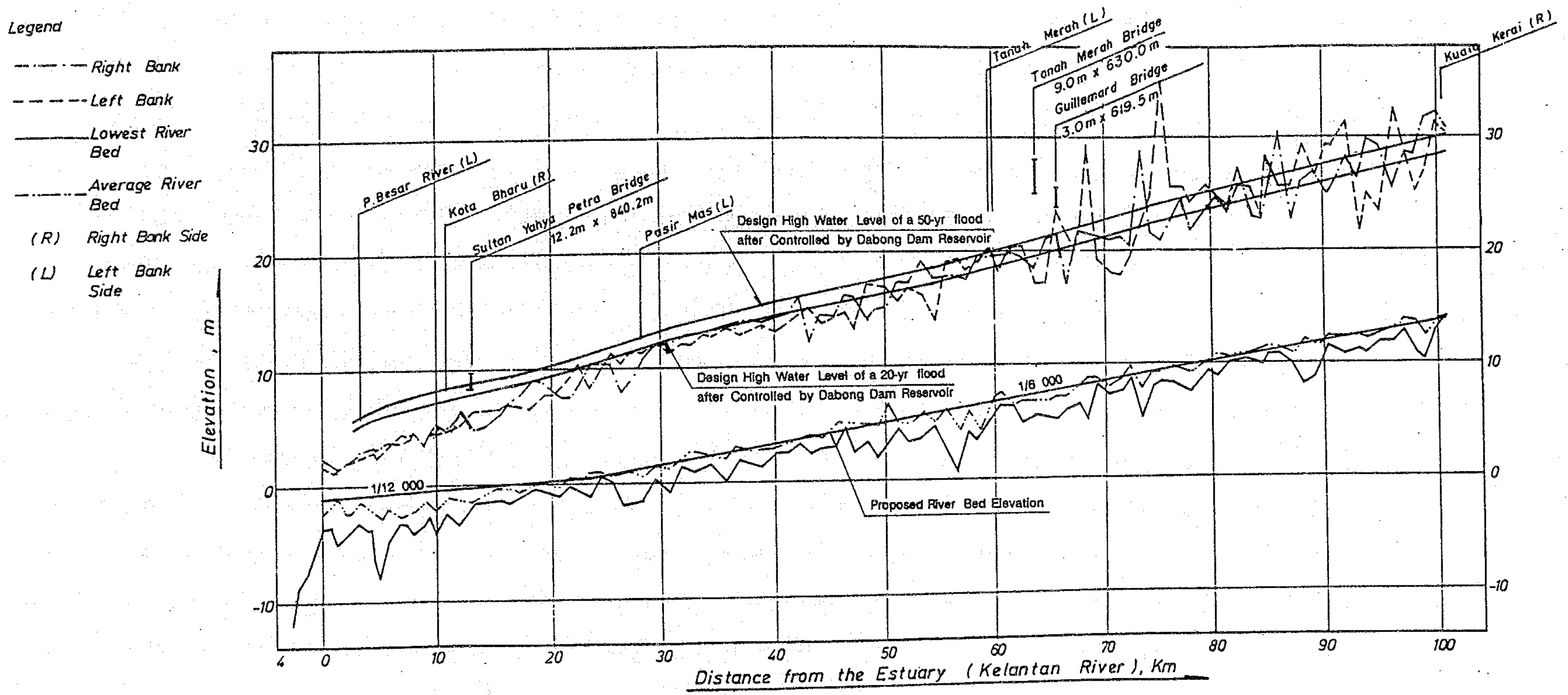

Fig.VIII.5.1

Longitudinal Profile of River Improvement for the Suitable Combination Plan

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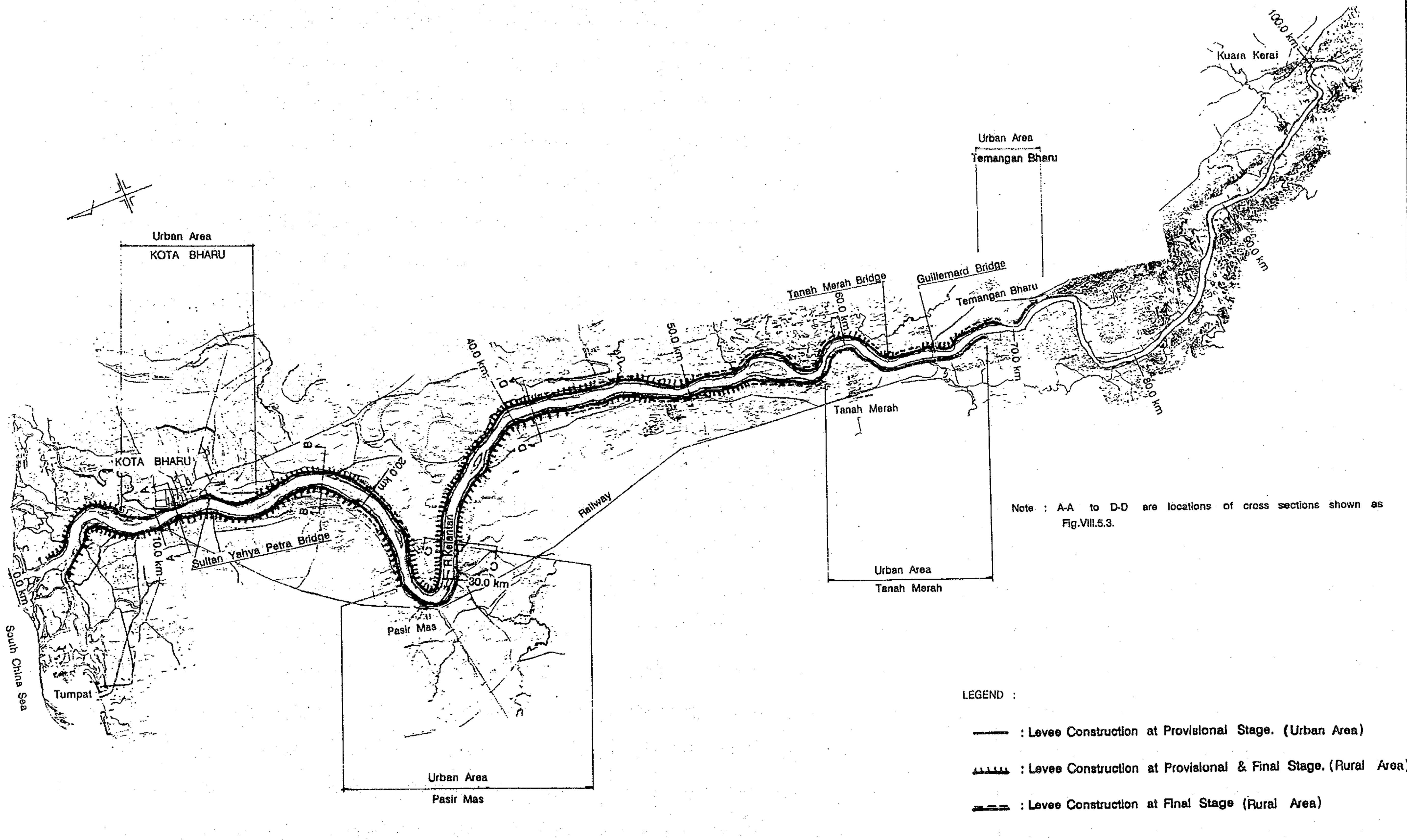

RIVER IMPROVEMENT PLAN (LEVEE ARRANGEMENT) OF SUITABLE COMBINATION PLAN (DABONG DAM + RIVER IMPROVEMENT)

Fig.VIII.5.2

Plan of River Improvement for the Suitable Combination Plan

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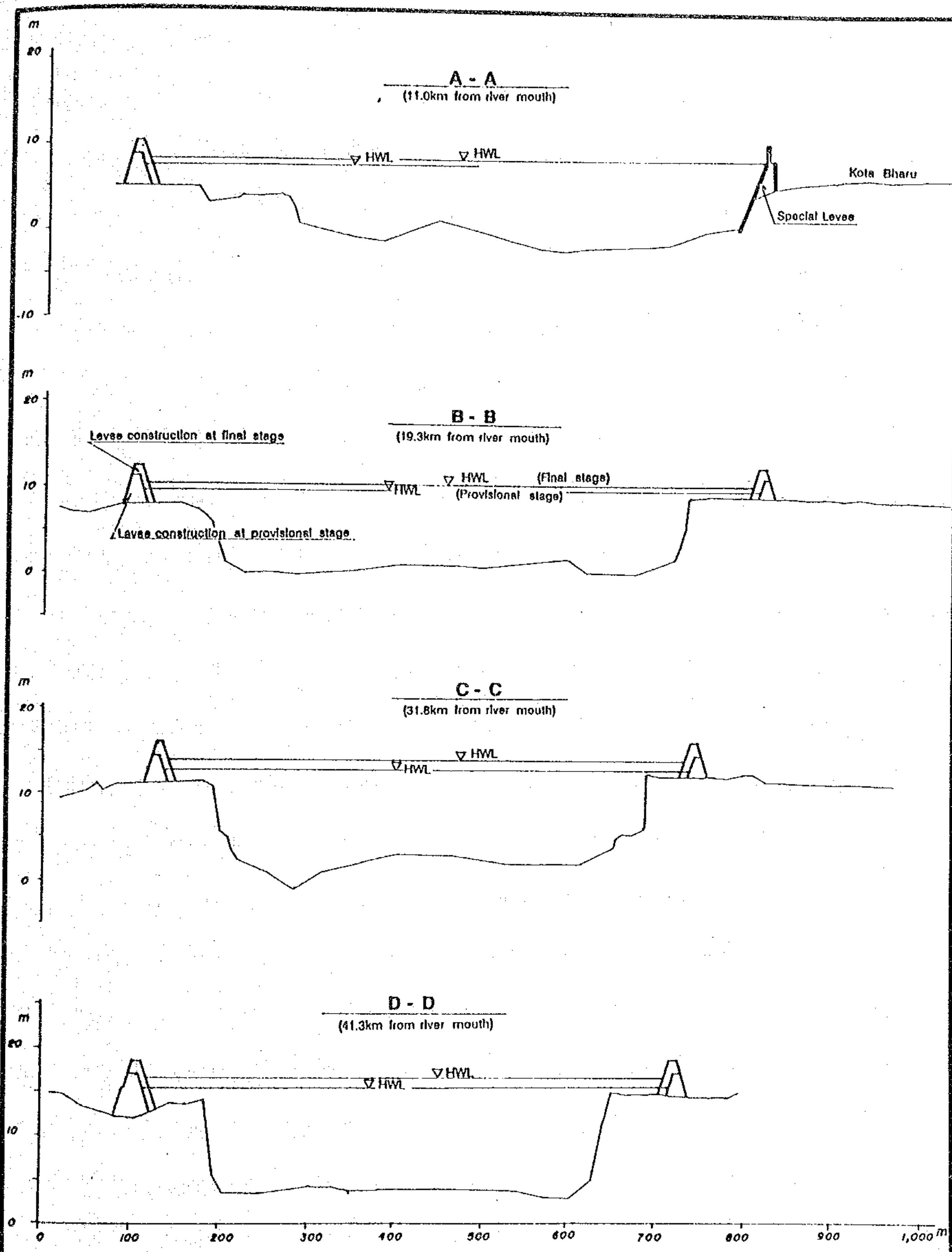

Note : (1) Refer to Fig.VIII.5.2 for location of cross sections above.

(2) HWL means design high water level.

Fig.VIII.5.3

Typical Cross Section of River Improvement for the Suitable Combination Plan

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ANNEX IX

STUDY

ON

FLOOD MITIGATION PLAN

TO MINIMIZE SOCIAL IMPACTS

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IX. FLOOD MITIGATION PLAN TO MINIMIZE SOCIAL IMPACTS

1. INTRODUCTION

1.1 General

As discussed in Annex VIII, the Dabong dam plus river improvement was selected as the most promising plan for the dual objectives of water resources development stressing on hydropower generation and the flood mitigation in the downstream reaches of the Kelantan River.

However, this multipurpose dam scheme requires a large scale relocation for houses, plantations and public facilities, causing considerable social impacts. Consequently, it was strongly requested by the State Government through the discussion of the Interim Report to study a number of new combinations of dams and river improvement with emphasis on the minimization of social impacts.

In accordance with this request, the flood mitigation study was carried out incorporating newly obtained topographic data at the proposed Dabong, Kemubu and Lower Pergau damsites and referring to the situation of flood occurred in November 1988. The formulation of flood mitigation plan stressing on the minimization of social impacts is discussed hereinafter.

1.2 Objectives of the Study

The objectives of the study consist of the following;

(i) To formulate a basin-wide flood mitigation plan giving the priority to the minimization of social impacts, and

(ii) To select the flood mitigation plan to be taken up as the pre-feasibility study in the following stage.

2. FORMULATION OF FLOOD MITIGATION PLANS

2.1 Basic Concept

The basic concept in formulating the flood mitigation plan of the Kelantan River basin stressing on the minimization of social impacts is summarized as follows:

a. Flood mitigation Master Plan of the Kelantan River is targeted for a 50-year flood, considering the development of the flood-prone area extended in the downstream reaches and habitual flooding.

b. A levee with 7 m high will be required to safely release flood water of 17,400 m^3/sec at Guillemard Bridge, when without dam. Levee is desired to be as low as possible, taking into account the damage caused by the break of high levee. Thus, flood water of the Kelantan River is to control with the dams built in the upstream reaches as much as possible for making the burden to the levee lighter.

c. The dams will be built with a single purpose of flood mitigation to reduce the social impacts by lowering their height. Unless the inclusion of hydropower generation causes the change of reservoir capacity and flood mitigation effect, the dam scheme is considered as the one with dual purposes of flood mitigation and hydropower generation.

d. Flood peak discharge at Guillemard Bridge is aimed at controlling to below 11,000 m^3/sec by the dams to be built in the upstream reaches based on the following reasons:

   - Flood water level should be kept within 3 m higher than the ground level (A levee height will be within 5 m at a maximum point as referred to Fig. IX.2.1).

   - Since the present flow capacity ranges from 4,500 m^3/sec at Kota Bharu in the downstream reaches to 11,000 m^3/sec in the upstream reaches of Guillemard Bridge (refer to Fig. IX.2.2), the design flood peak discharge of 11,000 m^3/sec is not considered to be heavy burden for levee construction, and levee with height lower than 5 m can be constructed even for the highest case (refer to Fig. IX.2.3).

   - The relocation of existing and under-construction bridges should be avoided (refer to Fig. IX.2.3).

   - The treatment of tributaries against backwater from the Kelantan River should be in the reasonable extent.

   - Treatment of interior water should be in the reasonable range.

   - Influence to the existing irrigation facilities should be minimized (for example, reconstruction of water intake facilities caused by the river bed deepening with a large scale).

- As intangible factors, the separation of local communities by levee should be avoided, and the change of micro-climate at local places should be minimized.

2.2 Selection of Damsites for Flood Mitigation

In order to study the flood mitigation plan by flood mitigation dam, potential dam sites were selected from the basin area concentrating in the river stretch between Kuala Krai and about 150 km upstream from the confluence with Galas and Lebir rivers, since further upstream stretches form a steep river bed slope and reservoir storage sufficient for flood mitigation cannot be ensured.

The site selection was made based on the topographic map with 1 to 63,360, and 15 potential damsites were identified in this study as shown in Fig. IX.2.4 (refer to Appendix-2 of Annex VI); six sites in the Galas River, one site in the Pergau River, four sites in the Nenggiri River and four sites in the Lebir River. The longitudinal profile for these 15 potential damsites is illustrated in Fig. IX.2.5.

In order to carry out the flood mitigation study by dam, it is necessary to screen out the damsites suitable for flood mitigation study from among 15 potential damsites. The study on this screening was made in the following manners;

(i) The flood mitigation dam is planned for all of the potential damsites.

(ii) Among the combination of flood mitigation dams contemplated in (i), the damsites suitable for flood mitigation are selected from the viewpoint of the amount of construction cost and extent of flood peak reduction.

The standard for the dam plan is as follows;

(i) For all of 15 potential damsites, the mini-scale dams are created by utilizing the head between the neighbouring sites. However, remarkable mini-scale dams are neglected.

(ii) For the certain damsites, the small scale dam which is the minimum scale for discharging safely probable maximum flood (PMF) is created and for other sites, the mini-scale dam utilizing the head between the damsites is created, and

(iii) The small scale dams which have a minimum scale for PMF are created only at the certain damsites.

The potential damsites will be divided into several groups; namely, Dabong group of sites 1 and 2, Kemubu group of sites 4, 5, 6 and 7, Nenggiri group of sites 8, 9, 10, and 11, and Lebir group of sites 12, 13, 14 and 15. It is considered that if the dam which has a minimum scale for PMF in the Dabong group is planned, the dam in the Kemubu group cannot topographically be constructed due to the submergence by dam in Dabong group. On the contrary, if the dam which has a minimum scale for PMF in the Kemubu group is planned, the dam in Dabong group cannot be constructed; that is, the Dabong and Kemubu groups are mutually exclusive.

By applying the foregoing standard for dam plan to the 15 potential damsites, the following combination groups will be contemplated;

(i) Group-1 ; Mini-scale dam not to cause the social impact is planned for potential damsites.

(ii) Group-2 ; The flood mitigation dam which has a minimum scale for PMF is planned giving the priority on the Dabong group.

(iii) Group-3 ; The flood mitigation dam which has a minimum scale for PMF is planned giving the priority on the Kemubu group.

Table IX.2.1 shows the alternatives for each group mentioned above, while the breakdown of the storage volume for these alternatives is given in Table IX.2.2. The relation among the flood peak reduction at Guillemard Bridge by conceivable dams, cost for the conceivable dams and river improvement cost required to discharge the flood peak at Guillemard Bridge was studied for these combinations as given in Table IX.2.1.

In this table, the alternatives with the least construction cost in each group are as follows;

Group	Alternative	Damsites involved					
1	A - 2	1	3	5	8	9	13
2	A - 7				2	9	13
3	A - 13					7	13

In group-1 in which mini-scale dams are built in a series not to cauce the social impact, Alternative-2 is considered as the suitable combination from the viewpoint of the amount of construction cost. However, effect of flood peak reduction is little expected by building mini-scale dams in a series. Considering these situations, combinations for group-1 were deleted in terms of flood peak reduction. It was thus determined to carry out the flood mitigation study by means of single purpose dam at the site of Dabong (No.2), Kemubu (No.7), Nenggiri (No.9) and Lebir (No.13) as given in groups-2 and 3.

