T A B L E & F I G U R E

Table III-1 FEATURES OF POSSIBLE DAMSITES

No. Damsite	/1 Catchment Area (km^2)	/2 Dead Storage ($x10^6$ m^3)	/3 Effective Storage ($x10^6$ m^3)	/4 Dam Height (m)	/5 Dam Body Volume ($x10^6$ m^3)	Effective Storage per Dam Body Volume (m^3/m^3)	/6 Flood Control Potentiality (km^2/km^2)
1. Milian (1)	950	19	300*	97	9	33	0.089
2. Milian (2)	1,640	33	600*	42	8	75	0.153
3. Melikop	290	6	100*	20	3	33	0.027
4. Pinangah	1,200	24	1,200	35	1	1,200	0.112
5. Tongod	660	13	70*	32	1	70	0.062
6. Imbak	390	8	100*	51	2	50	0.036
7. Karamuak	450	9	200*	24	2	100	0.042
8. Kuamut (1)	980	20	200*	81	7	29	0.091
9. Kuamut (2)	2,770	55	2,770	95	22	126	0.258
10. Kuamut	3,100	62	3,100	76	24	129	0.289
11. Milian	6,650	133	6,650	45	11	605	0.620
12. Deramakot	10,360	207	10,360	46	10	1,036	0.966
13. Balat	10,730	215	10,730	43	8	1,341	1.000

Note : /1 For the sizes of the respective basins, numbered 1 to 13 inclusive, see Fig.III-1
/2 Equivalent to 100-year volume at unit silt deposit of 200 m^3/km^2/year.
/3 Effective storage is estimated by the unit volume of $1x10^6$ m^3/km^2/year which is the annual available rainfall.
* Effective storage modified by the topographic configuration of the respective damsites.
/4 Height of dam crest above the presumed existing riverbed.
/5 Dam body volume is computed on the basis of a fill dam with face slope of 1 : 3.0 on both up- and down-stream of the dam body.
/6 The ratio of catchment areas between Balat dam and the other dams.

Table III-2 COMPARISON OF THREE NOMINATED DAMSITES

Unit : 10^6US$

Damsite	Milian-Kuamut	Deramakot	Balat
Cost (C)	1,380.0	820.1	707.4
Benefit (B)	60.7	59.4	58.1
(B) / (C)	0.04	0.07	0.08

Table III-3 CONSTRUCTION COST OF BALAT DAM

Unit: 10^3 US$

	Work Item	Foreign Currency	Local Currency	Total
1.	Main Works			
	Access Road	2,900	3,400	6,300
	Diversion	10,000	6,900	16,900
	Dam Body	11,000	12,000	23,000
	Spillway	24,200	21,200	45,400
	Outlet Facility	21,900	11,700	33,600
	Preparatory Work	7,000	5,500	12,500
	Sub Total	77,000	60,700	137,700
2.	Land Acquisition and House Evacuation	-	30,800	30,800
3.	Engineering Service	11,000	2,800	13,800
4.	Physical Contingency	8,800	9,400	18,200
	Total	96,800	103,700	200,500

