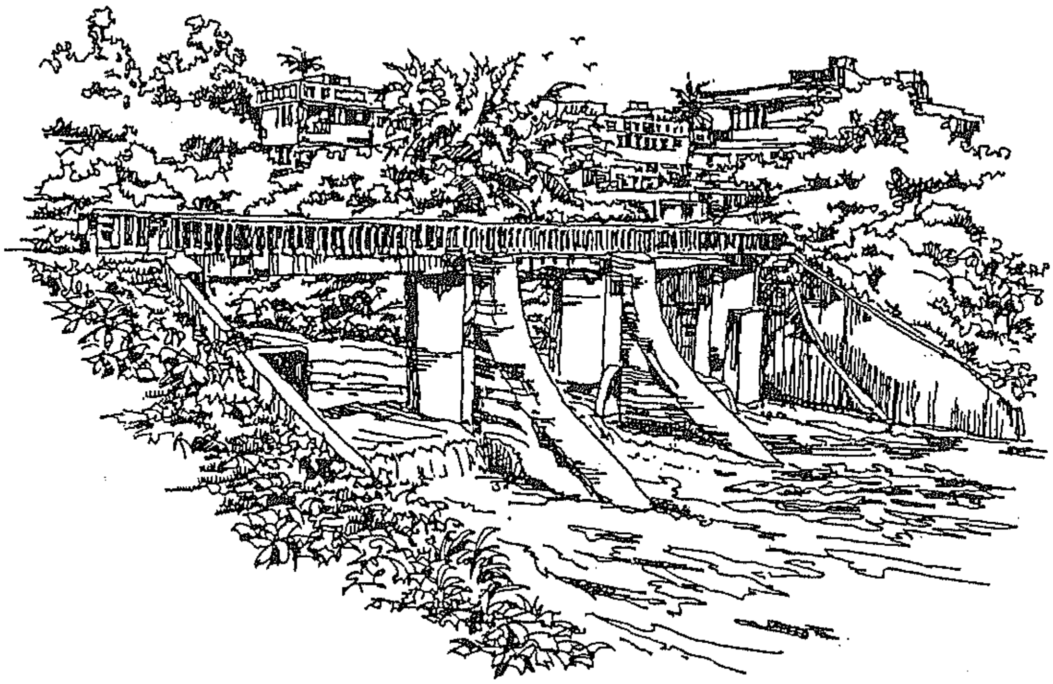
APPENDIX E: PRESENT CONDITIONS OF THE KLANG RIVER AND THE BASIN



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1. GENERAL DESCRIPTION OF THE BASIN

The Klang River basin with a catchment area of 1,288.4 km^2 occupies the central third of Selangor State on the west coast of Peninsular Malaysia.

The basin is bounded by latitudes of 2°55'N and 3°25'N and longitudes of 10°20'E and 10°50'E. It extends roughly for 55 km from the north to south and 56 km from the east to west. The seaward edge of the basin faces the Straits of Malacca to the West.

The 120 km long Klang River originates in the main range at an altitude of 1,330 m in the east of the Basin. It then follows a predominantly southwesterly direction, flowing past Kuala Lumpur, then turns west after Puchong Drop, and drains into the Straits of Malacca.

There are two major tributaries in the upper basin. These are Gombak and Batu Rivers, which merge into each other before joining the Klang River in the City Center.

In the upper basin, approximately 15 km upstream of the City Center, there are the Klang Gates Dam and the Batu Dam. Above the dam sites, the terrain is mountainous with fairly steep slopes. In some of the lower areas, there are rubber plantations and other cultivated vegetation, but for the most part, the mountains are covered by tropical jungle.

The metropolitan area of Kuala Lumpur stands at the heart of the Klang River basin. There is a broader flood plain here, providing available space for what has become the largest concentration of population in the nation. Besides being the capital city and center of government, Kuala Lumpur is also the center of industry and commerce. Consequently, it is also the hub of significant transportation and communication networks.

Urban and suburban types of development extend in some places to the tops of the low hills and within 2 to 3 km of the dam sites. These developments, together with the refilling of many ex-mining ponds, have brought about the severe problem of increased rainfall run-off and the accompanying land erosion.

In the lower stretch downstream of Kuala Lumpur, the topography is low and rolling. The hills are mostly covered by rubber and oil palm plantations with isolated spots of original jungle type vegetation scattered throughout. The low lying areas are used in a number of ways, but are mostly under cultivation.

The river in this section is continuous with a well defined bed. The lowest stretch of the basin near the river mouth is occupied by flat coastal plains where mangroves flourish along the water edge with coconut palms further inland. Here, the Klang River is meandering in its path. General area map of the Klang River is shown in Fig. E-1.

2. PRESENT CONDITIONS OF RIVERS

The Klang River and its two main tributaries, the Gombak and Batu Rivers are characterized by relative smooth bed slopes, as illustrated in Fig. E-2. The system drains a total catchment area of 1,288.4 km^2. Broadly speaking, the Klang River can be classified into three stretches, namely an upstream stretch with steep slope, a middle stretch between confluence with the Gombak River and a point at about 10 km downstream of the Puchong Drop, where a slope transition occurs, changing from the steep slope of approximately 1/2,300 and a lower stretch downstream with relatively gentle slopes, where the bed slope of the river further decreases gradually from approximately 1/2,300 to 1/10,000 at the river mouth.

The Gombak and Batu Rivers possess only a single upstream stretch, with characteristics similar to that of the upstream stretch of the Klang River.

Longitudinal river profiles and cross sections had been obtained throughout the entire length of the Klang River, with no reports of active meanders.

Local erosion occurs at meanders along the middle stretch, while bank erosion in the lower river stretch is probably affected by tidal action. Soils loosened from banks in the lower river stretch may be contributing towards siltation at the river mouth, while formation of sand bars and shoals in the upper and middle river stretches are largely affected by sediment deposits from housing development sites.
The existing river reserve for downstream stretch of the Klang River is illustrated in Fig. E-3.

(1) Upstream River Stretch

a) Upstream Stretch of the Klang River

The upstream of Klang River drains a catchment of approximately 189 km^2. The stretch lying between the existing Klang Gates Dam site and the confluence with the Gombak River is approximately 13 km long. The estimated sediment run-off at the point of the Klang Gates Dam is 476 $m^3/km^2/yr$. The average slope of this stretch is approximately 1/520. It flows mainly in a southerly direction to Ulu Klang before turning west flowing almost parallel to Ampang Road before changing into a southwesterly direction after crossing Tun Razak Road to enter the city center of Kuala Lumpur. The upstream stretch of the Klang River ends at the confluence with the Gombak River right in the heart of Kuala Lumpur city near its crossing with Tun Perak Road.

The banks of the entire upstream stretch of the Klang River almost fully occupied right from the dam site to the Gombak River confluence, being lined with legitimate housing developments or squatter settlements, with little open space in between adjoining settlements.

The area upstream of the Klang Gates Dam is covered with tropical forest reserve.

b) The Gombak River

The stretch of the Gombak River from the proposed dam site to the confluence with the Klang River is approximately 15 km long. It drains a catchment of approximately 130 km^2 before its confluence with the Klang River. The average slope of this stretch is 1/460. Its general flow direction is south-southwest over the entire stretch. This section from about 1.5 km downstream of its confluence with Sg. Batang Pusu to the Tun Razak Road crossing has also been densely populated, mainly with legitimate housing developments, though a few squatter settlements have been found amongst the legitimate developments. The stretch upstream of Kampung Tangut (1.5 km downstream of the Batang Pusu confluence) is relatively uninhabited.

The area upstream of the proposed Gombak Dam site is relatively unforested, with available space for living along the valley.

c) Batu River

The Batu River is the major tributary of the Gombak River, it merges first with the Gombak River at a point in the vicinity of the Putra World Trade Center some 2 km before the Gombak River joins the Klang River. The Batu River drains a catchment of approximately 145 km^2 before its confluence with the Gombak River. The stretch of the Batu River lying between the existing Batu Dam site and its confluence point is approximately 14 km long. The average slope of this stretch is 1/360. The banks of the section of the River between the Ipoh Road crossing and the Segambut Road crossing is most densely populated, about half by legitimate housing developments and half by squatter settlements, with practically no open space between adjoining settlements. The stretch upstream of the Ipoh Road crossing remains relatively uninhabited, being occupied by a large track of ex-mining land which had only recently been worked. There exists a large cluster of ex-mining ponds on the right bank of the Batu River, mainly around the Jinjang River, with some smaller ones near the Keroh River.

The area upstream of the Batu Dam site is covered by tropical forest reserve.

River improvement works, including dredging and lining of the river courses, have been carried out along some 2.72 km of the Gombak River and an additional 1.13 km of the Batu River, just upstream of its confluence with the Gombak River.

(2) Middle River Stretch

The middle stretch of the Klang River lies between its confluences with the Gombak and Damansara Rivers, covering a distance of some 30 km. This stretch runs through relatively low rolling country, bounded on the west by the hills of Damansara district and on the south by hills of the Petaling districts on which are sited the housing estates of Overseas Union Garden and Salak South Garden. The slope of the river in this stretch changes from the relatively steep value of 1/700 to a relatively gentle value of 1/2,300. Within this stretch, the river changes course three times.

River improvement works have been carried out over some 19 km length in this stretch. The bulk of the roots covering 18 km were executed around the abrupt 180° bend stretching from some 5 km upstream of Puchong Drop to some 13 km downstream. This length of the river has been dredged. At the portion about 4 km upstream of the Damansara confluence, when the river goes through a series of sharp meanders, the river has been straightened by short-cutting through the meanders in addition to just dredging alone.

The river improvement work had been carried out for the stretch of 1 km in the city center, just downstream of the Klang-Gombak confluence. This involves both the dredging and lining of the river banks of the Klang River from downstream of the Jamek Mosque to the Sulaiman Bridge.