2.3 Relation between Dam Height and Facilities to be Relocated

In the combination plans of A-7 and A-13, four damsites, i.e. Dabong, Kemubu, Nenggiri and Lebir are selected for flood mitigation study.

Along the upstream stretches of the selected damsites, village, commercial and industrial establishment, public institution, infrastructures, irrigation and agricultural lands and so on have been developed. The construction of dam requires the relocation of these existing facilities and the extent of the facilities to be relocated will increase in proportion to the scale of the reservoir area.

In order to clarify the extent of the social impacts due to the submergence of reservoir, the relationship between dam height and facilities to be relocated was investigated based on the newly obtained topographic map with a scale of 1 to 10,000 for the conceivable Dabong and Kemubu reservoir areas and available data for the Nenggiri and Lebir reservoir areas.

Figs. IX.2.6, 2.7, 2.8 and 2.9 show the relationship between the dam height and facilities to be relocated for four schemes. Fig. IX.2.6 shows that the majority of the villages, public institutions and infrastructures submerges even if the dam with about 23m in height is constructed at the Dabong site. It also shows that if relocation of the existing railway has to be avoided, the dam height is obliged to be limited to less than 20m, resulting in no substantial flood mitigation effect.

Fig. IX.2.10 depicts the relative social impact among the Kemubu, Nenggiri and Lebir dam schemes, presenting a large number of households to be submerged in the Kemubu scheme compared with the Lebir and Nenggiri schemes, whilst the Lebir scheme is the greatest in the plantation area.

2.4 Combination Plans of Flood Mitigation Dams and River Improvement

In order to study the flood mitigation plan by means of flood mitigation dam, four dam schemes, i.e. Nenggiri, Kemubu, Dabong and Lebir, were selected. For these flood mitigation dams, three heights were examined in evaluating the flood mitigation effect; the minimum, medium and maximum scales.

The minimum scale is planned to lower the dam height as much as possible to minimize the social impacts. The dam height is decided by coinciding the crest of spillway with the sediment deposit level in the reservoir. The spillway has the scale capable of releasing P.M.F.

The maximum scale is the same as the one selected in the optimization study for flood mitigation and water utilization in the Annex VIII. The medium scale has the intermediate scale between the minimum and maximum.

Table IX.2.3 shows the relationship among the scale of dam and spillway, flood space in the reservoir, and flood peak discharge of inflow and outflow, whilst the relationship between the scale of dam and spillway and flood peak discharge at Guillemard Bridge is given in Table IX.2.4.

Besides the independent plan of each dam scheme, the study was carried out for the plans combined with the selected four schemes. The combination alternatives were prepared based on the combination plans, A-7 and A-13, discussed in the preceding Section 2.2 as follows:

(i) Dabong + Lebir
(ii) Dabong + Lebir + Nenggiri
(iii) Kemubu + Lebir
(iv) Lebir + Nenggiri.

For these four combination plans, three kinds of the dam scale; that is, the minimum, medium and maximum are contemplated. The consideration of three dam scales for the above combination plans and the independent plan of each dam scheme results in 48 alternatives; 12 alternatives prepared from the independent plan of each dam scheme, whilst 9 alternatives each for the combination plans of (i), (ii), (iii) and (iv).

In combination plan of (ii), only the minimum scale is considered for the Dabong dam scheme, because DFWL on the medium and maximum scales of the Dabong dam scheme is higher than the riverbed elevation of the Nenggiri dam scheme (refer to Table IX.2.3); that is the Dabong and Nenggiri dam schemes are only compatible in case of the minimum scale of the Dabong dam scheme.

In relation with the Kemubu and Nenggiri dam schemes, DFWL of the Kemubu dam scheme is higher than the riverbed elevation of the Nenggiri dam scheme even in the minimum scale, resulting in the mutual exclusiveness between the Kemubu and Nenggiri dam schemes in terms of flood mitigation. However, the relation between the tailwater level of El. 65.5 m (refer to Annex VI) for the Nenggiri dam scheme and NHWL of the Kemubu dam scheme, El. 65.7 m in the maximum scale, suggests that even if the Kemubu dam scheme is built, the Nenggiri dam scheme can be developed as the scheme with the objective of hydropower generation. It is noted that the proper treatment will be required for the toe end of the downstream slope of the Nenggiri dam, since the reservoir water level of the Kemubu dam scheme has high chances to become higher than the toe end of the downstream slope of Nenggiri dam.

Table IX.2.5 shows the reduction of flood peak discharge at Guillemard Bridge for the above 48 combinations, while Table IX.2.6 gives the construction cost required for the flood mitigation schemes combined the river improvement with the dam plan as well as the extent of social impacts caused by the creation of reservoirs for respective dam schemes. The economic viability for the flood mitigation plans was also examined in terms of EIRR.

2.5 Selection of Suitable Flood Mitigation Plan

A total of 48 combination plans as given in Tables IX.2.5 and IX.2.6 was prepared by varying dam height of the Dabong, Kemubu, Nenggiri and Lebir dam schemes as discussed in the preceding Section 2.4. Among 48 combination plans, only 15 combinations could meet the basic concept that flood peak discharge at Guillemard Bridge is aimed at controlling to below 11,000 m^3/sec by the dams to be built in the upstream reaches as summarized in Table IX.2.7.

Those 15 combination plans were grouped into two based on social impact, i.e. the number of households to be submerged in the reservoir as follows:

(a) Households to be submerged are 1,000 to 1,500

(b) Households to be submerged are 5,000 to 7,500.

The combination plans with the submerged households of more than 5,000 were discarded due to great social impact caused by the relocation of houses; that is, all the combinations including Dabong are eliminated.

Only three combinations, Ks+Ll+R/I, Km+Ll+R/I and Kl+Ll+R/I, are grouped in (a), i.e. relatively small number of households to be submerged in the reservoir (1,000 to 1,500). The difference on the flood mitigation effect of Kemubu dam is little in Ks to Kl. Thus, Kemubu with a small scale is selected to minimize the social impact. The general features of Ks are summarized as follows (refer to Fig. IX.2.11 on social impacts):

Dam crest elevation	73.4 m
DFWL	71.4 m
SWL	
- 50-year flood	63.1 m
- 25-year flood	62.3 m

NHWL	55.0 m
Submerged houses, nos	1,000
Submerged plantation, ha	
- SWL (25-year flood)	430
- SWL (50-year flood)	450
- Dam crest elevation	970
Submerged forest, ha	
- SWL (25-year flood)	750
- SWL (50-year flood)	790
- Dam crest elevation	1,910

On the other hand, Lebir is selected to be optimal with a large scale. Considering the submergence of a large area by building Lebir with a large scale, a study to search the possibility to lower the dam was tried by keeping the almost same flood mitigation effect with large scale dam (L1) as well as the possibility of water resources development. An ordinary overflow weir for flood mitigation was provided in the spillway to lower the dam by keeping the almost same flood mitigation effect with L1. As a result, L1' is proposed. Comparison of L1 and L1' on the social impacts to be expected is tabulated below (refer to Fig. IX.2.12):

Items	L1, m	L1', m
Dam crest elevation	91.1	84.9
DFWL	87.6	81.4
SWL		
- 50-year flood	84.9	78.0
- 25-year flood	84.4	77.2
NHWL	80.0	70.0
Submerged houses, nos	165	156
Submerged plantation, ha		
- SWL (25-year flood)	12,200	8,300
- SWL (50-year flood)	12,450	8,700
- Dam Crest Elevation	17,130	12,450
Submerged forest, ha		
- SWL (25-year flood)	6,800	5,000
- SWL (50-year flood)	7,000	5,300
- Dam Crest Elevation	8,600	7,000
Peak Discharge at Guillemard Bridge, cms		
- 50-year flood	10,720	10,650

The above table shows that if the Lebir large scale dam is initially developed as the scheme for single purpose plus some possibility for water resource development, the area of plantation to be submerged is reduced to 12,450 ha compared with 17,130 ha for hydroelectric power scheme. In addition, 12,450 ha can be further reduced to about 8,700 ha if only land submerged by 50-year probable flood is considered.

A detailed comparison between L1 and L1' on social impacts is given in Fig. IX.2.13. Since L1' makes possible to reduce social impacts by keeping the same flood mitigation effect with L1, L1' is recommended as the plan of Lebir scheme. Thus, the combination plan of Ks + Ll' + R/I is proposed as an optimal plan of flood mitigation in the Kelantan River basin.

Reservoir water level comes up to El. 78.0 m with the frequency of once in 50 years in Ll'. Since this implies that water level goes above El. 78.0 m with quite rare chances, agricultural activities in the reservoir above El. 78.0 m can be allowed, while construction of structures such as houses, roads, bridges and so on is restricted up to the dam crest elevation (refer to Fig. IX.2.14). Fig. IX.2.15 dispicts that the acreage of plantation area at dam crest elevation and that at surface water level for 50-year probable flood for Ll'. While, Fig. IX.2.16 is for a 25-year probable flood.

The schemes to proceed in the pre-feasibility study stage are Lebir and Kemubu dam schemes and river improvement between Kuala Krai and the estuary. It is noted that the Lebir dam will be designed with the possibility to make dam higher for hydropower generation use in future as given in Fig. IX.2.17. Finally, a conceptual feature of the master plan for the Kelantan River flood mitigation is sketched as given in Fig. IX.2.18.

3. IMPLEMENTATION SCHEDULE

3.1 General

The flood mitigation of the Kelantan River basin was decided to carry out by the combination plan of the Lebir and Kemubu dams and river improvement. Considering the scale of project in terms of construction cost, period and so forth, a study was carried out to prepare a realistic time schedule for the implementation of this project.

The main things to be taken in consideration are to increase the substantial flood mitigation effect as early and much as possible considering the even distribution of financial burden.

3.2 Implementation Period

It is not considered that there will be a drastically high growth of development budget from now on, and that the annual development budget may grow at least at the same rate as the target economic growth rate of 5% in the Fifth Malaysia Plan.

Also, it is assumed that the future share of the State of Kelantan in the national development budget will be 6.5% based on the Fifth Plan. In like manner the future share of the "energy and public utilities" sector consisting of "electricity", "water supply" and "drainage and flood mitigation" will be 12.0%.

Upon the above assumptions the allocations to the "energy and public utilities" sector in the Sixth (1991-1995) to Ninth Malaysia Plan (2006-2010) work out at M$3,826, 4,883, 6,232 and 7,954 million, totalling M$22,895 million. On the other hand, the construction cost required for this project is M$1,302 million.

Although the construction cost of the project shares 5.7% of allocation to the energy and public utilities sector, it would be possible to implement the project by giving the high priority as the national project. As a conclusion, it would be adequate to implement the project for 20 years from sixth to ninth Malaysia Plan for avoiding excessive investment for the project, even if a greater allocation in the development budget would be necessary to the project.

3.3 Implementation Order

The Lebir and Kemubu dam schemes and river improvement will be implemented step by step for the investment period of 20 years. The implementation order of those schemes in the investment period will be studied by classifying into dam schemes and river improvement.

3.3.1 Implementation order of dam schemes

A simulation study of flood for the selected combination plan was carried out to predict probable peak discharges and hydrographs at the designated point, Guillemard Bridge, by applying a hydrological simulation model called storage function method.

As the results are summarized as given in Table IX.3.1, the simulation was carried out in the condition that not only both Lebir and Kemubu schemes are completed, but also either of them is built. In this simulation, it is assumed that inundation occurred at the reaches between Kuala Krai and Guillemard Bridge is confined in the river channel by river improvement (R/I).

The building of Lebir dam decreases the peak discharge of 50-year probable flood from 17,400 m^3/sec under R/I only to 12,900 m^3/sec, while 15,800 m^3/sec only with the Kemubu scheme and 10,650 m^3/sec with both Lebir and Kemubu schemes.

The above fact implies that the flood mitigation effect of the Lebir dam scheme is greater than that of the Kemubu dam scheme. It is therefore desired to implement both projects in the order of Lebir and Kemubu to gain the greater flood mitigation effect as early as possible. It takes six years for the construction of Lebir which is built as the rockfill type, while four years for Kemubu, which is built as the concrete gravity type.

3.3.2 Implementation order of river improvement

The height of levee, which is the main work of river improvement, is 4.3 m on an average including the freeboard of 2.0 m against the design flood discharge of 10,650 m^3/sec.

Urban areas developed along the Kelantan River sporadically exist in the rural areas, which are extensively used for agricultural development. Considering the high investment effect of the urban areas, the implementation programme of river improvement will be prepared by dividing the riparian areas into the urban and rural areas.

The river course of the Kelantan River is re-divided as shown in Fig. IX.3.1, considering the independence of river improvement works, work quantity and the difference of investment effect in the urban and rural areas. The independence of river improvement works means that the river improvement works of a certain river stretch located in the low elevation can bear the substantial flood mitigation effect by connecting the levee to the high place located at the uppermost end of that reach. In other words, the independence of river improvement works on a certain river stretch cannot be ensured without a high place free from flooding at the uppermost end of that stretch.

The urban area of Kota Bharu is in DR2, while DL2 for Pasir Mas, DL5 for Tanah Merah and DR6 for Kuala Krai. The information of population, population density, potential damage and so on for each division is summarized in Table IX.3.2. It can be said that the flood damage potential in the downstream river stretches and urban river stretches is higher than that of the upstream river stretch.

On the other hand, the flow capacity of the Kelantan River for each river division increases towards upstream reaches as given in Fig. IX.3.2. Taking into account the potential damage against flood and flow capacity, the river improvement works will be carried out from the downstream reaches towards the upstream reaches. It is noted that actual river improvement works in each river division is carried out from the uppermost and to the lowermost end.

3.3.3 Overall implementation programme for the project

An implementation programme for the flood mitigation plan of the Kelantan River basin was prepared as shown in Fig. IX.3.3 based on the discussions of implementation order of dam schemes and river improvement mentioned in the preceding Sections 3.3.1 and 3.3.2.

River improvement works of urban and rural areas are respectively commenced at the beginning of 1993 following the pre-requisite work such as feasibility study, financing, detailed design and tendering. The river improvement works of the urban areas will be completed by year 2000 or by the end of seventh Malaysia Plan to gain the benefit from flood mitigation as early as possible, while the river improvement works of the rural areas will be finished by year 2010.

The construction of the Lebir dam scheme will be started at the beginning of year 1993 following the pre-requisite work, and will be completed by the end of year 1998. Out of pre-requisite work, the feasibility study has been finished with the objective of hydropower generation, so that the feasibility study started in year 1990 will only be limited to the review work of it. On the other hand, the Kemubu dam will be built by the end of year 2010 for avoiding the intensive investment in sixth and seventh Malaysia Plans.

The disbursement schedule based on the implementation programme given in Fig. IX.3.3 is prepared as presented in Table IX.3.3. The relatively heavy financial burden is charged in sixth and seventh Malaysia Plans compared with the eighth and ninth Malaysia Plans.

The implementation of schemes based on Fig. IX.3.3 will gradually increase the protection level for floods. As an example, the river improvement works for the river division of DR2 (Kota Bharu area), which will be completed at the end of 1996, will make free from some 8-year flood as shown in Fig. IX.3.4. Furthermore, the protection level will increase by 20-year by the completion of the Lebir dam scheme at the end of year 1998. The final introduction of the Kemubu dam scheme in year

2010 will increase the protection level upto a 50-year flood, which is the flood mitigation target of the Kelantan River basin.

For other river divisions, the introduction of the Lebir dam in 1997 raises the substantial flood mitigation effect in a considerable level (refer to Fig. 6.22). This implies that the earlier implementation of the Lebir dam scheme is recommendable for the basin-wide mitigation of the Kelantan River.

Table IX.2.1. Alternatives of Combination Plan of Flood Mitigation Dams

Damsite		Combination Plan of Flood Mitigation Dams													
		Group-1			Group-2					Group-3					
No.	Location	A-1	A-2	A-3	A-4	A-5	A-6	A-7	A-8	A-9	A-10	A-11	A-12	A-13	A-14
1	Dabong	W(18)	W(18)	W(18)	D	D	W(6)	-	W(6)	W(18)	W(18)	W(18)	-	-	W(18)
2		-	-	-	-	-	D	D	D	-	-	-	-	-	-
4	Kemubu	-	-	-	-	-	-	-	-	-	-	-	-	-	-
5		W(14)	W(14)	W(14)	-	-	-	-	-	D	-	-	-	-	-
6		-	-	-	-	-	-	-	-	-	D	-	-	-	-
7		-	-	-	-	-	-	-	-	-	-	D	D	D	D
8	Nenggiri	W(11)	W(11)	W(11)	-	-	-	-	-	-	-	-	-	-	-
9		W(29)	D	W(7)	D	D	D	D	W(13)	-	-	-	-	-	-
10		-	-	D	-	-	-	-	-	-	-	-	-	-	-
11		-	-	-	-	-	-	-	D	D	D	D	D	-	-
3	L.Pergau	W(16)	W(16)	W(16)	-	-	-	-	-	W(16)	W(16)	W(16)	-	-	-
12	Lebir	-	-	-	D	-	-	-	W(9)	W(5)	W(5)	-	-	-	-
13		D	D	D	-	D	D	D	-	-	-	D	D	D	D
14		-	-	-	-	-	-	-	-	D	D	-	-	-	-
15		-	-	-	-	-	-	-	D	-	-	-	-	-	-
Numbers	Dam	1	2	2	3	3	3	3	3	3	3	3	3	2	2
	Weir	5	4	5	0	0	1	0	3	3	3	2	0	0	1
Storage Vol.(MCM)		1,055	1,339	1,372	2,555	2,555	2,581	2,555	2,656	2,115	2,115	2,085	1,630	1,250	1,486
Peak Discharge at Guillemard Bridge (cms) 1/		15,660	15,270	15,230	11,930	11,930	11,880	11,930	11,657	12,930	12,930	13,030	13,240	13,770	13,560
Construction Cost (million M$)															
- Dam & Weir		546	544	627	883	867	811	771	992	747	728	651	538	359	439
- R/I		812	796	795	647	647	644	647	633	695	695	700	709	733	724
- Total Cost		1,358	1,340	1,422	1,530	1,514	1,455	1,418	1,625	1,442	1,423	1,351	1,247	1,092	1,163

Remarks : W means weir.
D means flood mitigation dam with minimum height.
Parenthized figure indicates the provisional height of weir.
1/ ; 50-year probable flood.