Fig. III-1 LOCATION MAP OF POSSIBLE DAMSITES

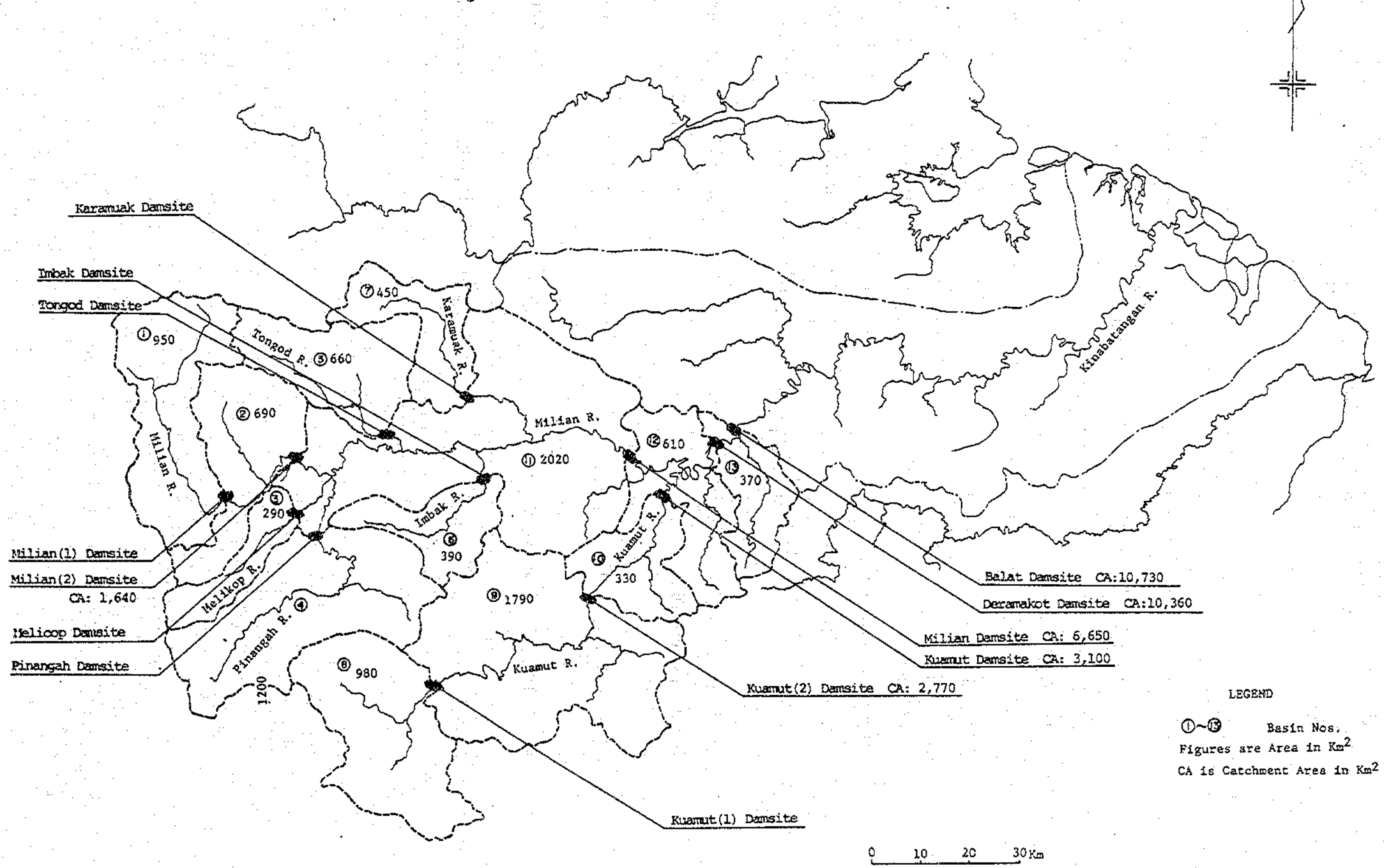


Fig. III-2 LOCATION OF NOMINATED DAMSITES

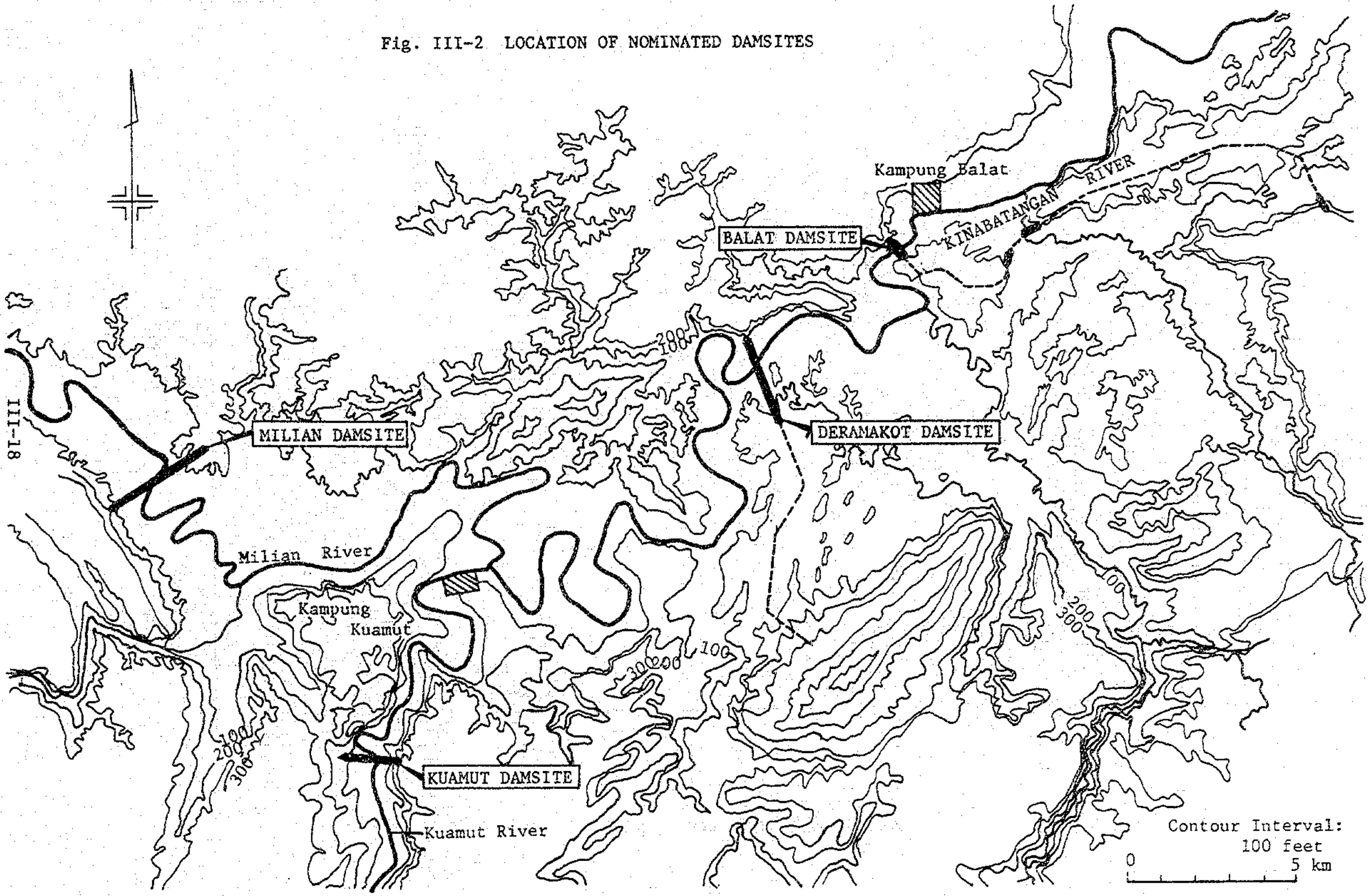


Fig. III-3 DISTRIBUTION OF KAMPUNG BY GROUND HEIGHT

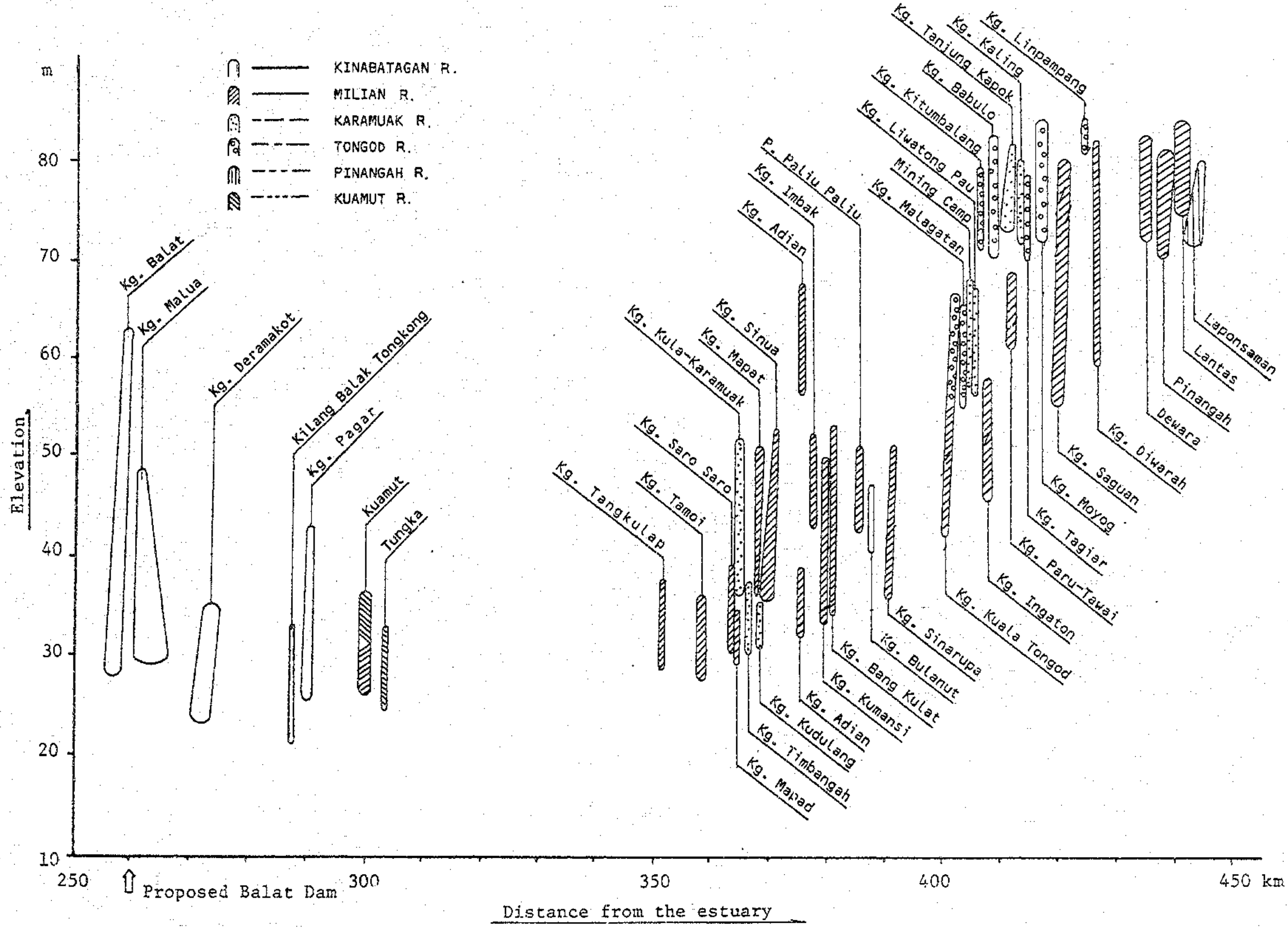


Fig. III-4 NUMBER OF HOUSES IN SUBMERGED AREA BY GROUND HEIGHT

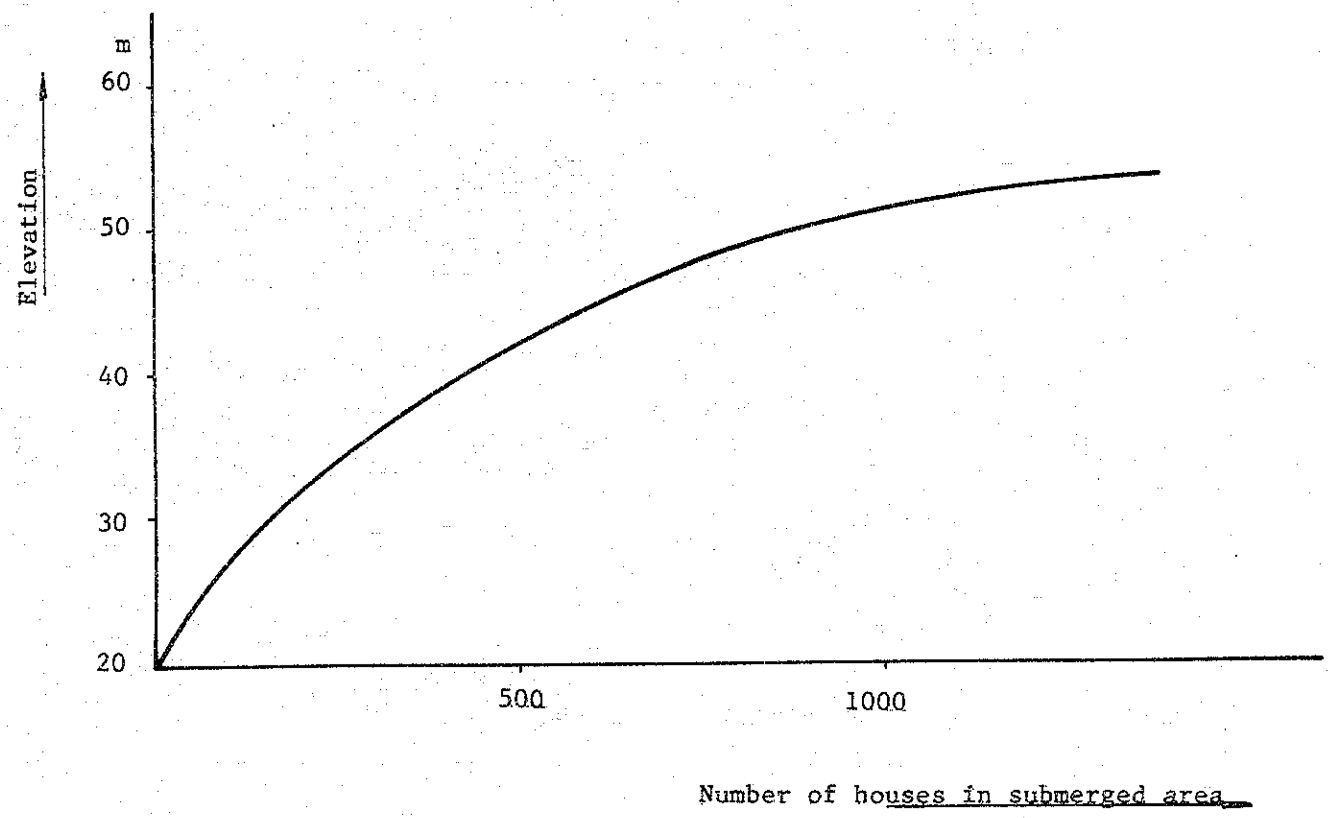


Fig. III-5 SUBMERGED AREA BY BALAT DAM

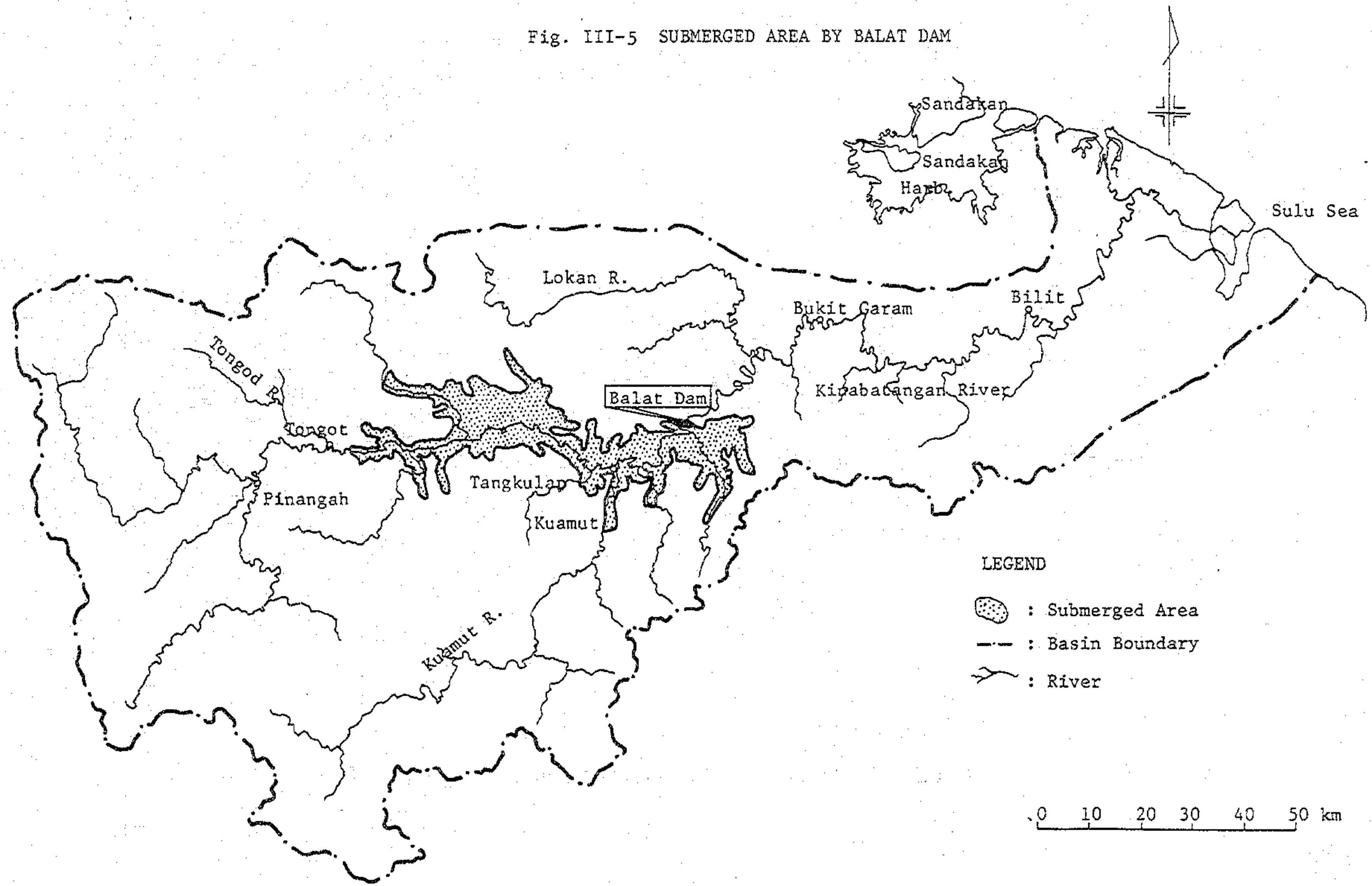
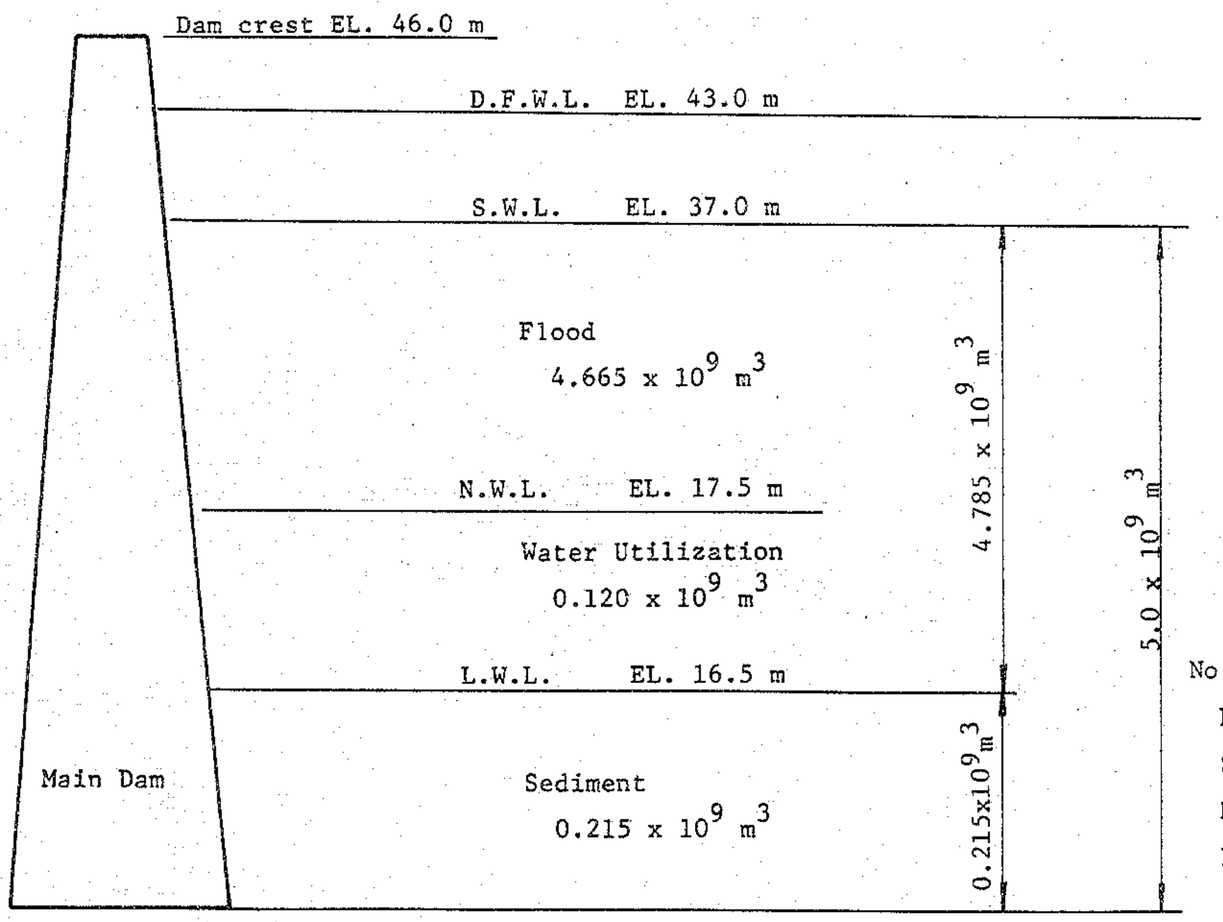


Fig. III-6 ALLOCATION OF RESERVOIR STORAGE CAPACITY



Note :

D.F.W.L.: Design Flood Water Level
S.W.L. : Surcharge Water Level
N.W.L. : Normal Water Level
L.W.L. : Low Water Level

Fig. III-7 ELEVATION, STORAGE VOLUME AND SURFACE AREA

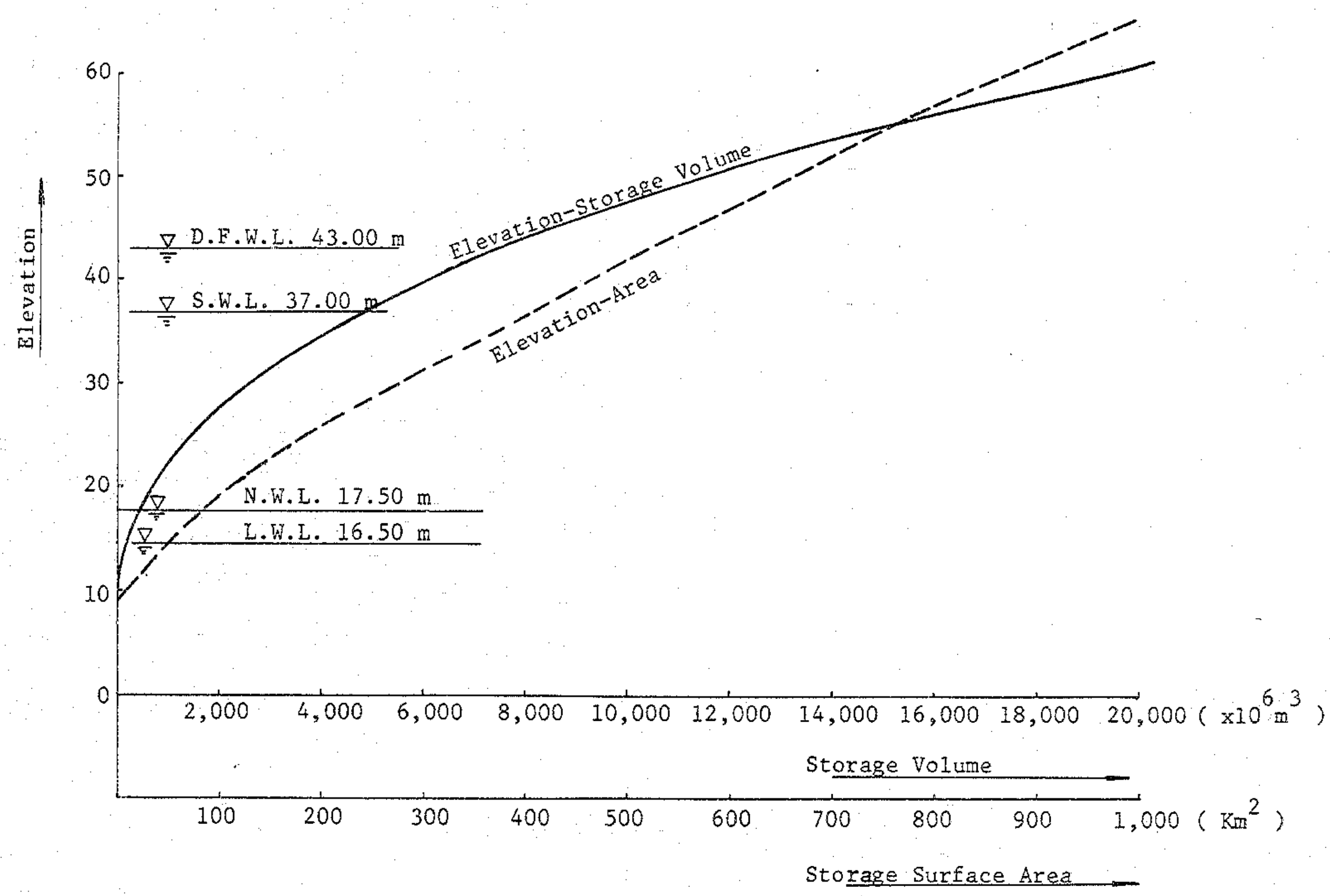
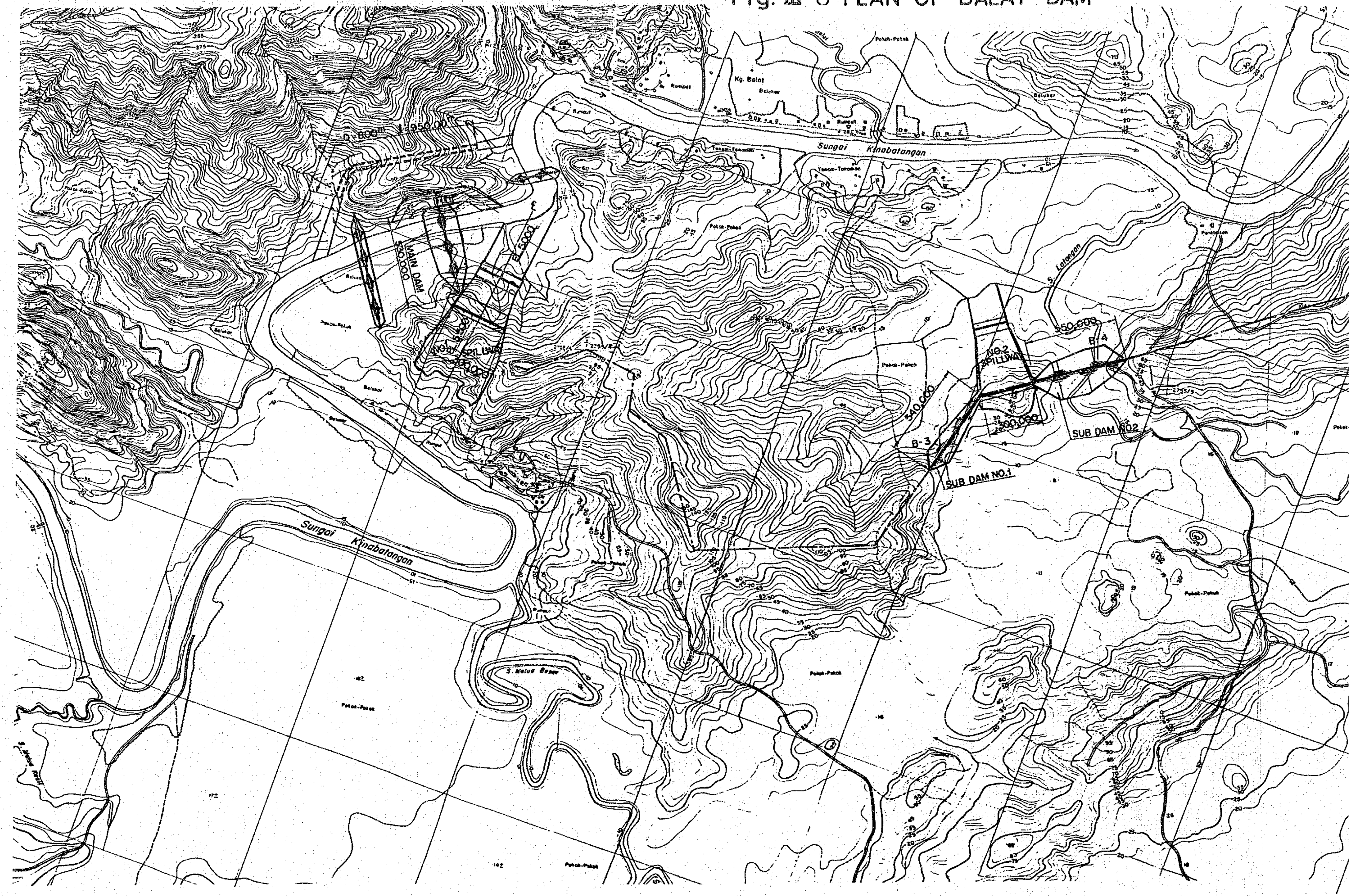
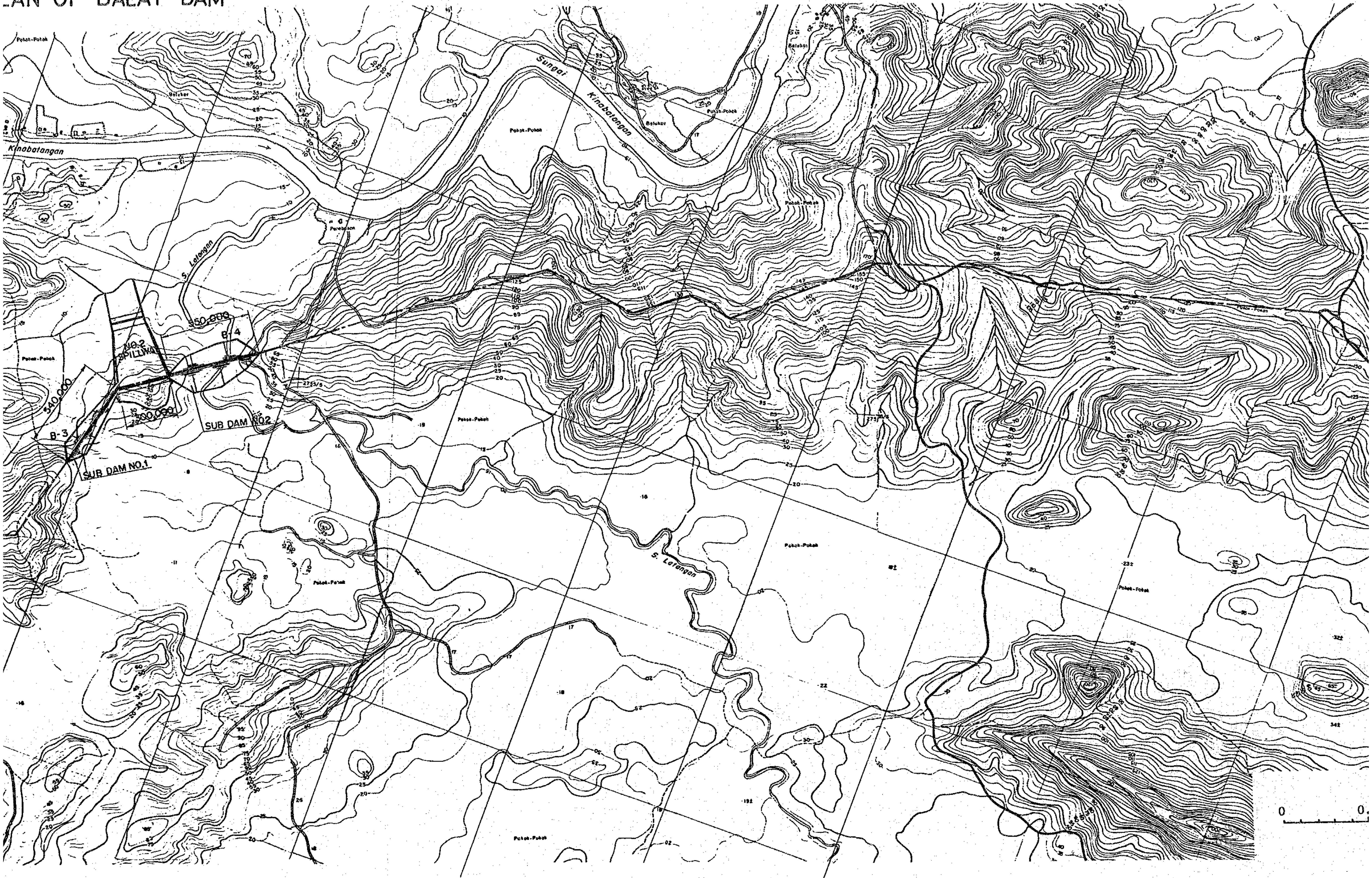


