The cost disbursement schedule is as follows:

(Unit: million M$)

Year	SEK-1 (RES) 11.8MW	SEK-2 (RES) 17.0MW	K'WIT (RES) 25.1MW	MUKOH (RUN) 1.94MW	KAPIT-2 (RES) 4.2MW	PASIA (RUN) 12.4MW	MED-2 (RUN) 4.6MW
1	23.6	37.8	54.2	3.8	11.6	16.0	9.6
2	29.5	47.3	67.8	9.4	14.5	40.0	24.1
3	41.3	66.1	94.8	5.7	20.3	24.0	14.4
4	15.3	29.8	40.6	-	7.9	-	-
Extension*	7.9	8.0	13.5	2.4	3.7	7.0	-
Total	117.6	189.0	270.9	21.3	58.0	86.0	48.1

Note : * Installation of 2nd unit

(2) OM cost

Operation and maintenance costs of the hydropower stations are estimated at 1.0% and 0.5% of the direct construction cost excluding engineering service and land acquisition/compensation costs.

14.3.2 Thermal power costs

(1) Construction cost

In view of relatively small size of the proposed hydropower schemes, diesel power is selected at this study stage to be the most-likely alternative thermal plant (Ref. Section 13.1 hereinbefore).

In developing the cost stream, following are taken into consideration:

(a) Annual growth of power demand is less than 1 MW in all the demand centres. The extension of system capacity would be a series of installation of 1 MW class diesel generators.

(b) Installation of diesel will be at 2-year interval or more (not to be in every year).

(c) Retirement of the existing diesel generators will be as scheduled by SESCO up to year 1991 and subsequently at the end of service life herein assumed to be 15 years.

Unit construction cost of diesel generators to be newly installed is estimated as M$3,200/kW (Ref. Subsection 13.2.1 hereinbefore). The equipment will be of a light fuel oil burning type.

(2) OM cost

(a) Fixed OM cost : 3% of capital cost per annum

(b) Variable OM cost : M¢ 0.52 (=US¢ 0.20) per kWh of generation

(3) Fuel cost

The following rates are used in evaluation:

Description	Light Fuel Oil	High Speed Diesel Oil
Fuel price 1/	M cent 40/lit.	M cent 60/lit.
Consumption per kWh	0.3 lit.	0.3 lit.
Fuel cost per kWh	M$ 0.12	M$ 0.18

Note : 1/ Average price in 1985-86

In calculating the fuel costs, following are also taken into account:

(a) Fuel consumption for station use : approximately 4% of power generation for supply to the system,

(b) Higher fuel price by 6% in Kapit area.

14.3.3 Cost streams

Merit of hydropower schemes is evaluated by comparing the following two cost streams:

(a) All diesel programme (to represent a benefit stream)

(b) Hydro + diesel programme (to represent a cost stream)

Construction of cost streams takes the following into consideration:

(a) Investment horizon : 25 years from 1986 through 2010

(b) Evaluation horizon : 25 years from that hydropower is commissioned

(c) Power demand : As projected by SESCO (Ref. 25, See page 82)

(d) System capacity	:	Peak demand + reserve capacity (largest diesel unit or 20% of peak demand, whichever is larger)
(e) Hydro energy	:	A particular aspect is that, owing to relatively small size of power demands, all of hydropower energy would not be fed by the system during the initial period. Saleable hydro energy in each year was computed through a flow duration-load duration simulation analysis.

A cash flow schedule was prepared initially on the basis of financial cost for each scheme. Examples of the cash flow schedule are presented in Tables 14.2 to 14.6 for the cases of Mukoh, Pasia and Medamit-2, including that for the case of "All Diesel Programme" for Kapit and Limbang systems. These cash flow schedules are later used as the cost stream for economic analysis, after being converted to economic cost.

14.3.4 Economic costs used in evaluation

The evaluation is based on economic costs assessed for both hydropower and diesel alternatives. In this evaluation, the following conversion factors are introduced to derive the economic cost of each component of the works:

	Conversion Factor
Hydro cost:	
- Civil works	0.76
- Access road	0.76
- Generating equipment	0.86
- Transmission line	0.85
- Contingency	Weighted average of above
- Operation and maintenance	0.97
Diesel cost:	
- Diesel capital cost	0.85
- Operation and maintenance	0.97
- Fuel	0.86

Source : Mini-Hydro Project, Final Report, ENEX Mini-Hydro Consultants, May 1982

14.3.5 Evaluated indices

Evaluation is based on present worth of economic cost streams over the evaluation horizon set forth in Subsection 14.3.3 above. The cost stream analysis has revealed the following indices:

<u>Evaluation Indices for Seven Schemes</u>
(Basic Case)

Demand Centre	Sri Aman		Sarikei	Kapit		Limbang	
Scheme	SEK-1	SEK-2	K'WIT	MUKOH	KAPIT-2	PASIA	MED-2
Net present value, B-C (million M$) 1/, 2/	-44.5	-65.3	-105.2	+1.0	-24.6	-1.1	-3.4
B/C 1/	0.75	0.67	0.66	1.04	0.57	0.99	0.96
IRR (%)	5.5	5.3	5.0	10.8	4.3	9.8	9.3

Note : 1/ At discount rate of 10% per annum
2/ Represent saving in thermal cost

As indicated above, favourable index values are accorded to three (3) schemes; Mukoh for Kapit system and Pasia and Medamit-2 for Limbang system.

14.4 Run-of-river Scheme with Regulating Pondage

All of three (3) schemes favourably evaluated above are run-of-river type development. For these schemes, an additional evaluation was attempted to examine merit of the scheme to have a diurnal peaking capability with provision of a regulating pondage.

In examining the plan, the pondage is planned to have a diurnal regulating capacity for 6-hour peak operation under a load factor of 0.5. The plant discharge is selected at two times greater than firm discharge.

The plans are evaluated by the method identical to that used in preceding Section 14.3. The results of the evaluation are summarized below in comparison with the plans examined in Section 14.3 (plans without regulating pondage):

Evaluation Indices of Three Run-of-River Schemes

Item	Mukoh		Pasia		Medamit-2	
	Without Pondage	With Pondage	Without Pondage	With Pondage	Without Pondage	With Pondage
- Installed capacity (MW)	1.94	4.45	12.4	18.7	4.6	4.5
- Dependable capacity (MW)	1.94	4.45	8.5	18.7	2.0	4.5
- Annual energy (GWh)						
- Primary	16.7	19.1	72.0	80.5	16.9	19.3
- Secondary	0	17.5	34.9	73.3	19.7	17.4
Total	16.7	36.6	106.9	153.8	36.6	36.7
- Construction cost (M$ mill)	21.3	37.1	86.0	108.6	48.1	51.1
- kWh cost (M¢/kWh)*	16.1	12.8	10.1	8.9	16.6	17.6
- EIRR (%)	10.8	9.3	9.8	9.1	8.9	10.8

* On basis that all energy is consumed.

It is seen in the table that relative merit of Medamit-2 site is much improved if the scheme is provided with a regulating pondage. Accordingly, Medamit-2 will be planned to have a regulating pondage to be used for diurnal peaking operation.

While, the plans at Mukoh and Pasia sites are evaluated to have a lower evaluation index in term of EIRR. The main reason is that the plan with a regulating pondage is too large in output capacity compared with demand level of the power supply system and relatively large investment cost required for the plan with a pondage is not justified at this moment.

14.5 Schemes Proposed for Subsequent Feasibility Study

Based on the outcomes of comparative studies in preceding Sections 14.3 and 14.4, this Section preliminarily examines the candidate schemes to be taken up in subsequent feasibility study.

The selection was made in a manner firstly to list one scheme (basically the scheme giving the higher EIRR value) for each load centre, but exceptionally for Limbang area two (2) competitive schemes are listed for a further comparison in succeeding Sections.

Prospective Site for Each Load Centre

Load Centre	Power Demand(MW) 2000	2010	Name of Scheme	Installed Capacity(MW)	EIRR (%)
Sri Aman	8.6	17.0	Sekrang-1	11.8	5.5
Sarikei	13.0	27.0	Kanowit	25.1	5.0
Kapit	2.5	4.2	Mukoh	1.94	10.8
Limbang	7.0	12.4	Medamit-2	4.5	10.8
			Pasia	12.4	9.8

Of the above, Sekrang-1 and Kanowit have relatively low EIRR values and are presumably out of further consideration by SESCO. The remaining three (3) schemes, Mukoh, Pasia and Medamit-2, are finally retained as the candidates for feasibility study. The main features of these (3) schemes are reproduced below for mutual comparison of the schemes.

Scheme Proposed for Feasibility Study

Description	Name of Scheme		
	Mukoh	Pasia	Medamit-2
Load centre	Kapit	Limbang	Limbang
Type of development	RUN	RUN	RUN with regulatin pondage
Installed capacity (MW)	1.94	12.4	4.49
Annual energy (GWh)			
- Primary	16.7	72.0	19.3
- Secondary	0	34.9	17.4
Total	16.7	106.9	36.7
Construction cost (million M$)	21.3	86.0	51.1
Cost indices			
- Const. cost/kW (M$/kW)	11,210	6,940	11,380
- Const. cost/kW (M$/kWh*)	1.28	0.80	1.39
- kWh cost (M ¢/kWh*)	16.1	10.1	17.6
EIRR (%)	10.8	9.8	10.8

Note: * On basis of total annual energy

Breakdowned details of the estimated construction cost are contained in Appendix VII (Volume VIII). It is furthermore noted that a flow duration curve derived from monthly runoff data instead of daily runoff data is used for the evaluation of run-of-river schemes, and that Supplementary Note No. 6 in this volume tries to evaluate the three remained schemes with the flow duration curve prepared with daily runoff data for reference.

14.6 Sensitivity Tests

A further evaluation was made for the three favourably evaluated schemes (Mukoh, Pasia and Medamit-2) to examine sensitivity for several cases of variation in conditions relevant to the projects. The tests examined are the following cases:

(a) Variation in the construction cost on hydro and diesel plant and the fuel price

(b) Extra power demands from timber industries for Mukoh

(c) Consideration of benefits accrued from transfer and cold reserve of excess diesels.

14.6.1 Variation in the construction cost and fuel price

The sensitivity tests varying the construction cost on hydro and diesel plant and the fuel price are examined for the following cases, placing an emphasis on the variation of fuel price:

Case	Basic Fuel Price	Escalation	Diesel Cost	Hydro Cost
A1	As estimated (M ¢ 40/lit)	0	-20%	As estimated
A2	"	0	As estimated	+20%
A3	"	0	As estimated	-10%
A4	"	2% p.a.	As estimated	As estimated
B1	Price as at March 1986 (M ¢ 34.3/lit)	0	"	"
B2	"	3.86% p.a.	"	"

A tentative rate of 2% per annum is based on the assumption that the price of oil will increase in a long term, while the rate of 3.86% per annum is based on the SESCO's forecast.

The results of sensitivity test varying the construction cost on hydro and diesel plant and the fuel price are detailed in Table 14.7. The EIRR values obtained are summarized below:

Result of Sensitivity Test

Case	Economic Internal Rate of Return (%)		
	Mukoh	Pasia	Medamit-2
Base	10.8	9.8	10.8
<u>Sensivity test</u>			
A1	10.0	9.3	9.9
A2	8.8	8.3	8.7
A3	12.0	10.8	12.1
A4	13.8	12.7	13.7
B1	9.7	9.0	9.7
B2	15.5	14.5	15.3

The above shows that all three schemes have a fair viability in all cases, with IRR to be higher than 8%.

It is projected that oil price would gradually increase over a long term. If this is taken into account, the viability of the schemes would be as high as 13 to 15% in terms of EIRR value (represented by Cases A3 and B2 above).

14.6.2 Extra power demands from timber industries for Mukoh

There is a great possibility of future power demand increase in Kapit area in view of potentiality for development of timber industries in the area. A sensitivity test is examined to see how the merit of Mukoh scheme would be improved in case such incremental demands from timber industries (saw mills) arise.

It is at moment not known in what extent timber companies would pay interest to future improved supply condition in Kapit area which would be attainable by incorporation of the Mukoh scheme.

This study assumes the following three scenarios of increment of demands:

(a) Demand from timber industries will be 0.5 MW in 1994 when the Mukoh is commissioned and thereafter increase by 0.1 MW per year up to 1 MW in total demand.

(b) Demand will be 1.0 MW initially in 1994 and increase at a rate of 0.2 MW per year to 2 MW in total demand.

(c) Demand in Kapit area is as large as 6.6 MW in 1994, which would feed all primary energy from the Mukoh scheme (16.7 GWh). This case represents that most part of hydro benefit arises from the beginning.

Load factor is assumed to be 0.5.

Two (2) alternative development scales examined in Section 14.3 and 14.4 are also taken into consideration in this study as follows:

Case	Installed capacity (MW)	Energy (GWh)	Description
Case-1	1.94	16.7	Run-of-river development at minimum scale with $Q = 7.4m^3/s$ (firm discharge)

Case-2	4.45	36.6	Run-of-river development of Q =14.8 m^3/s (2 times of firm discharge)

The detailed features are given in Table 14.8.

The evaluation of scheme was made by preparing cash flows. The results evaluated in terms of EIRR are summarized as follows:

Evaluated Index (EIRR in %)

Demand Scenario	Development Scale Case-1 (1.9 MW)	case-2 (4.5 MW)
(a) Additional demand 0.5 MW 1994 + 0.1 MW x 5 years	12.5	10.6
(b) Additional demand 1.0 MW in 1994 + 0.2 MW x 5 years	13.2	12.0
(c) System demand suffuciently large at 6.6 MW in 1994	15.7	15.8

As seen above, the attractiveness of Mukoh scheme will be significantly improved if the scheme supplies its unused energy to timber industries. It is noted that Case-1 (run-of-river development as a base power plant) remains to be more beneficial than Case-2 in cases of demand scenarios (a) and (b). However, Case-2 turns to be attractive in demand scenario (c). Further details are refer to Supplementary Note No. 2 in this volume.

14.6.3 Consideration of transfer and cold reserve

The development of a hydropower scheme with a relatively large scale on the isolated power system will make possible the transfer and cold reserve of diesel plant retained in the power system beyond the reserve capacity, which are taken into account as the negative cost and reduction of O & M costs in the cash flow diagram of economic evaluation, respectively. The merit of transfer and cold reserve on excess diesel plant is examined as the sensitivity test of Mukoh and Medamit-2. Following are the conditions and assumptions for this sensitivity test:

(1) Excess diesel plants will be tranferred to other load centres, if they are not required in the system at least for succeeding three years.

A criterion given herein is that, during initial period after removal of excess diesel units, the system should still retain a sufficient capacity of diesel units which would be capable of meeting the demand even under malfunction of one unit of hydropower plant. Only surplus diesel unit beyond this requirement is transferred to the other places.

(2) Excess diesel plants will be kept as cold-reserve unit, if they are again required within the succeeding three years.

(3) In the evaluation, costs of transferable diesel plant are regarded to be saving in purchasing new diesel plant otherwise required at the other load centres, which is counted as benefit accorded to the hydropower project. The value of diesel plant is estimated at 80% of equipment cost (M$2,000 x 0.8 = M$1,600/kW) after deduction of removal costs.

In case of cold reserve, saving of fixed O/M cost on diesel units is counted in the evaluation.

Alternative capacities examined in the study are as follows:

Mukoh	Medamit-2	Remarks
1.94 MW	4.5 MW	Base case
3.1 MW	5.5 MW	Alternative case-1
4.2 MW	6.5 MW	Alternative case-2

The plant will be installed at its full capacity in 1994, i.e. installation of two units at one stage.

Results of evaluation are summarized hereunder:

Site	Installed capacity of hydropower (MW)	Transferable diesel capacity (MW)	Duration to the next installation of diesel (year)	B-C $(M\$ x 10^6)$	EIRR (%)
1.Basic case (not considering transfer and cold reserve)					
MUKOH	1.94	-	-	1.0	10.8
MEDAMIT-2	4.49	-	-	2.3	10.8
2.This Study (considering transfer and cold reserve)					
MUKOH	1.94	1.3	4	2.6	12.0
	3.1	2.7	7	4.0	12.1
	4.2	2.7	14	0.6	10.3

MEDAMIT-2	4.49	2.1	3	1.5	10.5
	5.5	2.3	4	3.9	11.1
	6.5	2.8	5	1.5	10.4

As shown in the above table, the optimum development scale is evaluated to be 3.1 MW and 5.5 MW for Mukoh and Medamit-2, respectively, which are larger in installed capacity than the base cases by around 1 MW. Furthermore, if this evaluation method (transfer of excess diesel units) is taken into account, EIRR value is improved by 1.3 and 0.3%, respectively.

It will be interesting to evaluate the above, including study on practicability of transfer of diesel units. Further details are discussed in Supplementary Note No. 8 in this volume.

14.7 Technical Features of Selected Three Schemes

Table 14.9 summarizes technical features of the three schemes. In general, no major technical constraint is foreseen for all the schemes. Major works involved in the scheme are the construction of an intake weir of about 5 to 20 m high and a headrace tunnel of about 2 m diameter, while geology at all the sites is assessed to be competent to accommodate these structures.

A difficulty to be noted is the remoteness of Pasia site, due to which the scheme would involve a relatively heavy work for the access and transmission line as noted in the table.

No specific social/environmental problem is foreseen for all three (3) schemes. Common to all schemes, land acquisition/ resettlement requirement is minimal and the river is not used for navigation in the reach where the scheme is proposed. A particular aspect is that logging activity is in progress or is about to start in all three basins. The subsequent study should take into account this aspect in its runoff study. In case subsequent study reveals the passage of migratory fish in the river reaches, a provision of fish will have to be planned at the weir.

14.8 Schemes to Proceed into the Feasibility Study Stage

A steering committee meeting was held at Kuching on January 21, 1987 for selecting the schemes to proceed into the feasibility study stage among three promising schemes in development; Mukoh, Pasia and Medamit-2. Taking into account the project viability discussed above, Mukoh for the Kapit load centre and Medamit-2 for the Limbang load centre were then selected as the schemes to advance to the feasibility study stage.

A standard design criterion was proposed for the estimate of construction cost in the identification stage as discussed in Section 11.2 due to the reason that an aim in the identification stage is to find out the relative attractiveness in development among the identified schemes. The characteristics at the site, when the construction cost is estimated for Mukoh and Medamit-2 in the coming feasibility stage, should carefully be taken into account not only to increase the economic viability of the scheme, but also to reduce the financial burden to the executing agency.

A cut-and-cover conduit type was proposed besides the tunnel type as the headrace of Mukoh in Supplementary Note No.3 in this volume in order to increase the economic viability. Although cost comparison on both types showed the tunnel plan is less costly, a cut-and-cover conduit type would be worthly to be considered as an alternative headrace in the coming feasibility study.

Economic viability at the minimum development of Medamit-2 was examined on Supplementary Note No. 4 in this volume for reducing the burden of initial investment cost, obtaining the promising figures in the evaluation index. This plan with a minimum development scale would be worthy to be taken into account as an idea of stage development.

A 66 kV transmission line of 60 km long is required for supplying the power generated at Medamit-2 to Limbang and is one of shackles for its development. Steel is originally conceived as the material to build towers for supporting the transmission line, but the use of wooden poles was examined on Supplementary Note No. 5 in this volume for reducing the construction cost, resulting in much improvement in the economic viability. Wooden poles will be considered in the feasibility study stage as one of methods to support the transmission line.

14.9 Power Supply to Lawas and Brunei on Pasia

Pasia was intended to develop as the power source to the Limbang area. The distance from the project site to Limbang is some 60 km in a crow line, but the geography that East Brunei is located between the site and Limbang makes the transmission line of 110 km long. In addition, the development scale is limited to 12.4 MW to meet the power requirement of Limbang in 2010, which would be far small compared with the optimal development scale. Due to the reasons mentioned above, Pasia results in less viable compared with Mukoh and Medamit-2.

A study is examined to see additional merits which may be accorded to the Pasia scheme, in case it supplies power to Lawas and Brunei (both east and west parts of Brunei) in addition to Limbang area.

14.9.1 Development scale of Pasia scheme

Following four alternative cases of development at Pasia were examined for this purpose:

Case	Installed Capacity (MW)	Energy (GWh)	Description
Case-1	12.4	106.9	Run-of-river (ROR) type at a scale with Q = 5.3 m^3/s
Case-2	25.9	189.0	ROR at a scale assessed to produce lowest cost energy; (refer to Fig. 14.1) Q = 11.1 m^3/s
Case-3	18.7	153.8	ROR with a regulating pondage Qmax = 7.2 m^3/s
Case-4	29.0	211.6	ROR with a regulating pondage = 11.1 m^3/s (same discharge as for Case-2)

14.9.2 Transmission line system

Power will be supplied to the following demand centres:

Major Load Centres	Demand Level (MW) 1990	1995	2000	2010
(a) Lawas	1.2	1.8	2.5	4.5
(b) East Brunei	(To be informed)			
(c) Limbang	3.2	5.0	7.0	12.4
(d) West Brunei	(To be informed)			

In the above case, the transmission line route would be as given in Fig 14.3 . In order to ensure a reliable supply of power to Brunei, the line would be of double circuits construction. The line voltage and length will be:

Section	Line Length (km)	Voltage/ circuit
Pasia - Trusan	69	66 kV DC
Trusan - Brunei (east) border	3	66 kV DC

Brunei (east) territory	26	66 kV DC
Border - Limbang	7	66 kV DC
Limbang - Brunei (west) border	15	66 kV DC
(66 kV DC)	120 km	
Trusan - Lawas	17	33 kV DC
Total	17 km	

14.9.3 Evaluation results

The method of evaluation is virtually same as adopted in Section 14.3.

The results of evaluation are shown below:

Evaluated Indices

Description	Case-1	Case-2	Case-3	Case-4
Type of development	ROR	ROR	ROR with pondage	ROR with pondage
Power :				
Installed capacity (MW)	12.4	25.9	18.7	29.0
Dependable output (MW)	8.5	8.5	18.7	29.0
Annual energy (GWh)	106.9	189.0	153.8	211.6
Evaluation indices :				
kWh cost* (M¢/kWh)	10.3	8.0	9.0	8.0
Net present value** (million M$)	27.8	58.9	51.2	72.9
B/C**	1.35	1.61	1.59	1.77
EIRR	18.5	21.4	20.5	21.9

Note: * On the basis that all energy is consumed
** At discount rate of 10% p.a.

As indicated above, high evaluation is accorded in all alternative cases. Although relative merits of both Case-2 and Case-4 in terms of EIRR are almost comparable, a recommened plan would be Case-4 in view that it has a larger dependable output capacity and accordingly is more flexible for meeting the demands in Brunei.

Although it is noted, however, that the above gives optimistic indices in view of an assumption that all the surplus energy would be saleable to Brunei, Pasia is worthy to keep as the scheme to proceed into the feasibility study stage. Further detailed discussions are referred to the Supplementary Note No. 1 in this volume.

14.10 Preliminary Study on Low Head Schemes

The schemes identified for the Sri Aman and Sarikei demand centres have low viability compared with those in the Kapit and Limbang load centres. The sites where relatively high head can be created were searched as a basic rule for identifying hydropower schemes. An attempt to search the sites with possibilities of hydropower schemes by ample discharge even having relatively low head was made to meet the power demands particularly for the Sri Aman and Sarikei areas.

The proposed schemes would be a scale meeting future power demand of 2 to 32 MW (see Subsection 7.2.3), and the sites should have a relatively large discharge, i.e. a large runoff catchment area if planned as a low head scheme. Such sites would only be found in lower river reaches already developed in most cases to some extent, whereat impounding of water at a high level is practically difficult. Hence, this study tentatively assumes the scheme to have a 3 m head of water impounding which would presumably be possible within the existing river channel, although the actual condition may vary by site.

Through a study on 1 to 50,000 scale maps, the following five (5) sites were identified to be potential sites:

Load Centre	Site (River)	Catchment Area, km^2	Air Distance from Load Centre, km
Sri Aman	Btg. Lupar	2,220	25
Sarikei	S. Kanowit	2,530	50
Kapit	Btg. Katibas	3,150	45
	Btg. Baleh	12,150	20
Limbang	S. Limbang	2,820	30

The location of sites is shown in Fig. 14.4.

Outlines of the proposed schemes are shown in Table 14.10. Information required for estimating the basic features of schemes (such as length of weir, etc) was obtained on 1 to 50,000 map.

Construction cost was estimated on a very preliminary basis by applying the same unit rates to all the sites. The proposed schemes are compared in terms of cost indices based on the above information as summarized below:

<u>Comparison of Low Head Schemes</u>

Description	Btg. Lupar	Sg. Kanowit	Btg. Katibas	Btg. Baleh	Sg. Limbang
Installed capacity(MW)	5.7	3.2	5.0	24.5	3.0
Annual energy (GWh)					
- Primary	24.7	13.9	21.5	105.1	12.9
- Secondary	19.8	11.1	17.2	84.1	10.3
Total	44.5	25.0	38.7	189.2	23.2
Construction cost (million M$)	67.0	49.5	72.0	330.0	56.0
Cost indices					
- Construction cost/kW (M$/kW)	11,750	15,470	14,400	13,470	18,670
- Construction cost/kWh* (M$/kWh)	1.51	1.98	1.86	1.74	2.41
- kWh cost* (M¢/kWh)	19.0	24.9	23.4	22.0	30.4
EIRR (%)	7.1	6.6	4.2	2.4	4.6

Note: * Primary energy + 1.0 x Secondary energy

Batang Lupar has a relatively fair index,i.e. 7.1% in EIRR. The present evaluation is based on supply of power limited to Sri Aman area where the size of power demand is still relatively small; 2.2 MW in 1986, 3.4 MW in 1990, 8.6 MW in 2000 and 16.9 MW in 2010. If all energy is consumable, the index will be a higher figure.

Notwithstanding a relatively high kWh cost, Sungai Kanowit is accorded a fair index of 6.6% as compared with other three schemes. This is due to relatively large demand size of Sarikei which consumes most of Sungai Kanowit energy from the initial period.

Further details are discussed in Supplementary Note No.7 in this volume.

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TABLES

TABLE 1.1 INSTALLED CAPACITY, GENERATED ENERGY AND CONSUMPTION OF ELECTRICITY IN SARAWAK

Year	Installed Capacity (KW)	Generated Energy (MWh)	Number of Consumer	Consumption (GWh) Domestic	Industrial	Street	Total
1975	80,885	199,924	46,631	41,662	125,450	2,924	170,034
1976	86,602	228,555	50,138	47,337	142,415	3,432	193,183
1977	102,184	258,155	53,477	53,137	164,217	3,271	220,625
1978	138,362	301,193	61,433	56,458	198,411	3,412	258,280
1979	147,387	343,178	65,722	69,034	227,240	3,688	299,962
1980	152,755	383,319	73,212	93,270	232,502	4,194	329,965
1981	156,002	429,201	83,358	107,655	259,026	4,396	371,077
1982	189,246	483,059	94,200	120,788	286,658	4,807	412,253
1983	203,499	551,852	106,102	147,464	328,066	5,408	480,938
1984	228,508	601,987	116,107	148,295	356,279	5,806	510,379

Source : Annual Statistical Bulletin Sarawak, 1984

TABLE 3.1 ROUTE LENGTH OF DISTRIBUTION NETWORK

(Unit:km)

Voltage Type	33 kV	11 kV	6.6 kV	400/230V
Overhead Line	140	702	95	1,864
Underground Cable	22	474	114	346
Total	162	1,176	209	2,210

TABLE 3.2 ENERGY GENERATED IN SARAWAK

(Unit : MWh)

Station	1982	1983	1984	1985
1. Kuching	230,048	261,034	295,458*	344,975*
2. Sibu	80,217	88,018	91,941	101,412
3. Miri	70,224	78,053	81,186	92,343
4. Bintulu	24,996	33,615	37,908	53,481
5. Sarikei	9,016	9,718	10,234	13,375
6. Sri Aman	8,372	9,294	9,546	10,223
7. Limbang	7,506	8,781	9,462	10,609
8. Kapit	3,465	3,838	4,209	5,038
9. Marudi	3,091	3,192	3,312	3,614
10. Lawas	2,024	2,619	2,855	3,544
Total (For Whole Sarawak)	451,242	513,397	563,317	656,593

Remarks :

* 1984, 1985 for Kuching inclusive of Batang Ai Station

TABLE 3.3 ENERGY SOLD IN SARAWAK

(Unit : MWh)

Station	1982	1983	1984	1985
1. Kuching	191,954	220,585	239,067	270,682
2. Sibu	68,528	78,238	78,597	84,572
3. Miri	56,168	65,802	66,403	62,686
4. Bintulu	21,441	29,572	32,849	47,845
5. Sarikei	8,291	8,863	9,672	10,890
6. Sri Aman	7,222	7,966	8,170	8,776
7. Limbang	6,331	7,499	8,083	9,239
8. Kapit	3,038	3,398	3,689	4,611
9. Marudi	2,584	2,737	2,834	3,117
10. Lawas	1,688	2,175	2,338	2,835
Total (For Whole Sarawak)	382,604	445,518	473,806	532,897

TABLE 3.4 MAXIMUM DEMAND IN SARAWAK

(Unit : kW)

Station	1982	1983	1984	1985
1. Kuching	54,140	55,600	60,500	68,500
2. Sibu	17,050	18,050	19,320	20,450
3. Miri	12,350	13,810	15,300	16,500
4. Bintulu	5,409	6,532	7,200	11,500
5. Sarikei	1,910	2,060	2,480	3,030
6. Sri Aman	1,751	1,993	1,960	1,971
7. Limbang	1,541	1,659	1,912	2,006
8. Kapit	738	796	948	1,164
9. Marudi	800	589	661	782
10. Lawas	430	582	585	820
Total (For Whole Sarawak)	100,580	107,194	116,939	133,507

TABLE 3.5 NUMBER OF CONSUMER IN SARAWAK

Station	1982	1983	1984	1985
1. Kuching	36,737	40,136	44,261	48,874
2. Sibu	16,754	17,923	18,790	19,835
3. Miri	8,939	10,234	11,386	12,673
4. Bintulu	3,018	4,027	4,756	5,827
5. Sarikei	2,760	2,860	3,161	3,522
6. Sri Aman	2,637	2,801	2,966	3,203
7. Limbang	1,753	1,960	2,109	2,289
8. Kapit	742	817	958	1,074
9. Marudi	1,032	1,079	1,141	1,193
10. Lawas	595	733	764	787
Total (For Whole Sarawak)	93,200	105,102	115,106	128,949

TABLE 3.6 PRIVATE POWER SECTOR

Description Name	Installed Capacity	Location
Malaysia Liquifed Natural Gas (MLNG)	(S) 3 x 10 MW (G) 2 x 20 MW	Bintulu
Asea Bintulu Fertilizer (AGF)	(D) 2 x 8 MW	ditto
Sarawak Shell Berhad (SSB)	(D) 7 x 1 MW	Miri
Total		

Remarks : (S) : Steam Turbine
(G) : Gas Turbine
(D) : Duel Fuel

TABLE 3.7 MAJOR CONSUMERS IN THE SELECTED 4 LOAD CENTRES

(Unit:kWh/month)

Station	Name of Major Consumers	Monthly Power Consumption	Remarks
Sarikei	CTC Factory	78,720	
	King Eastern Food	37,020	June 1986
	Sea Food Trading	34,525	
	Rejang Icework	26,506	
	Govt. Hospital	21,002	
	Total	197,773	-
Sri Aman	JKR Pump House	66,890	July 1986
	Tentera	53,367	June 1986
	RTM	36,790	August 1986
	Telecom	26,220	August 1986
	General Hospital	24,614	July 1986
	Total	207,881	-
Limbang	Limbang Trading Co.,	86,653	
	Transmitting	54,702	
	Hospital	26,407	
	Microwave Station	20,403	
	Broadcasting Station	19,526	
	Total	207,691	(Share=23%)
	Energy Sold/month	908,409	-
Kapit	Water Treatment Plant	38,370	
	Federal Complex	11,298	
	Booster Pump House	28,988	
	VHF Station	10,163	
	Meligai Hotal	13,612	
	Total	102,431	(Share=24%)
	Energry Sold/month	431,209	-

(NOTE) The figures for both Limbang and Kapit show the average over past three months from June to August, 1986.

TABLE 3.8 SYSTEM LOSSES AND STATION USES

(Unit : MWh)

Year / Description	Energy Generated	Energy Sold	Station Uses	System Losses	Remarks
Limbang					
1983	8,781	7,499	264	1,018	
1984	9,462	8,083	272	1,107	
1985	10,609	9,239	320	1,050	
1986	7,613	6,727	283	603	until Aug.
Total	36,465	31,548	1,139	3,778	
Kapit					
1983	3,838	3,398	156	284	
1984	4,209	3,689	167	353	
1985	5,038	4,611	191	236	
1986	3,676	3,337	139	200	until Aug.
Total	16,761	15,035	653	1,073	

TABLE 3.9 MONTHLY OIL CONSUMPTION

(Unit : kl)

Year / Description	Fuel	Lubricating Oil	Remarks
Limbang			
1983	2,494	38	
1984	2,640	53	
1985	2,900	46	
1986	2,045	36	Unitl Aug.
Total	10,079	173	
Kapit (diesel)			
1983	1,164	9	
1984	1,294	10	
1985	1,501	13	
1986	1,070	8	Until Aug.
Total	5,029	40	

Remark : In Limbang, the fuel has been changed from diesel to light fuel from April, 1986.

TABLE 3.10 SESCO's POWER EXPANSION PROGRAMME

Station	Unit No.	kW Rating	Type	Use	Year Install
(A) Kuching/ Batang Ai)	No addition				
(B) Sri Aman)					
(C) Sibu					
(D) Mukah	1	280	D	B	1987
	1	450	D	B	1988
	1	300	D	B	1989
	1	600	D	B	1991
(E) Sarikei	No addition				
(F) Kapit	1	300	D	B	1986
	(retire 1 unit 75 kW in 1986)				
	(retire 2 units 144 kW each in 1987)				
	1	400	D	B	1988
	1	1,000	D	B	1990
(G) Miri	1	15,000	GT	B	1987
	1	20,000	GT	B	1989
(H) Bintulu	1	10,000	GT	B	1987
(I) Marudi	2	300	D	B	1987
	1	600	D	B	1990
(J) Limbang	1	600	D	B	1987
	1	1,000	D	B	1989
	2	75	H	B	
(K) Lawas	1	400	D	B	1987
(L) Other Stations	*70	*5,775	D	B	1986
	10	75	D	B	1987
	*11	*1,275	D	B	1988
	*16	*1,581	D	B	1989
	*13	*1,361	D	B	1990
	*3	*300	D	B	1991
	*3	*450	H	B	1987

(Remarks) D : Diesel, GT : Gas-turbine, H : Hydro and
B : Base Load
The figures marked with * show the total value.