Table IX.2.2. Storage Volume of Flood Mitigation Dams

(Unit : MCM)

Damsite		Combination Plan of Flood Mitigation Dams													
No.	Location	A-1	A-2	A-3	A-4	A-5	A-6	A-7	A-8	A-9	A-10	A-11	A-12	A-13	A-14
1		236.3	236.3	236.3	1814.0	1814.0	25.8		25.8	236.3	236.3	236.3			236.3
2	Dabong						1814.0	1814.0	1814.0						
4															
5		121.7	121.7	121.7						889.0					
6											889.0				
7	Kemubu											889.0	889.0	889.0	889.0
8		22.0	22.0	22.0											
9	Nenggiri	95.6	380.0	33.1	380.0	380.0	380.0	380.0	12.1						
10				380.0											
11									380.0	380.0	380.0	380.0	380.0		
3	L.Pergau	218.3	218.3	218.3						218.3	218.3	218.3			
12					361.0				62.6	29.9	29.9				
13	Lebir	361.0	361.0	361.0		361.0	361.0	361.0				361.0	361.0	361.0	361.0
14										361.0	361.0				
15									361.0						
Storage (MCM)		1054.9	1339.3	1372.4	2555.0	2555.0	2580.8	2555.0	2655.5	2114.5	2114.5	2084.6	1630.0	1250.0	1486.3

Table IX.2.3. Variation of Scale of Storage Dams

Storage Dam	Catchment Area (sq.km)	Scale	Riverbed El. (m)	Spillway Width (m)	Dimension (El;m) NHWL	DFWL	Dam Crest	Dam Height (m)	Storage (MCM) at NHWL	at DFWL	Peak Discharge (cms) Inflow 1/	Outflow	Peakcut Ratio (%)
		Maximum		75	157.0	166.0	169.0	108.0	3,101	4,213	4,668	1,120	76
Nenggiri	3,690	Medium	61	75	126.0	141.0	144.0	83.0	899	1,686	4,668	2,087	55
		Minimum		75	95.0	115.0	119.0	58.0	152	532	4,668	3,552	24
		Maximum		100	65.7	80.0	82.0	46.0	726	2,163	4,943	4,184	15.4
Kemubu	5,630	Medium	36	100	59.6	75.7	77.7	41.7	352	1,461	4,943	4,215	14.7
		Minimum		100	55.0	71.4	73.4	37.4	250	1,139	4,943	4,389	11
		Maximum		100	66.7	78.0	80.0	58.0	3,707	6,631	8,431	3,457	59
Dabong	7,480	Medium	22	85	54.8	69.0	71.0	49.0	1,532	4,294	8,431	4,768	43
		Minimum		70	40.0	60.0	62.0	40.0	307	2,121	8,431	6,319	25
		Maximum		150	80.0	87.6	91.1	61.1	2,393	3,917	5,561	3,503	37
Lebir	2,480	Medium	30	150	63.3	73.2	76.7	46.7	726	1,563	5,561	4,942	11
		Minimum		150	47.0	58.8	62.3	32.3	102	463	5,561	5,322	4

Note : 1/ Peak discharge of 50-year probable flood.

Table IX.2.4 Flood Mitigation Effect of Storage Dam

Storage Dam	Catchment Area (km2)	Scale	Spillway Width (m)	Peak Discharge (cms) Inflow 1/	Peak Discharge (cms) Outflow	Peakcut Ratio (%)	Peak Discharge at Guillemard Bridge (cms)
Nenggiri	3,690	Maximum	75	4,668	1,120	76	16,299 (1,121)
		Medium	75	4,668	2,087	55	16,550 (870)
		Minimum	75	4,668	3,552	24	16,890 (530)
Kemubu	5,630	Maximum	100	4,943	4,184	15.4	15,185 (2,235)
		Medium	100	4,943	4,215	14.7	15,279 (2,141)
		Minimum	100	4,943	4,389	11	15,802 (1,618)
Dabong	7,480	Maximum	100	8,431	3,457	59	11,079 (6,341)
		Medium	85	8,431	4,768	43	12,334 (5,086)
		Minimum	70	8,431	6,319	25	13,602 (3,818)
Lebir	2,480	Maximum	150	5,561	3,503	37	13,213 (4,207)
		Medium	150	5,561	4,942	11	15,265 (2,155)
		Minimum	150	5,561	5,322	4	16,257 (1,163)

Note : 1/ Peak discharge of 50-year probable flood.
2/ Parenthesized figures are obtained by subtracting peak discharge at Guillemard Bridge from that of river improvement only. (17,420 cms)

Table IX.2.5 Peak Discharge at Guillemard Bridge by the Combination of Dam Plan

No.	Combination	Peak Discharge at Guillemard Bridge (cms)
1	R/I only	17,420
2	Ds	13,602
3	Dm	12,334
4	Dl	11,079
5	Ls	16,257
6	Lm	15,265
7	Ll	13,213
8	Ns	16,890
9	Nm	16,550
10	Nl	16,229
11	Ks	15,802
12	Km	15,279
13	Kl	15,185
14	Ds + Ls	13,033
15	Dm + Ls	11,765
16	Dl + Ls	10,510
17	Ds + Lm	12,014
18	Dm + Lm	10,746
19	Dl + Lm	9,491
20	Ds + Ll	9,989
21	Dm + Ll	8,721
22	Dl + Ll	7,466
23	Ds + Ls + Ns	11,928
24	Ds + Lm + Ns	11,648
25	Ds + Ll + Ns	11,327
26	Ds + Ls + Nm	10,926
27	Ds + Lm + Nm	10,656
28	Ds + Ll + Nm	10,335
29	Ds + Ls + Nl	8,874
30	Ds + Lm + Nl	8,604
31	Ds + Ll + Nl	8,283
32	Ks + Ls	13,768
33	Km + Ls	13,245
34	Kl + Ls	13,151
35	Ks + Lm	12,776
36	Km + Lm	12,253
37	Kl + Lm	12,159
38	Ks + Ll	10,724
39	Km + Ll	10,201
40	Kl + Ll	10,107
41	Ns + Ls	15,736
42	Nm + Ls	15,466
43	Nl + Ls	15,145
44	Ns + Lm	14,744
45	Nm + Lm	14,474
46	Nl + Lm	14,153
47	Ns + Ll	12,692
48	Nm + Ll	12,422
49	Nl + Ll	12,101

Remarks ; Dam scheme D : Dabong N : Nenggiri
L : Lebir K : Kemubu

Dam scale l : maximum m : medium
s : minimum

Table IX.2.6 Construction Cost and Social Impact for each Flood Mitigation Plan

No.	Combination	CONSTRUCTION COST (million M$) Dam						SOCIAL IMPACT Dabong							Lebir					Nenggiri		Kemubu					R/I		(A) Total for H (nos) (1)-(4)	(B) Total for H (nos) (1)-(5)	Total for Plant (ha)
		Dabong	Lebir	Nenggiri	Kemubu	R/I	Total	H(nos) (1)	P(ha)	OP(ha)	RP(ha)	F(ha)	R(km)	PR(km)	H(nos) (2)	OP(ha)	RP(ha)	F(ha)	PR(km)	H(nos) (3)	F(ha)	H(nos) (4)	OP(ha)	RP(ha)	F(ha)	R(km)	H(nos) (5)	B(nos)			
1	R/I only					883	883																				800	3	0	800	
2	Ds + R/I	445				726	1,171	4,800	40	390	5,580	4,110	30	26													800	2	4,800	5600	5,97
3	Dm + R/I	555				668	1,223	6,100	40	540	6,090	6,030	35	44													800	2	6,100	6900	6,63
4	Dl + R/I	745				603	1,348	7,300	40	1,400	9,850	11,230	55	57													770	1	7,300	8070	11,25
5	Ls + R/I		220			838	1,058								90	2,100	1,200	2,300									800	3	90	890	3,30
6	Lm + R/I		351			798	1,149								140	5,400	2,900	4,600									800	3	140	940	8,30
7	Ll + R/I		611			708	1,319								165	11,800	5,300	8,600	5								800	2	165	965	17,10
8	Ns + R/I			106		862	968													320	1,600						800	3	320	1120	
9	Nm + R/I			246		848	1,094													510	6,100						800	3	510	1310	
10	Nl + R/I			403		835	1,238													640	13,900						800	3	640	1440	
11	Ks + R/I				139	819	958															1,000	180	790	1,910	16	800	3	1,000	1800	97
12	Km + R/I				189	798	987															1,200	560	1,660	3,780	23	800	3	1,200	2000	2,22
13	Kl + R/I				246	793	1,039															1,295	1,160	2,990	6,600	28	800	3	1,295	2095	4,15
14	Ds + Ls + R/I	445	220			698	1,363	4,800	40	390	5,580	4,110	30	26	90	2,100	1,200	2,300									800	2	4,890	5690	9,27
15	Dm + Ls + R/I	555	220			638	1,413	6,100	40	540	6,090	6,030	35	44	90	2,100	1,200	2,300									780	1	6,190	6970	9,93
16	Dl + Ls + R/I	745	220			563	1,528	7,300	40	1,400	9,850	11,230	55	57	90	2,100	1,200	2,300									770	1	7,390	8160	14,55
17	Ds + Lm + R/I	445	351			652	1,448	4,800	40	390	5,580	4,110	30	26	140	5,400	2,900	4,600									800	2	4,940	5740	14,27
18	Dm + Lm + R/I	555	351			580	1,486	6,100	40	540	6,090	6,030	35	44	140	5,400	2,900	4,600									770	1	6,240	7010	14,93
19	Dl + Lm + R/I	745	351			492	1,588	7,300	40	1,400	9,850	11,230	55	57	140	5,400	2,900	4,600									750	1	7,440	8190	19,55
20	Ds + Ll + R/I	445	611			529	1,585	4,800	40	390	5,580	4,110	30	26	165	11,800	5,300	8,600	5								760	1	4,965	5725	23,07
21	Dm + Ll + R/I	555	611			428	1,594	6,100	40	540	6,090	6,030	35	44	165	11,800	5,300	8,600	5								740	1	6,265	7005	23,73
22	Dl + Ll + R/I	745	611			318	1,674	7,300	40	1,400	9,850	11,230	55	57	165	11,800	5,300	8,600	5								670	1	7,465	8135	28,35
23	Ds + Ls + Ns + R/I	445	220	106		647	1,418	4,800	40	390	5,580	4,110	30	26	90	2,100	1,200	2,300		320	1,600						800	1	5,210	6010	9,27
24	Ds + Lm + Ns + R/I	445	351	106		634	1,536	4,800	40	390	5,580	4,110	30	26	140	5,400	2,900	4,600		320	1,600						790	1	5,260	6050	14,27
25	Ds + Ll + Ns + R/I	445	611	106		613	1,775	4,800	40	390	5,580	4,110	30	26	165	11,800	5,300	8,600	5	320	1,600						780	1	5,285	6065	23,07
26	Ds + Ls + Nm + R/I	445	220	246		590	1,501	4,800	40	390	5,580	4,110	30	26	90	2,100	1,200	2,300		510	6,100						770	1	5,400	6170	9,27
27	Ds + Lm + Nm + R/I	445	351	246		573	1,615	4,800	40	390	5,580	4,110	30	26	140	5,400	2,900	4,600		510	6,100						770	1	5,450	6220	14,27
28	Ds + Ll + Nm + R/I	445	611	246		555	1,857	4,800	40	390	5,580	4,110	30	26	165	11,800	5,300	8,600	5	510	6,100						760	1	5,475	6235	23,07
29	Ds + Ls + Nl + R/I	445	220	403		443	1,511	4,800	40	390	5,580	4,110	30	26	90	2,100	1,200	2,300		640	13,900						740	1	5,530	6270	9,27
30	Ds + Lm + Nl + R/I	445	351	403		420	1,619	4,800	40	390	5,580	4,110	30	26	140	5,400	2,900	4,600		640	13,900						730	1	5,580	6310	14,27
31	Ds + Ll + Nl + R/I	445	611	403		393	1,852	4,800	40	390	5,580	4,110	30	26	165	11,800	5,300	8,600	5	640	13,900						720	1	5,605	6325	23,0
32	Ks + Ls + R/I		220		139	732	1,091								90	2,100	1,200	2,300				1,000	180	790	1,910	16	800	2	1,090	1890	4,2
33	Km + Ls + R/I		220		189	710	1,119								90	2,100	1,200	2,300				1,200	560	1,660	3,780	23	800	2	1,290	2090	5,5
34	Kl + Ls + R/I		220		246	705	1,171								90	2,100	1,200	2,300				1,295	1,160	2,990	6,600	28	800	2	1,385	2185	7,4
35	Ks + Lm + R/I		351		139	688	1,178								140	5,400	2,900	4,600				1,000	180	790	1,910	16	800	2	1,140	1940	9,2
36	Km + Lm + R/I		351		189	665	1,205								140	5,400	2,900	4,600				1,200	560	1,660	3,780	23	800	2	1,340	2140	10,5
37	Kl + Lm + R/I		351		246	658	1,255								140	5,400	2,900	4,600				1,295	1,160	2,990	6,600	28	800	2	1,435	2235	12,4
38	Ks + Ll + R/I		611		139	577	1,327								165	11,800	5,300	8,600	5			1,000	180	790	1,910	16	770	1	1,165	1935	18,0
39	Km + Ll + R/I		611		189	540	1,340								165	11,800	5,300	8,600	5			1,200	560	1,660	3,780	23	760	1	1,365	2125	19,3
40	Kl + Ll + R/I		611		246	537	1,394								165	11,800	5,300	8,600	5			1,295	1,160	2,990	6,600	28	760	1	1,460	2220	21,2
41	Ns + Ls + R/I		220	106		816	1,142								90	2,100	1,200	2,300		320	1,600						800	3	410	1210	3,3
42	Nm + Ls + R/I		220	246		805	1,271								90	2,100	1,200	2,300		510	6,100						800	3	600	1400	3,3
43	Nl + Ls + R/I		220	403		792	1,415								90	2,100	1,200	2,300		640	13,900						800	3	730	1530	3,3
44	Ns + Lm + R/I		351	106		775	1,232								140	5,400	2,900	4,600		320	1,600						800	3	460	1260	8,3
45	Nm + Lm + R/I		351	246		764	1,361								140	5,400	2,900	4,600		510	6,100						800	3	650	1450	8,3
46	Nl + Lm + R/I		351	403		748	1,502								140	5,400	2,900	4,600		640	13,900						800	3	780	1580	8,3
47	Ns + Ll + R/I		611	106		684	1,401								165	11,800	5,300	8,600	5	320	1,600						800	2	485	1285	17,1
48	Nm + Ll + R/I		611	246		670	1,527								165	11,800	5,300	8,600	5	510	6,100						800	2	675	1475	17,1
49	Nl + Ll + R/I		611	403		655	1,669								165	11,800	5,300	8,600	5	640	13,900						800	2	805	1605	17,1

Remarks : Dam Scheme D : Dabong L : Lebir N : Nenggiri K : Kemubu
Dam Scale s : small m : medium l : large
Compensation H : houses P : Paddy OP : Oil palm RP : Rubber R : Railway PR : Public road F : Forest B : Bridge
EIRR F.M. : Flood mitigation P.G. : Power generation

