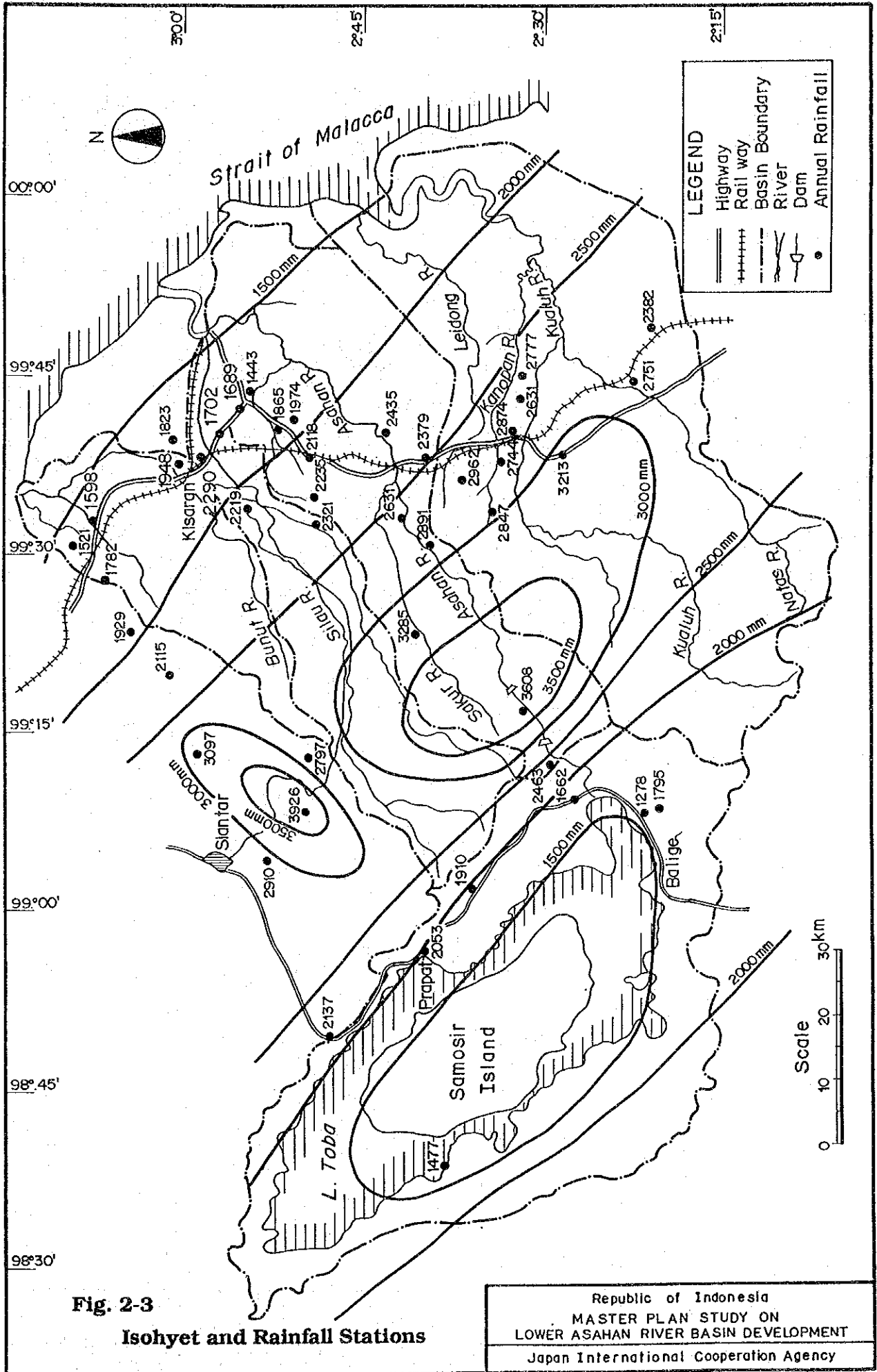
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 0 10 20 30 km

**Fig. 2-1**  
**Administrative Boundary**

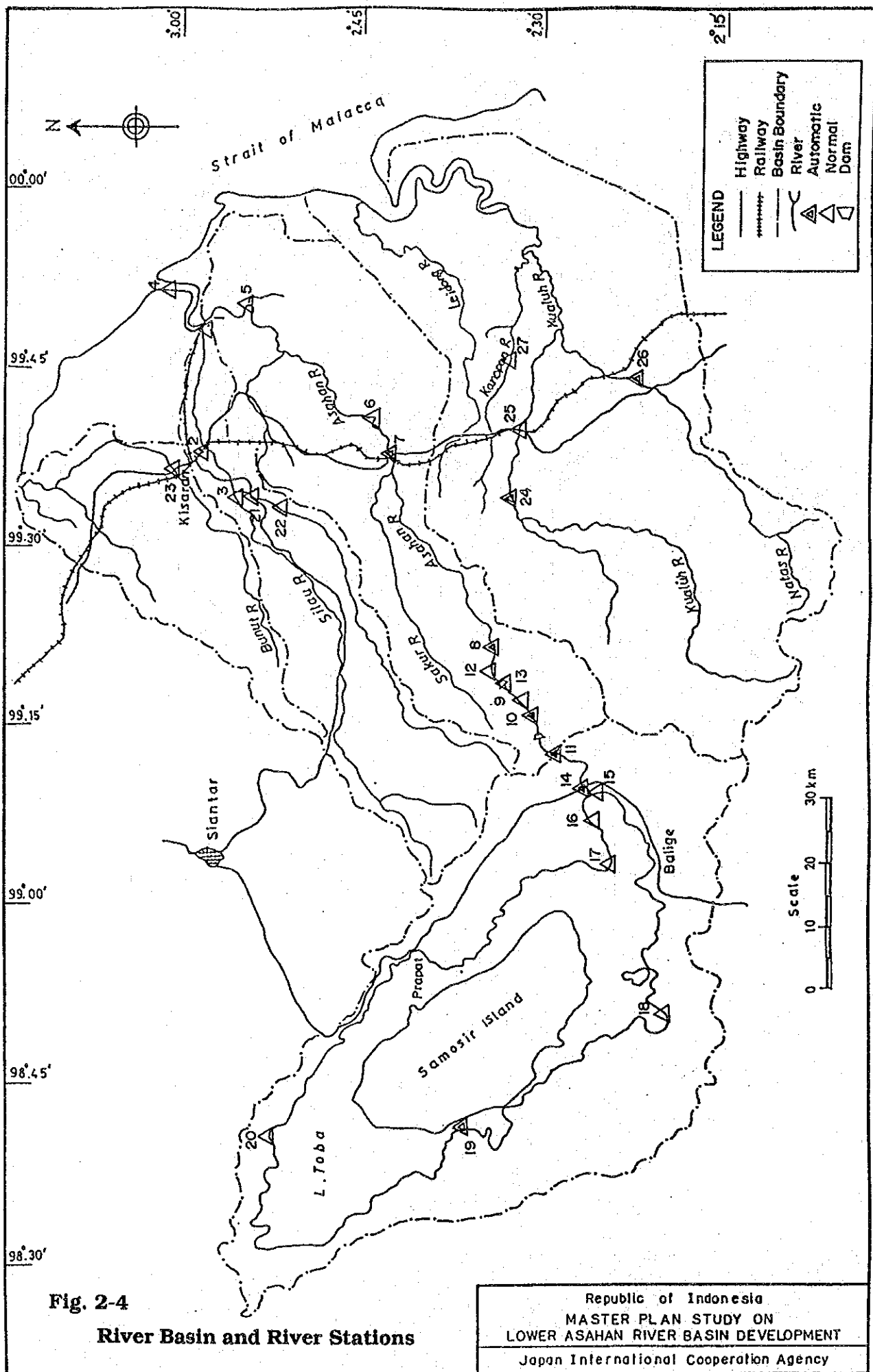
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**Fig. 2-2**  
**Distribution of Monthly Rainfall**

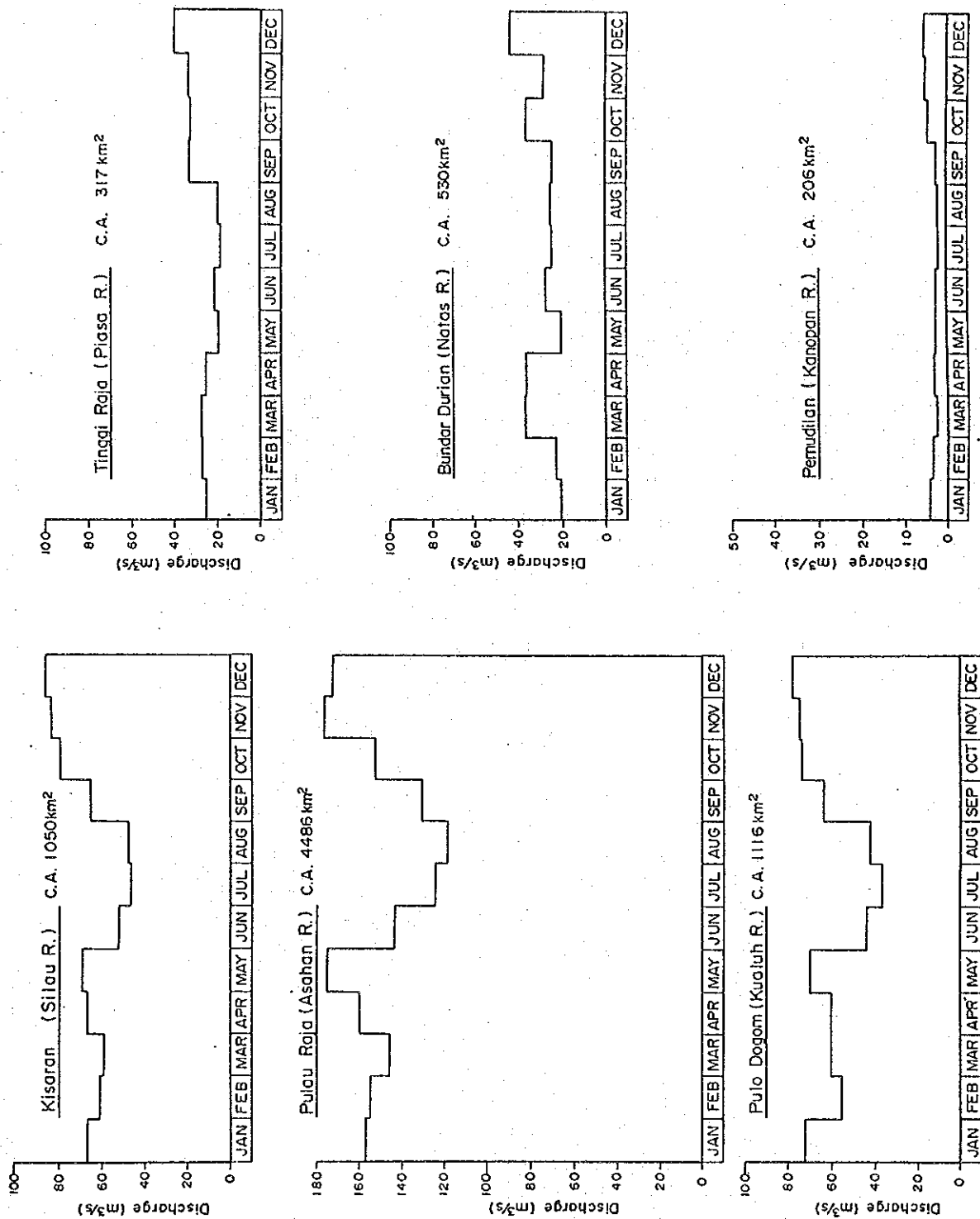






**Fig. 2-4**  
**River Basin and River Stations**

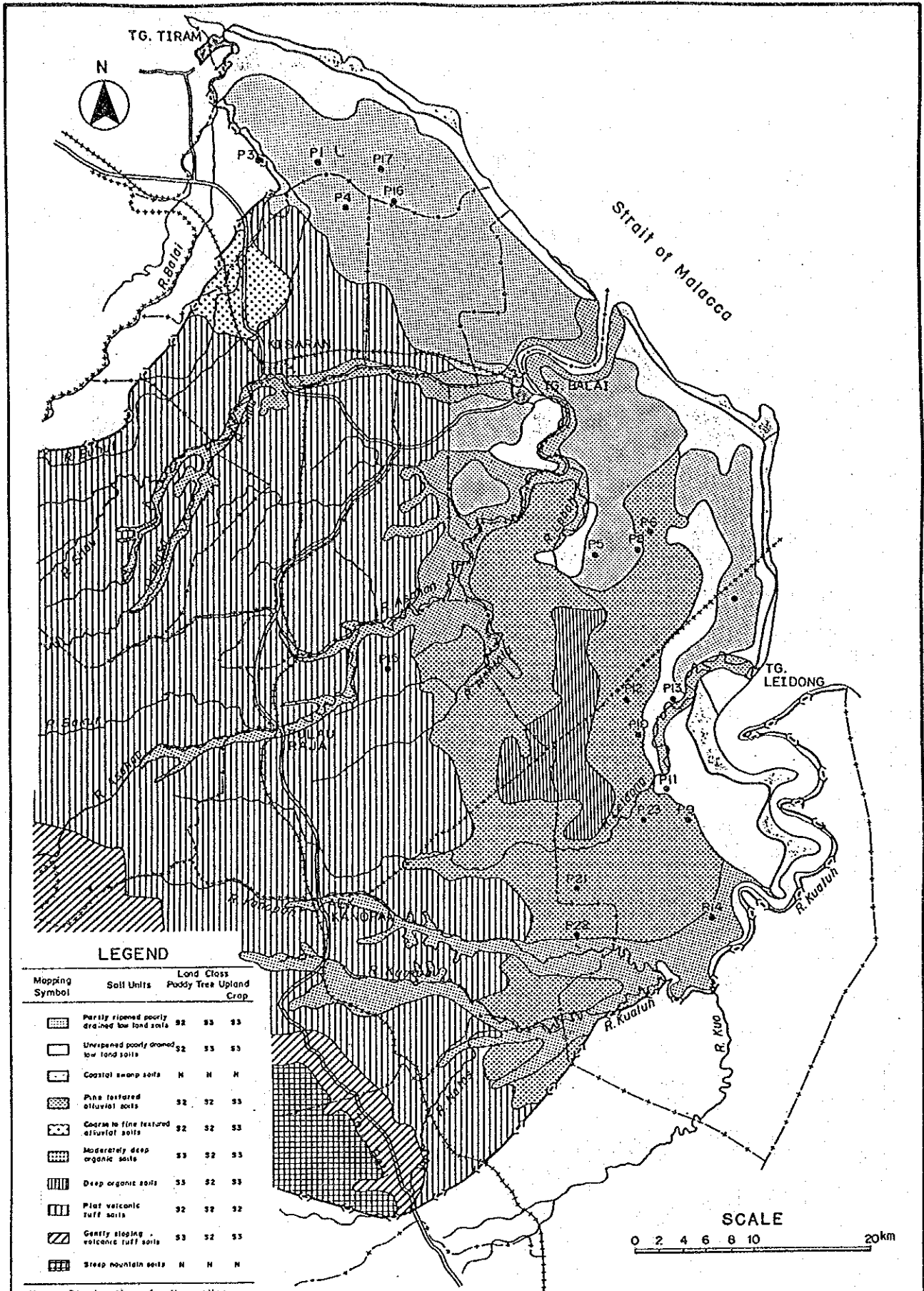
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**Fig. 2-5**

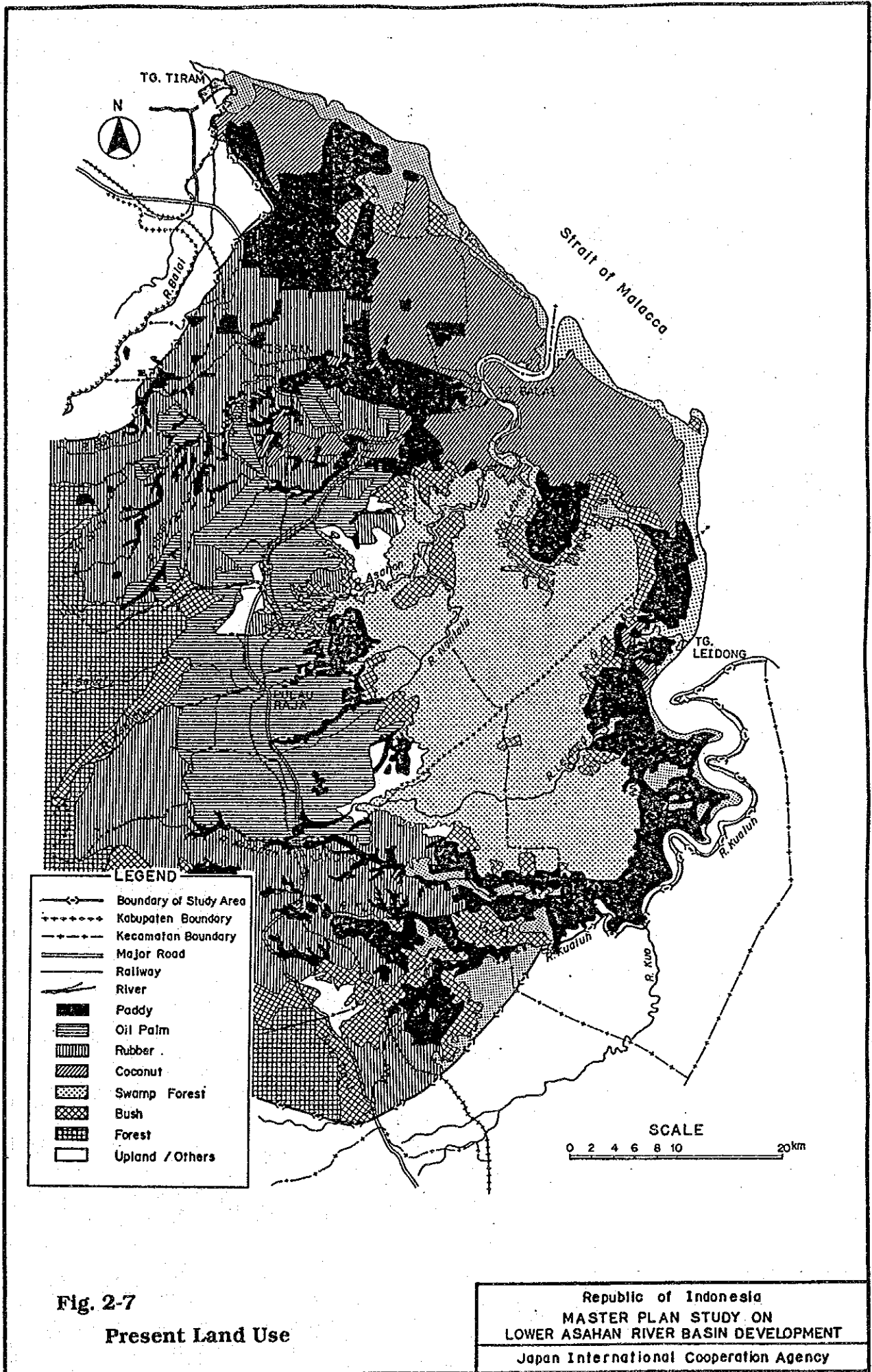
**Distribution of River Runoff**

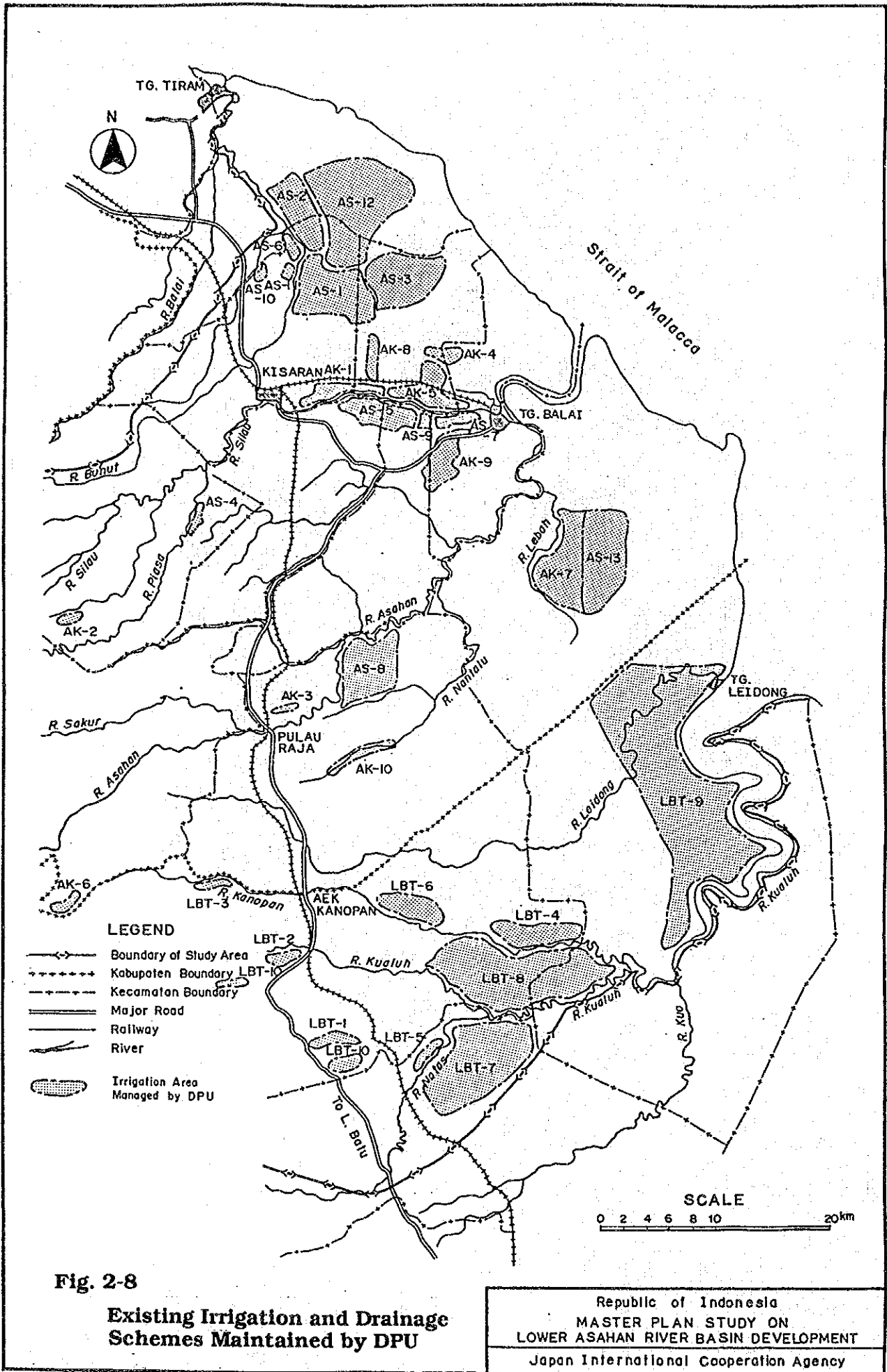
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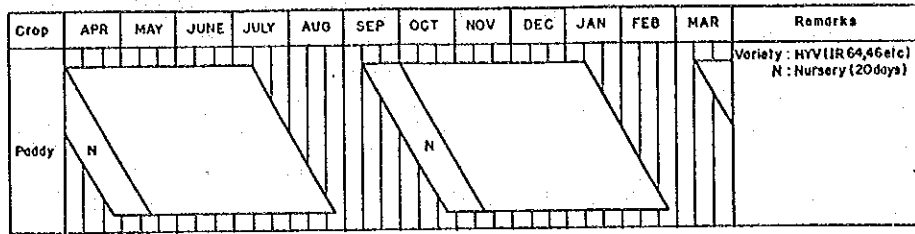
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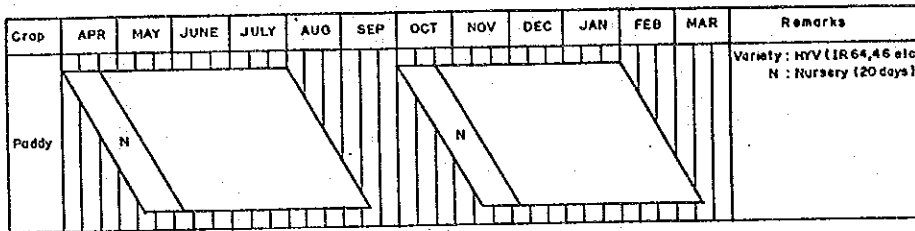




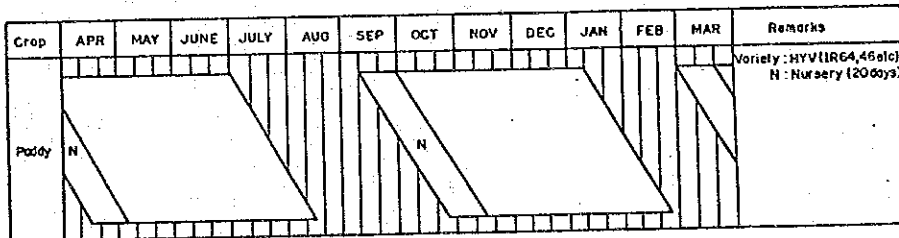
### Cropping Pattern 1, applied for the proposed project No.1,2 and 3



### Cropping Pattern 2, applied for the proposed project No.4,5,6,8,9 and 10



### Cropping Pattern 3, applied for the proposed project No.7



### Climate Data, Rainfall and Sunshine Hours

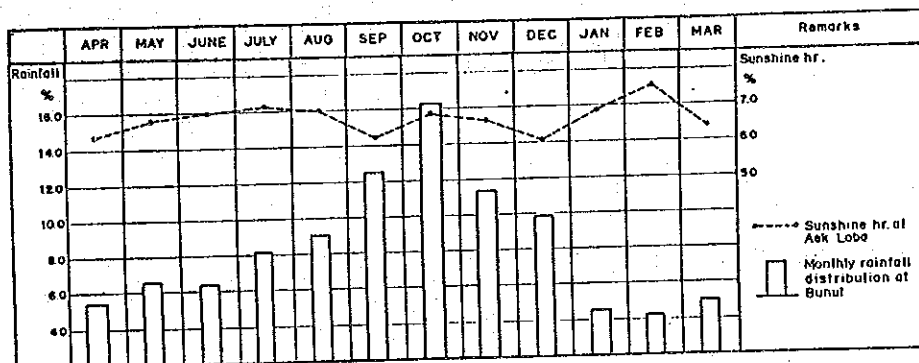


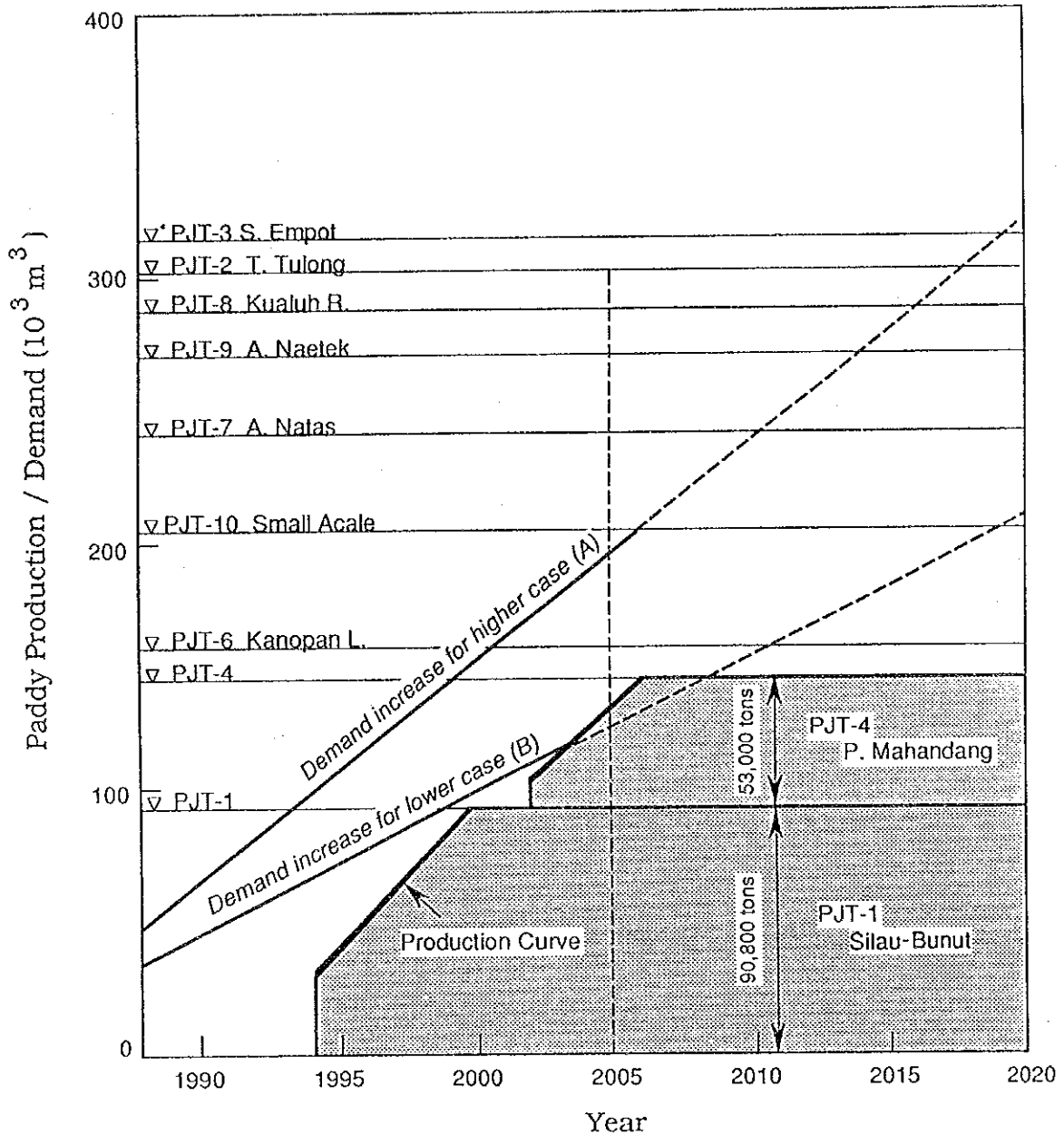
Fig. 4-1  
Proposed Cropping Pattern

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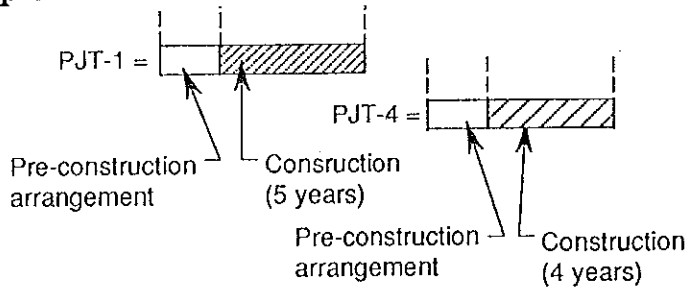
**Demand increase curve**

(A): 15% of demand increase in North Sumatra Province is produced in this study area.