Tidal effects are felt only in the downstream river stretch, possibly up to the Klang-Damansara confluence.

(3) Lower River Stretch

The lower river stretch commences downstream of the confluence of the Klang River and its last major tributary, the Sg. Damansara. This stretch runs through flat low lying plains, initially in a general westerly direction, though the river meanders substantially along its seaward approach, for about 12 km straight-line distance before making a 45° turn towards the south at the point where it is joined by its last minor tributary, the Sg. Pulus, before making its final approach to the sea. This stretch of the river is also characterized by substantial meandering. The width of the river increases with distances from the Klang-Damansara confluence, varying from 50 m just downstream of the confluence to a width of 300 m in a slight distance upstream of the river mouth. The series of 3 largest meanders is just upstream of the river mouth, occupying about half the rectilinear distance between the Klang-Pulus confluence and the river mouth.

The slope of this lower river stretch is very gentle varying from about 1/2,300 at the Klang-Damansara confluence to less than 1/10,000 when the river meets the sea.

A small section of the river, which lies about 2 km downstream of the Klang-Damansara confluence, has been cut short to remove two of the sharpest meandering loops out of the river course.

Active sand mining is going on along the middle section of the Sg. Kayu Ara, the largest upstream tributary of the Sg. Damansara.

3. EXISTING FLOW CAPACITY OF RIVERS

Existing flow capacity of three rivers, the Klang, Gombak and Batu Rivers are estimated under the conditions described below.

- The cross sections and longitudinal profiles of the rivers are based on the results of river survey carried out in this study.

- Water level at initial point of the river mouth of the Klang River is 1.948 m.

- Estimation of longitudinal profile of the water level is based on the non-uniform flow method.

- Flow capacity is estimated under the bankful condition.

Figs. E-4, E-5 and E-6 show flow capacity and river width of each river.

The results of calculation are summarized as follows:

- The stretch between river mouth and Klang Town has a flow capacity of more than 2,000 m^3/s because of large river width and levee.

- The stretch between Klang Town and Sg. Damansara have a flow capacity of less than 200 m^3/s. Low lying area without levee in this stretch may be inundated due to high tide alone.

- The stretch between Sg. Damansa and Sg. Rasau has comparatively small river section and a flow capacity of 0 ~ 200 m^3/s. In this area, the ground level is still low and affected by high tide.

- The stretch between Sg. Rasau and Puchong Drop has 400 ~ 600 m^3/s of flow capacity.

- In the upstream stretch of Puchong Drop, the flow capacity decreases gradually to the upstream from 300 m^3/s.

- As for the Gombak River, the improved stretch between the confluence with the Klang River and the Batu River has flow capacity of 300 m^3/s.
  In the upstream stretch of the confluence with the Batu River, a flow capacity is 60 m^3/s.

- The Batu River has 80 m^3/s of flow capacity.

4. RIVER AND RELATED STRUCTURES

In the Klang River and its tributaries, there exist the following river and related structures besides the existing two dams.

The river improvement works of the Kuala Lumpur Flood Mitigation Project (KLFMP) and existing two dams are described in Appendix H.

4.1 River Structures

Gabion

In certain stretches of the Gombak River, Gabions were installed in order to restore the river banks eroded due to flooding.

Drop Structures

In the upstreams of the Batu and Gombak Rivers, two drop structures were constructed for maintaining the river bed. In the middle stretch of the Klang River there exists a drop structure of 3 m height and 40 m length named as Puchong Drop. A plan and typical section of this drop are shown in Fig. E-7.

Levee

In the upstream of the Klang River at the Kampong Baru area, a levee with a height of about 3 m has been built for flood protection. Also, a similar levee may be found in the middle stretch of this river.

In the downstream of the Klang River, between the Puchong Drop and the river mouth, for the protection against high tidal waters, there is a levee of 3 m in height and about 30 km in length.

Sluice Gate

In the low lying areas of the Kampong Baru and some regions, some sluice gates are installed to protect the land areas from flooding during high water levels in the river. Also in the lower stretch of the Klang River about 30 tidal sluice gates are installed. Location of these tidal gates are shown in Fig. E-8.

Drainage

There are many drainage pipes along the river in and around the city areas.

4.2 Bridges

Downstream of the dam sites of the Klang, Gombak and Batu rivers, there are 58 bridges. Although most of these are concrete bridges, there are also 3 railway bridges. The locations of these bridges are shown in Fig. E-9. The principal features of the bridges and river conditions around them in the urgent project area are also shown in Tables E-1 and E-2.

Some of those bridges are supported by closely spaced piers and also located relatively close to each other, especially in the city center. This restriction has often resulted in flooding in the upstream of the river.

The existing river improvement plan stipulates the deepening of river beds to enhance the river flow capacity. However there exists no plan to replace any of these bridges. Then it may be necessary to undertake the necessary structural measures to improve the stability of the bridge foundations in case of no replacement.

In order to evaluate the effect on the flood flow due to these bridges, the study on the following items was carried out under the present conditions.

a) Span Length

The span length is the most important factor besides the clearance to estimate the soundness of the bridge related to the flood. The flood flows with a lot of debris, especially driftwood. It is necessary to have a span length long enough so that this driftwood in the flood does not obstruct the flow. Past studies have shown that it is desirable that the span to have a length more than 12.5 meters for a 25 meters bridge.

b) Clearance

The clearance should be taken as the gap between soffit level of the bridge and maximum water level; which is decided considering the present river bank level. However, since it seems that the current estimate of maximum water level is in error, in this study it is defined that the clearance should be more than 0 meter for the time being.

c) Reduction Rate of River Width due to Piers

If the reduction rate comes to over six percent, it is said, from the past study, that the natural river flow is disturbed and the flow capacity of river is rapidly decreased.

d) Reduction Rate of Cross Sectional Area of the River at the Bridge

The cross sectional area of the river at many bridges has been reduced. Some of these reductions are caused by the construction of the bridge, that is, the length of bridge is much shorter than the original river width. Other factors are caused by sediment or structures under the bridge. It is desirable that the maximum reduction rate should be less than 20 percent.

e) Actual Flood Damage due to Bridge

In some studies, it is very difficult to verify whether the reason of the flood damage is related directly to the bridge. On the other hand, only two instances of flood damage have been reported which were clearly caused by bridges.

f) Scouring

The scouring depth is obtained from the ratio of maximum water height to pier width. The depth of pier footing should be deeper than the scouring depth calculated from Larsen's formula. However, since the footing depth of piers for all the bridges is not obvious, the rule of thumb used for this study is that the effect of scouring becomes severe if the ratio exceeds five. On the other hand, the best shape of piers to give the least drag to the river bed is a long oval shape, as the square pier accelerates scouring. Therefore, the shape of piers is a factor in studying the possibility of scouring.

The result of the study of existing bridges based on the criterias mentioned above is shown in Table E-3. As seen, most of the bridges do not have enough clearance and the possibility of scouring is still very high due to the ratio and piers shape described before. In addition, the cross sectional area of the river at the bridge is decreased owing to the various reasons. Many bridges are built at the river bend portion, causing obstruction and disturbance to the floods, and there are many pipeline or pipe bridge crossing at level lower than the main bridges.

The overall estimate for flood damage due to the bridges are based on (1) span length, (2) clearance, (3) width reduction ratio, (4) area reduction ratio, and (5) actual flood damage reported. The effect of pipeline crossings, etc. is also taken into consideration. These results are shown in Table E-4.

As a result of the overall estimate, the following four bridges are identified as potential problems, under their existing conditions itself, they are the Jalan Tun Perak Bridge (upstream side), Jalan Tun Razak Bridge (upstream side), Jalan Damai Bridge and Jalan Segambut Bridge. Of these bridges, the Jalan Tun Razak, is already planned for renovation under the on-going river improvement project. The rest of the bridges are to be reconstructed based on the river improvement plans of this Master Plan, and are dealt with in Appendix J.

5. EXISTING URBAN DRAINAGE SYSTEM

As described in the APPENDIX G, urban areas, especially Kuala Lumpur city center are often flooded not only along the main rivers such as the Klang, Gombak and Batu Rivers but also along some of its tributaries and drains.

The main causes of flooding along tributaries and drains are as follows:

- Insufficient depth or width of river or drain.
- Sedimentation in river bed together with dense vegetation growth on its banks.
- Rapid housing development which causes heavy silting and increase of peak discharge.

- Backwater from main river.

- Clogging and choking with rubbish and other waste materials.

- Breached river banks/levees.

- The settlements are situated in low lying areas without any drainage systems.

Urban drainage works within the Klang River basin have been carried out by DID Federal Territory, DID Selangor, City Hall and Municipalities such as Petaling Jaya, Klang and Shah Alam. In addition to these, some drains were constructed by housing developers after approval from related agencies when they developed the housing schemes.

Drainage works have been implemented based on "Urban Drainage Design Standards and Procedures for Peninsular Malaysia", established by DID in 1975. According to this design standards and procedure, the drainage systems are planned for the design flood of a 2-year return period storm in the residential areas and a 5-year return period storm in commercial and industrial areas. In addition, wherever possible the system is designed to contain the 100-year storm within the proposed reserves, to prevent any major damage from a major storm. These improved drainage works are described in Appendix H.