Table IX.2.6 Construction Cost and Social Impact for each Flood Mitigation Plan

ION COST (million M$)				SOCIAL IMPACT																								ORDER				EIRR	
nn				Dabong							Lebir					Nenggiri		Kemubu					R/I										
enggiri	Kemubu	R/I	Total	H(nos) (1)	P(ha)	OP(ha)	RP(ha)	F(ha)	R(km)	PR(km)	H(nos) (2)	OP(ha)	RP(ha)	F(ha)	PR(km)	H(nos) (3)	F(ha)	H(nos) (4)	OP(ha)	RP(ha)	F(ha)	R(km)	H(nos) (5)	B(nos)	(A) Total for H (nos) (1)-(4)	(B) Total for H (nos) (1)-(5)	Total for Plant. (ha)	(C) Const. Cost	(D) Social Impact for(A)	(E) Social Impact for(B)	Total (C)+(E)	F.M. (%)	F.M. & P.G. (%)
		883	883																				800	3	0	800		1		1	2	4.5	
		726	1,171	4,800	40	390	5,580	4,110	30	26													800	2	4,800	5600	5,970	13	28	29	42	2.6	
		668	1,223	6,100	40	540	6,090	6,030	35	44													800	2	6,100	6900	6,630	16	41	42	58	2.3	4.8
		603	1,348	7,300	40	1,400	9,850	11,230	55	57													770	1	7,300	8070	11,250	24	45	46	70	1.9	9.1
		838	1,058								90	2,100	1,200	2,300									800	3	90	890	3,300	6	1	2	8	3.2	
		798	1,149								140	5,400	2,900	4,600									800	3	140	940	8,300	11	2	3	14	2.8	3.7
		708	1,319								165	11,800	5,300	8,600	5								800	2	165	965	17,100	21	3	4	25	2.0	5.6
106		862	968													320	1,600						800	3	320	1120		3	4	5	8	3.8	
246		848	1,094													510	6,100						800	3	510	1310		8	8	9	17	3.1	6.1
403		835	1,238													640	13,900						800	3	640	1440		18	10	11	29	2.2	10.2
	139	819	958															1,000	180	790	1,910	16	800	3	1,000	1800	970	2	16	17	19	3.8	
	189	798	987															1,200	560	1,660	3,780	23	800	3	1,200	2000	2,220	4	20	21	25	3.6	
	246	793	1,039															1,295	1,160	2,990	6,600	28	800	3	1,295	2095	4,150	5	22	23	28	3.3	
		698	1,363	4,800	40	390	5,580	4,110	30	26	90	2,100	1,200	2,300									800	2	4,890	5690	9,270	26	29	30	56	1.8	
		638	1,413	6,100	40	540	6,090	6,030	35	44	90	2,100	1,200	2,300									780	1	6,190	6970	9,930	29	42	43	72	1.7	3.5
		563	1,528	7,300	40	1,400	9,850	11,230	55	57	90	2,100	1,200	2,300									770	1	7,390	8160	14,550	38	47	48	86	1.4	7.9
		652	1,448	4,800	40	390	5,580	4,110	30	26	140	5,400	2,900	4,600									800	2	4,940	5740	14,270	32	31	31	63	1.8	2.6
		580	1,486	6,100	40	540	6,090	6,030	35	44	140	5,400	2,900	4,600									770	1	6,240	7010	14,930	33	44	45	78	1.7	4.0
		492	1,588	7,300	40	1,400	9,850	11,230	55	57	140	5,400	2,900	4,600									750	1	7,440	8190	19,550	41	48	49	90	1.4	8.0
		529	1,585	4,800	40	390	5,580	4,110	30	26	165	11,800	5,300	8,600	5								760	1	4,965	5725	23,070	40	30	32	72	1.7	4.4
		428	1,594	6,100	40	540	6,090	6,030	35	44	165	11,800	5,300	8,600	5								740	1	6,265	7005	23,730	42	43	44	86	1.3	5.7
		318	1,674	7,300	40	1,400	9,850	11,230	55	57	165	11,800	5,300	8,600	5								670	1	7,465	8135	28,350	46	46	47	93	1.1	9.0
106		647	1,418	4,800	40	390	5,580	4,110	30	26	90	2,100	1,200	2,300		320	1,600						800	1	5,210	6010	9,270	31	32	33	64	1.7	
106		634	1,536	4,800	40	390	5,580	4,110	30	26	140	5,400	2,900	4,600		320	1,600						790	1	5,260	6050	14,270	39	33	34	73	1.6	2.1
106		613	1,775	4,800	40	390	5,580	4,110	30	26	165	11,800	5,300	8,600	5	320	1,600						780	1	5,285	6065	23,070	47	34	35	82	0.7	3.8
246		590	1,501	4,800	40	390	5,580	4,110	30	26	90	2,100	1,200	2,300		510	6,100						770	1	5,400	6170	9,270	34	35	36	70	1.6	3.9
246		573	1,615	4,800	40	390	5,580	4,110	30	26	140	5,400	2,900	4,600		510	6,100						770	1	5,450	6220	14,270	43	36	37	80	1.4	4.0
246		555	1,857	4,800	40	390	5,580	4,110	30	26	165	11,800	5,300	8,600	5	510	6,100						760	1	5,475	6235	23,070	49	37	38	87	0.6	5.1
403		443	1,511	4,800	40	390	5,580	4,110	30	26	90	2,100	1,200	2,300		640	13,900						740	1	5,530	6270	9,270	36	38	39	75	1.6	6.8
403		420	1,619	4,800	40	390	5,580	4,110	30	26	140	5,400	2,900	4,600		640	13,900						730	1	5,580	6310	14,270	44	39	40	84	1.4	7.4
403		393	1,852	4,800	40	390	5,580	4,110	30	26	165	11,800	5,300	8,600	5	640	13,900						720	1	5,605	6325	23,070	48	40	41	89	0.6	7.8
	139	732	1,091								90	2,100	1,200	2,300				1,000	180	790	1,910	16	800	2	1,090	1890	4,270	7	17	18	25	3.0	
	189	710	1,119								90	2,100	1,200	2,300				1,200	560	1,660	3,780	23	800	2	1,290	2090	5,520	9	21	22	31	2.9	
	246	705	1,171								90	2,100	1,200	2,300				1,295	1,160	2,990	6,600	28	800	2	1,385	2185	7,450	12	25	26	38	2.7	
	139	688	1,178								140	5,400	2,900	4,600				1,000	180	790	1,910	16	800	2	1,140	1940	9,270	14	19	20	34	2.8	3.6
	189	665	1,205								140	5,400	2,900	4,600				1,200	560	1,660	3,780	23	800	2	1,340	2140	10,520	15	24	25	40	2.7	3.3
	246	658	1,255								140	5,400	2,900	4,600				1,295	1,160	2,990	6,600	28	800	2	1,435	2235	12,450	19	27	28	47	2.5	3.3
	139	577	1,327								165	11,800	5,300	8,600	5			1,000	180	790	1,910	16	770	1	1,165	1935	18,070	22	18	19	41	2.1	5.7
	189	540	1,340								165	11,800	5,300	8,600	5			1,200	560	1,660	3,780	23	760	1	1,365	2125	19,320	23	23	24	47	1.9	5.5
	246	537	1,394								165	11,800	5,300	8,600	5			1,295	1,160	2,990	6,600	28	760	1	1,460	2220	21,250	27	26	27	54	1.9	5.6
106		816	1,142								90	2,100	1,200	2,300		320	1,600						800	3	410	1210	3,300	10	5	6	16	2.7	
246		805	1,271								90	2,100	1,200	2,300		510	6,100						800	3	600	1400	3,300	20	9	10	30	2.2	5.1
403		792	1,415								90	2,100	1,200	2,300		640	13,900						800	3	730	1530	3,300	30	13	14	44	1.6	9.2
106		775	1,232								140	5,400	2,900	4,600		320	1,600						800	3	460	1260	8,300	17	6	7	24	2.5	3.4
246		764	1,361								140	5,400	2,900	4,600		510	6,100						800	3	650	1450	8,300	25	11	12	37	2.0	5.1
403		748	1,502								140	5,400	2,900	4,600		640	13,900						800	3	780	1580	8,300	35	14	15	50	1.5	8.3
106		684	1,401								165	11,800	5,300	8,600	5	320	1,600						800	2	485	1285	17,100	28	7	8	36	1.8	5.3
246		670	1,527								165	11,800	5,300	8,600	5	510	6,100						800	2	675	1475	17,100	37	12	13	50	1.4	6.4
403		655	1,669								165	11,800	5,300	8,600	5	640	13,900						800	2	805	1605	17,100	45	15	16	61	0.9	8.9

L : Lebir N : Nenggiri K : Kemubu
m : medium l : large
P : Paddy OP : Oil palm RP : Rubber R : Railway PR : Public road F : Forest B : Bridge
mitigation P.G. : Power generation

Table IX.2.7 Combinations to Meet the Basic Concept on Peak Discharge at Guillemard Bridge

No.	Combination	Peak discharge at Guillemard Bridge, m^3/sec	Households to be submerged, nos
1	Dl + Ls	10,510	6,190
2	Dm + Lm	10,746	6,240
3	Dl + Lm	9,491	7,440
4	Ds + Ll	9,989	4,965
5	Dm + Ll	8,721	6,265
6	Dl + Ll	7,466	7,465
7	Ds + Ls + Nm	10,926	5,400
8	Ds + Lm + Nm	10,656	5,450
9	Ds + Ll + Nm	10,335	5,475
10	Ds + Ls + Nl	8,874	5,530
11	Ds + Lm + Nl	8,604	5,580
12	Ds + Ll + Nl	8,283	5,605
13	Ks + Ll	10,724	1,165
14	Km + Ll	10,201	1,365
15	Kl + Ll	10,107	1,460

Remarks : Dam scheme D : Dabong L : Lebir
K : Kemubu N : Nenggiri
Dam scale l : maximum m : medium s : minimum

Table IX.3.1 Flood Mitigation Effect at Guillemard Bridge

(Unit : m^3/sec)

Case	Combination	Probability				
		1/5	1/10	1/20	1/30	1/50
1.	Natural condition	8,680	11,430	13,470	14,770	16,370
2.	R/I only 1/	9,190	12,100	14,350	15,760	17,420
3.	Lebir + R/I	6,860	8,840	10,520	11,530	12,910
4.	Kemubu + R/I	8,630	11,440	13,180	14,290	15,800
5.	Lebir + Kemubu + R/I	6,260	8,060	9,270	9,940	10,650

Note : 1/ Flood discharge inundated at the reaches between Kuala Krai and Guillemard Bridge is confined in the river channel by river improvement.

Table IX.3.2 River Division for Implementation

River stretches	Urban/ Rural	Distance, km (A)	Area, km^2	Population, persons	Population density, persons/km^2	Annual potential damage (50-year flood), 10^6 M$ (B)	(B)/(A), 10^6M$/km
Left bank							
DL1	Rural	25.0	239.1	130,084	544	8.70	0.348
DL2	Urban	5.0	62.8 (19.9)	38,217 (23,145)	609 (1,166)	3.81 (0.80)	0.762
DL3	Rural	18.0	69.8	18,590	266	1.38	0.077
DL4	Rural	11.0	19.6	5,665	290	0.95	0.086
DL5	Urban	9.0	34.2	31,206	912	1.53	0.170
DL6	Rural	33.0	31.5	6,508	207	1.34	0.041
Right bank							
DR1	Rural	6.5	25.3	20,965	829	0.33	0.051
DR2	Urban	9.5	163.5 (10.9)	237,317 (41,869)	1,451 (3,852)	12.38 (9.54)	1.303
DR3	Rural	19.0	174.2	94,681	544	5.06	0.266
DR4	Rural	11.0	124.8	67,806	543	2.47	0.225
DR5	Rural	52.0	141.2	43,943	311	3.51	0.068
DR6	Urban	3.0	17.2	38,750	2,252	1.11	0.370

Table IX.3.3 Disbursement Schedule for the Flood Mitigation Plan of the Kelantan River Basin

Unit : Million M$

Schemes	Malaysia Plan																			
	6th					7th					8th					9th				
	'91	'92	'93	'94	'95	'96	'97	'98	'99	2000	'01	'02	'03	'04	'05	'06	'07	'08	'09	'10
1. River Improvement																				
1.1 Urban area			31.7	23.5	23.5	23.5	16.2	16.2	15.2	15.2										
1.2 Rural area			39.4	11.5	11.5	11.5	18.9	18.9	19.9	19.9	26.0	26.0	26.0	26.0	26.0	26.0	26.0	26.0	26.0	26.0
2. Dam Schemes																				
2.1 Lebir			117.3	57.5	71.7	84.7	112.0	57.5												
2.2 Kemubu																	69.6	51.2	52.7	52.0
Total			188.4	92.5	106.1	119.7	147.1	92.6	35.1	35.1	26.0	26.0	26.0	26.0	26.0	26.0	95.6	77.2	78.7	78.0
Total in each Malaysian Plan	387.0					429.6					130.0					355.6				

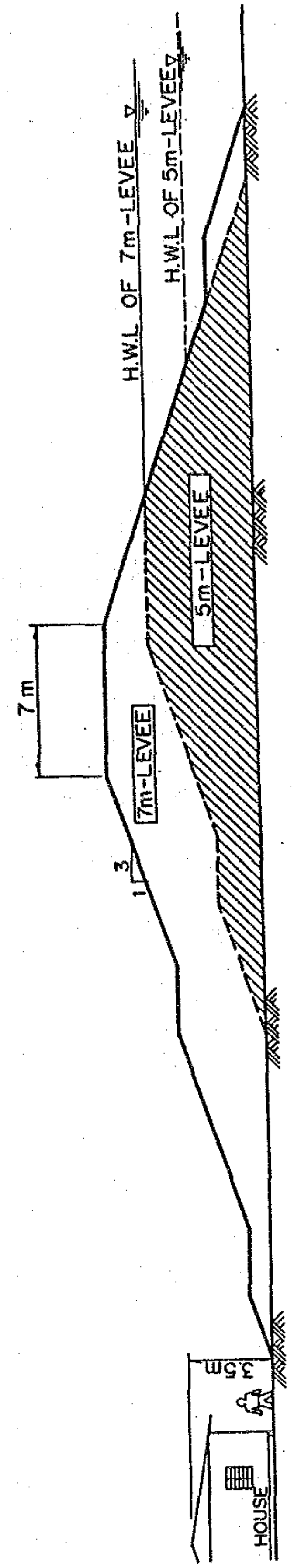

Fig. IX. 2. 1
Comparison between 5m and 7m High Levee

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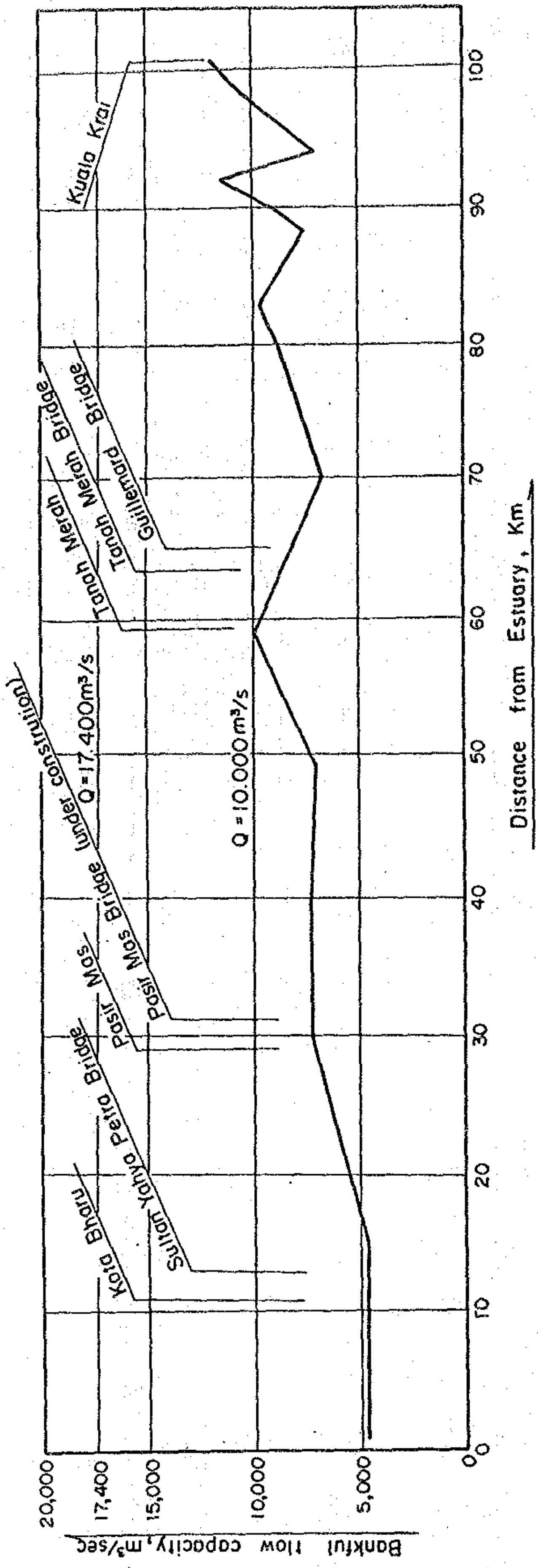

Fig. IX. 2. 2

Flow Capacity of the Kelantan River

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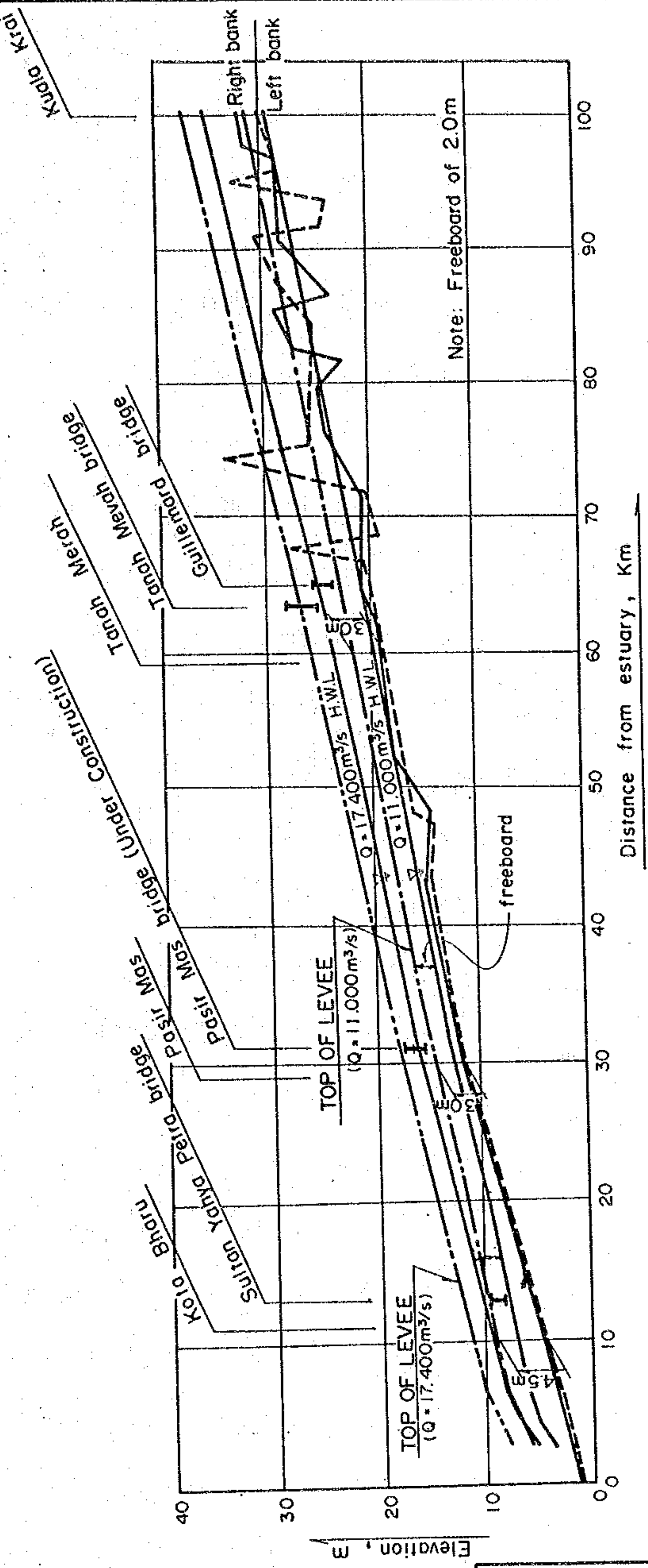