TABLE 5.1 BASIN LOSS FOR THE SELECTED 15 RIVER BASINS

(unit : mm)

Station Name	Catchmant Area (sq.km)	Annual Average Rainfall	Annual Average Runoff Depth	Annual Average Basin Loss
Serian	941	3,666	2,021	1,645
Sg.Bedup	46	3,516	2,050	1,466
Sg.Pedi	123	4,417	2,959	1,458
Buan Bidi	217	4,259	2,258	2,001
Kpg. Git	425	4,177	2,687	1,490
Lubok Antu	1,300	3,527	2,399	1,128
Rh. Bilong	21,266	4,539	3,039	1,500
Batang Balleh	10,309	4,190	2,690	1,500
Nanga Gaat	1,701	3,750	2,538	1,212
Rumah Nyabong	10,931	4,131	2,631	1,500
Lio Matu	2,630	3,081	1,915	1,166
Long Pilah	9,292	4,049	2,579	1,470
Long Jegan	2,390	4,949	4,046	913
Long Terawan	3,360	4,193	3,265	928
Ng. Medamit	2,817	4,312	2,157	2,155

TABLE 5.2 MEAN ANNUAL RUNOFF FOR 21 POTENTIAL SITES

No.	Project	Catchmant Area (sq.Km)	Rainfall (mm)	Mean Evapo. (mm)	Annual Runoff (mm)	Runoff Volume (MCM)
	SARIKEI					
1.	Kanowit	1,331	3,600	1,480	2,120	2,822
2.	Sari-1	160	3,300	1,480	1,820	291
3.	Sari-2	20	3,400	1,480	1,920	38
	SRI AMAN					
4.	Lemanak	184	3,400	1,450	1,950	359
5.	Sekerang-1	360	3,400	1,450	1,950	702
6.	Sekerang-2	508	3,400	1,480	1,920	975
7.	Sria-1	65	3,300	1,480	1,820	118
8.	Sria-2	90	3,500	1,470	2,030	183
	KAPIT					
9.	Bangkit	167	4,100	1,395	2,705	452
10.	Kapit-1	101	4,000	1,470	2,530	256
11.	Kapit-2	220	4,100	1,430	2,670	587
12.	Ayat	59	4,000	1,355	2,645	156
13.	Ibau	163	3,500	1,465	2,035	332
14.	Tekalit	518	3,250	1,490	1,760	912
	LIMBANG					
15.	Trusan	2,027	3,500	1,370	2,130	4,318
16.	Tengoa	221	4,000	1,415	2,585	571
17.	Medamit-1	145	4,000	1,390	2,610	378
18.	Medamit-2	186	3,750	1,410	2,340	435
19.	Limbang	1,860	4,250	1,440	2,810	5,227
20.	Lawas	718	4,250	1,470	2,780	1,996
21.	Pasia	177	3,500	1,180	2,320	411

TABLE 5.3 DIMENSIONLESS FLOW DURATION CURVE

(unit: %)

Duration (%)	Station Serian	Kg.Git	Pk.Buan Bidi	Average
10	176.6	194.8	190.2	187
20	140.2	142.8	129.7	138
30	115.9	117.3	107.8	113
40	98.3	97.0	91.2	96
50	83.7	80.0	78.2	81
60	73.4	65.9	65.6	68
70	63.6	52.5	55.3	57
80	50.8	39.9	46.9	46
90	39.8	29.6	38.7	36
95	31.6	20.4	32.7	28
97	27.6	17.8	30.4	25
100	13.5	6.8	21.6	14

TABLE 5.4 DIMENSIONLESS STORAGE DRAFT CURVE

(unit : %)

Draft Rate (%)	Gauging Station Serian	Kg.Git	Pk.Buan Bidi	Average
20	0.3	1.6	1.7	1.2
40	4.3	9.8	2.1	5.1
50	8.1	16.7	5.1	10.0
60	13.1	24.4	9.3	15.6
70	18.7	33.2	15.3	22.4
80	25.4	45.4	23.1	31.3
85	31.1	58.7	30.0	39.9
90	48.6	85.2	39.6	57.8
95	92.7	149.8	54.9	99.1
100	161.0	313.5	118.1	197.5

TABLE 9. 1 ANNUAL MAXIMUM DAILY RAINFALL DEPTH AT RIDDAN

STATION NAME : RIDDAN
STATION NO. : 1217011

YEAR	ANNUAL MAX. DEPTH (mm)			
	1DAY	2DAY	3DAY	5DAY
1963	154.2	154.2	158.8	169.0
1964	119.4	134.9	138.2	163.5
1965	80.5	119.4	121.2	151.4
1966	118.9	164.6	198.1	279.1
1967	254.0	254.0	254.0	381.0
1968	104.0	132.3	148.0	174.2
1969	110.7	146.3	189.5	209.9
1970	97.0	122.1	134.3	158.2
1971	(missing)			
1972	99.8	108.0	151.1	174.2
1973	89.4	144.3	201.2	214.1
1974	80.8	131.0	173.0	227.3
1975	208.8	221.5	235.0	300.8
1976	126.5	127.3	156.7	218.6
1977	119.4	144.8	160.0	186.0
1978	94.0	134.0	166.6	186.5
1979	62.0	110.0	125.0	160.0
1980	49.5	80.0	95.0	124.0
1981	48.0	81.0	100.0	133.0
1982	45.0	45.0	65.0	81.0

TABLE 9. 2   ANNUAL MAXIMUM DAILY RAINFALL DEPTH AT KANOWIT W/WORKS

STATION NAME : KANOWIT W/WORKS
STATION NO. : 2021036

YEAR	ANNUAL MAX. DEPTH (mm)			
	1DAY	2DAY	3DAY	5DAY
1964	111.5	152.1	190.2	197.6
1965	111.0	164.3	167.6	174.5
1966	91.2	134.6	135.4	176.6
1967	102.9	166.4	188.2	218.7
1968	90.2	109.8	138.7	169.2
1969	107.7	136.4	167.4	234.5
1970	120.1	120.9	153.6	213.2
1971	78.2	121.6	156.9	188.6
1972	99.1	138.5	143.3	176.3
1973	128.0	128.0	144.3	210.9
1974	84.3	90.1	121.8	149.2
1975	215.4	215.4	215.4	269.3
1976	97.8	101.1	125.9	155.1
1977	97.5	122.9	140.0	216.4
1978	134.0	134.0	179.0	229.0
1979	168.0	170.0	171.0	189.0
1980	101.0	114.0	123.5	130.0
1981		(missing)		
1982	95.0	95.0	96.0	125.0
1983	89.0	139.5	148.0	174.0
1984	119.0	123.5	180.0	213.0

TABLE 9. 3 ANNUAL MAXIMUM DAILY RAINFALL DEPTH AT LONG BILONG

STATION NAME : LONG BILONG
STATION NO. : 4349016

YEAR	ANNUAL MAX. DEPTH (mm)			
	1DAY	2DAY	3DAY	5DAY
1973	154.7	182.9	245.4	282.0
1974	184.1	184.1	233.1	322.5
1975	128.3	165.1	176.6	263.4
1976	132.1	199.2	209.6	242.3
1977	131.2	143.0	204.4	261.4
1978	106.0	153.6	153.6	195.4
1979	133.6	253.8	253.8	253.8
1980	115.6	166.6	209.8	235.8
1981	174.0	174.0	228.4	268.2
1982	108.2	144.4	169.4	207.2
1983	116.5	152.0	198.0	205.0

Table 9.4 ANNUAL MAXIMUM DAILY RAINFALL DEPTH AT LONG SEMADOH

STATION NAME : LONG SEMADOH
STATION NO. : 4255006

YEAR	ANNUAL MAX. DEPTH (mm)			
	1DAY	2DAY	3DAY	5DAY
1963	73.9	117.6	139.0	214.7
1964	54.6	66.0	87.7	102.9
1965	69.6	112.3	148.4	176.8
1966	69.1	102.1	120.6	147.1
1967	73.2	102.9	119.4	164.3
1968	88.9	95.2	127.0	187.7
1969	74.7	103.1	118.8	156.7
1970	89.7	110.3	128.8	174.1
1971	93.5	101.9	115.3	157.7
1972	51.1	85.1	111.0	160.3
1973	75.2	98.6	124.0	148.6
1974	58.2	101.8	128.5	166.2
1975	49.3	67.8	86.8	122.6
1976	51.8	89.9	100.6	137.4
1977	57.2	88.1	106.9	144.0
1978	52.1	100.1	107.2	148.9
1979	95.0	148.6	160.5	200.6
1980	107.5	152.5	165.5	176.5
1981	130.6	192.5	285.0	355.0
1982	81.5	85.0	94.1	134.2
1983	93.4	102.0	136.0	185.0
1984	71.0	78.0	109.5	131.0

TABLE 9. 5 ANNUAL MAXIMUM DAILY RAINFALL DEPTH AT KAPIT P.W.D

STATION NAME : KAPIT P.W.D
STATION NO. : 2029001

YEAR	ANNUAL MAX. DEPTH (mm)			
	1DAY	2DAY	3DAY	5DAY
1948	101.6	121.9	180.3	193.0
1949	112.3	147.1	148.1	172.8
1950	100.1	100.1	168.4	195.0
1951	82.8	97.5	142.5	156.0
1952	82.8	119.4	173.2	263.4
1953	129.3	131.8	158.5	226.8
1954	61.0	85.3	107.4	136.6
1955	48.8	59.7	71.9	95.3
1956	70.6	120.7	156.8	160.9
1957	92.7	121.9	153.6	197.6
1958	87.1	88.6	117.1	148.1
1959	96.3	124.0	133.2	175.0
1960	127.3	198.8	234.9	260.0
1961	136.7	258.9	286.3	341.5
1962	91.7	135.1	156.7	175.5
1963	73.2	127.7	144.3	203.7
1964	118.9	151.4	224.3	278.4
1965	120.1	124.7	156.7	196.6
1966	156.0	158.5	172.8	272.9
1967	94.7	109.5	127.5	156.7
1968	143.5	153.7	199.7	236.0
1969	106.7	119.4	190.5	193.3
1970	107.7	173.0	240.6	291.9
1971	151.4	176.5	209.3	335.3
1972	135.6	229.8	231.6	250.6
1973	107.9	145.0	177.5	218.7
1974	101.6	102.6	132.3	180.3
1975	101.6	135.1	158.5	194.3
1976	89.4	114.0	114.0	162.3
1977	91.0	117.0	128.5	205.9
1978	90.0	139.0	197.0	248.0
1979	90.0	131.0	140.5	240.5
1980	112.0	167.0	197.0	231.0
1981	124.0	193.5	226.0	319.0
1982	120.0	143.5	162.5	270.0
1983	174.0	277.0	318.5	336.0
1984	136.5	179.0	242.0	350.0

TABLE 9. 6 ANNUAL MAXIMUM DAILY RAINFALL DEPTH AT SONG

STATION NAME : SONG
STATION NO. : 2025012

YEAR	ANNUAL MAX. DEPTH (mm)			
	1DAY	2DAY	3DAY	5DAY
1962	54.9	61.0	82.3	111.5
1963	101.1	112.2	140.3	198.2
1964	76.2	100.3	133.3	185.4
1965	105.4	105.9	110.0	130.0
1966	86.4	97.5	147.5	186.4
1967	152.4	184.1	200.6	210.5
1968	50.8	74.2	96.8	134.6
1969	64.8	97.8	119.7	145.9
1970	125.2	133.8	148.3	183.3
1971	86.4	146.1	182.9	257.8
1972	55.1	61.2	78.0	95.7
1973	93.5	112.5	122.7	167.9
1974	79.5	124.2	131.4	202.0
1975	101.6	160.5	171.4	197.1
1976	66.0	94.2	94.2	127.8
1977	150.0	164.0	169.0	218.0
1978	76.0	78.0	106.5	156.0
1979	54.0	92.0	98.0	133.0
1980	50.0	84.0	91.0	117.5
1981	95.0	100.0	119.0	124.0
1982	65.0	100.0	148.0	165.0
1983	89.5	133.5	133.5	174.5
1984	57.5	80.5	120.0	173.5

TABLE 9. 7 ANNUAL MAXIMUM DAILY RAINFALL DEPTH AT NANGA BANGKIT

STATION NAME : NANGA BANGKIT
STATION NO. : 1726041

YEAR	ANNUAL MAX. DEPTH (mm)			
	1DAY	2DAY	3DAY	5DAY
1964	75.4	109.4	133.8	167.5
1965	100.3	146.8	178.0	267.2
1966	124.2	136.9	175.0	269.7
1967	81.5	113.6	117.4	133.2
1968	103.4	116.1	143.2	167.6
1969	71.9	71.9	76.7	109.3
1970	113.0	152.9	207.0	225.8
1971	234.9	318.7	321.7	441.0
1972	75.9	129.0	183.6	207.7
1973	95.2	146.3	160.7	223.5
1974	93.7	154.9	232.4	301.0
1975	85.1	100.3	148.3	199.1
1976	72.6	97.3	106.2	184.1
1977	(missing)			
1978	(missing)			
1979	80.0	106.0	130.0	180.0
1980	115.5	157.0	201.0	248.5

TABLE 9. 8 RESULTS OF GUMBEL FREQUENCY ANALYSIS

DAILY RAINFALL DATA (UNIT: mm)

STATION NAME & STATION NO.	STORM DURATION (DAYS)	RETURN PERIOD (YEAR) 2	5	10	20	50	100	200
RIDDAN	1	101	156	192	227	272	306	340
	2	128	176	209	240	280	310	339
1217011	3	150	198	231	262	302	332	362
n=19	5	184	256	303	348	407	451	495
KANOWIT	1	107	140	162	183	210	231	251
W/WORKS	2	130	160	180	200	225	244	262
2021036	3	150	180	199	218	242	260	279
n=20	5	185	223	248	272	303	326	349
LONG SEMADOH	1	72	94	108	122	139	152	165
	2	100	130	149	168	192	210	229
4255006	3	122	164	192	219	253	279	305
n=22	5	161	211	245	277	319	350	381
LONG BILONG	1	131	160	179	198	221	239	257
	2	170	206	229	252	281	303	324
4349016	3	203	239	262	285	314	336	357
n=11	5	244	286	313	340	374	400	426
KAPIT	1	103	130	147	164	186	202	218
	2	136	180	210	239	275	303	330
2029001	3	164	219	255	290	335	369	402
n=37	5	314	276	317	356	407	445	483
SONG	1	80	110	130	149	173	192	210
	2	104	137	159	181	208	229	249
2025012	3	123	167	179	120	227	248	268
n=23	5	159	200	227	253	287	312	337
NANGA	1	96	139	168	196	232	258	285
BANGKIT	2	129	190	229	268	317	354	391
1726041	3	159	223	265	305	358	397	436
n=15	5	211	296	353	408	478	531	584

Note : n indicates number of years (Calendar Year) of record used in analysis.

TABLE 9. 9 RESULTS OF IWAI FREQUENCY ANALYSIS

DAILY RAINFALL DATA (UNIT: mm)

STATION NAME & STATION NO.	STORM DURATION (DAYS)	RETURN PERIOD (YEAR) 2	5	10	20	50	100	200
RIDDAN	1	98	146	182	218	267	306	348
	2	127	170	197	222	253	276	299
1217011	3	149	191	215	236	262	280	297
n=19	5	184	246	288	328	381	420	460
KANOWIT	1	109	136	156	177	207	232	258
W/WORKS	2	131	156	169	181	195	205	213
2021036	3	152	177	190	202	216	226	234
n=20	5	187	221	241	258	280	295	310
LONG SEMADOH	1	73	94	108	122	139	152	165
	2	100	130	149	168	192	210	229
4255006	3	124	154	171	187	207	220	234
n=22	5	163	110	223	245	272	292	312
LONG BILONG	1	133	157	174	190	212	228	245
	2	172	203	227	252	288	318	350
4349016	3	205	234	251	266	284	296	308
n=11	5	246	281	303	322	346	364	381
KAPIT	1	104	127	141	153	167	177	186
	2	136	178	206	232	266	292	318
2029001	3	162	212	240	266	296	317	337
n=37	5	215	270	302	330	364	388	410
SONG	1	80	108	130	151	181	206	231
	2	104	133	150	167	187	201	215
2025012	3	124	153	171	188	208	222	236
n=23	5	160	196	216	234	255	270	284
NANGA	1	96	125	142	159	179	195	210
BANGKIT	2	129	171	198	223	255	280	304
1726041	3	159	211	245	278	317	347	376
n=15	5	210	276	316	352	396	428	458

Note : n indicates number of years (Calendar Year) of record used in analysis.

TABLE 9.10 RESULTS OF LOG PEARSON TYPE III FREQUENCY ANALYSIS

DAILY RAINFALL DATA (UNIT: mm)

STATION NAME & STATION NO.	STORM DURATION (DAYS)	RETURN PERIOD (YEAR) 2	5	10	20	50	100	200
RIDDAN	1	97	144	177	210	257	293	332
	2	127	173	204	233	272	301	331
1217011	3	149	196	226	254	291	318	345
n=19	5	184	245	284	321	370	406	443
KANOWIT	1	103	128	149	173	208	239	274
W/WORKS	2	129	156	173	188	210	225	241
2021036	3	152	178	193	207	224	236	247
n=20	5	187	221	241	258	280	295	310
LONG SEMADOH	1	72	91	103	115	130	142	154
	2	98	123	141	159	184	205	227
4255006	3	116	147	173	203	251	293	342
n=22	5	154	193	225	259	312	356	407
LONG BILONG	1	130	153	169	185	205	221	238
	2	166	194	215	236	267	291	318
4349016	3	205	234	251	266	284	296	308
n=11	5	246	279	299	315	335	349	363
KAPIT	1	104	129	145	160	178	191	204
	2	136	176	202	225	257	280	304
2029001	3	162	227	271	312	369	412	456
n=37	5	215	274	311	345	389	421	453
SONG	1	78	104	123	141	167	187	208
	2	104	133	152	170	193	210	227
2025012	3	124	154	188	198	209	224	239
n=23	5	160	197	220	240	266	285	303
NANGA	1	88	117	143	176	231	283	346
BANGKIT	2	122	165	202	242	305	361	425
1726041	3	159	212	247	280	323	355	387
n=15	5	207	278	326	372	436	485	536

TABLE 9.11 DESIGN RAINFALL AT THE POTENTIAL SITES (1/4)

POTENTIAL SITE : KANOWIT
CATCHMENT AREA : 1331(SQ.KM)

(Unit:mm)

RETURN PERIOD (YEARS)	DURATION(HRS) 3	6	9	12	15	18	21	24	TOTAL
2	9	14	15	20	21	7	6	5	97
5	12	19	20	26	28	9	7	6	127
10	14	22	23	30	32	11	9	7	147
20	16	24	26	34	36	12	10	8	167
50	19	28	30	39	42	14	11	9	191
100	20	31	33	43	46	15	12	10	210
200	22	34	36	47	50	16	13	11	228

POTENTIAL SITE : SEKRANG-1
CATCHMENT AREA : 508(SQ.KM)

(Unit:mm)

RETURN PERIOD (YEARS)	DURATION(HRS) 3	6	9	12	15	18	21	24	TOTAL
2	9	14	14	19	20	7	5	4	93
5	14	21	22	29	31	10	8	7	144
10	17	26	28	36	39	13	10	8	177
20	20	31	33	43	46	15	12	10	209
50	24	37	39	51	55	18	15	12	250
100	27	41	44	58	61	20	16	13	282
200	30	46	49	64	68	23	18	15	313

POTENTIAL SITE : SEKRANG-2
CATCHMENT AREA : 360(SQ.KM)

(Unit:mm)

RETURN PERIOD (YEARS)	DURATION(HRS) 3	6	9	12	15	18	21	24	TOTAL
2	9	14	15	19	20	7	5	4	94
5	14	21	23	30	32	10	8	7	145
10	17	26	28	37	39	13	10	8	179
20	20	31	33	43	46	15	12	10	211
50	25	37	39	52	55	18	15	12	253
100	28	42	44	58	62	20	17	13	285
200	31	46	49	65	69	23	18	15	316

TABLE 9.12 DESIGN RAINFALL AT THE POTENTIAL SITES (2/4)

POTENTIAL SITE : KAPIT-1
CATCHMENT AREA : 101(SQ.KM)

(Unit:mm)

RETURN PERIOD (YEARS)	DURATION(HRS) 3	6	9	12	15	18	21	24	TOTAL
2	10	15	15	20	22	7	6	5	99
5	12	18	19	26	27	9	7	6	125
10	14	21	22	29	31	10	8	7	141
20	15	23	25	32	34	11	9	7	157
50	17	26	28	37	39	13	10	8	179
100	19	29	30	40	42	14	11	9	194
200	20	31	33	43	46	15	12	10	209

POTENTIAL SITE : KAPIT-2
CATCHMENT AREA : 220(SQ.KM)

(Unit:mm)

RETURN PERIOD (YEARS)	DURATION(HRS) 3	6	9	12	15	18	21	24	TOTAL
2	9	13	14	18	20	6	5	4	90
5	13	19	20	27	28	9	8	6	131
10	15	23	25	32	34	11	9	7	158
20	18	27	29	38	40	13	11	9	184
50	21	32	34	45	48	16	13	10	218
100	24	36	38	50	53	17	14	11	243
200	26	39	42	55	58	19	16	13	268

POTENTIAL SITE : IBAU
CATCHMENT AREA : 163(SQ.KM)

(Unit:mm)

RETURN PERIOD (YEARS)	DURATION(HRS) 3	6	9	12	15	18	21	24	TOTAL
2	7	11	12	16	17	5	4	4	76
5	10	15	16	21	23	8	6	5	105
10	12	18	19	25	27	9	7	6	124
20	14	21	22	29	31	10	8	7	142
50	16	24	26	34	36	12	10	8	164
100	18	27	28	37	40	13	11	9	182
200	19	29	31	41	43	14	12	9	200

TABLE 9.13 DESIGN RAINFALL AT THE POTENTIAL SITES (3/4)

POTENTIAL SITE : BANGKIT
CATCHMENT AREA : 167(SQ.KM)

(Unit:mm)

RETURN PERIOD (YEARS)	DURATION(HRS) 3	6	9	12	15	18	21	24	TOTAL
2	9	13	14	19	20	7	5	4	91
5	13	19	21	27	29	10	8	6	132
10	15	23	25	33	35	11	9	8	160
20	18	27	29	38	41	13	11	9	186
50	21	32	34	45	48	16	13	10	220
100	24	36	38	50	53	18	14	12	245
200	26	40	42	56	59	19	16	13	271

POTENTIAL SITE : AYAT
CATCHMENT AREA : 59(SQ.KM)

(Unit:mm)

RETURN PERIOD (YEARS)	DURATION(HRS) 3	6	9	12	15	18	21	24	TOTAL
2	9	14	15	19	20	7	5	4	93
5	13	20	21	28	29	10	8	6	135
10	16	24	25	33	36	12	9	8	163
20	18	28	30	39	41	14	11	9	190
50	22	33	35	46	49	16	13	11	225
100	24	37	39	51	55	18	15	12	250
200	27	41	43	57	60	20	16	13	276

POTENTIAL SITE : MEDAMIT-2
CATCHMENT AREA : 186(SQ.KM)

(Unit:mm)

RETURN PERIOD (YEARS)	DURATION(HRS) 3	6	9	12	15	18	21	24	TOTAL
2	12	18	19	25	27	9	7	6	123
5	15	22	23	31	33	11	9	7	150
10	16	25	26	34	37	12	10	8	168
20	18	27	29	38	41	13	11	9	186
50	20	31	32	43	45	15	12	10	208
100	22	33	35	46	49	16	13	11	225
200	23	36	38	50	53	17	14	11	242

TABLE 9.14 DESIGN RAINFALL AT THE POTENTIAL SITES (4/4)

POTENTIAL SITE : PASIA
CATCHMENT AREA : 177(SQ.KM)

(Unit:mm)

RETURN PERIOD (YEARS)	DURATION(HRS)								TOTAL
	3	6	9	12	15	18	21	24	
2	7	10	11	14	15	5	4	3	68
5	9	13	14	18	19	6	5	4	88
10	10	15	16	21	22	7	6	5	102
20	11	17	18	24	25	8	7	5	115
50	13	19	20	27	28	9	8	6	131
100	14	21	22	29	31	10	8	7	143
200	15	23	24	32	34	11	9	7	155

POTENTIAL SITE : MUKOH
CATCHMENT AREA : 292(SQ.KM)

(Unit:mm)

RETURN PERIOD (YEARS)	DURATION(HRS)								TOTAL
	3	6	9	12	15	18	21	24	
2	9	13	14	18	19	6	5	4	89
5	13	19	20	27	28	9	7	6	129
10	15	23	24	32	34	11	9	7	156
20	18	27	28	37	40	13	11	9	182
50	21	32	34	44	47	16	13	10	216
100	23	35	37	49	52	17	14	11	240
200	26	39	41	54	58	19	15	12	265

TABLE 9.15 SUMMARY OF FLOOD ANALYSIS (1/2)

POTENTIAL SITE (LOAD CENTER)	CATCHMENT AREA (sq.km)	RETURN PERIOD (years)	FLOOD VOLUME (MCM)	PEAK DISCHARGE (cms)	SPECIFIC DISCHARGE (cms/sq.km)
PASIA (LIMBANG)	177	2	3.4	101	0.6
		5	6.1	160	0.9
		10	8.1	201	1.1
		20	10.1	239	1.4
		50	12.6	287	1.6
		100	14.6	323	1.8
		200	16.6	358	2.0
MEDAMIT-2 (LIMBANG)	186	2	12.0	277	1.5
		5	16.6	361	1.9
		10	19.8	417	2.2
		20	23.1	473	2.5
		50	27.1	542	2.9
		100	30.2	595	3.2
		200	33.3	648	3.5
KANOWIT (SARIKEI)	1,331	2	49.5	1,040	0.8
		5	80.3	1,554	1.2
		10	102.3	1,899	1.4
		20	124.7	2,243	1.7
		50	152.2	2,656	2.0
		100	173.9	2,984	2.3
		200	194.6	3,294	2.5
SEKRANG-1 (SRI AMAN)	508	2	18.4	413	0.8
		5	40.0	784	1.5
		10	55.1	1,026	2.0
		20	70.0	1,261	2.5
		50	89.1	1,562	3.1
		100	103.9	1,797	3.5
		200	118.4	2,023	4.0
SEKRANG-2 (SRI AMAN)	360	2	13.8	324	0.9
		5	29.6	608	1.7
		10	41.0	798	2.2
		20	52.0	977	2.7
		50	66.3	1,212	3.4
		100	77.3	1,390	3.9
		200	87.9	1,563	4.3

TABLE 9.16 SUMMARY OF FLOOD ANALYSIS (2/2)

POTENTIAL SITE (LOAD CENTER)	CATCHMENT AREA (sq.km)	RETURN PERIOD (years)	FLOOD VOLUME (MCM)	PEAK DISCHARGE (cms)	SPECIFIC DISCHARGE (cms/sq.km)
KAPIT-1 (KAPIT)	101	2	4.5	121	1.2
		5	6.8	169	1.7
		10	8.4	199	2.0
		20	9.9	228	2.3
		50	12.2	269	2.7
		100	13.7	297	2.9
		200	15.2	324	3.2
KAPIT-2 (KAPIT)	220	2	8.0	210	1.0
		5	15.9	363	1.7
		10	21.5	464	2.1
		20	27.2	561	2.6
		50	34.6	688	3.1
		100	40.0	781	3.6
		200	45.5	874	4.0
IBAU (KAPIT)	163	2	4.1	113	0.7
		5	7.9	192	1.2
		10	10.6	244	1.5
		20	13.3	293	1.8
		50	16.7	353	2.2
		100	19.6	403	2.5
		200	22.5	451	2.8
BANGKIT (KAPIT)	167	2	6.3	177	1.1
		5	12.4	302	1.8
		10	16.9	388	2.3
		20	21.3	467	2.8
		50	27.0	571	3.4
		100	31.3	647	3.9
		200	35.6	727	4.4
AYAT (KAPIT)	59	2	2.4	71	1.2
		5	4.6	120	2.0
		10	6.3	153	2.6
		20	7.9	185	3.1
		50	10.1	226	3.8
		100	11.6	255	4.3
		200	13.2	285	4.8
MUKOH (KAPIT)	292	2	10.3	273	0.9
		5	20.3	469	1.6
		10	27.7	601	2.1
		20	35.1	705	2.4
		50	44.8	895	3.1
		100	51.7	1,012	3.5
		200	58.9	1,135	3.9

TABLE 9.17 PROBABLE MAXIMUM PRECIPITATION

(Unit : mm)

Potential Site	Catchment Area (sq. km)	PMP			
		1-day	2-day	3-day	5-day
Pasia	177	384	531	706	885
Medamit-2	186	541	686	761	906
Kapit-1	101	512	768	935	1,128
Kapit-2	220	427	585	657	878
Ibau	163	542	646	700	880
Bangkit	167	431	592	664	888
Ayat	59	440	604	678	907
Mukoh	292	422	579	649	868
Kanowit	1,331	496	524	558	700
Sekrang-1	508	495	501	538	730
Sekrang-2	360	495	501	538	730

TABLE 9.18 DESIGN HYETOGRAPH OF PROBABLE MAXIMUM PRECIPITATION

(Unit : mm)

Potential Site	PMP Hyetograph				
	1st-day	2nd-day	3rd-day	4th-day	5th-day
Pasia	90	175	384	147	90
Medamit-2	73	145	541	75	73
Kapit-1	97	256	512	167	97
Kapit-2	110	158	427	110	72
Ibau	90	104	542	90	54
Bangkit	112	161	431	112	72
Ayat	115	164	440	115	74
Mukoh	110	157	422	110	70
Kanowit	34	71	496	71	28
Sekrang-1	37	96	495	96	6
Sekrang-2	37	96	495	96	6

TABLE 11.1 PRINCIPAL FEATURES OF MAJOR STRUCTURES

	SEK-1	SEK-2	K'WIT	MUKOH	KAPIT-2	PASIA	MED-2
1. Development type	RES	RES	RES	RUN	RES	RUN	RUN with pondage
2. Installed capy.(MW)	11.8	21.3	25.1	1.94	4.2	12.4	4.49
3. Max. discharge (cms)	44.8	37.4	102.8	7.4	13.2	5.3	7.8
4. Dam							
Type	Rock-fill	Rock-fill	Rock-fill	concrete weir	Rock-fill	concrete weir	concrete weir
Height (m)	54	93	55	7	56	6	21
Crest length (m)	189	369	433	60	143	40	102
5. Spillway							
Type	Overflow chuteway	Over-flow chuteway	Over-flow chuteway	Overflow weir	Over-flow chuteway	Overflow weir	Overflow weir
Design flood (cms)	2,430	1,880	3,200	1,012	1,050	323	595
6. Waterway							
Type	Pressure tunnel	Pre-ssure tunnel	Pre-ssure tunnel	Non-Pre-ssure tunnel	Pre-ssure tunnel	Non-Pre-ssure tunnel	Non-Pre-ssure tunnel
length (m)	300	400	200	1,660	300	3,800	4,400
Numbers	1	1	1	1	1	1	1
Diameter (m)	4.4	4.0	6.6	2.0	2.4	1.8	2.3
7. Penstock							
Length (m)	20	40	140	40	50	950	130
Numbers	1	1	1	1	1	1	1
Diameter (m)	3.1	2.8	4.7	1.5	1.7	1.1	1.7
8. Nos. of generator	2	2	2	2	2	2	2
9. Transmission line							
Length (km)	30	45	65	25	27	110	60
10. Access road							
Length (km)	16	35	40	6	6	20	1

Note: RES; Reservoir type development

TABLE 11.2 APPLICATION RANGE OF TURBINES

Turbine Type	Turbine Output (kW)	Effective Head (m)	Ns (m-kW)
Verical Shaft Francis Turbine	2,000-20,000	30-300	80-300
Horizontal Shaft Francis Turbine	200-5,000	15-200	60-240
Kaplan Turbine	1,000-20,000	10-70	250-800
Tubular Turbine	200-5,000	3-20	400-1,000
Pelton Turbine	200-20,000	more than 100	8-28
Cross-Flow Turbine	50-1,000	5-100	45-180

TABLE 11.3 COMPARISION OF SYNCHRONOUS GENERATOR AND INDUCTION GENERATOR

Item	Synchronous Generator	Induction Generator
Capacity	Suitable for a large-capacity generator.	Suitable for a small-capacity generator.
Speed	Although high-speed large-capcity generators of this type are difficult to manufacture, there are no other problems with regard to speed.	For low-speed generator, the exciting current increases, resulting in a low power factor.
Exciter	An exciter is required for supplying a direct current to field windings.	No exciter is required because an exciting current run through armeture windings from the power system.
Independent Operation	Possible	Impossible. Power cannot be generated unless an an exicting current is supplied from the power system.
Voltage Adjustment	Possible	Impossible. Voltage is always at the same level as the electric system.
Power Factor Control	Possible. The power factors of both leading and lagging can be adjusted. Reactive power also can be adjusted.	Impossible. The generator can only be operated with the leading power factor which is primarily determined by load. When necessary to improve the power factor, a condenser is required.
Parallel connection with Electric Power System	Control is complicated because parallel connection requires adjustment of voltage, frequency and phase.	Control is simple because parallel connection is made by merely approximating generator speed to synchronous speed.
Impact on Electric Power System at Time of Parallel Connection	Almost none	Excess current runs because of forced parallel connection. It is essary to consider fully the effect of a voltage drop in the electric system.

- continued -

Item	Synchronous Generator	Induction Generator
Rotor construction	Complicated because field pole and exciter are necessary.	Simple and sturdy because of squirrel cago rotor.
Maintenance	Need maintenance for field exicting equipment and control system.	Maintenance is easy because the construction is simple and no excitor is required.
Cost	Higher than induction generator.	Low cost, but low speed machines are expensive.

TABLE 14.1 ESTIMATED CONSTRUCTION COST OF 7 SELECTED SCHEMES

(For Optimized Development Scale at Each Site)

(Unit: M$ million)

Item	SRI AMAN SEK-1	SRI AMAN SEK-2	SARIKEI K'WIT	KAPIT MUKOH	KAPIT KAPIT-2	LIMBANG PASIA	LIMBANG MED-2*
Installed Capacity (MW)	11.8	17.0	25.1	1.94	4.2	12.4	4.6
Construction Cost :							
1. Civil Works							
- Preparatory works	9.18	15.02	21.49	1.16	4.65	2.95	2.90
- Main work	61.22	100.10	143.79	7.75	30.98	19.64	19.32
Sub-total	70.40	115.12	165.28	8.91	35.63	22.59	22.22
2. Generating Equipment	12.54	12.58	21.30	3.74	5.88	6.22	5.34
3. Transmission Line	4.80	7.20	10.40	1.80	1.94	26.40	9.60
4. Access Road	5.12	13.83	12.80	2.38	2.38	9.60	0.86
Sub-total of 1 to 4	92.86	148.73	209.78	16.83	45.83	64.81	38.02
5. Land Acquisition	0.08	0.75	4.80	0	0	0	0
6. Engineering and Administration	9.29	14.87	20.98	1.68	4.58	6.48	3.80
7. Contingency	15.33	24.65	35.33	2.78	7.56	10.69	6.28
Total	117.56 = 117.6	189.0	270.89 = 271.9	21.29 = 21.3	57.97 = 58.0	81.98 = 86.0	48.10 = 48.1

Note: (1) Estimate at mid 1986 price, excluding price contingency.
(2) See Appendix VII for breakdowned detail.
(3) * Run-of-river scheme without pondage.