Among these drainage works, improvement of drains within Kuala Lumpur conurbation have been carried out based on the "Kuala Lumpur Flood Mitigation Project Drainage Improvement, Master Drainage Plan" which was prepared by DID in 1978. The summary of this Master Drainage Plan is as follows:

a) The Master Drainage Plan covers the catchment of all trunk drains within Kuala Lumpur conurbation. The area is 409 km^2 (158 $miles^2$) and includes the Federal Territory, Petaling Jaya and sections of Petaling, Ulu Langat and Gombak Districts. This Master Drainage Plan deals with 364 km (226 miles) of trunk drains serving total minimum areas of about 40 hectares (100 acres).

b) The studies and works undertaken in this Master Drainage Plan included:

- preparing design standards and procedures
- preparing a preliminary master drainage plan
- detailed survey of the trunk drainage system
- detailed design and construction of priority works
- preparing master working plans

c) The estimated costs for drainage improvement was M$128,691,000 as at 1978 price level.

Based on this Master Drainage Plan, inner water drainage works has been carried out with minor modifications by agencies concerned.

These local improvements of the drainage system causes an increase of run-off peak discharge and possibility of inundation in the downstream area. Hence, the design scale of drainage system especially for newly developed areas should take into overall considerations of the whole downstream river, the flow capacity, improvement plan and etc.

6. EXISTING EX-MINING POND

(1) General

In the Klang Valley, the development of tin mines commenced in the middle of the last century in the Ampang area.

As of 1986, in the basin, total active mining area is about 1,400 ha and existing ex-mining areas amounts to some 6,900 ha. The ex-mining areas developed into housing schemes is some 4,100 ha.

In the Kuala Lumpur City there exists no active mining area. Most of these ex-mining areas is scheduled for housing or industry development or reclamation.

(2) Present Status of Ex-mining Pond

The total area of ex-mining ponds, located in the basin upstream of Puchong Drop of the Klang River, is about 650 ha. Some of these ponds are partially used for fish breeding, but some have simply been abandoned. Some ponds have been colonized by squatters who settled on their edges, and used the ponds as dumping grounds for their wastes.

However, the water in most of the uncolonized ponds is generally clean. From the viewpoint of flood mitigation, these ponds may be greatly useful for retarding run-off from their catchment. Fig. E-10 shows the location of existing ex-mining ponds in the Kuala Lumpur conurbation area.

Number and area of existing ex-mining ponds for each river basin is shown in Table E-5. The sizes of these ponds differ substantially, ranging from 0.5 ha to 90 ha. The deepest pond has a water depth of about 30 m at its deepest point.

Most of these ex-mining ponds have been ear-marked as potential sites for housing or industrial development in the near future. Only several deep ponds are to remain without being slated for refilling because of expensive construction cost.

(3) Use of Ex-mining Pond for Flood Mitigation

There are two uses to which the ex-mining ponds can be put in the context of flood mitigation.

The first is for regulation of run-off discharge into the main river or its tributaries. For this purpose, the pond needs to be of a comparatively large capacity. It might be located near the rivers and at a level where it is able to control the discharge into the river by gravity flow. The active depth of a regulation pond will be limited to 4 to 5 m according to the river depth.

The second is for flood control of developed areas far away from the river. For this purpose, the ponds may have a comparatively small size, since they act as storage for a small area only.

In case these ponds are located downstream of a newly developed area, these ponds may serve the dual purpose of sediment trap during the construction period. The depth of these ponds will be decided by the downstream river conditions.

The intended development of the ex-mining ponds into multipurpose ecological parks serving both flood mitigation (during periods of intense rainfalls) and recreational (during dry and relatively dry periods when only the permanent pond is filled) needs is expected to bring beneficial social effects to the surrounding communities.

Table E-1 PRINCIPAL FEATURES OF BRIDGES

Ref. No.	Bridge Name	Bridge CH NO. (km)	Bridge Length (m)	Bridge Width (m)	Pier Width (m)	Pier Nos.	Pier Gross W (m)	Pier Span (m)	Pier Shape	Soffit Level (m)
K- 17	Jalan Sulaiman	20.46	49.40	15.70	1.5	2	3.0	15	Square	31.3
K- 18	Jalan Kinabalu (flyover)	20.70	-	35.10	0.7	2	1.4	18	Square	33.8
K- 19	Jalan Cheng Lock	21.04	53.02	32.00	1.0	2	2.0	17	Square	30.3
K- 20	Dayabumi Foot Bypass	21.23	36.20	6.00	0.8	2	1.6	12	Circle	30.8
K- 21	Leboh Pasar	21.43	43.40	18.70	-	0	-	-	-	29.7
K- 22	Jalan Tun Perak (2 Lanes)	21.73	33.00	26.50	0.8/2	1/1	0.8/2	16/16	Circle	29.2
K- 23	Jalan Munshi Abdullah (2 Lanes)	22.21	28.10	53.60	0.7/-	2/0	1.4/-	17/-	Circle	30.5
K- 24	Jalan Dang Wangi	22.64	38.78	17.10	-	0	-	-	-	30.3
K- 25	Jalan Sultan Ismail	23.04	39.89	29.45	0.4	2	0.8	12	Circle	32.0
K- 26	Jalan Tun Razak (2 Lanes)	24.60	57.72	27.20	1/1	2/2	2/2	10/10	Cir/Squ	32.2
K- 26'	Jalan Damai (broken)	26.43		3.00						
K- 27	Jalan Jelatek	26.88	52.62	22.50	0.6	2	1.2	14	Circle	37.7
K- 28	Near Sterling Drug	30.23	36.04	12.30	0.6	2	1.2	9	Circle	45.3
K- 29	Near Taman Seri Keramat Tengah	32.31	35.82	12.40	0.8	2	1.6	10	Circle	50.5
K- 30	Jalan Hulu Klang Zoo	33.75	36.36	12.00	0.8	2	1.6	11	Circle	54.1
K- 31	Jalan Melawati Lima	34.99	30.24	11.62	-	0	-	-	-	56.9
G- 1	Sultan Hishamuddin	38.26	30.25	16.25	1.0	1	1.0	15	Oval	30.0
G- 2	Jalan Parlimen	38.44	31.33	23.40	0.6	2	1.2	11	Oval	30.6
G- 3	Jalan Sultan Ismail (flyover)	39.66	-	8.30	1.1	2	2.2	14	Circle	31.6
G- 4	(Jalan Putra) Near PWTC	40.24	-	26.35	1.0	2	2.0	10	Circle	34.0
G- 5	Jalan Ipoh (2 Lanes)	40.56	31.20	21.00	0.6/0.6	2	1.2/1.2	10	Circle	31.9
G- 6	Jalan Tun Razak (2 Lanes)	41.00	31.20	26.15	0.7/0.7	2	1.4/1.4	10	Circle	31.6
G- 7	Near Sentul Flats off Jalan Pahang	43.00	28.40	2.45	1.3	2	2.6	12	Oval	38.0
G- 8	Jalan Kampung Puah Sabarang	43.85	24.15	1.80	-	0	-	-	-	38.1
G- 9	Jalan Chubadak Dalam	45.26	18.40	11.17	1.0	2	2.0	7	Oval	42.4
G- 10	Foot Bridge (2 Lanes)	46.40	18.00	4.00	0.6/-	2/0	1.2/-	6/-	Square	43.8
G- 11	Jalan Batu Cave	49.39	19.10	6.31	1.1	1	1.1	9	Square	55.2
G- 12	Karak Highway (flyover)	50.62	-	11.55	1.2	2	2.4	14	Circle	64.0
B- 1	Jalan Tun Ismail	51.91	47.90	38.80	1.0	2	2.0	16	Square	32.1
B- 2	Jalan Kolam Air	52.81	33.50	11.17	0.7	2	1.4	11	Square	32.0
B- 3	2.5 Mile Jalan Ipoh Railway	53.16	23.00	4.46	-	0	-	-	-	34.7
B- 4	Jalan Selvadurai	53.58	27.80	11.88	0.4	2	0.8	8	Square	33.7
B- 5	Jalan Segambut	54.15	27.75	15.20	0.6	4	2.4	4	Circle	35.2
B- 6	Jalan Cenderuh	55.88	21.40	7.51	0.4	1	0.4	8	Circle	38.2
B- 7	4.25 Mile off Jalan Ipoh	56.10	20.50	7.38	0.3	1	0.3	11	Square	38.0
B- 8	4.5 Mile Jalan Ipoh	56.70	27.21	9.70	0.3	3	0.9	7	Square	41.4
B- 9	4.5 Mile Jalan Ipoh Railway	56.91	22.68	5.05	-	0	-	-	-	42.4
B- 10	7.5 Mile Jalan Ipoh Railway	60.85	22.85	4.26	-	0	-	-	-	51.0
B- 11	7.5 Mile Jalan Ipoh (flyover)	60.88	-	11.03	0.9	2	1.8	16	Square	56.2
B- 12	Jalan Batu Cave	61.16	22.95	8.82	1.5	1	1.5	11	Oval	52.0
B- 13	Kg Nakhoda Bridge off Jalan Sg Tua	64.36	25.01	5.40	-	0	-	-	-	64.6
B- 14	Kg Nakhoda Bridge off Jalan Sugai Tua	65.36	21.70	4.28	-	0	-	-	-	64.1
B- 15	Near Dam Site	65.99	67.32	9.66	-	0	-	-	-	72.5