(B): 10% of demand increase in North Sumatra Province is produced in this study area.



**Implementation Schedule**



**Fig. 5-1**  
**Recommended Paddy Demand and Production Balance**

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## **Appendix 3-A**

# **Meteorology and Hydrology**





**Appendix 3-A**  
**METEOROLOGY AND HYDROLOGY**

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Table A-1 SUMMARY OF CLIMATIC CONDITIONS

Item	JAN.	FEB.	MAR.	APR.	MAY	JUNE	JULY	AUG.	SEP.	OCT.	NOV.	DEC.	Annual
<b>Mean Temperatur (degree C.)</b>													
Sei Dadap ('66-'88)	25.7	26.0	26.3	26.6	26.7	26.6	26.4	26.3	26.2	26.2	26.2	25.9	26.3
Marihat ('73-'88)	23.9	24.3	24.6	24.8	24.8	24.8	24.4	24.4	24.2	24.2	24.2	24.0	24.4
Balige ('73-'88)	18.6	18.5	18.9	18.9	19.0	18.8	18.7	18.5	18.5	18.6	18.8	18.8	18.7
<b>Daily-Max Temperature (degress C.)</b>													
Sei Dadap ('66-'82)	31.5	32.0	32.4	32.7	32.9	32.9	32.6	32.4	32.1	31.8	31.4	31.3	32.2
Marihat ('73-'88)	29.4	30.0	30.3	30.4	30.4	30.6	30.2	30.2	29.6	29.6	29.3	29.3	29.9
Balige ('73-'88)	25.5	25.8	25.5	26.0	26.4	26.2	26.1	25.9	25.4	25.7	25.6	24.6	25.7
<b>Daily-Min Temperature (degress C.)</b>													
Sei Dadap ('69-'82)	21.8	21.5	21.9	22.7	22.7	22.5	22.3	22.2	22.5	22.6	22.5	22.2	22.3
Marihat ('73-'88)	19.5	19.8	20.0	20.4	20.4	20.0	19.6	19.8	19.9	19.9	20.0	19.7	19.9
Balige ('75-'88)	14.7	14.9	15.0	15.5	15.7	15.1	15.1	15.0	15.0	15.1	15.0	15.6	15.1
<b>Absolute-Max Temperature (degress C.)</b>													
Sei Dadap ('66-'82)	34.5	35.0	35.0	35.5	36.0	36.0	35.5	35.5	35.5	35.0	33.5	35.0	36.0
Marihat ('73-'88)	33.0	33.0	33.0	34.0	33.5	33.5	33.5	34.0	34.5	33.5	33.5	33.5	34.5
Balige ('73-'88)	29.8	29.8	29.6	29.0	28.6	28.6	29.0	29.8	28.2	28.2	29.8	27.5	29.8
<b>Absolute-Min Temperature (degress C.)</b>													
Sei Dadap ('69-'82)	16.8	17.0	18.6	18.7	20.0	13.5	18.2	16.5	19.5	19.0	20.0	18.6	13.5
Marihat ('73-'88)	16.5	16.0	17.5	18.5	17.5	15.5	16.0	16.5	17.5	16.0	17.0	17.5	15.5
Balige ('75-'88)	10.2	13.0	12.6	13.0	12.0	13.0	12.5	11.0	12.0	10.5	13.0	12.5	10.2
<b>Relative Humidity (%)</b>													
Sei Dadap ('66-'88)	88.7	87.6	88.2	88.4	87.9	86.8	87.0	88.3	88.5	89.4	89.7	89.3	88.3
Marihat ('73-'88)	84.7	83.6	84.1	85.4	84.8	82.6	83.5	83.6	86.1	86.2	86.4	86.1	84.8
Balige ('73-'88)	87.0	86.3	87.8	87.2	86.2	86.1	86.5	86.2	86.9	87.8	87.6	85.8	86.8
<b>Wind Velocity (m/s)</b>													
Sei Dadap ('79-'88)	0.19	0.24	0.25	0.23	0.24	0.25	0.25	0.23	0.28	0.22	0.21	0.21	0.23
Marihat ('84-'88)	0.24	0.29	0.28	0.23	0.19	0.20	0.18	0.23	0.20	0.18	0.24	0.29	0.23
Balige ('85-'88)	0.89	0.70	0.74	0.65	0.58	1.12	0.48	0.45	0.56	0.50	0.66	-	0.66
<b>Sunshine Duration (%)</b>													
Sei Dadap	-	-	-	-	-	-	-	-	-	-	-	-	-
Ack Loba ('70-'88)	57.5	65.2	54.0	54.2	57.8	59.5	62.1	59.9	52.2	59.1	57.0	50.2	57.4
Marihat ('73-'88)	60.5	69.2	68.8	67.1	66.1	68.2	65.6	64.1	56.4	55.1	52.0	57.7	62.6
Balige ('73-'88)	58.3	55.5	62.5	54.6	53.8	62.2	54.3	54.8	39.0	36.8	43.6	40.3	51.3
<b>Evaporation (mm)</b>													
Sei Dadap ('79-'88)	93.5	104.8	111.5	112.5	111.9	108.3	112.4	114.8	106.0	105.5	87.9	91.9	1261.0
Marihat ('84-'88)	100.7	100.0	107.9	107.0	104.5	108.5	107.3	88.5	86.7	92.6	84.1	91.5	1179.3
Balige	-	-	-	-	-	-	-	-	-	-	-	-	-
<b>Rainfall (mm)</b>													
Sei Dadap ('58-'88)	102	78	99	106	131	119	143	151	230	242	164	137	1,702.0
Ack Loba ('70-'88)	144	92	158	112	187	227	222	201	272	324	251	189	2,379.0
Marihat ('73-'88)	214	193	205	230	310	157	219	211	320	356	253	256	2,924.0
Balige ('73-'88)	127	138	120	171	130	98	118	85	173	192	229	218	1,799.0

Source: Badan Meteorologi dan Geofisika (BMG), Balai Wilayah I, Sampali

Table A-2 MONTHLY MEAN TEMPERATURE AT SEI DADAP

YEAR	(Unit : degrees Centigrade)												
	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	AVE.
1966	-	26.1	26.1	27.0	27.3	26.6	26.3	26.5	26.1	25.9	25.9	25.6	-
1967	24.8	25.4	26.4	26.6	27.0	26.5	26.1	26.0	25.9	25.6	25.7	25.8	26.0
1968	25.2	25.4	26.6	26.4	25.5	26.4	26.0	26.2	25.9	26.1	25.9	25.8	26.0
1969	26.1	26.4	27.2	27.5	27.3	27.0	26.8	26.3	26.3	26.3	26.4	25.7	26.6
1970	25.5	26.4	26.6	26.9	26.8	27.3	26.3	26.5	25.6	25.9	25.7	26.1	26.3
1971	-	25.4	25.6	26.2	26.5	26.5	25.9	25.8	25.9	25.7	26.1	25.2	-
1972	25.2	25.6	26.1	26.1	27.0	26.8	27.3	26.9	26.2	26.8	26.5	26.4	26.4
1973	-	26.8	-	27.2	27.1	27.2	27.1	-	26.5	26.4	26.7	25.5	-
1974	-	-	-	-	-	-	-	-	26.2	-	26.2	25.8	-
1975	26.4	26.4	26.2	26.4	26.6	26.4	27.4	26.0	26.8	26.4	26.2	26.2	26.5
1976	25.4	25.9	26.2	26.6	26.4	26.2	-	26.2	26.2	26.6	26.2	26.2	-
1977	26.0	25.8	26.0	27.1	27.0	26.8	27.0	26.2	26.8	26.0	26.0	26.4	26.4
1978	26.2	26.2	26.7	26.8	27.4	27.1	26.1	26.9	26.2	26.1	26.0	26.0	26.5
1979	26.1	26.2	26.5	26.6	26.9	26.9	26.4	26.6	26.2	26.3	26.2	26.0	26.4
1980	26.0	26.2	26.0	26.7	27.0	26.8	26.8	26.3	26.6	26.4	26.4	26.2	26.5
1981	25.8	25.8	26.0	26.2	26.6	26.8	26.4	26.2	26.4	26.4	26.4	26.0	26.3
1982	25.6	25.6	26.0	26.5	26.6	26.6	26.2	26.2	26.4	26.4	26.4	26.4	26.2
1983	26.0	26.4	26.6	26.8	26.8	26.8	26.4	26.6	26.4	26.6	26.2	26.0	26.5
1984	25.6	25.9	26.2	26.6	26.6	26.4	26.1	26.0	26.1	26.4	25.8	25.7	26.1
1985	25.6	26.0	25.8	26.4	26.2	25.8	25.6	25.6	-	-	-	-	-
1986	-	-	-	-	-	-	-	-	-	-	-	-	-
1987	26.2	25.6	26.2	26.4	26.2	26.4	25.8	-	-	-	-	-	-
1988	25.1	26.2	26.3	26.4	26.4	26.2	25.9	25.8	-	-	-	-	-
AVE.	25.7	26.0	26.3	26.6	26.7	26.6	26.4	26.3	26.2	26.2	26.2	25.9	26.3
MAX.	26.4	26.8	27.2	27.5	27.4	27.3	27.4	26.9	26.8	26.8	26.7	26.4	26.6
MIN.	24.8	25.4	25.6	26.1	26.2	25.8	25.6	25.6	25.9	25.6	25.7	25.2	26.0

Source : Badan Meteorologi dan Geofisika (BMG)

Table A-3 MEAN DAILY MAXIMUM TEMPERATURE AT SEI DADAP

YEAR	(Unit : degrees Centigrade)												
	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
1966	-	32.1	31.9	32.8	33.1	32.6	31.9	32.4	31.6	30.7	30.6	30.4	31.8
1967	30.3	30.7	32.1	32.0	32.4	32.1	32.0	31.9	31.5	31.1	31.0	31.1	31.5
1968	30.8	31.6	32.5	32.5	31.1	33.0	33.1	33.2	32.6	32.1	32.2	31.4	32.2
1969	31.9	32.8	33.1	34.0	33.1	33.0	33.4	32.3	32.1	31.1	30.3	30.7	32.3
1970	31.1	32.5	33.4	32.5	32.1	33.4	32.1	32.7	31.3	31.1	31.0	31.0	32.0
1971	-	31.4	31.5	32.5	32.3	32.1	32.1	31.4	31.3	31.2	30.3	29.7	31.4
1972	30.3	32.0	32.6	32.1	33.0	32.9	33.7	33.1	33.6	32.2	31.3	31.3	32.2
1973	-	32.6	-	33.0	32.2	33.4	33.0	-	32.0	32.0	31.3	30.8	-
1974	-	-	-	-	-	-	-	-	31.5	-	31.0	31.6	-
1975	32.0	32.5	32.5	33.0	32.5	33.2	32.0	32.0	31.5	32.0	31.5	31.5	32.2
1976	31.3	30.2	32.4	33.4	33.1	32.2	-	31.3	32.5	32.2	32.0	31.6	32.0
1977	32.2	31.5	32.5	32.0	33.4	32.5	33.3	32.5	32.7	31.2	31.8	32.2	32.3
1978	32.0	33.0	33.0	33.1	33.0	33.0	32.2	33.0	32.0	32.1	31.8	32.1	32.5
1979	32.0	32.5	33.4	32.5	33.2	33.1	32.1	32.7	32.0	32.1	31.0	31.5	32.3
1980	32.0	32.4	32.7	32.5	32.8	33.0	32.8	31.6	32.5	32.0	31.9	31.5	32.3
1981	31.5	32.0	32.4	32.7	32.8	33.2	32.8	32.8	32.4	32.6	32.7	32.0	32.5
1982	32.0	32.0	30.5	33.0	32.0	33.0	32.7	32.9	-	32.8	32.5	-	32.3
1983	-	-	-	-	-	-	-	-	-	-	-	-	-
1984	-	-	-	-	-	-	-	-	-	-	-	-	-
1985	-	-	-	-	-	-	-	-	-	-	-	-	-
1986	-	-	-	-	-	-	-	-	-	-	-	-	-
1987	-	-	-	-	-	-	-	-	-	-	-	-	-
1988	-	-	-	-	-	-	-	-	-	-	-	-	-
AVE.	31.5	32.0	32.4	32.7	32.9	32.9	32.6	32.4	32.1	31.8	31.4	31.3	32.2

Source : Badan Meteorologi dan Geofisika (BMG)

Table A-4 MEAN DAILY MINIMUM TEMPERATURE AT SEI DADAP

YEAR	(Unit ; degrees Centigrade)												ANNUAL
	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	
1966	-	-	-	-	-	-	-	-	-	-	-	-	-
1967	-	-	-	-	-	-	-	-	-	-	-	-	-
1968	-	-	-	-	-	-	-	-	-	-	-	-	-
1969	-	-	-	-	-	-	-	-	22.5	21.6	21.6	21.6	-
1970	21.7	20.6	21.0	21.4	21.5	21.4	21.0	20.8	20.6	21.4	21.0	20.9	21.1
1971	-	20.2	20.7	23.0	22.8	22.3	21.1	21.5	22.4	22.5	21.9	22.0	22.0
1972	20.7	20.8	21.5	22.4	22.1	23.2	22.7	22.2	23.3	22.7	23.4	23.3	22.3
1973	-	23.5	-	23.7	23.3	23.6	23.3	-	23.0	23.5	22.9	22.2	-
1974	-	-	-	-	-	-	-	-	23.0	-	23.5	22.0	-
1975	22.0	22.3	22.0	23.0	23.0	22.5	22.5	23.0	22.0	22.5	22.0	23.0	22.5
1976	21.4	20.1	22.0	22.0	22.0	22.4	-	22.1	22.3	22.6	22.4	22.4	22.0
1977	21.5	21.5	22.0	22.8	22.8	22.5	22.4	22.6	23.0	22.9	22.8	23.0	20.6
1978	22.5	22.2	23.0	22.6	23.5	23.0	22.4	22.8	22.5	22.8	22.8	21.7	22.7
1979	23.2	22.3	22.2	23.0	23.1	23.1	22.8	22.5	23.0	22.9	23.1	22.0	22.8
1980	21.9	21.3	22.0	23.0	23.1	23.0	23.0	22.4	23.0	23.0	22.6	23.0	23.4
1981	22.0	22.0	22.0	22.6	23.1	22.5	22.0	21.7	22.5	22.6	22.6	22.1	22.3
1982	21.5	21.5	22.0	22.5	22.5	19.9	22.6	-	-	-	-	-	-
1983	-	-	-	-	-	-	-	-	-	-	-	-	-
1984	-	-	-	-	-	-	-	-	-	-	-	-	-
1985	-	-	-	-	-	-	-	-	-	-	-	-	-
1986	-	-	-	-	-	-	-	-	-	-	-	-	-
1987	-	-	-	-	-	-	-	-	-	-	-	-	-
1988	-	-	-	-	-	-	-	-	-	-	-	-	-
AVE.	21.8	21.5	21.9	22.7	22.7	22.5	22.3	22.2	22.5	22.6	22.5	22.2	22.3

Source ; Badan Meteorologi dan Geofisika (BMG)

Table A-5 ABSOLUTE MAXIMUM TEMPERATURE AT SEI DADAP

YEAR	(Unit ; degrees Centigrade)												MAX
	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	
1966	-	33.5	33.5	34.5	36.0	35.0	34.5	34.5	34.0	32.5	33.5	32.0	36.0
1967	32.5	32.5	33.5	34.5	35.0	35.0	33.5	33.5	33.5	32.5	32.5	32.5	35.0
1968	32.5	33.5	34.0	34.0	32.5	33.5	35.5	34.0	34.0	33.5	33.0	33.5	35.5
1969	33.0	33.5	35.0	35.5	36.0	34.0	35.0	33.5	35.0	32.5	32.5	32.0	36.0
1970	32.5	34.5	34.5	34.5	34.0	35.0	34.0	35.0	33.5	33.0	33.0	35.0	35.0
1971	-	33.1	33.5	34.0	34.0	34.8	34.5	33.0	33.0	33.0	32.0	31.8	34.8
1972	32.5	33.5	34.3	34.0	34.5	35.0	35.2	35.0	33.6	33.0	33.0	33.5	35.2
1973	-	34.2	-	35.0	35.0	36.0	35.0	-	34.0	35.0	33.0	32.5	-
1974	-	-	-	-	-	-	-	-	34.0	-	32.5	32.5	-
1975	34.5	33.5	33.5	34.0	34.5	34.5	34.0	34.5	34.0	34.0	33.5	32.5	34.5
1976	33.0	33.5	34.0	34.5	35.0	34.5	-	34.5	33.5	33.5	33.5	33.0	35.0
1977	33.5	33.5	34.5	35.5	35.5	34.5	35.5	35.5	32.5	33.0	34.5	34.5	35.5
1978	33.5	35.0	34.5	34.5	34.5	34.5	34.0	34.5	34.0	33.0	33.0	33.0	35.0
1979	33.5	34.0	35.0	34.5	34.5	35.0	34.0	35.0	34.5	34.5	33.0	33.0	35.0
1980	33.0	34.0	34.5	33.5	33.5	34.5	34.0	33.0	33.5	33.5	33.0	33.0	34.5
1981	32.5	34.0	33.5	34.0	34.0	33.5	34.5	34.0	33.0	33.5	33.5	33.6	34.5
1982	33.5	32.5	33.5	33.5	33.0	33.5	33.5	33.0	-	33.0	33.0	-	33.5
1983	-	-	-	-	-	-	-	-	-	-	-	-	-
1984	-	-	-	-	-	-	-	-	-	-	-	-	-
1985	-	-	-	-	-	-	-	-	-	-	-	-	-
1986	-	-	-	-	-	-	-	-	-	-	-	-	-
1987	-	-	-	-	-	-	-	-	-	-	-	-	-
1988	-	-	-	-	-	-	-	-	-	-	-	-	-
MAX.	34.5	35.0	35.0	35.5	36.0	36.0	35.5	35.5	35.5	35.0	33.5	35.0	36.0

Source ; Badan Meteorologi dan Geofisika (BMG)



Table A-6 ABSOLUTE MINIMUM TEMPERATURE AT SEI DADAP

YEAR	(Unit : degrees Centigrade)												MIN.
	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	
1966	-	-	-	-	-	-	-	-	-	-	-	-	-
1967	-	-	-	-	-	-	-	-	-	-	-	-	-
1968	-	-	-	-	-	-	-	-	-	-	-	-	-
1969	-	-	-	-	-	-	-	-	20.5	20.0	20.5	20.5	-
1970	20.0	18.5	19.5	20.5	20.5	19.5	19.0	19.0	19.5	20.5	20.0	18.6	18.6
1971	-	18.5	18.6	18.7	20.0	19.0	18.2	20.5	19.5	19.0	20.5	19.9	18.2
1972	16.8	17.0	19.4	21.0	20.5	21.4	20.2	20.4	-	21.5	22.2	21.5	16.8
1973	-	21.3	-	21.0	21.5	22.2	21.5	-	21.0	22.0	21.5	20.5	-
1974	-	-	-	-	-	-	-	-	20.0	-	21.5	20.5	-
1975	20.0	20.5	20.5	21.5	21.5	20.5	20.5	21.0	20.5	21.5	21.0	21.0	20.0
1976	19.0	19.5	20.0	21.0	20.0	19.0	-	16.5	20.5	21.5	20.5	21.0	16.5
1977	19.0	18.0	21.0	20.5	21.0	20.0	21.0	20.5	21.0	22.0	20.5	21.0	18.0
1978	20.5	19.0	21.5	21.5	21.5	21.5	20.5	21.5	21.0	20.5	20.5	20.5	19.0
1979	19.5	20.5	20.0	22.0	21.5	22.5	21.0	21.0	21.0	21.5	21.5	19.5	19.5
1980	20.0	20.5	21.5	22.0	21.5	22.0	20.5	21.0	22.0	21.5	21.5	21.5	20.0
1981	20.0	21.0	21.0	22.0	22.0	22.0	21.0	21.0	21.5	21.5	21.0	21.0	20.0
1982	19.0	20.0	20.0	21.5	22.0	13.5	22.0	-	-	-	-	-	-
1983	-	-	-	-	-	-	-	-	-	-	-	-	-
1984	-	-	-	-	-	-	-	-	-	-	-	-	-
1985	-	-	-	-	-	-	-	-	-	-	-	-	-
1986	-	-	-	-	-	-	-	-	-	-	-	-	-
1987	-	-	-	-	-	-	-	-	-	-	-	-	-
1988	-	-	-	-	-	-	-	-	-	-	-	-	-
MIN.	16.8	17.0	18.6	18.7	20.0	13.5	18.2	16.5	19.5	19.0	20.0	18.6	13.5

Source : Badan Meteorologi dan Geofisika (BMG)

Table A-7 RELATIVE HUMIDITY AT SEI DADAP

YEAR	(Unit : %)												AVE.
	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	
1966	-	86.9	89.5	88.5	85.4	88.8	91.5	90.6	87.7	89.6	90.2	89.7	-
1967	89.0	88.0	86.0	87.0	87.0	88.0	92.0	94.0	96.0	97.0	97.0	97.0	91.5
1968	97.0	97.0	96.0	97.0	97.0	84.0	93.0	94.0	97.0	94.0	97.0	91.0	94.5
1969	89.0	90.0	96.0	96.0	92.0	87.0	84.0	88.0	84.0	88.0	91.0	90.0	89.6
1970	91.0	87.0	90.0	85.0	89.0	88.0	88.0	90.0	93.0	92.0	93.0	91.0	89.8
1971	-	87.0	90.0	87.0	87.0	87.0	88.0	89.0	89.0	90.0	88.0	93.0	-
1972	94.0	90.0	89.0	94.0	92.0	88.0	85.0	89.0	88.0	87.0	90.0	91.0	89.8
1973	-	82.0	-	91.0	87.0	85.0	85.0	-	88.0	90.0	87.0	90.0	-
1974	-	-	-	-	-	-	-	-	87.0	-	90.0	88.0	-
1975	86.0	88.0	88.0	87.0	87.0	87.0	88.0	86.0	89.0	89.0	88.0	91.0	87.8
1976	89.0	87.0	87.0	89.0	89.0	88.0	-	88.0	90.0	92.0	92.0	89.0	-
1977	89.0	88.0	85.0	84.0	84.0	84.0	82.0	85.0	84.0	87.0	87.0	85.0	85.3
1978	84.0	84.0	85.0	84.0	85.0	87.0	88.0	86.0	87.0	86.0	88.0	87.0	85.9
1979	86.0	87.0	84.0	86.0	85.0	86.0	86.0	85.0	87.0	87.0	88.0	86.0	86.1
1980	86.0	86.0	87.0	87.0	85.0	86.0	82.0	86.0	87.0	87.0	87.0	88.0	86.2
1981	87.0	87.0	86.0	88.0	88.0	85.0	86.0	85.0	86.0	88.0	87.0	85.0	86.5
1982	87.0	88.0	88.0	87.0	89.0	86.0	86.0	89.0	86.0	89.0	86.0	87.0	87.3
1983	88.0	86.0	86.0	86.0	86.0	87.0	86.0	87.0	88.0	88.0	88.0	88.0	87.0
1984	90.0	88.0	88.0	88.0	88.0	88.0	88.0	88.0	88.0	88.0	90.0	90.0	88.5
1985	88.0	89.0	89.0	89.0	88.0	86.0	88.0	88.0	-	-	-	-	-
1986	-	-	-	-	-	-	-	-	-	-	-	-	-
1987	87.0	87.0	87.0	88.0	88.0	88.0	87.0	-	-	-	-	-	-
1988	90.0	87.0	87.0	87.0	87.0	88.0	87.0	90.0	-	-	-	-	-
AVE.	88.7	87.6	88.2	88.4	87.9	86.8	87.0	88.3	88.5	89.4	89.7	89.3	88.3
MAX.	97.0	97.0	96.0	97.0	97.0	88.8	93.0	94.0	97.0	97.0	97.0	97.0	94.5
MIN.	84.0	82.0	84.0	84.0	84.0	84.0	82.0	85.0	84.0	86.0	86.0	85.0	85.3

Source : Badan Meteorologi dan Geofisika (BMG)

Table A-8 WIND VELOCITY AT SEI DADAP

													(Unit ; m/sec)
YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	AVE
1979	-	-	-	-	0.36	0.43	0.36	0.31	0.47	0.24	0.22	0.21	-
1980	-	0.23	0.30	0.31	0.35	0.30	0.34	0.27	0.31	0.26	0.24	0.23	-
1981	0.27	0.30	0.31	0.27	0.26	0.30	0.29	0.30	0.28	0.24	0.19	0.25	0.27
1982	0.25	0.28	0.25	0.27	0.25	0.32	0.36	0.30	0.25	0.24	0.27	0.19	0.27
1983	0.22	0.25	0.26	0.27	0.25	0.30	0.33	0.29	0.29	0.23	0.24	0.21	0.26
1984	0.18	0.27	0.25	0.24	0.20	0.10	0.06	0.02	0.09	0.09	0.08	0.15	0.14
1985	0.18	0.25	0.26	0.23	0.23	0.23	0.24	0.26	-	-	-	-	-
1986	-	-	-	-	-	-	-	-	-	-	-	-	-
1987	0.16	0.22	0.26	0.17	0.17	0.19	0.17	-	-	-	-	-	-
1988	0.05	0.09	0.07	0.11	0.09	0.08	0.10	0.06	-	-	-	-	-
AVE.	0.19	0.24	0.25	0.23	0.24	0.25	0.25	0.23	0.28	0.22	0.21	0.21	0.23
MAX.	0.27	0.30	0.31	0.31	0.36	0.43	0.36	0.31	0.47	0.26	0.27	0.25	0.27
MIN.	0.05	0.09	0.07	0.11	0.09	0.08	0.10	0.02	0.09	0.09	0.08	0.15	0.14

Source ; Badan Meteorologi dan Geofisika (BMG)

Table A-9 EVAPORATION AT SEI DADAP

													(Unit ; mm)
YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
1979	-	-	-	-	118.0	96.0	74.0	109.0	84.0	84.0	69.0	99.0	-
1980	-	103.0	108.0	109.0	104.0	114.0	136.0	106.0	120.0	113.0	98.0	113.0	-
1981	102.0	115.0	115.0	114.0	118.0	123.0	130.0	136.0	111.0	105.0	93.0	93.0	1138.0
1982	99.0	95.0	105.0	114.0	109.0	114.0	124.0	115.0	114.0	112.0	102.0	96.0	1105.0
1983	99.0	104.0	124.0	120.0	118.0	114.0	121.0	121.0	105.0	127.0	105.0	84.0	1139.0
1984	77.9	83.9	121.3	115.8	98.4	88.7	81.5	98.3	101.9	91.9	60.6	66.5	924.9
1985	100.5	106.1	103.2	109.3	108.4	129.1	117.8	129.2	-	-	-	-	-
1986	-	-	-	-	-	-	-	-	-	-	-	-	-
1987	85.9	128.1	118.3	107.7	107.7	112.0	121.6	-	-	-	-	-	-
1988	90.2	103.3	97.5	110.2	125.6	83.5	105.9	103.6	-	-	-	-	-
AVE.	93.5	104.8	111.5	112.5	111.9	108.3	112.4	114.8	106.0	105.5	87.9	91.9	1062.7
MAX.	102.0	128.1	124.0	120.0	125.6	129.1	136.0	136.0	120.0	127.0	105.0	113.0	1139.0
MIN.	77.9	83.9	97.5	107.7	98.4	83.5	74.0	98.3	84.0	84.0	60.6	66.5	1086.7