Fig. III-8 PLAN OF BALAT DAM



-LAN OF BALAT DAM



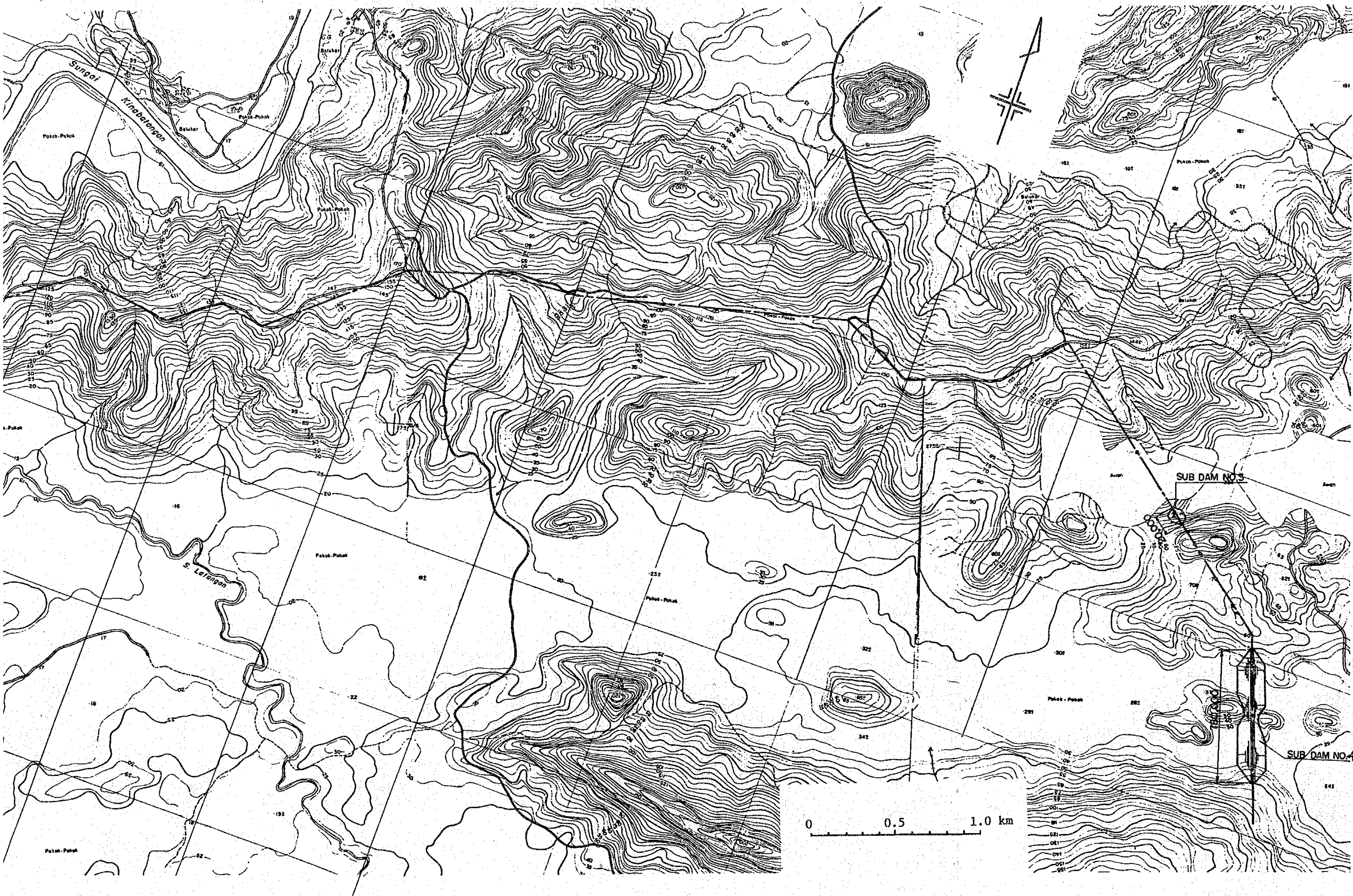
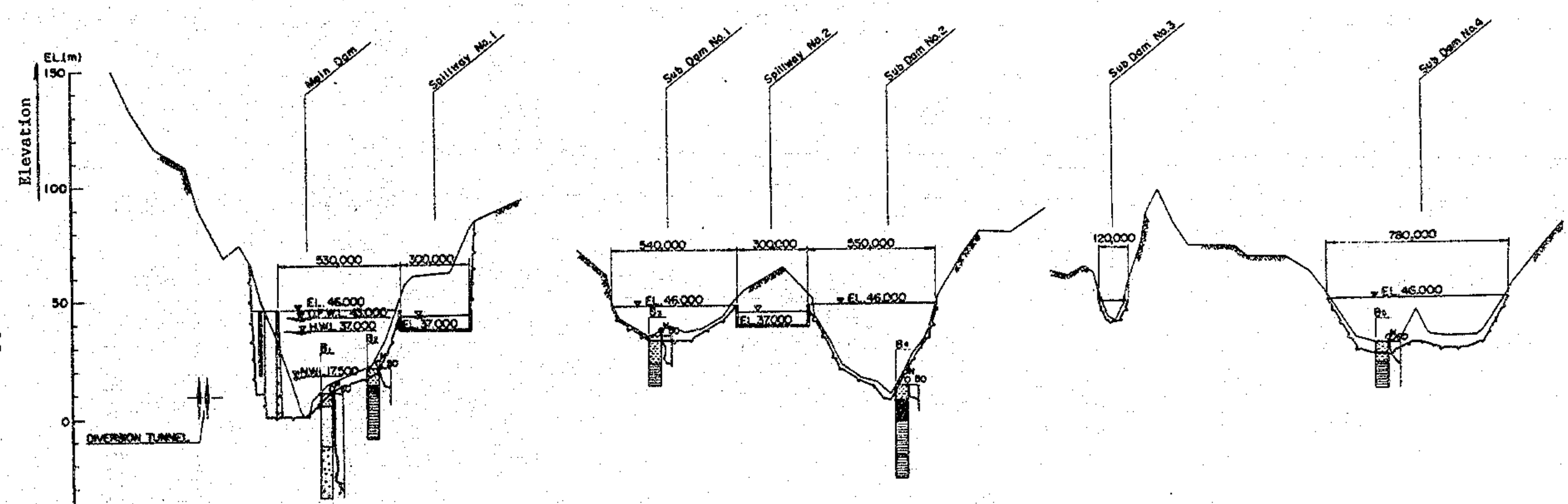

Sungai Kinabatangan
S. Letangan
Pokok-Pokok
Belukar
SUB DAM NO.3
SUB DAM NO.4
0
0.5
1.0 km

Fig. III-9 PROFILE ALONG AXIS OF DAM



NOTE

D.F.W.L : Design Flood Water Level

H.W.L : High Water Level

N.W.L : Normal Water Level

LEGEND

Silt & Clay

Sand Stone

Mud Stone

Sand

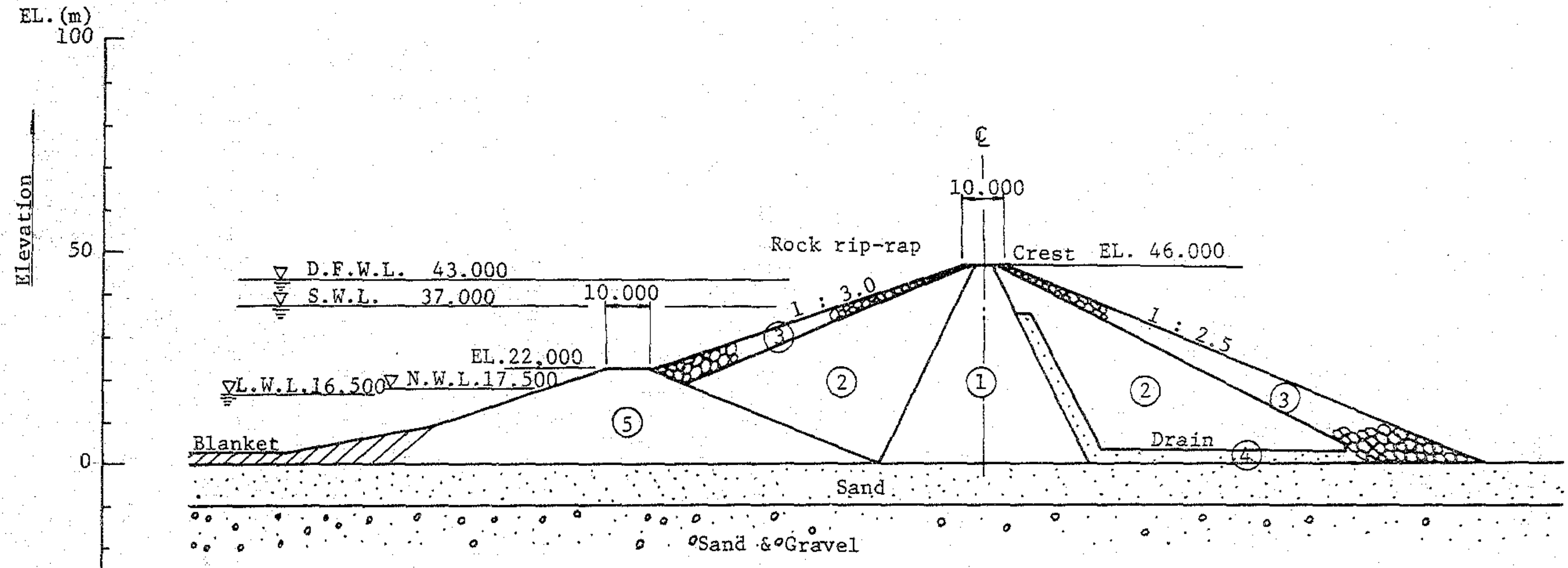
Sand & Gravel

Bn : Bore Hole No.n

H : 0 100 200 300 400 500m

V : 0 10 20 30 40 50m

Fig. III-10 TYPICAL CROSS-SECTION OF DAM



Note :

D.F.W.L. : Desigh Flood Water Level

S.W.L. : Surcharge Water Level

N.W.L. : Normal Water Level

L.W.L. : Low Water Level

LEGEND:

① Core

② Random

③ Rock

④ Drain

⑤ Coffer Dam

Fig. III-11 COMPARISOM OF THREE MEASURES

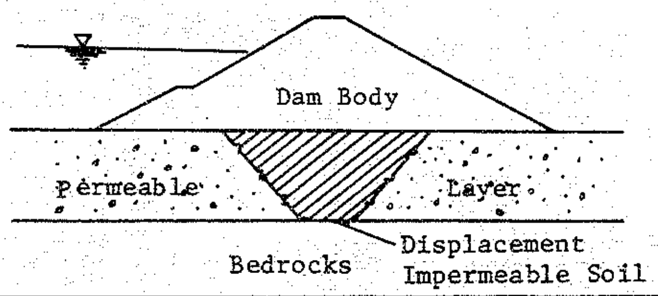
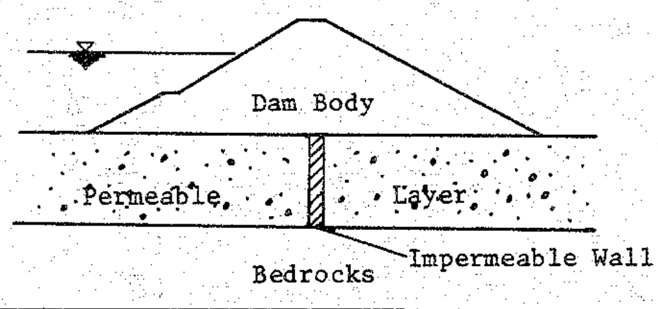
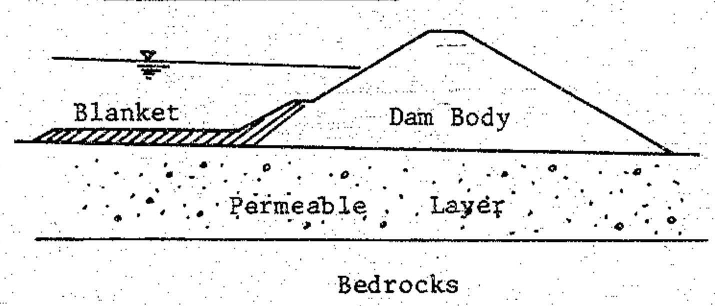
Measures	Quantity & Construction Cost	Remarks
Cut-off Trench 	Displacement Volume .... 700,000 m^3 Construction Cost ..... 9.2×10^6 US$	Difficulties of execution where the permeable layer or sediment covering the bedrocks is so deep.
Continuous Cut-off Wall 	Area of Cut-off Wall .... 14,000 m^3 Construction Cost .... 6.1×10^6 US$	Actual construction records are few where the wall is deep.
Impermeable Blanket 	Volume of Blanket .... 150,000 m^3 Construction Cost .... 2.6×10^6 US$	No problem, even the permeable layer is still deeper.