Table E-2 RIVER CONDITIONS AROUND THE BRIDGES

Ref. No.	Bridge Name		River Width (m)	River Area at Bridge (m2)	River Area near Bridge (m2)	Max. W.L. (m)	River Bed (m)	Max. W.H. (m)	Pipe, etc. Location	Dimension
K- 17	Jalan Sulaiman		47.1	261.5	303.1	30.4	23.5	6.9	U/S(L)	Pipe w/pier, Pipe Truss w/pier
K- 18	Jalan Kinabalu	(flyover)	44.4	378.5	303.1	30.5	21.7	8.8	-	-
K- 19	Jalan Cheng Lock		53.0	186.0	228.8	30.8	24.7	6.1	-	-
K- 20	Dayabumi Foot Bypass		36.0	228.8	228.8	30.6	22.3	8.3	-	-
K- 21	Lebuh Pasar		41.0	152.5	184.8	29.8	23.7	6.1	D/S(L)	2 * Pipe w/pier, Pipe Truss w/pier
K- 22	Jalan Tun Perak	(2 Lanes)	33.1	40.6/67.7	112.9	29.9	25.2	4.7	U/S(L)	Pipe, Pipe Truss
K- 23	Jalan Munshi Abdullah	(2 Lanes)	20.3	92.3/99.8	123.0	30.9	26.3	4.6	U/S(S),D/S(S)	Pipe Truss, Pipe w/pier
K- 24	Jalan Dang Wangi		27.3	68.5	73.3	30.7	26.2	4.5	U/S(S)	2 * Pipe w/pier
K- 25	Jalan Sultan Ismail		37.6	83.0	78.9	31.0	27.0	4.0	D/S(L)	Foot Path w/pier
K- 26	Jalan Tun Razak	(2 Lanes)	31.7	63.7/36.8	81.7	32.6	28.4	4.2	U/S(S),D/S(S)	2 * Pipe w/pier, Pipe Truss
K- 26'	Jalan Damai	(broken)							U/S(S)	Pipe
K- 27	Jalan Jelatek		44.0	100.0	127.3	37.2	32.5	4.7	U/S(S),D/S(S)	Pipe Truss w/pier, Pipe w/pier
K- 28	Near Sterling Drug		27.1	45.5	69.4	45.8	42.9	2.9	D/S(L)	Pipe w/pier
K- 29	Near Taman Seri Keramat Tengah		32.0	51.5	84.1	51.3	47.4	3.9	-	-
K- 30	Jalan Hulu Klang Zoo		34.2	60.0	41.6	53.1	51.0	2.1	U/S(L)	Pipe w/pier, Pipe, etc.
K- 31	Jalan Melawati Lima		31.5	55.5	68.2	57.8	54.2	3.6	-	-
G- 1	Sultan Hishamuddin		30.5	102.0	122.5	29.8	25.7	4.1	D/S(S)	Pipe
G- 2	Jalan Parlimen		35.7	128.0	164.9	30.9	25.2	5.7	U/S(S)	Pipe Truss w/pier
G- 3	Jalan Sultan Ismail	(flyover)	44.5	154.5	179.1	30.8	26.7	4.1	-	-
G- 4	(Jalan Putra) Near PWTC		32.0	98.5	88.4	30.8	27.8	3.0	D/S(L)	Foot Path w/pier
G- 5	Jalan Ipoh	(2 Lanes)	31.8	65.0	65.0	31.2	27.9	3.3	D/S(S)	Pipe w/pier
G- 6	Jalan Tun Razak	(2 Lanes)	30.8	53.0	159.4	31.6	28.6	3.0	D/S(S)	Pipe Truss
G- 7	Near Sentul Flats off Jalan Pahang		36.9	137.0	148.9	36.4	33.2	3.2	-	-
G- 8	Jalan Kampong Puah Sabarang		18.9	57.5	117.5	38.1	34.0	4.1	-	-
G- 9	Jalan Chubadak Dalam		21.9	60.5	41.3	39.9	38.6	1.3	D/S(U)	Pipe Truss
G- 10	Foot Bridge	(2 Lanes)	17.0	25.5	48.8	43.9	41.6	2.3	-	-
G- 11	Jalan Batu Cave		19.0	51.5	40.5	53.6	50.6	3.0	U/S(S),D/S(S)	Pipe Truss, Pipe
G- 12	Karak Highway	(flyover)	42.5	191.0	35.2	56.8	55.3	1.5	D/S(L)	Foot Path
B- 1	Jalan Tun Ismail		49.0	141.5	271.1	31.8	28.2	3.6	U/S(S),D/S(S)	Pipe, Pipe
B- 2	Jalan Kolam Air		34.4	52.5	75.3	32.0	28.8	3.2	-	-
B- 3	2.5 Mile Jalan Ipoh Railway		22.2	75.5	67.2	32.6	29.0	3.6	D/S(L)	Pipe
B- 4	Jalan Selvadurai		25.8	44.0	49.1	33.8	30.7	3.1	-	-
B- 5	Jalan Segambut		24.0	50.0	25.5	34.3	32.5	1.8	D/S(L)	Pipe w/pier
B- 6	Jalan Cenderuh		17.0	30.0	36.0	38.3	34.4	3.9	-	-
B- 7	4.25 Mile off Jalan Ipoh		22.2	20.0	40.9	38.4	35.5	2.9	-	-
B- 8	4.5 Mile Jalan Ipoh		29.9	60.5	24.8	39.8	37.3	2.5	U/S(S),D/S(L)	Pipe, Pipe w/pier
B- 9	4.5 Mile Jalan Ipoh Railway		31.5	84.0	30.3	40.1	38.0	2.1	-	-
B- 10	7.5 Mile Jalan Ipoh Railway		21.0	48.5	50.6	49.5	47.6	1.9	-	-
B- 11	7.5 Mile Jalan Ipoh	(flyover)	50.5	299.0	50.6	49.8	48.0	1.8	-	-
B- 12	Jalan Batu Cave		22.3	56.0	50.6	50.7	48.5	2.2	U/S(S),D/S(L)	Pipe w/pier, Pipe w/pier & Pipe Truss
B- 13	Kg Nakhoda Bridge off Jalan Sg Tua		27.9	96.3	131.0	63.5	58.4	5.1	-	-
B- 14	Kg Nakhoda Bridge off Jalan Sugai Tua		22.4	35.0	64.6	65.0	61.9	3.1	U/S(U),D/S(U)	Pipe Truss, Pipe Truss
B- 15	Near Dam Site		55.2	179.5	167.4	70.0	68.0	2.0	-	

1) U/S means Up Stream.
2) D/S means Down Stream.
3) (L) means Lower level than the location of the bridge.
4) (U) means Upper level than the location of the bridge.

Table E-3 ESTIMATE FOR SOUNDNESS OF BRIDGES

Ref. No.	Bridge Name	Span (m)	Clea-rance (m)	Width Reduct. Ratio (%)	Area Reduct. Ratio (%)	Max.W.H. / Pier Width	Shape of Pier	Actual Damage occured	Remarks
K- 17	Jalan Sulaiman	15	0.9	6	86	4.6	Square		
K- 18	Jalan Kinabalu (flyover)	18	3.3	3	>100	12.6	Square		
K- 19	Jalan Cheng Lock	17	-0.5	4	81	6.1	Square		
K- 20	Dayabumi Foot Bypass	12	0.2	4	100	10.3	Circle		River Bend Portion
K- 21	Leboh Pasar	-	-0.1	-	83	-	-		
K- 22	Jalan Tun Perak (2 Lanes)	16/16	-0.7	2/6	36/60	5.9/2.3	Circle		Structure under Bridge
K- 23	Jalan Munshi Abdullah (2 Lanes)	17/-	-0.4	7/-	75/91	6.7/-	Circle		
K- 24	Jalan Dang Wangi	-	-0.4	-	93	-	-		River Bend Portion
K- 25	Jalan Sultan Ismail	12	1.0	2	>100	10.0	Circle		
K- 26	Jalan Tun Razak (2 Lanes)	10/10	-0.4	6	78/45	4.2	Cir/Squ	√	River Bend Portion
K- 26'	Jalan Damai (broken)							√	
K- 27	Jalan Jelatek	14	0.5	3	79	7.9	Circle		
K- 28	Near Sterling Drug	9	-0.4	4	66	4.8	Circle		River Bend Portion
K- 29	Near Taman Seri Keramat Tengah	10	-0.8	5	61	4.9	Circle		
K- 30	Jalan Hulu Klang Zoo	11	1.1	5	>100	2.6	Circle		
K- 31	Jalan Melawati Lima	-	-0.9	-	81	-	-		
G- 1	Sultan Hishamuddin	15	0.2	3	83	4.1	Oval		Abutment is in River
G- 2	Jalan Parlimen	11	-0.3	3	78	9.5	Oval		Abutment is in River
G- 3	Jalan Sultan Ismail (flyover)	14	0.8	5	86	3.7	Circle		
G- 4	*(Jalan Putra) Near PWTC*	*10*	*3.2*	*6*	*>100*	*3.0*	*Circle*		
G- 5	Jalan Ipoh (2 Lanes)	10	0.7	4	100	5.5	Circle		Sediment
G- 6	Jalan Tun Razak (2 Lanes)	10	0.0	5	33	4.3	Circle		Sediment
G- 7	Near Sentul Flats off Jalan Pahang	12	1.6	7	92	2.5	Oval		There is a Drop
G- 8	Jalan Kampung Puah Sabarang	-	0.0	-	49	-	-		
G- 9	Jalan Chubadak Dalam	7	2.5	9	>100	1.3	Oval		
G- 10	Foot Bridge (2 Lanes)	6/-	-0.1	4/-	52	3.8/-	Square		
G- 11	Jalan Batu Cave	9	1.6	6	>100	2.7	Square		There is a Drop
G- 12	Karak Highway (flyover)	14	7.2	6	>100	1.2	Circle		
B- 1	Jalan Tun Ismail	16	0.3	4	52	3.6	Square		
B- 2	Jalan Kolam Air	11	0.0	4	70	4.6	Square		Sediment
B- 3	2.5 Mile Jalan Ipoh Railway	-	2.1	-	>100	-	-		River Bend Portion
B- 4	Jalan Selvadurai	8	0.0	3	90	7.7	Square		Erosion
B- 5	Jalan Segambut	4	1.0	10	>100	2.9	Circle		River Bend Portion
B- 6	Jalan Cenderuh	8	-0.1	2	83	9.7	Circle		River Bend Portion
B- 7	4.25 Mile off Jalan Ipoh	11	-0.4	1	49	9.7	Square		River Bend Portion
B- 8	4.5 Mile Jalan Ipoh	7	1.6	3	>100	8.3	Square		River Bend Portion
B- 9	4.5 Mile Jalan Ipoh Railway	-	2.3	-	>100	-	-		
B- 10	7.5 Mile Jalan Ipoh Railway	-	1.4	-	96	-	-		
B- 11	7.5 Mile Jalan Ipoh (flyover)	16	6.4	4	>100	2.0	Square		
B- 12	Jalan Batu Cave	11	1.2	7	>100	1.5	Oval		
B- 13	Kg Nakhoda Bridge off Jalan Sg Tua	-	1.0	-	74	-	-		Abutment is in River
B- 14	Kg Nakhoda Bridge off Jalan Sugai Tua	-	-0.9	-	54	-	-		
B- 15	Near Dam Site	-	2.5	-	>100	-	-		