Source ; Badan Meteorologi dan Geofisika (BMG)

Table A-10 SUNSHINE DURATION AT AEK LOBA

(Unit ; %)

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
1977	67	59	72	66	68	61	68	61	62	47	56	62	749
1978	68	72	53	63	69	51	61	65	63	55	-	64	-
1979	69	69	66	66	77	66	59	72	68	53	51	67	783
1980	69	66	67	57	70	61	65	60	69	-	42	40	-
1981	68	70	50	60	65	58	68	80	69	52	48	50	738
1982	63	72	23	46	60	66	63	59	55	47	52	52	658
1983	50	72	59	45	57	67	63	56	25	39	57	34	624
1984	44	44	35	32	17	34	31	41	35	44	23	31	411
1985	56	49	44	35	24	60	66	53	30	53	40	46	556
1986	42	69	47	65	63	73	70	57	51	43	63	54	697
1987	47	87	75	66	50	47	68	62	47	51	36	48	684
1988	47	53	57	49	73	70	63	53	52	48	45	54	664
AVE.	57.5	65.2	54.0	54.2	57.8	59.5	62.1	59.9	52.2	59.1	57.0	50.2	689
MAX.	69	87	75	66	77	73	70	80	69	55	63	67	783
MIN.	42	44	23	32	17	34	31	41	25	39	23	31	411

Source ; Badan Meteorologi dan Geofisika (BMG)

Table A-11 MONTHLY RAINFALL AT SEI DADAP

YEAR	(Unit : mm)												ANNUAL
	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	
1968	17.0	17.8	16.8	18.2	22.3	38.7	35.3	29.7	51.4	34.7	31.7	24.7	28.2
1969	25.5	18.1	11.4	10.9	15.5	12.2	14.0	14.4	19.6	28.9	60.1	44.0	22.9
1970	28.7	13.9	16.2	21.6	15.6	21.8	21.8	21.9	33.7	34.6	41.9	28.7	25.1
1971	18.2	24.8	32.7	15.0	13.4	17.2	10.9	16.0	25.0	15.4	11.1	21.3	18.4
1972	11.5	9.1	6.5	5.7	6.0	5.0	3.6	3.8	10.8	12.9	18.7	12.1	8.8
1973	19.8	14.1	20.9	29.3	19.3	22.6	12.0	18.8	26.2	28.3	23.8	69.3	25.5
1974	28.2	28.6	19.8	21.7	19.3	18.0	17.2	15.8	20.1	23.4	29.2	26.0	22.2
1975	25.1	22.0	20.9	34.7	28.7	18.3	17.4	13.7	28.4	28.8	32.6	30.5	25.1
1976	28.7	22.5	16.8	26.7	21.3	20.4	19.3	19.3	19.1	26.4	35.5	28.7	23.7
1977	20.2	16.4	14.2	14.3	15.7	15.5	9.5	13.0	17.7	43.0	32.6	27.9	20.0
1978	15.9	17.0	14.2	13.8	16.0	19.3	15.5	8.5	15.4	21.3	21.0	23.5	16.8
1979	16.8	13.5	11.5	20.1	13.9	19.6	13.1	9.9	16.8	20.4	33.3	22.0	17.5
1980	16.6	13.7	25.3	15.9	23.8	13.2	10.4	25.2	17.0	20.5	32.0	22.7	19.7
1981	24.3	19.0	12.6	16.3	29.2	14.7	14.4	9.4	26.7	27.9	24.7	15.3	19.5
1982	15.5	19.0	23.2	31.5	34.0	14.2	13.6	15.2	17.6	22.0	20.4	18.1	20.4
1983	14.3	10.1	11.9	7.4	14.3	12.5	14.6	13.3	24.9	30.4	15.6	28.4	16.5
1984	37.7	38.0	32.2	27.8	46.6	25.1	19.5	19.5	21.4	28.0	30.8	33.3	30.0
1985	24.6	18.1	23.2	22.2	26.3	11.4	15.9	14.4	23.3	36.4	43.2	41.8	25.1
1986	35.5	32.5	24.5	37.9	16.2	19.9	11.6	9.0	13.1	36.5	28.3	31.7	24.6
1987	15.4	10.9	24.7	24.0	22.6	13.8	14.3	25.3	23.9	41.7	33.5	29.8	23.4
1988	27.0	35.1	28.5	16.1	19.7	24.4	23.7	20.0	39.5	19.5	30.2	34.0	26.4
Total	439.4	379.1	379.5	414.8	420.0	353.3	304.1	316.0	452.1	561.5	600.0	579.7	433.5
Ave.	20.9	18.1	18.1	19.8	20.0	16.8	14.5	15.0	21.5	26.7	28.6	27.6	20.6

Table A-12 MONTHLY RAINFALL AT AEK LOBA

YEAR	(Unit : mm)												ANNUAL
	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	
1977	54.0	171.0	57.0	89.0	136.0	170.0	108.0	362.0	245.0	256.0	185.0	144.0	1977.0
1978	97.0	55.0	136.6	216.3	146.9	198.4	212.0	190.0	241.1	-	-	-	-
1979	-	-	-	-	70.0	318.0	138.0	186.0	112.0	268.0	372.0	78.0	-
1980	105.6	81.0	133.0	132.1	266.2	226.6	244.4	349.2	205.4	571.8	183.4	-	-
1981	246.5	79.7	39.0	112.0	408.0	230.2	341.0	121.0	482.0	248.0	285.0	110.0	2702.4
1982	122.0	55.0	240.9	82.0	107.0	96.0	187.7	127.9	200.0	240.0	109.0	88.0	1655.5
1983	78.0	22.0	13.0	60.0	155.0	301.0	216.0	191.0	357.0	283.0	201.3	-	-
1984	-	-	-	-	-	-	-	-	-	339.0	88.0	244.9	-
1985	100.2	82.0	196.4	114.0	200.0	37.0	205.0	193.5	166.3	330.3	267.4	346.7	2238.8
1986	143.2	118.1	199.0	165.7	177.0	280.5	327.8	166.0	224.7	432.4	314.8	158.4	2707.6
1987	268.4	0.0	266.5	-	-	-	-	120.5	416.8	383.8	460.1	-	-
1988	229.3	251.2	297.7	35.8	205.9	412.5	240.0	198.5	344.7	213.8	295.8	345.1	3070.3
AVE.	144.4	91.5	157.9	111.9	187.2	227.0	222.0	200.5	272.3	324.2	251.1	189.4	2379.4
MAX.	268.4	251.2	297.7	216.3	408.0	412.5	341.0	362.0	482.0	571.8	460.1	346.7	3070.3
MIN.	54.0	0.0	13.0	35.8	70.0	37.0	108.0	120.5	112.0	213.8	88.0	78.0	1655.5

Source ; Badan Meteorologi dan Geofisika (BMG)



Table A-13 AVERAGE MONTHLY RAINFALL AND MAXIMUM DAILY RAINFALL

Code of Station	(Unit : mm)												Max. Daily Rainfall	
	Jan.	Feb.	Mar.	Apr.	May.	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.		Annual
5.04	98.8	82.2	86.4	92.0	124.0	106.3	120.0	130.2	197.7	241.9	178.8	139.7	1,596.0	May. 14 1956 109.0
5.15	78.1	79.0	77.8	97.8	99.4	90.9	107.8	141.8	196.6	230.3	177.5	144.3	1,520.8	Dec. 10 1978 144.0
6.01	144.4	91.5	157.9	111.9	187.2	227.0	222.0	200.5	272.3	324.3	251.1	189.4	2,379.4	Feb. 4 1976 380.0
6.02	205.6	167.6	206.4	239.5	287.2	252.4	250.8	298.7	350.7	380.7	343.9	301.9	3,285.4	Aug. 22 1976 408.0
6.04/145 D	157.7	130.6	188.3	182.8	260.3	223.8	207.9	252.6	324.4	381.4	334.1	248.7	2,890.6	
6.06	113.4	102.5	106.2	127.1	135.4	127.9	153.9	186.6	256.4	271.6	195.8	171.7	1,948.5	Sep. 6 1972 113.0
6.07	150.7	108.8	154.4	164.2	223.4	190.2	191.8	243.5	288.1	381.0	294.4	240.8	2,631.3	Jan. 26 1957 166.0
6.08	125.2	109.2	128.6	175.8	159.3	127.8	156.5	181.5	249.5	245.2	222.2	163.7	2,044.5	
6.09/146 B	102.0	86.6	96.1	189.8	146.8	137.4	141.5	185.9	286.2	326.2	230.8	188.7	2,118.1	Oct. 1 1977 169.0
6.10/147	96.9	80.5	76.4	96.8	123.1	108.1	146.6	154.6	221.0	241.2	181.4	162.3	1,698.7	Nov. 21 1977 130.0
6.11	151.5	123.6	146.0	198.6	208.2	153.8	202.8	226.6	273.1	301.0	258.2	211.2	2,454.6	May. 20 1966 250.0
6.12	92.1	96.7	86.1	120.6	143.4	122.6	131.8	149.5	234.5	255.7	194.4	168.7	1,796.1	Sep. 28 1976 143.0
6.14	121.1	119.6	120.1	146.8	209.2	177.2	183.8	194.6	276.6	345.9	231.8	194.8	2,321.5	May. 23 1969 126.0
6.15	126.4	98.6	130.7	149.7	182.0	139.4	178.1	208.1	269.1	326.5	232.8	194.0	2,235.4	Oct. 4 1954 240.0
6.16	127.7	96.4	170.4	172.1	186.1	171.0	188.8	243.6	270.1	359.2	245.4	203.7	2,434.5	
6.18	78.3	74.8	77.0	76.1	110.3	108.9	128.1	137.3	211.5	228.2	163.8	142.2	1,536.5	Aug. 25 1969 200.0
6.19/145 B	102.2	78.4	99.0	105.6	130.9	118.9	143.0	150.5	230.3	241.8	164.1	137.4	1,702.1	Oct. 3 1977 169.0
6.21/145 B	129.0	112.9	126.1	164.9	173.9	158.9	163.5	204.9	255.9	311.2	236.1	179.5	2,218.8	Sep. 21 1987 155.0
6.23	133.5	75.8	58.6	115.1	132.2	73.2	81.9	129.1	181.1	186.2	153.5	123.2	1,443.4	Oct. 30 1963 144.0
6.24	128.5	90.2	97.8	131.1	153.2	101.3	147.8	190.0	254.8	279.9	236.0	163.8	1,974.4	Jan. 23 1976 135.0
6.26	112.4	71.0	96.0	134.4	162.2	140.0	130.3	163.0	243.9	275.7	187.4	148.3	1,864.6	May. 11 1974 360.0
6.27	114.5	107.3	92.1	161.4	162.2	126.6	131.4	150.2	234.0	246.9	163.4	180.5	1,805.8	Sep. 27 1976 140.0
6.28	92.9	100.0	85.6	108.6	111.6	151.3	160.4	190.8	237.5	232.5	179.0	194.7	1,845.9	Jul. 16 1970 150.0
7.03	202.5	160.6	203.8	210.0	239.9	166.8	187.1	196.6	295.4	320.5	292.6	265.3	2,751.1	Apr. 6 1981 189.0
7.07	215.8	140.9	264.6	246.6	264.1	215.7	227.6	255.9	296.2	363.8	385.6	335.7	3,212.5	
7.08	184.5	100.9	180.3	151.7	219.5	181.8	186.3	238.4	316.5	363.8	320.3	268.8	2,732.8	
7.09	168.8	140.9	155.2	175.0	247.1	205.0	192.9	243.0	335.9	339.0	296.0	245.2	2,744.0	Aug. 6 1957 240.0
7.10	162.0	113.4	164.1	165.0	208.3	182.1	200.7	228.2	339.4	336.8	294.5	238.0	2,630.5	Sep. 5 1982 288.0
7.11	155.5	145.7	183.1	189.6	236.7	264.1	208.1	250.5	319.4	325.9	318.2	230.5	2,847.3	Aug. 5 1957 128.0
7.13/149 B	174.2	145.3	161.0	187.4	263.0	210.5	196.4	267.9	335.4	352	342.0	238.5	2,873.6	Nov. 16 1980 281.0
7.17	160.7	95.9	132.5	139.5	207.0	163.0	169.9	202.8	267.2	314.5	302.0	226.9	2,381.9	Oct. 30 1969 210.0
7.27	146.1	95.1	160.5	141.0	235.4	190.7	177.5	237.1	284.8	325.4	261.4	180.8	2,435.8	Jan. 23 1986 180.0
8.14	78.3	95.3	96.7	141.1	111.1	124.8	128.8	158.7	249.6	217.3	205.9	174.4	1,782.0	Sep. 16 1986 125.0
8.19	106.4	37.6	96.1	132.4	156.8	147.7	146.4	200.2	236.8	268.9	197.3	152.7	1,929.3	Oct. 23 1981 107.0
8.27	78.7	85.3	94.6	107.3	102.5	118.7	117.7	156.3	224.1	241.6	191.1	154.5	1,690.4	
10.12	119.6	100.5	145.6	135.5	133.0	98.8	82.2	106.4	159.9	183.0	186.5	212.6	1,661.6	May. 23 1974 112.0
10.13	176.5	190.9	246.2	180.0	202.6	126.5	112.2	173.4	235.9	241.1	255.5	322.6	2,463.4	Dec. 8 1965 280.0
10.14	260.1	272.2	338.1	306.0	303.8	208.2	184.6	222.6	328.4	417.3	363.1	403.3	3,607.7	May 21 1969 154.0
84 C	166.2	178.7	238.4	238.8	151.6	99.0	94.6	112.6	181.3	218.3	209.6	233.1	2,114.5	Apr. 14 1974 109.0
87	80.1	105.4	144.8	111.0	81.6	62.8	68.2	69.2	96.4	147.5	141.9	168.7	1,277.6	
87 B	73.8	73.7	119.2	138.2	85.3	51.3	60.2	80.5	134.7	118.1	131.6	124.0	1,190.6	Apr. 8 1982 500.0
90	91.8	153.8	235.9	264.6	133.1	106.3	89.4	73.8	168.2	167.1	205.2	169.5	1,798.7	Nov. 26 1972 124.0
143 A	141.3	127.3	181.3	220.2	207.1	91.8	123.1	115.1	158.0	247.7	231.8	208.1	2,052.8	Nov. 15 1987 213.0
143 C	178.0	193.0	181.5	221.1	273.2	223.3	232.6	286.0	374.8	422.5	317.2	253.7	3,096.9	Feb. 3 1966 295.0
144 D	199.8	148.3	156.4	202.8	271.9	204.2	199.7	226.7	328.6	367.0	266.6	225.3	2,797.3	Jan. 24 1957 177.0
144 I	272.2	213.3	304.5	367.0	367.0	249.4	230.6	323.5	431.2	447.8	354.5	334.7	3,895.7	Aug. 31 1974 208.0
145	134.9	120.8	98.2	175.4	121.1	146.3	181.8	229.9	299.0	342.5	228.4	220.9	2,290.2	Oct. 13 1978 247.0

Source : Badan Meteorologi dan Geofisika (BMG), Reserch Institute of Sumatra Planters' Association (RUSPA)  
Departemen Pekerjaan Umum (DPU)

Table A-14 CORRELATION COEFFICIENT OF MONTHLY RAINFALL

STATION CODE NO.	7.09	7.03	6.02	5.15	6.07	143A	144D	6.26	6.21	10.13
7.09										
7.03	0.53									
6.02	0.50	0.56								
5.15	0.59	0.36	0.45							
6.07	0.73	0.52	0.52	0.57						
143A	0.31	0.37	0.28	0.30	0.34					
144D	0.59	0.41	0.37	0.41	0.59	0.70				
6.26	0.59	0.42	0.33	0.62	0.60	0.41	0.54			
6.21	0.51	0.39	0.51	0.56	0.59	0.23	0.45	0.51		
10.13	0.34	0.25	0.46	0.14	0.35	-	0.22	0.25	0.21	

Note:

- 1) Locations of the stations are presented in Fig. A-5.
- 2) The above 10 stations are selected among 80 stations taking into account the observation period and locations.
- 3) Correlation between selected stations are very low of less than 0.6

Table A-15 PROBABLE MAXIMUM DAILY RAINFALL OF RIVER BASIN

( Unit : mm/day )

Return Period (Station)	Silau-Bunut River Basin (Teluk Manto)	Asahan River Basin (Aek Loba Empt)	Kualuh River Basin (Labuhan Haji)
1/2	89	106	112
1/5	151	175	159
1/10	193	221	190
1/20	232	265	220
1/30	255	290	237
1/50	283	322	258
1/100	322	363	287

Note:

- 1) Values presented above are the maximum probable daily rainfall among the selected stations located in each river basin. Probable rainfall of the selected stations are presented in Table A-16.
- 2) Gumbel method is applied for the estimate of the probable rainfall.



Table A-16 PROBABLE DAILY RAINFALL  
(EXCEEDANCE PROBABILITY)

(Unit : mm)

Return Period	Bunut, Silau River Basin				Asahan River Basin			Kualuh River Basin		
	6.22	6.19	6.24	6.26	6.01	7.03	7.09	7.10	7.13	7.17
2	84	88	85	89	106	101	100	112	110	105
5	106	112	102	151	175	131	133	159	148	141
10	121	128	114	193	221	151	155	190	174	165
20	135	143	125	232	290	170	176	220	198	188
30	143	152	131	255	290	182	188	237	212	201
50	154	163	139	283	322	195	203	258	230	217
100	167	178	150	322	363	214	223	287	253	239

Note: 1)

Code	Station Name
6.22:	Serbangan
6.19:	Sei Dadap
6.24:	Teluk Dolam
6.26:	Teluk Manto
6.01:	Aek Lobà
7.03:	Aek Pamlengke
7.09:	Kanopan Ulu
7.10:	Labuhan Haji
7.13:	Mcmbang Muda
7.17:	Padang Malabah

2) Locations of the rainfall stations are presented in Fig. A-1.

Table A-17 PROBABLE MONTHLY RAINFALL  
(NON-EXCEEDANCE PROBABILITY)

(Return Period 1/5) (Unit : mm)

Code	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
5.04	56	48	38	51	67	70	56	85	136	151	92	87	1,354
6.01	76	29	61	77	131	133	106	123	186	198	139	93	1,971
6.04/145D	73	52	112	104	165	127	141	141	211	279	209	132	2,342
6.07	70	39	65	82	145	116	133	146	206	267	202	141	2,260
6.16/146C	71	48	99	86	144	63	184	128	181	278	169	104	2,134
6.18	32	28	30	34	45	53	44	72	124	122	76	58	1,167
6.19	46	36	55	43	74	61	77	82	138	143	87	60	1,547
6.22	42	34	51	53	69	68	90	96	129	202	106	113	1,574
7.03	115	73	103	101	150	101	118	112	185	231	199	165	2,258
7.09	67	59	90	89	178	134	110	151	229	250	186	151	2,377
7.10	70	62	95	82	133	108	125	135	217	218	172	133	2,219
7.13/149E	81	70	72	111	161	130	132	168	250	245	213	140	2,503
Ave.	67	48	73	76	122	97	110	120	183	215	154	115	1,976

(Return Period 1/10) (Unit : mm)

Code	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
5.04	35	30	27	37	42	47	32	58	106	132	58	70	1,280
6.01	45	17	19	50	115	92	74	93	144	150	87	73	1,669
6.04/145D	48	33	75	64	121	88	110	104	167	244	141	100	2,122
6.07	43	11	35	51	111	88	97	110	179	236	154	99	2,041
6.16/146C	36	22	49	57	128	41	162	105	158	239	150	77	2,010
6.18	15	17	17	18	26	30	21	46	98	87	39	36	977
6.19	30	21	37	23	49	41	51	63	105	100	68	35	1,415
6.22	22	14	29	38	49	46	70	69	94	173	82	95	1,500
7.03	82	49	71	65	105	83	103	85	151	176	151	129	2,060
7.09	41	34	63	54	145	99	89	126	200	206	126	111	2,167
7.10	41	36	58	43	103	79	86	114	191	188	116	91	2,107
7.13/149E	47	46	49	71	118	101	93	127	213	209	148	104	2,254
Ave.	40	28	44	48	93	70	82	92	151	178	110	85	1,800

Fig. A-2 (1/3) DAILY RAINFALL RECORDS

Code	Station	Source	Type	Coordinates
				19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53 54 55 56 57 58 59 60 61 62 63 64 65 66 67 68 69 70 71 72 73 74 75 76 77 78 79 80 81 82 83 84 85 86 87 88 89
69	Hareng Gotal	DPU	N	2-53N, 99-40E
			A	
	Bahai Gajah	PMG	N	2-52N, 99-57E
143M	Gorbus	PMG	N	2-48N, 98-49E
			A	
90	Pangunuran	PMG	N	2-37N, 98-42E
90A	Ambarella	PMG	N	2-40N, 98-50E
90D	Parmanganan	PMG	N	2-38N, 98-38E
90B	Palipi	PMG	N	2-29N, 98-49E
			A	
86A	Delaikanggul	PMG	N	2-15N, 99-45E
84B	Parmanganan	PMG	A	2-06N, 98-46E
84C	Hutaraja	PMG	N	2-15N, 99-48E
			A	
143A	Parappi	PMG	N	2-40N, 98-56E
87B	Runggahuhis	PMG	N	2-35N, 98-49E
84B	Oran Flunggu	PMG	N	2-27N, 98-59E
84C	Pitu-Pitu	PMG	N	2-16N, 99-00E
			A	
	Aek Nalob	PMG	N	2-36N, 98-07E
143A	Lumban Pao	PMG	N	2-35N, 99-03E
141	Kashdar	PMG	N	2-31N, 99-03E
87B	Parasa	PMG	N	2-28N, 98-07E
		DPU	A	2-27N, 99-10E
87	Balige	PMG	N	2-21N, 99-07E
86C	Sibarad	PMG	N	2-30N, 99-08E
			A	
1012	Parparesan	RISPA	N	2-27N, 99-09E
1013	Simangpak	RISPA	A	2-29N, 99-12E
1014	Pitu Pahan	RISPA	N	2-31N, 99-16E
	INALUM No. 1	INALUM	A	2-31N, 99-16E
	INALUM No. 2	INALUM	A	2-28N, 99-17E
	INALUM No. 3	INALUM	A	2-30N, 99-13E
	INALUM No. 4	INALUM	A	2-30N, 99-15E

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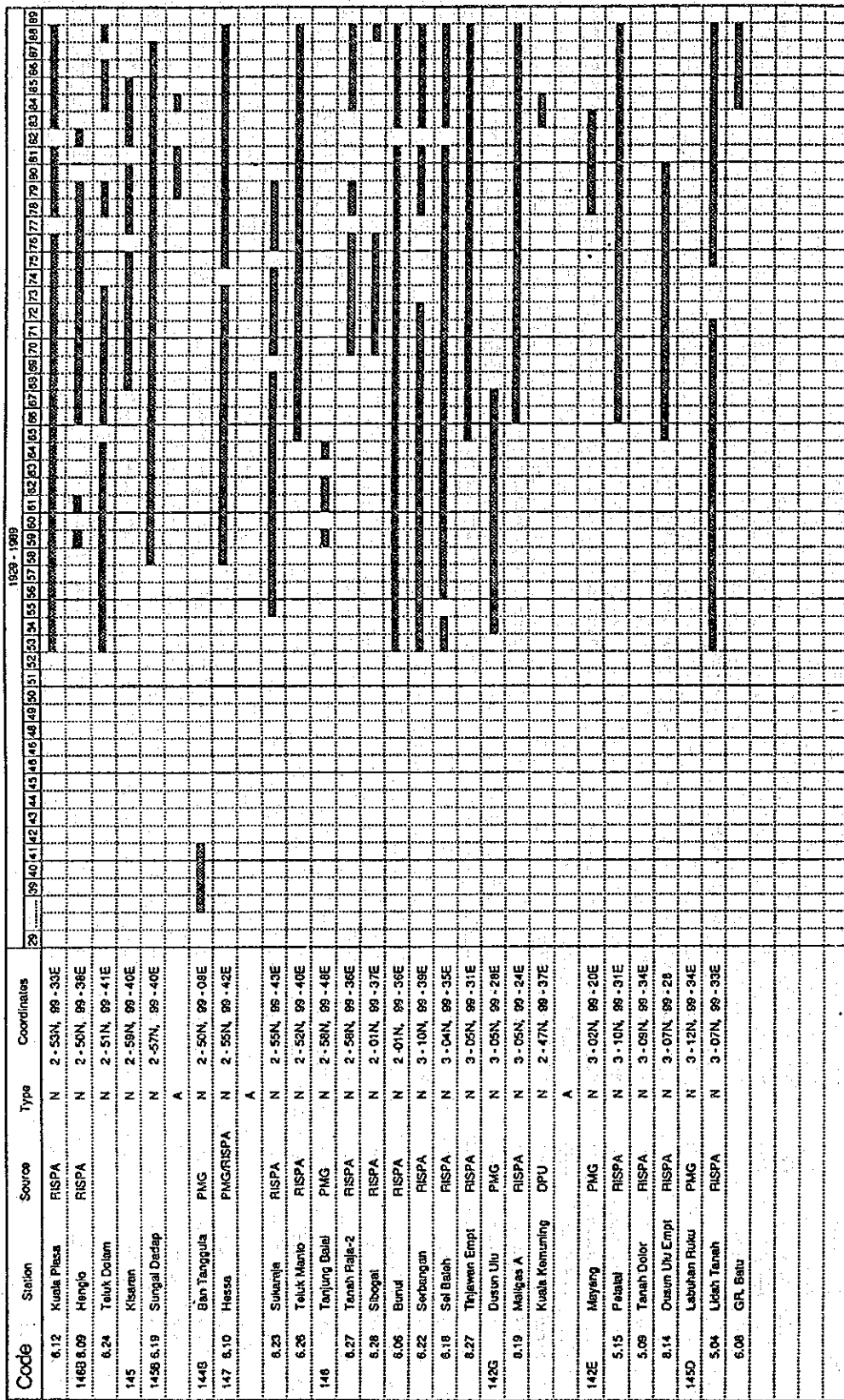
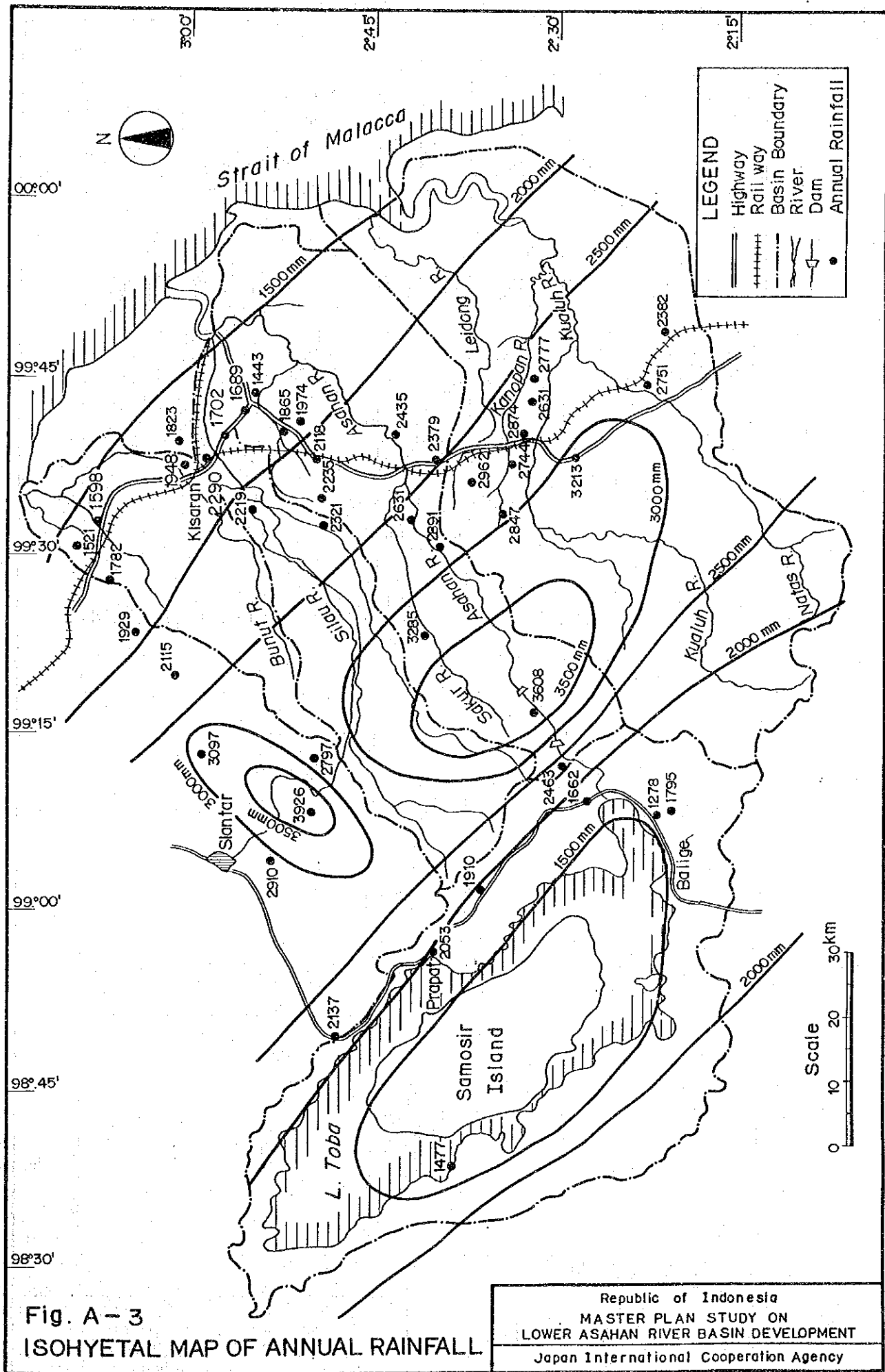