Fig. IX.2.3
Relationship between High water Level and Levee Height

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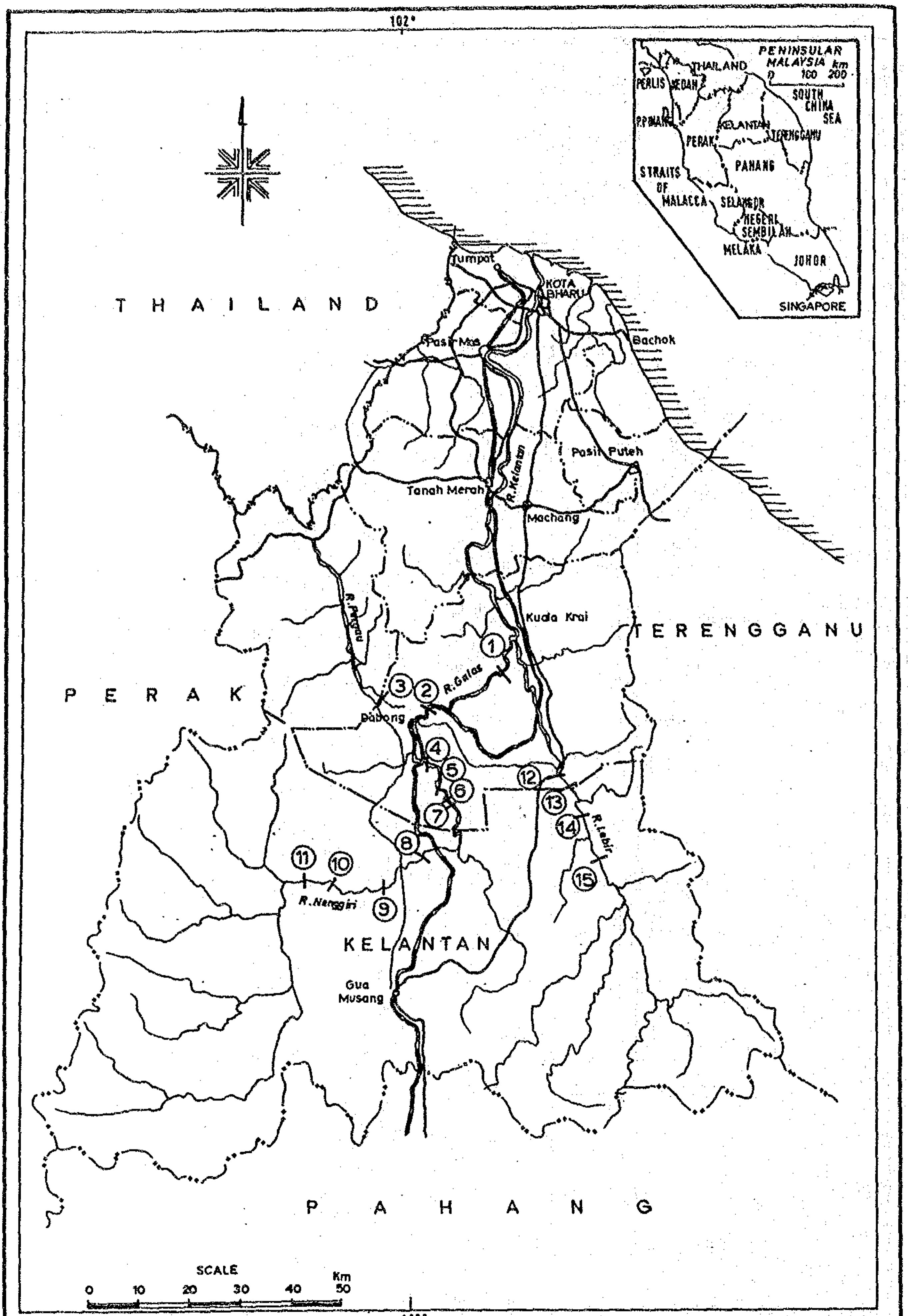

Fig. IX. 2. 4
Potential Damsites in the Kelantan River Basin

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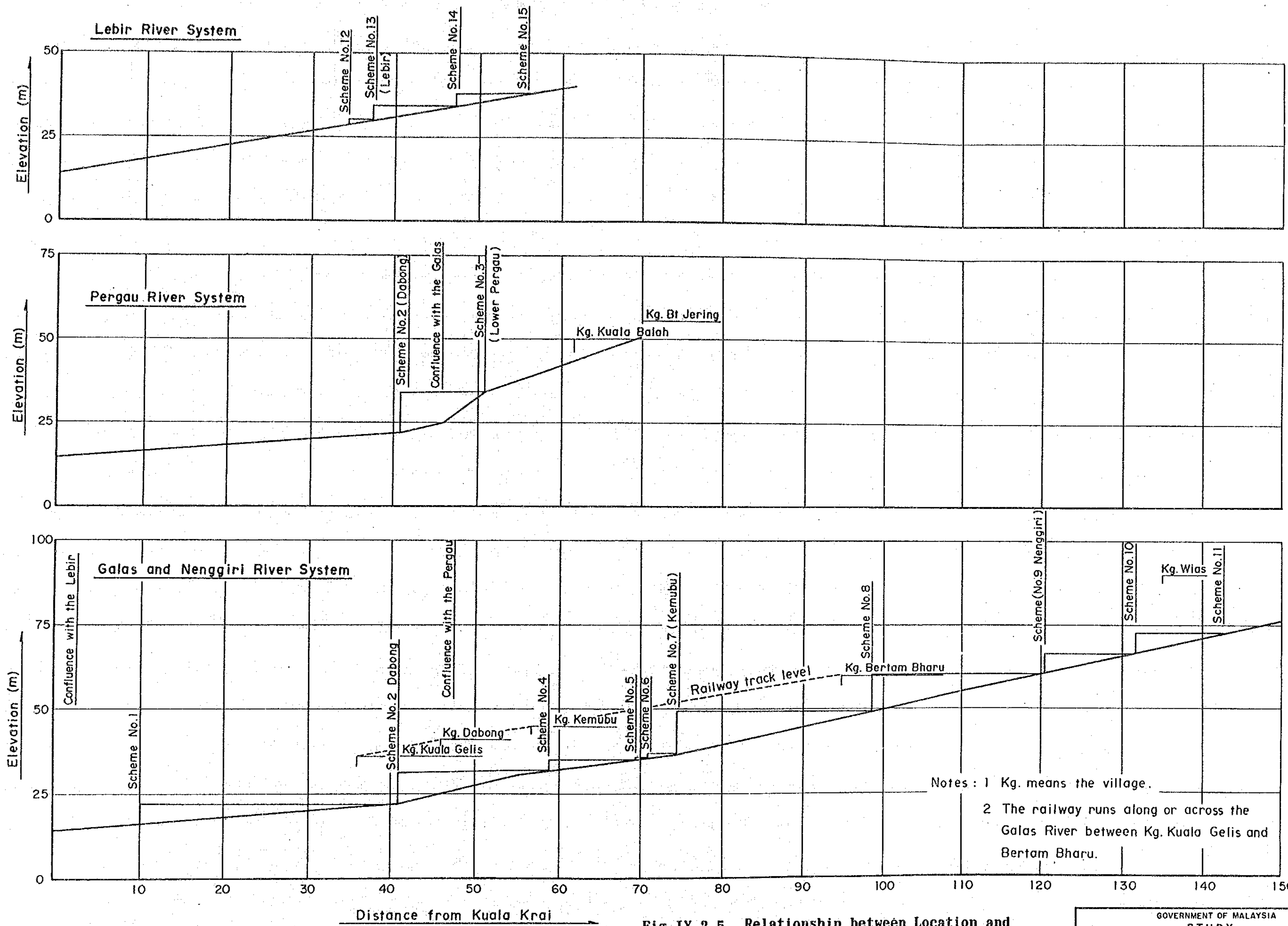

Fig. IX.2.5 Relationship between Location and Elevation for the Schemes Identified in the Kelantan River System

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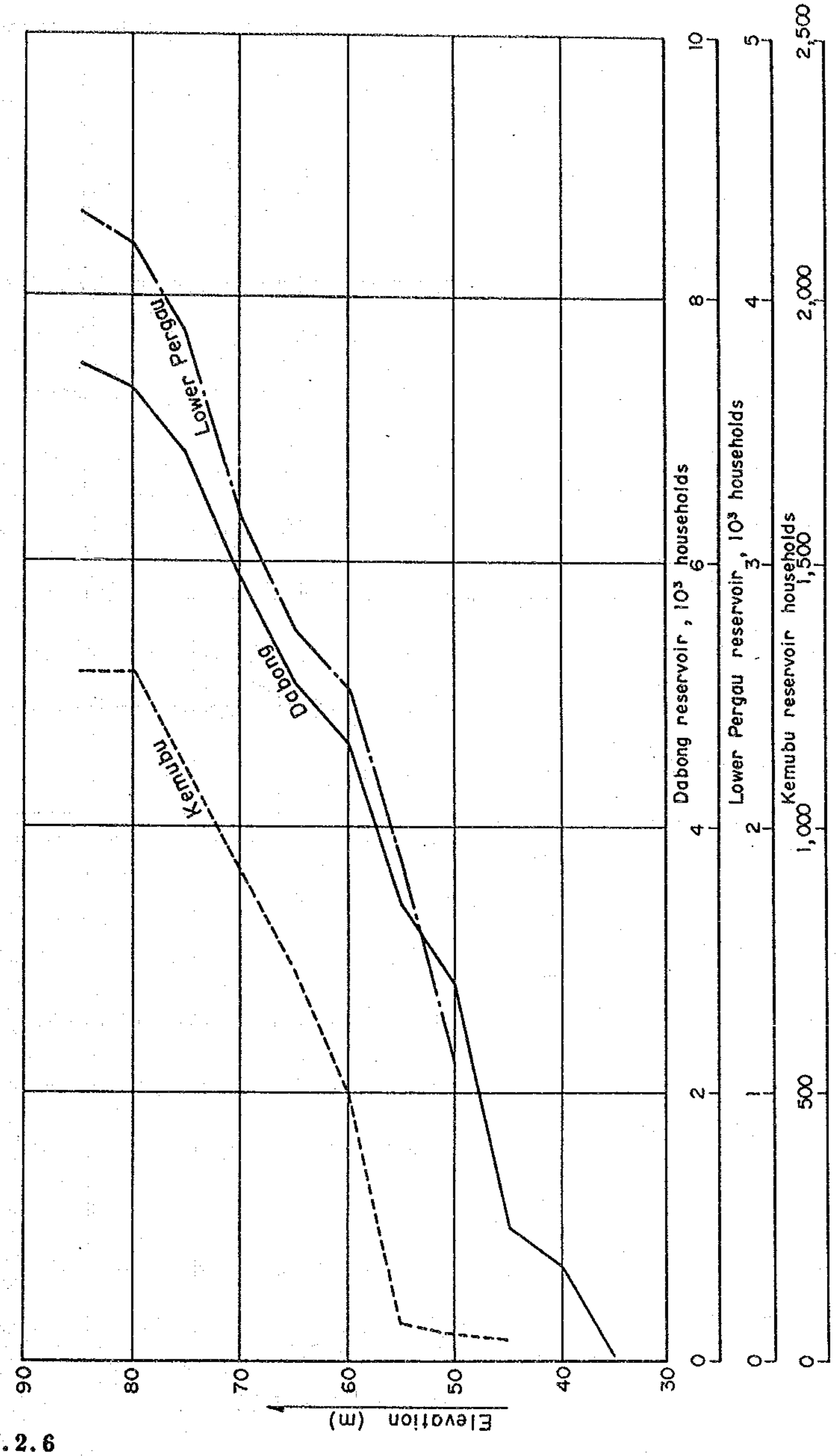

Fig. IX. 2. 6
Relationship between Elevation and Households to be Submerged for Dabong, Lower Pergau and Kemubu Reserviors

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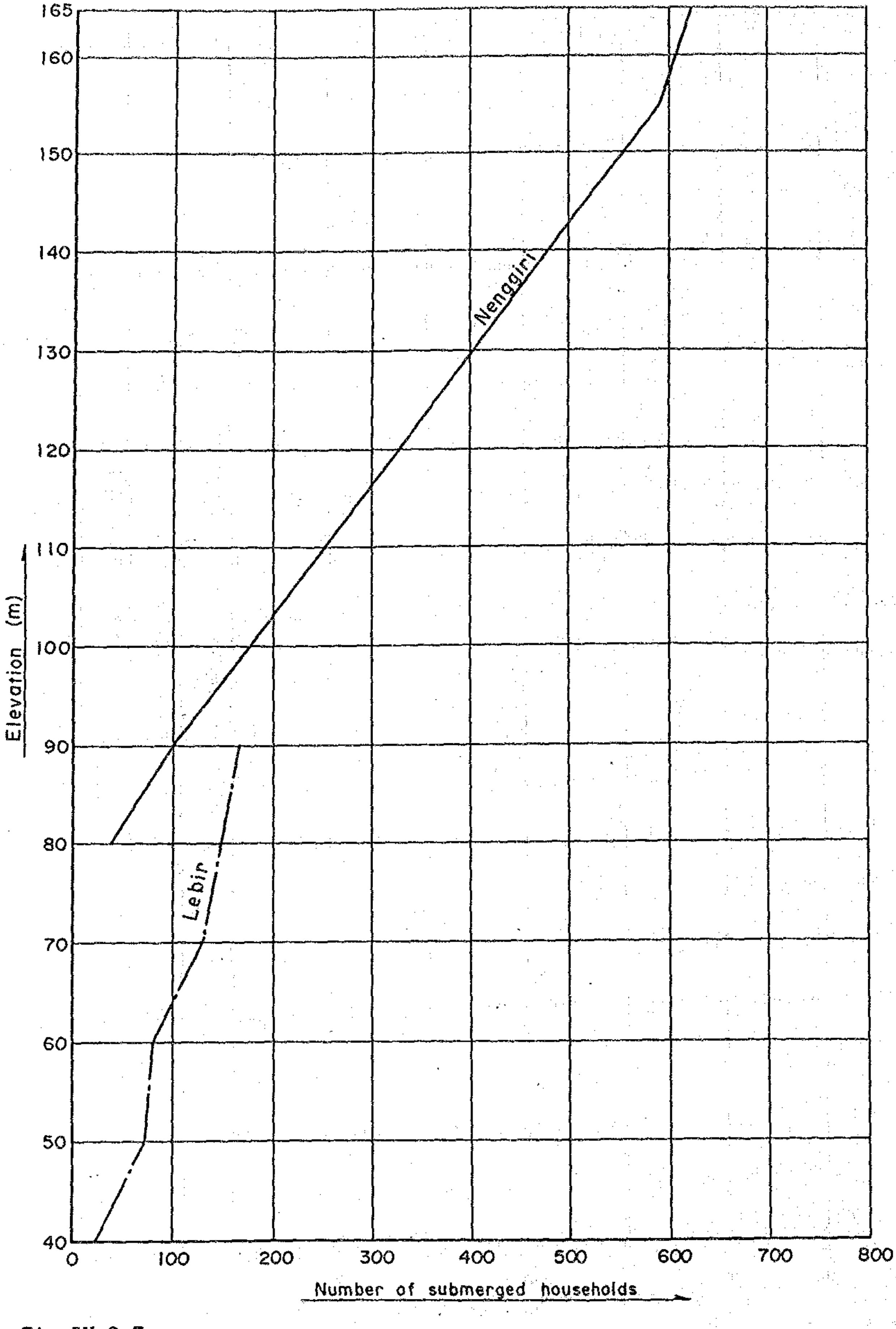

Fig. IX.2.7
Relationship between Elevation and Households to be Submerged for Nenggiri and Lebir Reservoirs

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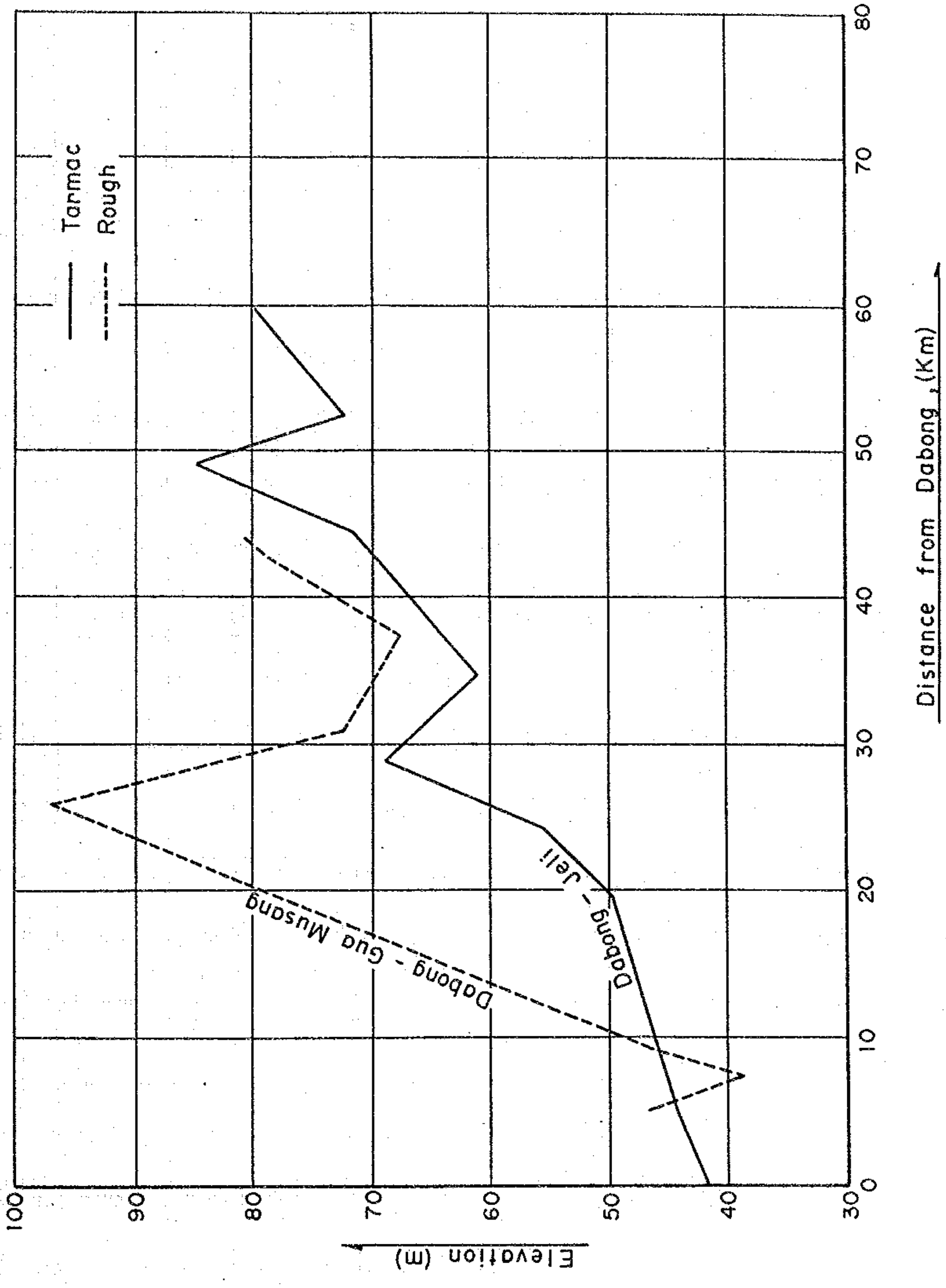