Table E-4 OVERALL ESTIMATE FOR BRIDGES

Ref. No.	Bridge Name	Span	Clearance	Width Reduct. Ratio	Area Reduct. Ratio	Actual Damage occured	Total Estimate	Max.W.H. / Pier Width	Shape of Pier	Possibility of Scouring	Pipe etc.
K- 17	Jalan Sulaiman	A	A	A	A	A	**A**	A	C	B	C
K- 18	Jalan Kinabalu (flyover)	A	A	A	A	A	**A**	C	C	C	A
K- 19	Jalan Cheng Lock	A	C	A	A	A	**B**	B	C	C	A
K- 20	Dayabumi Foot Bypass	B	A	A	A	A	**A**	C	B	C	A
K- 21	Leboh Pasar	A	B	A	A	A	**A**	A	A	A	C
K- 22	Jalan Tun Perak (2 Lanes)	A	C	A	C/B	A	**C/B**	B/A	B	B	C
K- 23	Jalan Munshi Abdullah (2 Lanes)	C/A	B	B/A	B/A	A	**B/A**	B/A	B	B	B
K- 24	Jalan Dang Wangi	A	B	A	A	A	**A**	A	A	A	B
K- 25	Jalan Sultan Ismail	B	A	A	A	A	**A**	C	B	C	C
K- 26	Jalan Tun Razak (2 Lanes)	B	B	A	B/C	C	**B/C**	A	B/C	B	B
K- 26'	Jalan Damai (broken)	C	C	B	C	C	**C**	C	C	C	A
K- 27	Jalan Jelatek	A	A	A	B	A	**A**	B	B	B	B
K- 28	Near Sterling Drug	C	B	A	B	A	**B**	A	B	B	C
K- 29	Near Taman Seri Keramat Tengah	B	C	A	B	A	**B**	A	B	B	A
K- 30	Jalan Hulu Klang Zoo	B	A	A	A	A	**A**	A	B	B	C
K- 31	Jalan Melawati Lima	A	C	A	A	A	**B**	A	A	A	A
G- 1	Sultan Hishamuddin	A	A	A	A	A	**A**	A	A	A	A
G- 2	Jalan Parlimen	B	B	A	B	A	**B**	B	A	B	B
G- 3	Jalan Sultan Ismail (flyover)	A	A	A	A	A	**A**	A	B	B	A
G- 4	(Jalan Putra) Near PWTC	B	A	A	A	A	**A**	A	B	B	C
G- 5	Jalan Ipoh (2 Lanes)	B	A	A	A	A	**A**	B	B	B	B
G- 6	Jalan Tun Razak (2 Lanes)	B	B	A	C	A	**B**	A	B	B	A
G- 7	Near Sentul Flats off Jalan Pahang	B	A	B	A	A	**B**	A	A	A	A
G- 8	Jalan Kampung Puah Sabarang	A	B	A	C	A	**B**	A	A	A	A
G- 9	Jalan Chubadak Dalam	C	A	B	A	A	**B**	A	A	A	A
G- 10	Foot Bridge (2 Lanes)	C/A	B	A	B	A	**B**	A	C	B	A
G- 11	Jalan Batu Cave	C	A	A	A	A	**B**	A	C	B	A
G- 12	Karak Highway (flyover)	A	A	A	A	A	**A**	A	B	B	C
B- 1	Jalan Tun Ismail	C	A	A	B	A	**B**	A	C	B	A
B- 2	Jalan Kolam Air	B	B	A	B	A	**B**	A	C	B	A
B- 3	2.5 Mile Jalan Ipoh Railway	A	A	A	A	A	**A**	A	A	A	C
B- 4	Jalan Selvadurai	C	B	A	A	A	**B**	B	C	C	A
B- 5	Jalan Segambut	C	A	C	A	A	**C**	A	B	B	C
B- 6	Jalan Cenderuh	C	B	A	A	A	**B**	B	B	B	A
B- 7	4.25 Mile off Jalan Ipoh	B	B	A	C	A	**B**	B	C	C	A
B- 8	4.5 Mile Jalan Ipoh	C	A	A	A	A	**B**	B	C	C	C
B- 9	4.5 Mile Jalan Ipoh Railway	A	A	A	A	A	**A**	A	A	A	A
B- 10	7.5 Mile Jalan Ipoh Railway	A	A	A	A	A	**A**	A	A	A	A
B- 11	7.5 Mile Jalan Ipoh (flyover)	A	A	A	A	A	**A**	A	C	B	A
B- 12	Jalan Batu Cave	B	A	B	A	A	**B**	A	A	A	C
B- 13	Kg Nakhoda Bridge off Jalan Sg Tua	A	A	A	B	A	**A**	A	A	A	A
B- 14	Kg Nakhoda Bridge off Jalan Sugai Tua	A	C	A	B	A	**B**	A	A	A	A
B- 15	Near Dam Site	A	A	A	A	A	**A**	A	A	A	A

Rank (A) means that the brigde has no problem.
Rank (B) means that the bridge has some problem.
Rank (C) means that the bridge has severe problem.

Table E-5 EXISTING EX-MINING PONDS FOR EACH CATCHMENT AREA

(Located within Area the Minimum Approach of
in is 3.5 km Upstream of Puchong Drop)

Catchment Area	No. of Pond	Area (m2)
Sungai Jinjang (J)	10	1,111,000
Sungai Keroh (KR)	6	288,000
Sungai Kamusing (KS)	7	417,000
Sungai Batu (B)	8	1,909,000
Sungai Gombak (G)	5	442,000
Sungai Belongkong	1	70,000
Sungai Bunus	1	65,000
Sungai Ampang	9	400,000
Sungai Kerayong	26	777,000
Sungai Kuyoh	9	613,000
Sungai Klang		
a) upstream	3	49,000
b) downstream	6	339,000
Total	91	6,480,000

(Existing Park Ponds)

Park	Area (m2)
Taman Tasik Perdana	18,750
Taman Tasik Ampang	31,250
Taman Tasik Titiwangsa	87,500
Total	137,400