Fig. III-12 SELECTION OF SIZE OF SPILLWAY

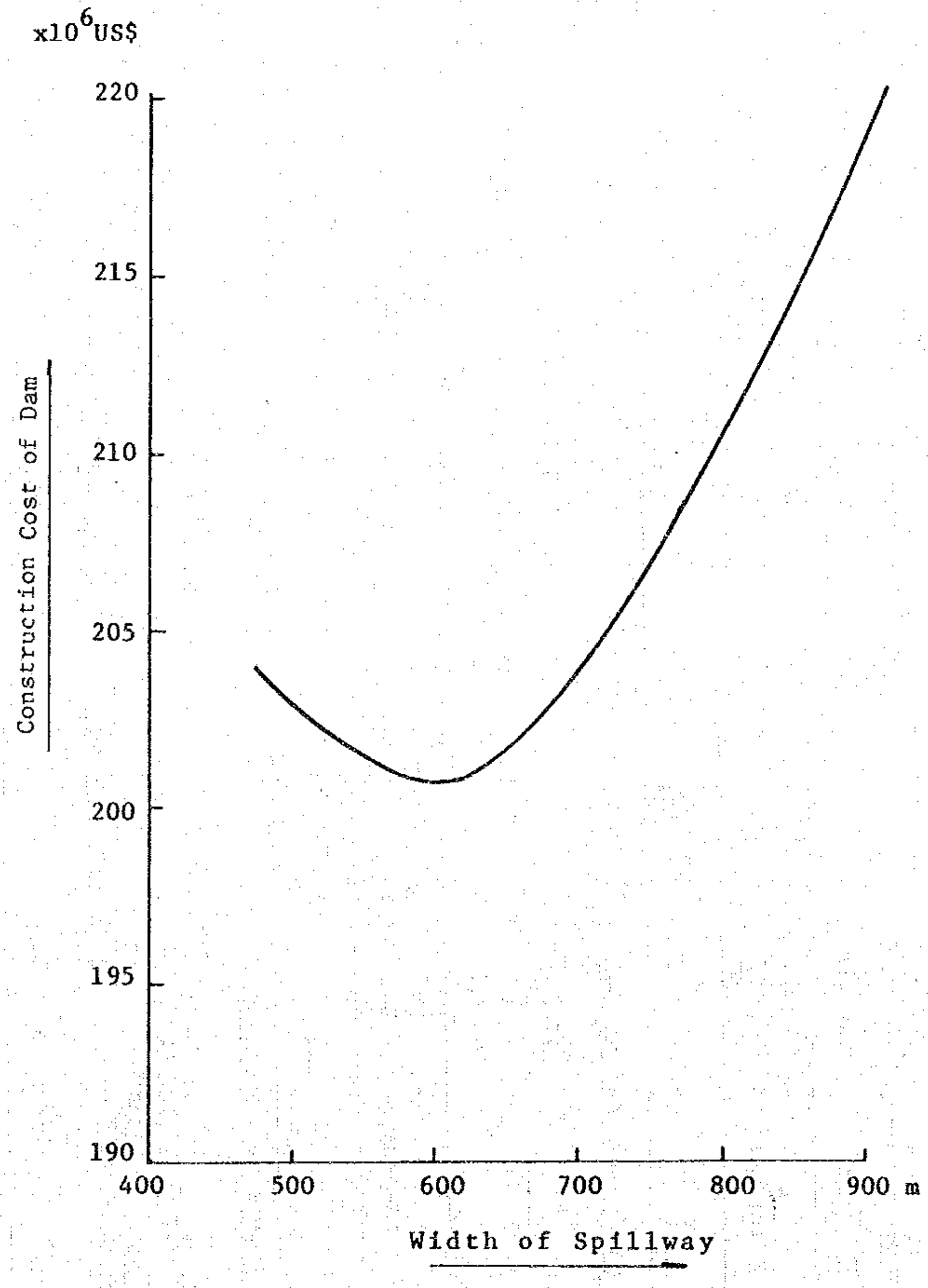


Fig. III-13 SPILLWAY PROFILE & CROSS-SECTION

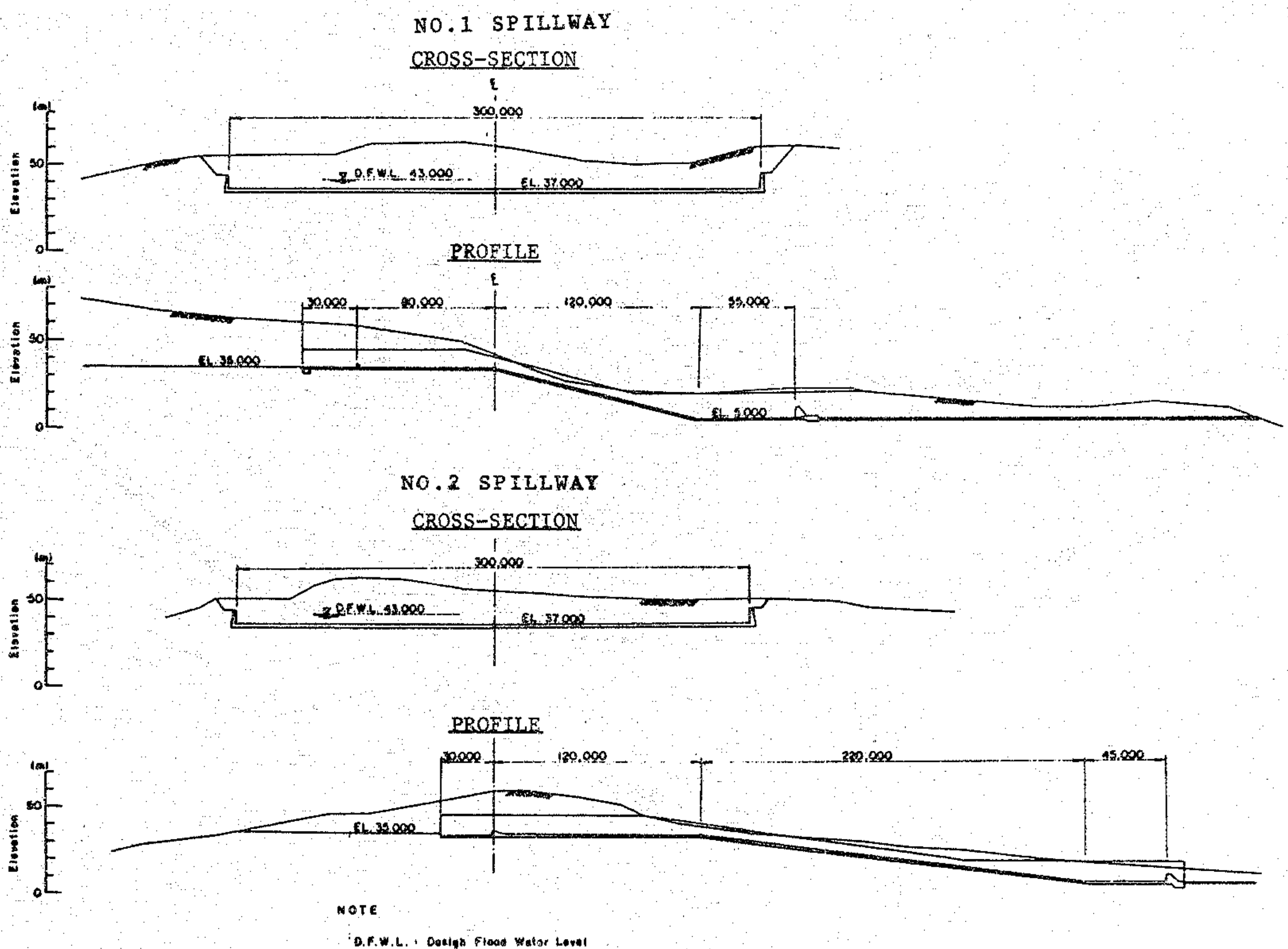


Fig. III-14 PLAN OF OUTLET FACILITY

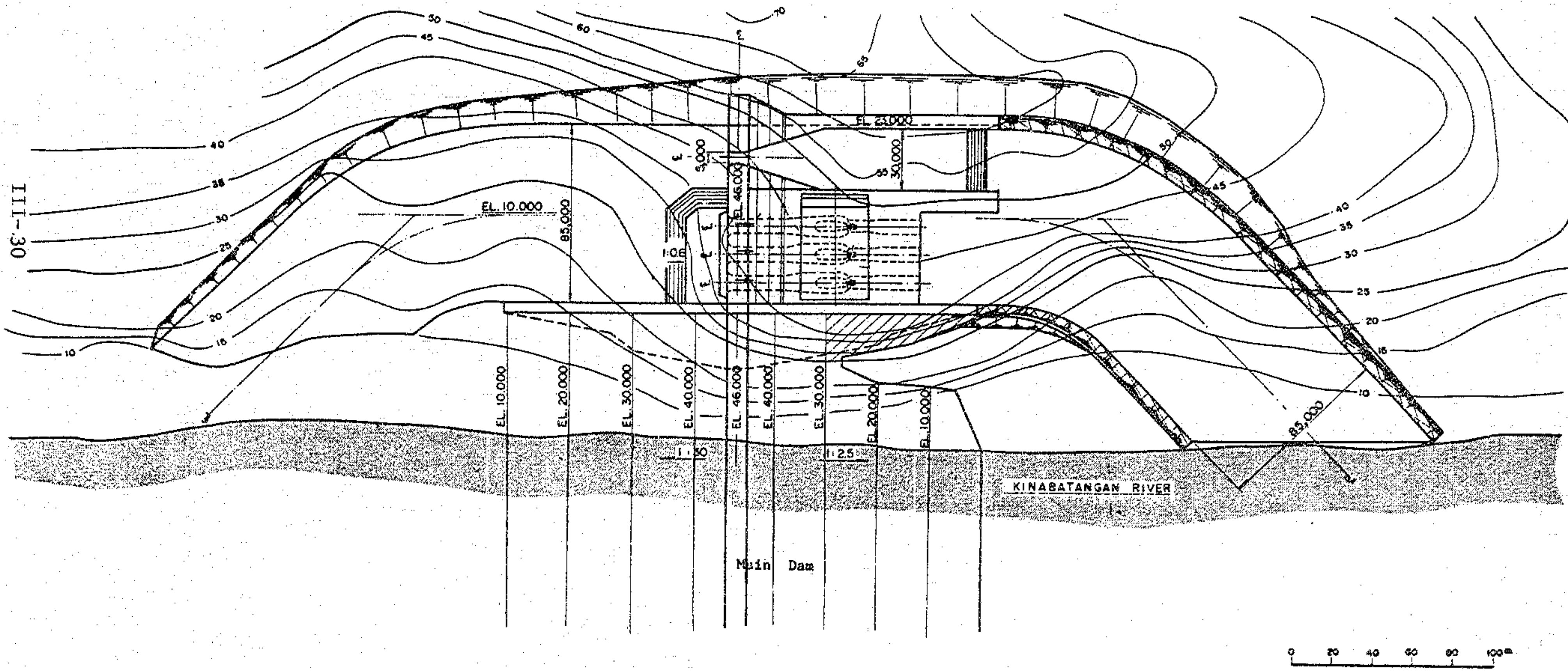


Fig. III-15 ROUTE MAP OF ACCESS ROAD

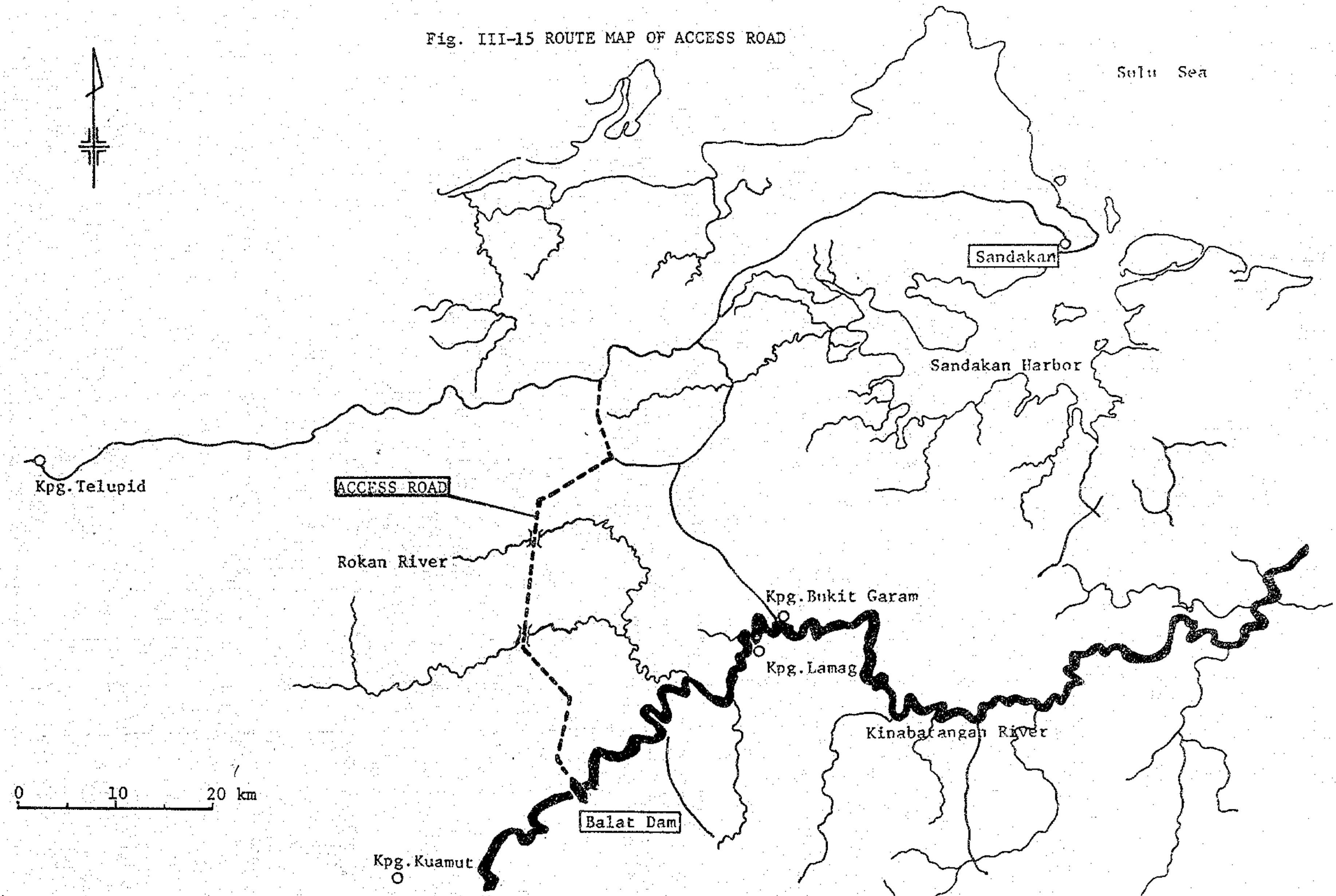
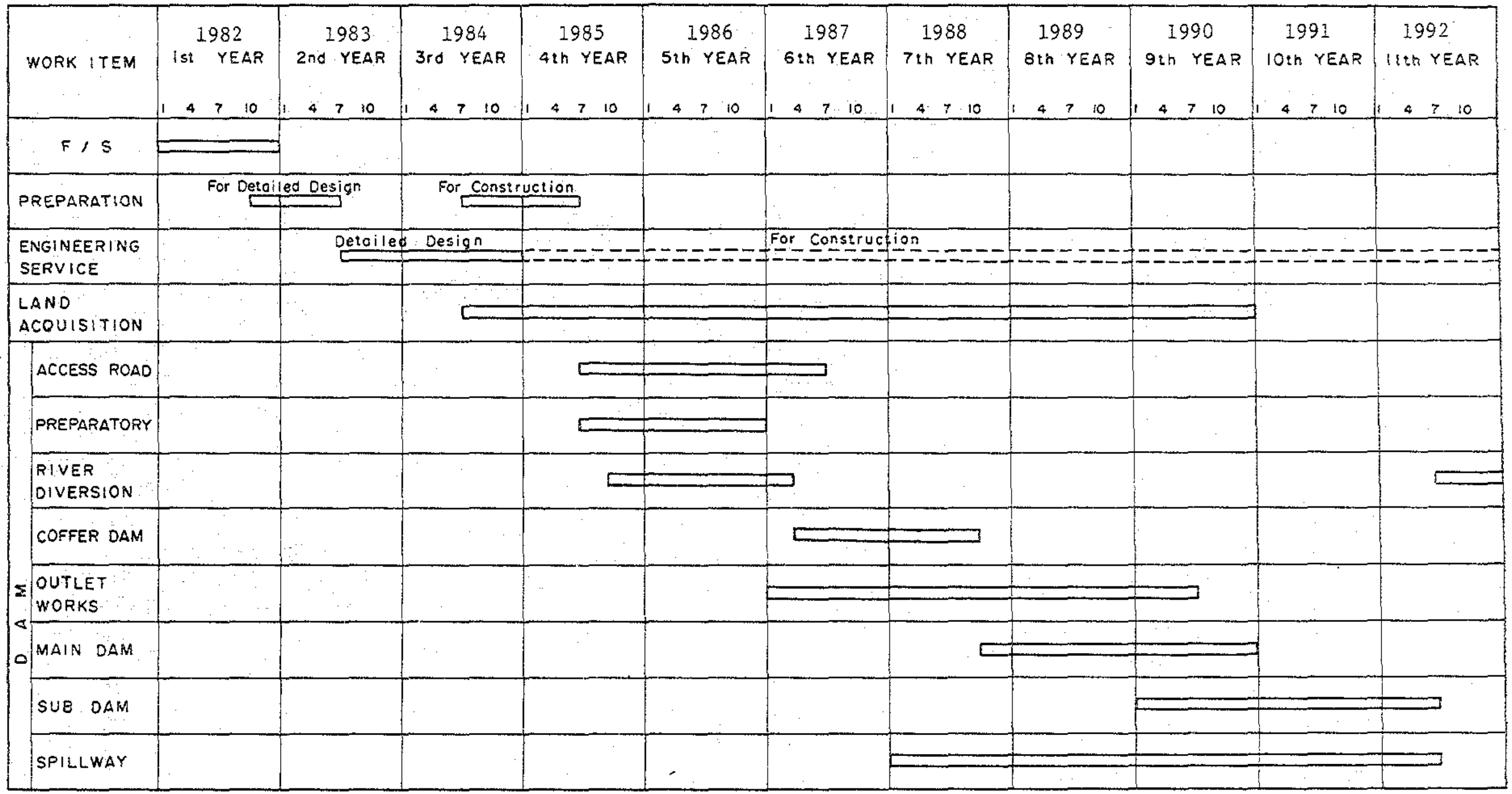