Fig. IX. 2. 8
Relationship between Distance and Elevation for Public Roads

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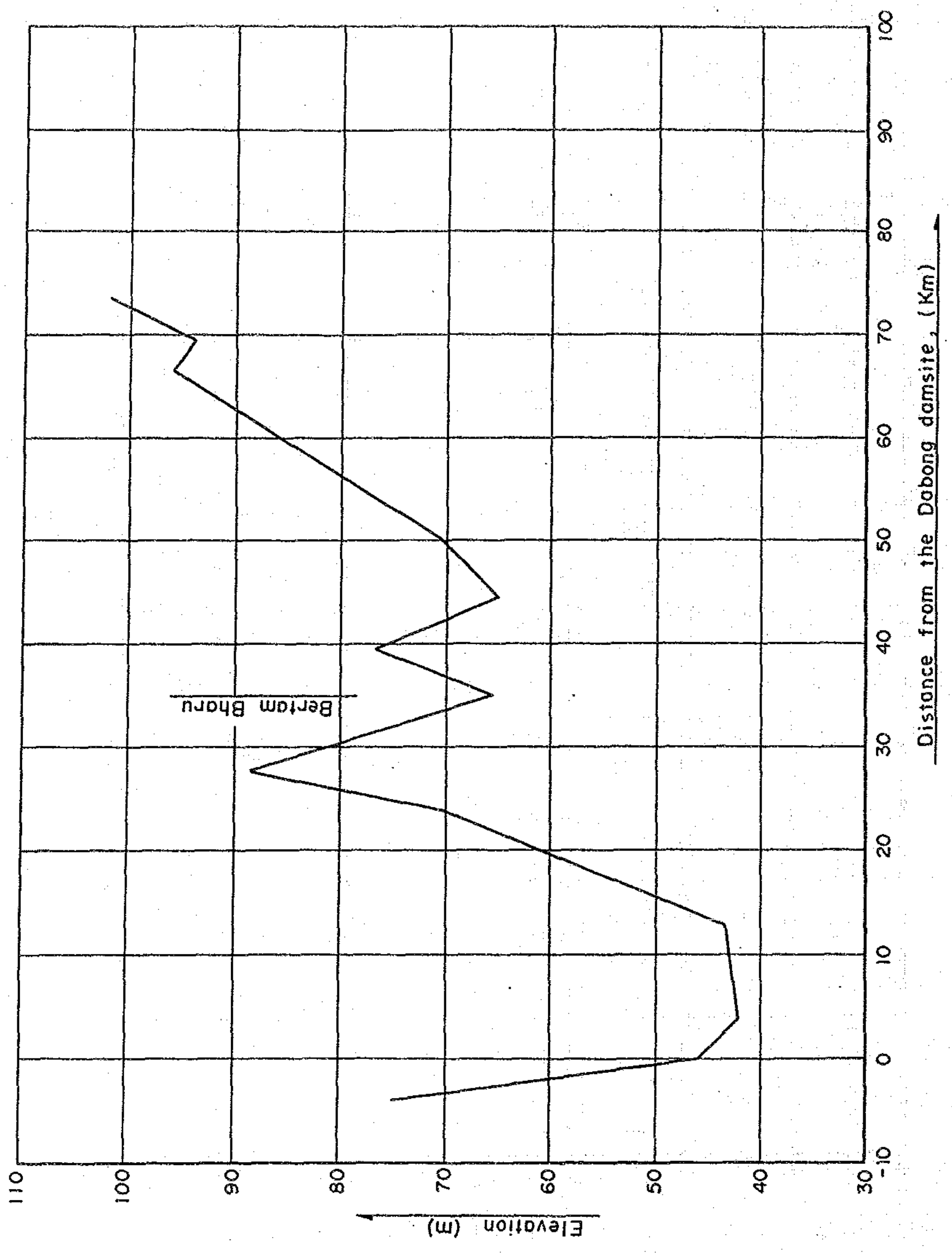

Fig. IX. 2. 9
Relationship between Distance and Elevation for Railway

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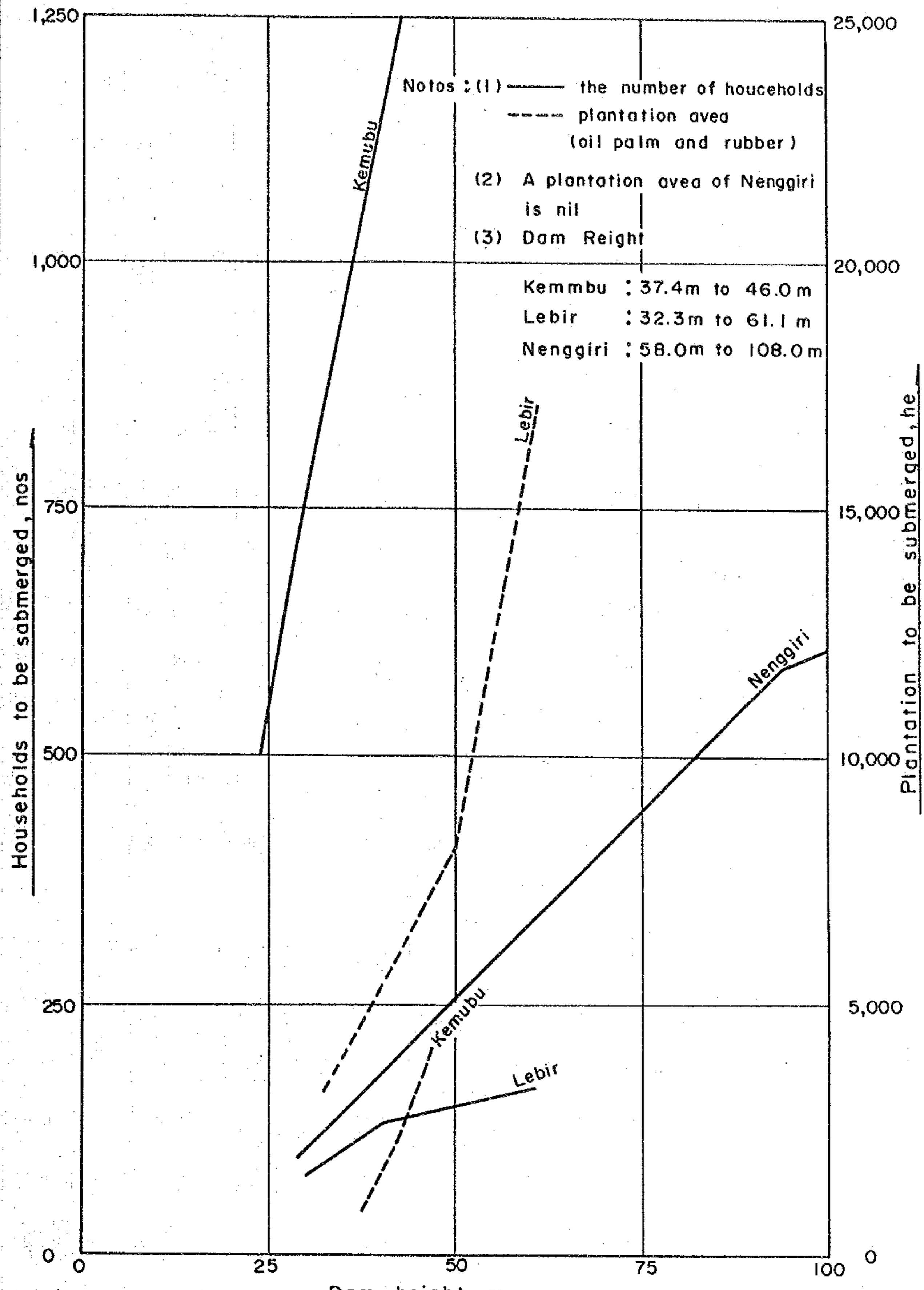

Fig. IX. 2. 10
Comparison of Social Impact among the Kemubu, Nenggiri and Lebir Dam schemes

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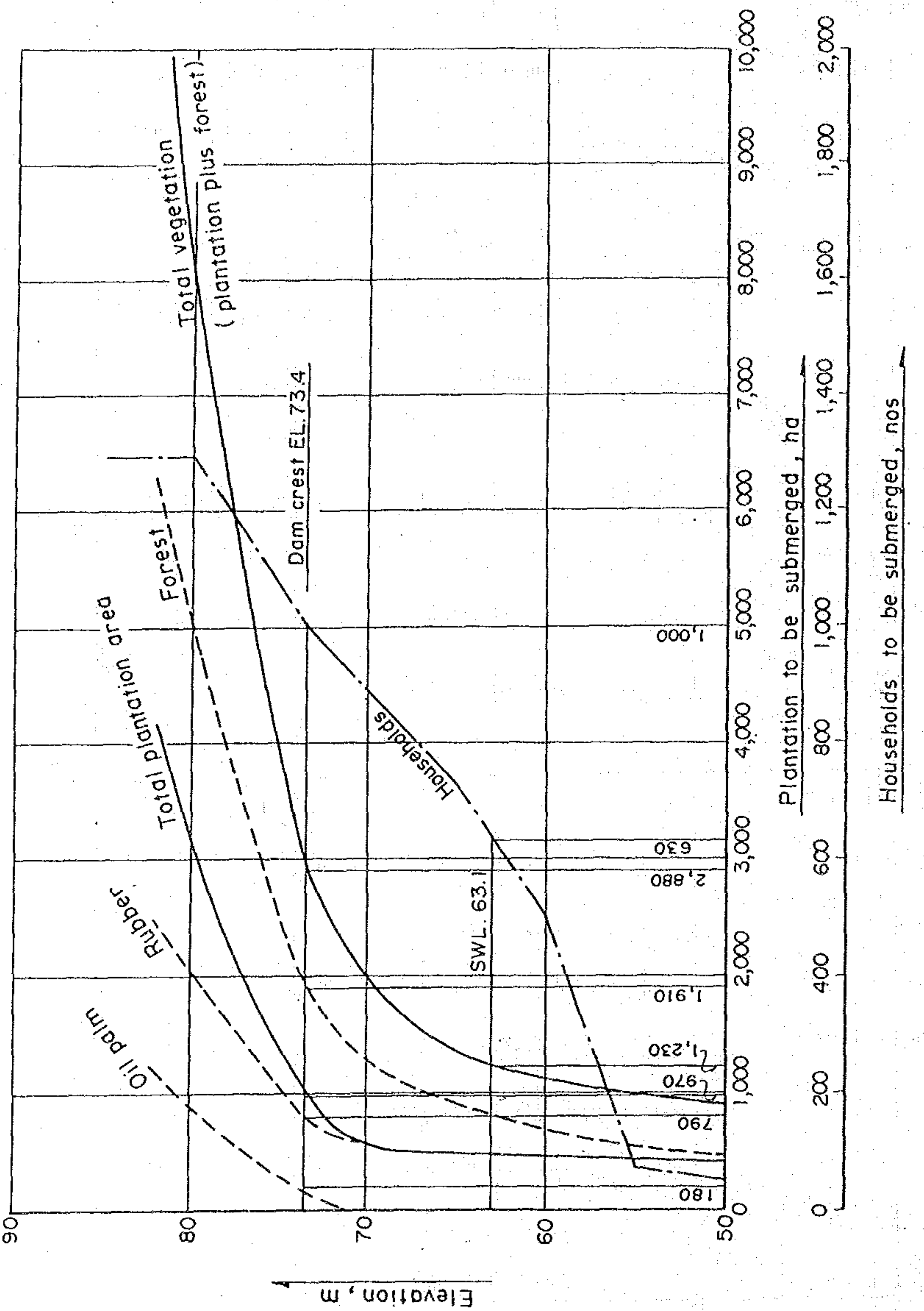

Fig.IX.2.11

Relationship between Elevation and Social Impact (Kemubu Scheme)

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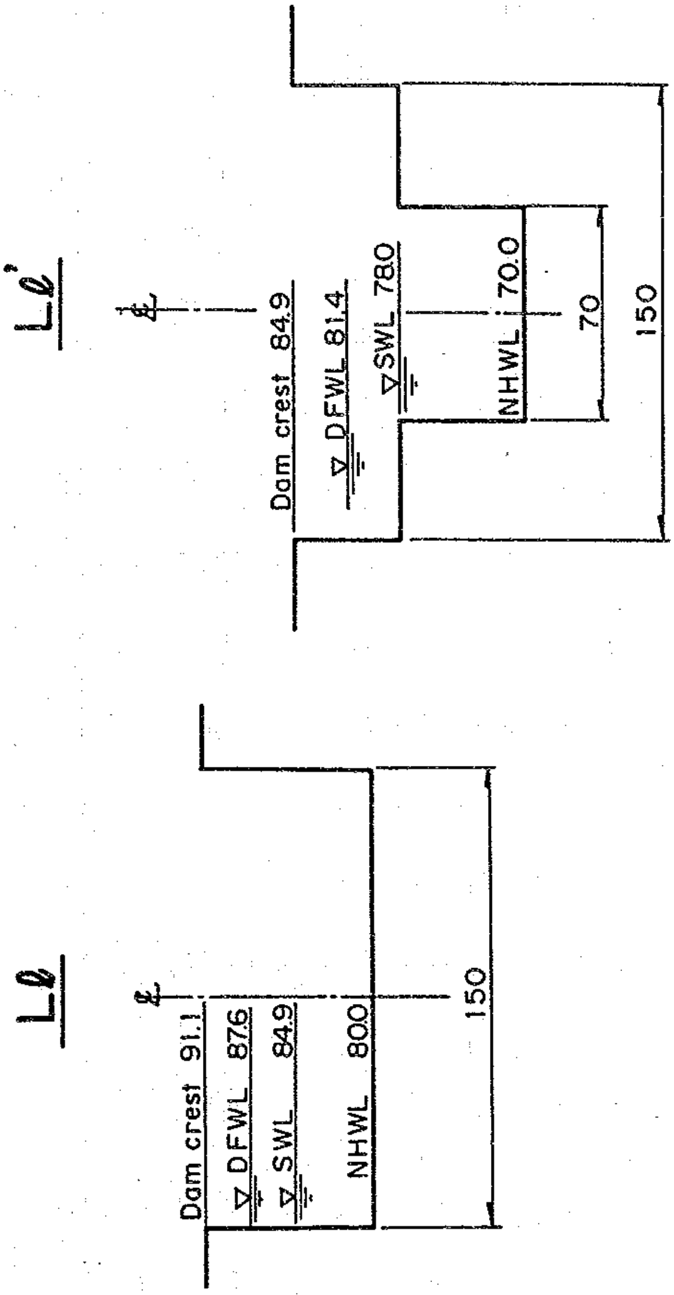

Fig.IX.2.12
Dimensional Comparison of Spillway between Lℓ and Lℓ'

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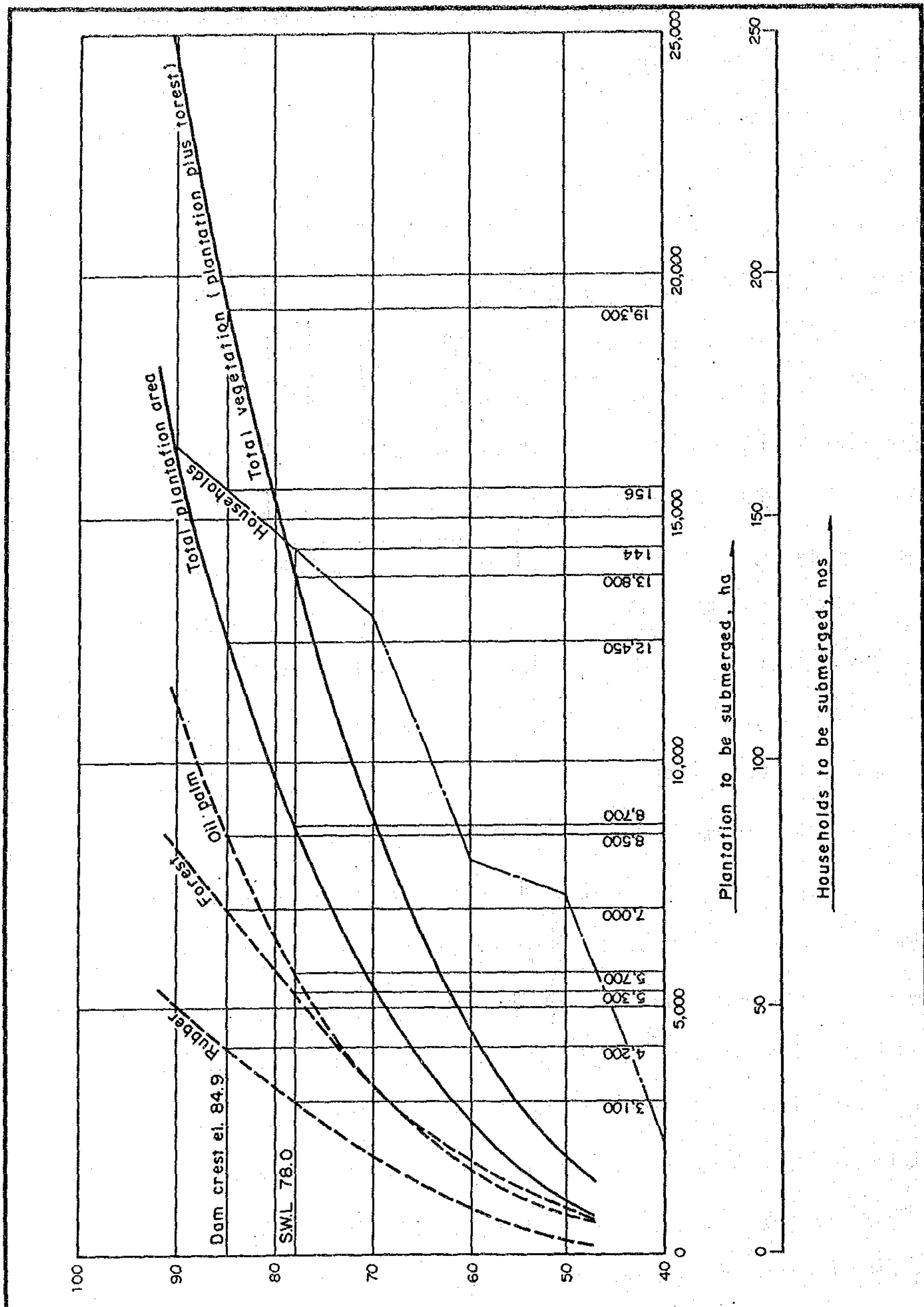