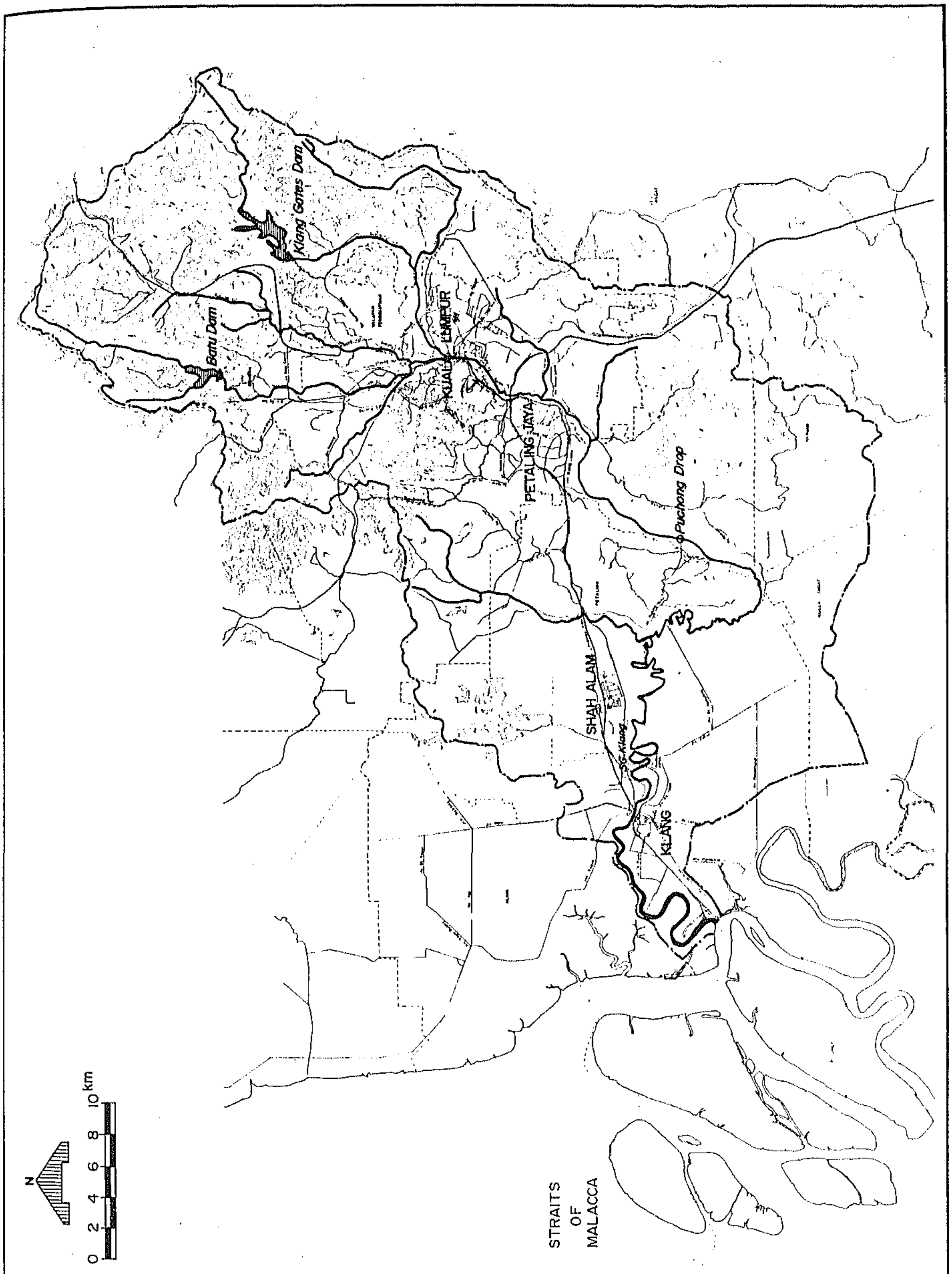


FIG. E-1	GENERAL AREA MAP OF THE KLANG RIVER BASIN

THE STUDY ON THE FLOOD MITIGATION OF THE KLANG RIVER BASIN

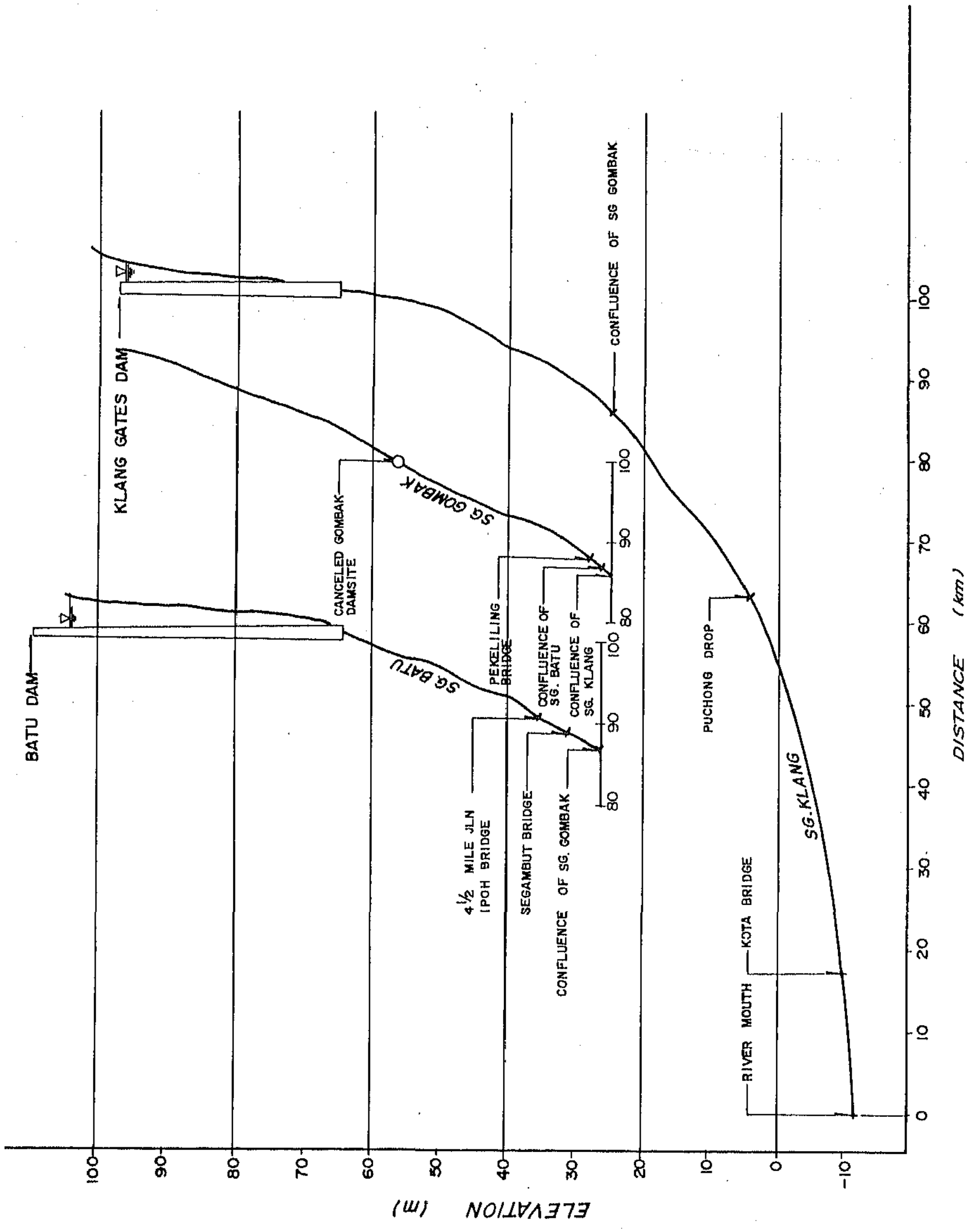


FIG. E-2	LONGITUDINAL PROFILE OF THE KLANG RIVER AND TRIBUTARIES

THE STUDY ON THE FLOOD MITIGATION OF THE KLANG RIVER BASIN

JICA

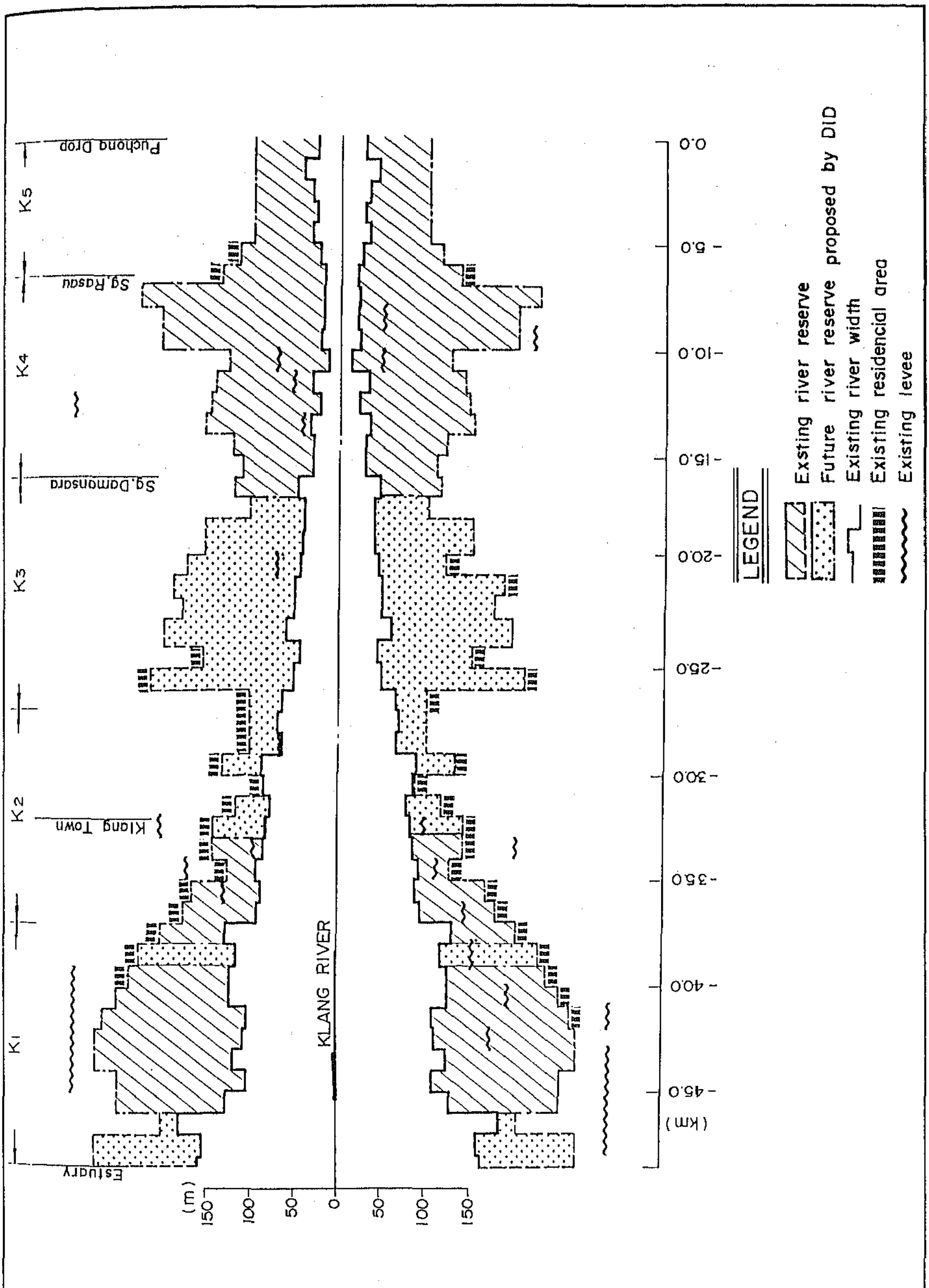