Fig. A-2 (3/3)

DAILY RAINFALL RECORDS

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**Fig. A-3**  
**ISOHYETAL MAP OF ANNUAL RAINFALL**

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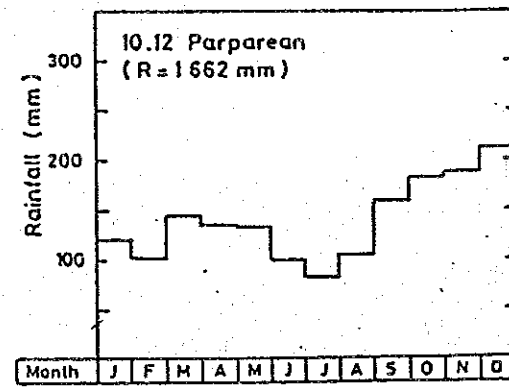
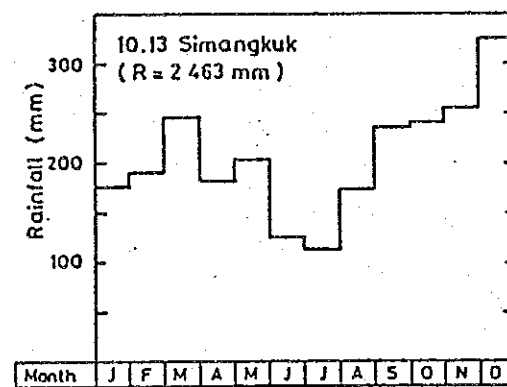
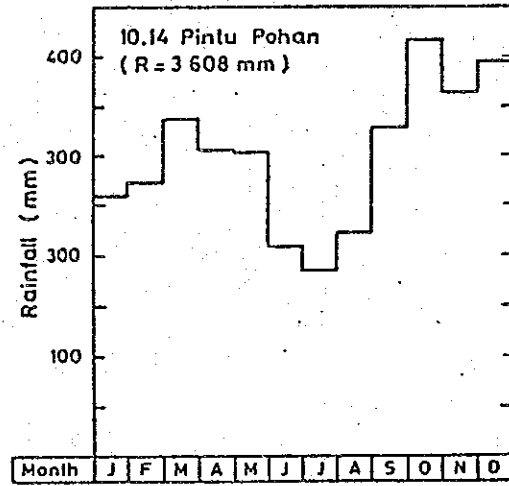
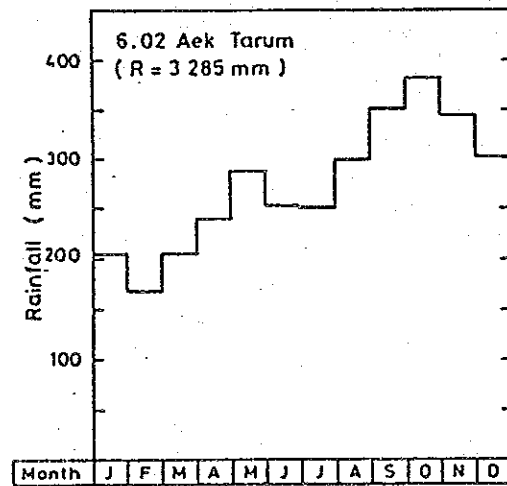
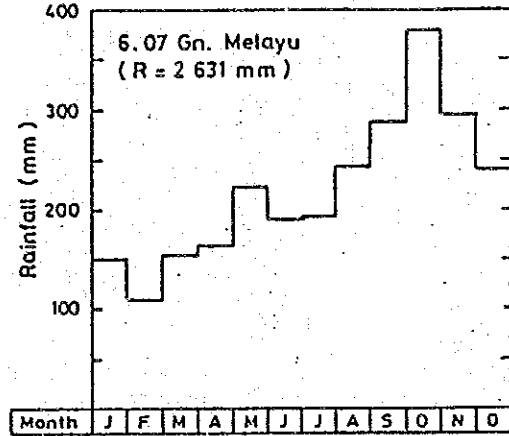
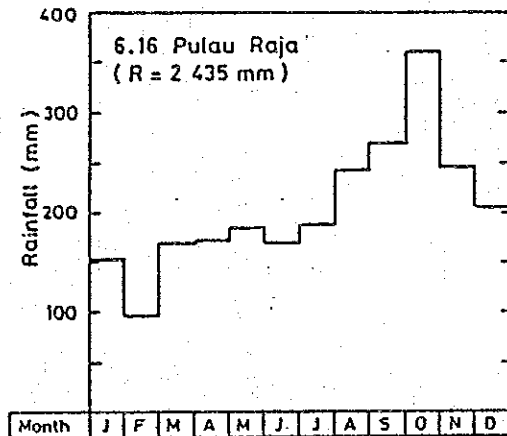
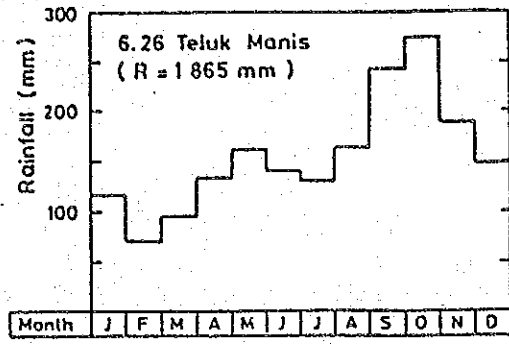
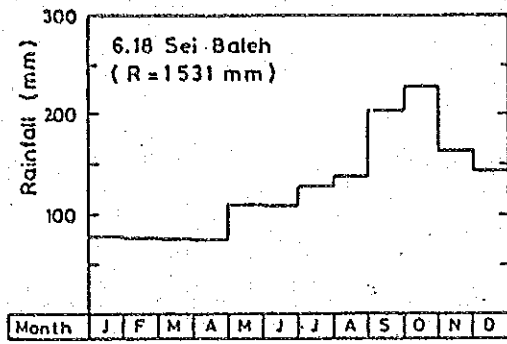


Fig. A-4  
TYPICAL ANNUAL RAINFALL PATTERN

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Table A-18 MAIN FEATURES OF RIVER BASIN AND CHANNEL

Item	Unit	Silau	Asahan	Kualuh	Bunut
1. Catchment area at river mouth	(sq.km)	1,183 (conf. with Asahan)	6,863	3,820	621 (conf. with Kiri)
2. River length	(km)	124	152	198	59
3. Elevation of upper basin	(EL.m)	1,100	1,450 (900 m at lake Toba)	1,600	300
4. Average basin slope		1/113	1/170	1/120	1/195
5. Elevation of river bed at 50 km point from river mouth and its slope	(EL.m)	22.5 1/1,550	2.6 1/5,810	-4.8 1/29,000	13.6 (37 km point) 1/2,230
6. Meandering of river course		Small	Remarkable	Remarkable	Small
7. Topography and geology					
- Mountain area		Tertiary volcanic rocks	do. as left	do. as left	do. as left
- Hilly area		Laterite underlain by soft white turf	do. as left	do. as left	do. as left
- Alluvial plain		Fine silty soils	do. as left	do. as left	do. as left
- Coastal sand bar		Alluvial terrace deposit	do. as left	do. as left	do. as left
8. Land use					
- Mountain area		Forest	do. as left	do. as left	do. as left
- Hilly area		Plantation of palm oil and rubber	do. as left	do. as left	do. as left
- Alluvial plain		Paddy field, bush, swamps	do. as left	do. as left	do. as left
9. Mean annual rainfall	(mm)	2,800	1,900-2,000	2,500-2,600	2,300
10. Mean annual daily discharge	(cum)	See Table A-19	do. as left	do. as left	do. as left
11. Length as tidal reach	(km)	5	37	65	18
12. Length of saltwater intrusion	(km)	0	6.5	35	10



Table A-19 HYDROLOGICAL CHARACTERISTICS OF RIVERS

River	Gauge Station	Catchment Area (km <sup>2</sup> )	Average Annual Mean Discharge (m <sup>3</sup> /s/100 km <sup>2</sup> )	Average Annual Basin Rainfall (mm)	Runoff Rate	Observation Period
Asahan	Pulau Raja	4,486	3.40	1,900 - 2,000	0.55	1977-1988
Silau	Kisaran	1,050	6.21	2,800	0.70	1973-1989
Piasa	T. Raja	317	8.54	3,100	0.87	1985-1988
Kualuh	Pulo Dogom	1,116	5.41	2,500 - 2,600	0.67	1979-1989
Kanopan	Pemudilan	206	1.68	2,800	0.19	1985-1988
Natas	Bandar Durian	530	5.49	2,400 - 2,500	0.71	1984-1989

Note:

- 1) Average annual mean rainfall is estimated by using isohyetal map of mean annual-total precipitation.
- 2) Monthly mean discharges at Pulau Raja in the Asahan river, Kisaran in the Silau river, Tinggi Raja in the Piasa river, Pemudilan in the Kanopan river and Bandar Durian in the Natas river are shown in Tables A-20 to A-25.
- 3) According to the seasonal distribution of monthly mean discharge and annual runoff rate, streamflow characteristics of the rivers are enumerated as follows;
  - (i) A period of water shortage occurs in June, July and August. The most droughty discharge appears in August.
  - (ii) September through January and May can be categorized as flood season..
  - (iii) Average annual runoff rate of every river except the Kanopan river are estimated on the ranges from 0.67 to 0.87.
  - (iv) As to the Kanopan river, low runoff rate of 0.19 was obtained. This reason seems to be that since water gauging station is located in the upper swamp area, observed runoff from the swamp area is quite low. Based on the results of runoff rate in the Kanopan river, it is assumed that runoff rate in the swamp area is about 0.2.

Table A-20 MONTHLY MEAN DISCHARGE AT PULAU RAJA

Unit: m<sup>3</sup>/sec  
Catchment Area : 4,486 km<sup>2</sup>

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
1977				136.2	149.7	142.1	122.9	118.8	110.8	167.9	188.8	207.0	
1978	161.1	157.6	147.6	146.4	151.4	144.7	119.3	88.5	97.9	118.2	130.7	147.6	134.3
1979	117.5	100.1	90.4	113.9	97.0	127.0	91.4	78.8	100.5	122.4	180.5	179.4	116.6
1980	154.4	144.9	187.5	161.6	193.5	157.0	130.8	160.3	135.6	149.1	198.5	164.2	161.5
1981	188.6									144.0	192.9	107.5	
1982	88.0	91.5	105.7	235.0	337.1	190.7	107.4	96.6	142.0	147.0	168.9	161.3	155.9
1983	148.6	106.0	88.3	75.2	86.5	93.6	113.4	102.1	135.9	138.6	117.6	160.2	113.8
1984	226.8	322.9	223.2	267.3	305.2	198.1	152.8	141.4	146.5	168.3	159.4	175.2	207.3
1985	160.1	142.7	165.7	154.1	171.7	137.8	142.9	140.0	153.5	167.2	219.2	213.6	164.0
1986	193.6	174.4	169.2	194.5	143.4	148.0	131.4	126.3	145.0	186.1	194.6	195.6	166.8
1987	149.3	145.5	147.0	148.4	162.2	128.4	130.7	133.8	139.3	171.4	190.7	189.5	153.0
1988	144.2	164.9	140.2	131.0	134.4	122.1	129.3					165.1	
AVE.	157.5	155.1	146.5	160.3	175.6	144.5	124.8	118.7	130.7	152.7	176.5	172.2	152.6
per 100 km <sup>2</sup>	3.51	3.46	3.27	3.57	3.92	3.22	2.78	2.65	2.91	3.40	3.94	3.84	3.40

Table A-21 MONTHLY MEAN DISCHARGE AT KISARAN NAGA

Unit: m<sup>3</sup>/sec  
Catchment Area : 1,050 km<sup>2</sup>

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
1973	59.4	45.2	62.3	84.7	58.2	67.2	39.1	56.9	76.5	81.8	70.3	189.8	74.3
1974	81.5	83.5	59.6	64.6	58.3	55.0	52.7		60.6	71.2	84.6	75.9	
1975	73.3	66.2	62.3	99.0	82.9	55.8	53.1	43.5	82.3	83.1	93.4	87.7	73.6
1976	82.9	72.0	51.5	77.9	63.4	61.2	58.3	58.1	57.9	77.0	100.9	82.9	70.3
1977	60.5	51.2	44.7	45.3	48.8	48.3	32.5	41.5	54.3	120.6	93.4	80.8	60.2
1978	49.2	53.0	44.7	44.0	49.4	58.3	48.2	29.9	48.1	63.3	62.8	69.2	51.7
1979	51.6	43.7	37.6	60.4	44.0	59.2	41.8	33.4	51.9	61.1	95.3	65.2	53.8
1980	51.1		76.5	49.4	70.0	42.2	34.8	73.8	52.3	61.4	91.8	67.1	
1981	71.5	58.2	40.6	50.5	84.3	46.4	45.3	32.0	78.0	80.7	72.6	47.6	59.0
1982	48.2	58.2	68.4	90.6	96.8	45.1	43.1	47.5	54.0	65.2	61.2	54.9	61.1
1983	45.1	34.7	38.7	27.0	44.9	40.6	45.8	42.3	73.0	87.4	48.8	82.0	50.9
1984	106.5	107.8	92.2	80.7	130.1	73.7	58.7	58.7	63.9	81.2	88.8	94.9	86.4
1985	72.1	55.9	68.5	66.0	76.6	37.6	48.3	40.7	63.1	83.9	103.1	114.2	69.2
1986	100.7	87.6	81.8	99.7	51.3	53.8	38.0	31.0	48.1	105.3	86.3	79.6	71.9
1987	49.2	49.6	59.1	63.9	66.4	48.5	51.5	74.9					
1988									121.2	70.8			
1989	68.0	45.3											
AVE.	66.9	60.8	59.2	66.9	68.4	52.9	46.1	47.4	65.7	79.6	82.4	85.1	65.2
per 100 km <sup>2</sup>	6.37	5.79	5.64	6.37	6.51	5.03	4.39	4.52	6.26	7.58	7.85	8.11	6.21

Table A-22 MONTHLY MEAN DISCHARGE AT PEMUDILAN

Unit: m3/sec  
Catchment Area : 206 km2

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	AVE.
1985							1.68	2.58	2.65	4.45	5.36	5.31	
1986	4.74	4.88	3.14	3.80	2.76	3.46	2.23	1.54	2.57	5.15	4.66	5.06	3.67
1987	3.23	1.03	1.30	1.85	1.93	2.24	2.10						
1988	4.87	5.45	4.14	3.62	3.74				2.24	4.35	5.56	6.45	
AVE.	4.28	3.78	2.86	3.09	2.81	2.85	2.00	2.06	2.49	4.65	5.19	5.61	3.47
per 100 km2	2.519	1.837	1.389	1.499	1.365	1.383	0.972	1.000	1.207	2.258	2.521	2.722	1.684

Table A-23 MONTHLY MEAN DISCHARGE AT PULODOGOM

unit: m3/sec  
Catchment Area: 1116 km2

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
1979													
1980	52.7	44.2	78.5	59.1	72.6	45.9	28.0	49.3	43.8	69.3	84.6	59.8	57.3
1981	93.4	67.0	33.0	55.5	79.1	49.4	47.8	26.0	78.5	80.0	68.0	45.5	60.3
1982	34.2	55.5	58.3	81.4	79.6	42.3	36.6	43.0	52.7	78.4	53.8	63.0	56.6
1983	55.0	35.1	30.1	21.1	35.7	40.1	50.0	30.6	82.3	75.2	55.8	104.3	51.3
1984	111.1	80.9	87.4	103.3	116.6	57.9	47.4	42.4	50.1	68.8	59.7	80.6	75.5
1985	58.3	50.8	84.2	56.2	65.4	30.0	25.7	30.0	49.9	74.9	83.5	84.1	57.8
1986	96.8	85.1	63.5	70.5	51.2	46.3	27.6	21.1	24.5	81.7	111.3	83.5	63.6
1987													
1988								101.8	141.1	57.9	87.3	103.5	
1989	76.2	29.3	56.3	51.6									
AVE.	72.2	56.0	61.4	62.3	71.5	44.6	37.6	43.0	65.4	73.3	75.5	78.0	60.3
per 100 km2	6.47	5.02	5.50	5.59	6.40	3.99	3.37	3.86	5.86	6.57	6.77	6.99	5.41

Table A-24 MONTHLY MEAN DISCHARGE AT TINGGI RAJA

unit: m<sup>3</sup>/sec  
Catchment Area: 317 km<sup>2</sup>

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
1985	-	-	-	-	-	-	15.94	14.39	23.30	36.42	43.16	41.85	-
1986	35.52	35.50	28.31	37.88	16.16	25.04	-	-	13.08	36.45	28.28	31.98	-
1987	15.45	11.04	24.74	23.37	22.64	13.75	14.49	25.34	23.90	39.92	33.46	-	-
1988	26.77	35.05	28.55	16.07	19.74	24.42	23.75	20.00	39.47	19.48	30.17	46.55	27.50
AVE.	25.91	27.20	27.20	25.77	19.51	21.07	18.06	19.91	33.25	33.07	33.77	40.13	27.07
per 100 km <sup>2</sup>	8.17	8.58	8.58	8.13	6.15	6.65	5.70	6.28	10.49	10.43	10.65	12.66	8.54

Table A-25 MONTHLY MEAN DISCHARGE AT BANDAR DURIAN

unit: m<sup>3</sup>/sec  
Catchment Area: 530 km<sup>2</sup>

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
1984	-	-	-	-	-	-	-	-	-	35.7	31.9	41.4	-
1985	-	-	-	-	-	-	12.3	14.0	11.9	-	-	-	-
1986	-	-	30.0	38.0	19.2	25.8	-	10.6	20.2	43.0	-	-	-
1987	-	-	-	-	-	-	-	-	-	-	-	-	-
1988	-	-	-	26.8	21.3	29.2	37.2	52.0	41.9	31.7	26.6	46.5	-
1989	20.5	23.3	43.1	44.5	-	-	-	-	-	-	-	-	-
AVE.	20.5	23.3	36.6	36.4	20.3	27.5	24.8	25.5	24.7	36.8	29.3	44.0	29.1
per 100 km <sup>2</sup>	3.87	4.40	6.91	6.87	3.83	5.19	4.68	4.81	4.66	6.94	5.53	8.30	5.49

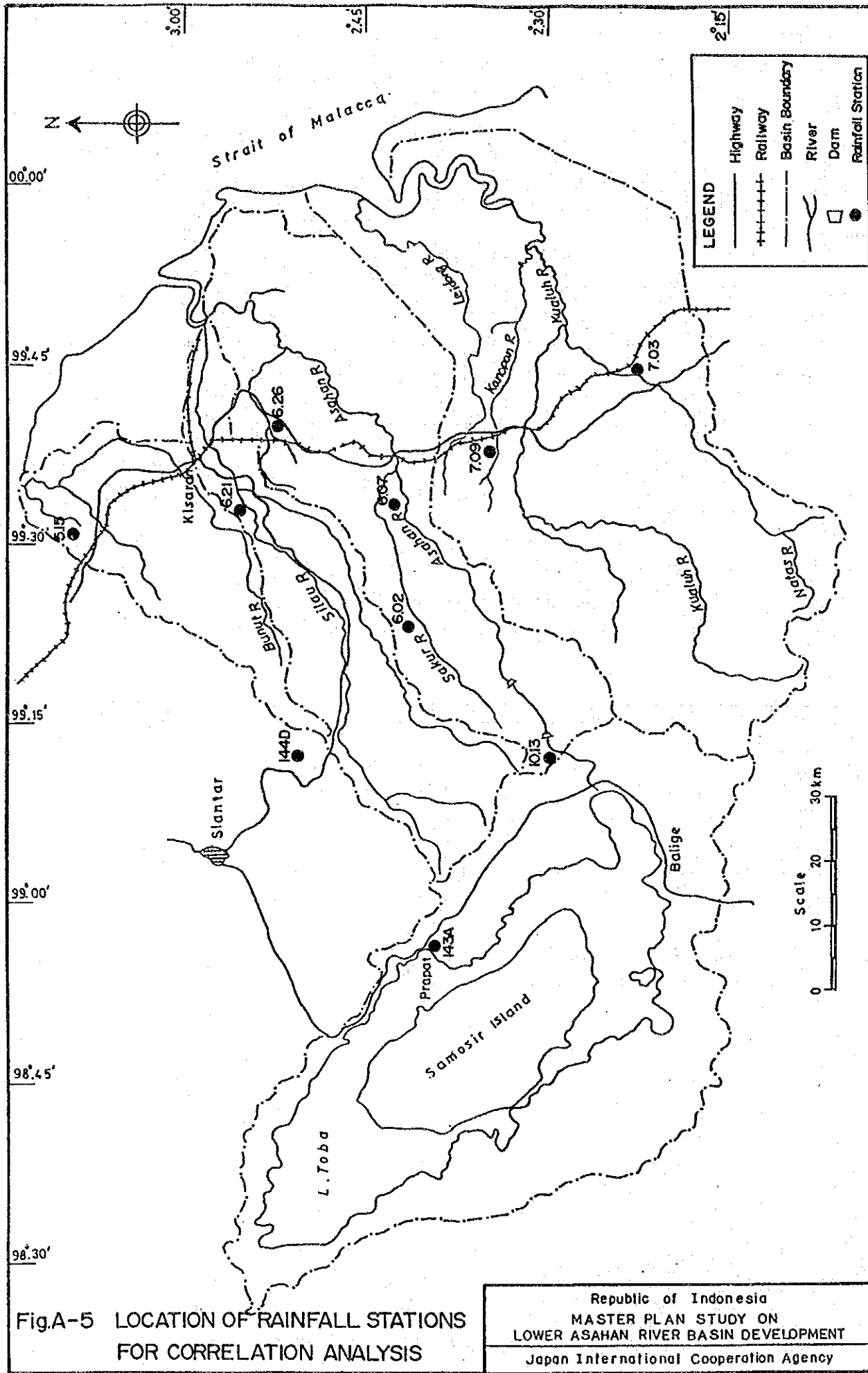
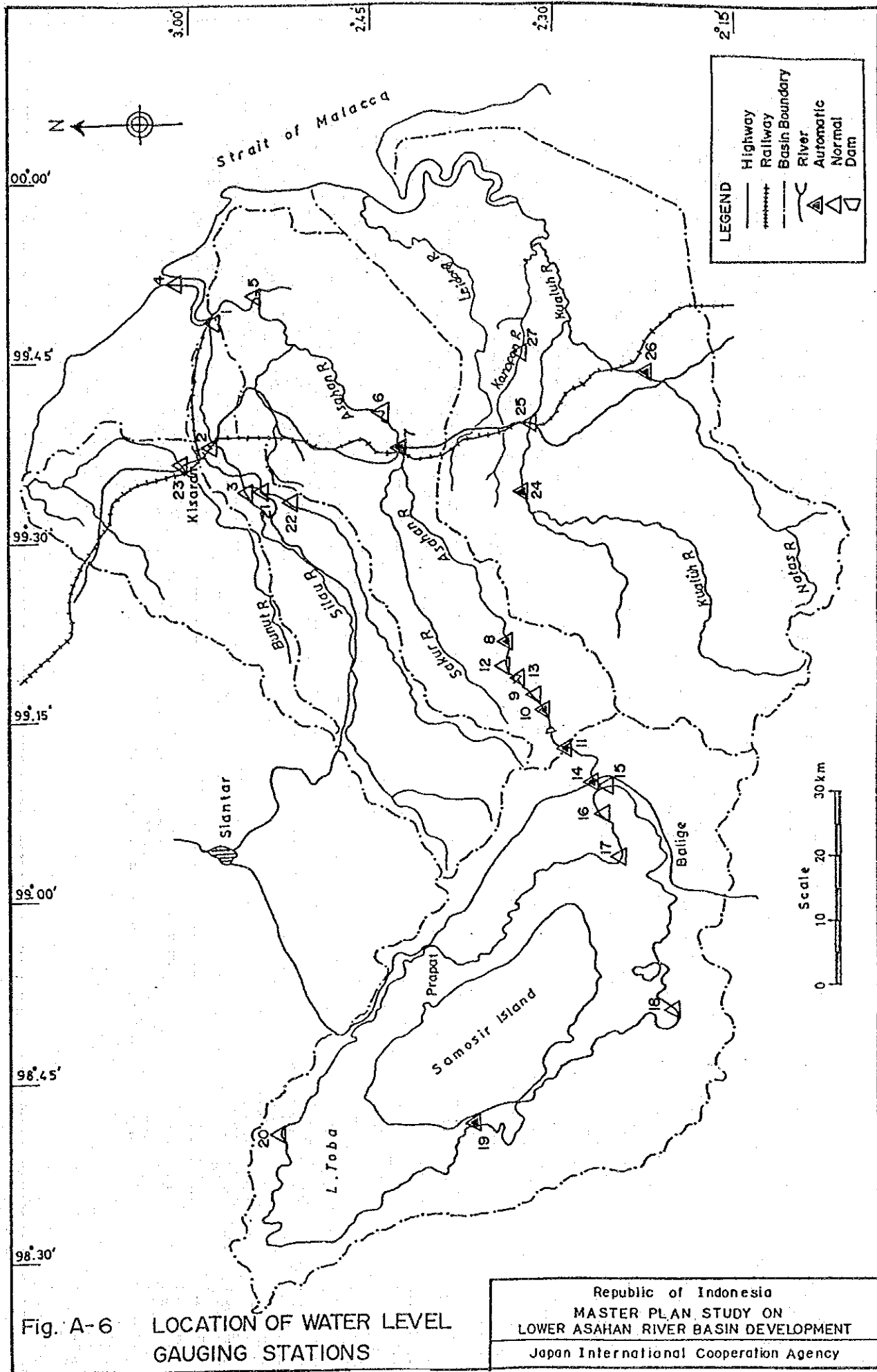
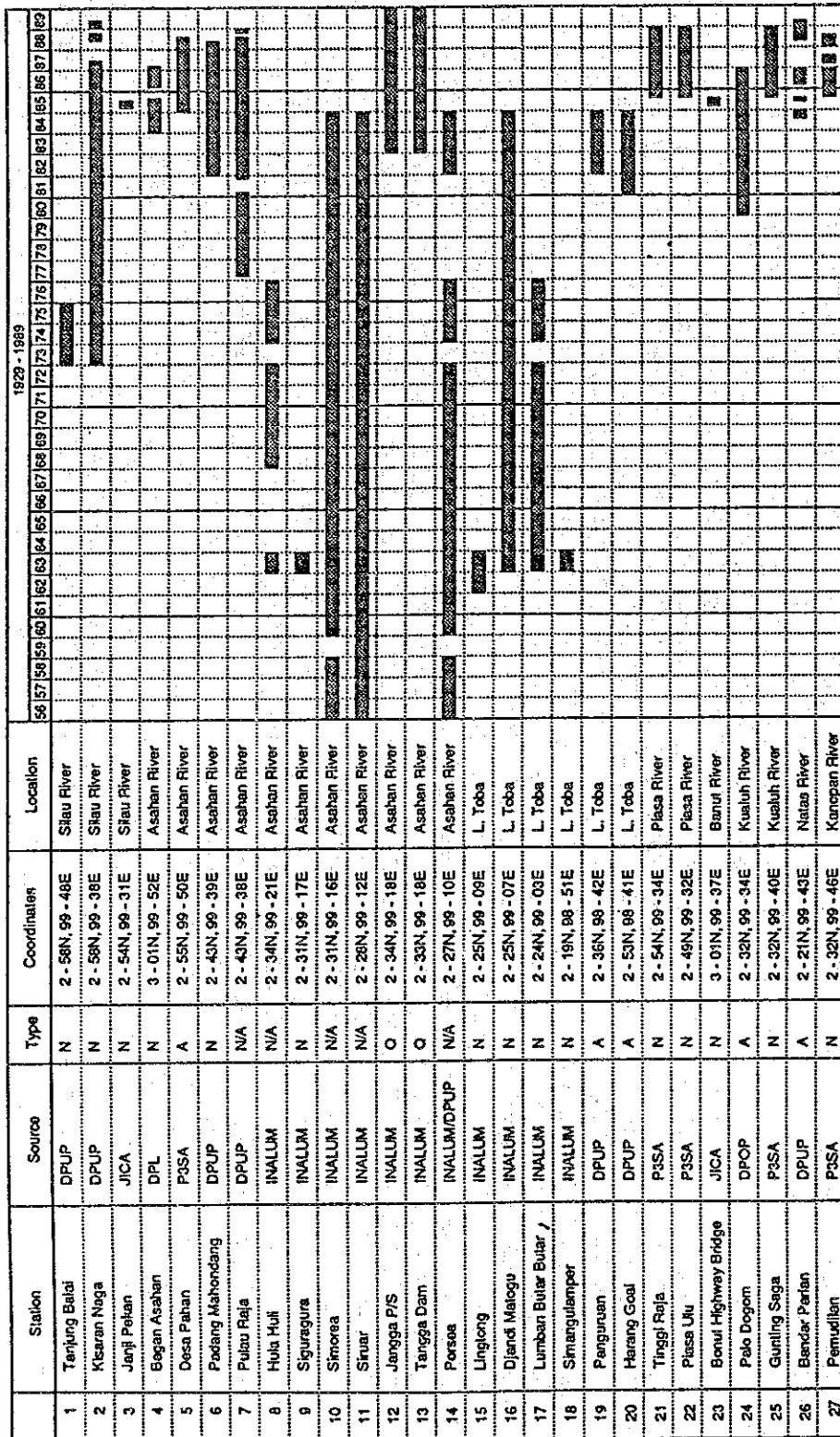