TABLE 14.2 EVALUATION OF PROJECT - CASH FLOW SCHEDULE

System : Limbang Project : Medamit-2 with Pondage (4.5 MW) Case: Basic Fuel price M$0.12/kWh

Description	Unit	1986	87	88	89	1990	91	92	93	94	95	96	97	98	99	2000	01	02	03	04	2005	06	07	08	09	2010	2011-33 Average	2033
1. Demand, peak power (MW)	MW	2.3	2.5	2.7	2.9	3.2	3.6	4.0	4.3	4.6	5.0	5.3	5.7	6.1	6.5	7.0	7.4	7.8	8.3	8.8	9.3	9.9	10.4	11.1	11.7	12.4	29.3	46.2
2. , energy (GWh)	GWh	11.8	12.7	13.8	15.0	16.5	18.2	20.1	21.7	23.3	25.0	26.7	28.6	30.5	32.6	34.9	37.0	39.1	41.4	43.9	46.4	49.2	52.1	55.1	58.4	61.8	145.9	230.0
3. Annual load factor	%	59	58	58	59	59	58	57	58	58	87	58	57	56	56	57	57	57	57	57	57	57	57	57	57	57	57	57
4. Reserve capacity	MW	1.0	1.0	1.0	4.0	1.0	1.0	1.0	1.0	1.0	1.0	1.1	1.1	1.2	1.3	1.4	1.5	1.6	1.7	1.8	1.9	2.0	2.1	2.2	2.3	2.5	5.9	
5. Required total capacity	MW	3.3	3.5	3.7	3.9	4.2	4.6	5.0	5.3	5.6	6.0	6.4	6.8	7.3	7.8	8.4	8.9	9.4	10.0	10.6	11.2	11.9	12.5	13.3	14.0	14.9	35.2	
6. Diesel retirement	MW							-0.675		-1.06		-0.2	-0.6				-1.05			-0.6		-1.0		-1.0				
7. Power addition, hydro	MW									2.25			2.25															
, diesel	MW			0.6		1.0		1.0									1.0		2.0			3.0		2.0		1.0		
8. System capacity	MW	3.6	3.6	4.2	4.2	5.2	5.2	5.5	5.5	6.7	6.7	6.5	3.7	8.7	8.7	8.7	9.7	9.7	11.7	11.1	11.1	13.1	13.1	14.1	14.1	15.1	35.2	
(L.O. units)	"									(4.4)	(4.4)	(4.2)	(4.2)	(4.2)	(4.2)	(4.2)	(5.2)	(5.2)	(7.2)	(6.6)	(6.6)	(8.6)	(8.6)	(9.6)	(9.6)	(10.6)	(30.7)	
9. Installation cost, hydro	M$ x mill						10.20	24.80	12.92		0.80	2.40																-
, diesel	"	0.48	1.44	0.80	2.40	0.80	2.40								0.80	2.40	1.60	4.80		2.40	7.20	1.60	4.80	0.80	2.40			-
10. Power generation, hydro	GWh									17.5	18.1	18.6	26.0	27.1	26.4	29.2	30.0	30.7	31.5	32.3	32.7	33.7	34.1	34.9	35.4	35.7	35.9	
, diesel	GWh	11.8	12.7	13.8	15.0	16.5	18.2	20.1	21.7	5.8	6.9	8.1	2.6	3.4	4.2	5.7	7.0	8.4	9.9	11.6	13.5	15.5	8.0	20.2	23.0	26.1	110.0	
11. Hydro OM cost	M$ x mill									0.37	0.37	0.37	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	
12. Diesel OM cost, fixed	M$ x mill	0.35	0.35	0.40	0.40	0.50	0.50	0.53	0.53	0.42	0.42	0.40	0.40	0.40	0.40	0.40	0.50	0.50	0.69	0.63	0.63	0.83	0.83	0.92	0.92	1.02	2.95	
variable	"	0.06	0.07	0.07	0.08	0.09	0.09	0.10	0.11	0.03	0.04	0.04	0.01	0.02	0.02	0.03	0.04	0.04	0.05	0.06	0.07	0.08	0.09	0.11	0.12	0.14	0.57	
fuel (HSD)	"																											
fuel (LO)	"	1.47	1.58	1.72	0.87	2.06	2.27	2.51	2.71	0.72	0.86	1.01	0.32	0.42	0.52	0.71	0.87	1.05	1.24	1.45	1.68	1.93	2.25	2.52	2.87	3.26	13.72	
13. Total cost (hydro + diesel)	M$ x mill	2.36	3.44	2.99	4.75	3.45	15.46	27.94	16.27	1.54	2.49	4.22	1.13	1.24	2.14	3.94	3.41	6.79	2.38	4.94	9.98	4.84	8.37	4.75	6.71	4.82	17.64	

Present Worth (M$ x mill):
Discount rate (%) 10.0
Net present value +2.30
B/C Ratio 1.04

Rate of Return : 10.8%

TABLE 14.3 EVALUATION OF PROJECT - CASH FLOW SCHEDULE

System : Limbang Project : Pasia (12.4 MW) Case: Basic = Fuel price M$0.12/kWh

Description	Unit	1986	87	88	89	1990	91	92	93	94	95	96	97	98	99	2000	01	02	03	04	2005	06	07	08	09	2010	2011-33 Average	2033
1. Demand, peak power (MW)	MW	2.3	2.5	2.7	2.9	3.2	3.6	4.0	4.3	4.6	5.0	5.3	5.7	6.1	6.5	7.0	7.4	7.8	8.3	8.8	9.3	9.9	10.4	11.1	11.7	12.4	29.3	46.2
2. , energy (GWh)	GWh	11.8	12.7	13.8	15.0	16.5	18.2	20.1	21.7	23.3	25.0	26.7	28.6	30.5	32.6	34.9	37.0	39.1	41.4	43.9	46.4	49.2	52.1	55.1	58.4	61.8	145.9	230.0
3. Annual load factor	%	59	58	58	59	59	58	57	58	58	57	58	57	57	57	57	57	57	57	57	57	57	57	57	57	57	57	57
4. Reserve capacity	MW																										5.9	
5. Required total capacity	MW	3.3	3.5	3.7	3.9	4.2	4.6	5.0	5.3	5.6	6.0	6.4	6.8	7.3	7.8	8.4	8.9	9.4	10.0	10.6	11.2	11.9	12.5	13.3	14.0	14.9	35.2	
6. Diesel retirement	MW							-0.675		-1.06		-0.2	-0.6				-1.05			-0.6		-1.0		-1.0				
7. Power addition, hydro	MW									6.2							2.3											
, diesel	MW			0.6		1.0		1.0													3.0			3.0		1.0		
8. System capacity	MW	3.6	3.6	4.2	4.2	5.2	5.2	5.5	5.5	10.6	10.6	10.4	9.8	9.8	9.8	9.8	11.1	11.1	11.1	10.5	13.5	12.5	12.5	14.5	14.5	15.5	35.2	
9. Installation cost, hydro	M$ x mill						15.64	39.0	23.4						1.0	3.0											-	
,diesel	"	0.48	1.44	0.80	2.40	0.80	2.40												2.40	7.20		2.40	7.20	0.80	2.40		-	
10. Power generation, hydro	GWh									23.3	25.0	26.7	28.6	30.5	32.4	34.4	37.0	39.0	41.3	43.7	46.2	48.9	51.8	54.6	57.86	61.0	98.8	
, diesel	GWh	11.8	12.7	13.8	15.0	16.5	18.2	20.1	21.7	0	0	0	0	0	0.2	0.5	0	0.1	0.1	0.2	0.2	0.3	0.3	0.5	0.6	0.8	47.1	
11. Hydro OM cost	M$ x mill									0.62	0.62	0.62	0.62	0.62	0.62	0.65	0.65	0.65	0.65	0.65	0.65	0.65	0.65	0.65	0.65	0.65	0.65	
12. Diesel OM cost, fixed	M$ x mill	0.35	0.35	0.40	0.40	0.50	0.50	0.53	0.53	0.42	0.42	0.40	0.35	0.35	0.35	0.35	0.25	0.25	0.25	0.19	0.48	0.38	0.38	0.58	0.58	0.67	2.55	
variable	"	0.06	0.07	0.07	0.08	0.09	0.09	0.10	0.11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.24	
fuel	"	1.47	1.58	1.72	1.87	2.06	2.27	2.51	0	0	0	0	0	0	0.02	0.06	0	0.01	0.01	0.02	0.02	0.04	0.04	0.06	0.07	0.10	5.88	
13. Total cost (hydro + diesel)	M$ x mill	2.36	3.44	2.99	4.75	3.45	20.86	42.14	24.04	1.04	1.04	1.04	0.97	0.97	1.99	4.06	0.90	0.91	3.31	8.06	1.15	3.47	8.27	2.09	3.70	1.42	9.29	

Present Worth (M$ x mill):
Discount rate (%) 10.0
Net present value -1.14
B/C Ratio 0.99

Rate of Return : 9.8%

TABLE 14.4 EVALUATION OF PROJECT - CASH FLOW SCHEDULE

System : Limbang Project : ALL DIESEL Case: Basic = Fuel price M$0.12/kWh

Description	Unit	1986	87	88	89	1990	91	92	93	94	95	96	97	98	99	2000	01	02	03	04	2005	06	07	08	09	2010	2011-33 Average	2033
1. Demand, peak power (MW)	MW	2.3	2.5	2.7	2.9	3.2	3.6	4.0	4.3	4.6	5.0	5.3	5.7	6.1	6.5	7.0	7.4	7.8	8.3	8.8	9.3	9.9	10.4	11.1	11.7	12.4	29.3	46.2
2. , energy (GWh)	GWh	11.8	12.7	13.8	15.0	16.5	18.2	20.1	21.7	23.3	25.0	26.7	28.6	30.5	32.6	34.9	37.0	39.1	41.4	43.9	46.4	49.2	52.1	55.1	58.4	61.8	145.9	230.0
3. Annual load factor	%	59	58	58	59	59	58	57	58	58	57	57	57	57	57	57	57	57	57	57	57	57	57	57	57	57	0.57	0.57
4. Reserve capacity	MW	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.1	1.1	1.2	1.3	1.4	1.5	1.6	1.7	1.8	1.9	2.0	2.1	2.2	2.3	2.5	5.9	
5. Required total capacity	MW	3.3	3.5	3.7	3.9	4.2	4.6	5.0	5.3	5.6	6.0	6.4	6.8	7.3	7.8	8.4	8.9	9.4	10.0	10.6	11.2	11.9	12.5	13.3	14.0	14.9	35.2	
6. Diesel retirement	MW							-0.675		-1.06		-0.2	-0.6				-1.05			-0.6		-1.0		-1.0		-2.0		
7. Power addition, hydro	MW																											
, diesel	MW			0.6		1.0		1.0		2.0		2.0			1.0		2.0		2.0		2.0		3.0		3.0			
8. System capacity	MW	3.6	3.6	4.2	4.2	5.2	5.2	5.5	5.5	6.4	6.4	8.2	7.6	7.6	8.6	8.6	9.5	9.5	11.5	10.9	12.9	11.9	14.9	13.9	16.9	14.9	35.2	
9. Installation cost, hydro	M$ x mill																											
,diesel	"	0.48	1.44	0.80	2.40	0.80	2.40	1.60	4.80	1.60	4.80		0.80	2.40	1.60	4.80	1.60	4.80	1.60	4.80	2.40	7.20	2.40	7.20		-		
10. Power generation, hydro	GWh																											
, diesel	GWh	11.8	12.7	13.8	15.0	16.5	18.2	20.1	21.7	23.3	25.0	26.7	28.6	30.5	32.6	34.9	37.0	39.1	41.4	43.9	46.4	49.2	52.1	55.1	58.4	61.8	145.9	
11. Hydro OM cost	M$ x mill																											
12. Diesel OM cost, fixed	M$ x mill	0.35	0.35	0.40	0.40	0.50	0.50	0.53	0.53	0.61	0.61	0.79	0.73	0.73	0.83	0.83	0.91	0.91	1.10	1.05	1.24	1.14	1.43	1.33	1.62	1.43	3.38	
variable	"	0.06	0.07	0.07	0.08	0.09	0.09	0.10	0.11	0.12	0.13	0.14	0.15	0.16	0.17	0.18	0.19	0.20	0.22	0.23	0.24	0.26	0.27	0.29	0.30	0.32	0.76	
fuel	"	1.47	1.58	1.72	1.87	2.06	2.27	2.51	2.71	2.91	3.12	3.33	3.57	3.81	4.07	4.36	4.62	4.88	5.17	5.48	5.79	6.14	6.50	6.88	7.29	7.71	18.21	
13. Total cost (all diesel)	M$ x mill	2.36	3.44	2.99	4.75	3.45	5.26	4.74	8.15	5.24	8.66	4.26	5.25	7.10	6.67	10.17	7.32	10.79	8.09	11.56	9.67	14.74	10.60	15.70	9.21	9.46	22.35	

TABLE 14.5 EVALUATION OF PROJECT - CASH FLOW SCHEDULE

System : Kapit Project : Mukoh (1.9 MW) Case: Fuel price M$0.12/kWh

Description	Unit	1986	87	88	89	1990	91	92	93	94	95	96	97	98	99	2000	01	02	03	04	2005	06	07	08	09	2010	2011-33 Average	2033
1. Demand, peak power (MW)	MW	1.27	1.34	1.40	1.47	1.55	1.63	1.71	1.80	1.89	1.98	2.08	2.18	2.29	2.40	2.52	2.65	2.78	2.92	3.06	3.21	3.38	3.55	3.73	3.91	4.11	8.39	12.66
2. , energy (GWh)	GWh	5.6	5.9	6.1	6.4	6.8	7.1	7.5	7.9	8.3	8.7	9.1	9.6	10.0	10.5	11.0	11.6	12.1	12.8	13.4	14.1	14.8	15.5	16.3	17.1	18.0	37.0	55.9
3. Annual load factor	%	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50
4. Reserve capacity	MW	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.64	0.68	0.71	0.75	0.78	0.82	1.68	
5. Required total capacity	MW	1.87	1.94	2.0	2.07	2.15	2.23	2.31	2.40	2.49	2.58	2.68	2.78	2.89	3.00	3.12	3.25	3.38	3.52	3.66	3.85	4.06	4.26	4.48	4.69	4.93	10.07	
6. Diesel retirement	MW		-0.075	-0.288							-0.2	-0.2	-0.2	-0.2			-1.2		-0.3		-0.4							
7. Power addition, hydro	MW									1.0					1.0													
, diesel	MW		+0.3	+0.4													+1.0		+1.0			+1.0						
8. System capacity	MW	2.36	2.59	2.3	2.7	2.7	2.7	2.7	2.7	3.7	3.5	3.3	3.1	2.9	3.9	3.9	3.7	3.7	4.4	4.4	4.0	5.0	5.0	5.0	5.0	5.0	10.1	
9. Installation cost, hydro	M$ x mill						3.78	9.45	5.67				0.60	1.80														
, diesel	"	0.96	0.32	0.96											0.80	2.40	0.80	2.40		0.80	2.4							
10. Power generation, hydro	GWh									7.0	7.1	7.4	7.6	7.7	10.2	10.6	11.0	11.3	11.8	12.1	12.5	12.9	12.9	13.3	14.1	14.5	16.9	
, diesel	GWh	5.6	5.9	6.1	6.4	6.8	7.1	7.5	7.9	1.3	1.6	1.7	2.0	2.3	0.3	0.4	0.6	0.8	1.0	1.3	1.6	1.9	12.2	2.0	3.0	3.5	20.1	
11. Hydro OM cost	M$ x mill									0.15	0.15	0.15	0.15	0.15	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.17	
12. Diesel OM cost, fixed	M$ x mill	0.23	0.25	0.22	0.26	0.36	0.36	0.36	0.36	0.26	0.24	0.22	0.20	0.18	0.18	0.18	0.16	0.16	0.23	0.23	0.19	0.29	0.29	0.29	0.29	0.29	0.78	
variable	"	0.03	0.03	0.03	0.03	0.04	0.04	0.04	0.04	0.01	0.01	0.01	0.01	0.01	0	0	0	0	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.02	0.10	
fuel (HSD)	"	1.11	1.04	1.07	0.94	1.13	1.04	1.10	1.17	0.19	0.23	0.24	0.27	0.29	0.04	0.05	0	0	0	0	0	0	0	0	0	0	0	
(LO)	"	0	0.09	0.09	0.22	0.23	0.24	0.26	0.27	0.04	0.06	0.07	0.09	0.11	0.01	0.02	0.08	0.11	0.13	0.17	0.21	0.25	0.29	0.34	0.40	0.46	2.66	
13. Total cost (hydro + diesel)	M$ x mill	2.33	1.73	2.37	1.45	1.76	5.46	11.21	7.51	0.65	0.69	0.69	1.32	2.54	1.20	2.82	1.21	2.84	0.54	1.38	2.98	0.72	0.76	0.81	0.88	0.94	3.71	

Present Worth (M$ x mill):
Discount rate (%) 10.0
Net present value +0.99
B/C Ratio 1.04

Rate of Return : 10.8%

TABLE 14.6 EVALUATION OF PROJECT - CASH FLOW SCHEDULE

System : Kapit Project : ALL DIESEL Case: Basic = Fuel price M$0.12/kWh

Description	Unit	1986	87	88	89	1990	91	92	93	94	95	96	97	98	99	2000	01	02	03	04	2005	06	07	08	09	2010	2011-33 Average	2033
1. Demand, peak power (MW)	MW	1.27	1.34	1.40	1.47	1.55	1.63	1.71	1.80	1.89	1.98	2.08	2.18	2.29	2.40	2.52	2.65	2.78	2.92	3.06	3.21	3.38	3.55	3.73	3.91	4.11	8.39	12.66
2. , energy (GWh)	GWh	5.6	5.9	6.1	6.4	6.8	7.1	7.5	7.9	8.3	8.7	9.1	9.6	10.0	10.5	11.0	11.6	12.1	12.8	13.4	14.1	14.8	15.5	16.3	17.1	18.0	37.0	55.9
3. Annual load factor	%	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50
4. Reserve capacity	MW	0.6	0.6	0.6	0.6	0.	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.64	0.68	0.71	0.75	0.78	0.82	1.68	
5. Required total capacity	MW	1.87	1.94	2.0	2.07	2.15	2.23	2.31	2.4	2.49	2.58	2.68	2.78	2.89	3.0	3.12	3.25	3.38	3.52	3.66	3.85	4.06	4.26	4.48	4.69	4.93	10.07	
6. Diesel retirement	MW		-0.075	-0.288							-0.2	-0.2	-0.2	-0.2			-1.2		-0.3		-0.4					-1.0	-	
7. Power addition, hydro	MW																										-	
, diesel	MW		+0.3		+0.4						+1.0				+1.0		+1.0		+1.0			1.0				+1.0	-	
8. System capacity	MW	2.36	2.59	2.3	2.7	2.7	2.7	2.7	2.7	2.7	3.5	3.3	3.1	2.9	3.9	3.9	3.7	3.7	4.4	4.4	4.0	5.0	5.0	5.0	5.0	5.0	10.1	
(H.S.D units)		2.36	2.3	2.0	2.0	2.0	2.0	2.0	2.0	2.0	1.8	1.6	1.4	1.2	1.2	1.2	0	0	0	0	0	0	0	0	0	0	0	
(L.O units)			0.3	0.3	0.7	0.7	0.7	0.7	0.7	0.7	1.7	1.7	1.7	1.7	2.7	2.7	3.7	3.7	4.4	4.4	4.0	5.0	5.0	5.0	5.0	5.0	10.1	
9. Installation cost, hydro	M$ x mill																											
,diesel	"	0.96	0.32	0.96					0.80	2.40			0.80	2.40	0.80	2.40	0.80	2.40		0.80	2.4			0.80	2.40		-	
10. Power generation, hydro	GWh																											
, diesel	GWh	5.6	5.9	6.1	6.4	6.8	7.1	7.5	7.9	8.3	8.7	9.1	9.6	10.0	10.5	11.0	11.6	12.1	12.8	13.4	14.1	14.8	15.5	16.3	17.1	18.0	37.0	
11. Hydro OM cost	M$ x mill																											
12. Diesel OM cost, fixed	M$ x mill	0.23	0.25	0.22	0.26	0.36	0.36	0.36	0.36	0.36	0.34	0.32	0.30	0.28	0.37	0.37	0.36	0.36	0.42	0.42	0.38	0.48	0.48	0.48	0.48	0.48	0.97	
variable	"	0.03	0.03	0.03	0.03	0.04	0.04	0.04	0.04	0.04	0.05	0.05	0.05	0.05	0.05	0.06	0.06	0.06	0.07	0.07	0.07	0.08	0.08	0.08	0.09	0.09	0.19	
fuel (HSD)	"	1.11	1.04	1.07	0.94	1.13	1.04	1.10	1.17	1.22	0.89	0.88	0.86	0.83	0.65	0.67	0	0	0	0	0	0	0	0	0	0	0	
(LO)	"	0	0.09	0.09	0.22	0.23	0.24	0.26	0.27	0.28	0.56	0.62	0.70	0.78	0.96	1.01	1.53	1.60	1.69	1.77	1.86	1.95	2.05	2.16	2.26	2.38	4.90	
13. Total cost (all diesel)	M$ x mill	2.33	1.73	2.37	1.45	1.76	1.68	1.76	2.64	4.30	1.84	1.87	2.71	4.34	2.83	4.51	2.75	4.42	2.18	3.06	4.71	2.51	2.61	3.52	5.23	2.95	6.06	

TABLE 14.7 SUMMARY OF SENSITIVITY TESTS

Case	Fuel Price: 1986 Basic Price	Fuel Price: Escalation	Diesel Cost	Hydro Cost	Mukoh NPV (M$'000)	Mukoh B/C	Mukoh IRR (%)	Pasia 5/ NPV (M$'000)	Pasia 5/ B/C	Pasia 5/ IRR (%)	Medamit-2 NPV (M$'000)	Medamit-2 B/C	Medamit-2 IRR (%)
Basic Sensitivity Test													
	As estimated 1/	0	As estimated	As estimated	+0.99	1.04	10.8	-1.1	0.99	9.8	+2.3	1.03	10.8
A1	As estimated (M¢ 40/lit)	0	-20% (M$2,560/ kW)	As estimated	+0.05	1.00	10.0	-4.67	0.94	9.3	-0.51	0.99	9.9
A2	As estimated 2/	0	As estimated (M$3,200/kW)	+20%	-1.83	0.94	8.8	-12.81	0.87	8.3	-4.80	0.95	8.7
A3	As estimated	0	As estimated	-10%	+2.43	1.09	12.0	+4.68	1.06	10.8	+5.84	1.08	12.1
A4	As estimated	2% p.a. 3/	As estimated	As estimated	+6.36	1.20	13.8	+22.70	1.24	12.7	+13.97	1.14	13.7
B1	Price as at Mar. 86 (M¢ 34.3/lit)	0	As estimated	As estimated	-0.45	0.98	9.7	-6.56	0.92	9.0	-0.96	0.99	9.7
B2	Price as at Mar. 86	3.86% 4/ p.a.	As estimated	As estimated	+11.21	1.31	15.5	+46.94	1.46	14.5	+24.30	1.19	15.3

Note: NPV : Net present value representing saving in thermal costs
1/ : Average of 1985-86 price
2/ : SESCO record
3/ : A tentative rate assumed for increase of oil price
4/ : SESCO's pricing schdule
5/ : With regulating pondage

Table 14.8 SALIENT FEATURES OF MUKOH DEVELOPMENT
(2 ALTERNATIVE PLANS)

Demand Scenario: Kapit + Timber Industries

Description		Case-1	Case-2
Type of development		ROR	ROR with pondage
Firm discharge	(m 3/s)	7.4	7.4
Plant discharge	(m 3/s)	7.4	14.8
Effective head	(m)	31.5	36.1
Full supply level	(m)	80.0	87.2
Min. operating level	(m)	-	80.7
Average operating level	(m)	80.0	85.0
Tailwater level	(m)	45.0	45.0
Dam/weir height		5	15.2
Headrace, length	(m)	1,660	1,660
diameter	(m)	2.0	2.7
Penstock, length	(m)	40	40
diameter	(m)	1.5	2.2
Installed capacity	(MW)	1.94	4.45
Dependable output	(MW)	1.94	4.45
Annual energy	(GWh)		
- Primary		16.7	19.1
- Secondary		0	17.5
Total		16.7	36.6
Transmission line			
- Length	(km)	25	25
- Voltage (kV) x circuit		33 x 1	33 x 1
Construction cost	(M$ mill)	21.3	37.1

TABLE 14.9 TECHNICAL FEATURES OF THREE CANDIDATE SITES

Item	MUKOH	PASIA	MEDAMIT-2
Type of development	Run-of-river	Run-of-river	Run-of-river
Topography	Banks at proposed dam (weir) site are steep and high allowing construction of a high dam. River width is 15 m, with exposed rocks. River deposit seems nil. No difficulty, except for relatively large excavation at powerhouse site due to steep topography thereat.	Damsite shows a steep V-shape topography. River width is 20 m and the gradient some 1/20. River-bed deposit is thin (1-2 m). Powerhouse area is also steep.	River at damsite shows meanders. The width is some 15 m, with exposed rocks on both banks. River deposit is presumably thin (2 m). Powerhouse topography is gentle. No topographical difficulty is foreseeen.
Geology	Damsite is in the zone of hard graywacke and powerhouse in hard slate. Overburden on both banks is very thin. No geological problem effecting the scheme is foreseen.	Whole area fall in graywacke zone. Generally hard and massive. Overburden is almost nil. Depth of weathering of rocks appears to be thin. No specific problem foreseen.	Damsite consists of graywacke (left bank) and shale, generally hard. Powerhouse is in limestone area. Overburden depth is 1 to 2 m left bank, but 5 m on right bank. A 5 m thick fractures zone is observed along limstone-shale boundary which crosses the penstock line, but seems not to constitute a critical constraint to the scheme.
Source of Aggregates	Sand/gravel deposit is scare in the vicinity of project area. To be transported from distant sources, 15-20 km away, or otherwise produced from excavated rocks.	Sand/gravel is scare in the river reaches along the site, but some found along the Batang Trusan. Presumably some to be transported from far deposits.	Sufficient quantity is available in river deposits along Sungai Medamit and Limbang.
Access	Existing logging road passes at 1.5 km from the site could be reached by providing a new road of 4 km in length. In general, accessibility is fair.	A new logging road is under construction to put into operation in end 1987. Upon its completion, access to Lawas is to be made possible. Construction of a new access road of 20 km in steep area would be necessary to reach the site.	Existing logging roads pass nearby the site. A new access road than 1 km. The existing road is under active operation and in a fair to good condition. Access condition is good.
Transmission Line	Transmission line length is 25 km to Kapit. The line passes through hilly areas. The vegetation is relatively thick. In general, the line route will be accessible from the existing logging roads.	Total line length will be some 110 km. Of which, 20 km passes in primary rain forest, crossing mountains of over 1,000 m in altitude, until it reaches the upper reach of the Medamit where the existing logging road exists. Difficulty is fore-seen in this section, both in line construction and future maintenance.	Line length is about 60 km to Limbang, passing mostly in undulating flat areas. Vegatation is relatively thick. Access to the line route is possible from the existing public and public and logging roads.
Land Acquisition and Resettlement	Impounding by pondage limited only in the existing river course. No resettlement of housings is required.	Impounding only in the present river course. No resettlement of housings.	Impounding only in the present river course. No resettlement of housing.
Downstream Water Use	No adverse effect.	No adverse effect.	No adverse effect.

Note : See Appendix III - Summary of Field Reconnaissance for further detailed descriptions.

Table 14.10 Main Features of Proposed Schemes for Low Head Plan

Description	Lupar	Kanowit	Katibas	Belah	Limbang
Load centre	Sri Aman	Sarikei	Kapit	Kapit	Limbang
Catchment area (km)	2,220	2,530	3,150	12,150	2,820
Average runoff (m^3/s)	220	250	290	1,300	190
Estimated firm discharge (m^3/s)	115	65	100	490	60
Plant discharge(m^3/s)	230	130	200	980	120
Power head (m)	3	3	3	3	3
Installed capacity (MW)	5.7	3.2	5.0	24.5	3.0
Dependable output (MW)	2.9	1.6	2.5	12.2	1.5
Annual energy (GWh)					
- Primary	24.7	13.9	21.5	105.1	12.9
- Secondary	19.8	11.1	17.2	84.1	10.3
Total	44.5	25.0	38.7	189.2	23.2
Weir					
- Height (m)	7	7	7	9	7
- Length (m)	70	50	50	150	100
- Pile foundation depth (m)	15	10	5	10	15
Access road (km)	1	5	60	20	4
Transmissioin line					
- Voltage (kV)	33	33	33	66	33
- Length (km)	35	47	50	18	33
Construction cost (million M$)	67.0	49.5	72.0	330.0	56.0

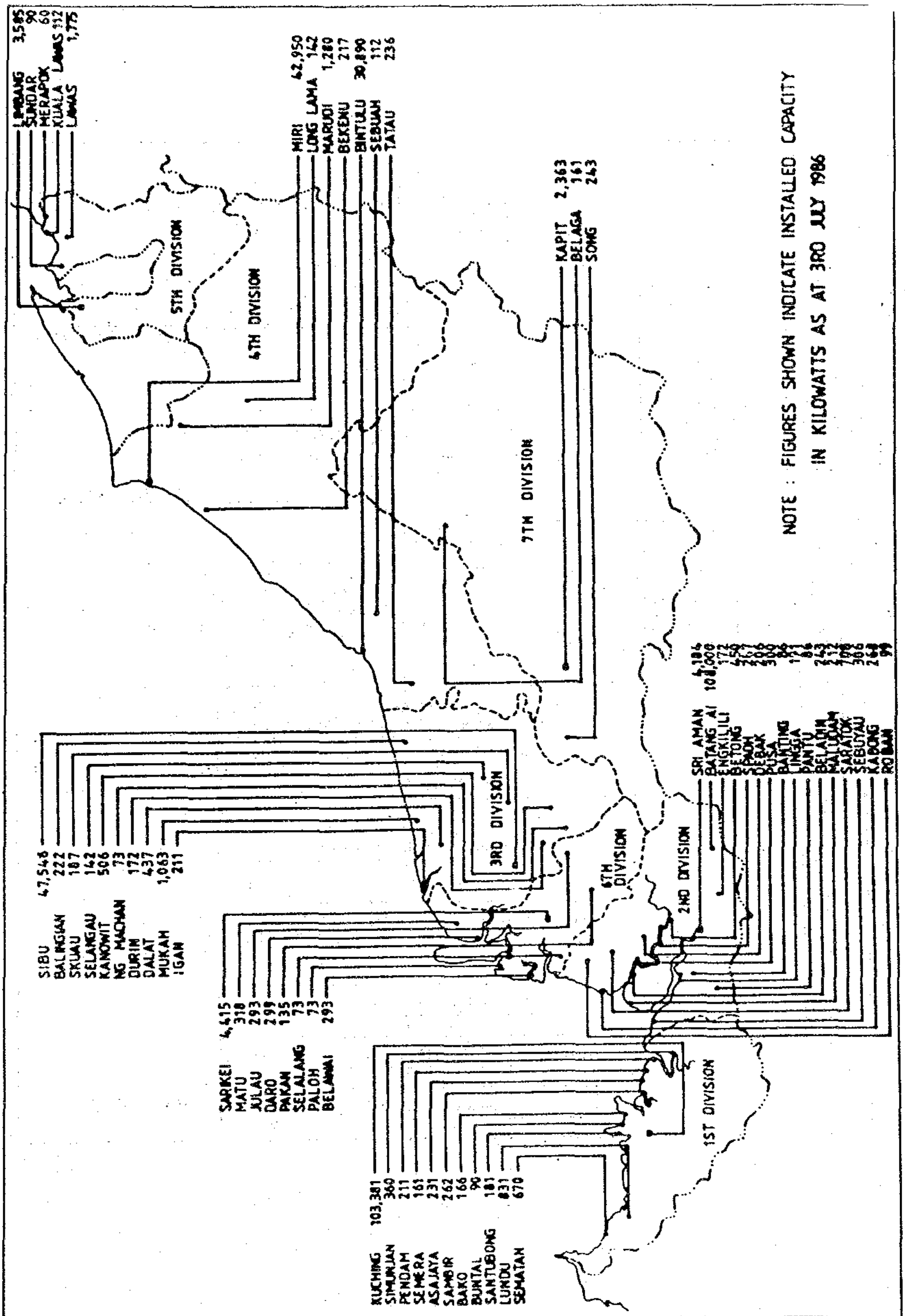

FIG.1.1 SESCO'S ADMINISTRATIVE REGIONS AND STATIONS

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FEASIBILITY STUDY
SMALL SCALE HYDROELECTRIC POWER PROJECT IN SARAWAK
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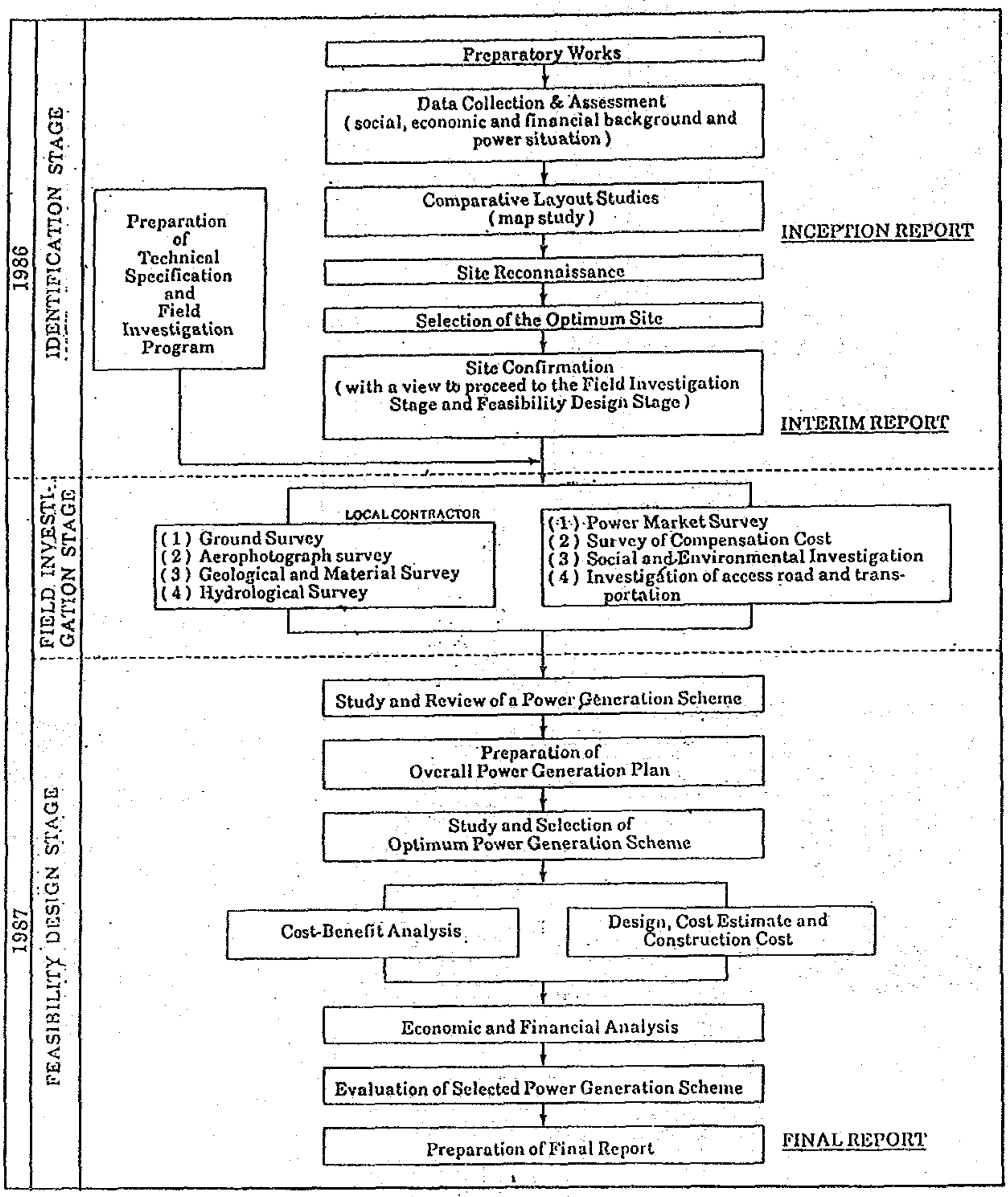

FIG. 2-1 FLOWCHART OF FEASIBILITY STUDY

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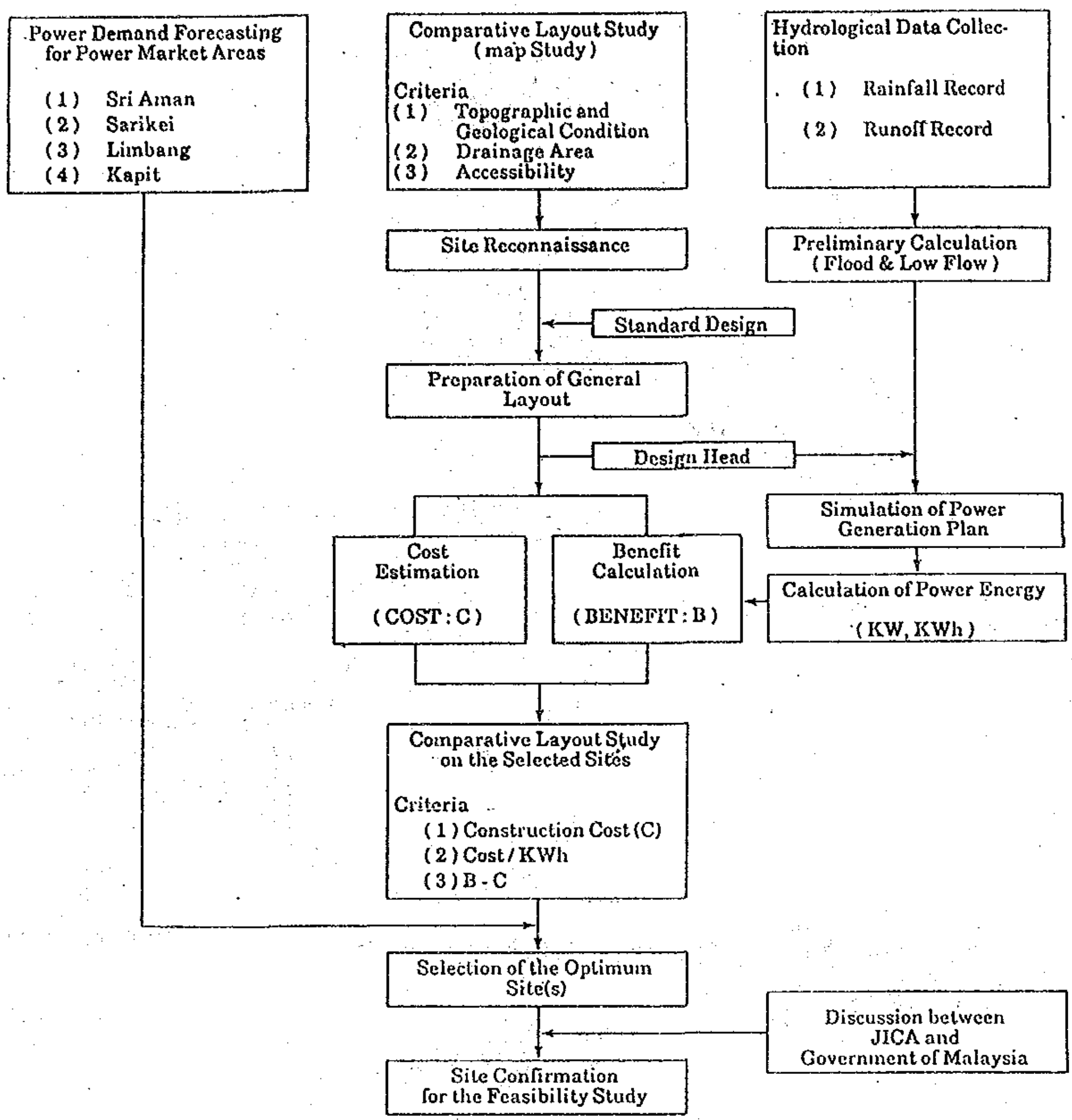