Fig.IX.2.13

Relationship between Elevation and Social Impact (Lebir Scheme)

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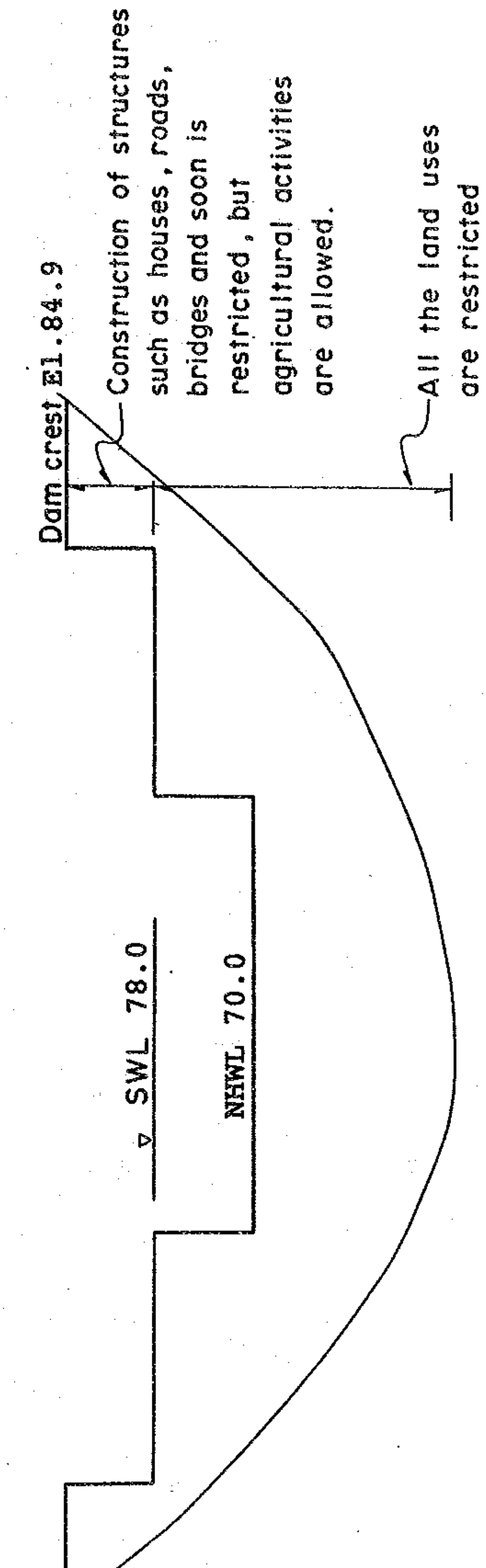

Fig.IX.2.14

Concept of Land Compensation

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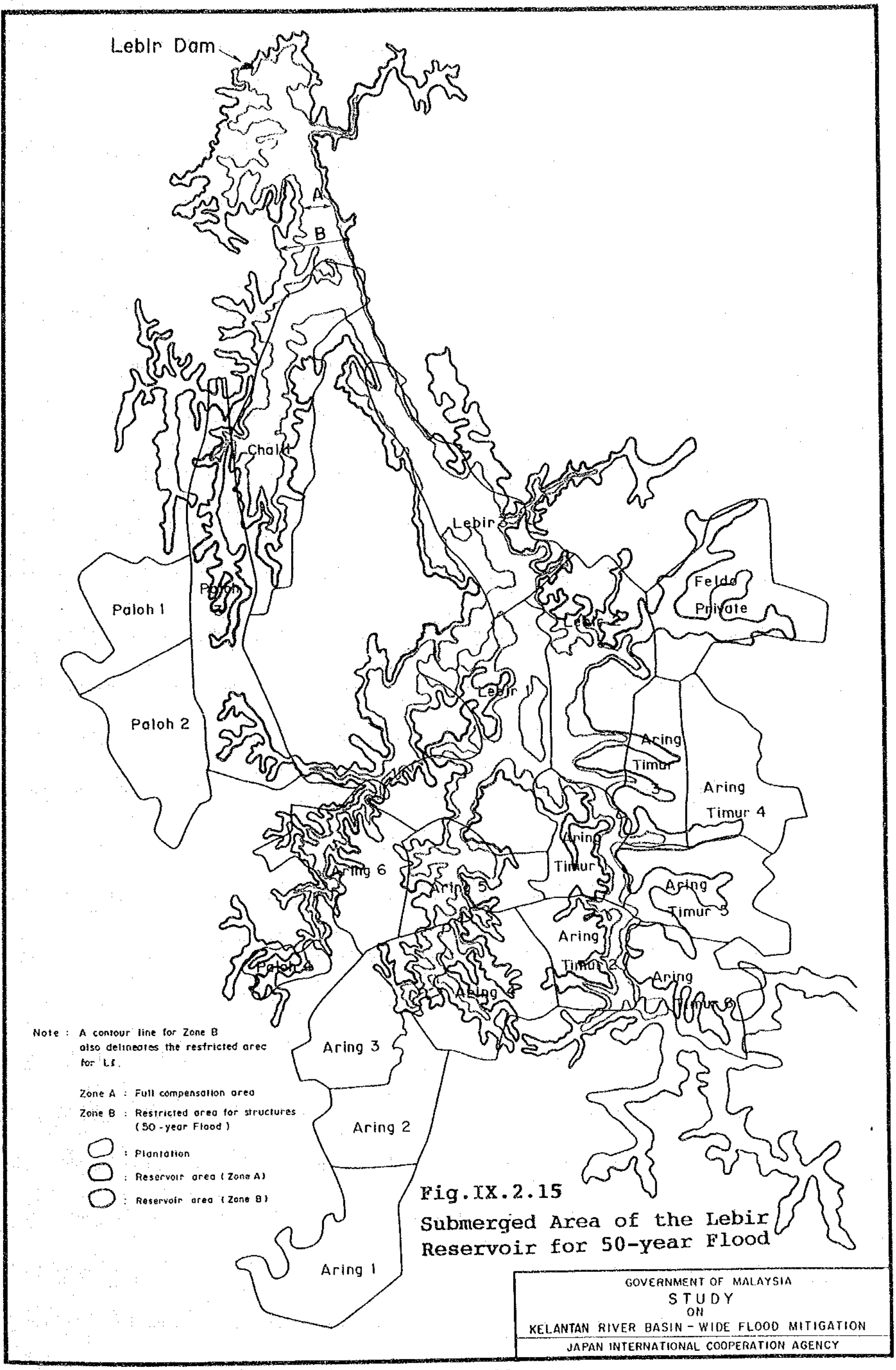

Fig.IX.2.15
Submerged Area of the Lebir Reservoir for 50-year Flood

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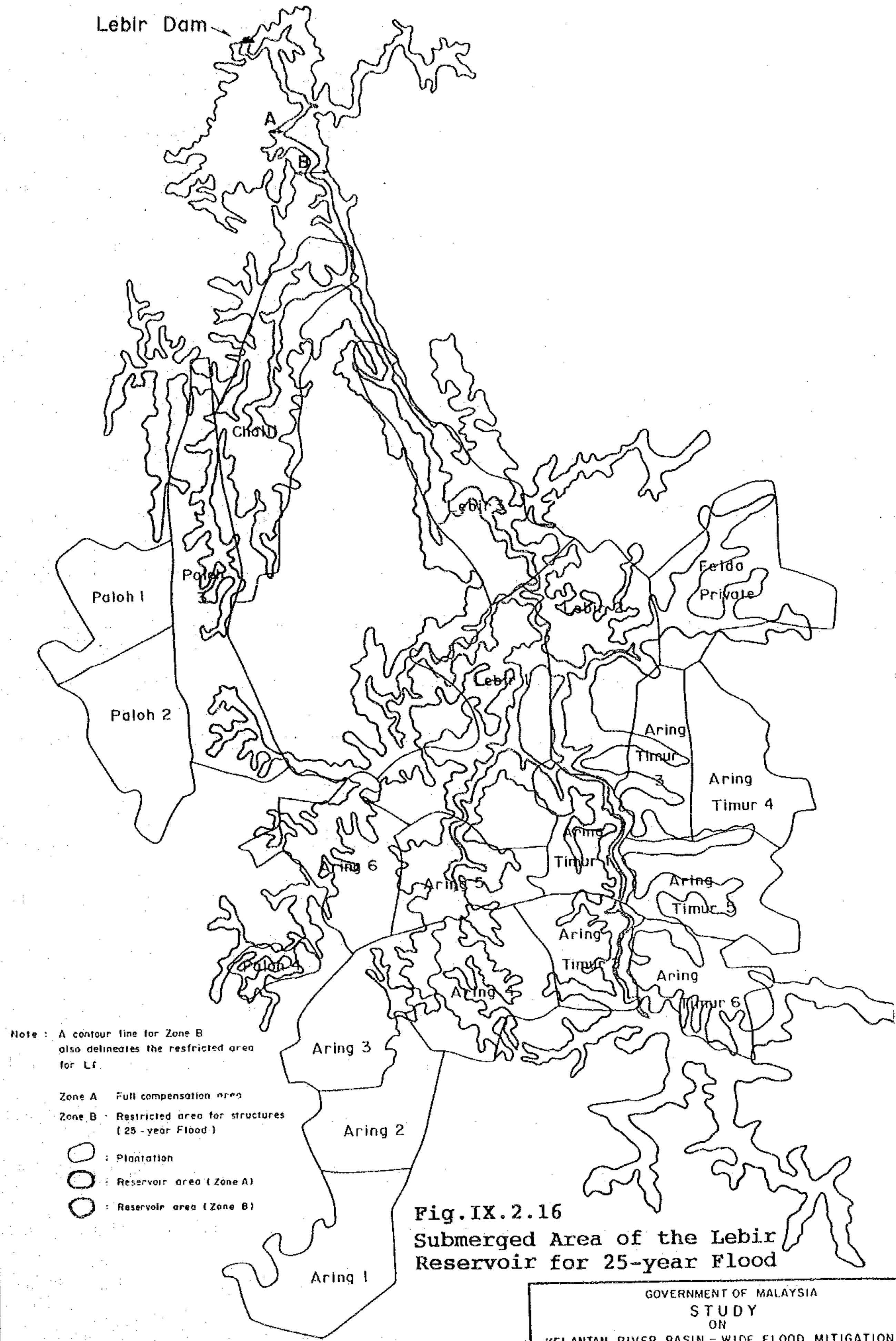

Fig.IX.2.16
Submerged Area of the Lebir Reservoir for 25-year Flood

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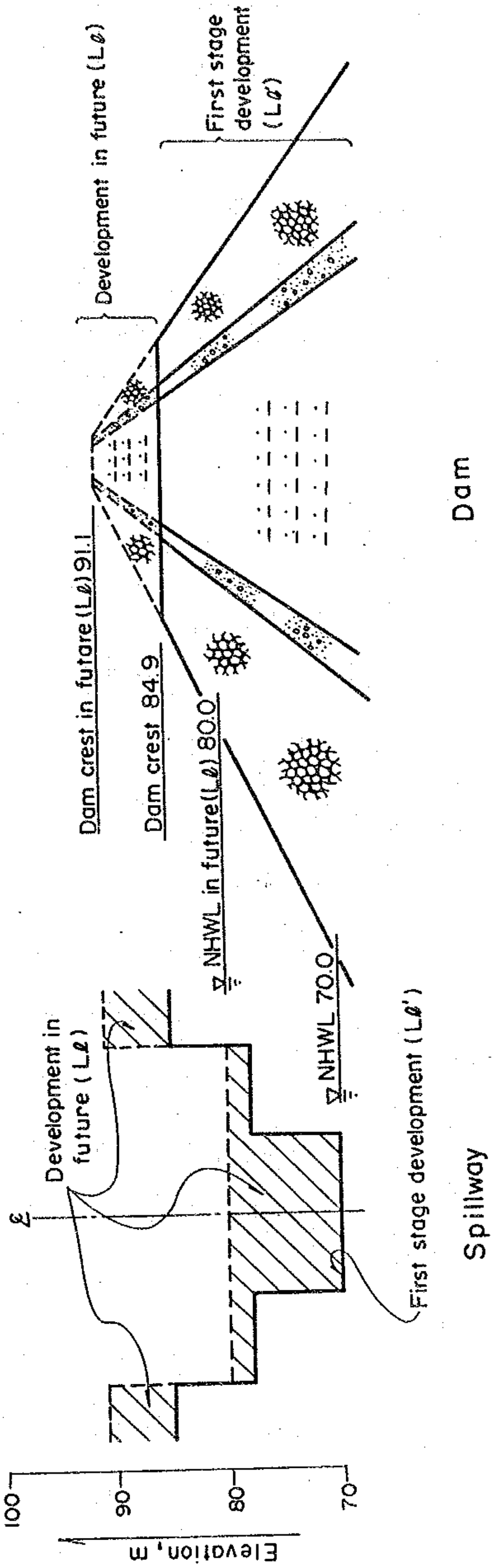

Fig.IX.2.17

Stage Development Plan of Lebir Dam

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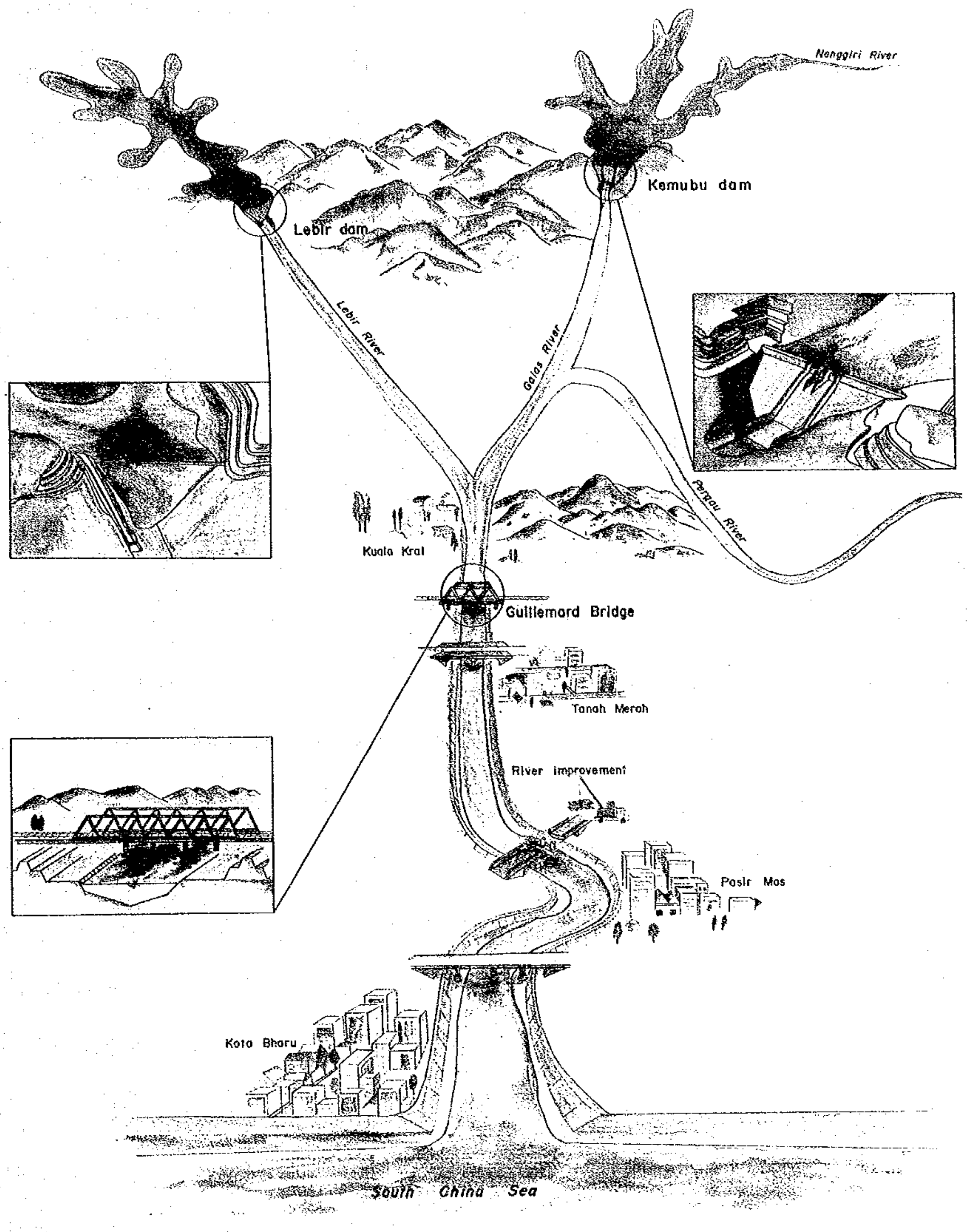