Fig.A-5 LOCATION OF RAINFALL STATIONS FOR CORRELATION ANALYSIS





Type: N : normal staff gauge  
 A : automatic water level gauge  
 Q : discharge record

Source : DPL = Direktorat Perhubungan Laut (National Port Authority)  
 P3SA = Proyek Perencanaan Pengembangan Sumber Air (Development Planning Division)  
 DPUP = Dinas Pekerjaan Umum Propinsi (Provincial Public Work Services)  
 INALUM = P.T. Indonesia Asahan Aluminium (Indonesia Asahan Aluminium Company)

Fig. A-7  
 WATER LEVEL AND DISCHARGE RECORDS

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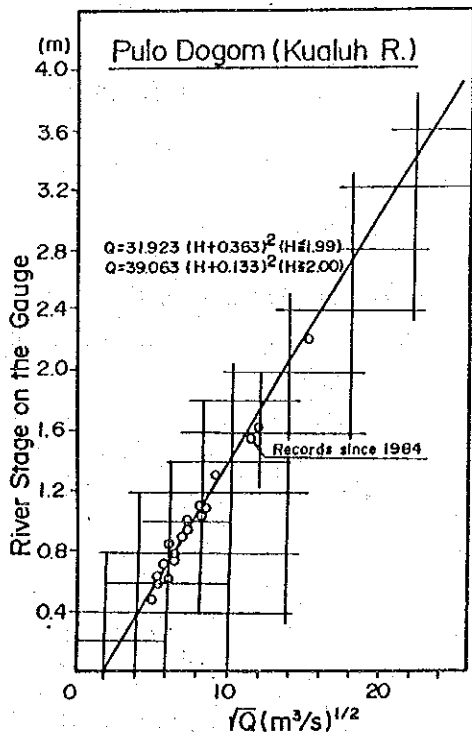
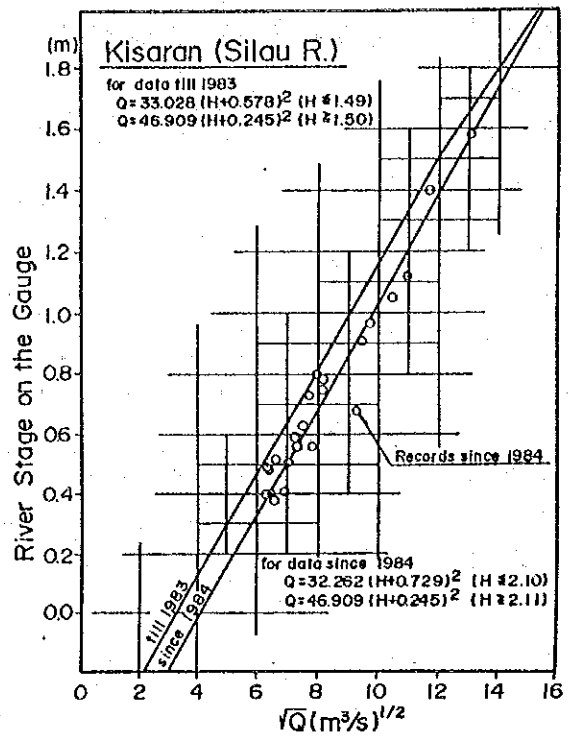
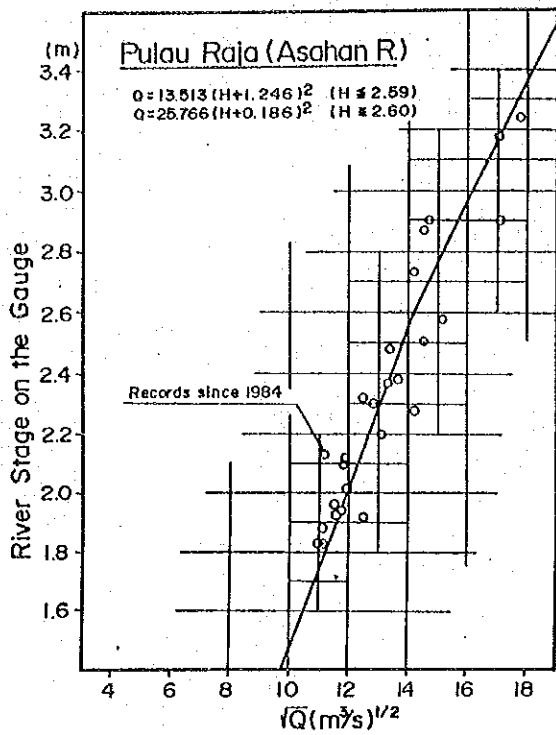


Fig. A-8(1/2) STAGE-DISCHARGE RELATION

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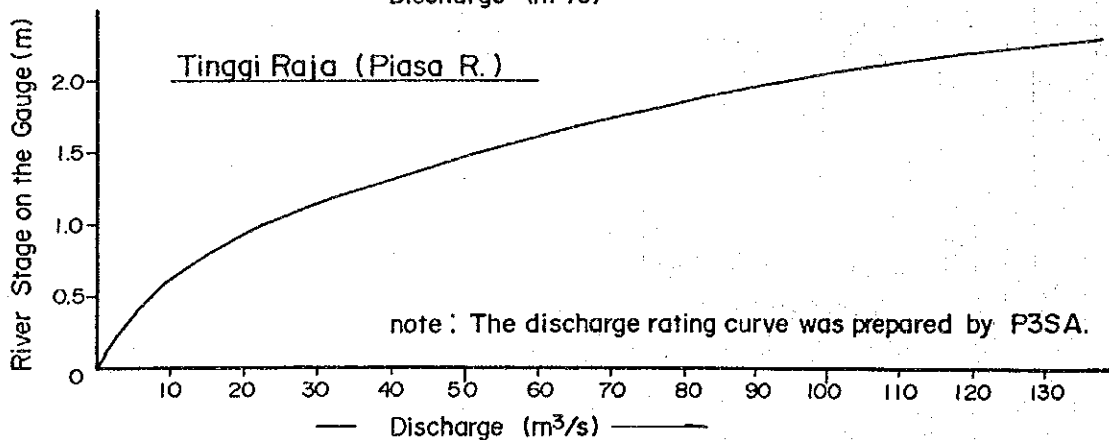
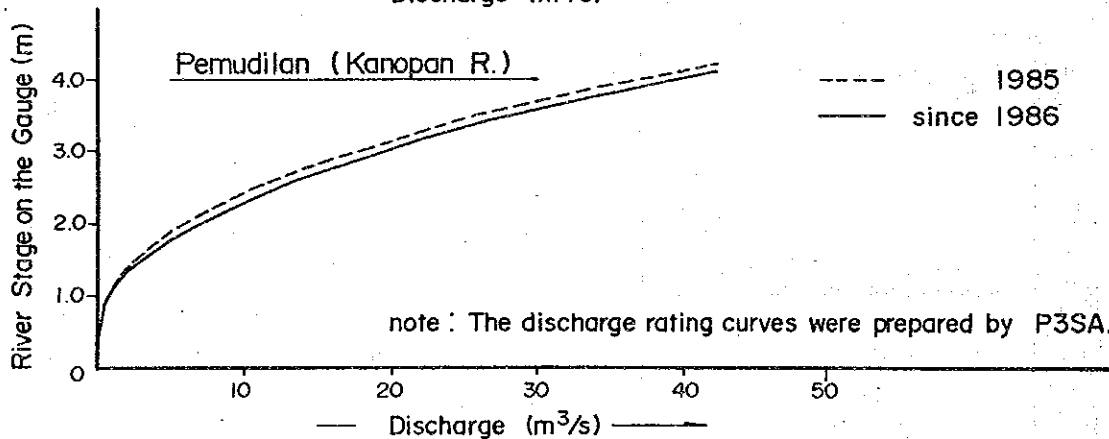
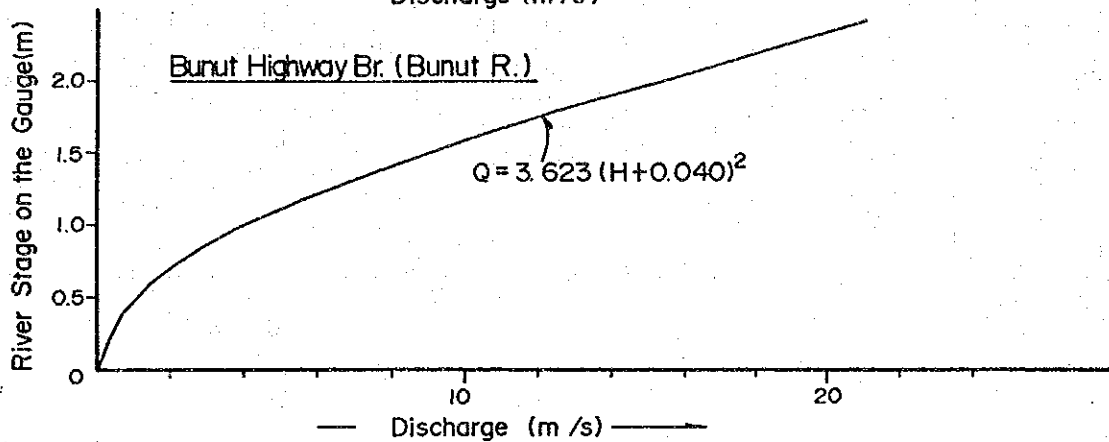
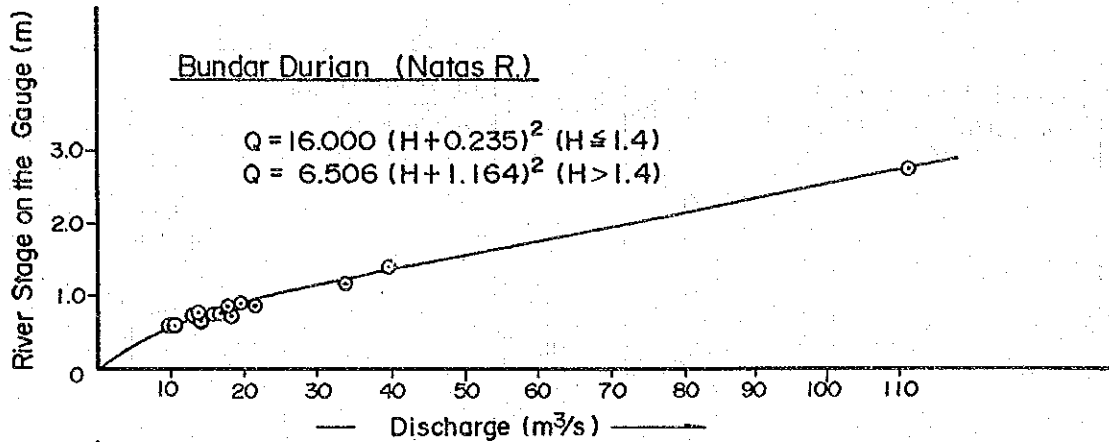


Fig. A-8(2/2) STAGE-DISCHARGE RELATION

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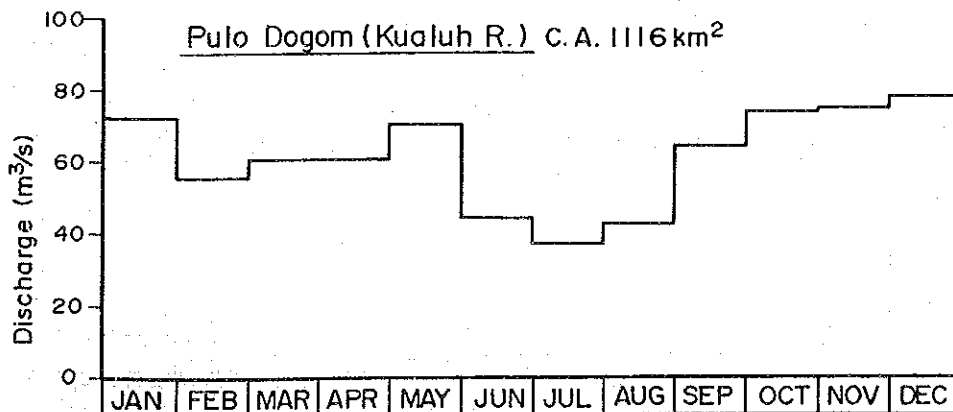
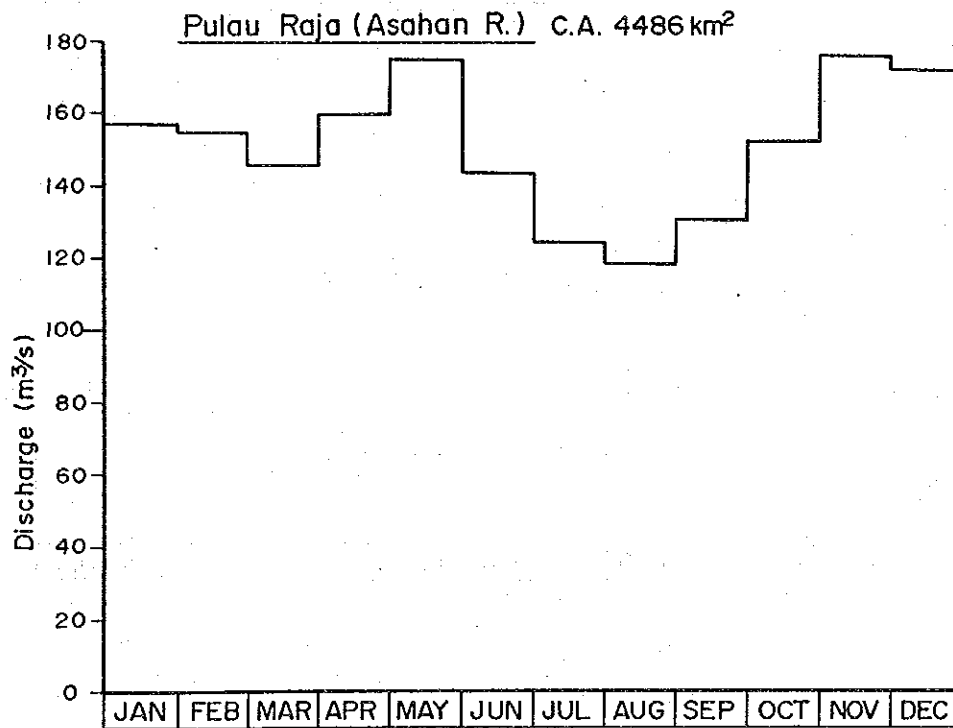
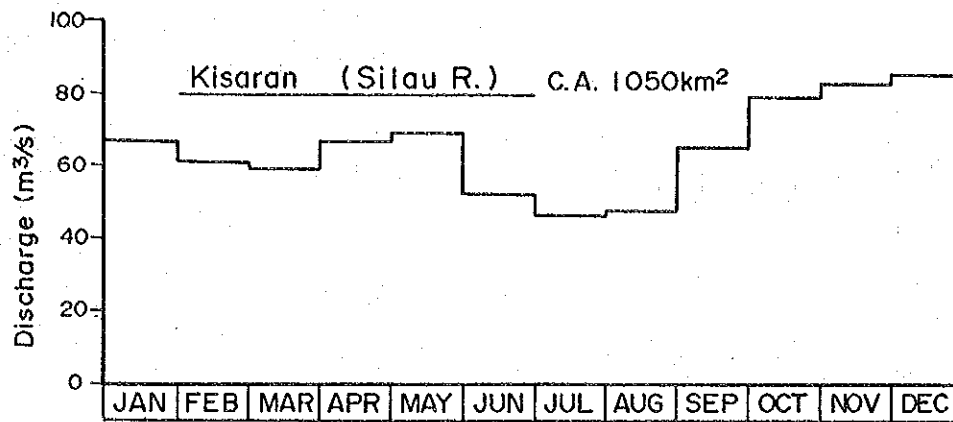


Fig. A-9(1/2) MONTHLY MEAN DISCHARGE

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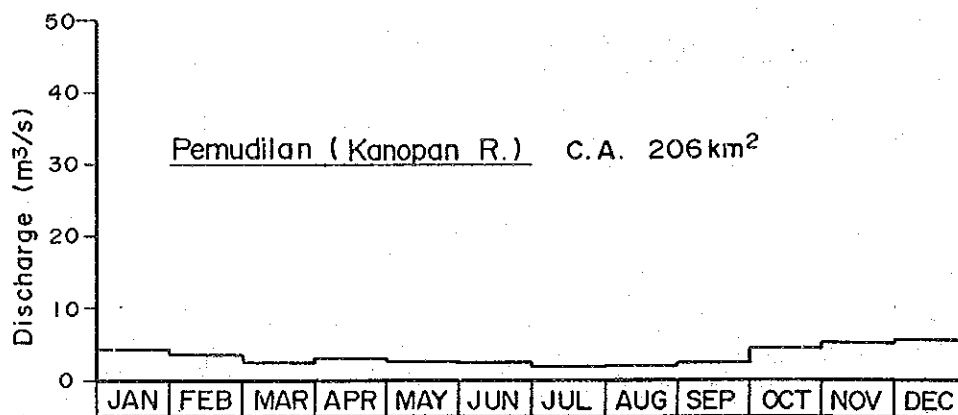
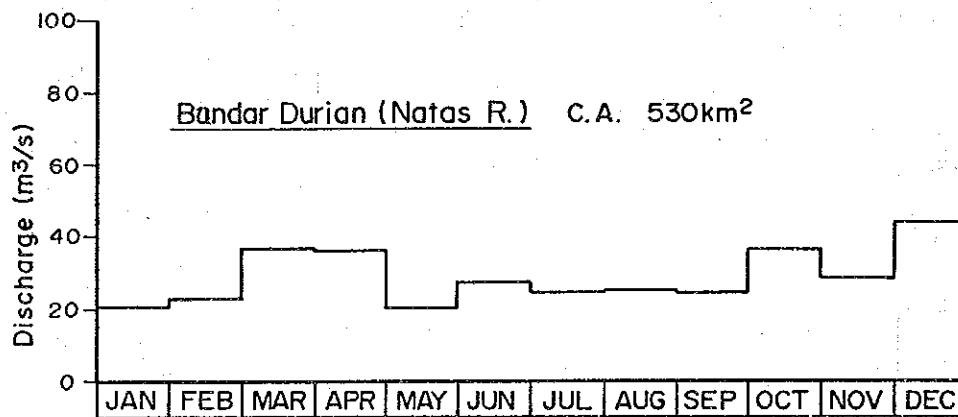
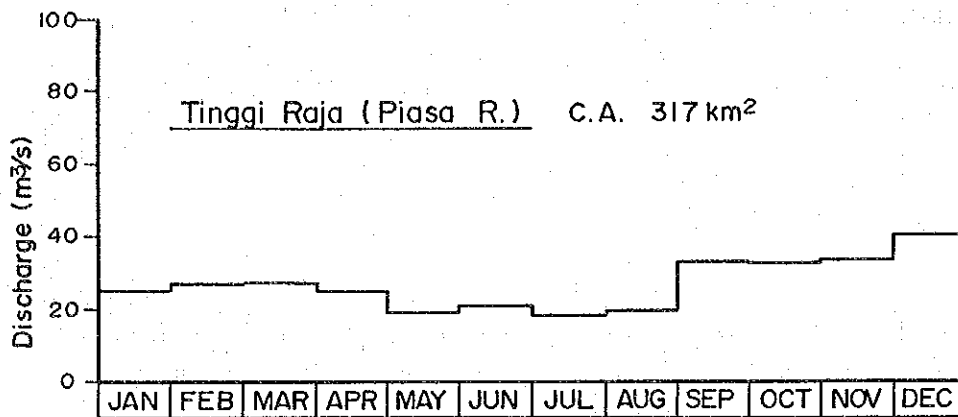


Fig. A-9(2/2) MONTHLY MEAN DISCHARGE

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Table A-26 SPECIFIC TIDE LEVELS

Item	HHHL	HHL	MHHL	MSL	MLLL	LLL	LLLL
<b>I Bagan Asahan</b>							
Gauge Height (m)	4.40	4.05	3.35	2.20	0.99	0.39	0.30
Elevation (m)	2.20	1.85	1.15	0.00	-1.21	-1.81	-1.90
<b>II Kuala Tanjung</b>							
Gauge Height (m)	3.22	2.97	2.37	1.52	0.66	-0.07	-0.45
Elevation (m)	1.70	1.45	0.84	0.00	-0.86	-1.59	-1.97

Note:

- 1) HHHL; Highest high level (recorded max.)  
 HHW; Higher high level (average of monthly max.)  
 MHHL; Mean higher high level (average of daily max.)  
 MSL; Mean sea level  
 MLLL; Mean lower low level (average of daily min.)  
 LLL; Lower low level (average of monthly min.)  
 LLLL; Lowest low level (recorded min.)
  
- 2) In the Strait of Malacca, both high and low tides regularly repeat twice a day.
  
- 3) Tide levels have been observed at Bagan Asahan, located in the lower end of the Asahan river facing to the Strait. Based on the recorded data in 1983 to 1987, the respective values have been compiled by the Detailed Design Team of the Lower Asahan River Flood Control Project in 1988. Tide gauge readings record at Bagan Asahan are shown in Table A-27.
  
- 4) Tide level records at Kuala Tanjung as shown in Table A-28 were newly collected after 1985 by adding to those collected by the Part 1 Study Team.

Table A-27 TIDE GAUGE READING AT BAGAN ASAHAN

(Unit : cm on gauge)

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual	
<b>Higher High Level (H.H.L)</b>														
1983	-	-	-	-	-	-	-	-	-	-	-	-	390	-
1984	390	400	420	420	400	380	390	430	430	440	380	-	440	
1985	370	390	400	420	430	420	410	400	-	-	-	-	-	
1986	-	390	410	420	400	390	390	390	380	390	430	440	440	
1987	400	400	-	-	-	-	-	-	-	-	-	-	-	
Max	400	400	420	420	430	420	410	430	430	440	430	440	440	
Ave	387	395	410	420	410	397	397	407	405	415	405	415	405	
<b>Mean Higher High Level (M.H.H.L)</b>														
1983	-	-	-	-	-	-	-	-	-	-	-	-	331	-
1984	329	328	332	338	330	329	336	340	336	335	321	-	332	
1985	323	337	319	335	349	345	337	333	-	-	-	-	-	
1986	-	334	341	341	333	331	344	332	342	337	346	345	339	
1987	333	333	-	-	-	-	-	-	-	-	-	-	-	
Ave	328	333	331	338	337	335	339	335	339	336	334	338	335	
<b>Mean Sea Level (M.S.L)</b>														
1983	-	-	-	-	-	-	-	-	-	-	-	-	213	-
1984	209	210	214	216	214	215	217	222	222	220	215	-	215	
1985	217	218	222	224	226	225	225	225	-	-	-	-	-	
1986	-	220	222	221	219	220	220	224	218	220	224	223	221	
1987	221	223	-	-	-	-	-	-	-	-	-	-	-	
Ave	216	218	219	220	220	220	221	224	220	220	220	218	220	
<b>Mean Lower Low Level (M.L.L.L)</b>														
1983	-	-	-	-	-	-	-	-	-	-	-	-	95	-
1984	88	91	96	93	98	101	97	103	108	105	108	-	99	
1985	102	90	105	103	99	101	109	117	-	-	-	-	-	
1986	-	91	88	91	101	102	105	115	90	88	100	96	97	
1987	94	103	-	-	-	-	-	-	-	-	-	-	-	
Ave	95	94	96	96	99	101	104	112	99	97	104	96	99	
<b>Lower Low Level (L.L.L)</b>														
1983	-	-	-	-	-	-	-	-	-	-	-	-	50	-
1984	40	40	40	40	50	50	50	40	40	40	40	-	40	
1985	40	40	40	30	30	30	30	40	-	-	-	-	-	
1986	-	30	30	30	30	30	30	40	50	50	40	40	30	
1987	40	30	-	-	-	-	-	-	-	-	-	-	-	
Ave	40	35	37	33	37	37	37	40	45	45	40	45	39	
Min	40	30	30	30	30	30	30	40	40	40	40	40	30	

Source : Direktorat Perhubungan Laut ( DPL : National Port Authority )

Table A-28 TIDE GAUGE READING AT KUALA TANJUNG

(Unit : cm on gauge)

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
<b>Higher High Level (H.H.L)</b>													
1983	-	-	-	292	305	293	285	291	300	302	322	283	-
1984	285	291	302	309	315	292	296	309	321	305	296	290	301
1985	270	280	291	305	317	314	288	281	293	317	316	295	297
1986	258	276	295	305	305	285	295	294	298	306	310	295	294
1987	270	270	277	293	300	295	296	299	302	303	-	-	-
1988	288	300	307	316	-	314	283	312	320	-	321	282	-
1989	269	279	-	-	-	-	-	-	-	-	-	-	-
Max	288	300	307	316	317	314	296	312	321	317	322	295	322
Ave	273	283	294	303	308	299	291	298	306	307	313	289	297
<b>Mean Higher High Level (M.H.H.L)</b>													
1983	-	-	-	233	245	271	228	238	242	249	256	231	-
1984	229	228	239	244	248	246	240	249	248	243	235	235	240
1985	219	223	229	235	242	253	237	236	236	248	246	229	236
1986	219	219	225	233	237	236	238	236	238	242	243	220	232
1987	209	216	221	223	236	231	251	241	236	234	-	-	-
1988	235	236	239	243	-	250	239	248	238	-	239	233	-
1989	227	232	-	-	-	-	-	-	-	-	-	-	-
Ave	223	226	231	235	242	248	239	241	240	243	244	230	237
<b>Mean Sea Level (M.S.L)</b>													
1983	-	-	-	148	160	177	148	151	150	158	169	150	-
1984	149	144	150	156	163	160	156	161	164	166	150	154	156
1985	139	143	140	138	157	172	160	154	153	152	155	149	151
1986	138	133	135	148	158	155	159	161	153	155	148	136	148
1987	130	133	129	137	160	163	165	154	150	155	-	-	-
1988	153	151	149	157	-	168	158	163	152	-	157	149	-
1989	140	140	-	-	-	-	-	-	-	-	-	-	-
Ave	142	141	141	147	160	166	158	157	154	157	156	148	152
<b>Mean Lower Low Level (M.L.L.L)</b>													
1983	-	-	-	63	74	82	67	63	58	66	82	69	-
1984	69	60	61	67	77	73	72	72	79	89	62	67	71
1985	60	51	54	60	67	87	75	64	63	72	70	68	66
1986	51	45	44	60	77	70	80	77	66	67	73	49	63
1987	45	47	36	52	75	77	76	67	61	69	-	-	-
1988	69	63	56	68	-	83	75	73	62	-	56	74	-
1989	53	40	-	-	-	-	-	-	-	-	-	-	-
Ave	58	51	50	62	74	79	74	69	65	73	69	65	66
<b>Lower Low Level (L.L.L)</b>													
1983	-	-	-	10	18	26	-1	-22	-24	-7	24	-7	-
1984	-18	-30	-24	-4	24	15	2	-8	-11	19	-16	-2	-4
1985	-10	-30	-39	-39	8	21	14	-10	-20	-8	-10	-4	-11
1986	-28	-37	-20	-2	10	6	12	3	6	0	-3	-16	-6
1987	-45	-37	-33	1	9	5	3	-13	-15	-2	-	-	-
1988	-23	-28	-20	10	-	1	1	-11	-7	-	3	5	-
1989	-24	-35	-	-	-	-	-	-	-	-	-	-	-
Ave	-25	-33	-27	-4	14	12	5	-10	-12	0	0	-5	-7
Min	-45	-37	-39	-39	8	1	-1	-22	-24	-8	-16	-16	-45

Source : INALUM (Indonesia Asahan Aluminium Company )

Table A-29 RANGE OF TIDAL REACH

River	Tidal reach range	
	Length from mouth (km)	Upper-end Point
1. Bunut River	18	- Road bridge located in the swampy area
2. Silau River	5	- About 5 km upstream of conf. with Asahan
3. Asahan River	37	- About 7 km downstream of conf. with Nantalu
4. Kualuh River	65	- About 10 km upstream of conf. with Kanopan
5. Kanopan River	19	- Road bridge
6. Leidong river	22	- Pasar 7

Note:

- 1) Length and upper-end point of the tidal reaches are estimated based on the field observation, information obtained from inhabitants and surveyed river channel profiles.