FIG. 2-2 FLOWCHART OF SITE CONFIRMATION FOR FEASIBILITY DESIGN

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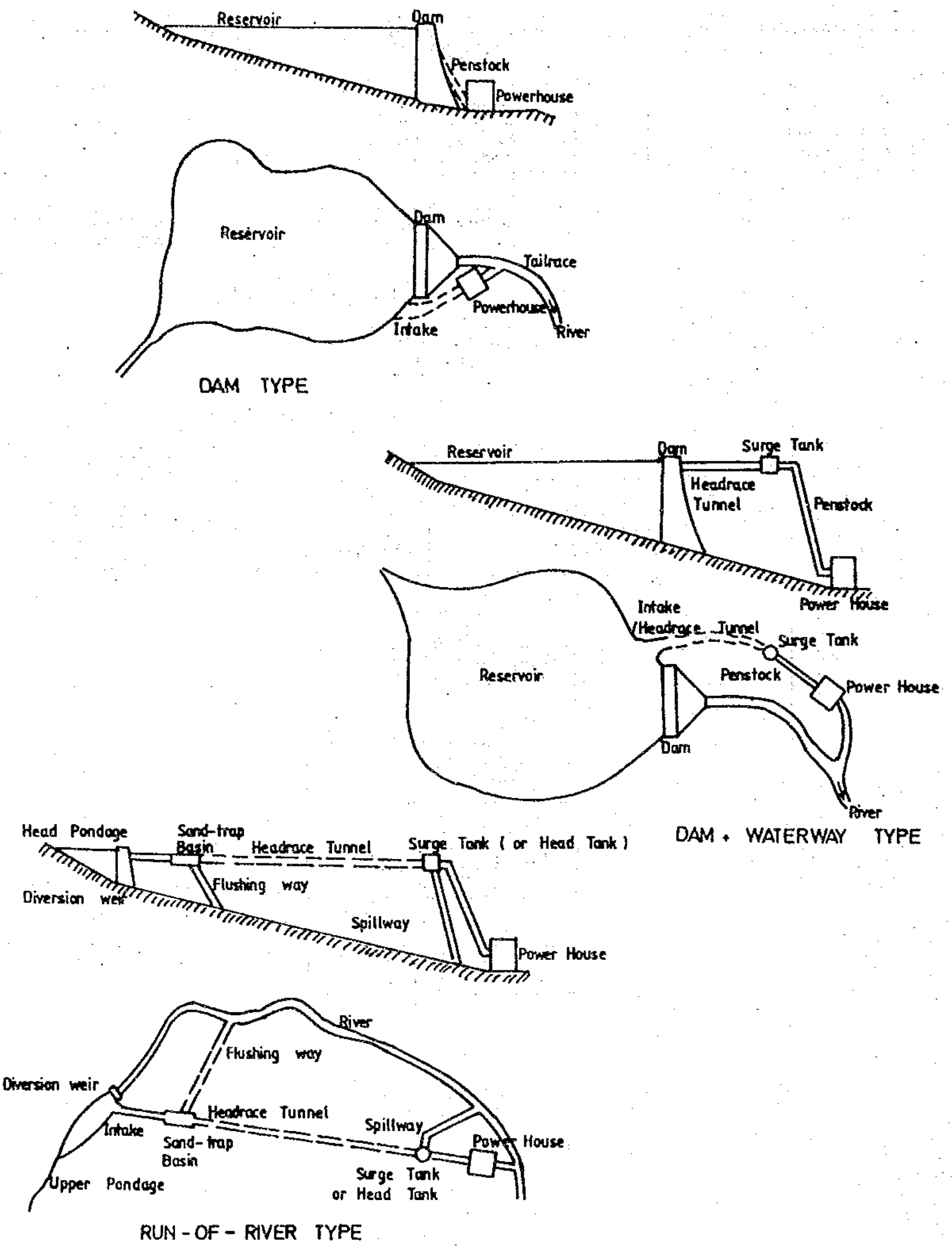

FIG.4.1 SCHEMATIC DIAGRAM OF POWER DEVELOPMENT

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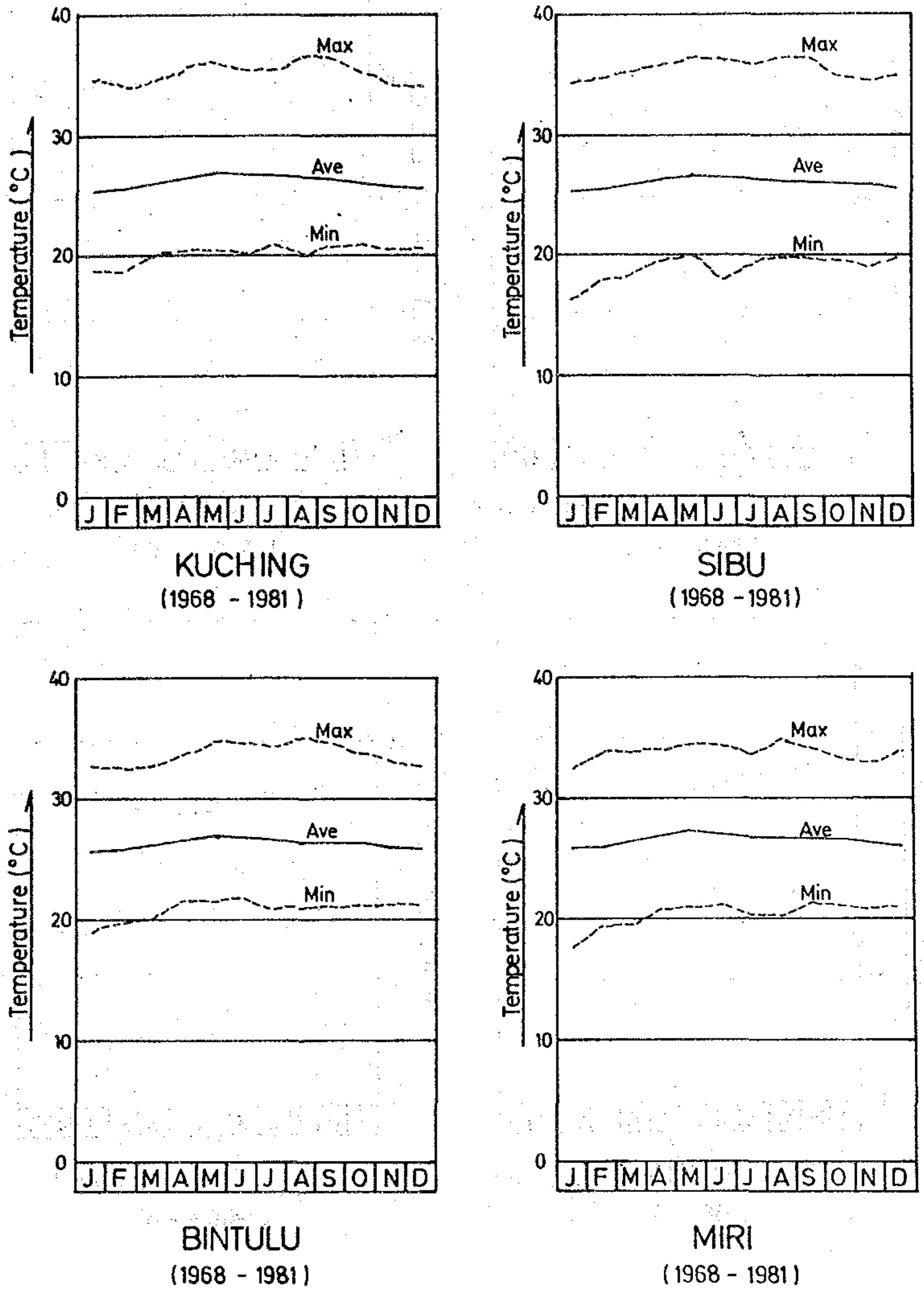

FIG.5.1 MEAN, MAXIMUM AND MINIMUM TEMPERATURE

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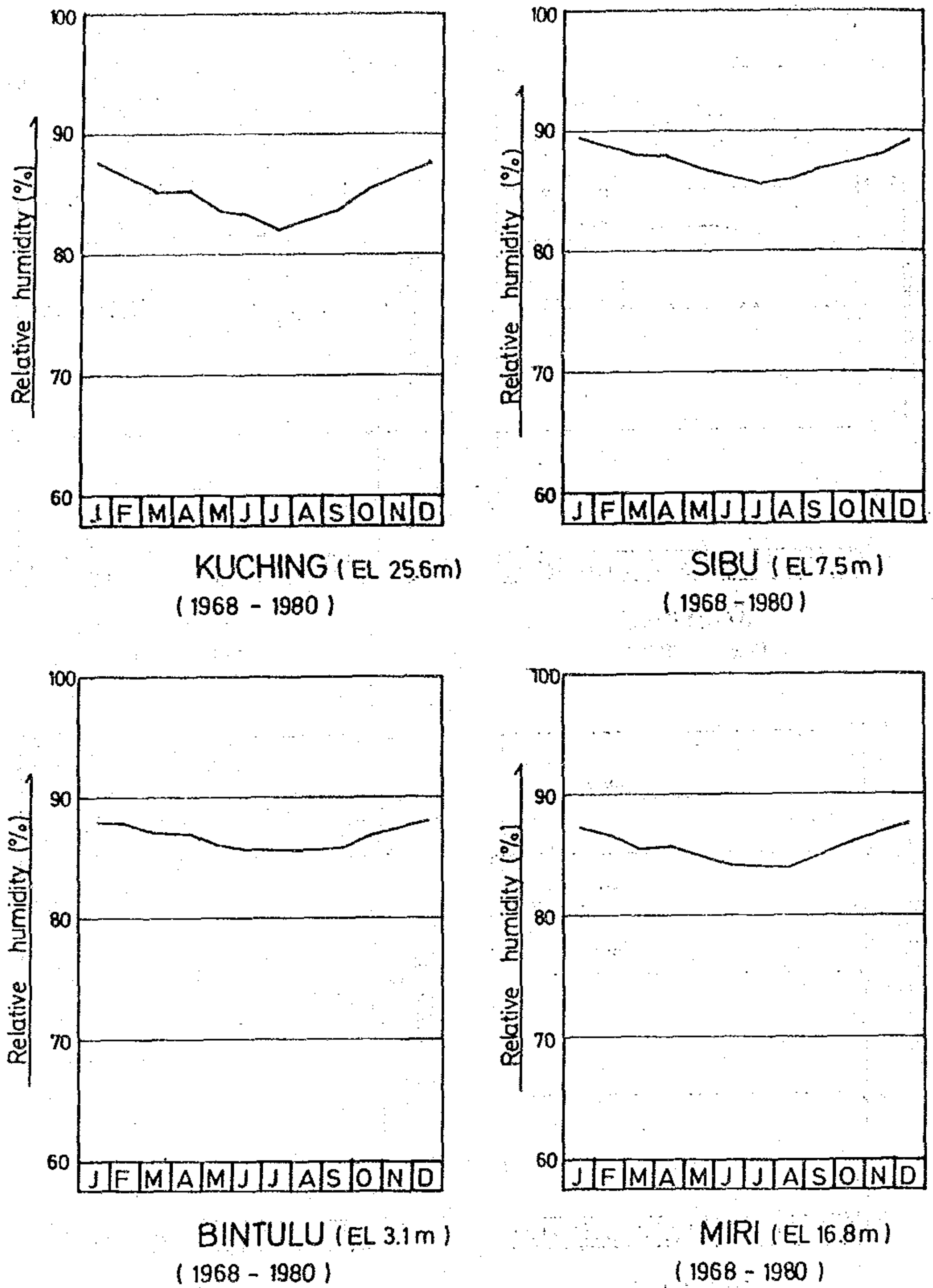

FIG.5.2 MEAN RELATIVE HUMIDITY

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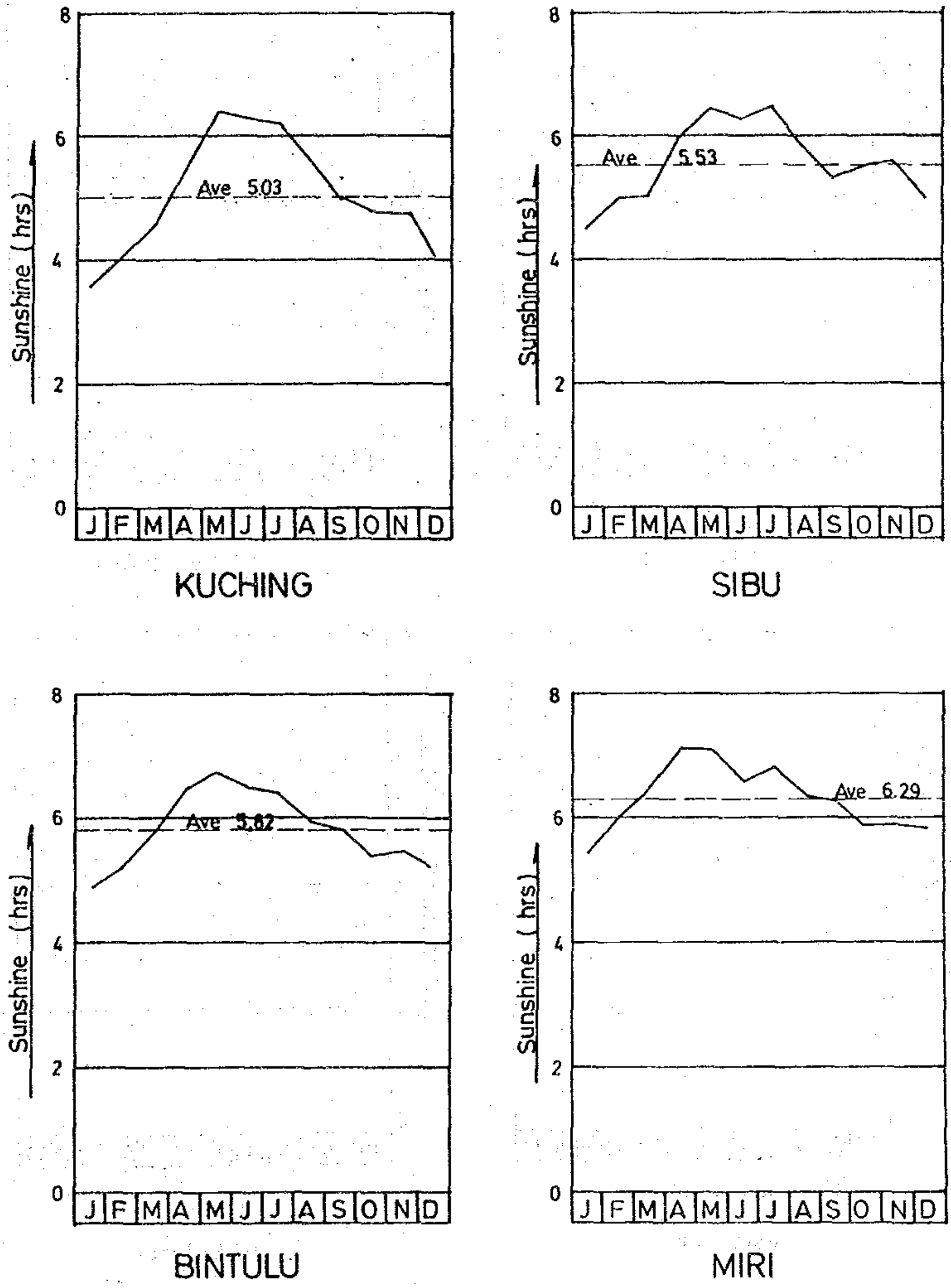

FIG.5.3 MEAN MONTHLY PATTERN OF SUNSHINE HOUR

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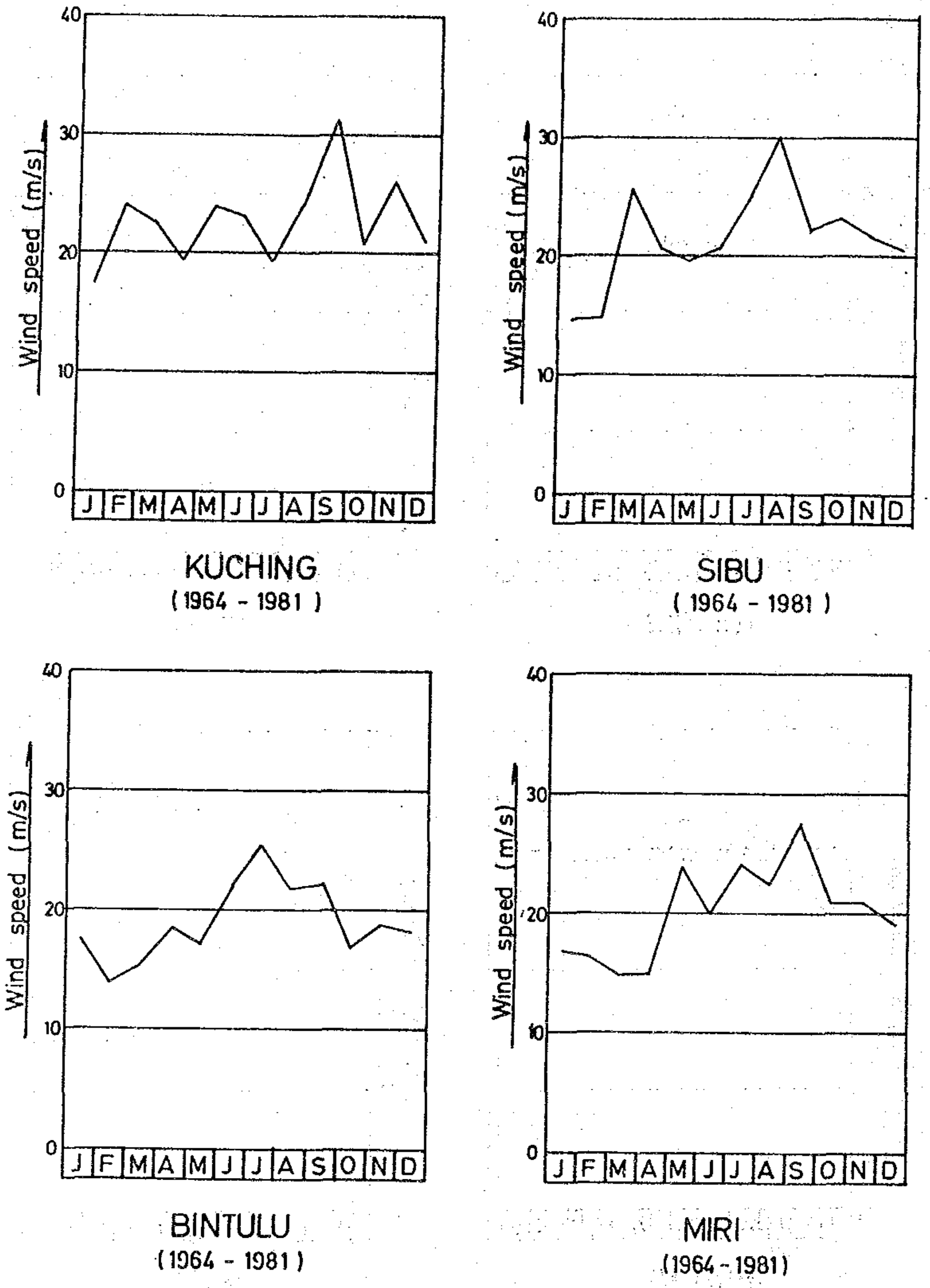

FIG.5.4 MAXIMUM SURFACE WIND SPEED

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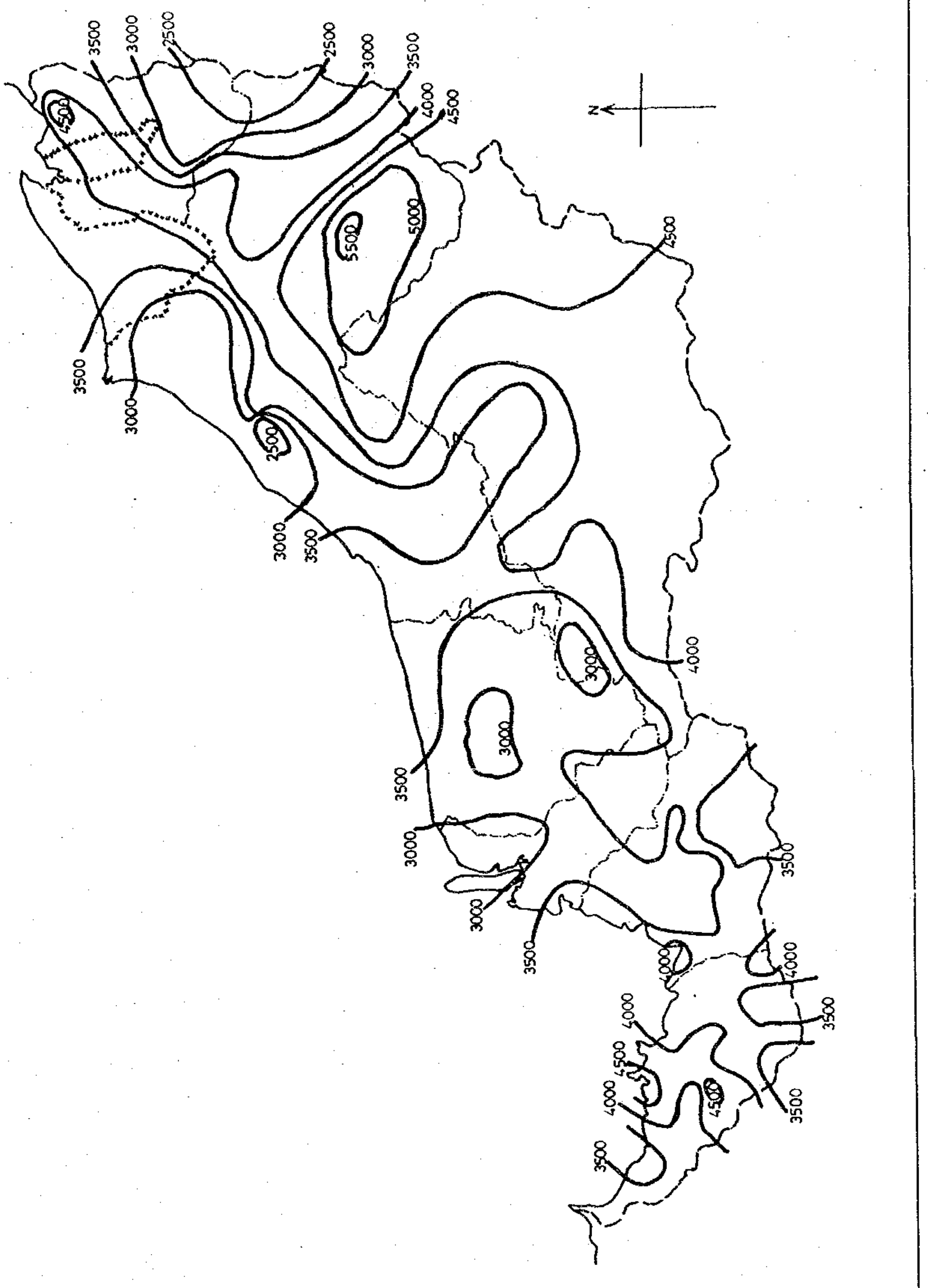

FIG.5.5 ISOHYETAL MAP OF MEAN ANNUAL RAINFALL

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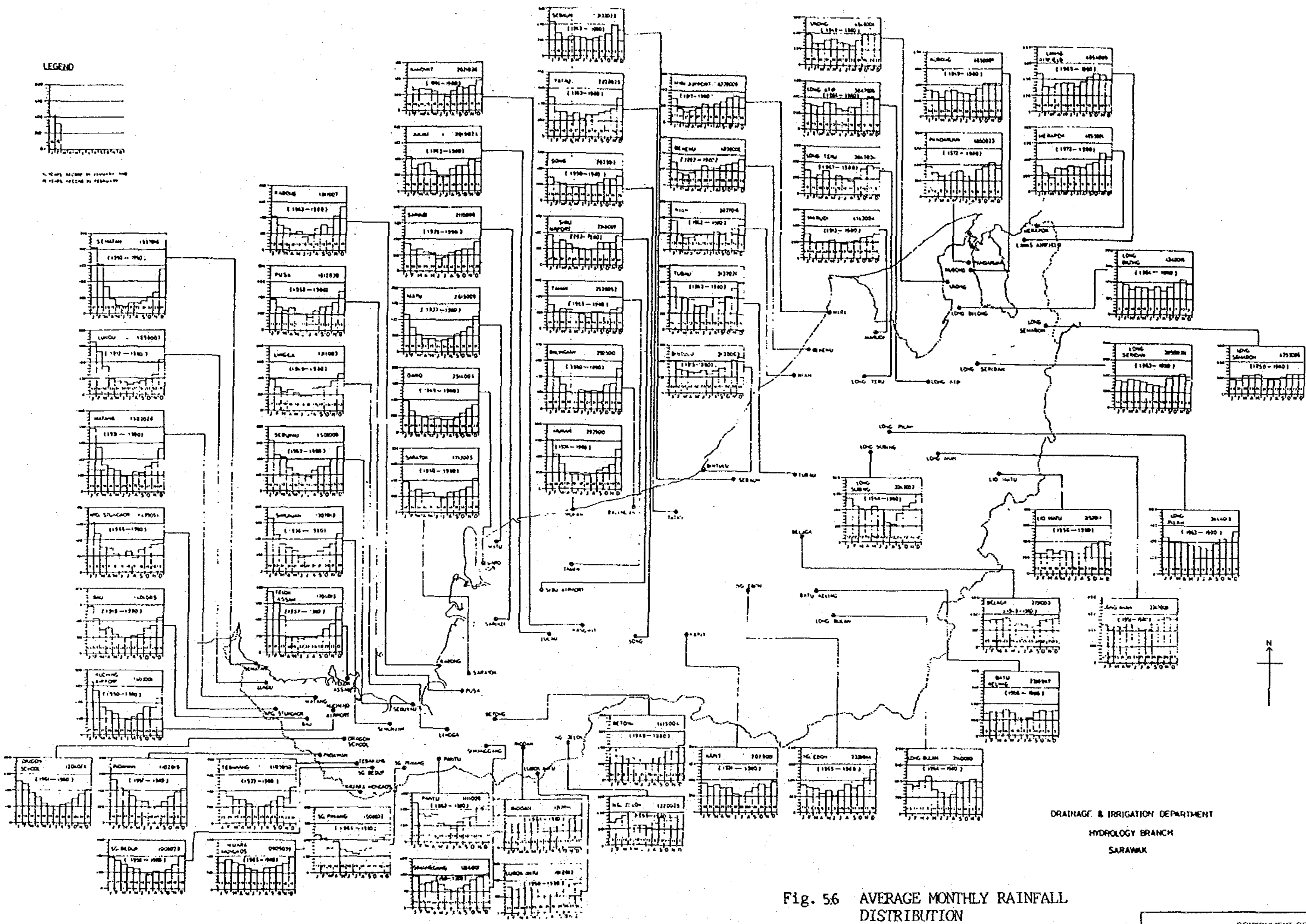

Fig. 5.6 AVERAGE MONTHLY RAINFALL DISTRIBUTION

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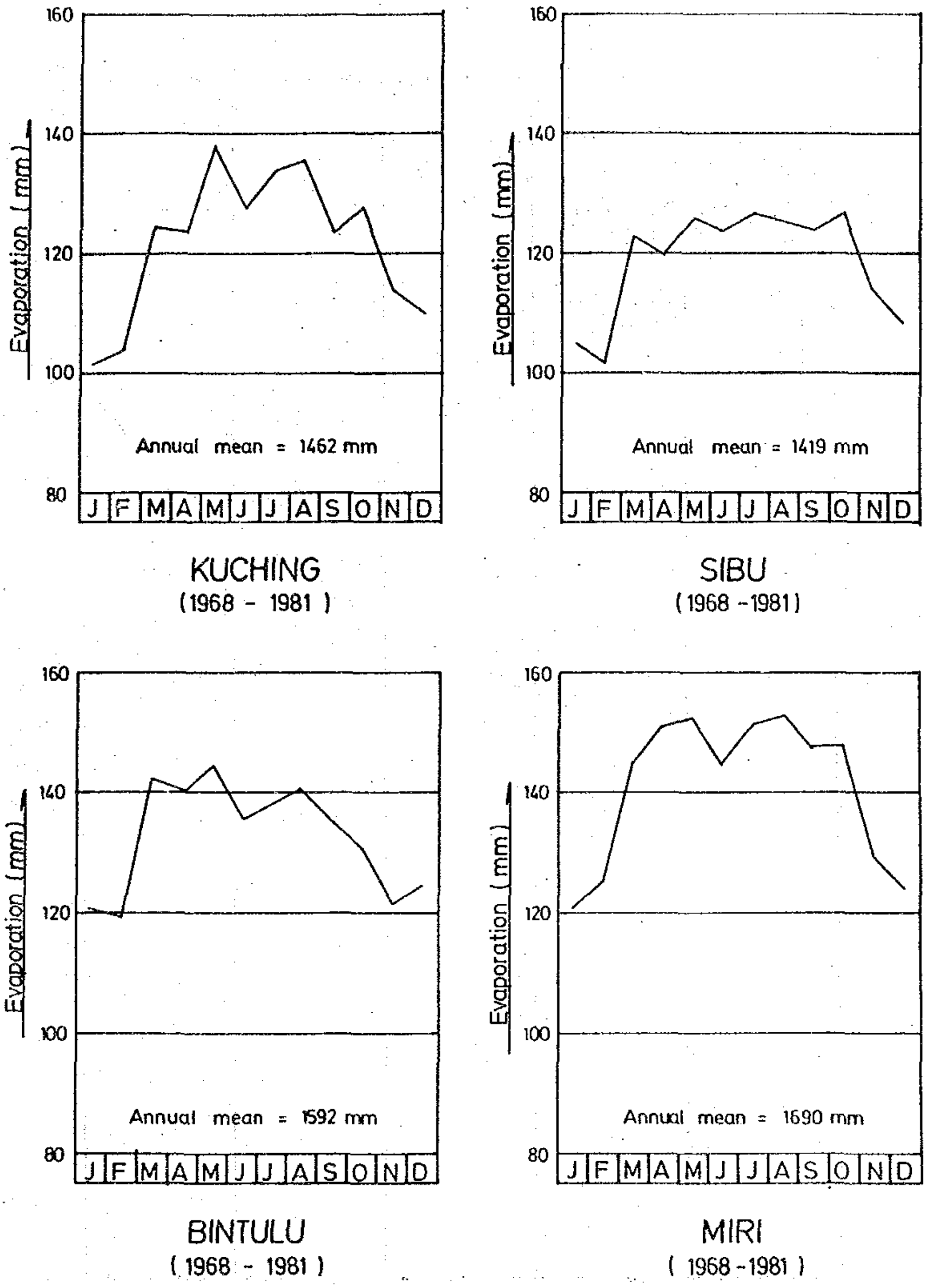

FIG.5.7 MEAN ANNUAL EVAPORATION

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SMALL SCALE HYDROELECTRIC POWER PROJECT IN SARAWAK
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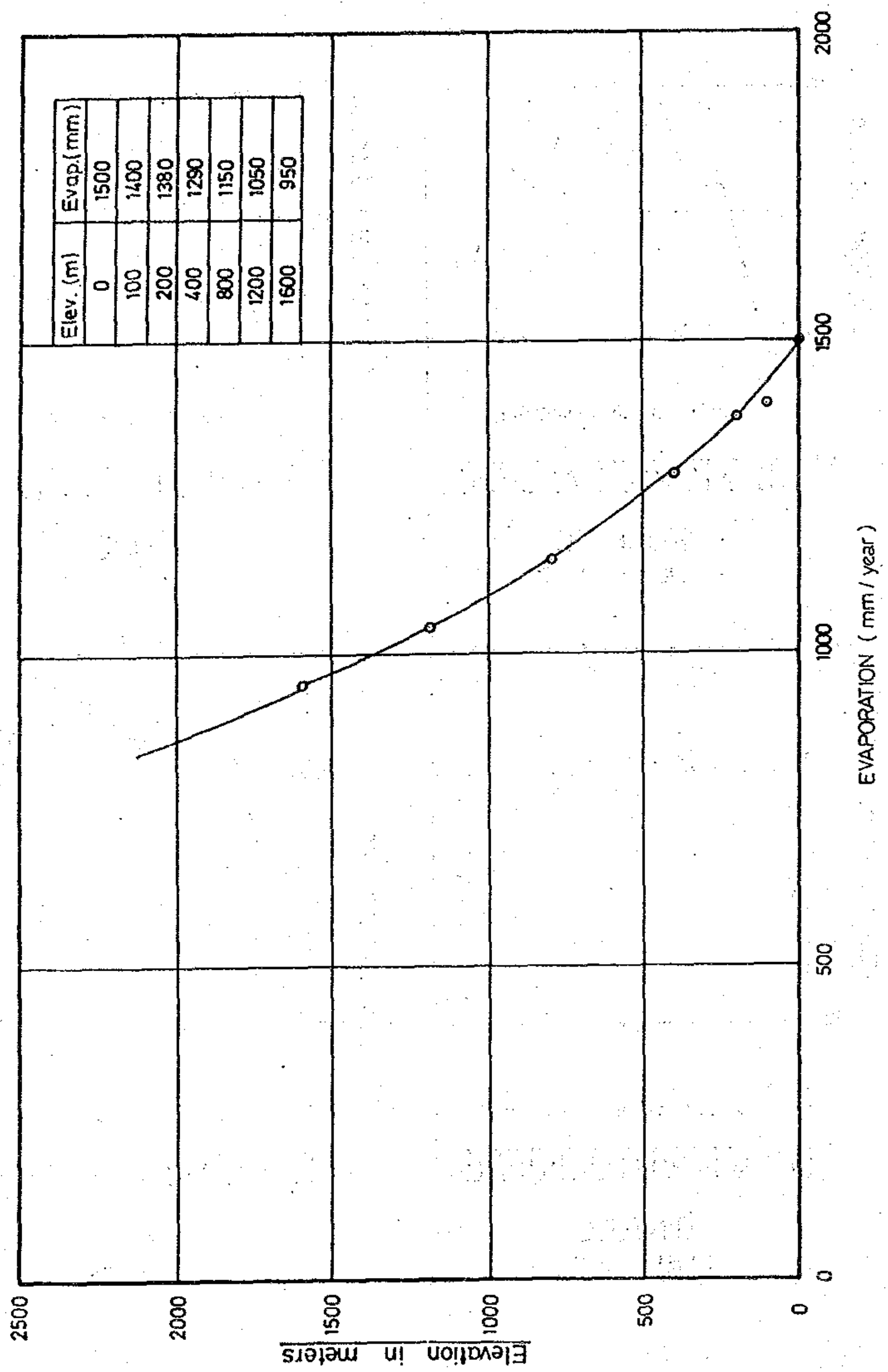

Elev. (m)	Evap.(mm)
0	1500
100	1400
200	1380
400	1290
800	1150
1200	1050
1600	950