Fig.IX.2.18

Master Plan of the Kelantan River Flood Mitigation

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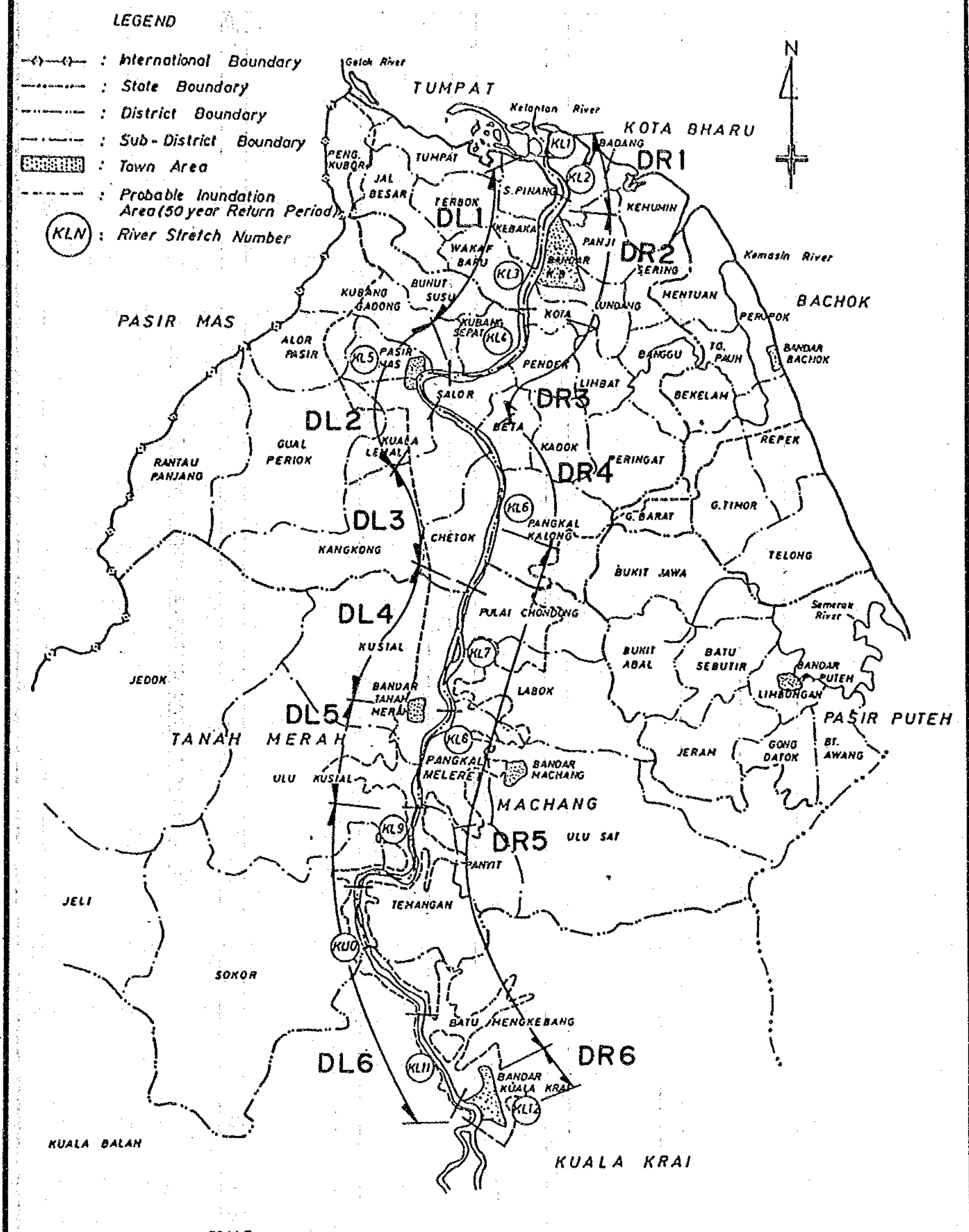

Fig IX.3.1
River Division for Implementation

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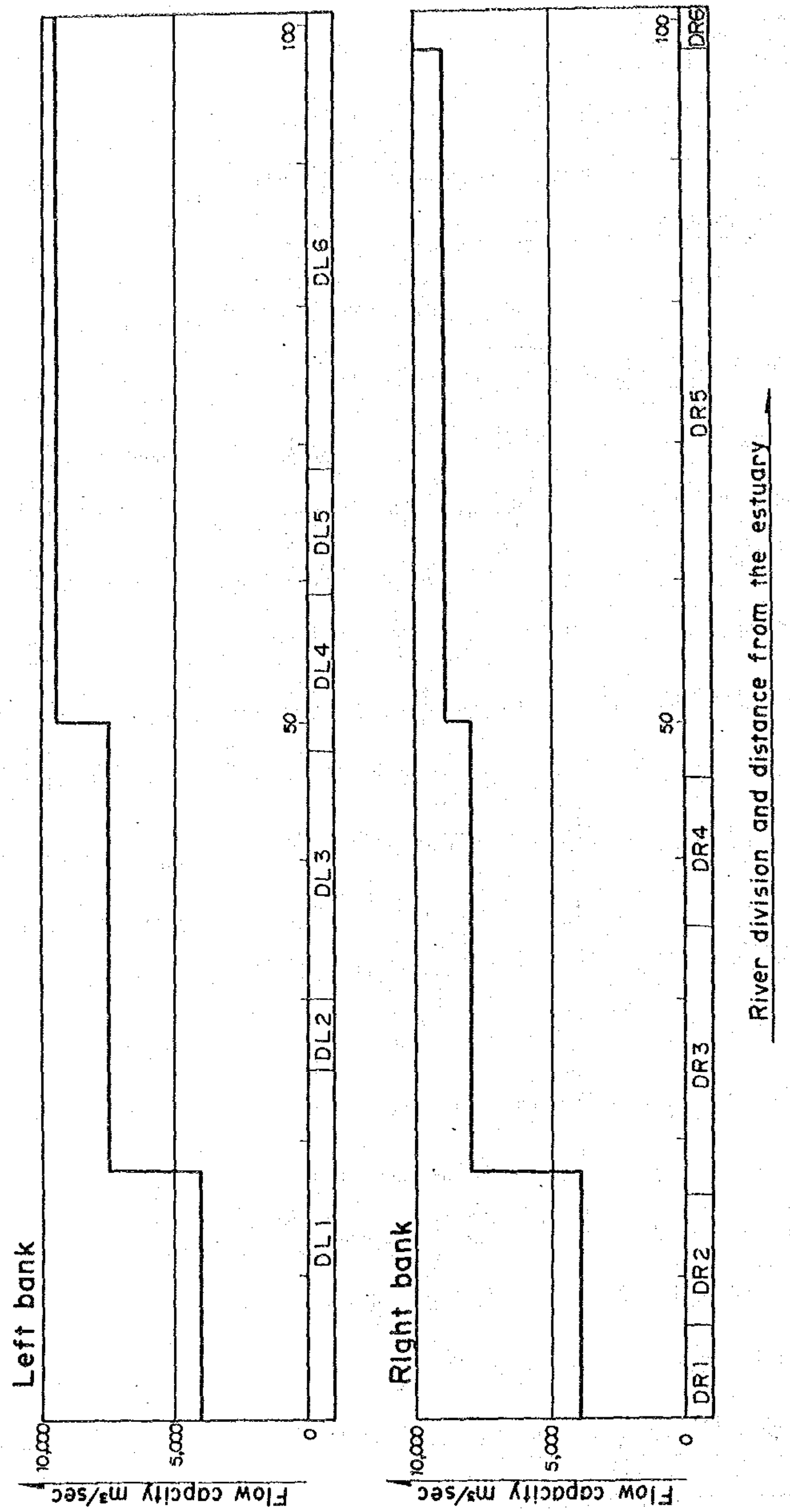

Fig.IX.3.2
Minimum Flow Copacity in Each River Division

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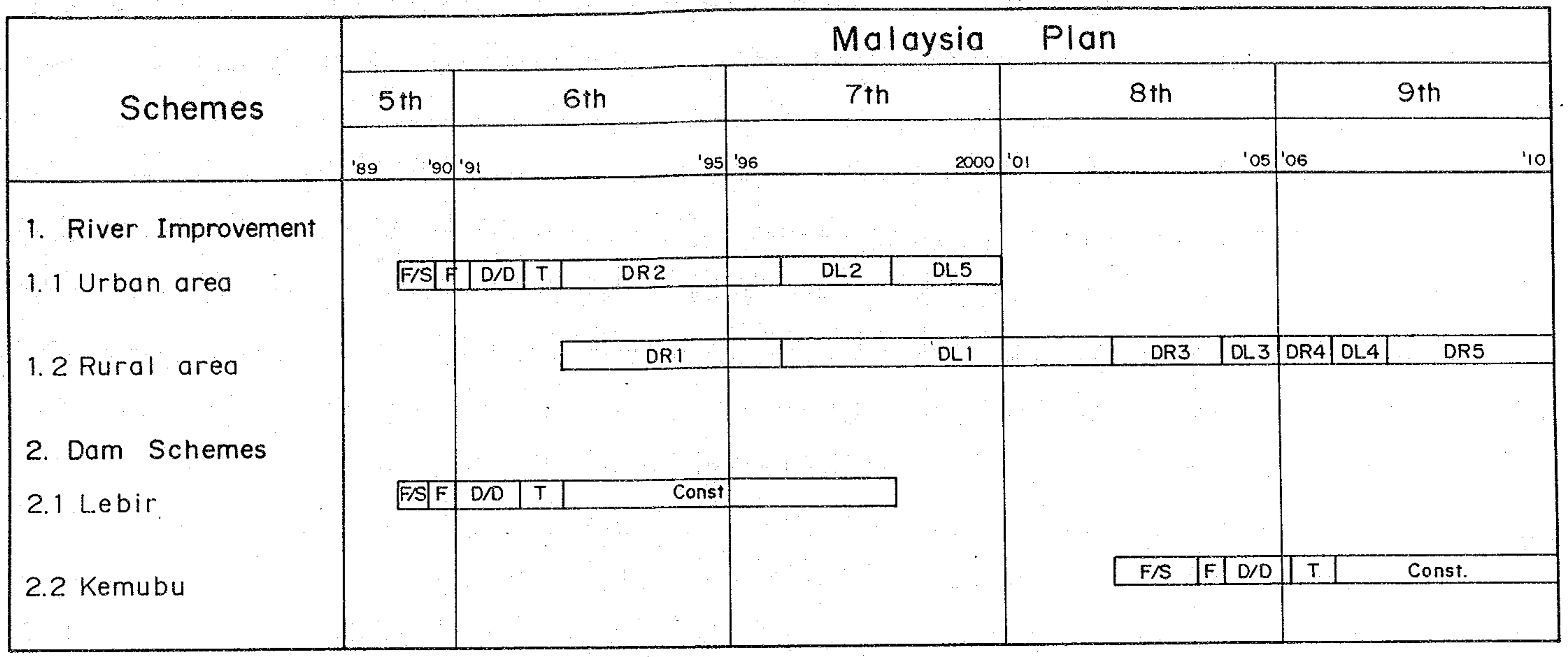

Notes : The feasibility study (F/S), detailed design (D/D) and financing (F) for all the river improvement works are carried out at the beginning of river improvement works for the urban area, whilst tender (T) is performed prior to the construction of each package. DR1, DL1 and so on denote the construction of respective river division.

Fig. IX.3.3
Implementation Programme for the Flood Mitigation Plan of the Kelantan River Basin

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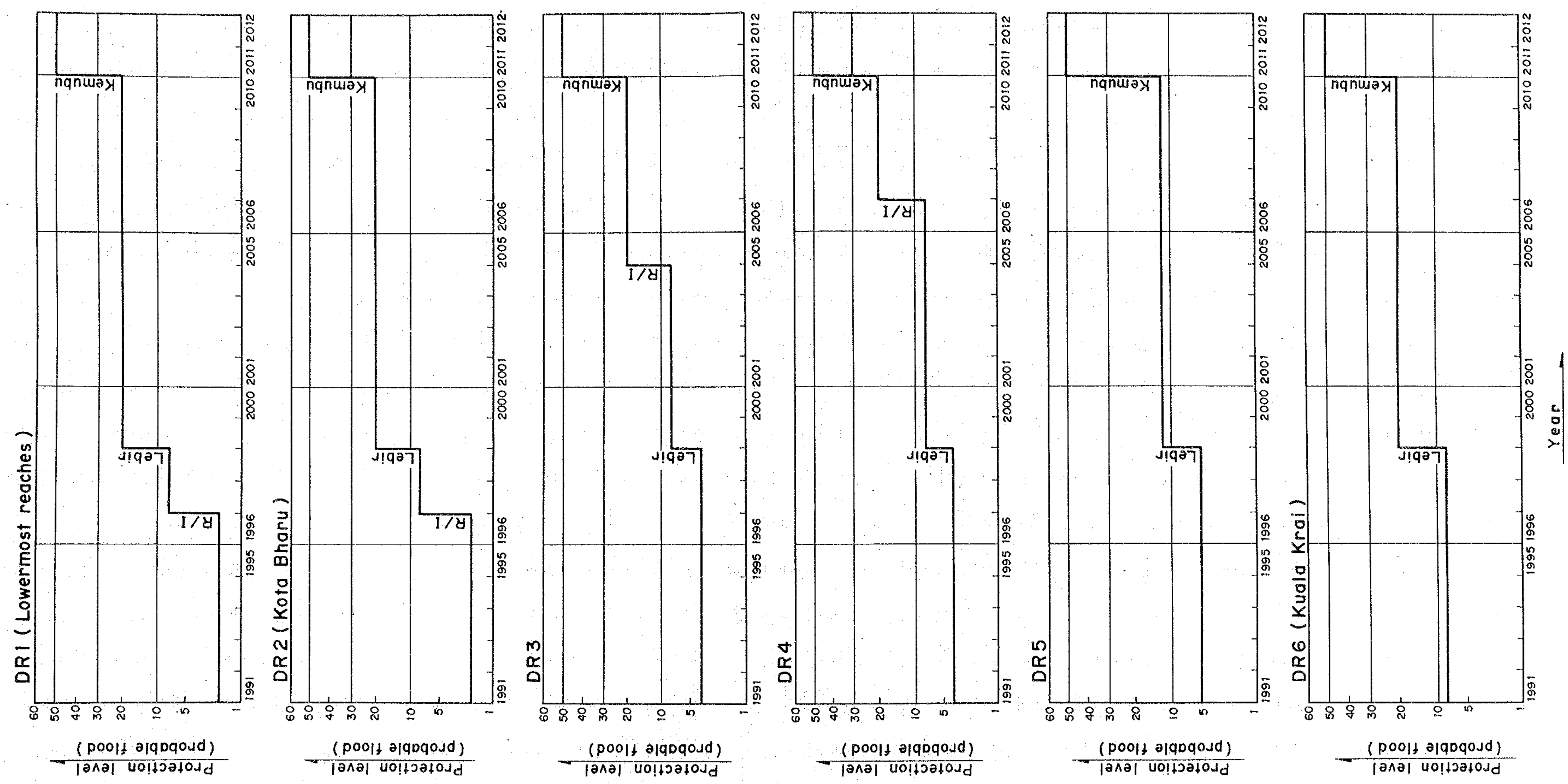

Fig. IX.3.4
Increase of Protection Level against Flood (1/2)

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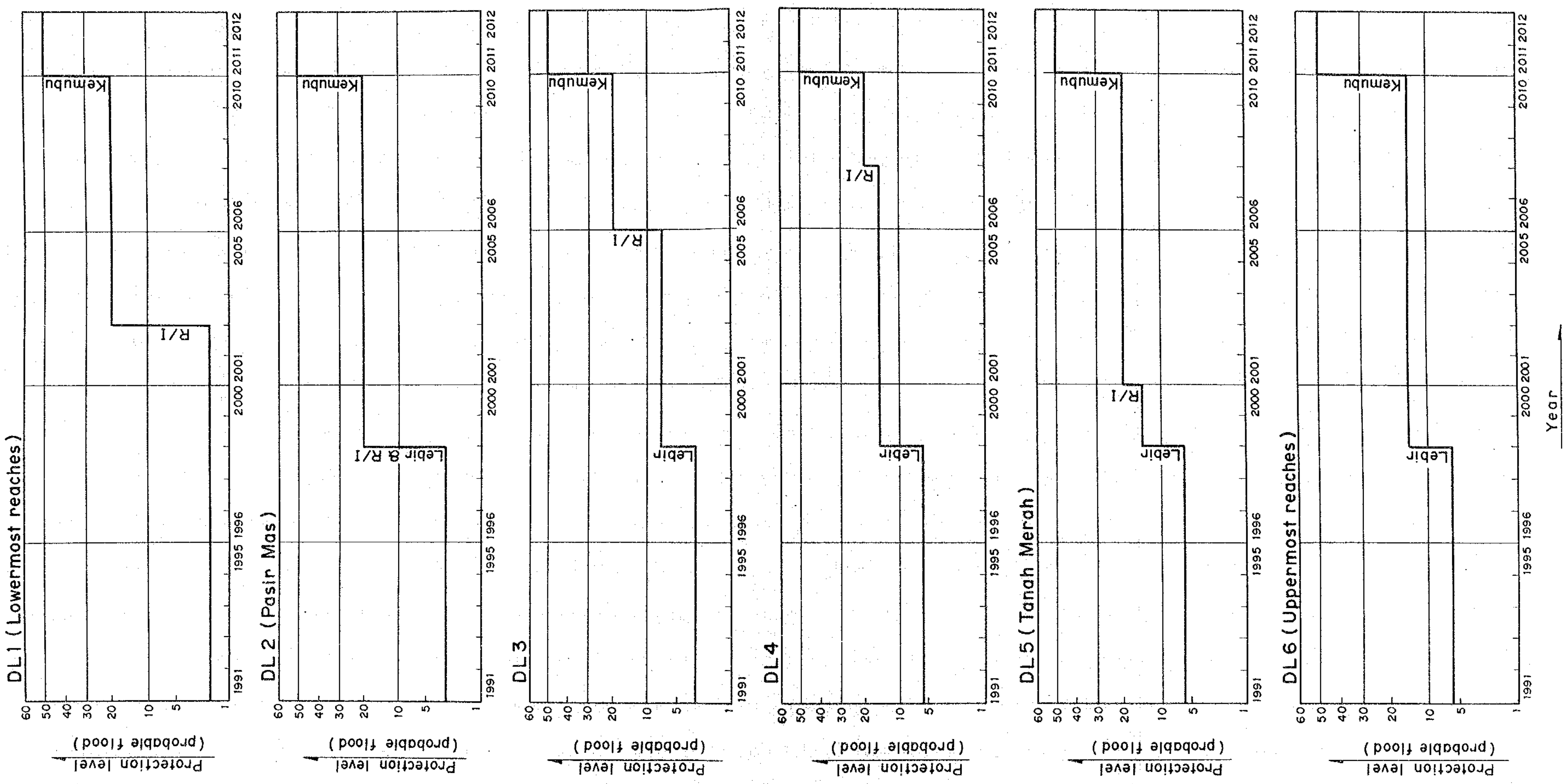

Fig. IX.3.4
Increase of Protection Level against Flood (2/2)

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