Table A-30 ESTIMATED RANGE OF SALT WATER INTRUSION

River	Length from Rivermouth (km)	Upper-end Point
1. Bunut	10	- Confluence with Balai river
2. Kualuh	35	- About 10 km downstream of the confluence with Kuo river
3. Kanopan	-	- No intrusion
4. Leidong	12	- Just upstream of rock bridge

Note:

- 1) Several field observations of the salt (chlorine) concentration of the river water were carried out during spring tide in order to know the seawater intrusion into the major rivers of Bunut, Asahan and Kualuh.
- 2) For Asahan river, the observation was made on March 8, 1985 when the river discharges were drought of  $147.m^3/s$  in the Asahan and  $35 m^3/s$  in the Silau. According to the above results, it was judged that the upper-end of the salt wedge be approximately 6 km upstream from its rivermouth.
- 3) For Bunut, Kualuh and Leidong rivers, the observations and discharge measurements were carried out in July and August, 1989. Sampling sites of the river water are presented on Fig. A-10. The tide level estimated at Bagan Asahan is illustrated on Fig. A-11. River discharges at the observation time are  $3.6.m^3/s$  in Bunut,  $80.m^3/s$  in the Kualuh, and  $3 m^3/s$  in the Leidong, respectively. The result of the observation is summarized in Tables A-31 to A-33 and Fig. A-12.



TABLE A-31 MEASUREMENT RESULT OF Cl- CONCENTRATION IN BUNUT RIVER

Sampling Site/Depth	Time : PM 4.00 July 20 '89			Time : PM 5.00 July 20 '89		
	Elevation (El.m)	Temperature (Degree C)	Cl-concentration (Mic.s/cm)	Elevation (El.m)	Temperature (Degree C)	Cl-concentration (Mic.s/cm)
<b>B-1 Site</b>						
Surface	1.50 /	30.0	more than 5,000	1.50	29.5	more than 5,000
Middle	-2.50 /	30.5	more than 5,000	-1.50	30.0	more than 5,000
Bottom	-4.10 /	30.0	more than 5,000	-3.50	30.0	more than 5,000
<b>B-2 Site</b>						
Surface	1.463 /	30.0	less than 200	1.603	29.0	less than 200
Bottom	0.463 /	29.5	less than 200	0.603	29.0	less than 200
<b>B-3 Site</b>						
Middle	3.01 /	30.0	less than 200	3.01	29.5	less than 200

TABLE A-32 MEASUREMENT RESULT OF Cl- CONCENTRATION IN KUALUH RIVER

Sampling Site/Depth	Time : AM 8.00 July 22 '89			Time : AM 9.00 July 22 '89		
	Elevation (El.m)	Temperature (Degree C)	Cl-concentration (Mic.s/cm)	Elevation (El.m)	Temperature (Degree C)	Cl-concentration (Mic.s/cm)
<b>K-1 Site</b>						
Surface	2.10	28.6	less than 200	2.15	28.5	less than 200
Middle	-1.90	28.5	less than 200	-0.85	28.5	less than 200
Bottom	-3.50	28.4	1,200	-2.85	28.5	less than 200
<b>K-2 Site</b>						
Surface	2.49	31.0	less than 200	2.53	30.5	less than 200
Middle	0.49	31.0	less than 200	0.53	30.9	less than 200
Bottom	-1.81	31.0	less than 200	-1.27	29.2	less than 200
<b>K-3 Site</b>						
Surface	d = 3 m	28.5	less than 200	d = 3 m	28.0	less than 200
Bottom		28.5	less than 200		27.8	less than 200
<b>K-4 Site</b>						
Surface	d = 2.8 m	31.0	less than 200	d = 2.8 m	30.8	less than 200
Bottom		31.0	less than 200		31.0	less than 200

Note : 1) Sites are given in Fig. A-10  
2) Samplings at K-1 and K-4 were made at PM 4.00 and PM 5.00 on July 21, '89

TABLE A-33 MEASUREMENT RESULT OF Cl- CONCENTRATION IN LEIDONG RIVER

Sampling Site/Depth	Time : AM 7.30 Aug. 21 '89			Time : AM 8.15 Aug. 21 '89		
	Elevation (El.m)	Temperature (Degree C)	Cl-concentration ( P P M )	Elevation (El.m)	Temperature (Degree C)	Cl-concentration ( P P M )
<b>L-1 Site</b>						
Surface	2.34	28.5	more than 5,000	2.15	28.0	more than 5,000
Middle	-0.36	28.2	more than 5,000	-0.55	28.0	more than 5,000
Bottom	-2.26	28.0	more than 5,000	-2.45	28.0	more than 5,000
<b>L-2 Site</b>						
Surface	2.18	28.0	3,200	2.08	28.2	3,400
Middle	0.18	28.5	3,100	0.08	28.2	4,000
Bottom	-2.12	28.4	3,100	-2.22	28.2	4,100
<b>L-3 Site</b>						
Bottom	d = 4 m	28.0	less than 200			
<b>L-4 Site</b>						
Bottom	d = 2 m	28.0	less than 200			

Note : 1). : Sampling at L-2 site was made at AM 8.00 and at AM 8.45 respectively.  
2). : Sampling at L-3 site was made at AM 7:45  
3). : Sampling at L-4 site was made at AM 8.30

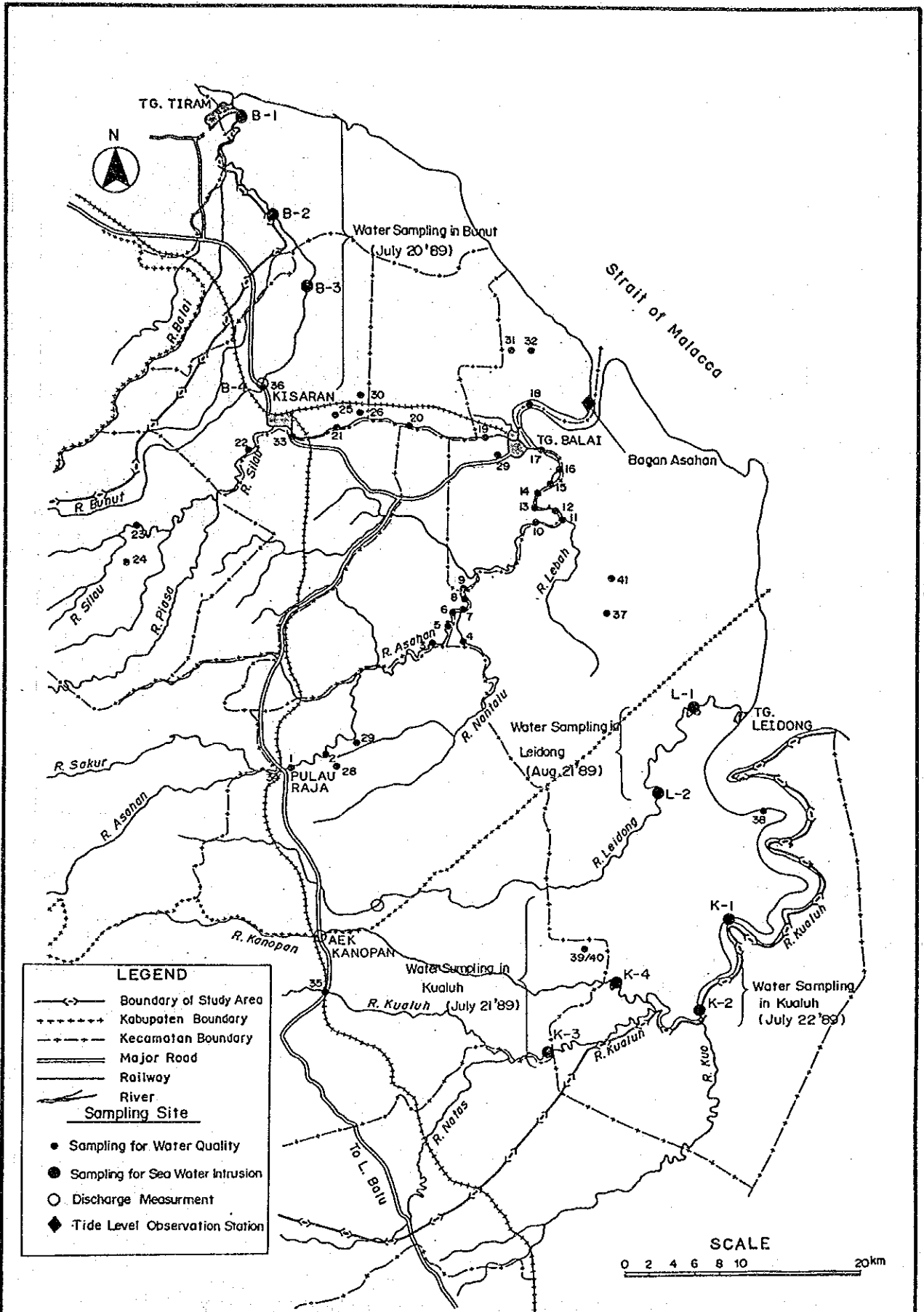
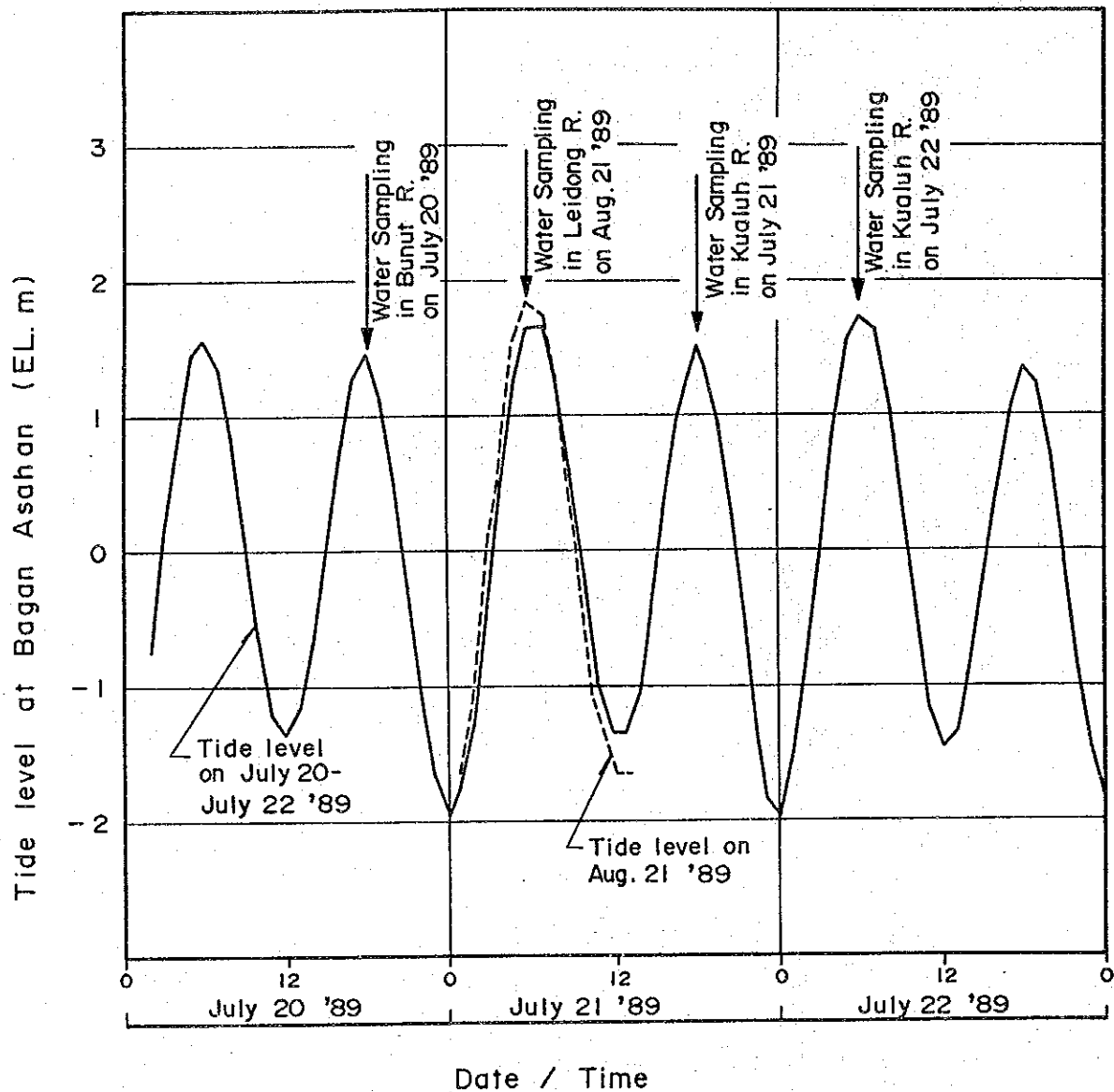


Fig. A-10 LOCATION OF WATER SAMPLING AND DISCHARGE MEASUREMENT

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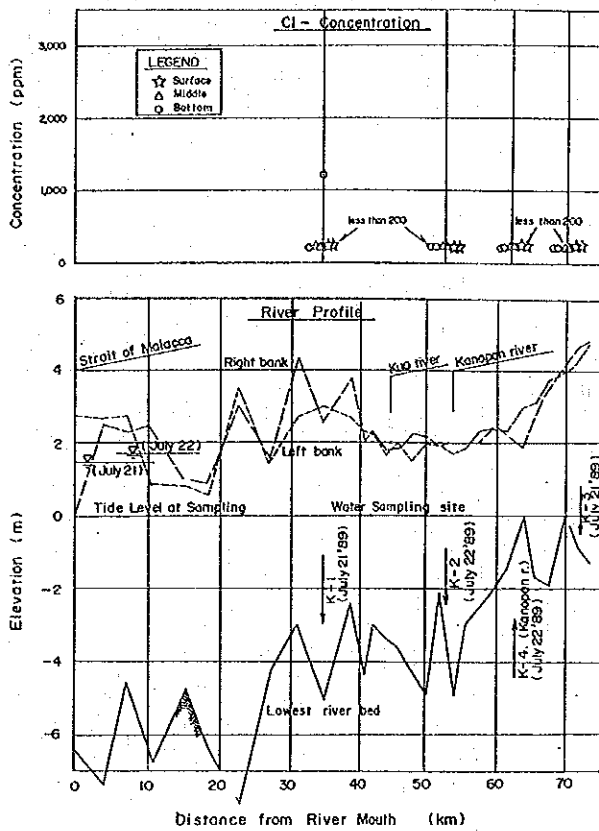


Source : Daftar Pasang Surut (Tide Tables)  
 Tahun 1989  
 TNI - AL  
 Dinas Hidro - Oseanografi

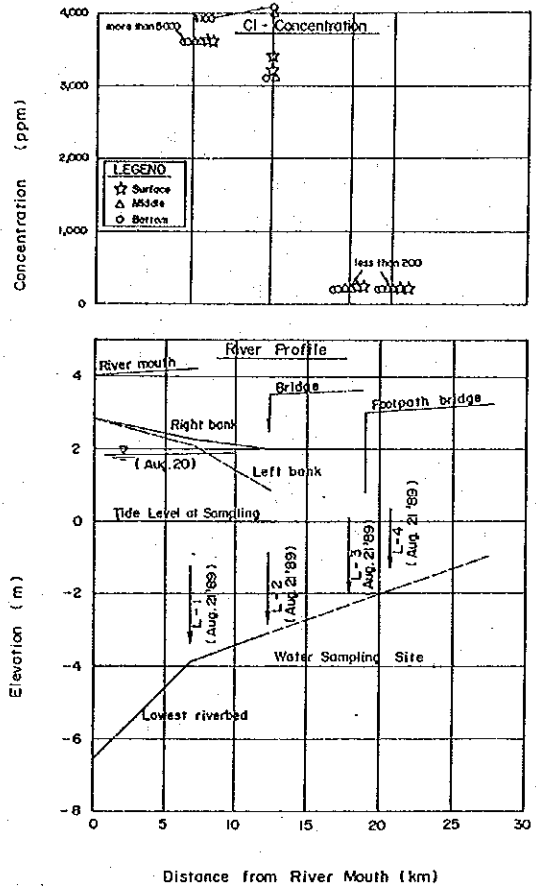
Fig. A-11 TIDAL VARIATION AT BAGAN ASAHAN AND WATER SAMPLING DATA

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### Kualuh river



### Bunut river



### Leidong river

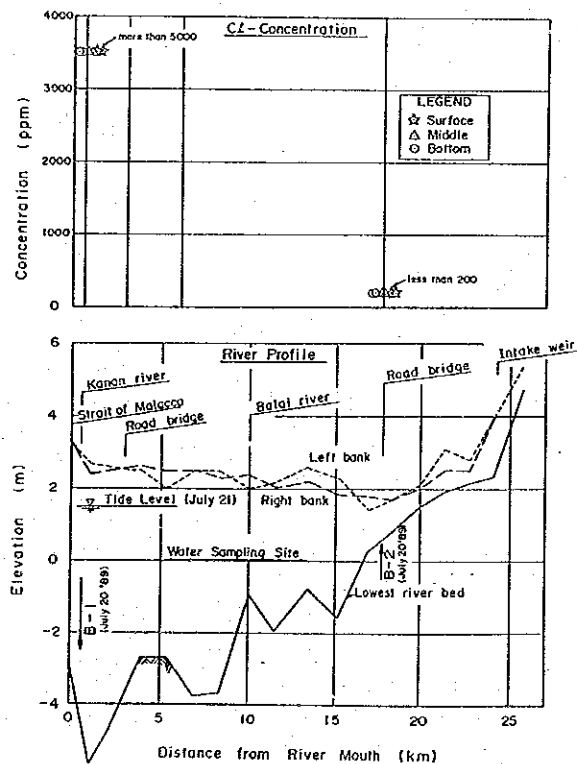


Fig. A-12 MEASUREMENT RESULTS OF CL-CONCENTRATION

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Table A-34 Water Quality Criteria for Irrigation

Parameter	Unit	Upperlimit	Remarks
<b>I. FAO's STANDARD CRITERIA</b>			
1. pH		6.5 - 8.5	
2. Ec	mmhos/cm	0.75	
3. adj.SAR		3.00	
4. Aluminium (Al)	mg/l	5.00	
5. Arsenic (As)	mg/l	0.10	
6. Beryllium (Be)	mg/l	0.10	
7. Boron (B)	mg/l	0.75	
8. Cadmium (Cd)	mg/l	0.01	
9. Chromium (Cr)	mg/l	0.10	
10. Cobalt (Co)	mg/l	0.05	
11. Copper (Cu)	mg/l	0.20	
12. Fluorine (F)	mg/l	1.00	
13. Iron (Fe)	mg/l	5.00	
14. Lead (Pb)	mg/l	5.00	
15. Lithium (Li)	mg/l	2.50	
16. Manganese (Mn)	mg/l	0.20	
17. Molybdenum (Mo)	mg/l	0.01	
18. Nickel (Ni)	mg/l	0.20	
19. Selenium (Se)	mg/l	0.02	
20. Vanadium (V)	mg/l	0.10	
21. Zinc (Zn)	mg/l	1.00	
22. Ammonia (NH <sub>3</sub> -N)	mg/l	5.00	
23. Nitrate (NO <sub>3</sub> -N)	mg/l	5.00	
<b>II. INDONESIA STANDARD</b>			
<b>1. Physics</b>			
Temperature	°C	normal water temperature	<u>1/</u>
Dissolved residue	mg/l	1,000 - 2,000	<u>1/</u>
Electric conductivity	µΩ/cm (25°C)	1,750 - 2,250	<u>2/</u>
<b>2. Chemistry</b>			
pH		5 - 9	
Manganese (Mn)	mg/l	2	
Copper (Cu)	mg/l	0.2	
Zinc (Zn)	mg/l	2	
Chromium (Cr)	mg/l	1	
Cadmium (Cd)	mg/l	0	
Mercury (Hg)	mg/l	0.005	
Lead (Pb)	mg/l	1	
Arsenic (As)	mg/l	1	
Selenium (Se)	mg/l	0.005	
Nichel (Ni)	mg/l	0.5	
Cobalt (Co)	mg/l	0.2	
Boron (B)	mg/l	1	
Sodium (Na)	%	60	
Sodium Absorption Ratio		10 - 18	<u>3/</u>
Residual Sodium Carbonate		1.25 - 2.5	<u>4/</u>
<b>3. Radioactivity</b>			
Total Beta activity	pCi/l	1,000	<u>5/</u>
Strontium 90	pCi/l	10	
Radium 226	pCi/l	3	

- 1/ According to local condition  
 2/ 1,750 for sensitive plant  
 2,250 for medium sensitive plant  
 3/ maximum 10 for sensitive plant  
 maximum 18 for low sensitive plant  
 4/ maximum 1.25 for sensitive plant  
 maximum 2.5 for low sensitive plant  
 5/ activities without Sr-90 and Ra-226

Source : Water quality standard for Kep. Men. Neg. KLHNO: Kep.-2/Men.KLH/1/1988

Table A-35 (1/2) PHYSICAL, CHEMICAL AND BIOLOGICAL CHARACTERISTICS OF WATER SAMPLES

No.	Parameter	Unit	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
<b>I Physical</b>																				
1	Air temperature	°C	28.0	31.0	29.0	32.0	31.5	30.5	29.0	28.5	26.0	31.0	34.0	26.0	28.0	28.0	29.0	26.0	27.0	30.0
2	Water temperature	°C	26.0	27.0	26.5	26.0	27.0	27.0	27.0	27.0	27.0	27.0	26.5	27.0	28.0	28.0	28.0	28.5	28.0	28.0
3	Colour	Unit Pt Co	10.0	10.0	10.0	5.0	10.0	25.0	25.0	25.0	25.0	25.0	210.0	5.0	10.0	10.0	85.0	45.0	95.0	40.0
4	ODP		NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
5	Turbidity	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	Turbid
6	Transparency	cm	>40.0	>40.0	92.0	90.0	90.0	90.0	85.0	80.0	40.0	70.0	69.0	50.0	40.0	37.5	47.5	55.0	40.0	31.0
7	DO	mg/l	10.5	4.0	1.0	6.5	3.5	3.5	5.0	5.0	3.0	4.0	1.0	3.5	5.0	7.5	17.0	5.0	3.5	7.5
8	TDSS	mg/l	84.0	76.0	75.0	70.0	60.0	68.0	65.0	70.0	66.0	81.0	54.0	62.0	70.0	72.0	64.0	76.0	59.0	132.0
9	TSS	mg/l	28.0	28.0	73.0	46.0	144.0	28.0	87.0	84.0	42.0	183.0	58.0	86.0	75.0	72.0	92.0	64.0	65.0	8.0
10	TSS	mg/l	112.0	104.0	148.0	116.0	204.0	96.0	130.0	115.0	102.0	266.0	112.0	148.0	150.0	144.0	136.0	140.0	124.0	140.0
11	Specific Conductivity	microsiemens/cm	123.0	130.0	93.0	89.0	75.0	91.0	92.0	84.0	86.0	101.0	68.0	77.0	87.0	100.0	105.0	115.0	83.0	192.0
<b>II Chemical</b>																				
12	pH	mg/l	722.0	7.5	6.7	7.1	7.0	7.0	7.0	7.1	7.1	7.1	7.1	6.5	6.9	7.0	6.9	7.1	6.4	7.1
13	CO2	mg/l	23.8	19.8	11.9	13.8	11.9	11.9	11.9	11.9	11.9	11.9	23.8	15.8	19.8	19.8	15.8	19.8	19.8	27.7
14	HCO3	mg/l	99.7	99.7	99.7	66.5	72.0	55.4	55.4	55.4	55.4	60.9	38.3	55.4	60.9	60.9	60.9	60.9	49.9	66.5
15	DO	mg/l	8.9	8.9	7.5	4.0	13.0	8.7	8.9	9.2	11.1	8.5	8.0	5.3	5.4	4.6	5.8	5.2	6.2	6.5
16	NO2-N	mg/l	0.3	0.2	0.2	0.3	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.6	0.6	0.5
17	NO3-N	mg/l	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
18	NH2-N	mg/l	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
19	PO4	mg/l	0.2	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
20	CO-D	mg/l	36.4	33.3	8.5	14.5	10.5	26.5	78.8	17.2	12.6	10.7	102.4	28.1	51.6	76.4	62.0	51.6	54.0	45.4
21	SO4	mg/l	0.0	2.5	0.8	2.0	2.0	2.0	2.3	3.0	3.0	3.0	5.3	2.3	3.0	0.0	0.0	1.5	2.3	0.0
22	Cl	mg/l	14.2	4.7	5.2	4.8	5.4	5.9	5.9	7.0	6.4	5.4	7.8	5.5	5.4	6.4	6.1	7.0	9.1	31.7
23	CL2	mg/l	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
24	Na	mg/l	9.2	10.0	7.3	6.6	5.3	6.7	6.0	5.4	4.7	5.4	4.2	6.5	6.7	8.4	7.9	9.7	7.9	22.0
25	K	mg/l	3.3	3.4	5.7	5.3	5.0	5.1	5.0	4.4	4.3	3.9	2.9	4.0	4.4	2.8	3.0	3.1	4.4	4.5
26	B	mg/l	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
27	Total hardness	mg/l CaCO3	2.6	3.1	2.8	4.0	3.2	7.0	4.0	3.6	3.4	3.6	3.6	4.0	4.4	2.8	3.0	3.1	4.4	4.5
28	Alkalinity	mg/l	52.2	54.0	72.0	100.5	63.8	70.0	63.8	72.0	60.0	80.0	46.5	81.0	80.0	39.1	40.5	45.2	50.0	39.5
29	Salinity	mg/l	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
30	Cu	mg/l	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004
31	Zn	mg/l	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004
32	Cr	mg/l	<0.017	<0.017	<0.017	<0.017	<0.017	<0.017	<0.017	<0.017	<0.017	<0.017	<0.017	<0.017	<0.017	<0.017	<0.017	<0.017	<0.017	<0.017
33	Cd	mg/l	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
34	Pb	mg/l	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
35	Fe	mg/l	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
36	Mn	mg/l	0.3	0.6	0.6	1.1	1.1	1.1	1.1	1.3	1.3	0.9	1.4	1.3	1.4	1.0	1.7	1.5	1.2	0.9
37	Ni	mg/l	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
38	Mg	mg/l	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
39	Al	mg/l	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
40	Dibenz	mg/l	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
41	Heptachlor	mg/l	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
42	DD D	mg/l	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
43	DD E	mg/l	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
44	A4	mg/l	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
45	Cu	mg/l	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
46	Mg	mg/l	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
<b>III Biology</b>																				
47	Total Flankton	Ind/l	67.0	63.0	22.0	29.0	17.0	28.0	45.0	42.0	42.0	38.0	40.0	54.0	247.0	107.0	83.0	144.0	152.0	247.0
48	DG Flankton	Ind/m2	2.5	2.5	2.5	2.1	1.7	1.6	2.6	2.7	2.1	2.2	1.9	1.6	1.7	2.1	1.1	1.6	0.5	1.7
49	Macrobenthos	Ind/m2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
50	DG Macrobenthos	Ind/m2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Note: - = not measured; nd = not detectable; NO = not defined; NT = not tested

- 1. Ashban river in Pullai Raja Highway Bridge
- 2. Ashban river in Pulai Raja Highway Bridge
- 3. Ashban river about 1 km upstream of confluence with Nantaba river
- 4. Ashban river about 1 km upstream of confluence with Ashban river
- 5. Ashban river about 1 km upstream of confluence with Nantaba river
- 6. Ashban river about 2 km downstream of confluence with Nantaba river
- 7. Ashban river about 3 km downstream of confluence with Nantaba river
- 8. Ashban river about 4 km downstream of confluence with Nantaba river
- 9. Ashban river about 4 km downstream of confluence with Nantaba river
- 10. Ashban river about 1 km upstream of confluence with Laboh river
- 11. Ashban river about 1 km upstream of confluence with Ashban river
- 12. Ashban river about 1 km downstream of confluence with Laboh river
- 13. Ashban river about 2 km downstream of confluence with Laboh river
- 14. Ashban river about 3 km downstream of confluence with Laboh river
- 15. Ashban river about 4 km downstream of confluence with Laboh river
- 16. Ashban river about 5 km downstream of confluence with Laboh river
- 17. Ashban river about 1 km upstream of Tanjung Bala City
- 18. Ashban river about 2.5 km downstream of Tanjung Bala City (after confluence with Kapuas River)

Data source: Reproton Environmental Impact Analysis



Table A-36 RECORDED ANNUAL MAXIMUM FLOOD PEAK DISCHARGES

Year	Asahan R. (Pulau Raja)			Silau R. (Kisaran)			Kualuh R. (Pulo Dogon)		
	Date	W.L. (m)	Discharge (cms)	Date	W.L. (m)	Discharge (cms)	Date	W.L. (m)	Discharge (cms)
1973	-	-	-	Dec. 1	3.90	800	-	-	-
1974	-	-	-	Sept. 30	2.25	292	-	-	-
1975	-	-	-	Dec. 29	2.16	271	-	-	-
1976	-	-	-	Feb. 5	2.05	247	-	-	-
1977	Sept. 29	3.62	373	Sept. 30	2.90	464	-	-	-
1978	Dec. 22	3.36	324	Jan. 25	1.83	202	-	-	-
1979	Dec. 13	3.10	278	Nov. 19	1.80	196	-	-	-
1980	Nov. 3	3.41	333	Mar. 17	1.75	187	Nov. 22	3.26	450
1981	Nov. 17	3.32	317	May. 29	2.22	285	Oct. 23	3.13	416
1982	May. 23	4.18	491	May. 24	2.47	346	Oct. 18	3.31	463
1983	Sept. 13	3.20	295	Dec. 18	2.00	236	Dec. 8	3.60	549
1984	Jan. 25	4.31	521	May. 24	2.10	258	Jan. 25	4.02	674
1985	Nov. 24	3.58	397	Dec. 4	2.42	333	Nov. 26	2.09	193
1986	Dec. 6	3.92	459	Dec. 7	2.80	435	Nov. 2	3.30	460
1987	Nov. 11	3.66	411	Dec. 7	2.60	380	-	-	-
1988	Feb. 16	3.25	304	Nov. 7	2.50	353	Sept. 9	2.75	325
Avg			375			330			441
Max	(1984, Jan.)		521	(1973, Dec.)		800	(1984, Jan.)		674
Min	(1979, Dec.)		278	(1980, Nov.)		187	(1985, Nov.)		193

Note: The peak discharge of the Asahan and Silau rivers are revised and updated in the detailed design work for the Silau and Asahan rivers by DGWRD. The peak discharges of the Asahan and Silau in 1988 and the Kualuh rivers in 1985 to 1988 are estimated in the Part-2 study.