FIG.5.8

RELATIONSHIP BETWEEN EVAPORATION AND ELEVATION

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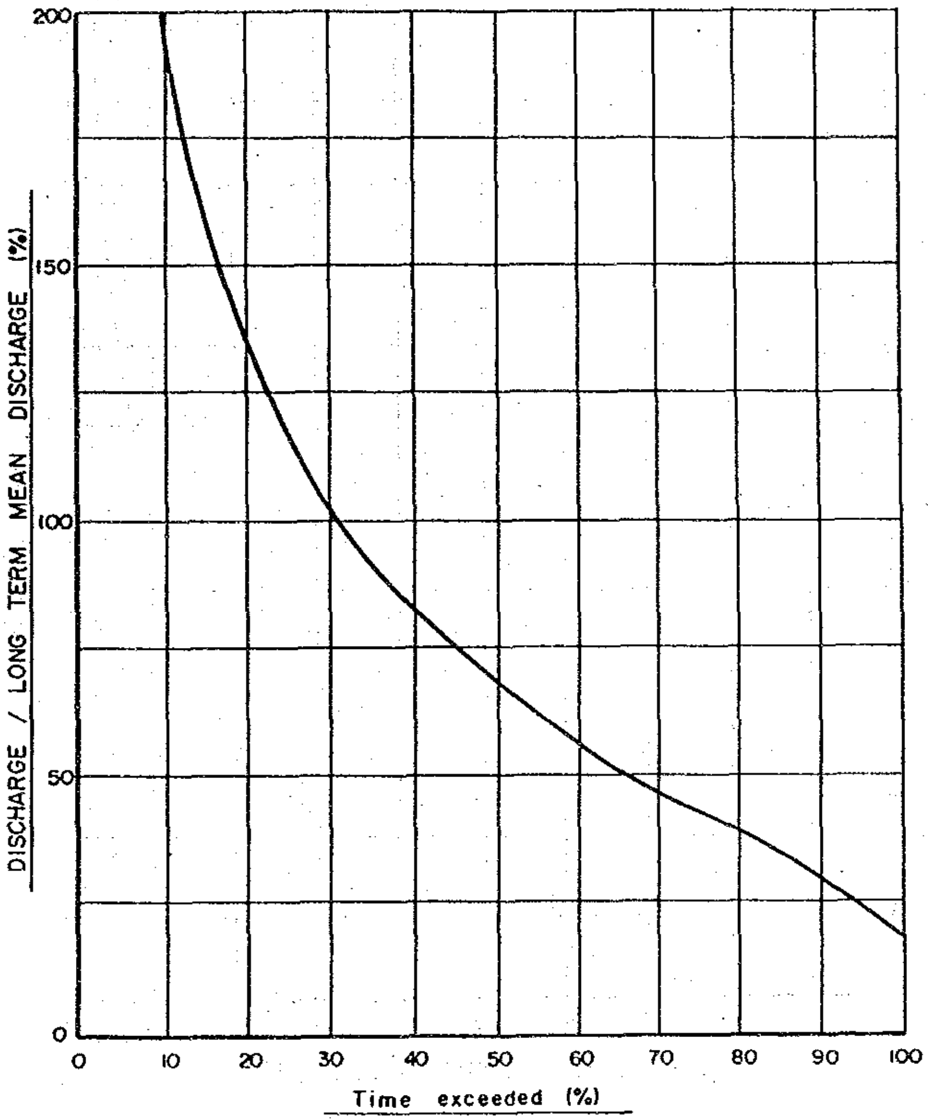

FIG.5.9 DIMENSIONLESS FLOW DURATION CURVE

GOVERNMENT OF MALAYSIA FEASIBILITY STUDY SMALL SCALE HYDROELECTRIC POWER PROJECT IN SARAWAK
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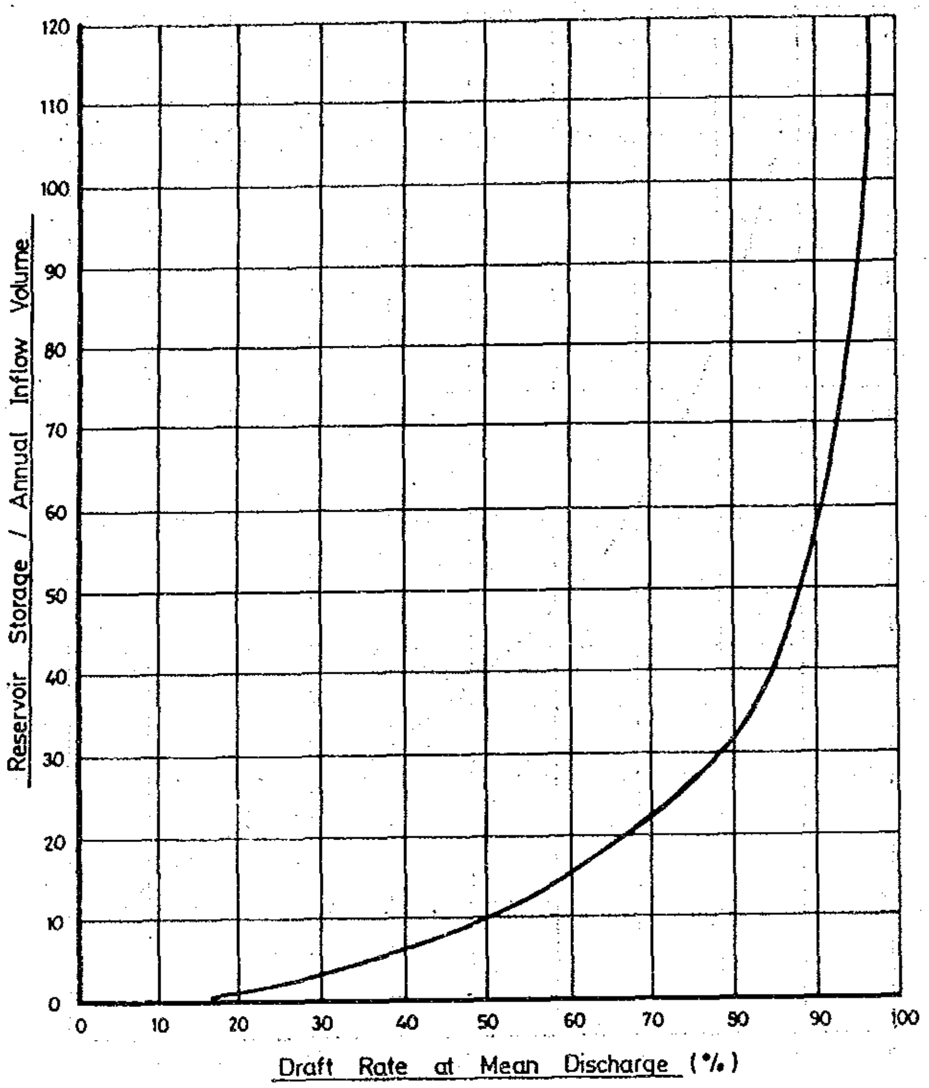

FIG.5.10 DIMENSIONLESS STORAGE DRAFT CURVE

GOVERNMENT OF MALAYSIA
FEASIBILITY STUDY
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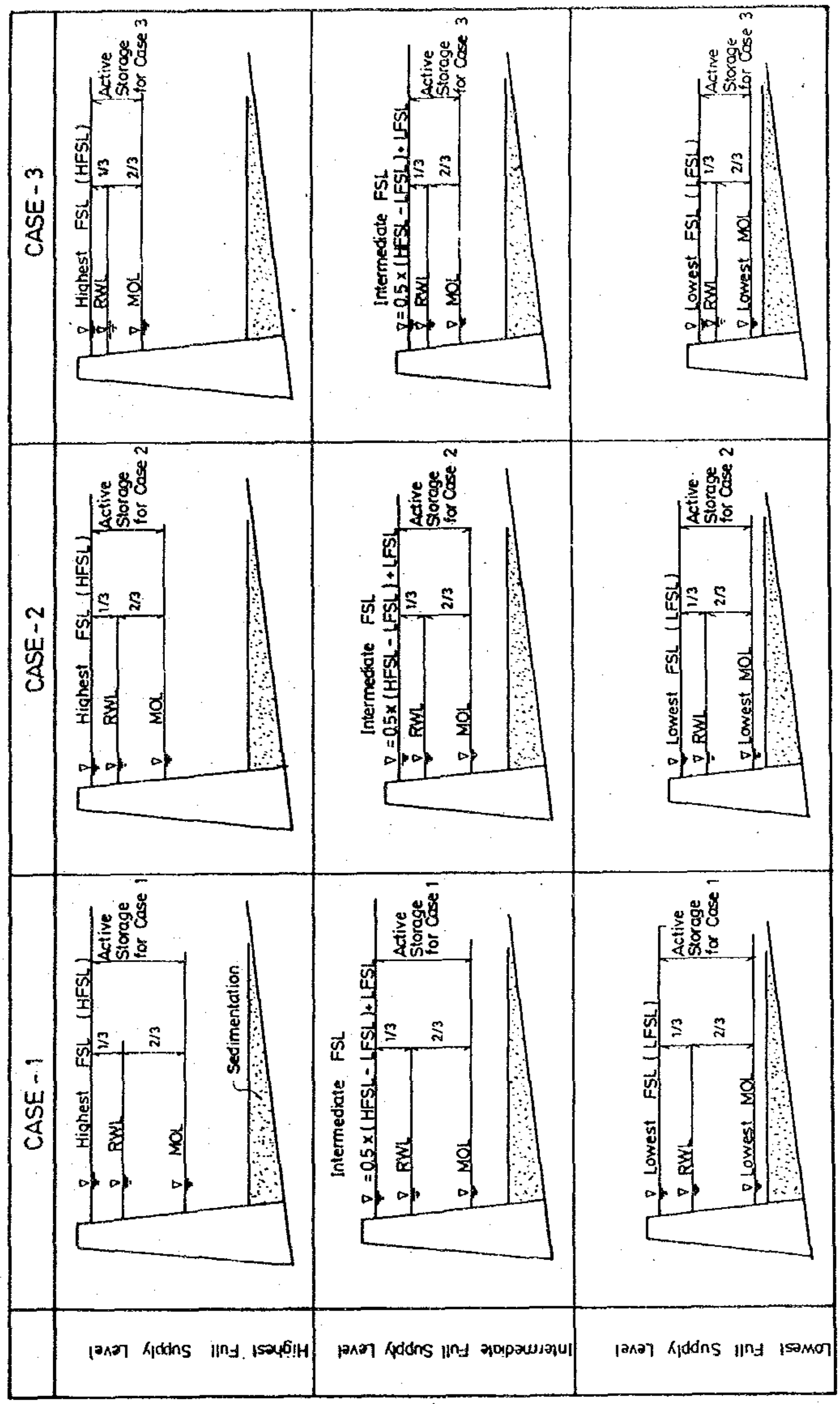

FIG.6.1 SCHEMATIC DIAGRAM OF PRELIMINARY POWER OUTPUT CALCULATION FOR RESERVOIR TYPE

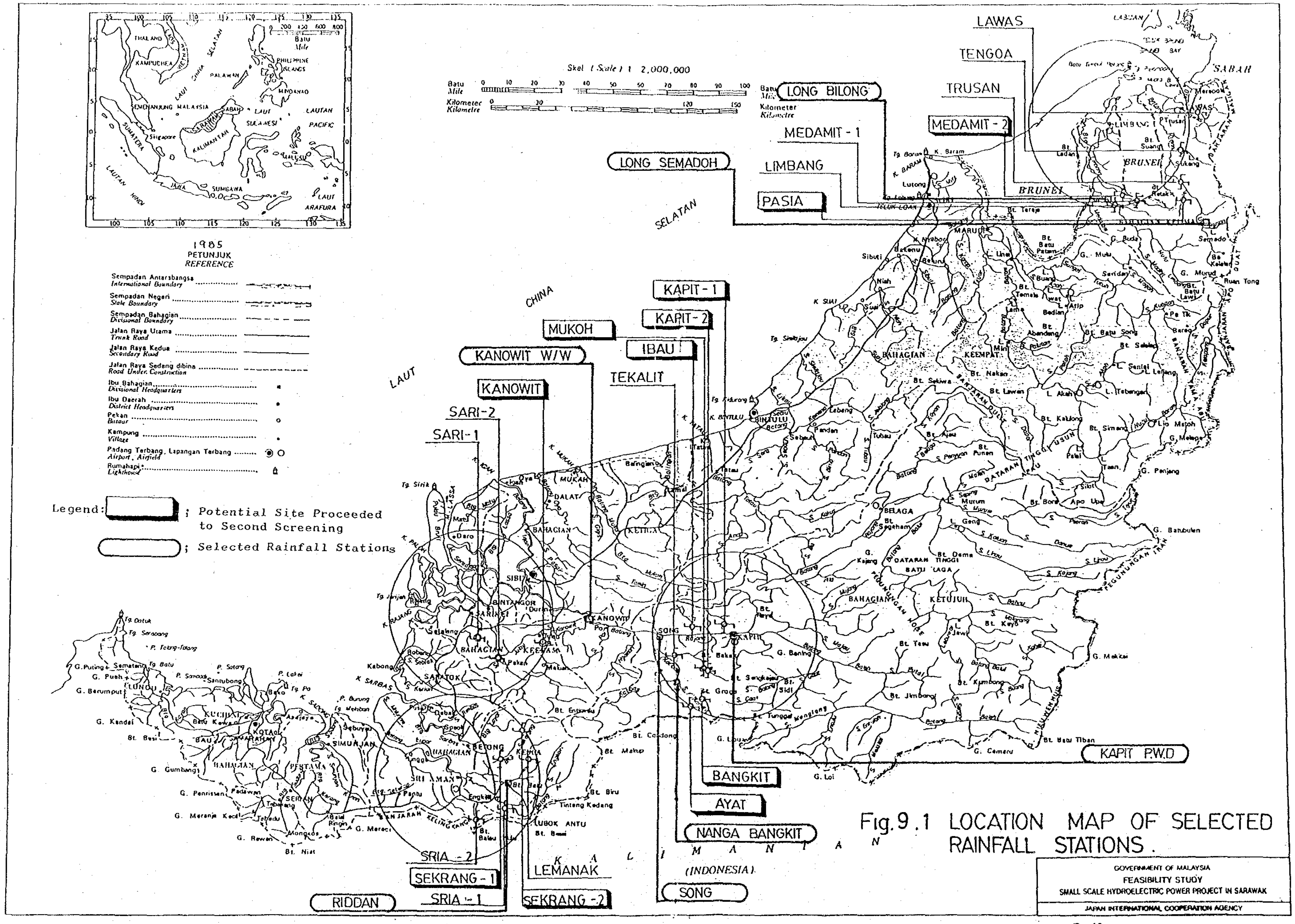

Fig. 9.1 LOCATION MAP OF SELECTED RAINFALL STATIONS.

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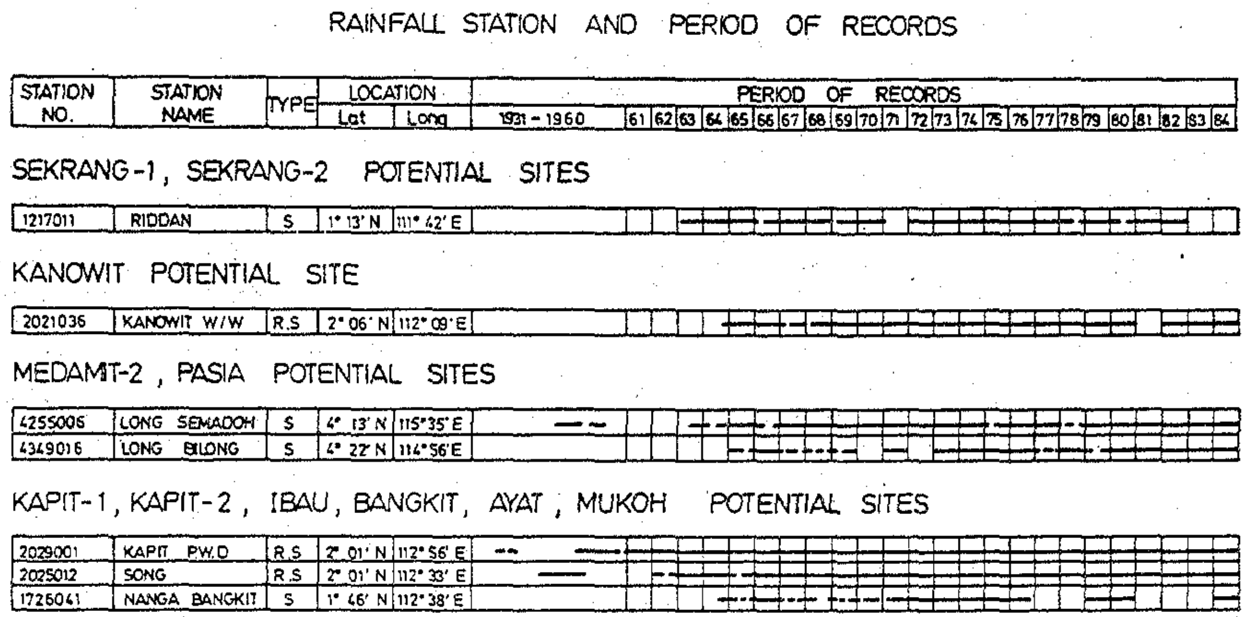

Fig. 9. 2 Recorded Period of Rainfall Data

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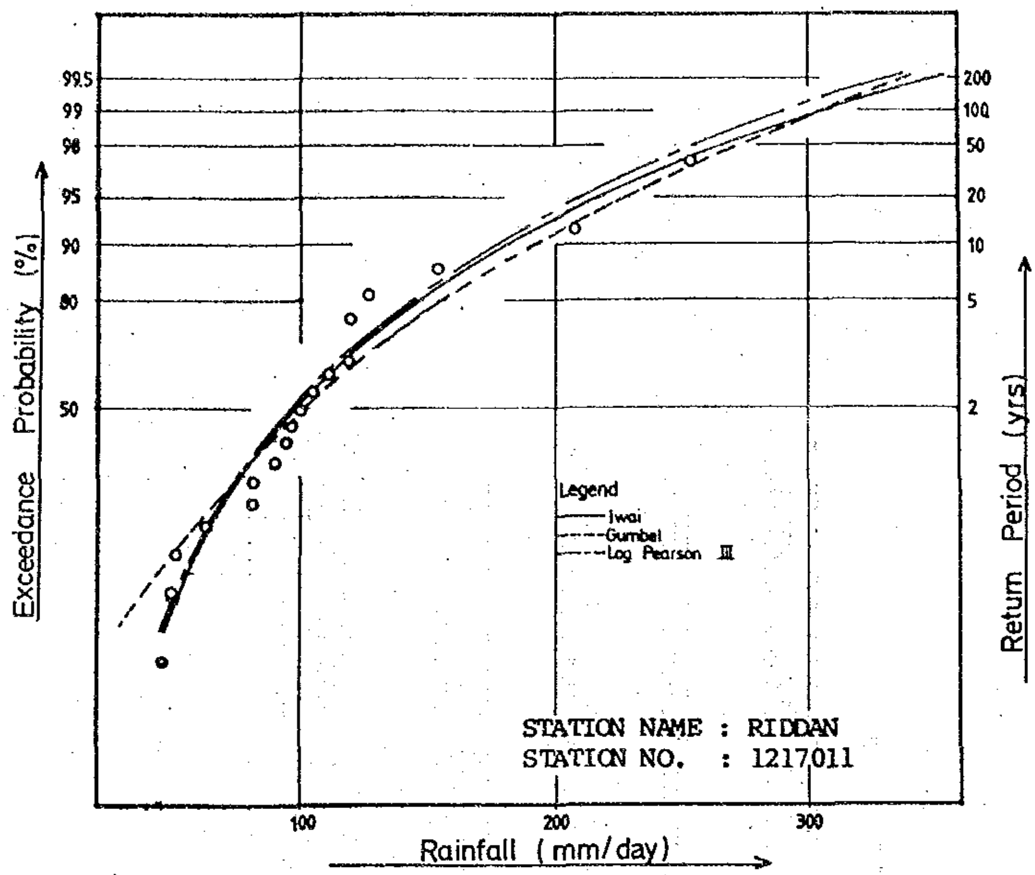

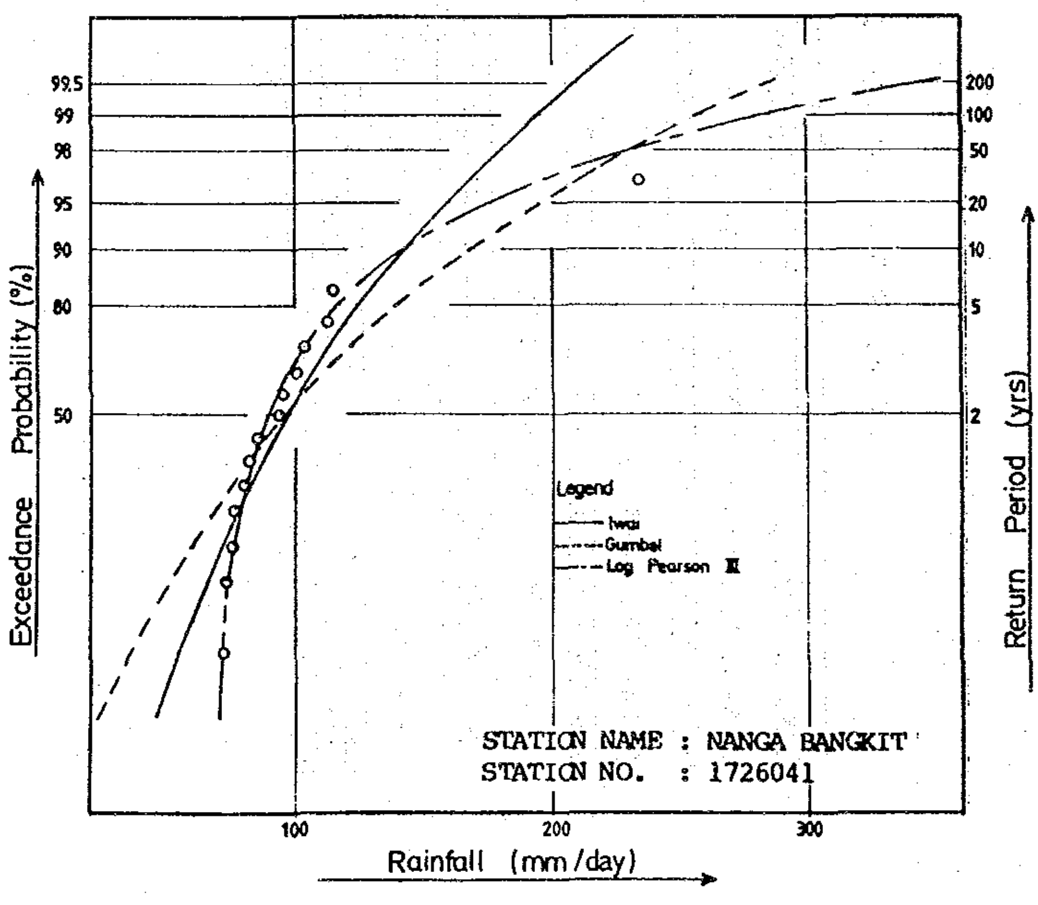

Fig. 9. 3 FREQUENCY ANALYSIS (1/4)

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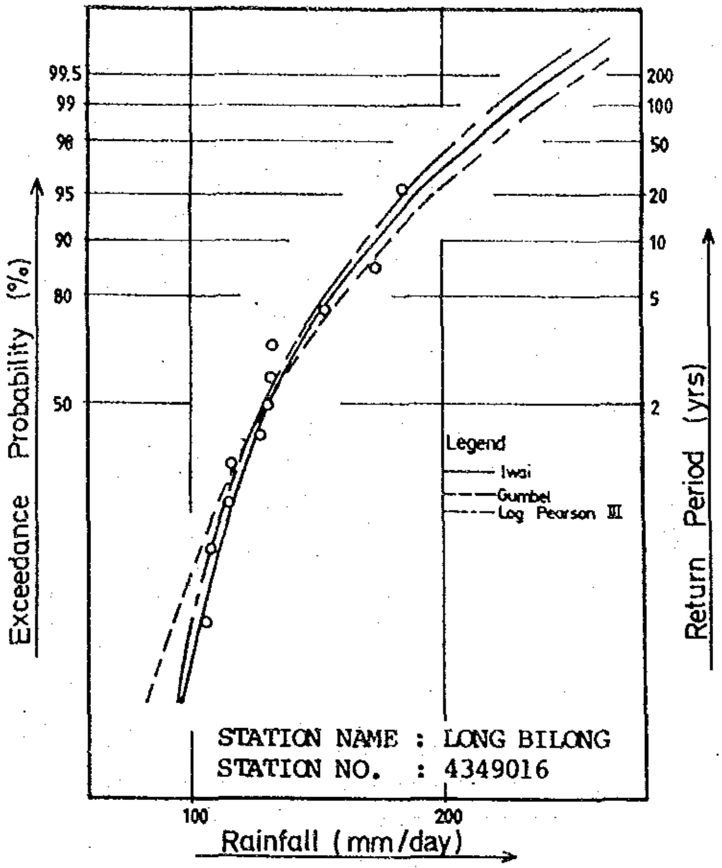
FEASIBILITY STUDY
SMALL SCALE HYDROELECTRIC POWER PROJECT IN SARAWAK

JAPAN INTERNATIONAL COOPERATION AGENCY



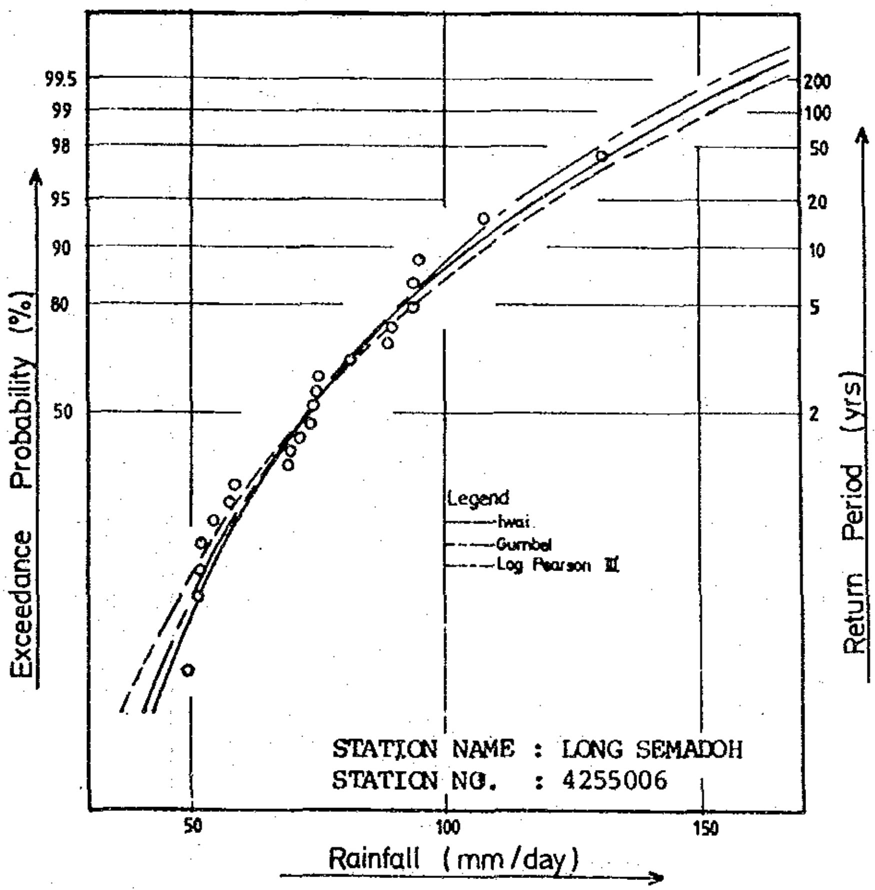
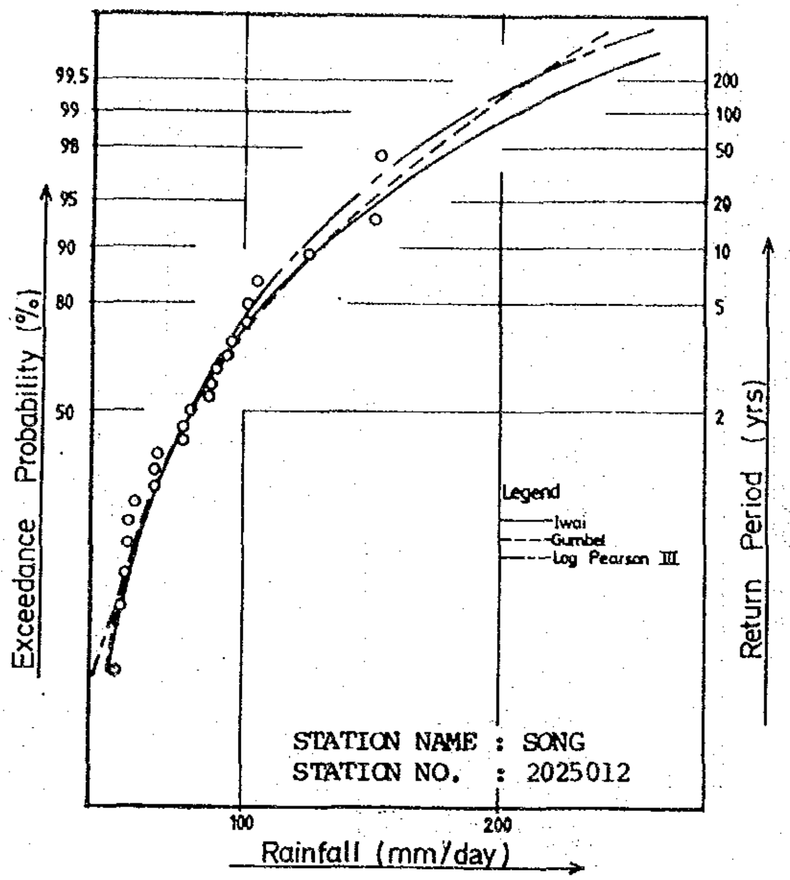


Fig. 9. 4 FREQUENCY ANALYSIS (2/4)

GOVERNMENT OF MALAYSIA
FEASIBILITY STUDY
SMALL SCALE HYDROELECTRIC POWER PROJECT IN SARAWAK
JAPAN INTERNATIONAL COOPERATION AGENCY



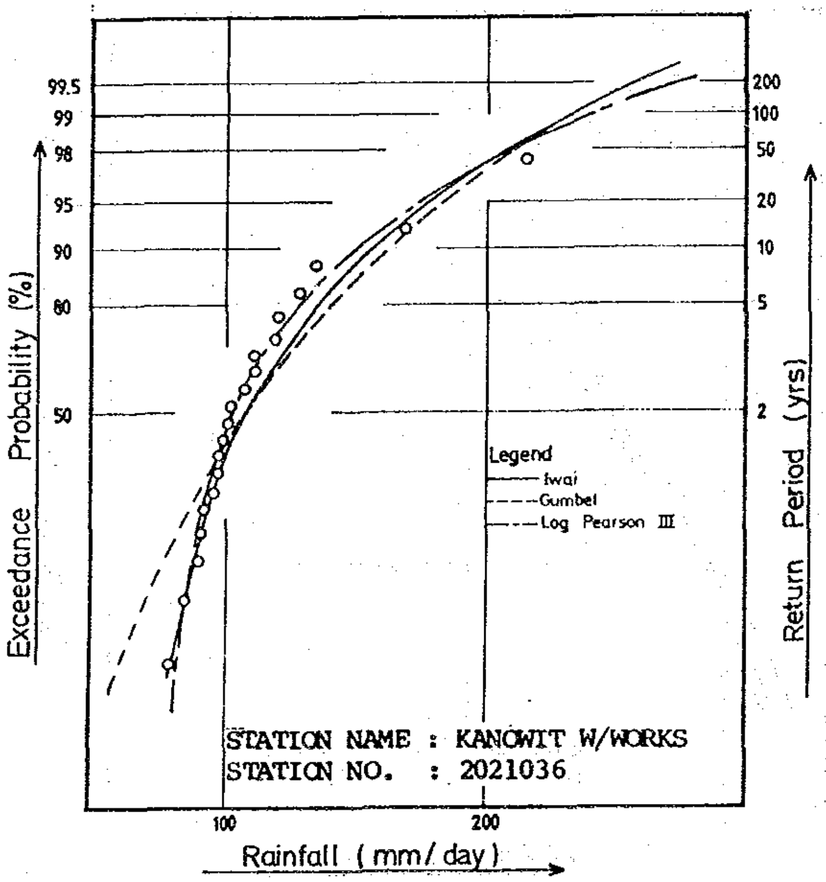


Fig. 9. 5 FREQUENCY ANALYSIS (3/4)

GOVERNMENT OF MALAYSIA
FEASIBILITY STUDY
SMALL SCALE HYDROELECTRIC POWER PROJECT IN SARAWAK
JAPAN INTERNATIONAL COOPERATION AGENCY

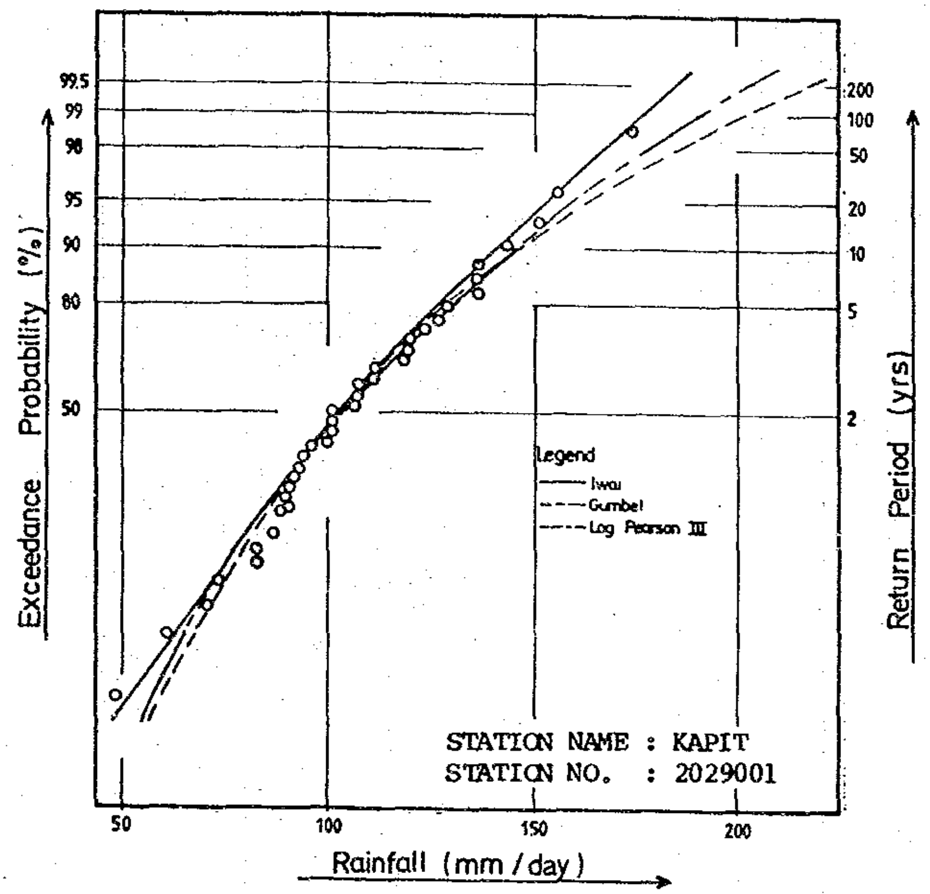


Fig. 9. 6 **FREQUENCY ANALYSIS (4/4)**

GOVERNMENT OF MALAYSIA
FEASIBILITY STUDY
SMALL SCALE HYDROELECTRIC POWER PROJECT IN SARAWAK
JAPAN INTERNATIONAL COOPERATION AGENCY