FIG. E-3 EXISTING RIVER RESERVE FOR DOWNSTREAM OF THE KLANG RIVER

THE STUDY ON THE FLOOD MITIGATION OF THE KLANG RIVER BASIN

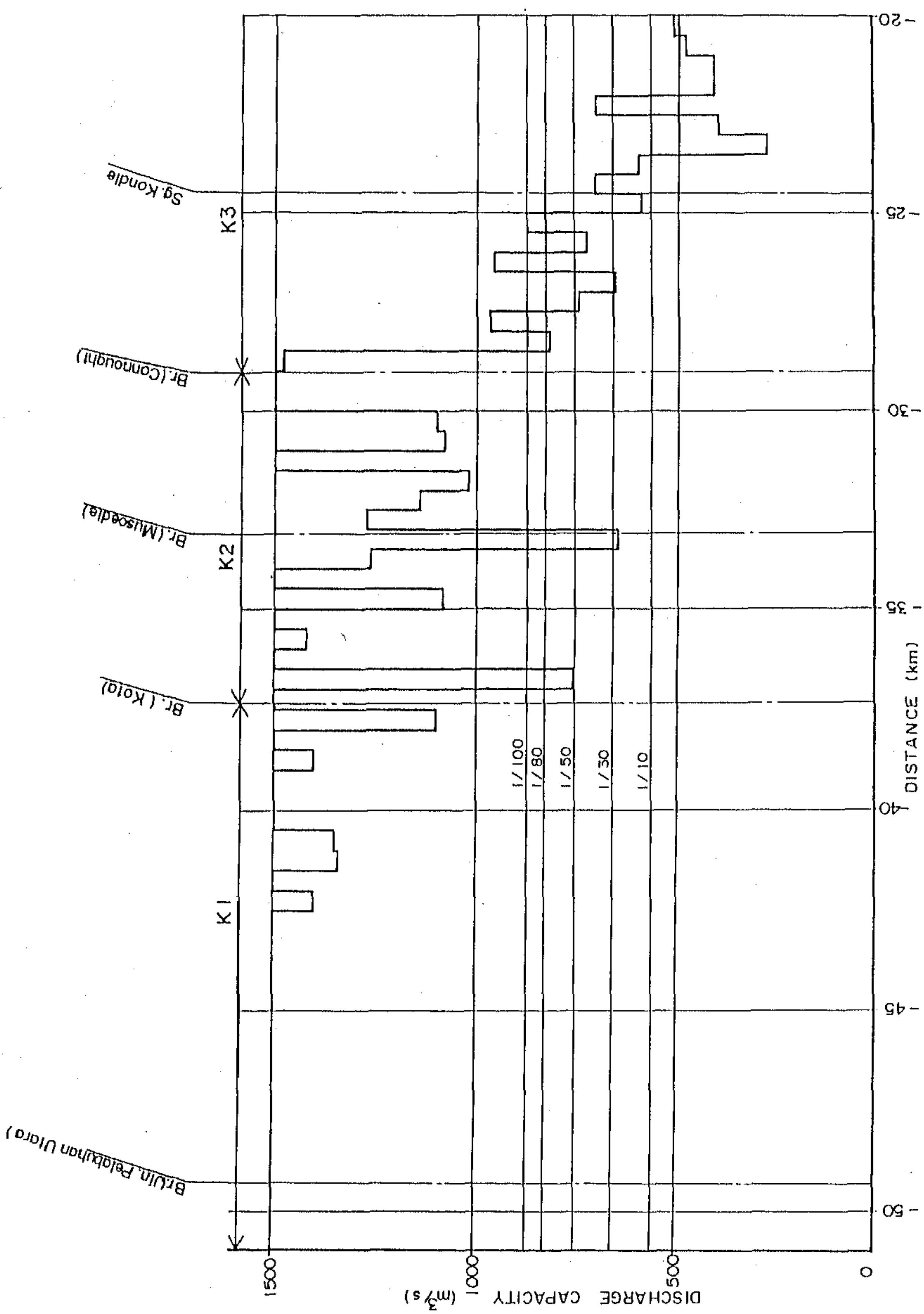


FIG. E-4	DISCHARGE CAPACITY OF THE KLANG RIVER (1/3)

THE STUDY ON THE FLOOD MITIGATION OF THE KLANG RIVER BASIN

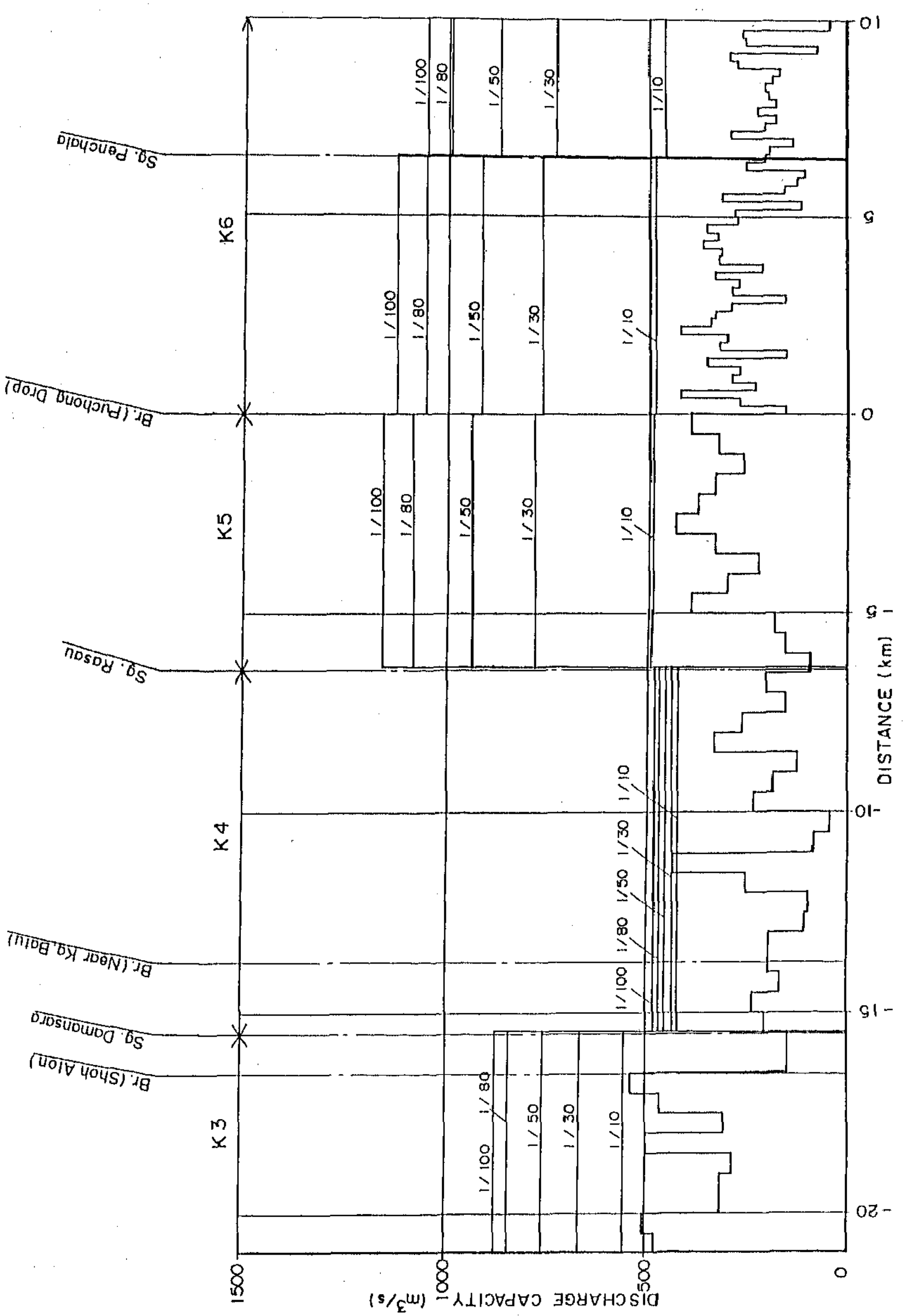


FIG. E-4 DISCHARGE CAPACITY OF THE KLANG RIVER (2/3)