Table A-37 PROBABLE PEAK FLOOD DISCHARGE OF ASAHAN AND SILAU RIVERS UNDER EXISTING CONDITION

(Unit: m<sup>3</sup>/s)

Site	Return Period (year)						
	2	5	10	15	30	50	100
<u>Asahan River</u>							
Regulation dam	315	400	400	400	400	400	400
Proposed site of Parhitean dam	394	562	650	698	807	899	1,033
Before join Sakur R.	512	675	810	882	1,061	1,182	1,403
Pulau Raja	625	826	1,001	1,106	1,355	1,523	1,839
After join Teluk R.	703	848	1,022	1,127	1,377	1,546	1,861
Flood area							
Inflow	904	1,001	1,081	1,187	1,437	1,607	1,923
Outflow	391	429	436	440	447	453	460
After join Kepayang R.	402	440	448	452	459	464	471
After join Silau R.	753	797	810	816	828	835	861
<u>Silau River</u>							
Kisaran	449	457	565	670	911	1,055	1,300
Tanjung Balai	362	369	375	403	463	490	532
<u>Tributaries</u>							
Sakur River	113	157	220	253	326	374	448
Masihi & Teluk Rivers	136	140	143	145	147	149	151
Nantalu & Lebah R.	140	142	143	144	145	145	146
Sukaraja River	106	106	106	106	109	116	124
<u>Max. Flooding W. Level</u>							
Asahan River (EL, m)	3.59	4.07	4.08	4.09	4.10	4.11	4.13
Silau River (EL, m)	3.52	3.56	3.59	3.75	4.07	4.22	4.45

Source: Appendix II in Master Plan Study on the Lower Asahan River Basin Development in Aug. 1985

Table A-38: PROBABLE PEAK FLOOD DISCHARGE OF KUALUH AND KIRI RIVERS UNDER EXISTING CONDITION

Site	(Unit: m <sup>3</sup> /s)						
	Return Period (year)						
	2	5	10	15	30	50	100
<u>Kualuh River</u>							
Pulo Dogom	661	729	880	978	1,101	1,270	1,378
Guntung Saga Atas	657	673	795	885	1,001	1,170	1,299
After join Simangalam River	547	575	605	676	765	877	967
After join Natas R.	760	791	828	914	1,022	1,155	1,265
After join Kanopan R.	669	691	705	714	734	782	822
After join Kuo R.	698	719	732	741	769	816	857
After join Leidong R.	747	772	789	799	812	828	849
<u>Kiri River</u>							
Bunut	51	63	70	73	80	88	95
Desa Gajah	77	92	101	105	113	121	129
After join Silau Tua R.	197	231	253	266	287	307	325
After join Balai R.	251	294	321	338	364	390	413
After join Kanan R.	290	339	353	366	389	412	433
<u>Tributaries</u>							
Tembus R.	221	265	324	362	411	468	521
Simangalam R.	110	111	111	111	112	112	115
Natas R.	214	218	226	240	258	279	299
Kanopan R.	82	82	83	83	83	84	84
Kuo R.	43	43	43	43	43	44	44
Leidong R.	54	54	54	54	54	54	54
Silau Tua R.	78	93	102	108	117	125	132
Balai R.	57	67	74	78	85	92	98
Kanan R.	34	41	46	48	53	57	61

Source: Appendix II in Master Plan Study on the Lower Asahan River Basin Development in Aug. 1985

Table A-39 PROBABLE PEAK FLOOD DISCHARGE OF ASAHAN AND SILAU RIVERS (URGENT PLAN AND LONG-TERM PLAN)

(Unit: m<sup>3</sup>/s)

Site	Urgent plan			Long-term plan			
	5-yr	10-yr	15-yr	with Dam		without Dam	
				15-yr	30-yr	50-yr	30-yr
<u>Asahan River</u>							
Regulation dam	400	400	400	400	400	400	400
Parhitean dam							
Inflow	562	650	698	698	807	899	807
Outflow	562	650	698	500	500	600	807
Before join Sakur R.	675	810	882	690	753	896	1,061
Pulau Raja	826	1,001	1,106	941	1,067	1,250	1,355
Retarding basin							
Inflow	948	1,044	1,106	1,057	1,127	1,250	1,355
Outflow	705	719	723	720	726	734	755
After join Kepayong R.	718	732	736	733	739	747	762
After join Silau R.	1,169	1,171	1,198	1,192	1,322	1,475	1,495
<u>Silau River</u>							
Kisaran	469	565	670	670	911	1,055	911
<u>Tributaries</u>							
Sakur River	157	220	253	253	326	374	326
Masihi & Teluk R.	140	143	145	145	147	149	147
Nantalu River	86	87	87	87	88	88	88
Sukaraja River	106	106	106	106	109	116	109
Lebah River	43	43	44	44	45	47	45
<u>Retarding basin</u>							
Max. W.L. (EL.m)	2.93	3.00	3.02	3.01	3.04	3.07	3.10
Max. Area (km <sup>2</sup> )	89.1	92.0	93.4	92.4	94.2	96.6	98.5
Max. Vol. (MCM)	82.5	87.5	90.0	88.2	91.6	96.3	100.0

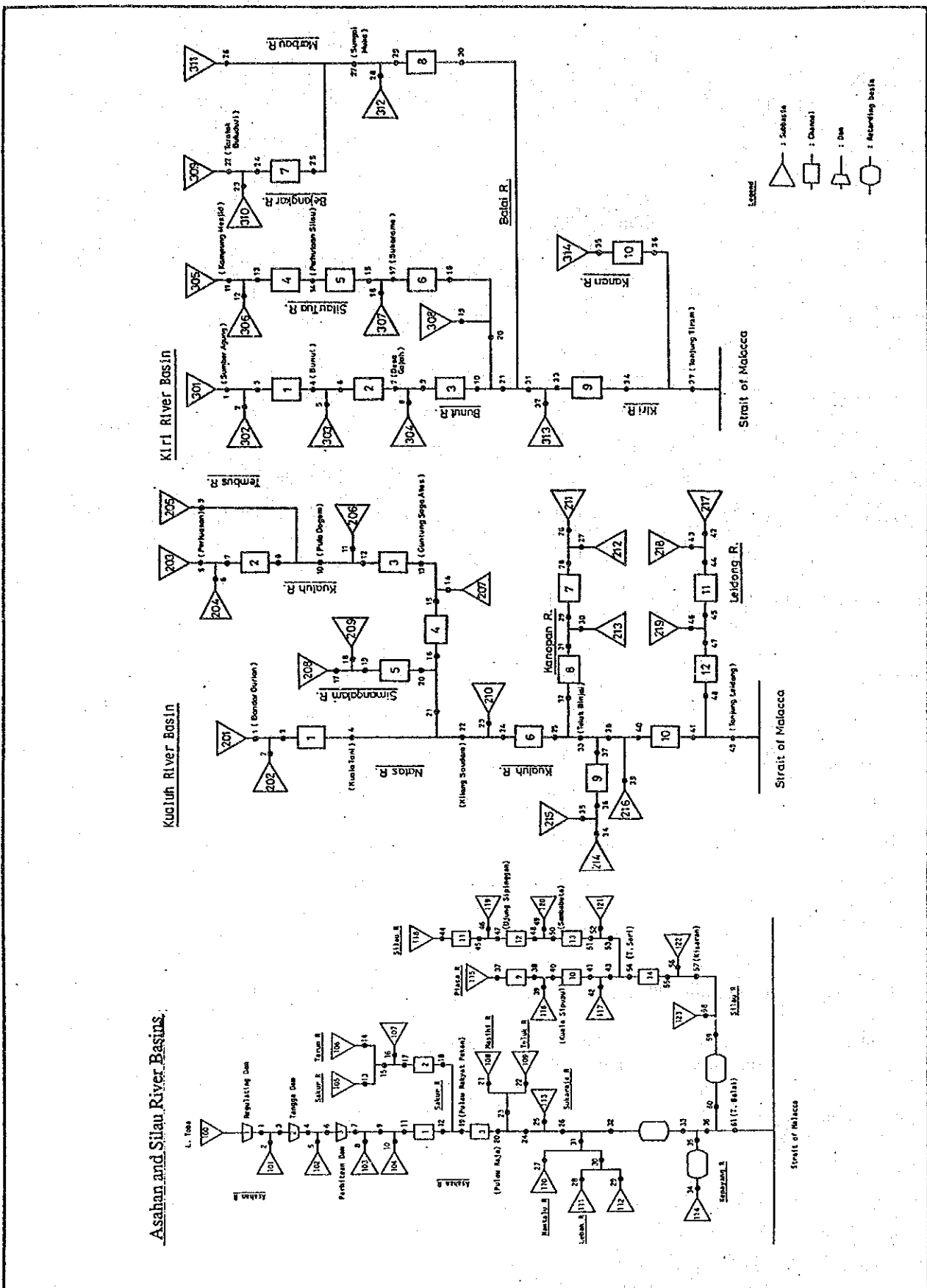
Source: Appendix II in Master Plan Study on the Lower Asahan River Basin Development in Aug. 1985

Table A-40 PROBABLE PEAK FLOOD DISCHARGE OF KUALUH AND KIRI RIVERS (LONG-TERM PLAN WITH CHANNEL IMPROVEMENT)

<u>Kualuh River</u>		<u>Kiri River</u>	
Site	Peak Discharge (m <sup>3</sup> /s)	Site	Peak Discharge (m <sup>3</sup> /s)
<u>Main Stream</u>		<u>Main Stream</u>	
Pulo Dogom	1,101	Bunut	80
Guntung Saga Atas	1,001	Desa Gajah	110
After join Simangalam R.	797	After join Silau Tua R.	298
After join Natas R.	1,055	After join Balai R.	377
After join Kanopan R.	1,006	After join Kanopan R.	394
After join Kuo R.	1,036		
After join Leidong R.	930		
<u>Tributaries</u>		<u>Tributaries</u>	
Tembus R.	411	Silau Tua R.	117
Simangalam R.	112	Balai R.	85
Natas R.	258	Kanan R.	53
Kanopan R.	118		
Kuo R.	43		
Leidong R.	54		

Remarks: Probability of rainfall volume is taken up for 30-year return period.

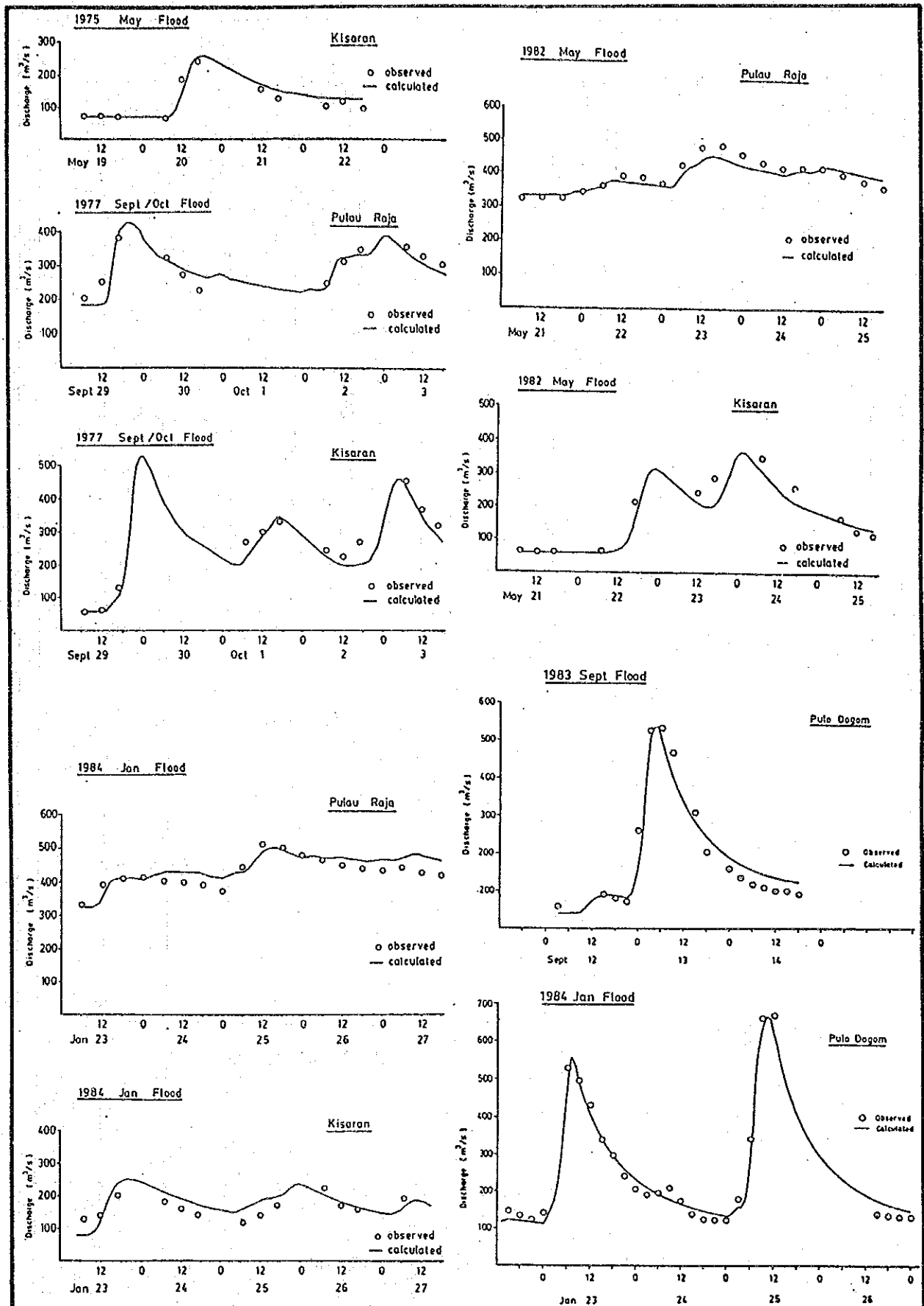
Source: Appendix II in Master Plan Study on the Lower Asahan River Basin Development in Aug. 1985



Source : Appendix II in Master Plan Study on the Lower Asahan River Basin Development in Aug. 1985

Fig. A-13 RUNOFF SIMULATION MODEL

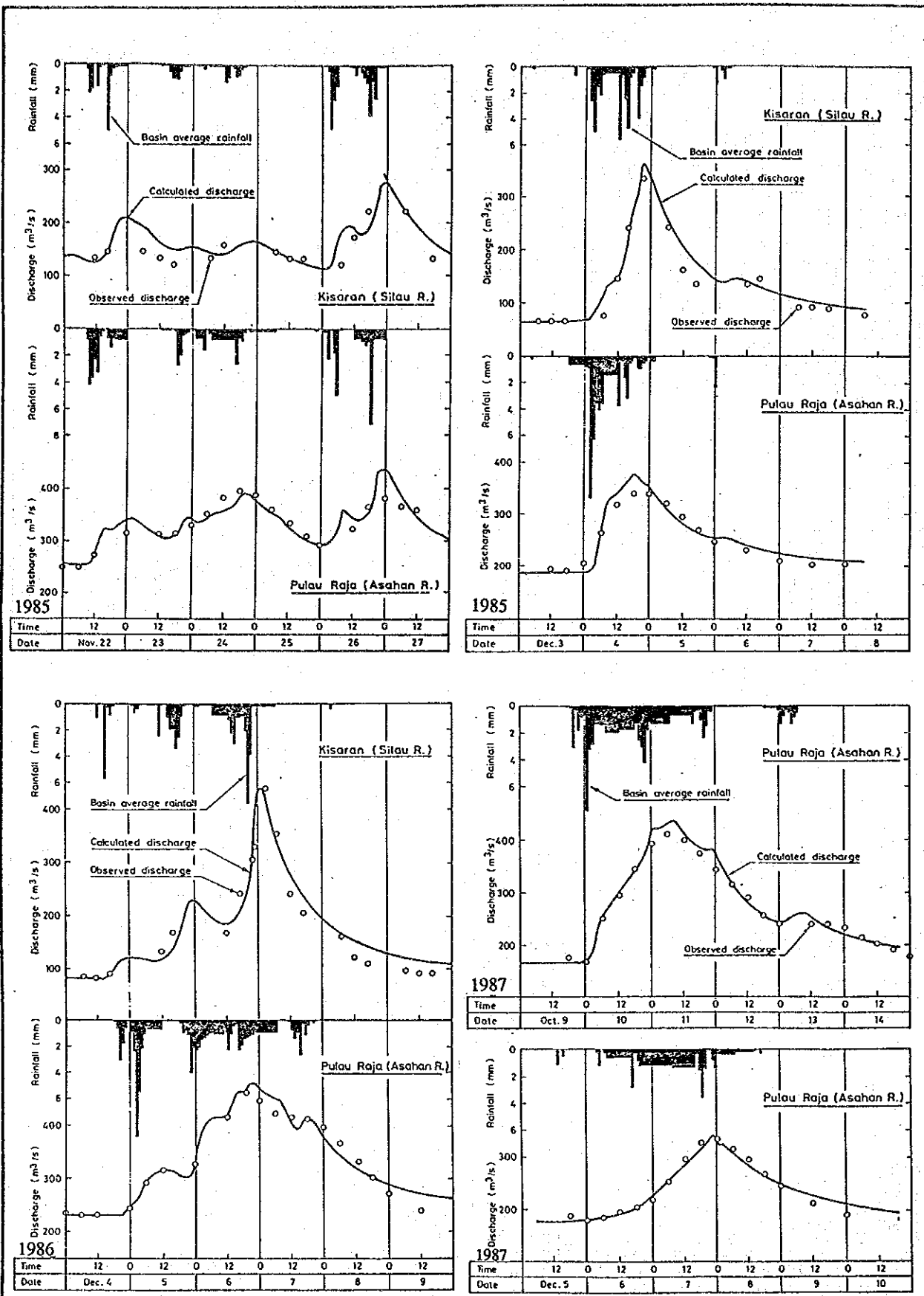
Republic of Indonesia  
 MASTER PLAN STUDY ON  
 LOWER ASAHAN RIVER BASIN DEVELOPMENT  
 Japan International Cooperation Agency



Source : Appendix II in Master Plan Study on the Lower Asahan River Basin Development in Aug. 1985

Fig. A-14 (1/2) DISCHARGE HYDROGRAPH OF MAJOR FLOOD

Republic of Indonesia  
 MASTER PLAN STUDY ON  
 LOWER ASAHAN RIVER BASIN DEVELOPMENT  
 Japan International Cooperation Agency



Source; Study Report on Hydrological Investigation in the Lower Asahan River Flood Control Project, Nov. 1988 DGWRD

Fig. A-14 (2/2) DISCHARGE HYDROGRAPH OF MAJOR FLOOD

Republic of Indonesia  
 MASTER PLAN STUDY ON  
 LOWER ASAHAN RIVER BASIN DEVELOPMENT  
 Japan International Cooperation Agency

Table A-41 DESIGN FLOOD DISCHARGES FOR RIVER STRUCTURES

(Unit : m<sup>3</sup>/s)

River	Type	Proposed Project	Design flood	10-year flood
Bunut	Intake facility	Silau - Bunut	80	70
Silau	Integrated weir	Silau - Bunut	950	600
Silau	Inter basin diversion facility	Silau - Bunut	600	350
Asahan	Intake facility	Leidong-Asahan Pd. Mahondang	1,100 (1,100)	1,100 (1,100)
Kualuh	Intake facility	Aek Naetek	1,050	800
Kualuh	Intake facility	Kualuh Right	1,050	800
Natas	Intake facility	Aek Natas	390	310

## Note:

- 1) Design flood discharges are basically estimated on the basis of the probable peak flood discharges calculated in Part 1 Study. The estimated runoff hydrographs obtained by the flood runoff analysis are shown in Fig. A-14 and the results of major sites of the respective rivers are shown in Tables A-37 to A-40.
- 2) As for the Asahan and Silau rivers, flood runoff was re-analyzed taking into account the additional flood records obtained after 1985 by the Detailed Design Team of the Lower Asahan River Flood Control Project (the Detailed Design Study) in 1988. The analysis is made by storage-function method with coefficients determined in The Part 1 Study. The results of the analysis demonstrated the appropriateness of the flood runoff simulation model constructed by the Part 1 Study Team.
- 3) Runoff simulation model is shown in Fig. A-13.
- 4) Design flood : 30-year return period is adopted in due consideration of long term flood control plan proposed in the Part 1 Study.



Table A-42 SUPPLEMENTAL FORMULA APPLIED FOR FILLING UP VACANT DATA

Station (Y)	Supplemental Station (X)	Correlation Rate	Nos. of Data	Supplemental formula
Tinggi Raja (Piasa R.)	Kisaran (Silau R.)	0.94	26	$\underline{1} Y = 0.4 x -95.2$
Pulo Dogom. (Kualuh R.)	$\underline{3}$ Asahan residual area (per 100 km <sup>2</sup> )	0.83	77	$\underline{2} Y = 6.65 x +9.25$
Bunut Highway Br. (Bunut R.)	Proposed diversion point (Prapat Janji, Silau R.)	0.83	5	$\underline{2} Y = 0.094 x -0.46$
Bandar Durian (Natas R.)	Pulo Dogom (Kualuh R.)	0.90	13	$\underline{2} Y = 0.5 x -1.8$
Pemudilan (Kanopan R.)	Pulo Dogom (Kualuh R.)	0.91	18	$\underline{1} Y = 0.043 x +32.0$

- Note:
- $\underline{1}$  X, Y - monthly total discharge (m<sup>3</sup>/s)
  - $\underline{2}$  X, Y - monthly mean discharge (m<sup>3</sup>/s)
  - $\underline{3}$  The discharge at Pulau Raja in the Asahan river has been affected by the regulation of Lake Toba and the dams upstream, it is not applied to the other stations. Monthly mean discharge at Pulau Raja from residual area excluding the catchment area, therefore, was estimated as the discharge from catchment area of 100 km<sup>2</sup>, based on the discharge at Siruar until 1982 and the inflow to the reservoir of the Tangga Power Station and outflow from its reservoir after 1983 in the upper reaches of the Asahan river. The estimated discharges above mentioned were applied to estimating for the discharge of the Kualuh river.

Table A-43 RUNOFF CHARACTERISTICS OF THE OBJECTIVE RIVERS

Calculating Point	River	Catchment Area (km <sup>2</sup> )	Average Annual Mean Discharge (m <sup>3</sup> /s/100km <sup>2</sup> )	Average Annual Basin Rainfall (mm)	Runoff Rate
Pulau Raja	Asahan	4,486	3.40	1,900 - 2,000	0.55
-	Asahan /1	100	7.42	3,200	0.73
Kisaran	Silau	1,050	6.21	2,800	0.70
Proposed Diversion Point (Prapat Janji)	Silau	605	5.75	2,700	0.67
T. Raja	Piasa	317	7.37	3,100	0.75
Bunut highway	Bunut	115	3.74	2,300	0.51
Aek Kanopan	Kanopan	148	3.70	2,800	0.42
Palo Dogom	Kualuh	1,116	5.29	2,500 - 2,600	0.65
Bandar Durian	Natas	530	5.33	2,400 - 2,500	0.69
Suka Sari	Leidong	50	1.34	2,200	0.19

Note: /1 Residual area excluding catchment area of Lake Toba.

- 1) Estimated monthly mean discharge of the respective rivers and those per catchment area of 100 km<sup>2</sup> are shown in Table A-44 to A-51 and in Fig. A-16.
- 2) The discharges of the Bunut and Kanopan river are estimated on the assumption that the runoff rates of the Bunut and Kanopan rivers are ranging from 0.4 and 0.5 by referring the field discharge measurement results by the Team in the drought season in 1989 and runoff rate of the Percut river, which is considered as similar river to these rivers, located between Medan and Kisaran and having drainage area of 340 km<sup>2</sup>.
- 3) The discharge of the Leidong river, its catchment area is extended over swamp area, is estimated on the assumption that runoff rate of the river is 0.20 by referring to runoff rate at Pemudilan of the Kanopan river.