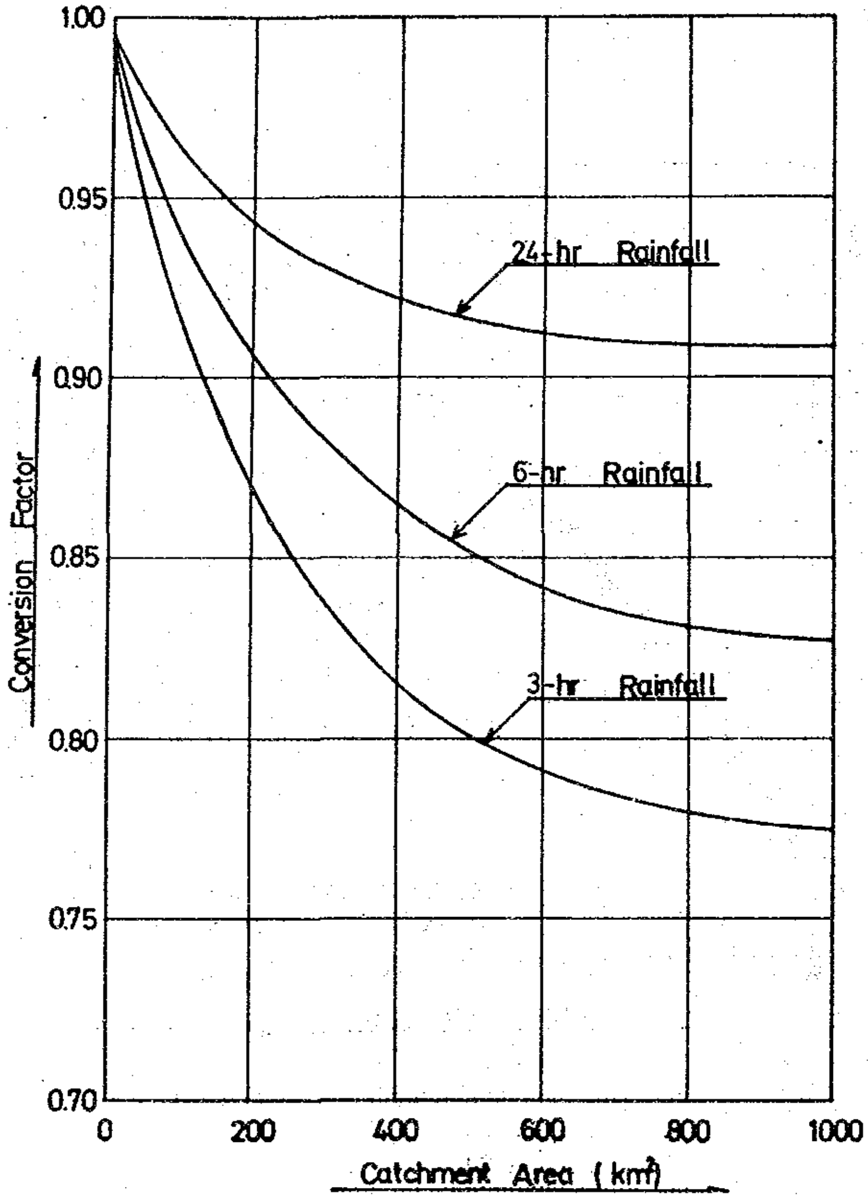


Fig. 9.7 Conversion Factor of Point Rainfall to Average Basin Rainfall

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FEASIBILITY STUDY
SMALL SCALE HYDROELECTRIC POWER PROJECT IN SARAWAK
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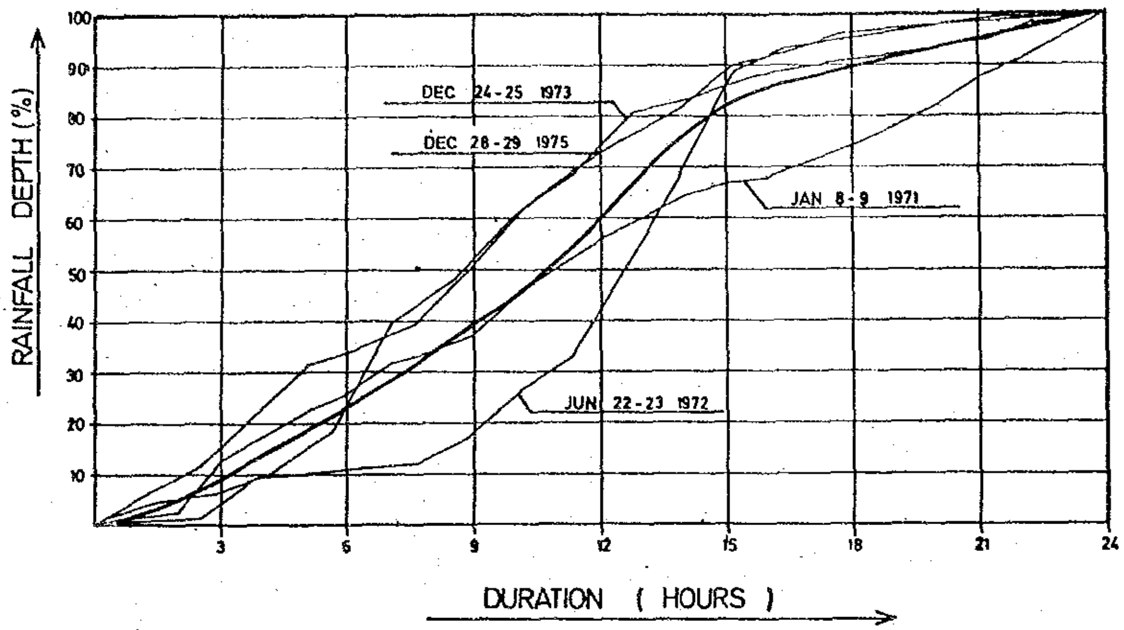

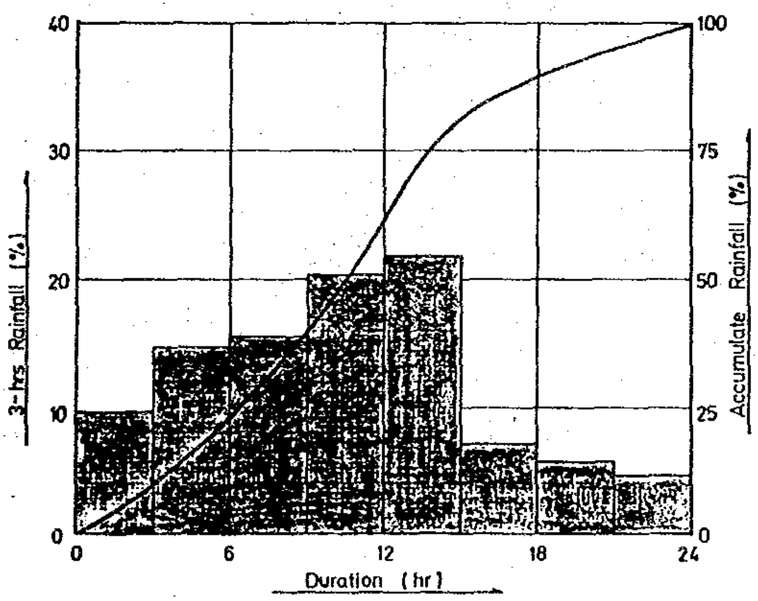

Fig. 9. 8 Depth Duration Analysis

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FEASIBILITY STUDY
SMALL SCALE HYDROELECTRIC POWER PROJECT IN SARAWAK
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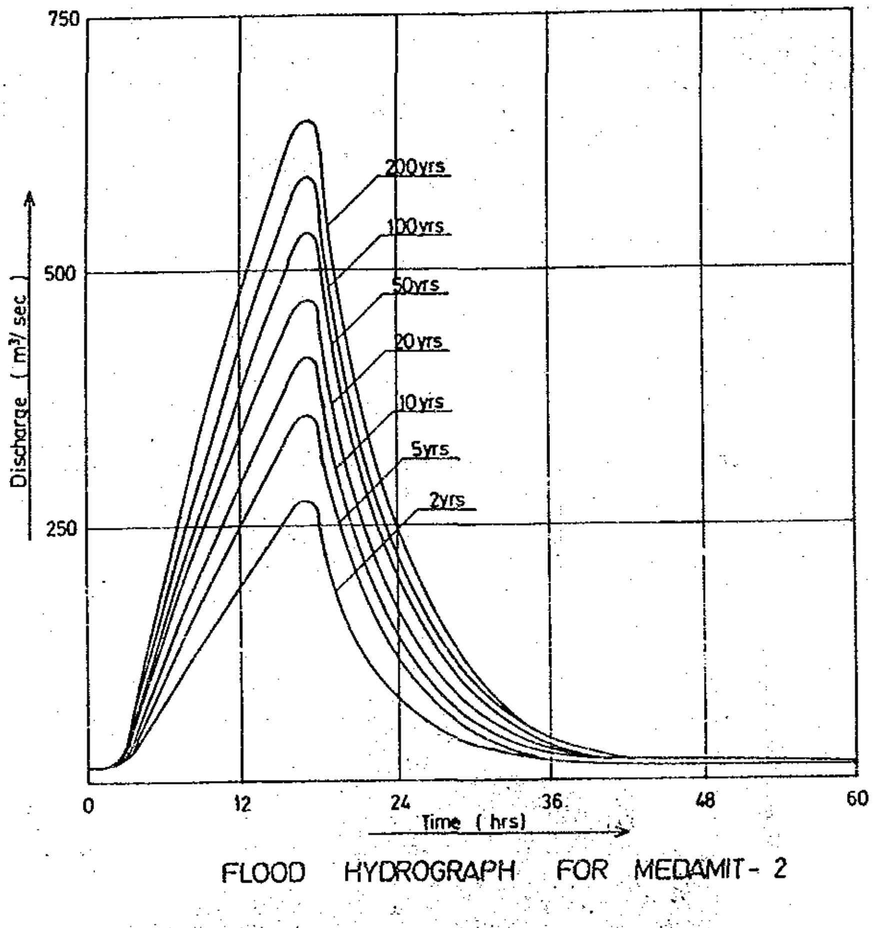

Fig. 9. 9 Flood Hydrograph for Medamit-2

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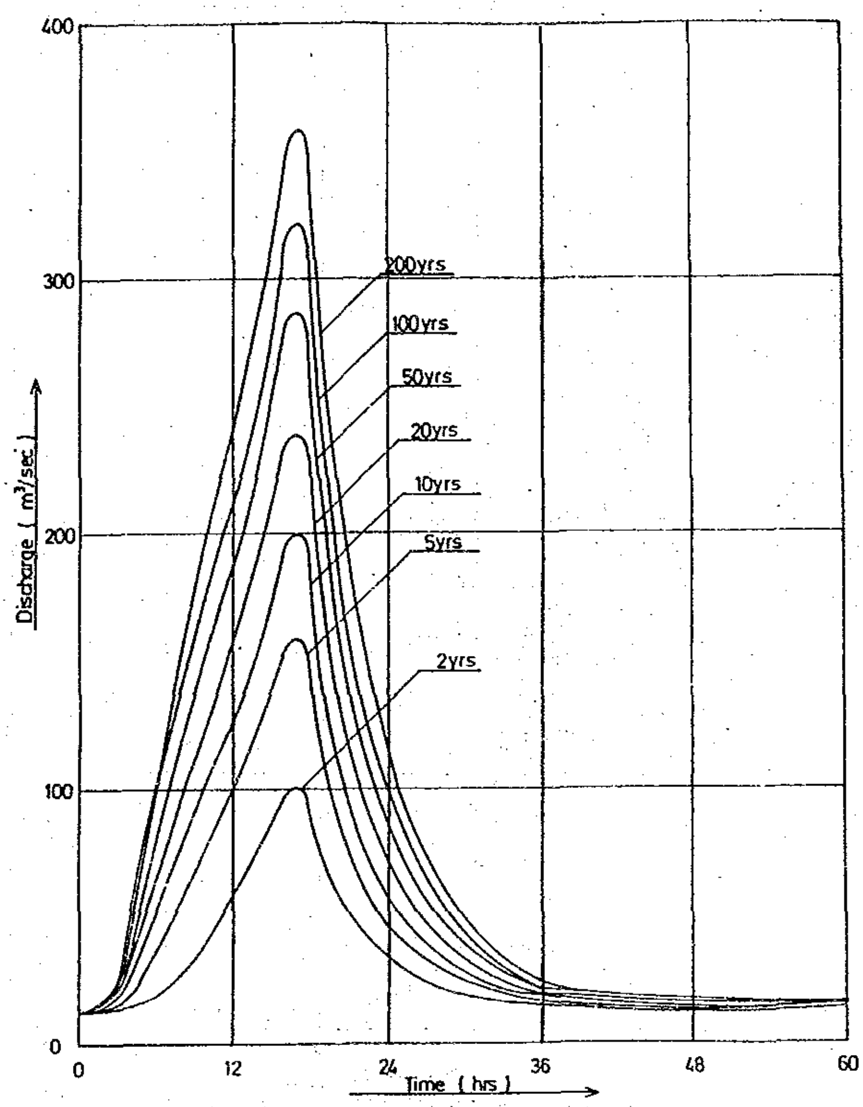

FLOOD HYDROGRAPH FOR PASIA

Fig. 9.10 Flood Hydrograph for pasia

GOVERNMENT OF MALAYSIA FEASIBILITY STUDY SMALL SCALE HYDROELECTRIC POWER PROJECT IN SARAWAK
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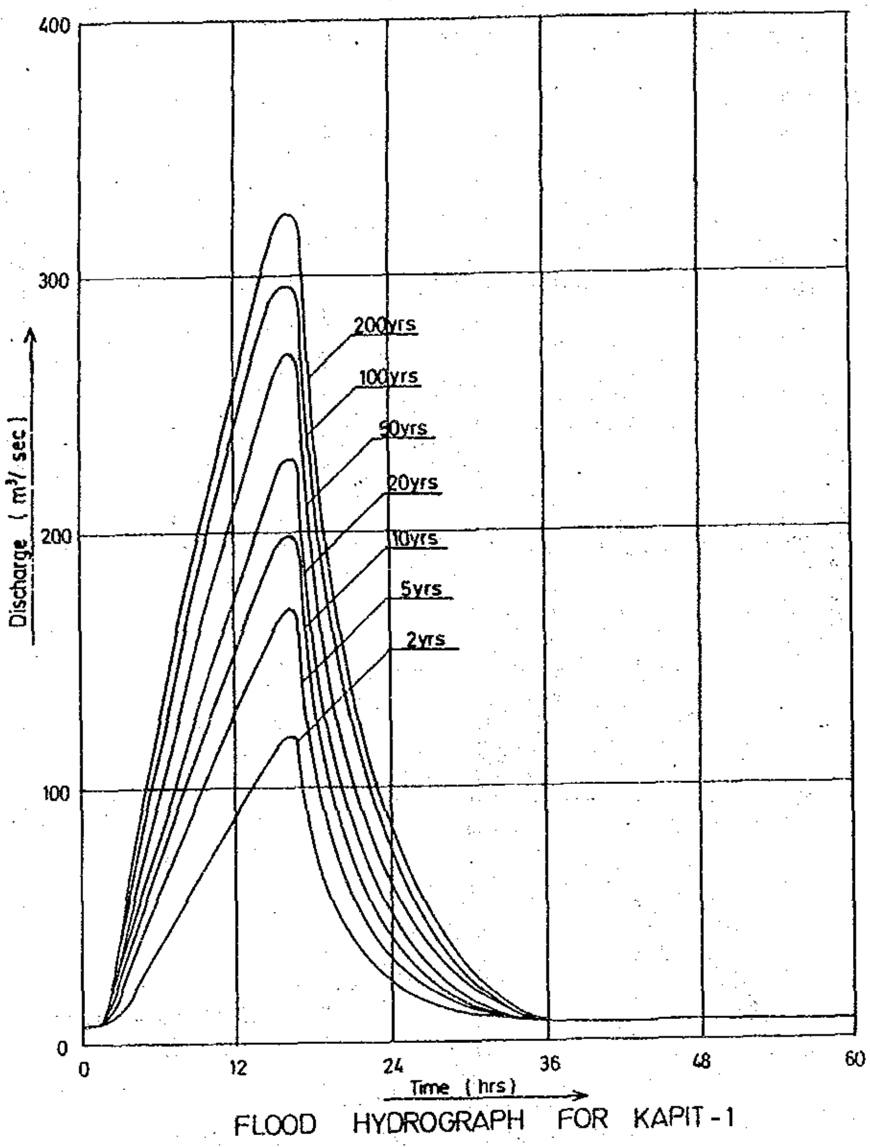

Fig. 9.11 Flood Hydrograph for Kapit-1

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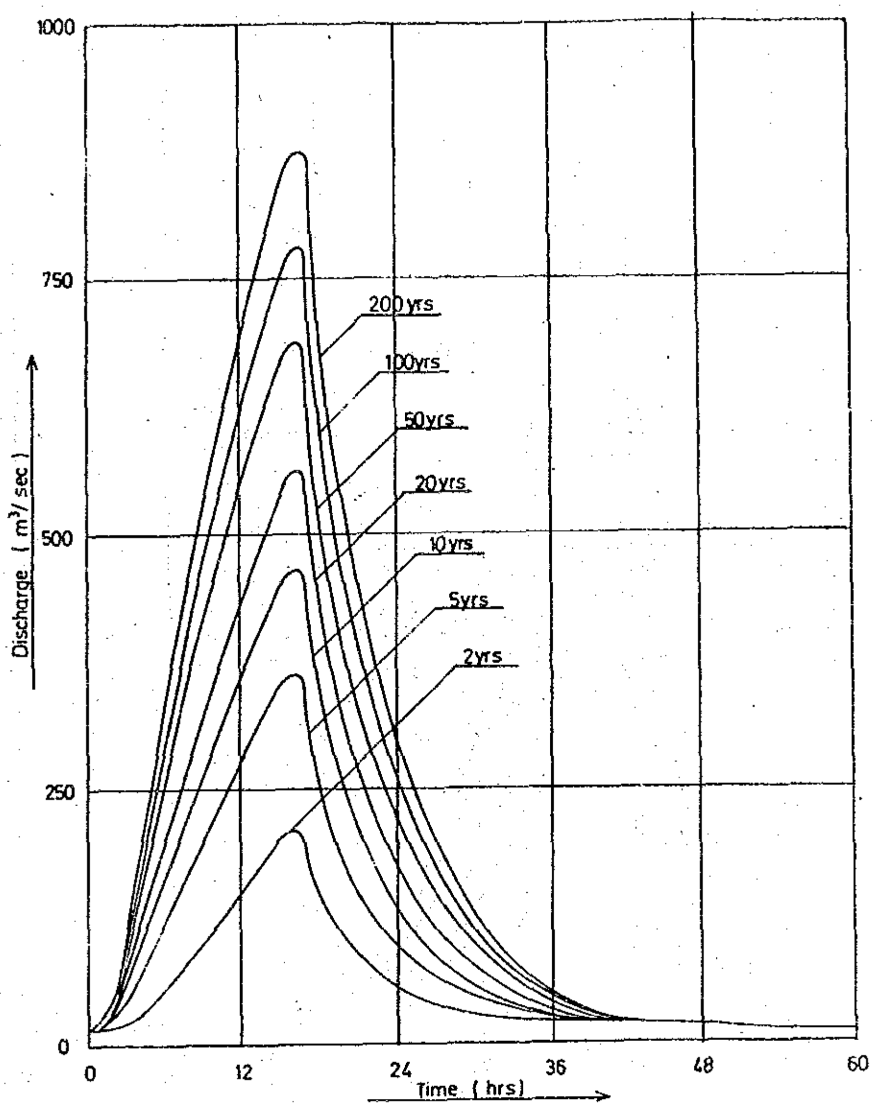

FLOOD HYDROGRAPH FOR KAPIT-2

Fig. 9.12 Flood Hydrograph for Kapit-2

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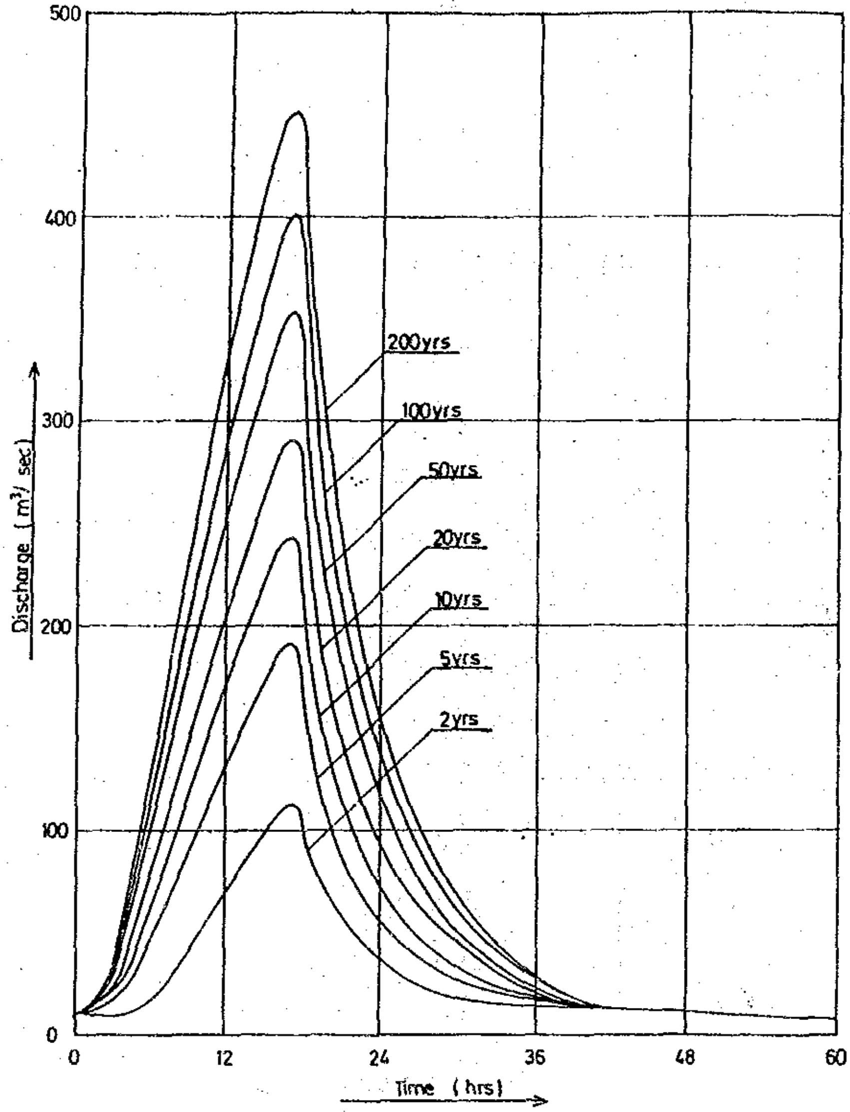

FLOOD HYDROGRAPH FOR IBAU

Fig. 9.13 Flood Hydrograph for Ibau

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FEASIBILITY STUDY
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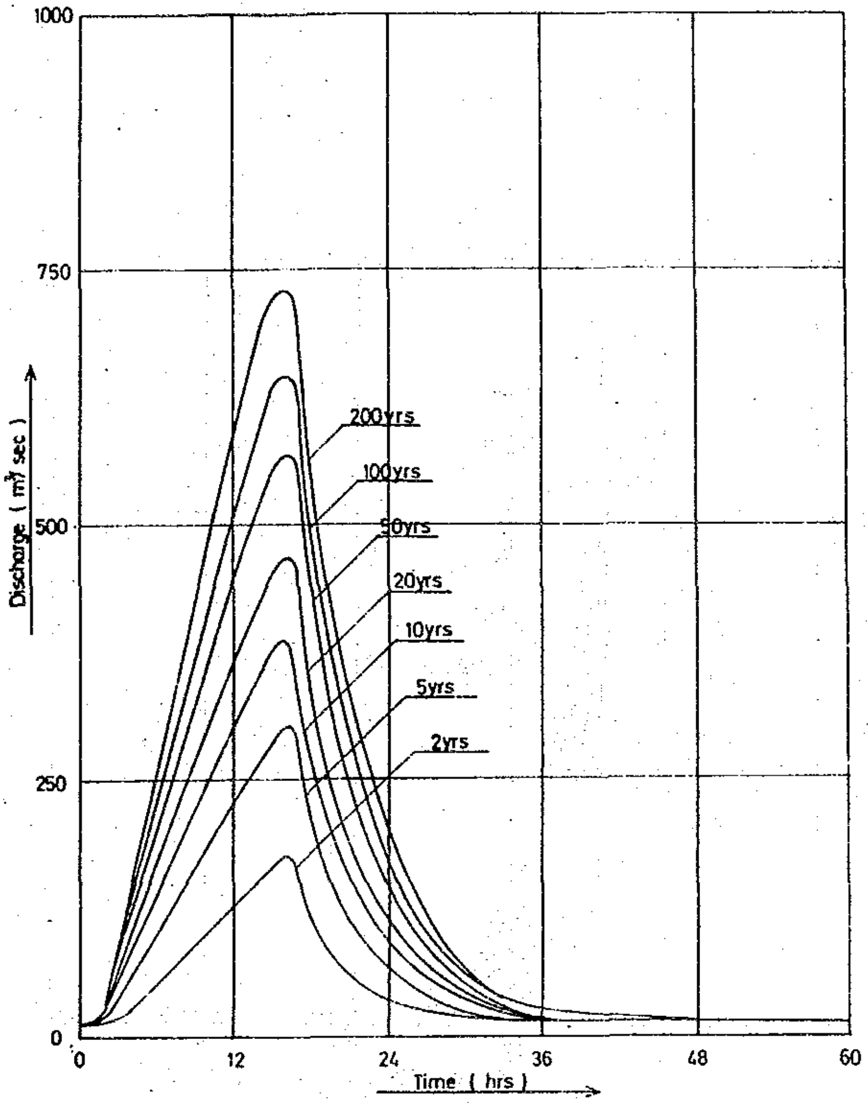
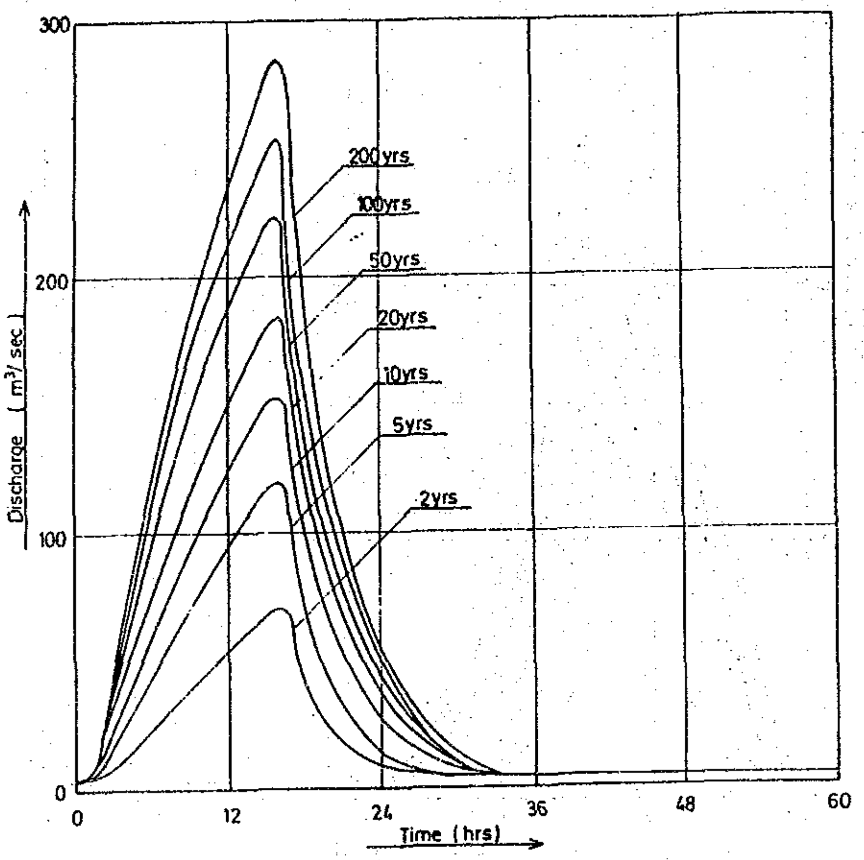


FLOOD HYDROGRAPH FOR BANGKIT

Fig. 9.14 Flood Hydrograph for Bangkit

GOVERNMENT OF MALAYSIA FEASIBILITY STUDY SMALL SCALE HYDROELECTRIC POWER PROJECT IN SARAWAK
JAPAN INTERNATIONAL COOPERATION AGENCY

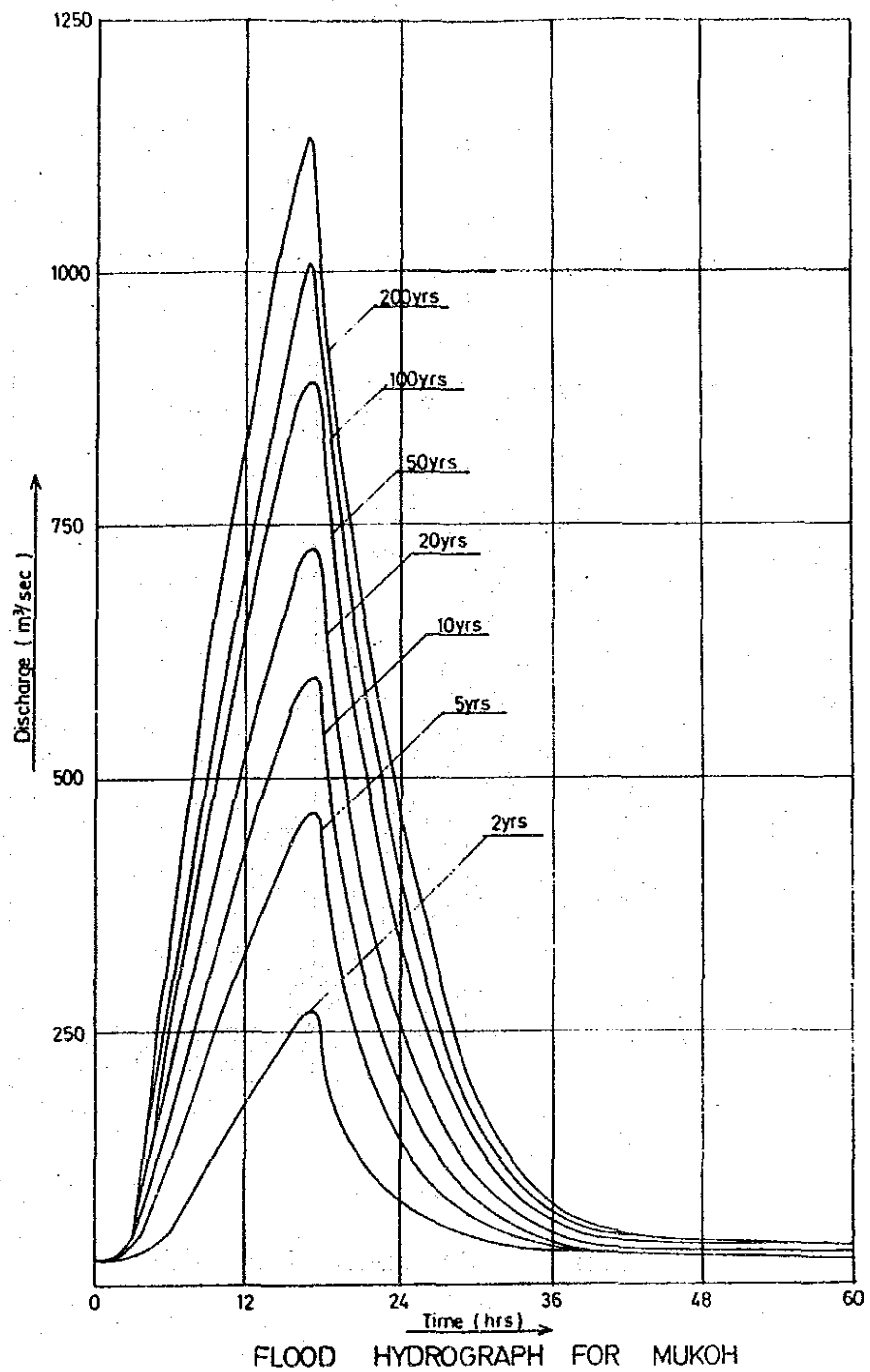


FLOOD HYDROGRAPH FOR AYAT

Fig. 9.15 Flood Hydrograph for Ayat

GOVERNMENT OF MALAYSIA
FEASIBILITY STUDY
SMALL SCALE HYDROELECTRIC POWER PROJECT IN SARAWAK

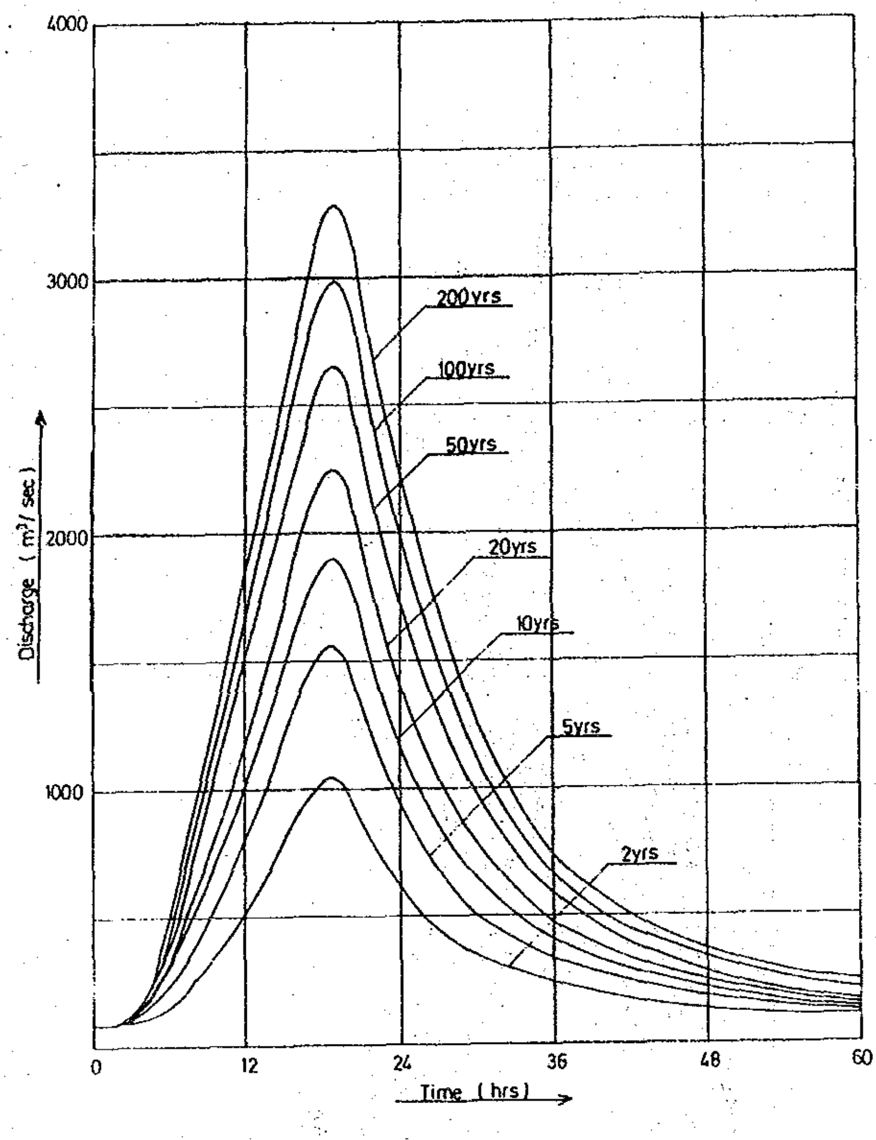
JAPAN INTERNATIONAL COOPERATION AGENCY



FLOOD HYDROGRAPH FOR MUKOH

Fig. 9.16 Flood Hydrograph for Mukoh

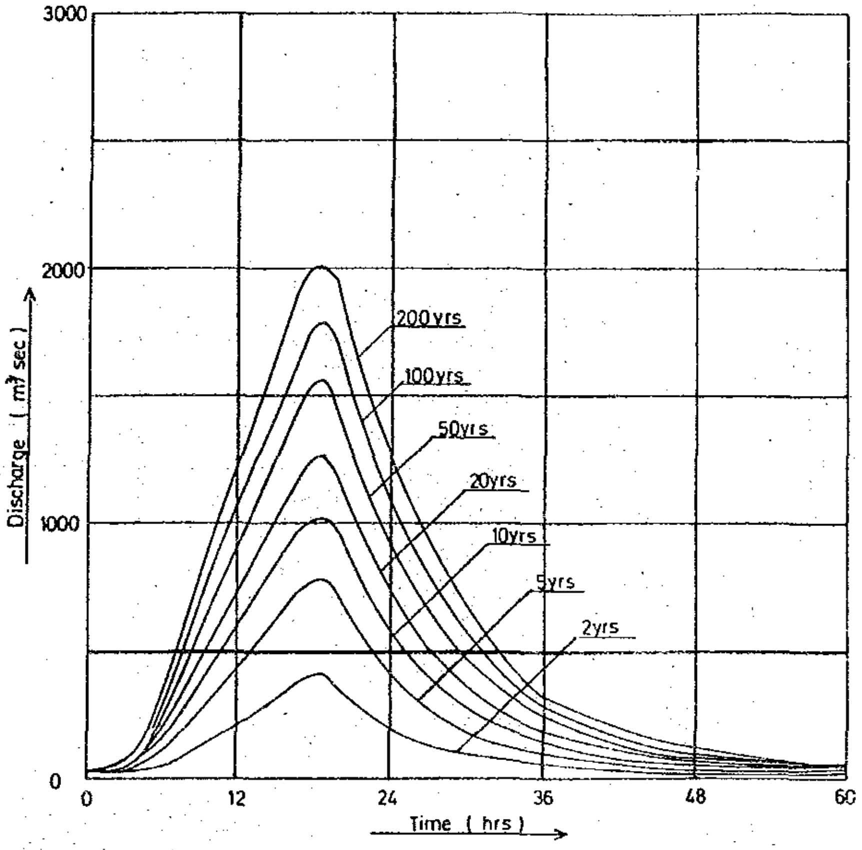
GOVERNMENT OF MALAYSIA *FEASIBILITY STUDY* SMALL SCALE HYDROELECTRIC POWER PROJECT IN SARAWAK
JAPAN INTERNATIONAL COOPERATION AGENCY