Fig. III-16 CONSTRUCTION SCHEDULE OF BALAT DAM



IV. FLOOD CONTROL

IV. CONTENTS OF FLOOD CONTROL

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1. GENERAL

The riparian area of the Kinabatangan River suffers every year from minor flooding and the lowlands in the Basin are habitually inundated during rainy season. Flood control scheme, therefore, is the prerequisite for smooth implementation of future development plan in the project area.

On the basis of the field reconnaissance over the area, the topographic survey which have been conducted by the authorities concerned of Government of Malaysia, and other data, the analysis of flood control scheme has been made about (1) the selection of optimum flood control measures, (2) optimum share of design flood between these measures and (3) flood control benefit.

2. PRESENT CONDITION

2.1 RIVER BASIN

The Kinabatangan River Basin covers a great part of Kinabatangan District, one of the three Districts of Sandakan Residency, on the East Coast of Sabah State.

The Kinabatangan River with the catchment area of 16,800 km^2 drains the eastern part of Sabah State, which is demarcated within 4°30' - 5°45' North Latitude and 116°25' - 118°40' East Longitude. The main stream of the river has its source in the Witti and the Trus Madi ranges, both of which are branching out from the Crocker Range, the physical spine of the State. The length of the river is about 560 km.

The upper Kinabatangan River is named the Milian River while it is flowing down through the mountainous region being joined by many tributaries and meets the Kuamut River at Kampoung Kuamut; the catchment areas of the Milian and the Kuamut are 6,825 km^2 and 3,140 km^2, respectively. The river flows down in the midst of the Basin joining with the Lokan River and other tributaries and drains into the Sulu Sea. Numerous tributaries are contributing to make the Kinabatangan a mighty river which may be likened to a trunk of giant tree with countless branches (refer to Table IV-1 and Fig. IV-1).

For a distance of 300 km from the mouth of the river, the riparian area is generally flat within the range of 15 m above mean sea level. Remarkable meandering in the middle and the lower reaches helped developing an extensive Alluvial plain due to sedimentation. At the estuary is extending a vast deltaic zone through which several channels branching off from the river are running down towards the sea.

2.2 RIVER CONDITION

2.2.1 River Channel

The existing river course heavily meanders in the middle and lower reaches. The actual river length measured along the meandering course indicates the increasing rate of about 1.5 times compared to the straight reaches.

Since the river has formed itself by driving through the silty soil formation in alluvial plain, the cross-sections present mostly single cross-section with natural eroded valley of which banks rise about 10 m or more high above the river bed. Figs. IV-2 and IV-3 show the location of cross-section survey and representative cross-sections of river channel, which has been conducted by the authorities concerned of the Government of Malaysia, respectively. On the other hand, as illustrated in Fig. IV-4, the river width along the river ranges from 150 m to 200 m.

River longitudinal gradient appears to be about 1/10,000 in the stretch from Balat to Bukit Garam/Barik Manis, 1/15,000 from Bukit Garam/Barik Manis to Sukau and 1/20,000 from Sukau to the estuary.

2.2.2 Present Flow Capacity

The minimum and average values of the present channel flow capacity downstream of Balat are estimated at 1,500 m^3/s and 1,800 m^3/s respectively, by uniform flow calculation, assuming that the coefficient of roughness is 0.03. The distribution of flow capacity is given in Fig. IV-5.

2.2.3 Riparian Facilities

Riparian facilities are scarce along the Kinabatangan river, except perhaps scattered floating stages for small boats, and piers for the ferry connecting Sandakan and Lahad Datu.

2.3 RIVER WATER UTILIZATION

The Kinabatangan River water is being utilized for navigation, irrigation and domestic use. However, the consumption of river water for irrigation and domestic use is extremely scarce.

River water utilization in the basin is almost entirely for navigation. River fishing boat, passenger boat, cargo boat and tag boat are named as kinds of boat for navigation.

2.4 FLOOD DAMAGE

Floods occur almost every year in the Kinabatangan River Basin. Once in several years, a large-scale flood causes loss of life, and considerable damages to the houses, crops and fowls. Therefore, they give great damage and much inconvenience to inhabitants of the Basin.

Although the actual conditions of the flood damage can not be exactly known because of lack of record, it is said that flood in 1963 was the biggest in the past few decades and lasted more than one month.

According to the comparably well-recorded data during the recent ten odd years, flood damage in January 1968 was the biggest, i.e., 8,000 people affected, 193 houses washed away and 700 houses damaged. Table IV-2 shows the flood damage during recent years but they were not estimated in monetary terms.

The inundation area of 20-year flood with discharge of 6,000 m^3/s at Barik Manis is estimated at 107,000 ha, which is illustrated in Fig. IV-6.

3. FLOOD CONTROL

3.1 FLOOD CONTROL SCALE

Design flood for flood control in the Kinabatangan River basin is proposed in magnitude of 20-year probability in due consideration of the following matters.

An appropriate magnitude of the design flood is generally determined taking into account economical and social aspects. Attention to the social aspect should be paid more than that to the economical aspect on a ground that (1) it is recommendable that flood control scale of rivers in Malaysia be standardized in a nation-wide level considering equal distribution of welfare, and (2) since such intangible benefits as reduction of loss of human life, reduction of disease, etc. which might have occurred during and/or after flood, are not incorporated in justifying economical viability of the flood control project, the magnitude of the design flood might be estimated less than the practical.

The standard for appropriate design flood scale in Malaysia, as describe below, has been set forth by the Survey Team for National Water Resources Development Project.

Return Period	Average Annual Damage (M$1000/km)	Population (persons/km)
1) 100-year	Large (20 over)	Severe flooding with casualt
2) 50-year	Large (20 over)	Densely population (500 over)
3) 20-year	Moderate (20 under)	Sparsely populated (500 under)

Judging from prospective developed conditions of the Kinabatangan Rive basin, item 3) above can be applied for the Kinabatangan River.

3.2 STANDARD PROJECT FLOOD

The flood discharge of 20-year return period has been decided on the basis of hydrological analysis in the basin (refer to "Hydrology" Sector). Eventually, the standard project flood discharge has been determined as follows:

Balat damsite	:	5,400 m^3/s
Barik Manis	:	6,000 m^3/s
Estuary	:	6,000 m^3/s

Fig.IV-7 shows the distribution of standard project flood.

3.3 FLOOD CONTROL MEASURE

The measures of flood control for reducing flood damage are enumerated as follows:

1) Dam
2) Floodway
3) River improvement including ring-levee, and
4) Retarding basin

These methods may be adopted either independently or jointly.

For the flood control, it is topographically extremely difficult to find an area suitable for a retarding basin to regulate a flood of 20-year return period along the Kinabatangan River. And also a floodway works has been found less advantageous than dam construction or river improvement works from the viewpoint of the construction cost.

Thus, the river improvement and dam construction were selected as the appropriate flood control measures.

The followings are the findings of comparative studies on a dam, a floodway and river improvements.

Dam

Based on the findings of the study under "Dam" Sector, Balat is selected as the optimum damsite taking technical feasibility, economical advantage and social impact into account. (Refer to Fig. IV-8)

When the proposed Balat dam is constructed with the scale enough to control a flood of 20-year return, a construction cost of US$200 million approx. will be required.

River Improvement

When the method of river improvement is only adopted from estuary to Balat damsite, about 200 km along the River to confine a flood of 20-year return period with discharge of 6,000 m^3/s at Barik Manis, the cost of river improvement is relatively high compared with that of the proposed dam.

The earthwork (excavation of river channel and embankment) volume and cost of river improvement work is estimated at 210 million cubic meter and US$370 million approx. respectively.

The ring-levee which is expected to be effective could not be identified due to lack of precise topographical map. The comparative study for possible application of ring-levee is therefore excluded.

Floodway

On the basis of the findings of the field reconnaissance over the area and the topographic map, scale 1:50,000, the proposed floodway as shown in Fig. IV-8, starting from Sebangan, located on the left bank about 200 km upstream of the estuary, and northeastwards, emptying into the Sandakan Harbour via the channel of the Bode River, is deemed appropriate among some alternative cases.

It is estimated that the excavation volume and construction cost of the proposed floodway will amount to 260 million cubic meter and US$640 million approx. respectively.

The proposed floodway cannot control a flood in the area upstream of the diversion point, while the proposed dam and river improvement can.

Besides the above, the combination measure of river improvement from Balat to Sebangan and the floodway has been studied in order to facilitate the same flood control effectiveness as the dam or river improvement. The excavation volume and construction cost of this combination measure will about 330 million cubic meter and US$770 million approx. respectively.

3.4 OPTIMUM SHARE OF FLOOD CONTROL

For the standard project flood of 6,000 m^3/s at Barik Manis, the optimum share of combination between dam and river improvement work will be determined on the basis of economical performance. To select the optimum share of combination, the total construction cost was calculated for each alternative case as shown below: .

	Discharge at Barik Manis	Regulated discharge by dam
Case 1	1,000 m^3/s	5,000 m^3/s
Case 2	1,500 m^3/s	4,500 m^3/s
Case 3	2,000 m^3/s	4,000 m^3/s
Case 4	2,500 m^3/s	3,500 m^3/s
Case 5	3,000 m^3/s	3,000 m^3/s

In the construction cost estimate mentioned above, the dam is assumed to be a single-purpose dam meant for flood control. As for river improvement work, it is assumed that banking and excavation of the existing channel are basically employed.

Fig. IV-9 shows the relationship between the construction cost and the discharge to be confined in the river channel at Barik Manis, derived from the calculation results for each alternative case.

Based upon this relationship, it has been arrived at that the river channel should control a discharge of 1,500 m^3/s in view of striking the most economically balanced combination of dam construction and river improvement work in the total cost. As the result, the flood control would be taken care of by the dam, and river improvement will not be required, since the present river can accommodate the flow of 1,500 m^3/s.

3.5 DESIGN FLOOD

Based on the aforementioned studies, the distribution of design flood as shown in Fig. IV-7 will be made as follows:

	Before regulation of dam	After regulation of dam
Balat	5,400 m^3/s	900 m^3/s
Barik Manis	6,000	1,500
Estuary	6,000	1,500

4. FLOOD CONTROL BENEFIT

Flood control benefit is defined as the flood damage reduction in the area downstream of proposed damsite due to implementation of the project. The annual benefit is given as the reduction in annual damages; and annual damages are obtained by multiplying the total damage potential by the probable flood rate.

Flood damage consists of direct damage indirect damage and intangible damage. Direct damages are defined as the monetary expenditure required, or which would be required, to restore the flood damaged property (buildings and interior effects and farm crop) to its pre-flood condition. Indirect damages include the net monetary cost of evacuation, relocation, lost wages, lost production and lost sales. Intangible flood damages are defined as flood effects which cannot be measured in monetary terms. In this study, only the direct damages to buildings and interior effects and the indirect damages are assessed and evaluated.

The mean annual flood damage is determined by summing up the potential direct damage (from floods of different frequencies) plus the potential indirect damage (estimated by applying an indirect damage rate).

Annual flood control benefit is estimated at US$290 thousand by calculating the total flood damage potential under with and without the project conditions.

The estimated annual damages to buildings and interior effects in the project area are tabulated below and its breakdown is shown in Table IV-3.

(unit: 10^3US$)

		Expected Damage	
		Without the project	With the Project
Building & Interior Effects	Direct	257	5
	Indirect	39	1
Total		296	6
Damage Reduction (Benefit)		296 - 6 = 290	

The damage estimation is based on the following assumptions:

1) Buildings and interior effects

The damage rate of 0.2 to buildings and interior effects was constantly applied for the flood damage estimation, regardless of the difference of flood discharge.

2) Farm Crops

The agricultural area existed in the project area at present is too small that damage estimation to farm crops was excluded in this study.

3) Indirect damage

The indirect damage to buildings and inteiror effects is fixed at 15% of direct damage.

T A B L E & F I G U R E

Table IV-1 MAJOR TRIBUTARIES OF THE KINABATANGAN RIVER

Tributary	Confluence from Estuary, km.	Length, km.	Catchment Area, km^2.
Lokan	220	150	1,460
Kuamut	298	180	3,140
Karamuak	357	90	680
Imbak	370	70	460
Tongod	396	60	660
Pinangah	434	130	1,300

Table IV-2 FLOOD DAMAGE

Item	Year						
	1968	1971	1974	1976	1977	1980	1981
Farmland:ha (acre)	*	*	*	*	58 (144)	11 (28)	227 (567)
Affected people : nos	8,000	5,000	*	*	2,500	*	*
Dead or lost : nos	*	*	*	13	*	*	1
House : nos							
-Washed away	193	*	3	*	20	1	>130
-Broken	700	*	*	*	>400	6	
-Inundated		*	*	*		123	300
Fowl : nos	*	*	*	*	1,090	*	*

Note : This is compiled based on the recods collected from Drainage & Irrigation Dept., District Office, and Relief Committee.