Table A-44 ESTIMATED MONTHLY MEAN DISCHARGE OF KUALUH RIVER AT PULO DAGOM

YEAR	unit: m3/sec Catchment Area : 1116 km2												ANNUAL
	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	
1973	56.3	46.0	57.9	72.0	55.9	61.0	42.6	53.7	67.0	68.5	63.2	140.3	65.4
1974	70.2	69.6	56.5	59.6	55.7	53.3	51.8	-	57.0	63.6	72.2	65.9	-
1975	65.0	60.5	58.1	81.1	70.9	53.8	52.1	45.8	70.6	71.2	77.5	74.1	65.1
1976	70.9	63.0	51.1	66.6	58.7	57.2	55.5	54.5	55.2	67.3	82.3	70.8	62.8
1977	57.0	51.1	46.6	38.6	46.9	48.7	47.5	47.2	57.5	85.9	74.5	65.3	55.6
1978	49.6	55.8	49.9	46.9	48.6	54.2	44.0	28.9	40.2	47.2	60.9	72.0	49.9
1979	46.0	34.6	26.3	42.4	31.2	55.1	28.1	22.7	36.2	53.9	84.4	67.3	44.0
1980	52.7	44.2	78.5	59.1	72.6	45.9	28.0	49.3	43.8	69.3	84.6	59.8	57.3
1981	93.4	67.0	33.0	55.5	79.1	49.4	47.8	26.0	78.5	80.0	68.0	45.5	60.3
1982	34.2	55.5	58.3	81.4	79.6	42.3	36.6	43.0	52.7	78.4	53.8	63.0	56.6
1983	55.0	35.1	30.1	21.1	35.7	40.1	50.0	30.6	82.3	75.2	55.8	104.3	51.3
1984	111.1	80.9	87.4	103.3	116.6	57.9	47.4	42.4	50.1	68.8	59.7	80.6	75.5
1985	58.3	50.8	84.2	56.2	65.4	30.0	25.7	30.0	49.9	74.9	83.5	84.1	57.8
1986	96.8	85.1	63.5	70.5	51.2	46.3	27.6	21.1	24.5	81.7	111.3	83.5	63.6
1987	46.3	43.5	45.1	50.3	65.0	33.7	40.0	54.1	59.3	89.1	106.8	104.7	61.5
1988	61.9	80.7	52.2	-	-	-	-	101.8	141.1	57.9	87.3	103.5	-
1989	76.2	29.3	56.3	51.6	-	-	-	-	-	-	-	-	-
AVE. per 100 km2	64.8	56.0	55.0	59.8	62.2	48.6	41.6	43.4	60.4	70.8	76.6	80.3	59.0
	5.80	5.02	4.93	5.36	5.57	4.35	3.73	3.89	5.41	6.34	6.86	7.19	5.29

Table A-45 ESTIMATED MONTHLY MEAN DISCHARGE OF PIASA RIVER AT TINGGI RAJA

YEAR	unit: m3/sec Catchment Area : 317 km2												ANNUAL
	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	
1973	20.68	14.69	21.85	30.70	20.21	23.71	12.55	19.70	27.43	29.67	24.96	72.86	26.58
1974	29.54	30.01	20.75	22.68	20.24	18.83	18.02	-	21.07	24.49	30.66	27.29	-
1975	26.25	23.06	21.86	36.41	30.09	19.16	18.18	14.32	29.75	30.18	34.19	32.01	26.29
1976	30.11	23.54	17.55	27.97	22.30	21.31	20.24	20.15	19.97	27.71	37.20	30.08	24.84
1977	21.12	17.41	14.81	14.96	16.46	16.14	9.92	13.54	18.55	45.16	34.20	29.24	20.96
1978	16.60	17.81	14.83	14.42	16.67	20.15	16.19	8.88	16.08	22.26	21.95	24.62	17.54
1979	17.55	14.08	11.95	21.00	14.55	20.52	13.66	10.29	17.57	21.37	34.96	23.00	18.38
1980	17.36	-	26.53	16.60	24.94	13.72	10.83	26.46	17.73	21.50	33.53	23.75	-
1981	25.51	19.90	13.18	17.02	30.65	15.40	15.05	9.74	28.02	29.23	25.88	15.96	20.46
1982	16.19	19.89	24.28	33.05	35.65	14.86	14.17	15.91	18.45	23.01	21.31	18.89	21.30
1983	14.97	10.48	12.39	7.61	14.91	13.09	15.26	13.86	26.04	31.88	16.34	29.73	17.21
1984	39.55	39.86	33.82	29.11	48.97	26.32	20.41	20.43	22.39	29.40	32.34	34.89	31.46
1985	25.76	18.96	24.34	23.21	27.58	11.88	15.94	14.39	23.30	36.42	43.16	41.85	25.57
1986	35.52	35.50	28.31	37.88	16.16	25.04	12.12	9.33	13.08	36.45	28.28	31.98	25.80
1987	15.45	11.04	24.74	23.37	22.64	13.75	14.49	25.34	23.90	39.92	33.46	-	-
1988	26.77	35.05	28.55	16.07	19.74	24.42	23.75	20.00	39.47	19.48	30.17	46.55	27.50
1989	24.13	14.71	-	-	-	-	-	-	-	-	-	-	-
AVE. per 100 km2	23.71	21.70	21.23	23.25	23.86	18.64	15.67	16.16	22.68	29.26	30.16	32.18	23.38
	7.48	6.85	6.70	7.34	7.53	5.88	4.94	5.10	7.15	9.23	9.51	10.15	7.37

Table A-46 ESTIMATED MONTHLY MEAN DISCHARGE OF NATAS RIVER AT BANDAR DURIAN

YEAR	Catchment Area: 530 km <sup>2</sup> unit: m <sup>3</sup> /sec												ANNUAL
	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	
1973	26.4	21.2	27.2	34.2	26.2	28.7	19.5	25.1	31.7	32.5	29.8	68.4	30.9
1974	33.3	33.0	26.5	28.0	26.1	24.9	24.1	-	26.7	30.0	34.3	31.2	-
1975	30.7	28.5	27.3	38.8	33.7	25.1	24.3	21.1	33.5	33.8	37.0	35.2	30.8
1976	33.7	29.7	23.8	31.5	27.6	26.8	26.0	25.5	25.8	31.9	39.4	33.6	29.6
1977	26.7	23.8	21.5	17.5	21.7	22.6	22.0	21.8	27.0	41.2	35.5	30.9	26.0
1978	23.0	26.1	23.2	21.7	22.5	25.3	20.2	12.7	18.3	21.8	28.7	34.2	23.1
1979	21.2	15.5	11.4	19.4	13.8	25.8	12.3	9.6	16.3	25.2	40.4	31.9	20.2
1980	24.6	20.3	37.5	27.8	34.5	21.2	12.2	22.9	20.1	32.9	40.5	28.1	26.9
1981	44.9	31.7	14.7	26.0	37.8	22.9	22.1	11.2	37.5	38.2	32.2	21.0	28.4
1982	15.3	26.0	27.4	38.9	38.0	19.4	16.5	19.7	24.6	37.4	25.1	29.7	26.5
1983	25.7	15.8	13.3	8.8	16.1	18.3	23.2	13.5	39.4	35.8	26.1	50.4	23.9
1984	53.8	38.7	41.9	49.9	56.5	27.2	21.9	19.4	23.3	35.7	31.9	41.4	36.8
1985	27.4	23.6	40.3	26.3	30.9	13.2	12.3	14.0	11.9	35.7	40.0	40.3	26.3
1986	46.6	40.8	30.0	38.0	19.2	25.8	12.0	10.6	20.2	43.0	53.9	40.0	31.7
1987	21.4	20.0	20.8	23.4	30.7	15.1	18.2	25.3	27.9	42.8	51.6	50.6	29.0
1988	29.2	38.6	24.3	26.8	21.3	29.2	37.2	52.0	41.9	31.7	26.6	46.5	33.8
1989	20.5	23.3	43.1	44.5	-	-	-	-	-	-	-	-	-
AVE.	29.7	26.9	26.7	29.5	28.5	23.2	20.3	20.3	26.6	34.4	35.8	38.3	28.3
per 100 km <sup>2</sup>	5.60	5.07	5.04	5.57	5.38	4.38	3.82	3.83	5.02	6.48	6.76	7.23	5.33

Table A-47 ESTIMATED MONTHLY MEAN DISCHARGE OF BUNUT RIVER AT HIGHWAY BRIDGE

YEAR	Catchment Area: 115 km <sup>2</sup> unit: m <sup>3</sup> /sec												ANNUAL
	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	
1973	3.94	3.11	4.11	5.51	3.88	4.44	2.71	3.79	5.00	5.31	4.62	11.92	4.86
1974	5.30	5.46	3.95	4.27	3.88	3.69	3.53	-	4.03	4.76	5.50	4.95	-
1975	4.79	4.40	4.11	6.39	5.40	3.73	3.56	2.98	5.35	5.40	6.04	5.68	4.82
1976	5.39	4.94	3.46	5.09	4.19	4.06	3.88	3.87	3.87	5.03	6.50	5.39	4.64
1977	4.02	3.45	3.05	3.09	3.30	3.29	2.31	2.85	3.64	7.69	6.04	5.26	4.00
1978	3.32	3.60	3.05	3.01	3.34	3.88	3.26	2.14	3.26	4.18	4.16	4.55	3.48
1979	3.47	3.01	2.61	4.02	3.00	3.94	2.87	2.36	3.50	4.05	6.15	4.30	3.61
1980	3.43	-	5.10	3.35	4.60	2.90	2.45	4.82	3.53	4.06	5.94	4.41	-
1981	4.70	3.90	2.79	3.42	5.46	3.16	3.08	2.27	5.10	5.25	4.76	3.22	3.93
1982	3.26	3.90	4.50	5.87	6.23	3.08	2.95	3.22	3.62	4.30	4.06	3.67	4.06
1983	3.06	2.47	2.68	1.98	3.06	2.80	3.11	2.89	4.79	5.66	3.31	5.34	3.43
1984	6.82	6.92	5.96	5.26	8.27	4.83	3.90	3.90	4.23	5.29	5.76	6.12	5.60
1985	4.72	3.77	4.51	4.36	4.99	2.62	3.30	2.68	4.05	4.84	6.10	7.38	4.44
1986	6.65	5.31	5.46	6.30	3.58	2.94	2.64	2.21	3.57	7.02	5.92	4.86	4.71
1987	3.43	3.94	3.51	4.13	4.47	3.53	3.77	5.05	-	-	-	-	-
1988	-	-	-	-	-	-	-	-	8.33	5.23	-	-	-
1989	4.47	3.13	-	-	-	-	-	-	-	-	-	-	-
AVE.	4.42	4.09	3.92	4.40	4.51	3.53	3.15	3.22	4.39	5.20	5.35	5.50	4.30
per 100 km <sup>2</sup>	3.85	3.55	3.41	3.83	3.92	3.07	2.74	2.80	3.82	4.53	4.65	4.79	3.74

Table A-48 ESTIMATED MONTHLY MEAN DISCHARGE OF KANOPAN RIVER AT A/K KANOPAN

YEAR	unit: m3/sec Catchment Area : 148 km2												
	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
1973	5.23	4.27	5.37	6.68	5.19	5.66	3.95	4.99	6.22	6.36	5.87	13.02	6.07
1974	6.52	6.46	5.24	5.53	5.17	4.95	4.81	-	5.29	5.90	6.70	6.12	-
1975	6.03	5.62	5.39	7.53	6.58	4.99	4.84	4.25	6.55	6.61	7.19	6.88	6.04
1976	6.58	5.85	4.74	6.18	5.45	5.31	5.15	5.06	5.12	6.25	7.64	6.57	5.83
1977	5.29	4.74	4.33	3.58	4.35	4.52	4.41	4.38	5.34	7.97	6.92	6.06	5.16
1978	4.60	5.18	4.63	4.35	4.51	5.03	4.08	2.68	3.73	4.38	5.65	6.68	4.63
1979	4.27	3.21	2.44	3.94	2.90	5.12	2.61	2.11	3.36	5.00	7.83	6.25	4.09
1980	4.89	4.10	7.29	5.49	6.74	4.26	2.60	4.58	4.07	6.43	7.85	5.55	5.32
1981	8.67	6.22	3.06	5.15	7.34	4.59	4.44	2.41	7.29	7.43	6.31	4.22	5.59
1982	3.17	5.15	5.41	7.56	7.39	3.93	3.40	3.99	4.89	7.28	4.99	5.85	5.25
1983	5.11	3.26	2.79	1.96	3.31	3.72	4.64	2.84	7.64	6.98	5.18	9.68	4.76
1984	10.31	7.51	8.11	9.59	10.82	5.37	4.40	3.94	4.65	6.39	5.54	7.48	7.01
1985	5.41	4.72	7.82	5.22	6.07	2.78	2.39	2.78	4.63	6.95	7.75	7.81	5.36
1986	8.99	7.90	5.89	6.54	4.75	4.30	2.56	1.96	2.27	7.58	10.33	7.75	5.90
1987	4.30	4.04	4.19	4.67	6.03	3.13	3.71	5.02	5.50	8.27	9.91	9.72	5.71
1988	5.75	7.49	4.85	-	-	-	-	9.45	13.10	5.37	8.10	9.61	-
1989	7.07	2.72	5.23	4.79	-	-	-	-	-	-	-	-	-
AVE.	6.01	5.20	5.11	5.55	5.77	4.51	3.87	4.03	5.60	6.57	7.11	7.45	5.48
per 100 km2	4.06	3.52	3.45	3.75	3.90	3.05	2.61	2.72	3.79	4.44	4.81	5.04	3.70

Table A-49 ESTIMATED MONTHLY MEAN SPECIFIC DISCHARGE OF ASAHAN RIVER

YEAR	unit: m3/sec Catchment Area: per 100 km2												
	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
1973	7.08	5.53	7.31	9.44	7.01	7.78	5.01	6.69	8.68	8.91	8.12	19.70	8.44
1974	9.16	9.08	7.10	7.57	6.98	6.62	6.40	-	7.18	8.17	9.46	8.52	-
1975	8.38	7.70	7.35	10.80	9.27	6.70	6.45	5.50	9.23	9.32	10.26	9.75	8.39
1976	9.27	8.09	6.30	8.62	7.43	7.21	6.95	6.80	6.91	8.73	10.98	9.26	8.05
1977	7.18	6.29	5.62	4.42	5.66	5.93	5.75	5.71	7.26	11.52	9.81	8.43	6.96
1978	6.07	7.00	6.11	5.66	5.91	6.76	5.23	2.96	4.65	5.71	7.77	9.44	6.11
1979	5.52	3.81	2.56	4.99	3.30	6.89	2.84	2.03	4.05	6.71	11.30	8.73	5.23
1980	6.01	5.21	9.05	5.62	9.54	5.65	4.22	7.95	5.63	7.14	13.00	8.12	7.26
1981	8.19	6.96	5.27	6.20	9.41	5.80	5.72	4.74	12.96	9.80	11.37	8.04	7.87
1982	5.95	6.68	7.45	7.94	10.97	6.84	6.34	5.63	6.01	8.95	5.58	6.69	6.69
1983	5.17	4.11	5.36	3.06	4.50	4.73	7.36	5.41	9.62	9.71	6.34	10.50	6.32
1984	11.34	7.70	8.92	8.42	9.68	9.86	6.92	5.68	6.77	10.14	8.54	10.75	8.73
1985	8.21	5.69	8.69	6.79	8.77	3.78	4.31	3.77	5.56	8.02	15.62	14.31	7.79
1986	11.53	9.08	7.84	11.68	4.64	5.39	3.45	2.69	5.50	11.55	12.49	12.49	8.19
1987	5.57	5.15	5.39	6.17	8.38	3.68	4.62	6.74	7.52	12.01	14.67	14.35	7.85
1988	7.91	10.74	6.46	-	-	-	-	-	13.17	7.78	-	-	-
1989	7.48	5.05	-	-	-	-	-	-	-	-	-	-	-
AVE.	7.65	6.70	6.67	7.16	7.43	6.24	5.44	5.16	7.54	9.01	10.35	10.61	7.42

Note: Discharge from the residual area only : the discharge from upstream catchment area of the Lake Toba is not included.

Table A-50 ESTIMATED MONTHLY MEAN DISCHARGE OF THE LEIDONG RIVER AT SUKA SARI

unit: m<sup>3</sup>/sec  
Catchment Area : 50 km<sup>2</sup>

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
1973	0.63	0.52	0.65	0.81	0.63	0.68	0.48	0.60	0.75	0.77	0.71	1.57	0.73
1974	0.79	0.78	0.63	0.67	0.62	0.60	0.58	-	0.64	0.71	0.81	0.74	-
1975	0.73	0.68	0.65	0.91	0.79	0.60	0.58	0.51	0.79	0.80	0.87	0.83	0.73
1976	0.79	0.71	0.57	0.75	0.66	0.64	0.62	0.61	0.62	0.75	0.92	0.79	0.70
1977	0.64	0.57	0.52	0.43	0.53	0.55	0.53	0.53	0.64	0.96	0.83	0.73	0.62
1978	0.56	0.63	0.56	0.53	0.54	0.61	0.49	0.32	0.45	0.53	0.68	0.81	0.56
1979	0.52	0.39	0.29	0.47	0.35	0.62	0.31	0.25	0.41	0.60	0.95	0.75	0.49
1980	0.59	0.50	0.88	0.66	0.81	0.51	0.31	0.55	0.49	0.78	0.95	0.67	0.64
1981	1.05	0.75	0.37	0.62	0.89	0.55	0.54	0.29	0.88	0.90	0.76	0.51	0.68
1982	0.38	0.62	0.65	0.91	0.89	0.47	0.41	0.48	0.59	0.88	0.60	0.71	0.63
1983	0.62	0.39	0.34	0.24	0.40	0.45	0.56	0.34	0.92	0.84	0.63	1.17	0.57
1984	1.24	0.91	0.98	1.16	1.31	0.65	0.53	0.47	0.56	0.77	0.67	0.90	0.85
1985	0.65	0.57	0.94	0.63	0.73	0.34	0.29	0.34	0.56	0.84	0.94	0.94	0.65
1986	1.08	0.95	0.71	0.79	0.57	0.52	0.31	0.24	0.27	0.92	1.25	0.94	0.71
1987	0.52	0.49	0.51	0.56	0.73	0.38	0.45	0.61	0.66	1.00	1.20	1.17	0.69
1988	0.69	0.90	0.58	-	-	-	-	1.14	1.58	0.65	0.98	1.16	-
1989	0.85	0.33	0.63	0.58	-	-	-	-	-	-	-	-	-
AVE.	0.73	0.63	0.62	0.67	0.70	0.54	0.47	0.49	0.68	0.79	0.86	0.90	0.67

Table A-51 ESTIMATED MONTHLY MEAN DISCHARGE OF SILAU RIVER AT PRAPAT JANJI  
(PROPOSED DIVERSION POINT)Catchment Area: 605 km<sup>2</sup>  
unit: m<sup>3</sup>/sec

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
1973	31.9	25.2	33.3	44.6	31.4	35.9	21.9	30.7	40.5	43.0	37.4	96.5	39.4
1974	42.9	44.2	32.0	34.6	31.4	29.9	28.6	-	32.6	38.5	44.5	40.1	-
1975	38.8	35.6	33.3	51.7	43.7	30.2	28.8	24.1	43.3	43.7	48.9	46.0	39.0
1976	43.6	40.0	28.0	41.2	33.9	32.9	31.4	31.3	31.3	40.7	52.6	43.6	37.5
1977	32.5	27.9	24.7	25.0	26.7	26.6	18.7	23.1	29.5	62.2	48.9	42.6	32.4
1978	26.9	29.1	24.7	24.4	27.0	31.4	26.4	17.3	26.4	33.8	33.7	36.8	28.2
1979	28.1	24.4	21.1	32.5	24.3	31.9	23.2	19.1	28.3	32.8	49.8	34.8	29.2
1980	27.8	-	41.3	27.1	37.2	23.5	19.8	39.0	28.6	32.9	48.1	35.7	-
1981	38.0	31.6	22.6	27.7	44.2	25.6	24.9	18.4	41.3	42.5	38.5	26.1	31.8
1982	26.4	31.6	36.4	47.5	50.4	24.9	23.9	26.1	29.3	34.8	32.9	29.7	32.8
1983	24.8	20.0	21.7	16.0	24.8	22.7	25.2	23.4	38.8	45.8	26.8	43.2	27.8
1984	55.2	56.0	48.2	42.6	66.9	39.1	31.6	31.6	34.2	42.8	46.6	49.5	45.4
1985	38.2	30.5	36.5	35.3	40.4	21.2	26.7	21.7	32.8	39.2	49.4	59.7	36.0
1986	53.8	43.0	44.2	51.0	29.0	23.8	21.4	17.9	28.9	56.8	47.9	39.3	38.1
1987	27.8	31.9	28.4	33.4	36.2	28.6	30.5	40.9	-	-	-	-	-
1988	-	-	-	-	-	-	-	-	67.4	42.3	-	-	-
1989	36.2	25.3	-	-	-	-	-	-	-	-	-	-	-
AVE.	35.8	33.1	31.8	35.6	36.5	28.5	25.5	26.0	35.5	42.1	43.3	44.5	34.8
per 100 km <sup>2</sup>	5.92	5.47	5.25	5.89	6.03	4.72	4.22	4.30	5.88	6.96	7.15	7.36	5.75

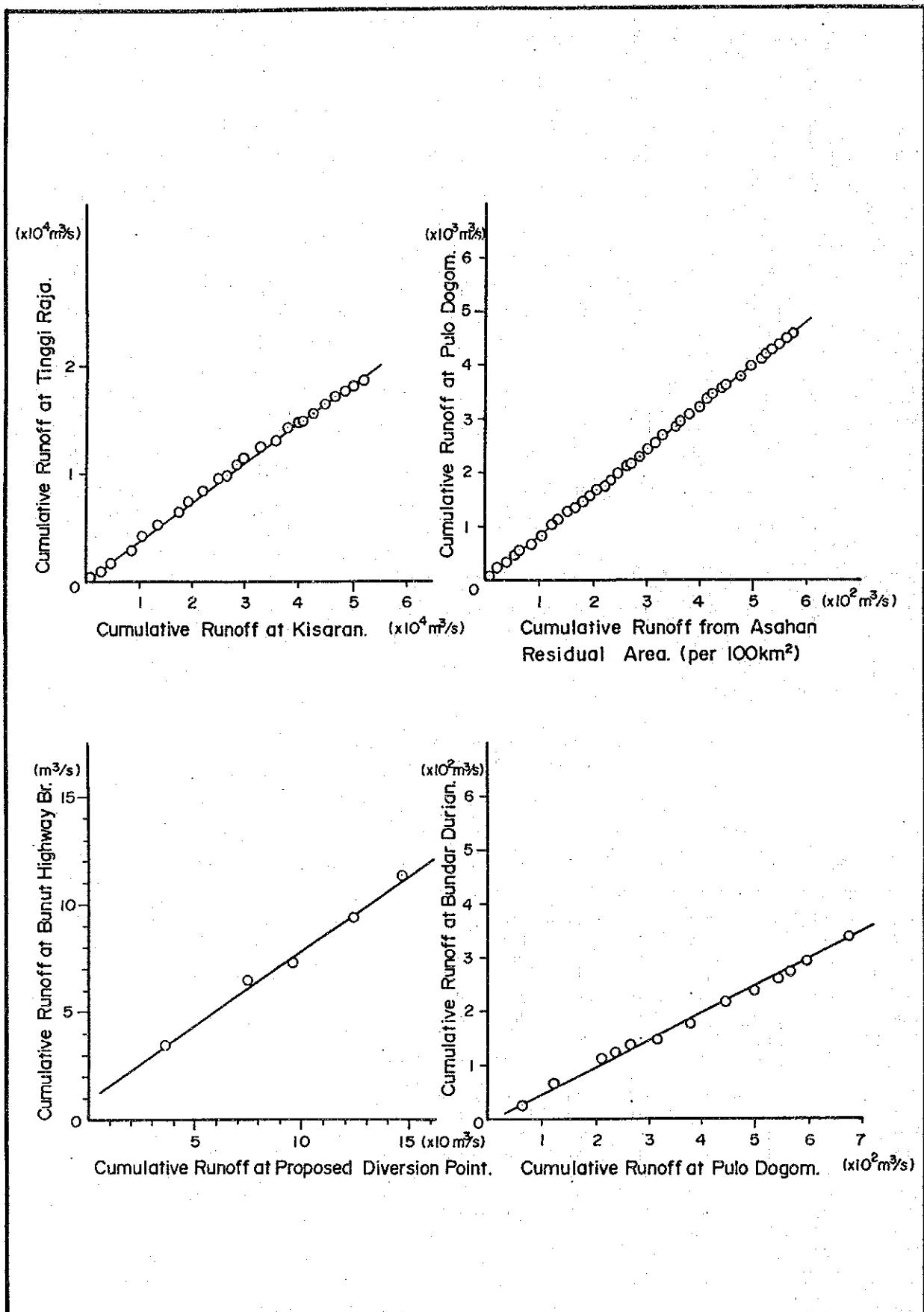


Fig. A-15 DOUBLE MASS CURVE FOR RIVER RUNOFF

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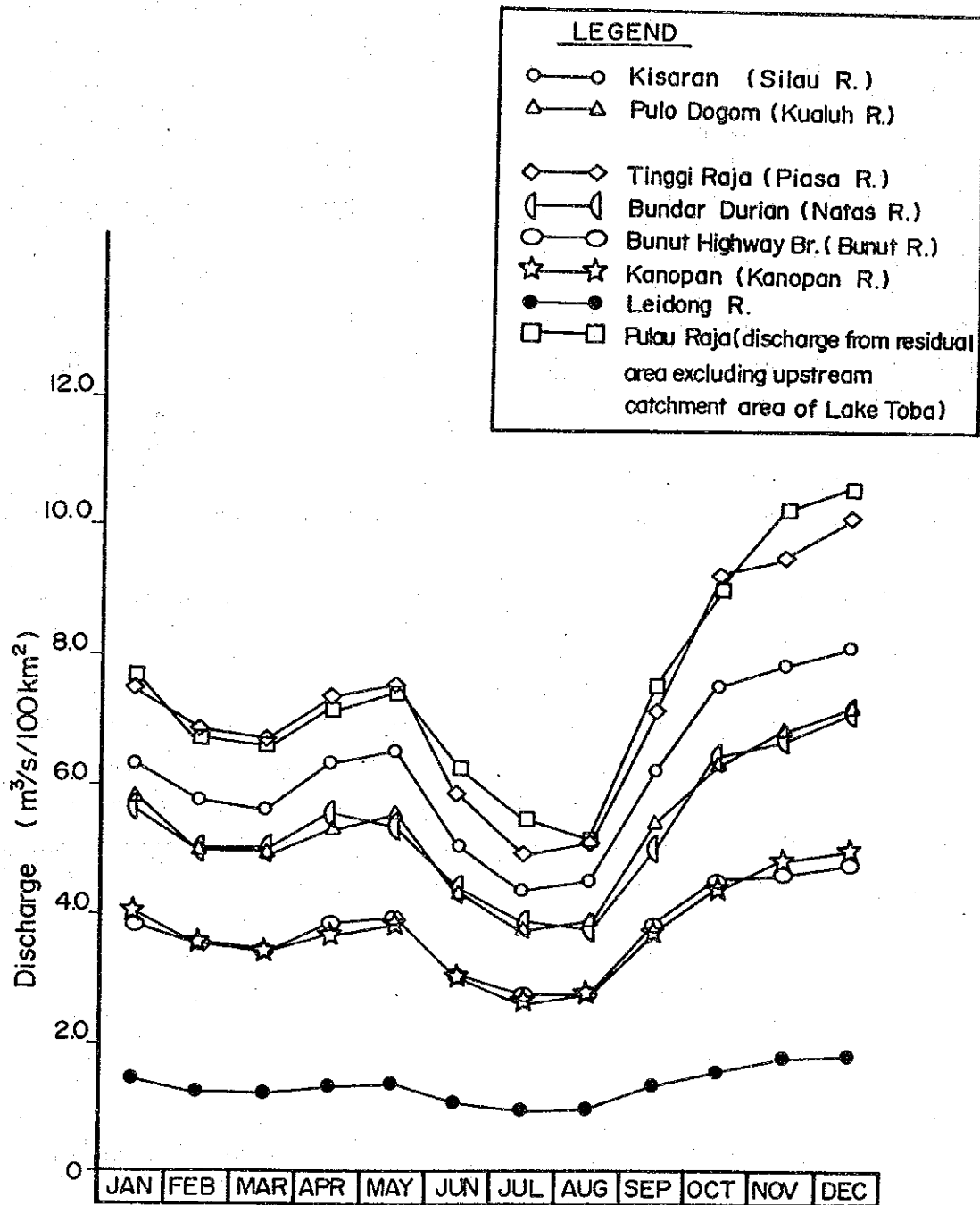


Fig. A-16 ESTIMATED MONTHLY MEAN SPECIFIC DISCHARGES

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Table A-52 SUMMARY OF PROBABLE DROUGHT DISCHARGES

Name of Station	Name of River	Catchment Area (km <sup>2</sup> )	Drought Discharge (m <sup>3</sup> /s)	Specific Drought Discharge (m <sup>3</sup> /s/km <sup>2</sup> )
Kisaran	Silau	1,050	29.9	0.028
Tinggi Raja	Piasa	317	9.3	0.029
Pulau Raja	Asahan	4,486	81.5	0.018
Pulo Dogom	Kualuh	1,116	24.4	0.022
Bandar Durian	Natas	530	10.9	0.021
Bunut highway bridge	Bunut	115	2.1	0.018
Kanopan	Kanopan	148	2.3	0.015
Proposed Diversion point	Silau	605	17.0	0.028

## Note:

- 1) Drought discharges of the respective rivers were estimated by Gumbel Method.
- 2) The results of monthly non-exceedance probability of the respective rivers are shown in Table A-53.
- 3) As for the Asahan river, the influence on the discharge at Pulau Raja due to the regulation of the dams does not exist judging from the observed monthly discharge before and after 1981. Drought discharge at Pulau Raja, therefore, was calculated in same method. At present No. 3 dam is projected downstream from Tangga dam in the Asahan river, however, proposed No. 3 dam will not affect drought discharge badly because of the regulation of it.

Table A-53 PROBABLE MONTHLY DISCHARGES OF RIVERS (NON-EXCEEDANCE)

## 5-years return period

River	Station	C.A (Km <sup>2</sup> )	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec	Annual
Silau	Kisaran	1,050	50.7	44.3	44.9	48.9	49.2	44.2	39.4	34.6	50.9	65.9	69.9	60.0	56.0
Piasa	Tinggi Raja	317	17.5	13.9	15.7	15.9	16.4	14.7	12.5	11.3	17.2	22.9	24.7	21.5	19.7
Asahan	Pulau Raja	4,486	126.6	105.1	110.5	114.2	110.7	119.1	111.4	97.1	116.3	135.5	154.9	150.5	128.6
Kualuh	Pulo Dogom	1,116	47.5	41.6	40.2	43.0	44.5	41.9	33.7	27.5	40.0	61.6	62.1	60.8	52.5
Natas	Bandar Durian	530	21.0	20.2	18.5	20.7	19.7	19.8	14.6	12.3	19.4	29.8	28.6	28.7	24.6
Bunut	Highway Br.	115	3.4	3.1	3.0	3.3	3.3	3.0	2.7	2.4	3.5	4.3	4.6	4.0	3.7
Kanopan	Aek Kanopan	148	4.4	3.9	3.7	4.0	4.1	3.9	3.1	2.6	3.7	5.7	5.8	5.6	4.9
Leidon		per 100	1.1	0.9	0.9	1.0	1.0	0.9	0.8	0.6	0.9	1.4	1.4	1.4	1.2
Silau	P.Janji *	605	27.7	25.1	24.5	26.8	27.1	24.1	22.1	19.5	28.0	35.2	37.5	32.0	30.3

## 10-years return period

River	Station	C.A (Km <sup>2</sup> )	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec	Annual
Silau	Kisaran	1,050	45.3	39.8	38.9	39.4	44.6	40.6	35.9	29.9	48.3	62.3	61.2	56.5	52.0
Piasa	Tinggi Raja	317	15.2	11.3	12.9	12.3	14.7	12.8	11.2	9.3	15.6	20.6	21.4	19.6	17.9
Asahan	Pulau Raja	4,486	110.9	96.4	93.4	97.4	93.4	108.8	103.4	85.0	106.0	125.6	139.1	135.6	118.3
Kualuh	Pulo Dogom	1,116	42.1	35.1	33.7	35.5	39.4	37.2	28.6	24.4	36.4	55.9	56.8	55.4	49.3
Natas	Bandar Durian	530	18.6	17.4	14.8	16.4	17.3	17.3	12.7	10.9	16.0	26.9	26.2	26.1	22.9
Bunut	Highway Br.	115	3.1	2.8	2.7	2.7	3.1	2.8	2.5	2.1	3.3	4.1	4.1	3.7	3.5
Kanopan	Aek Kanopan	148	3.9	3.3	3.1	3.3	3.7	3.5	2.7	2.3	3.4	5.2	5.3	5.1	4.6
Leidon		per 100	0.9	0.8	0.8	0.8	0.9	0.8	0.6	0.5	0.8	1.3	1.3	1.2	1.1
Silau	P.Janji *	605	25.1	22.8	21.6	22.2	24.8	22.3	20.3	17.2	26.9	33.4	33.2	30.3	28.3

Note: \* : Proposed diversion point from the Silau river to the Bunut river

C.A : Catchment area