FLOOD HYDROGRAPH FOR KANOWIT

Fig. 9.17 Flood Hydrograph for Kanowit

GOVERNMENT OF MALAYSIA
FEASIBILITY STUDY
SMALL SCALE HYDROELECTRIC POWER PROJECT IN SARAWAK
JAPAN INTERNATIONAL COOPERATION AGENCY



FLOOD HYDROGRAPH AT SEKRANG - 1

Fig. 9.18 Flood Hydrograph for Sekrang-1

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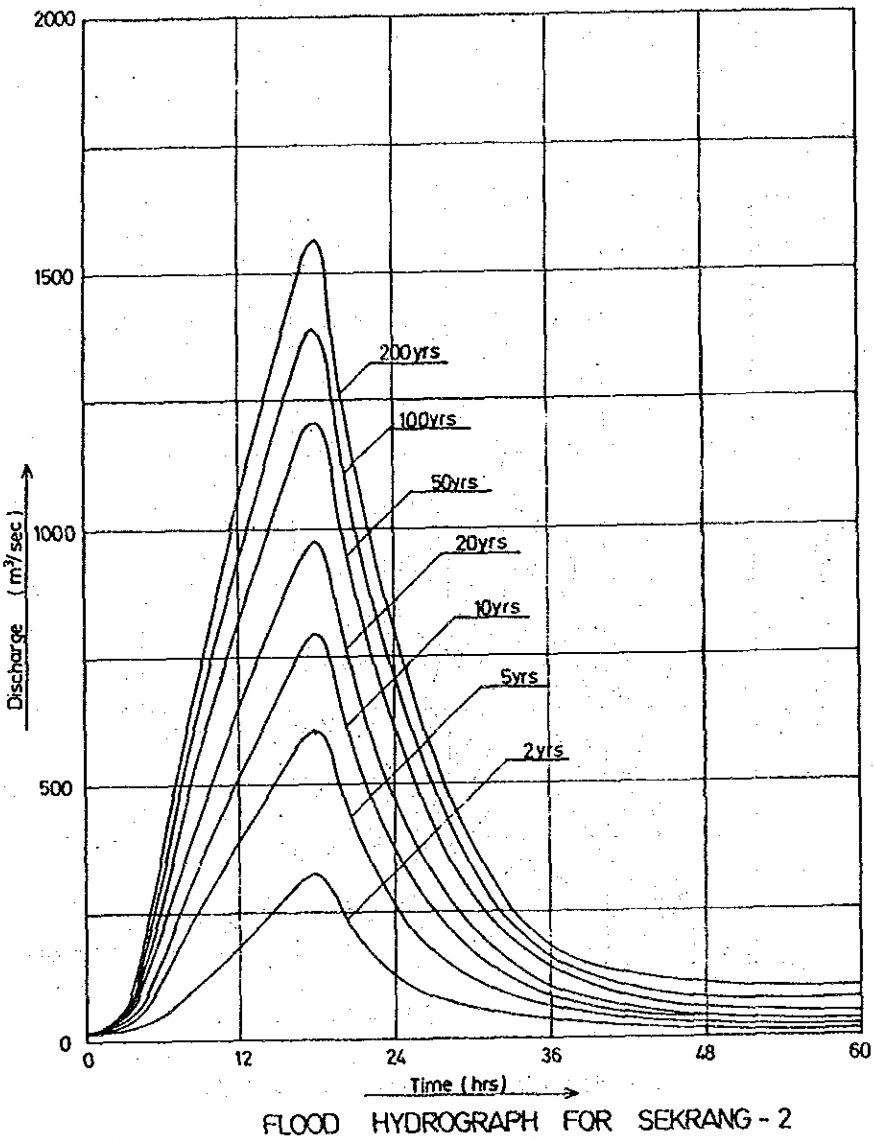

Fig. 9.19 Flood Hydrograph for Sekrang-2

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FEASIBILITY STUDY
SMALL SCALE HYDROELECTRIC POWER PROJECT IN SARAWAK

JAPAN INTERNATIONAL COOPERATION AGENCY

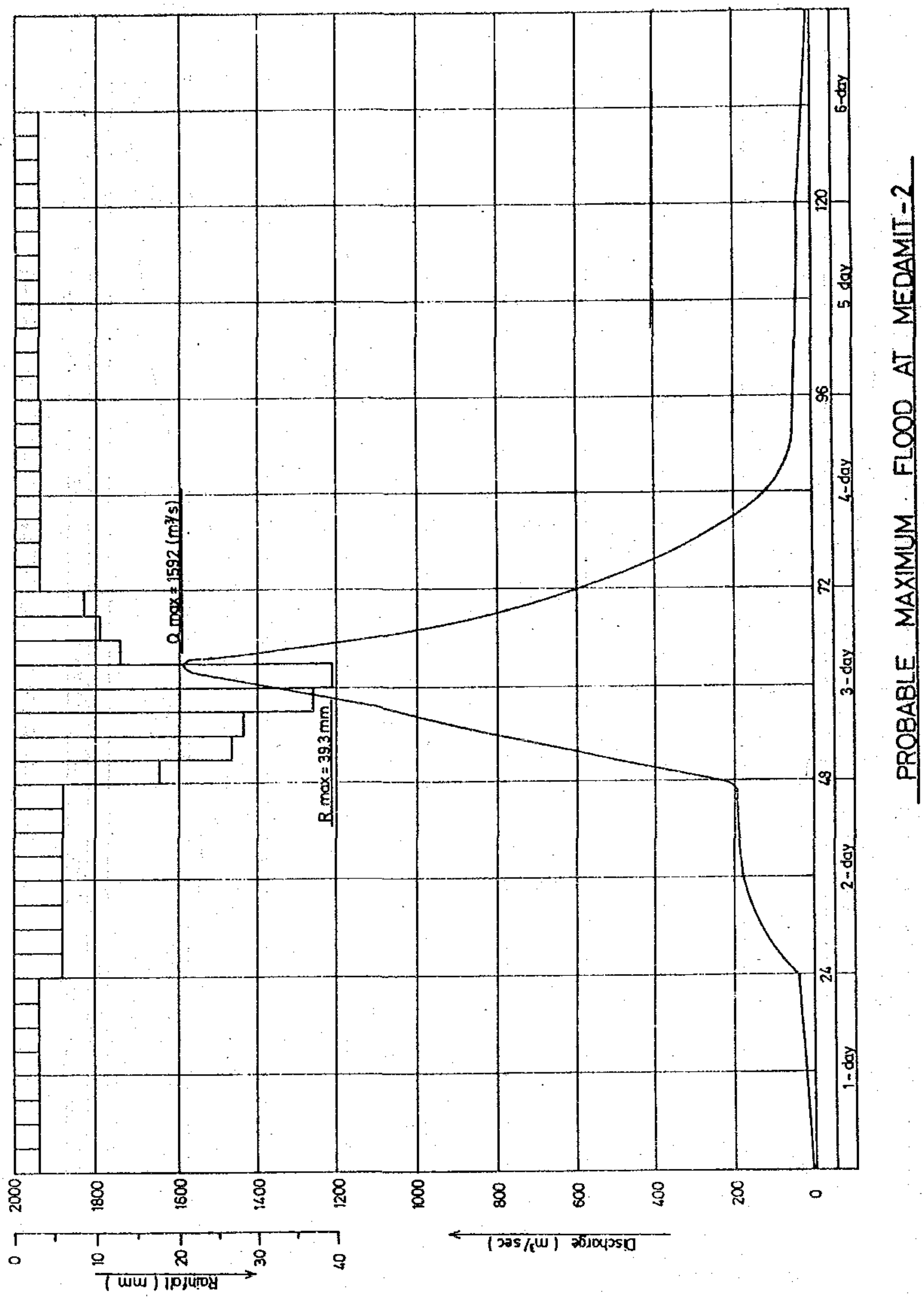

Fig. 9.20 Probable Maximum Flood for Medamit-2

GOVERNMENT OF MALAYSIA
FEASIBILITY STUDY
SMALL SCALE HYDROELECTRIC POWER PROJECT IN SARAWAK
JAPAN INTERNATIONAL COOPERATION AGENCY

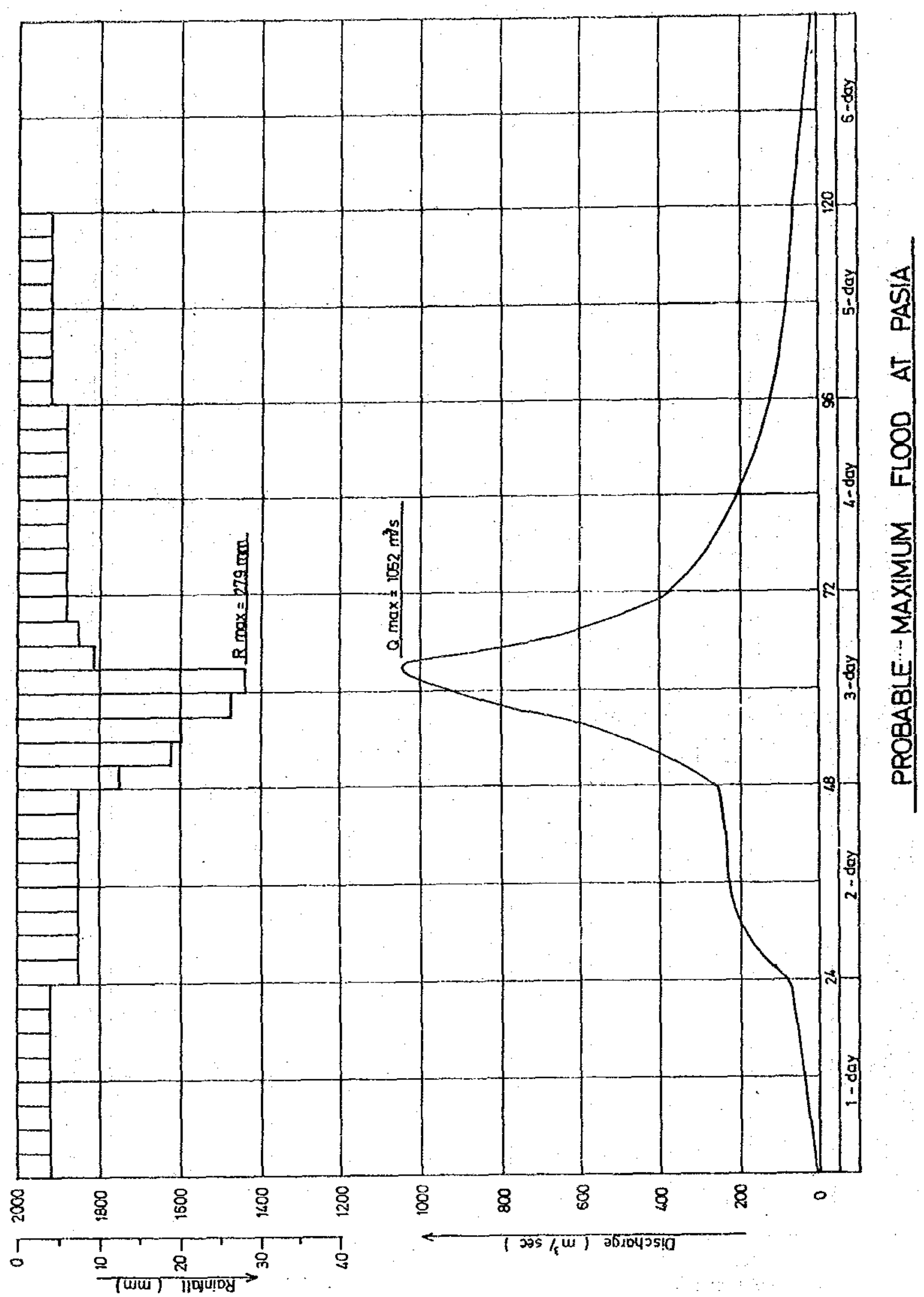

Fig. 9.21 Probable Maximum Flood for Pasia

GOVERNMENT OF MALAYSIA
FEASIBILITY STUDY
SMALL SCALE HYDROELECTRIC POWER PROJECT IN SARAWAK
JAPAN INTERNATIONAL COOPERATION AGENCY

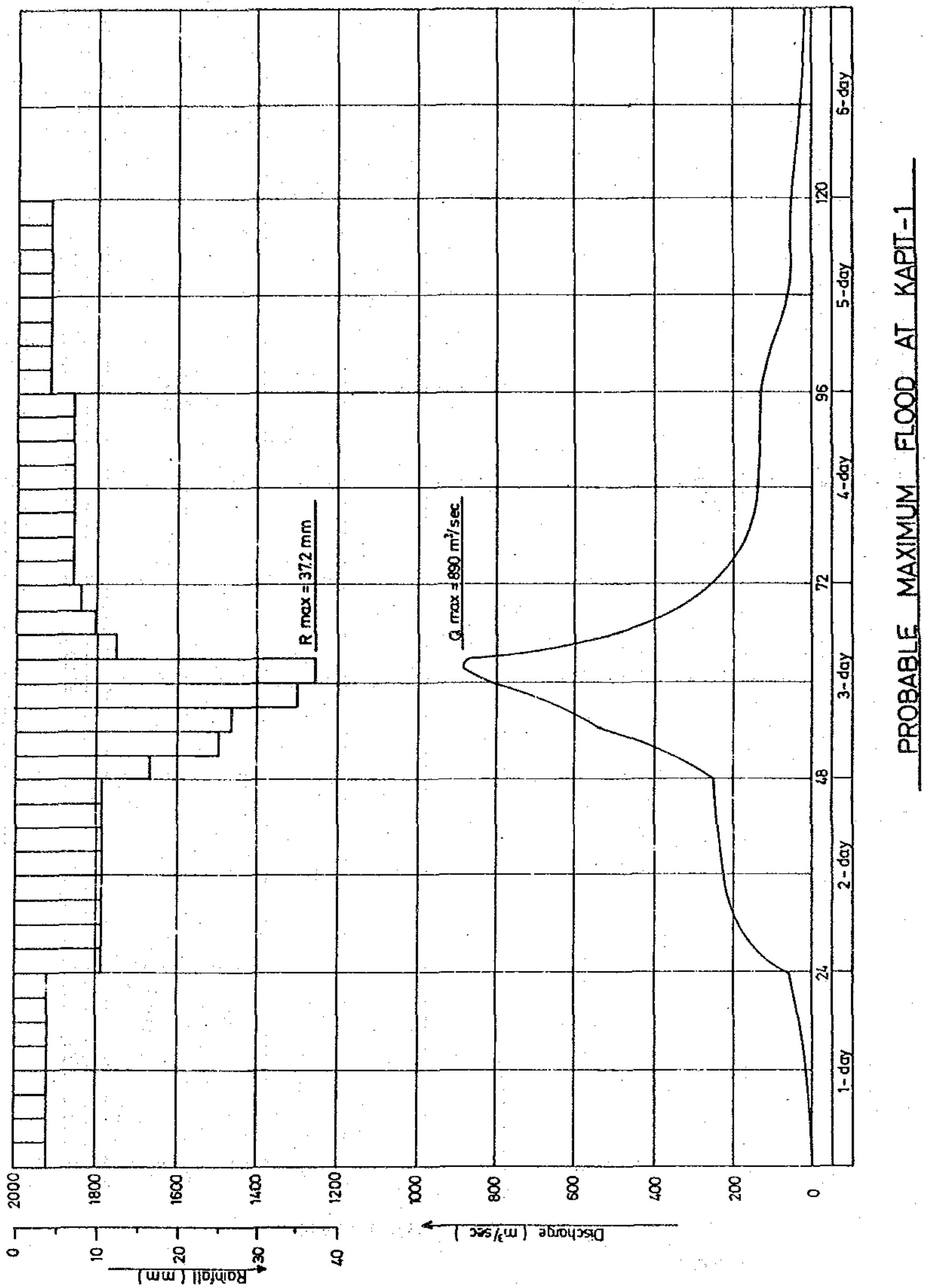

Fig. 9.22 Probable Maximum Flood for Kapit-1

GOVERNMENT OF MALAYSIA
FEASIBILITY STUDY
SMALL SCALE HYDROELECTRIC POWER PROJECT IN SARAWAK
JAPAN INTERNATIONAL COOPERATION AGENCY

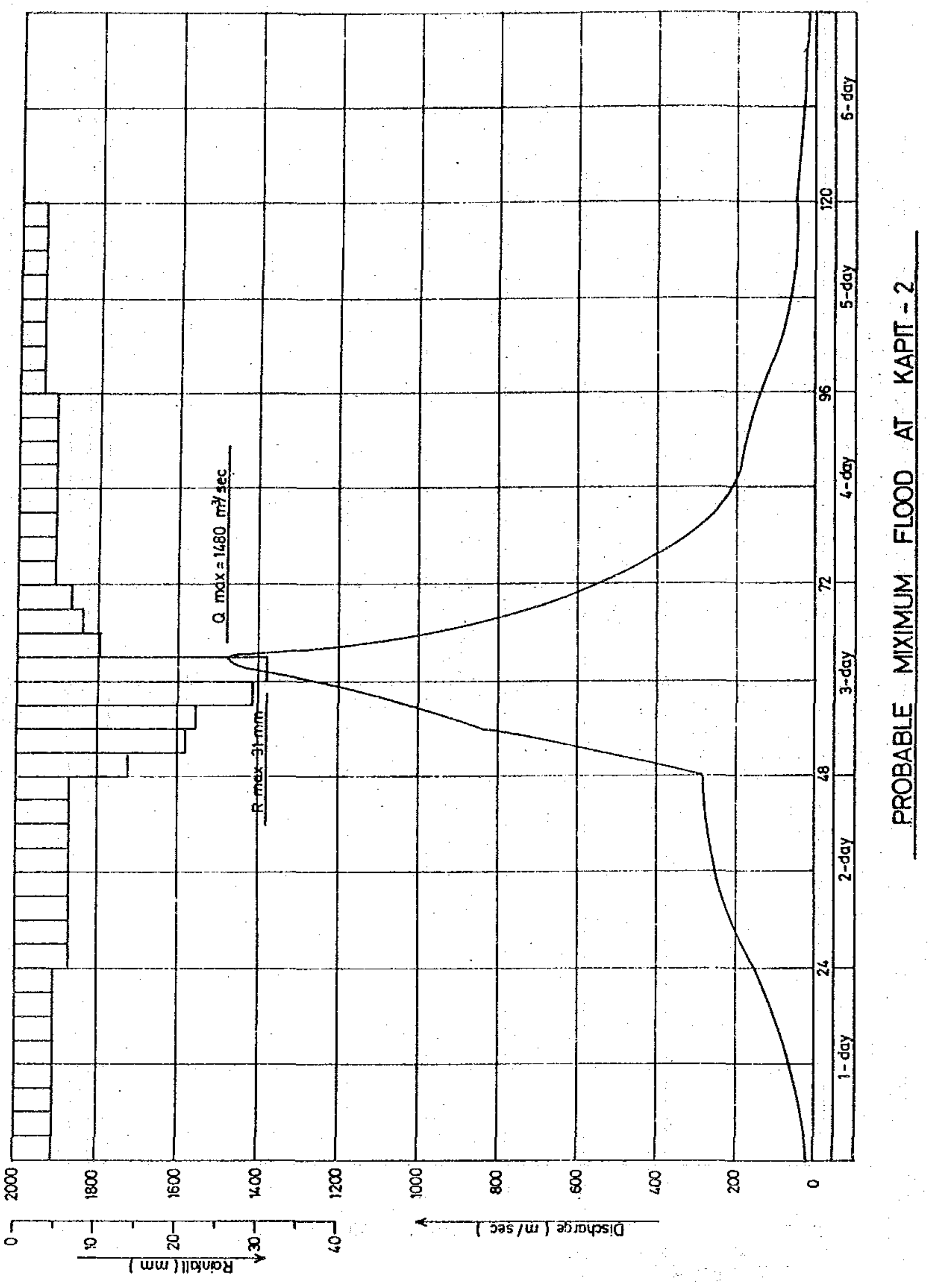

Fig. 9.23 Probable Maximum Flood for Kapit-2

GOVERNMENT OF MALAYSIA FEASIBILITY STUDY SMALL SCALE HYDROELECTRIC POWER PROJECT IN SARAWAK
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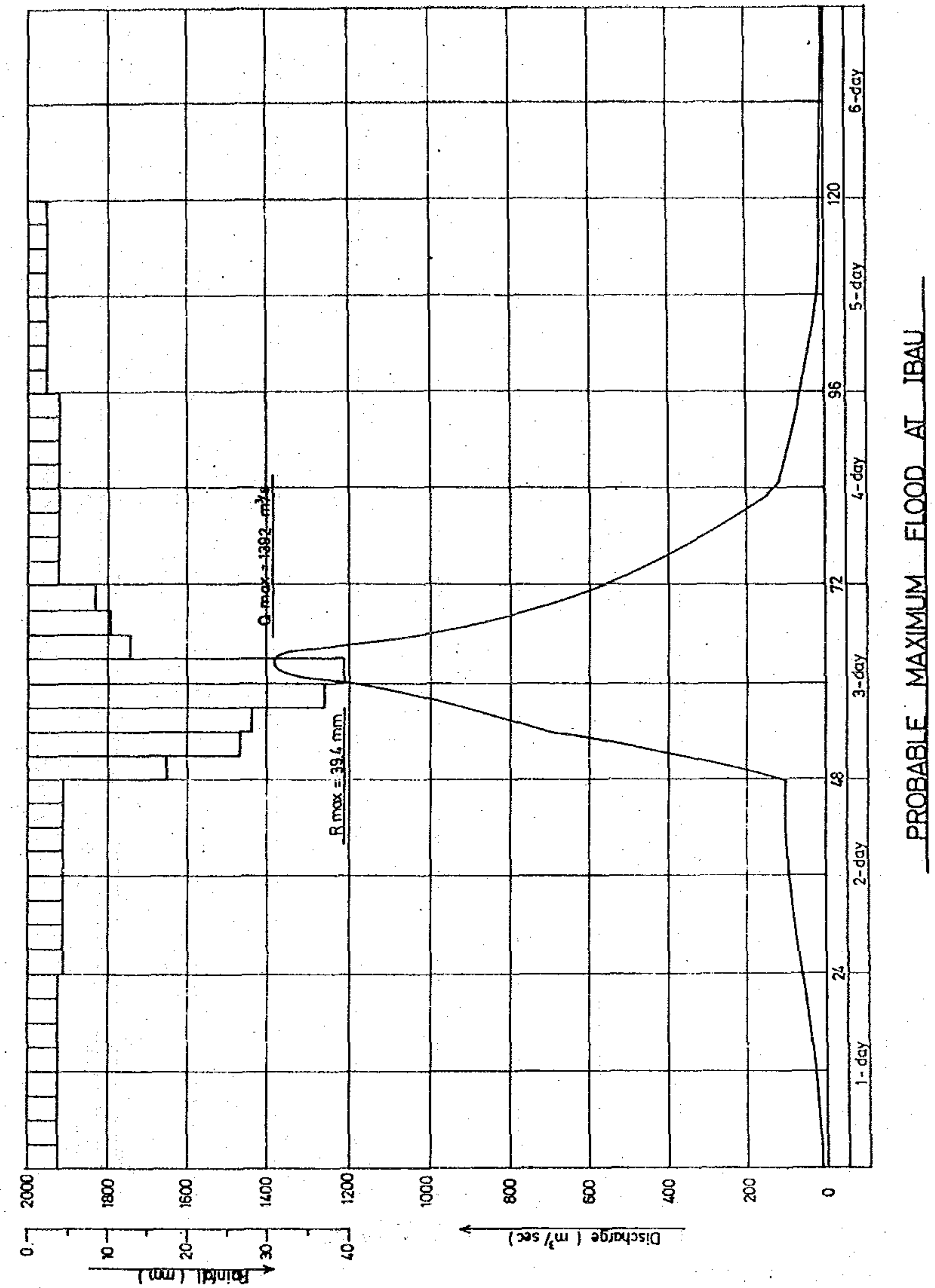

Fig. 9.24 Probable Maximum Flood for Ibau

GOVERNMENT OF MALAYSIA
FEASIBILITY STUDY
SMALL SCALE HYDROELECTRIC POWER PROJECT IN SARAWAK
JAPAN INTERNATIONAL COOPERATION AGENCY

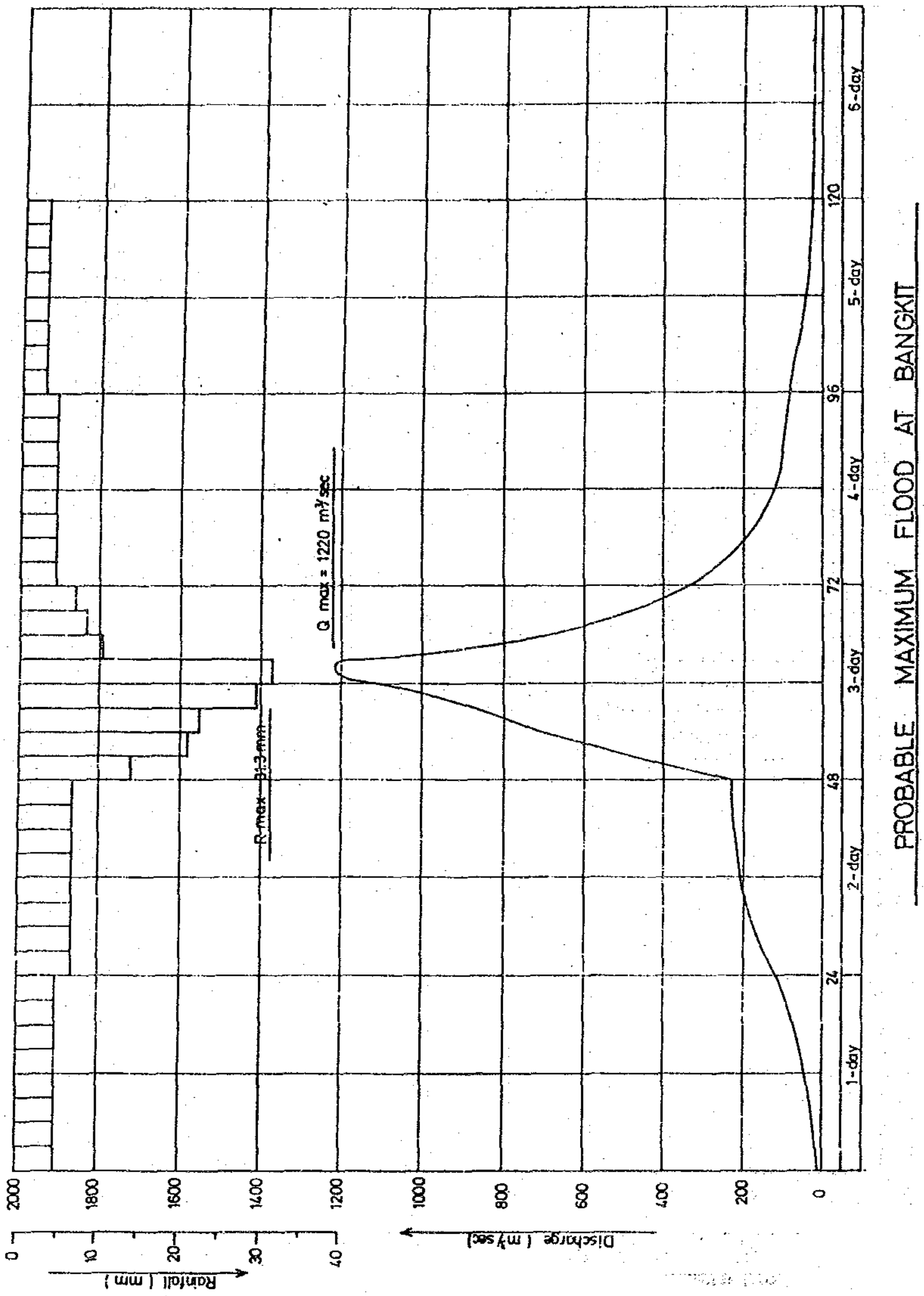

Fig. 9.25 Probable Maximum Flood for Bangkit

GOVERNMENT OF MALAYSIA
FEASIBILITY STUDY
SMALL SCALE HYDROELECTRIC POWER PROJECT IN SARAWAK
JAPAN INTERNATIONAL COOPERATION AGENCY

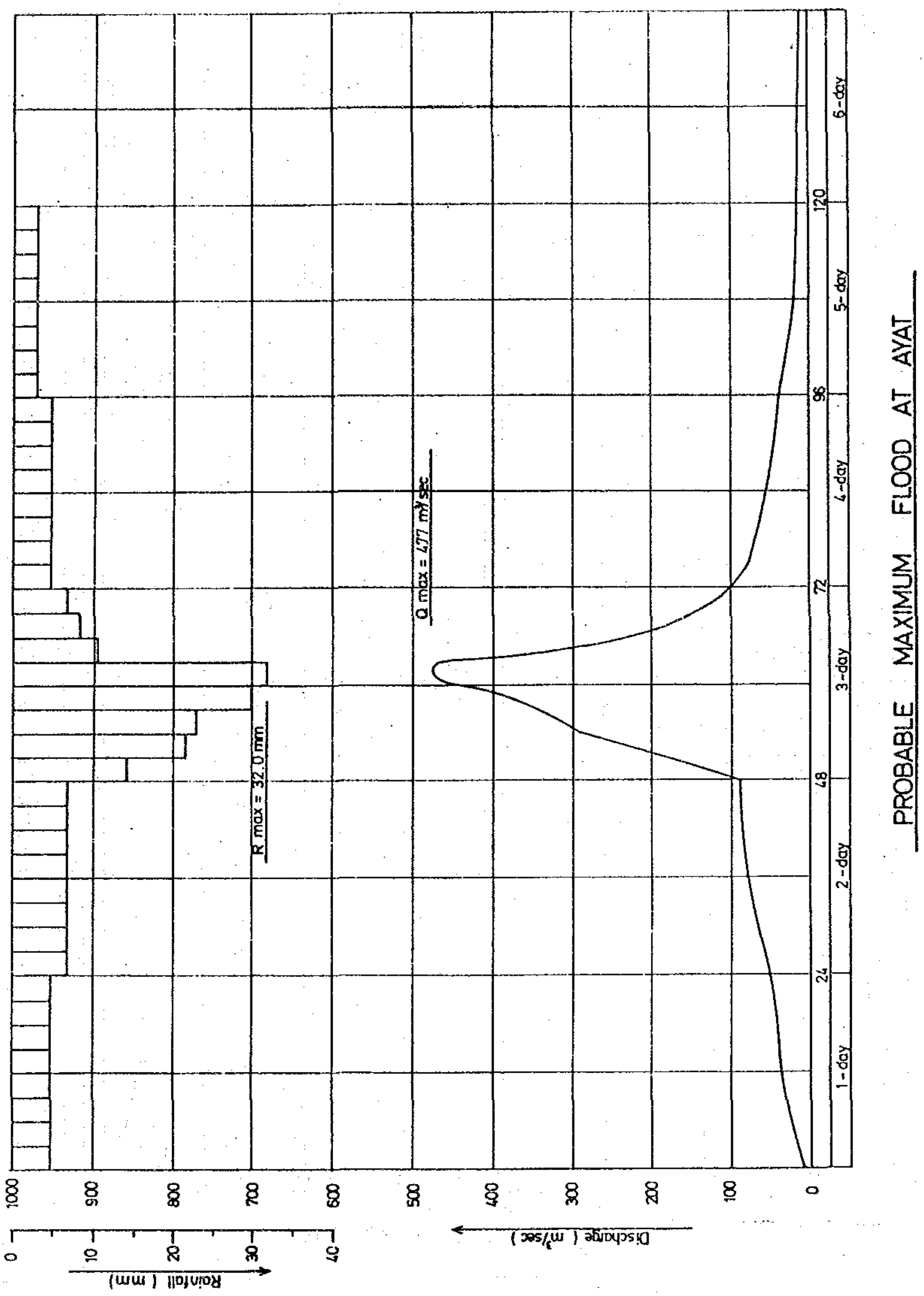

Fig. 9.26 Probable Maximum Flood for Ayat

GOVERNMENT OF MALAYSIA
FEASIBILITY STUDY SMALL SCALE HYDROELECTRIC POWER PROJECT IN SARAWAK
JAPAN INTERNATIONAL COOPERATION AGENCY

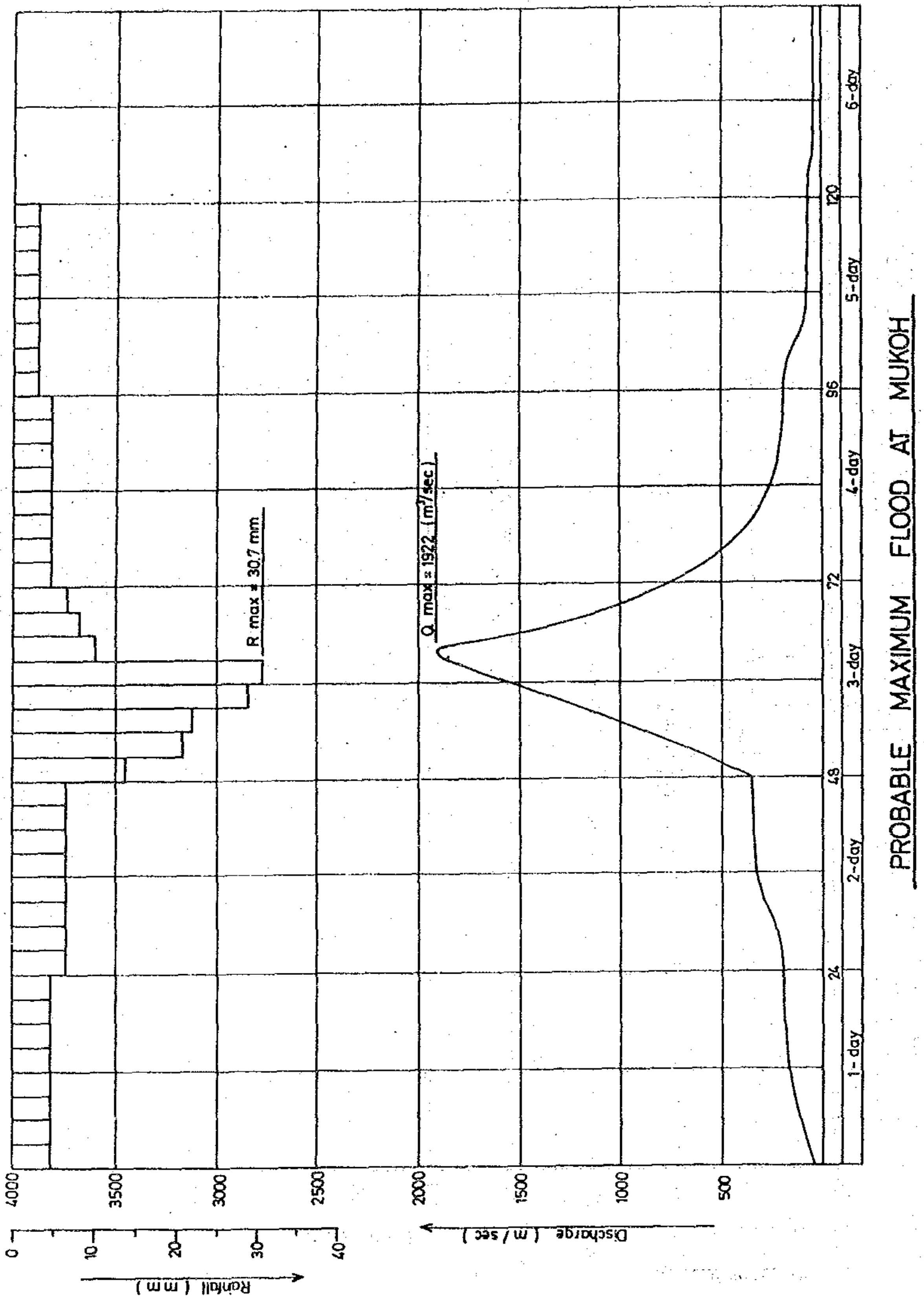

Fig. 9.27 Probable Maximum Flood for Mukoh

GOVERNMENT OF MALAYSIA
FEASIBILITY STUDY
SMALL SCALE HYDROELECTRIC POWER PROJECT IN SARAWAK
JAPAN INTERNATIONAL COOPERATION AGENCY