* No data available

Table IV-3 ANNUAL EXPECTED DIRECT FLOOD DAMAGE REDUCTION

1	2	3		4		5	6 (4 x 5)	
Return Period	Discharge (m^3/s)	Flood Damage (10^3US$)		Average Damage (10^3US$)		Expected Value	Expected Damage (10^3US$)	
		Without Dam	With Dam	Without Dam	With Dam		Without Dam	With Dam
1/1.2	1,500	0	0					
				265	0	0.633	168	0
1/5	3,890	531	0					
				531	0	0.100	53	0
1/10	4,840	531	0					
				531	0	0.050	27	0
1/20	6,000	531	0					
				531	265	0.017	9	5
1/30	6,450	531	531					
						Total	257	5

Fig. IV-1 PROFILE OF THE KINABATANGAN RIVER AND TRIBUTARIES

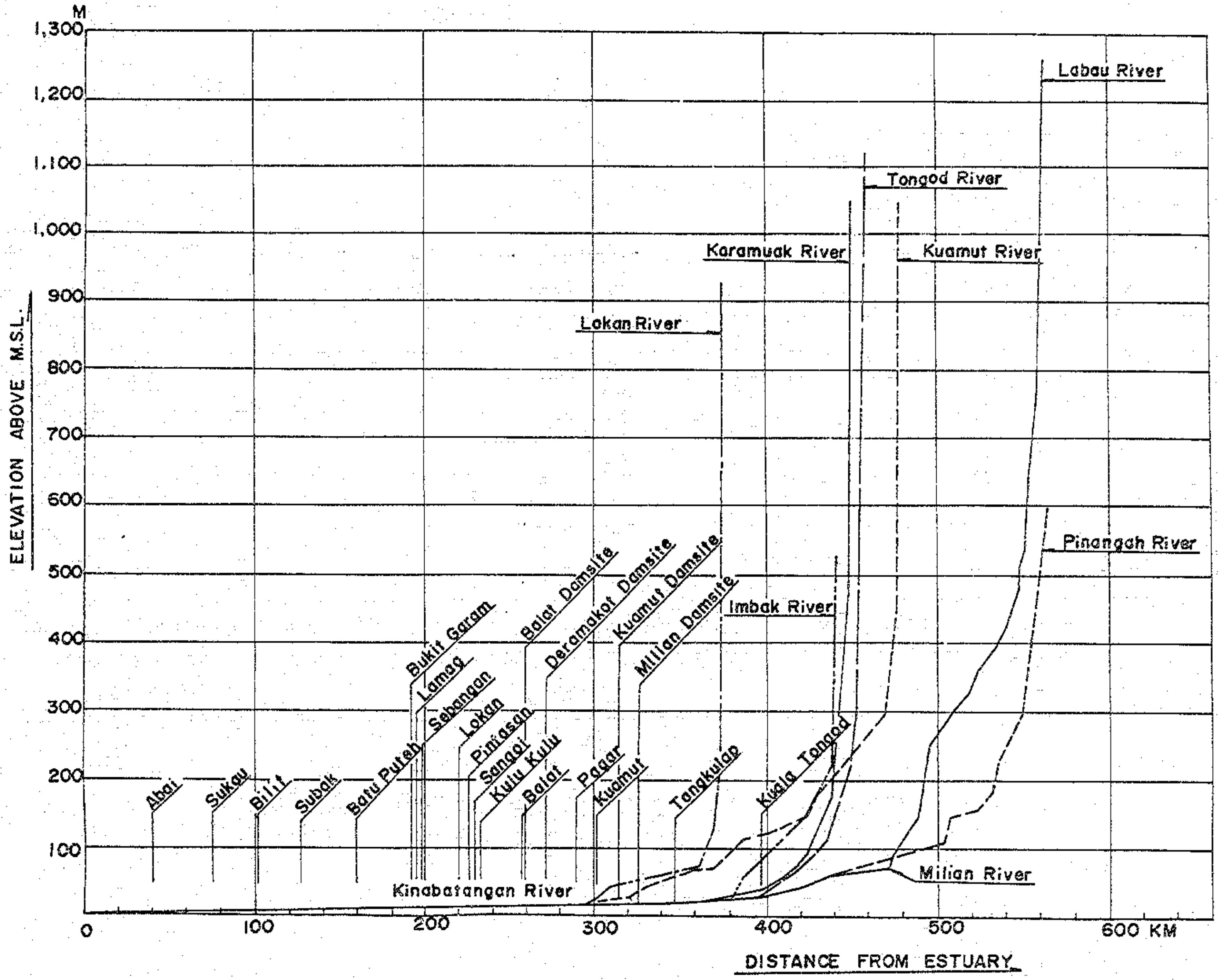


Fig. IV-2 LOCATION OF CROSS-SECTION SURVEY

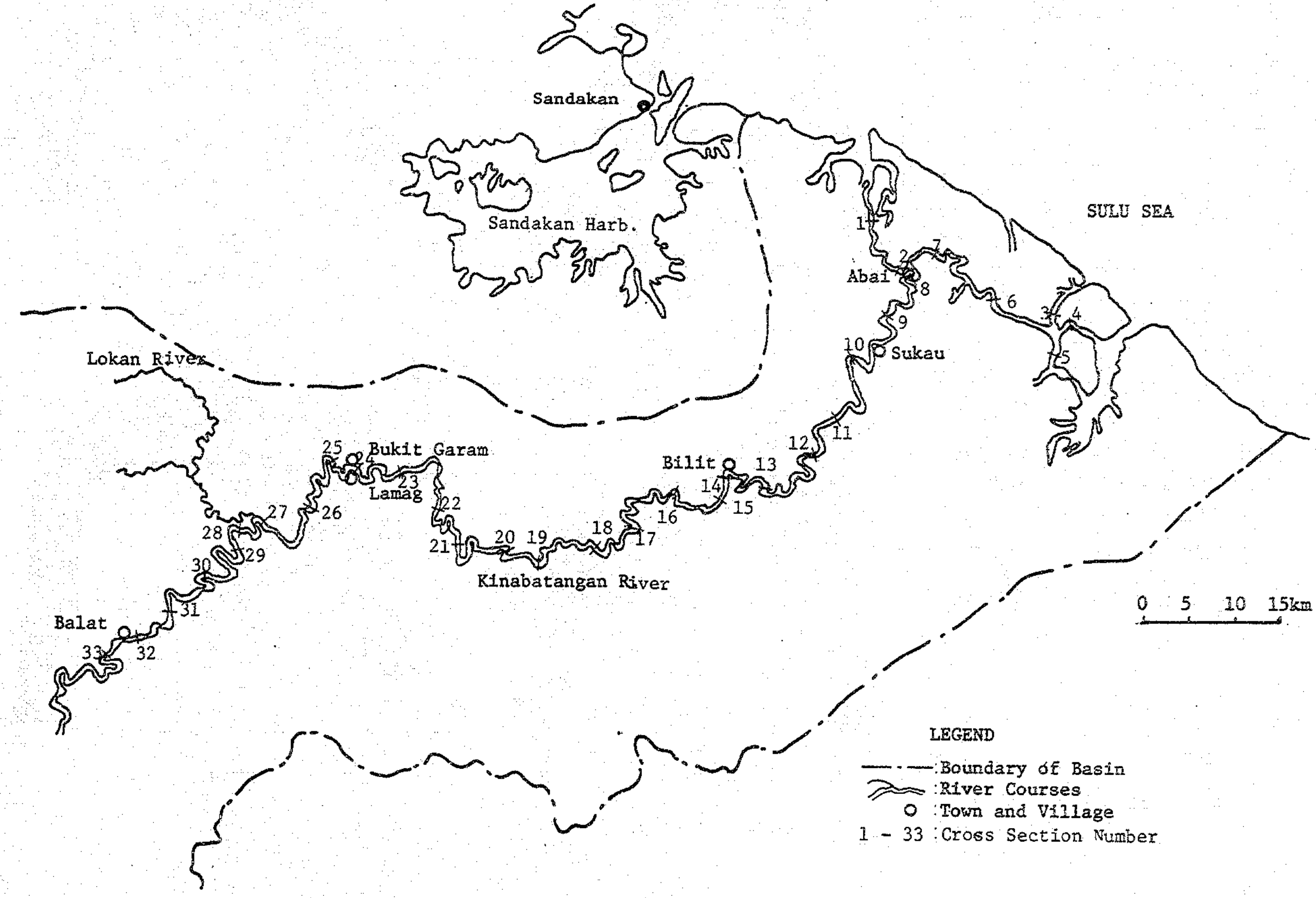
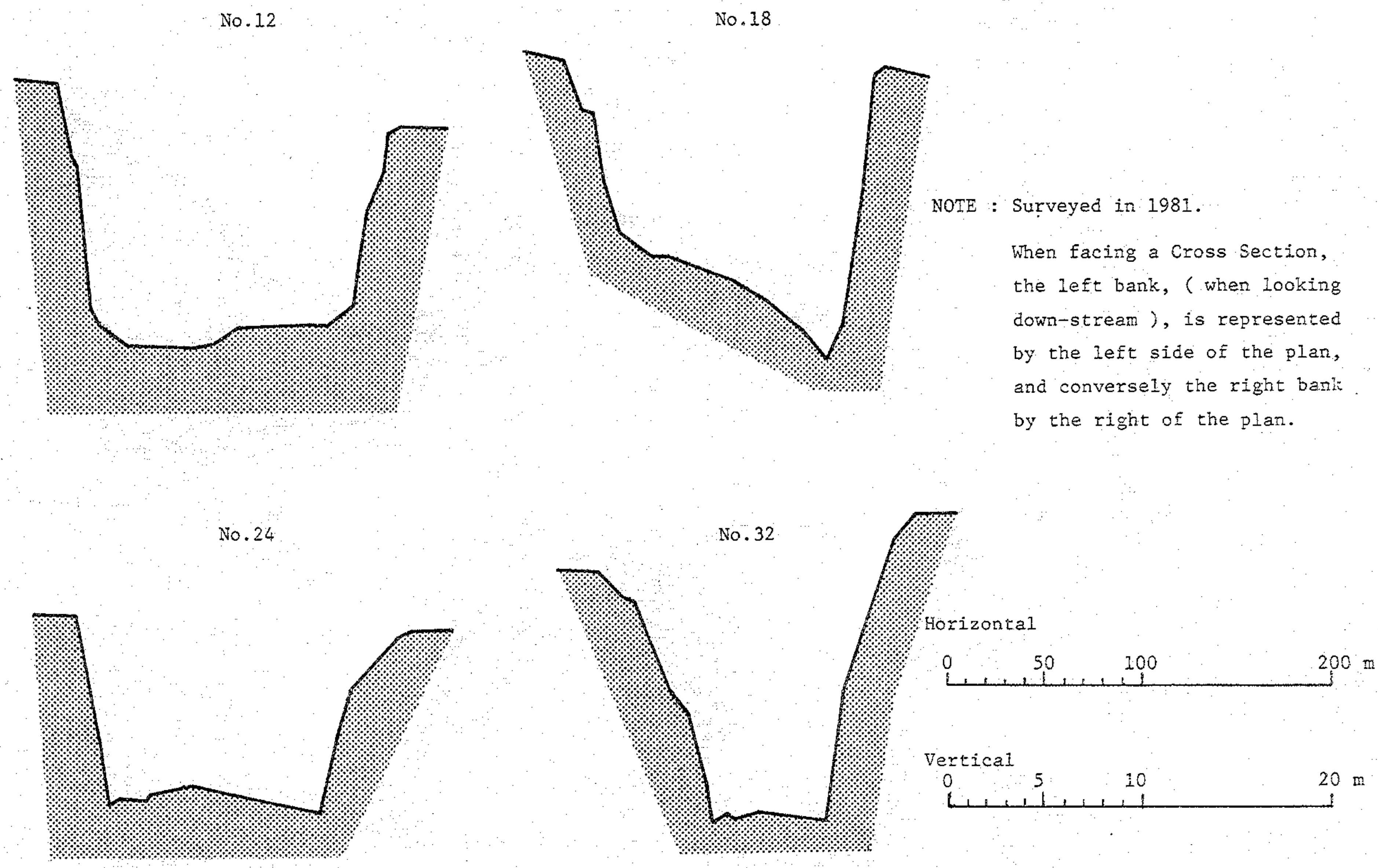


Fig. IV-3 CROSS-SECTION OF THE RIVER CHANNEL



NOTE : Surveyed in 1981.

When facing a Cross Section, the left bank, (when looking down-stream), is represented by the left side of the plan, and conversely the right bank by the right of the plan.

Fig. IV-4 CHANNEL WIDTH DISTRIBUTION

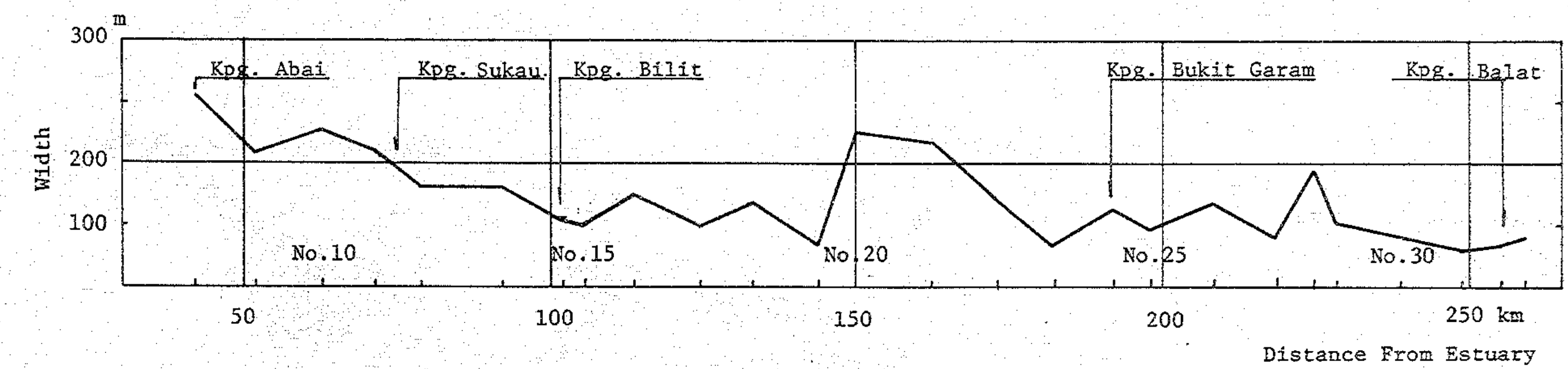
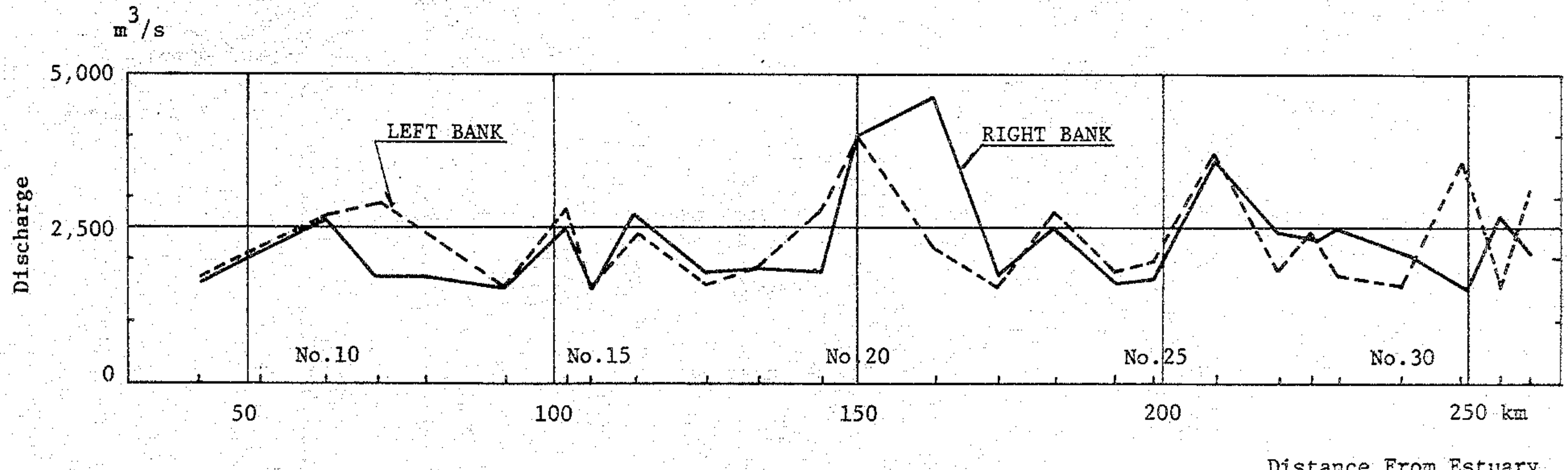


Fig. IV-5 PRESENT FLOW CAPACITY



NOTE : No.n is the number of cross section.
Location of cross section shown in Fig.VI-2.