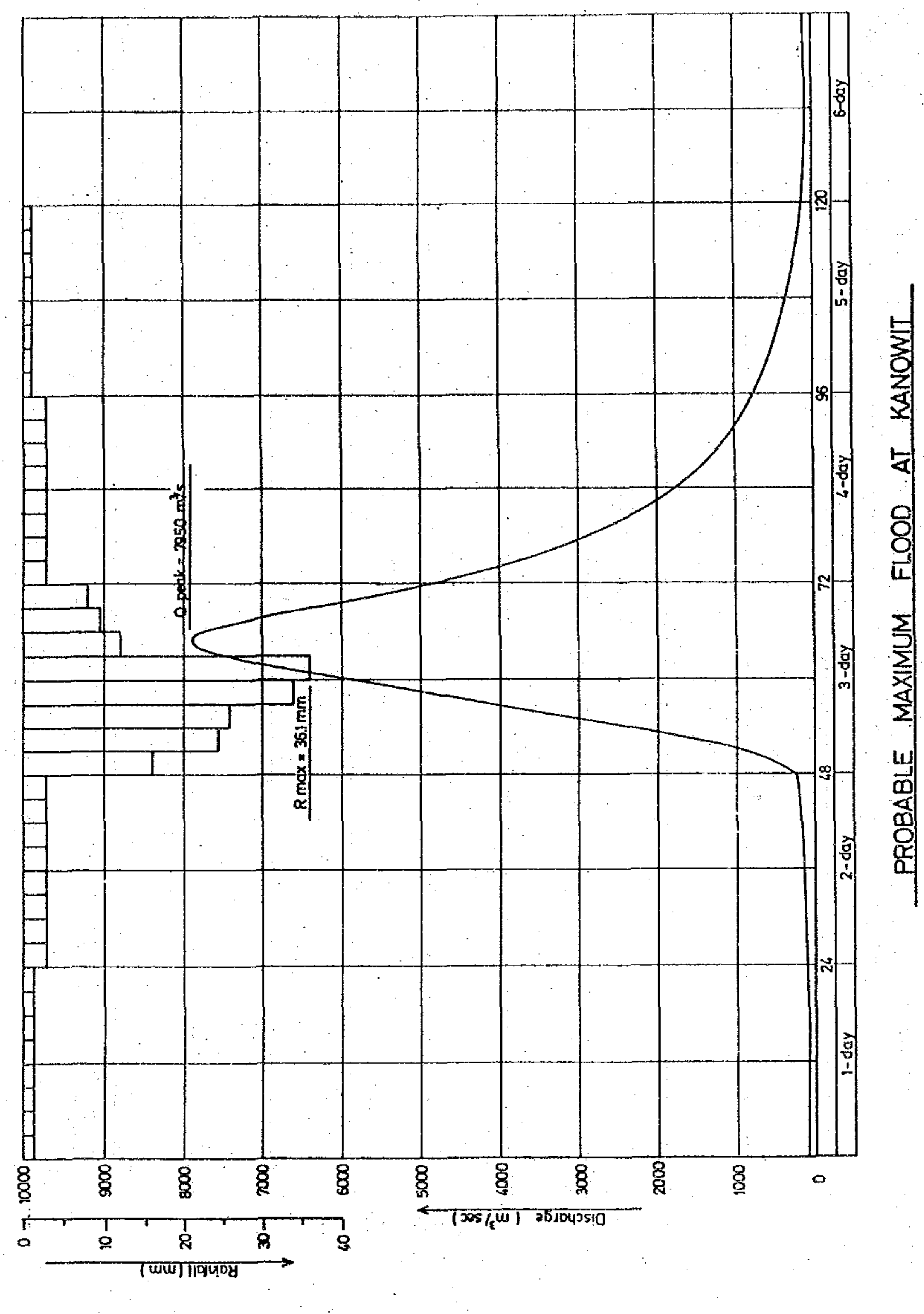

Fig. 9.28 Probable Maximum Flood for Kanowit

GOVERNMENT OF MALAYSIA
FEASIBILITY STUDY
SMALL SCALE HYDROELECTRIC POWER PROJECT IN SARAWAK
JAPAN INTERNATIONAL COOPERATION AGENCY

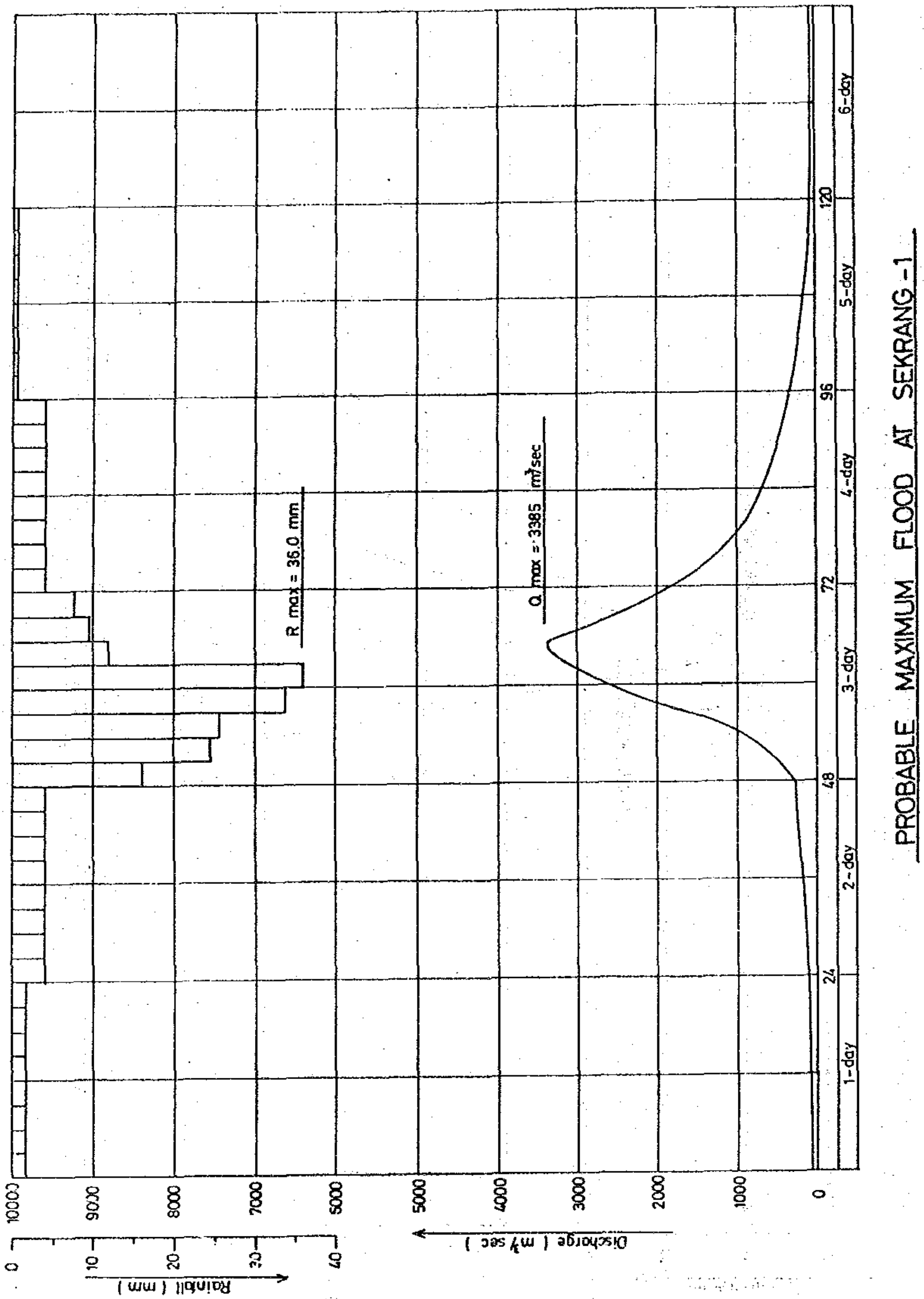

Fig. 9.29 Probable Maximum Flood for Sekrang-1

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FEASIBILITY STUDY
SMALL SCALE HYDROELECTRIC POWER PROJECT IN SARAWAK
JAPAN INTERNATIONAL COOPERATION AGENCY

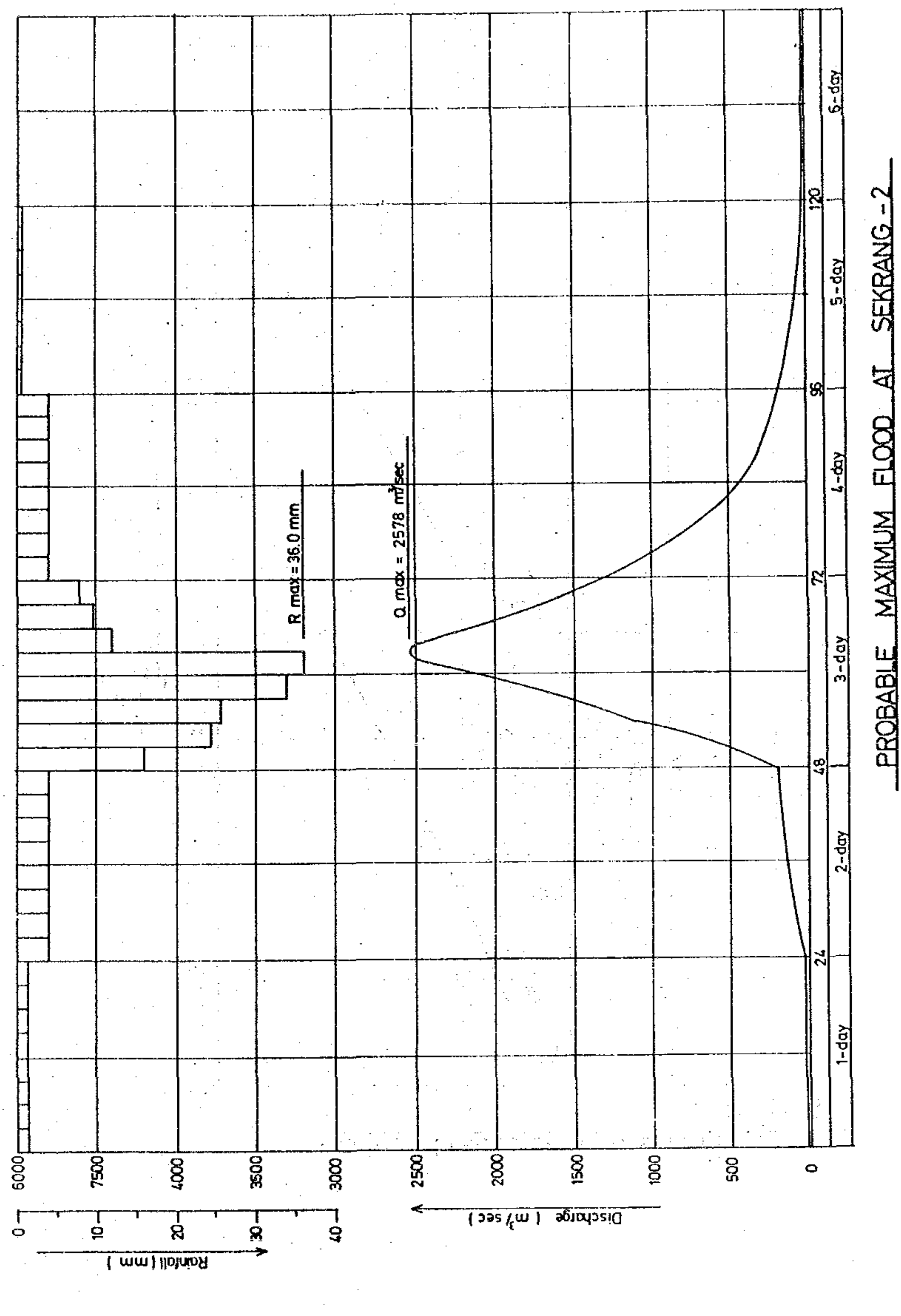

Fig. 9.30 Probable Maximum Flood for Sekrang-2

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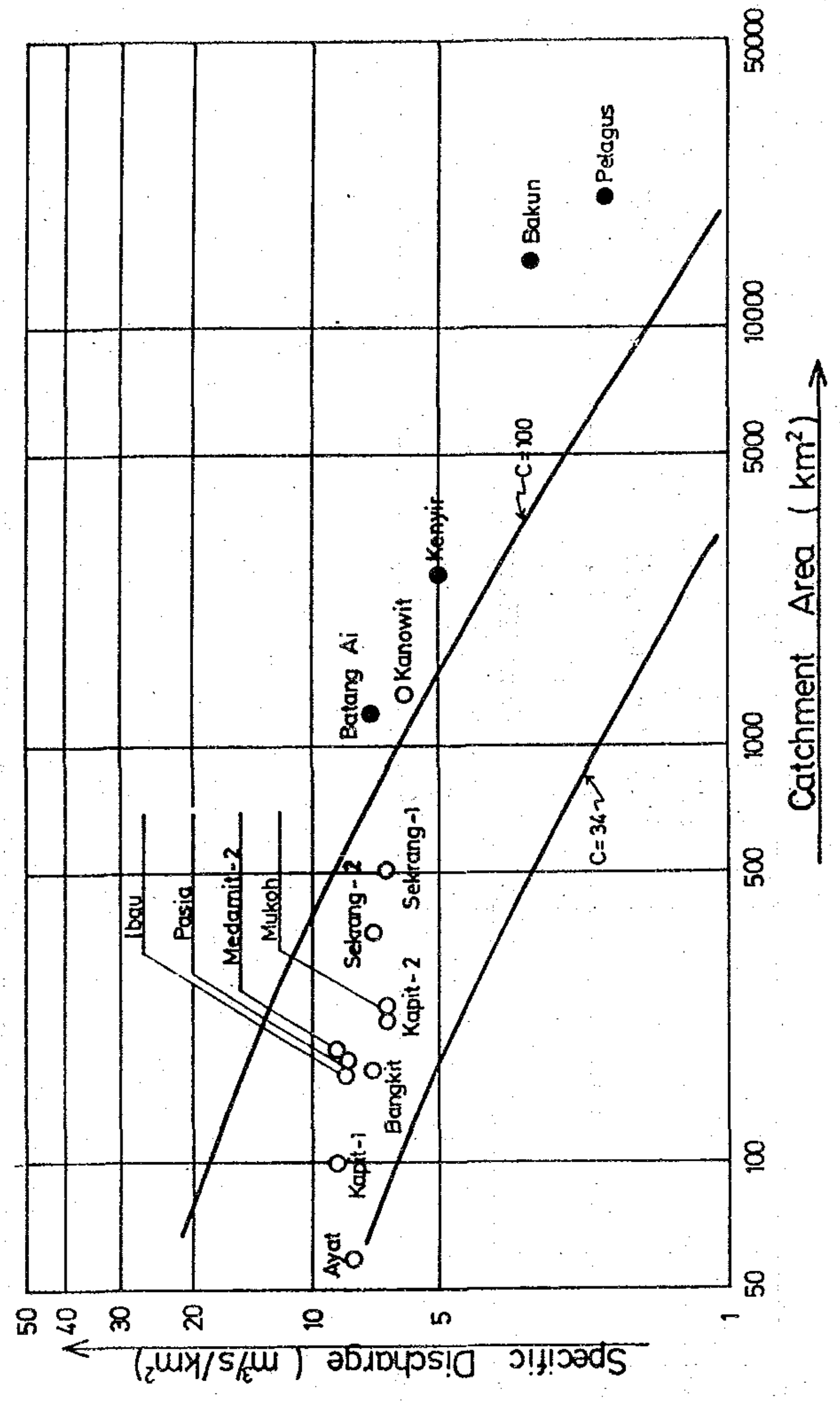

Fig. 9.31 Specific Discharge for Probable Maximum Flood

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FEASIBILITY STUDY
SMALL SCALE HYDROELECTRIC POWER PROJECT IN SARAWAK
JAPAN INTERNATIONAL COOPERATION AGENCY

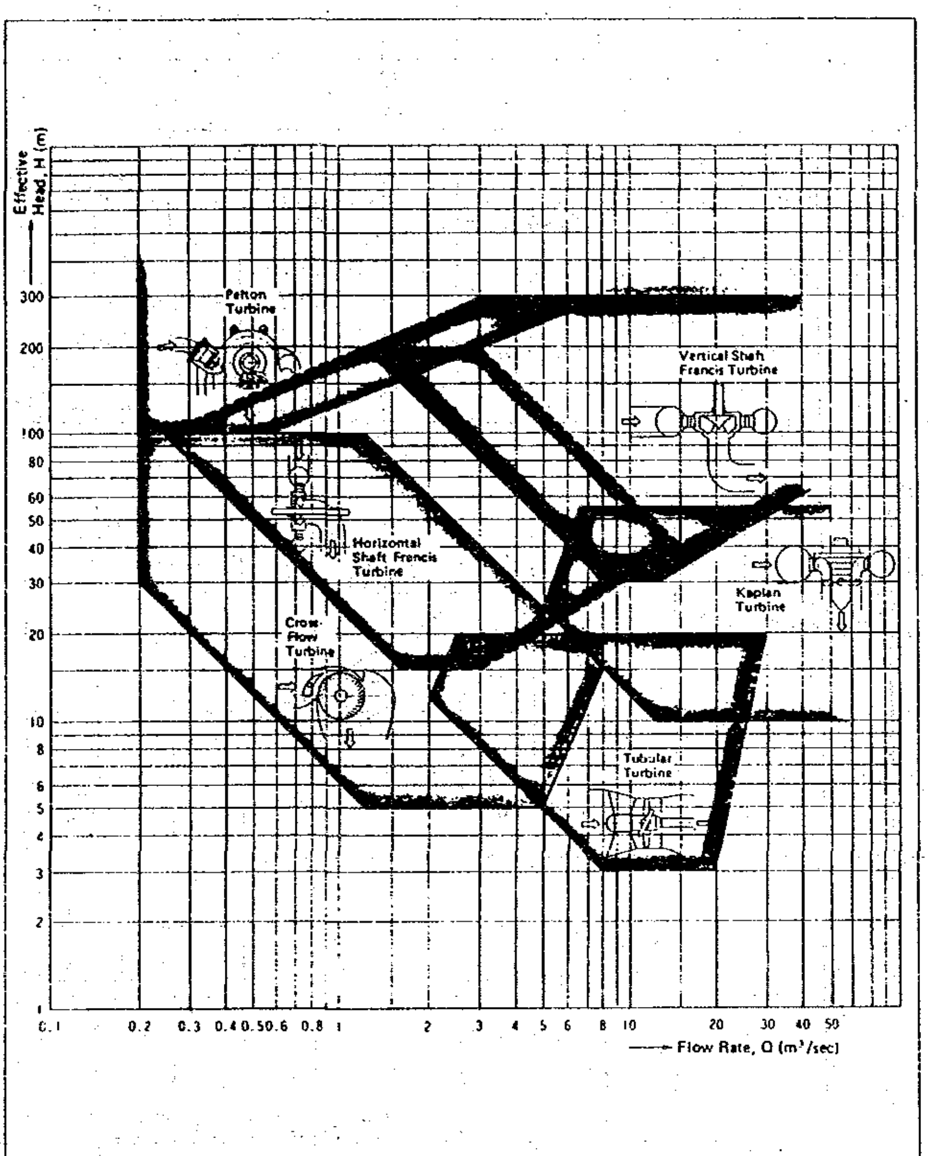

Fig. 11.1 Selection of Turbine Type

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SMALL SCALE HYDROELECTRIC POWER PROJECT IN SARAWAK
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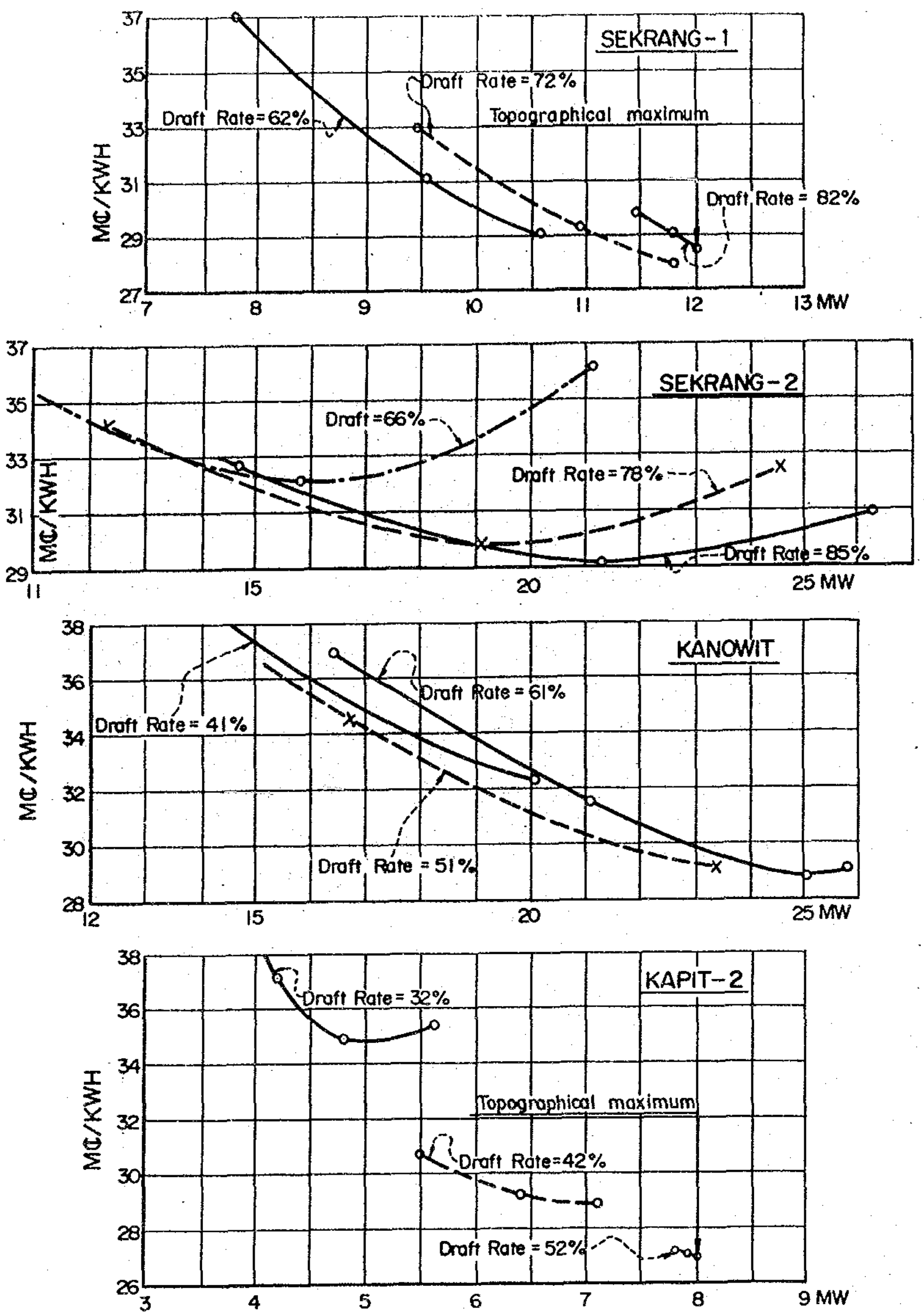

Fig. 14.1 Comparison of KWh Cost for Varied Development Scale (1/2)

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FEASIBILITY STUDY
SMALL SCALE HYDROELECTRIC POWER PROJECT IN SARAWAK
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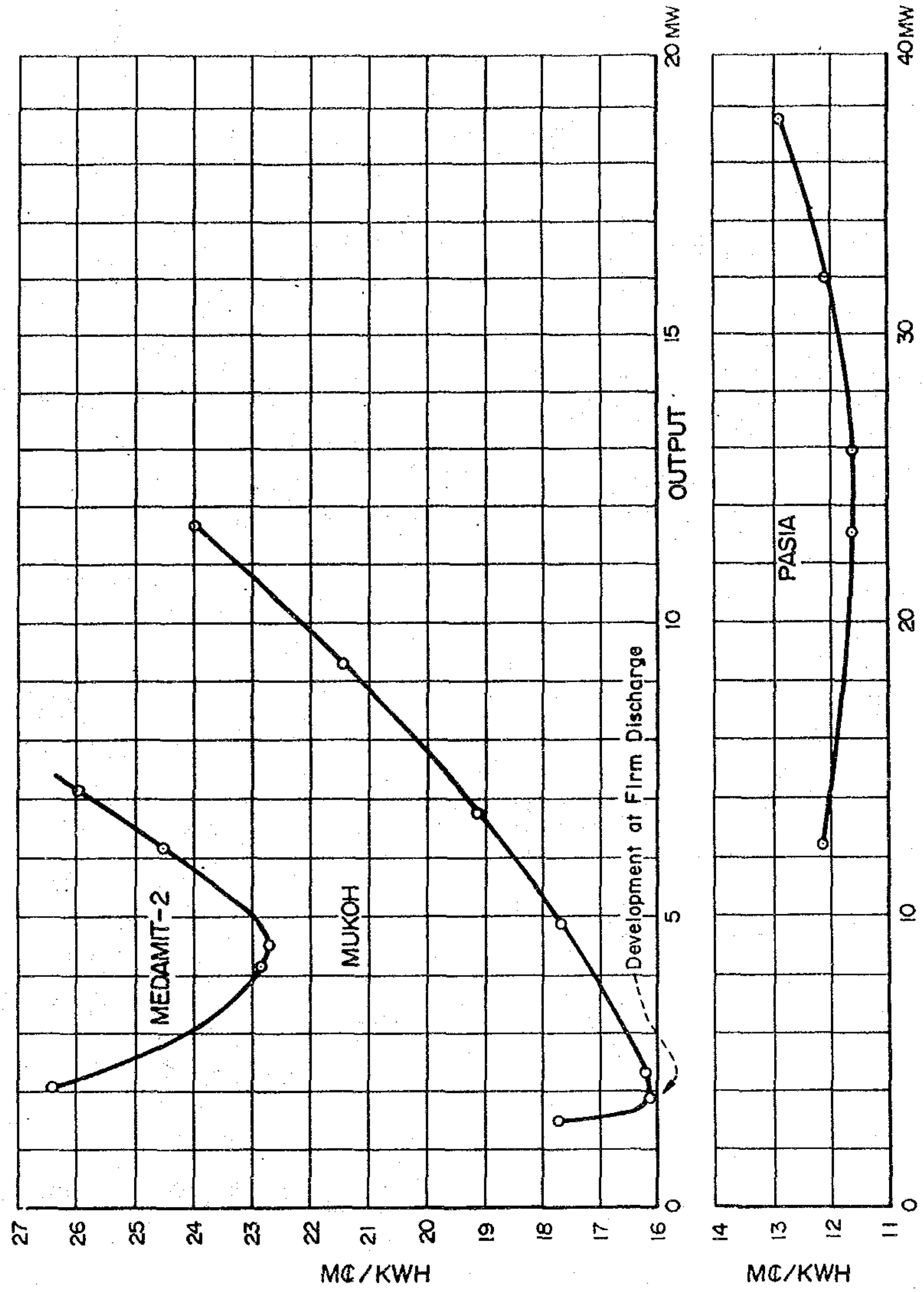

Fig. 14.2 Comparison of KWh Cost for Varied Development Scale (2/2)

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FEASIBILITY STUDY
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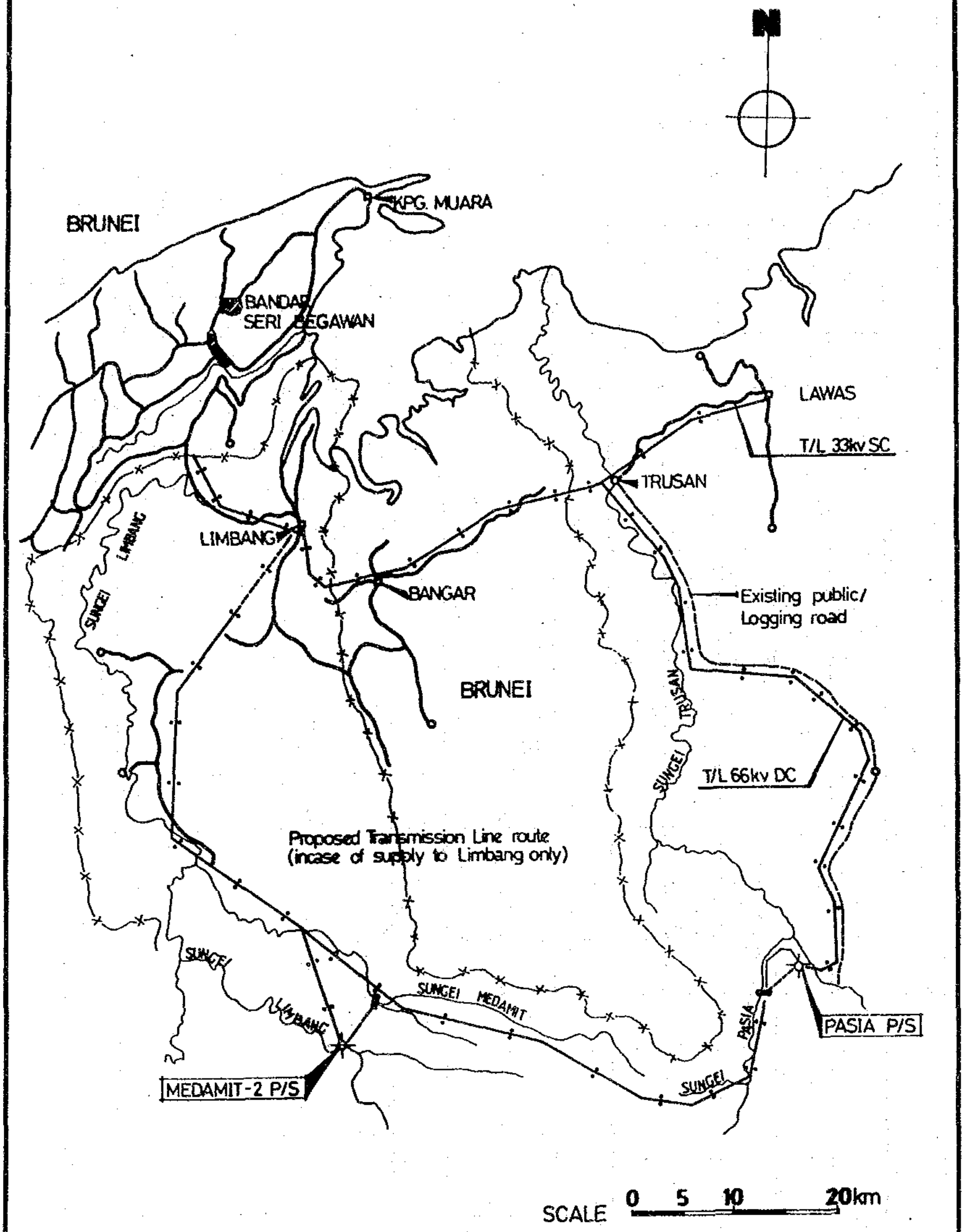

Fig. 14.3 Preliminary Plan of Transmission Line Route

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FEASIBILITY STUDY
SMALL SCALL HYDROELECTRIC POWER PROJECT IN SARAWAK
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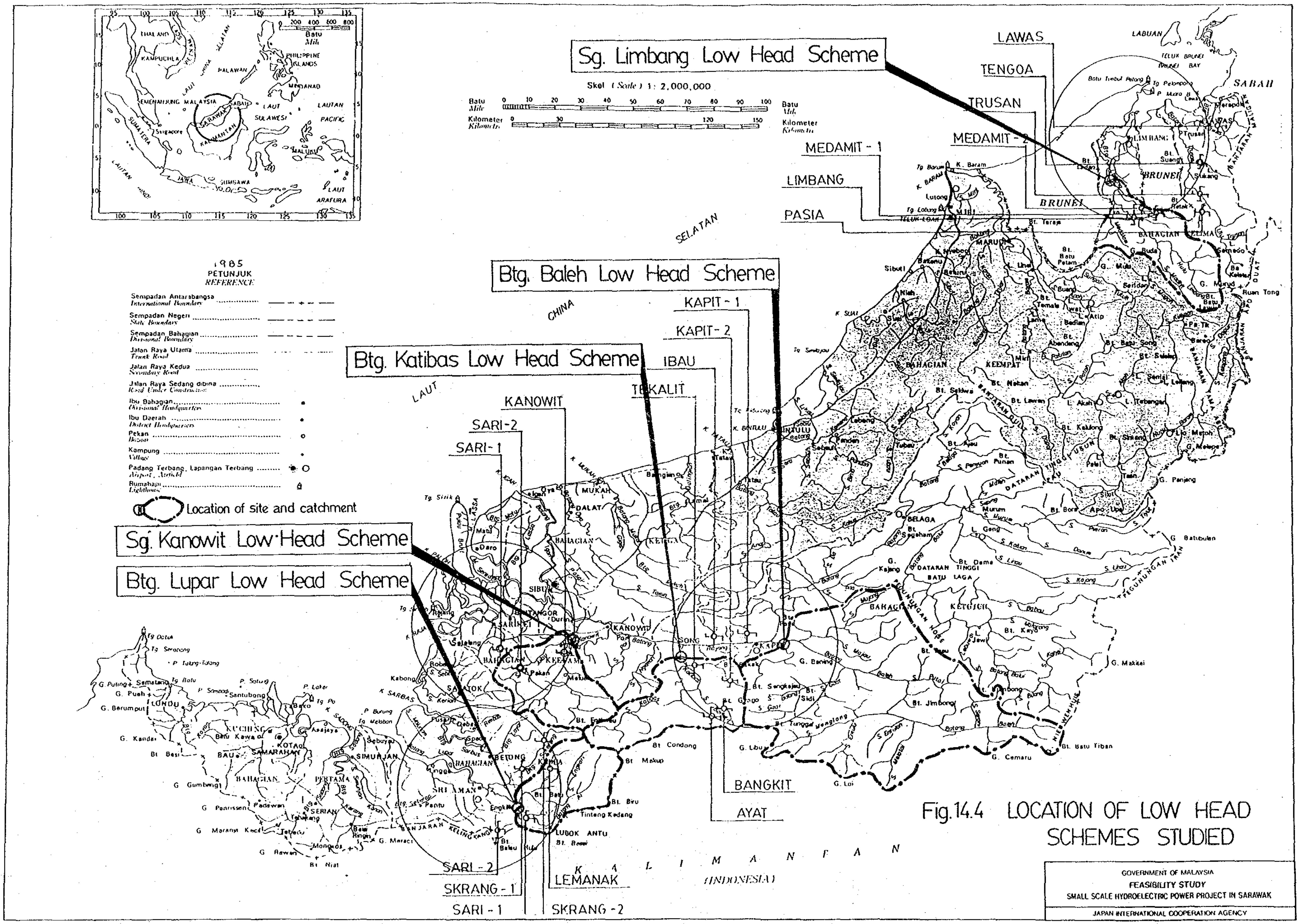

Fig.14.4 LOCATION OF LOW HEAD SCHEMES STUDIED

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