Fig. IV-6 INUNDATION AREA IN THE LOWER BASIN

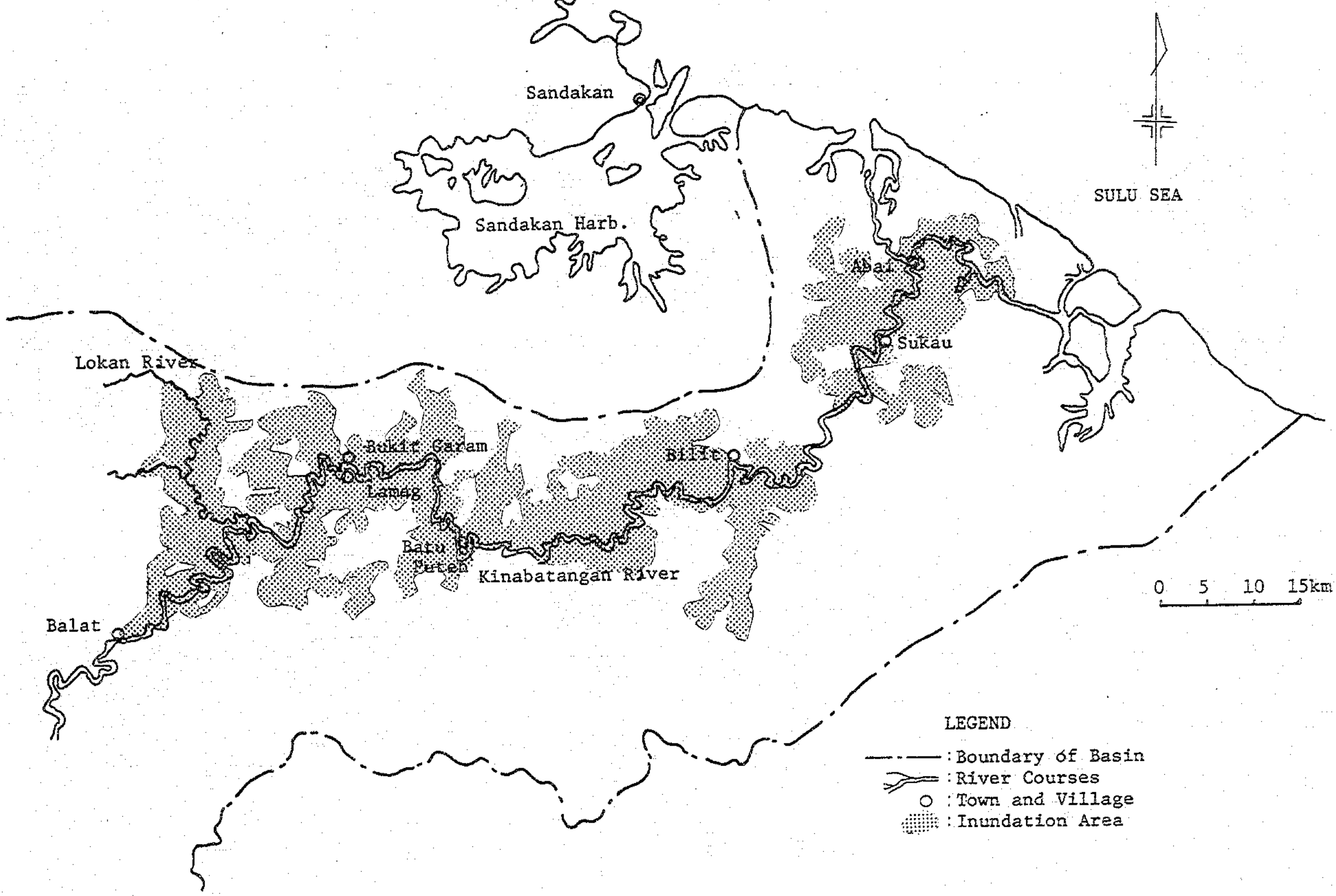
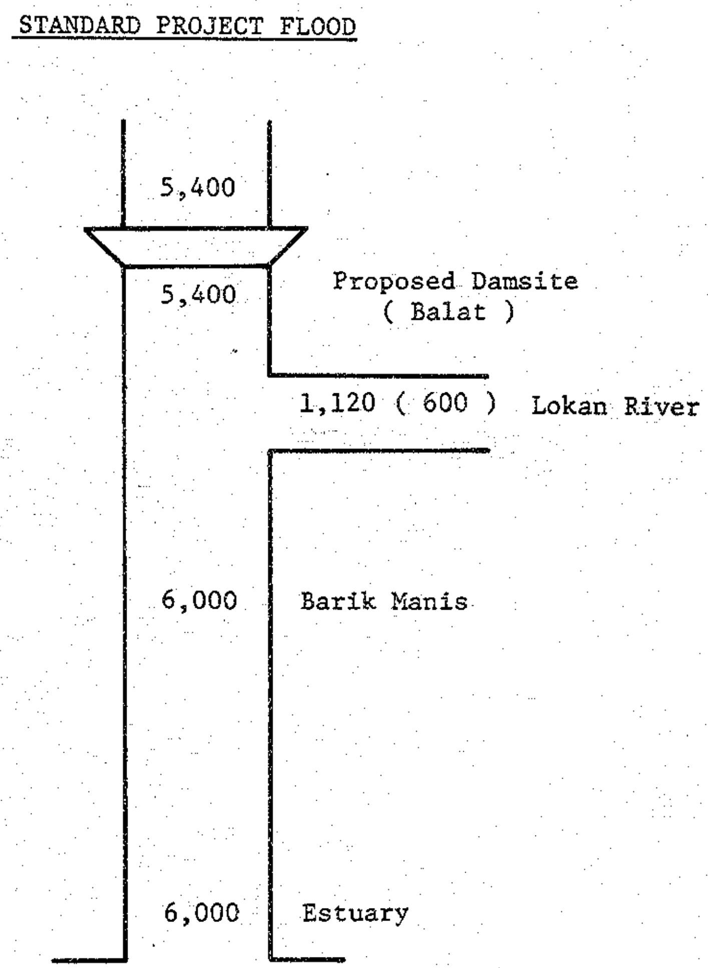


Fig. IV-7 STANDARD PROJECT AND DESIGN FLOOD DISTRIBUTION

Unit : m^3/s



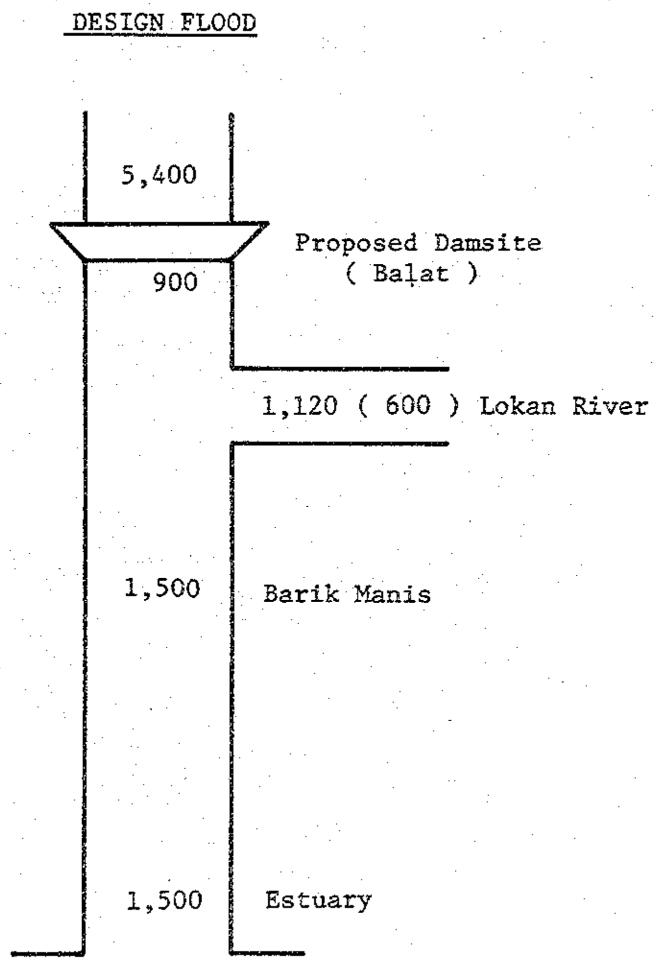


Fig. IV-8 LOCATION OF POSSIBLE FLOOD CONTROL FACILITIES

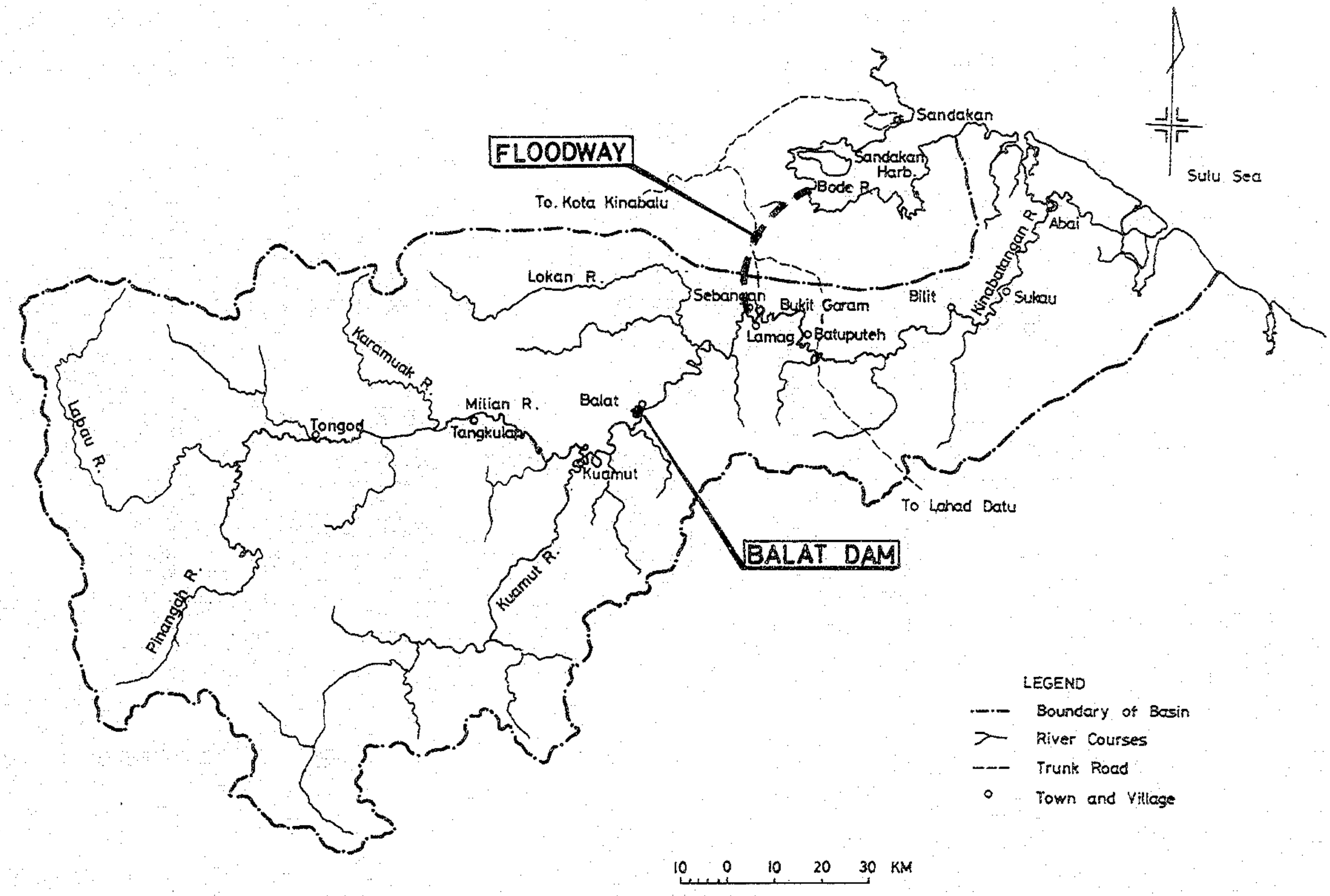
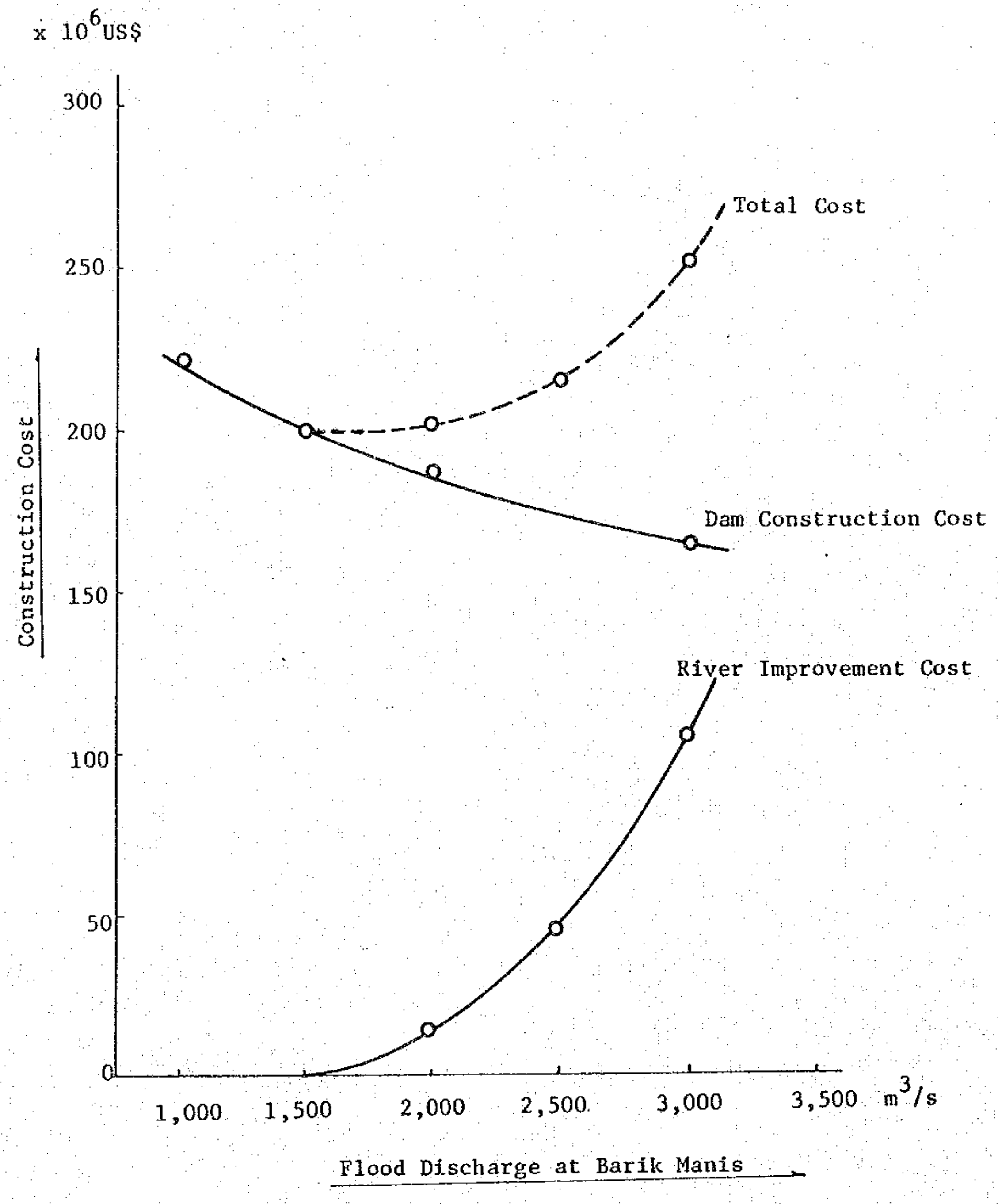


Fig. IV-9 LEAST CONSTRUCTION COST OF DAM AND RIVER IMPROVEMENT



V. AGRICULTURE AND IRRIGATION

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1. GENERAL

As for the agricultural development plan in this project, the study is conducted from the socio-economic and technical view points.

As the result, a plan for paddy production under irrigation is proposed in the net area of 44,000 ha which is to be relieved from flood damage after dam construction.

An overall approach has been made in conducting the study is in several sectors concerning agricultural development such as the soils, existing agriculture, land development plan, agricultural production plan and the development cost.

2. SOILS

2.1 SOIL SUITABILITY

The description of a variety of the types of soils and their parent materials available in the area is found in "The Land Resource Study, The Soils of Sabah, Vol. 2, Sandakan and Kinabatangan Districts", and "The Land Capability Classificaiton of Sabah" has also been compiled from the results of the soil survey and related studies in the past.

According to these reports, the Kinabatangan River Basin holds very extensive agricultural soils which are classified into five groups from their agricultural suitability. Group 1 soils which have no limitation for agricultural development does not occur in the Kinabatangan Basin area. Group 2 soils with high potential have a wide distribution in the Basin. (For details, refer to Table V-1 and Fig. V-1). The other two classifications, Group 4 and Group 5 soils, are not suitable for agriculture. The former is to be intended for mining and the latter has no practical use (refer to Table V-2).

The details of classification are as follows:

1) Soil Suitability Group 1; Soils with no limitation

These are generally deep, permeable and well aerated soils with good reserves of moisture; they are either well supplied with plant nutrients or readily responsive to fertilizers. They are developed on level or almost level land where the upper slope limit is 5°. Having no limitation to agricultural development, the soils are capable of growing a wide range of crops.

2) Soil Suitability Group 2; Soils with few minor limitations

The limitations may include, along or in combination, imperfect or poor drainage with a watertable occurring for a significant proportion of the year, within 120cm (48in) of the surface, rock or similar impenetrable materials occuring between 50cm (20in) and

120cm (48in) of the surface, extreme coarse textures, or moderate slopes generally falling within the 5 to 15° range which would not require any expensive form of antierosion control or shallow peat deposits never more than 50cm (20in) in depth. Although a wide range of crops can be grown on such soils, the choice is generally more restricted compared to Group 1 soils.

3) Soil Suitability Group 3; Soils with one serious limitation

This includes soils which are a little limited for agricultural development in comparison with Group 1 and Group 2 Soils because they are on sharply sloping land in the 15 - 25° range, soils on deposits of peat varying in depth from 50cm (20in) to 120cm (48in), very poorly drained soils in which swampy conditions sometimes prevail, very poorly structured soils, or soils with a very restricted rooting space due to rocks at shallow depths i.e. within 50cm (20in) of the soil surface, or soils showing acute plant nutrient deficiencies. This group also included alluvial soils subject to regular river floods, and unless the flooding is controlled they cannot be recommended for agricultural development.

4) Soil Suitability Group 4; Soils with more than one serious limitation

This would commonly include, for example, shallow soils developed on sharply sloping sites, or shallow soils with acute mineral deficiencies and highly indurated subsurface horizons such as found in many podzols, also very poorly drained soils which because of their especially low-lying nature on main river flood plains receive the maximum effect of floods, and saline soils in which permanent swampy conditions prevail. These disadvantages greatly restrict the range and yield of crops, and result in a considerable risk element for agricultural enterprise, even under a high standard of management.

5) Soil Suitability Group 5; Soils with at least one very serious limitation

This would include soils developed on steep lands in which slopes greater than 25° predominate, extremely stony, rocky and boulder-strewn soils or bare rock, soils with toxic levels of certain elements, and peat soils deeper than 120cm (48in). Agriculture on such soils would generally be prohibitive, but they have a wide range of capability for forestry, hydrological or wildlife and conservation purposes.

2.2 SOIL GROUPS 2 AND 3

The land which occupies an extensive area in the middle and lower reaches of the Kinabatangan River Basin consists mostly of the soils which belong to Group 2 and Group 3, but it will have to be taken note of that some of this land is subject to habitual flood damages at present.

The details of soil associations belong to Soil Group 2 and Group 3 are as follows (refer to Figs. V-1, V-2 and V-8):

Soil Group 2

1) Rumidi Association (26)/1

The majority of soils are formed from mudstone and sandstone often in the form of mixed colluvium. Mudstone and sandstone are particularly common near the Sungai Segaliud, Sungai Dumundong, Sungai Koyah and north of the Labuk road. The miscellaneous rock types are rarely extensive but tuffite is common near Sandakan, at Sungai Manila and east of the Sungai Samawang. Pebble deposits occur sporadically and are considered to be remnants of former terraces. In addition, alluvium occupies the main valley floors; this is normally fine-textured, but coarse-textured deposits occur adjacent to sandstone hills.

2) Silabukan Association (25)

The soils are developed on those parts of the Tanjong and Sandakan Formations where mudstone is predominant, but is interbedded with sandstone. Quartz and sandstone pebbles, often in the form of stonelines, occur sporadically and are considered to be colluvial remnants of once more extensive terrace deposits; they have been observed north of the Kinabatangan at Lamag, north of Sandakan and in the Lokan valley. In addition both fine- and coarse-textured alluvium occur on the valley floors.

3) Lungmanis Association (22)

Parent materials comprise mudstone and rare sandstone; they are bedded in the Lungmanis, Latangan, Lamag and Lumerau areas but elsewhere occur in slump formation. Sporadic pebble deposits on low hills at Dagat and in the Koyah and Segaliud valleys suggest that some areas may well be terrace remnants. Fine-textured alluvium occurs on the alluvial flats.

/1 : Key number

4) Tapang Association (20)

Parent materials are considered to be old alluvia derived mainly from basic and ultrabasic rocks which form the surrounding hills; these deposits are fine textured and stoneless. Outcrops of basic rocks are confined to incised lower slopes and to low hills above the general terrace level.

5) Semporna Association (21)

The parent material is coralline limestone of the Togopi Formation. This outcrops on minor hillocks and valley sides and fragments also occur on the soil surface.

6) Tungku Association (17)

It occurs on a low level coastal plain rising very gradually to the west. The soils are formed on calcareous alluvium which is predominantly fine-textured and underlain by coral or coral debris. The depth of this alluvium is aobut 120cm (48in) and outcrops of coral are confined to the sides of minor streams and stream beds. Deposits of more recent alluvium occur adjacent to the larger streams.

7) Tuaran Association (4)

In general, the levees are formed from coarse-textured deposits of sand with layers of silt of variable thickness and frequency; meander scrolls consist of low ridges and swales and they are composed of alluvium which is predominantly medium- to fine-textured, being finer in the swales; meander scars comprise infillings of fine-textured alluvium and old cut-off are in different stages of infilling with predominantly fine-textured deposits.

8) Labau Association (10)

Parent materials are predominantly moderately fine -to coarse-textured, often stony, alluvium derived wholly from sedimentary rocks except in the Kuamut valley, where it is derived in part from igneous rocks.

9) Karamuak Association (9)

Parent materials comprise mixed alluvia derived form basic, ultrabasic and sedimentary rocks. This is of variable texture, is rarely stony and lacks concretions. Coarse-textured alluvium with pebble beds is restricted to narrow floodplains, levees and eyots.

Soil Group 3

1) Dalit Association (31)

Parent materials comprise interbedded reddish brown sandstone and mudstone on the low hills and mainly coarse-textured alluvium on the flats. In addition, in the Mananam Plain some low hills are composed of medium-textured old alluvium representing terrace remnants.

2) Tenghah Nipah Association (32)

Parent materials comprise interbedded coarse soft sandstone and mudstone of the Ganduman Formation. In the narrow valleys coarse- and medium-textured alluvia have been deposited.

3) Kalabakan Association (29)

It is formed on low hills and ridges with a relief amplitude of about 60m (200ft) and slopes in the 10° to 20° range. These hills are composed of mudstone and sandstone identical to those in the Silabukan Association; mudstone is dominant, but sandstone is more common than in the Silabukan Association.

4) Kretam Association (33)

Parent materials comprise sandstone, mudstone and miscellaneous rocks in the Kuamut, Garinono and Chert-Spilite slump formations. Sandstones are dominant and profiles formed on stony sandstone colluvium are widespread. The miscellaneous rocks include serpentinite, spilite, tuffite, gabbro, dolerite, limestone and chert. These occur as erratics in regolith derived largely from sandstone, as minor outcrops, cappings, or as distinct knolls with steep slopes and stony surfaces.

5) Dagat Association (35)

Parent materials include tuffaceous rocks, mudstone, sandstone and slump deposits which are included in the Ayer Formation. Tuffite, which is dominant between the Segama and Tabin, varies considerably in particle size and constituents and in many cases has the appearance of a soft white sandstone. Black mudstones are dominant to the east of the Tabin. The majority of profiles are formed on deposits of colluvium in the east of the Tabin. The majority of profiles are formed on deposits of colluvium derived from these rocks and soils derived from rocks in situ are comparatively rare.

6) Sinarun Association (16)

Parent materials comprise deposits of medium- to fine-textured, sometimes pebbly, alluvium which overlines mudstone and sandstone. The majority of low hills have cappings of alluvium and the mudstone and sandstone outcrop on the lower slopes; on some hills cappings of alluvium have been completely removed. Alluvium in the valley flats is medium- or coarse-textured.

7) Brantian Association (12)

Old alluvium is the dominant parent material and this normally rests unconformably on interbedded sandstone and mudstone; rarely are the deposits thin enough for the rock to be exposed in soil profiles. The alluvium is mainly medium, rarely fine, in texture and in places contains variable amounts of pebbles. Deep pebble deposits also occur. The pebbles are mainly of quartz and sandstone but in addition are formed of chert in the Kuamut area, acid igneous rocks and chert at Tomanggong and basalt in the Mananam Plain. Alluvium at floodplain level varies from coarse to fine in texture.

8) Kinabatangan Association (5)

Parent materials comprise medium- and fine-textured alluvium. Coarse-textured alluvium occurs adjacent to sandstone hills, from which it is derived, and to the east of Dewhurst Bay, coarse-textured deposits of old beach bar formations are overlain by fine-textured alluvium.

9) Usukan Association (2)

Parent materials consist of coral debris overlying coral; the coral debris includes shells and shell fragments, varying from medium to coarse gravel in size. Swales and back-swamps are infilled with medium- to coarse-textured alluvium, which also contains abundant coral fragments. Small rock outcrops may also occur; examples include agglomerate on Selingan, sandstone on Libaran and chert to the north of Libaran.

2.3 SOIL ASSOCIATION AND AGRICULTURAL DEVELOPMENT

Each soil association in and around the project area and its suitability for agricultural development is summarized as follow:

2.3.1 Unsuitable Land

Land which is considered unsuitable for agricultural development includes land with very severe slope limitations, land with severe drainage and flooding limitations and land with severe nutrient imbalance. The most soil associations are included in Group 4 and Group 5 (see Table V-2).

2.3.2 Marginally Suitable Land

Large areas of the Kinabatangan District consist of land which is marginal in terms of suitability for agricultural development, but as in the case of land which has very severe limitations some of these marginal areas are already being used for agriculture. Eight soil associations are marginal for agricultural development because they have slope limitations (see Talbe V-1).

The Brantian Association is formed on terraces in varying stages of dissection with moderate to steep slopes on terrace edges. The terrace tops are generally level and only where Gleyic Podzols occur is the land quite unsuitable for development, minor limitations common to all sites result from the strongly leached and acid Acrisols with additional limitations of stoniness where pebble deposits occur.

The Kretam and Kalabakan Associations have short moderate to steep slopes and additional minor limitations. The Kretam Association has stony soils and large boulders are common in some areas; a further hazard to development is the unstable nature of the parent material which is prone to slumping when disturbed, for example, during road construction. Oil palm has been planted, however, at Tomanggong and Ulu Dusun and while growth is good, problems of erosion are being experienced on steeper slopes at Ulu Dusun. Mudstones are more common in the Kalabakna Associaiton, but slopes are moderate to steep and the presence of Luvisols is only a marginal advantage over the Acrisols of the Dalit Association. These Associations, which are marginal in development terms, are most suited for tree crops and both rubber and oil palm are already established in parts.

These soil associations above-mentioned are mostly included in Group 3.

2.3.3 Suitable Land

Land which has only minor limitations and which is eminently suitable for agricultural development is found in the Silabukan, Rumidi and Lungmanis Associations (see Table V-1).

The minor limitations to the agricultural use of land in the Lungmanis, Rumidi and Silabukan Associations are the slopes of the hills and imperfect to poor drainage in the valleys. Drainage limitations are more significant on alluvial flats in the Lungmanis Association, but while soils are similar to those in the Kinabatangan Association, the risk of flooding is less as most areas occur at greater distances from the main rivers. In the Sandakan hilly areas have been planted with rubber and others are currently being planted with oil palm.

These soil associations above-mentioned are included in Group 2.

The Kinabatangan Association consists of generally poorly drained soils with sporadic swampy conditions and the Tuaran Association comprises a range of soils where additional minor limitations include those of excessive drainage. It is on land included in these two associations that the local people subsist on annual crops, but none of these associations can be recommended for agricultural development in the foreseeable future. However, if measures are taken to control flooding and largescale drainage systems are installed then areas covered by the Tuaran and Kinabatangan Associations could be made available for agriculture; the area would be suitable for wet rice.

3. EXISTING AGRICULTURE

3.1 STATE AGRICULTURE

The agricultural sector plays a relatively small but increasingly important part in the external trade economy. However, in the internal economy it has a more important role in providing employment and a means of livelihood for a large part of the population. As Tables V-3 and V-4 show, oil palm is by now the most important crop with rubber, coconuts and cacao, the only other significant crops. Oil palm is mainly grown on large private estates and Government settlement schemes, while rubber and coconuts are generally grown on small to medium sized holdings. Cacao is a relatively new crop and its cultivation is at present limited. In the central parts of the State, there is shifting cultivation of rice, tapioca and maize. Although many people are involved, this cultivation plays little or no part in the cash economy.

3.1.1 Export of Products

Four major crops, except paddy, such as oil palm, cacao, rubber and coconuts are concerned in export of primary agricultural products such as palm oil, palm kernel, cacao beans, rubber and copra.

However, oil palm products and cacao are increasing rapidly while rubber and copra productiion has remained fairly constant. These figures are supported by the planting area indicated in Table V-4.

3.1.2 Imports of Agricultural Products and Materials

Agricultural Products

The most important import commodity is rice of which 68,000 tons were imported in 1980 (see Table V-53). Other imports of selected agricultural products are maize, groundnuts, sugar, pineapples, soya bean and chillies (see Table V-5).

Fertilizers and Chemicals

The introduction of modern agricultural technologies requires more fertilizers and chemicals. Therefore, importing of those commodities is increasing year by year because there are no production factories in Sabah (see Tables V-6 and V-7).

Farm Machinery

Farm machinery is also imported from abroad. However, the amount of imported machinery is still at a low level (see Table V-8).

3.2 AGRICULTURE-RELATED SECTORS

3.2.1 Livestock Industry

The livestock industry is at present mainly in the hands of private small holders. Rural Development Corporation (KPD) has, however, become actively involved in recent years, particularly through the import of cattle and the introduction of dairying.

The introduction of improved genetic material of livestock into Sabah and the subsequent establishment of breeding and multiplication units have enabled private livestock producers to partcipate in the livestock industry. The kampon type poultry, pig, duck, goat and cattle could be upgraded through the small commercial private farms in the rural areas. Livestock population figures in the State are given in Table V-9.

There is a trend of change from the traditional livestock raising practices to the adoption of modern technology in animal husbandry. The availability of credit facilities and marketing agency has also injected new hope for progress to those livestock producers who are aware of the need to supply more animal protein among the rural folks and the populace of the State in general.

At present, Sabah is practically self-sufficient in pork (93%), in poultry meat (93%), and in eggs (90%). Only about 25% of mutton requirements are supplied by locally raised sheep. About 24% of beef is imported and 80% of it are live cattle imported for slaughter from Australia./1 The number of livestock slaughtered in 1979 are shown in Table V-10.

3.2.2 Inland Fishery

Environmental conditions are suitable for the culture of several indigenous species and for the culture of high value exotic species. The Department of Fisheries has been actively encouraging the development of fresh-water fishponds, offering grants to those who build new ponds and subsidizing the import, production and distribution of fish fry. The number of ponds, their total area, and the number of fish fry distributed annually have all been increasing steadily over the past 18 years (see Tables V-11, V-12, V-13 and V-14).

3.2.3 Forestry

Forestry is the most important single sector in terms of its contribution to Sabah economy, although it currently employs only 5.5 per cent of the labour force. In 1978, it was responsible for 34 per cent of the Gross Domestic Product, and 65 per cent of the State revenue. It also contributed 45 per cent of Sabah's total export earnings./2

/1 : Sabah Regional Planning Study (SRPS), Final Report 2, Productive Sector Studies.

/2 : Source: SRPS