THE STUDY ON THE FLOOD MITIGATION OF THE KLANG RIVER BASIN

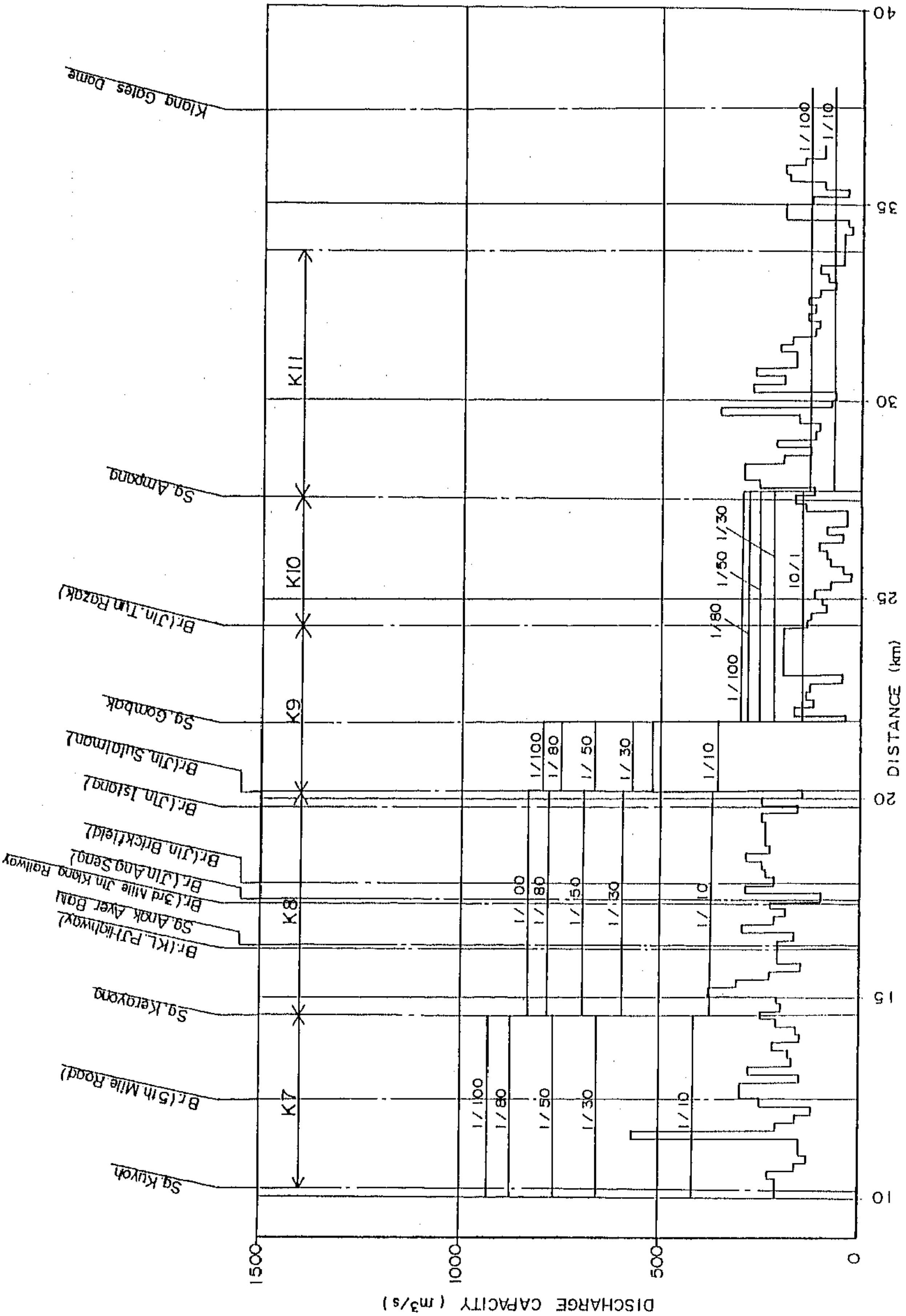


FIG. E-4	DISCHARGE CAPACITY OF THE KLANG RIVER (3/3)

THE STUDY ON THE FLOOD MITIGATION OF THE KLANG RIVER BASIN

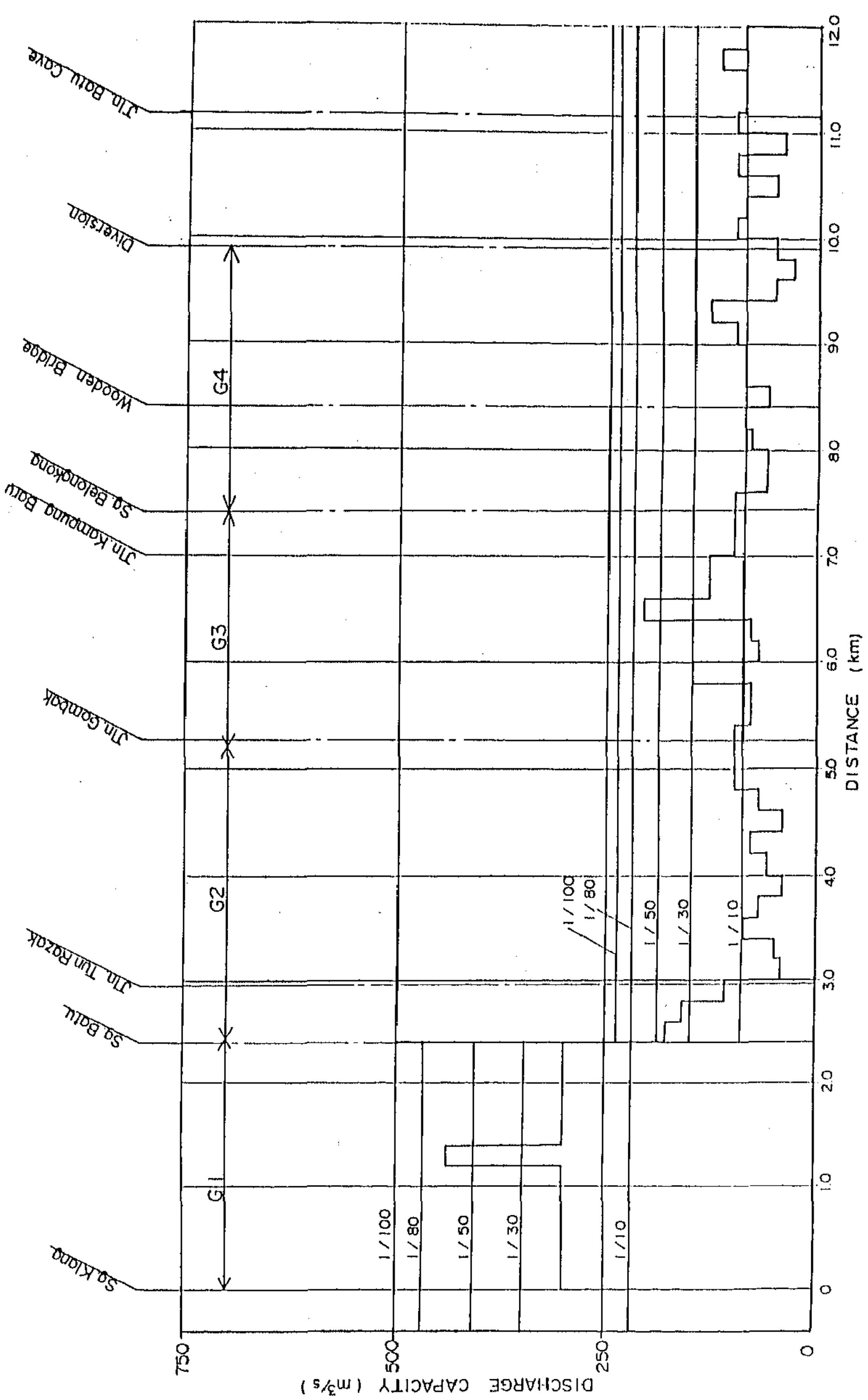


FIG. E-5	DISCHARGE CAPACITY OF THE GOMBAK RIVER

THE STUDY ON THE FLOOD MITIGATION OF THE KLANG RIVER BASIN

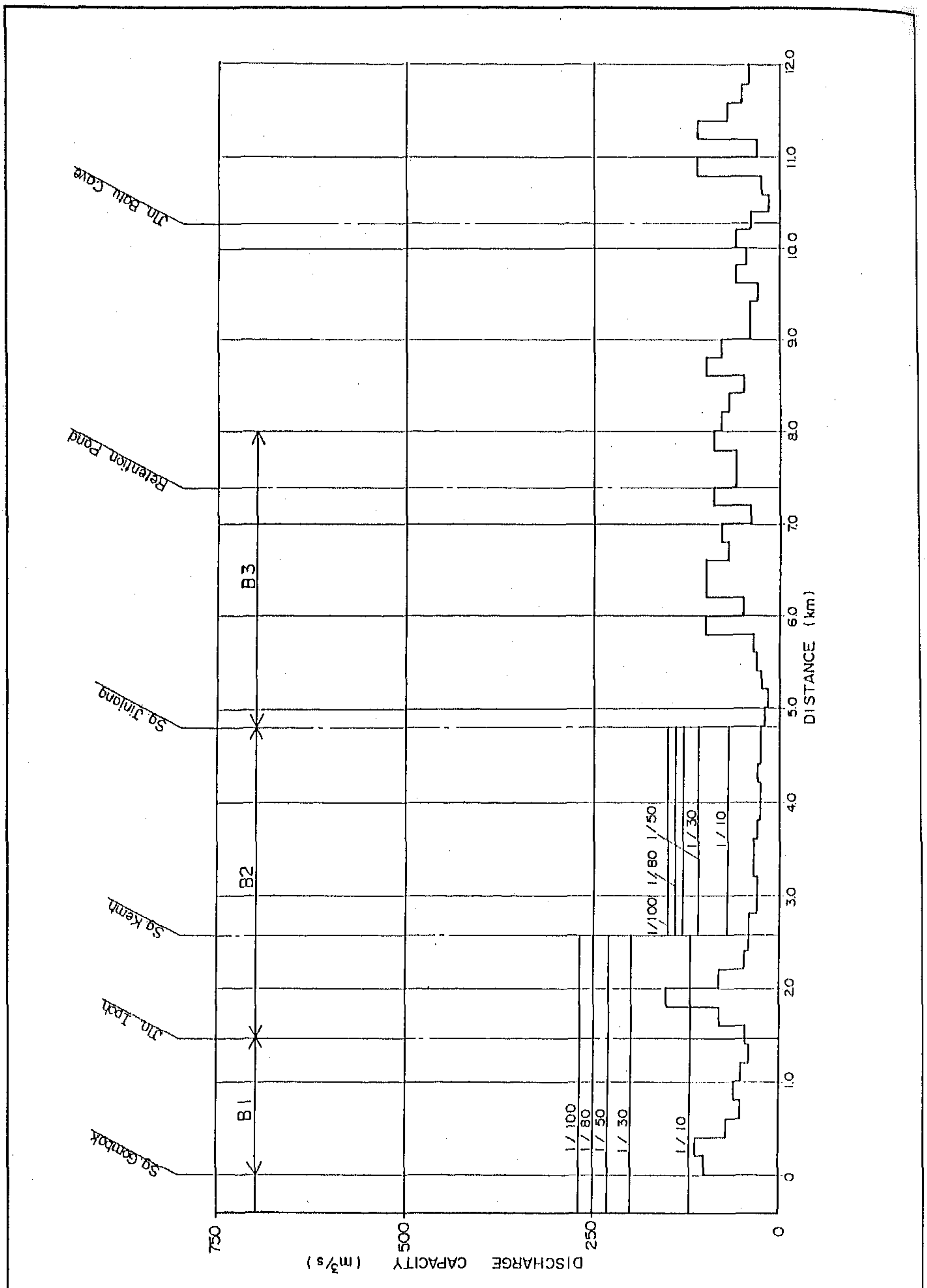
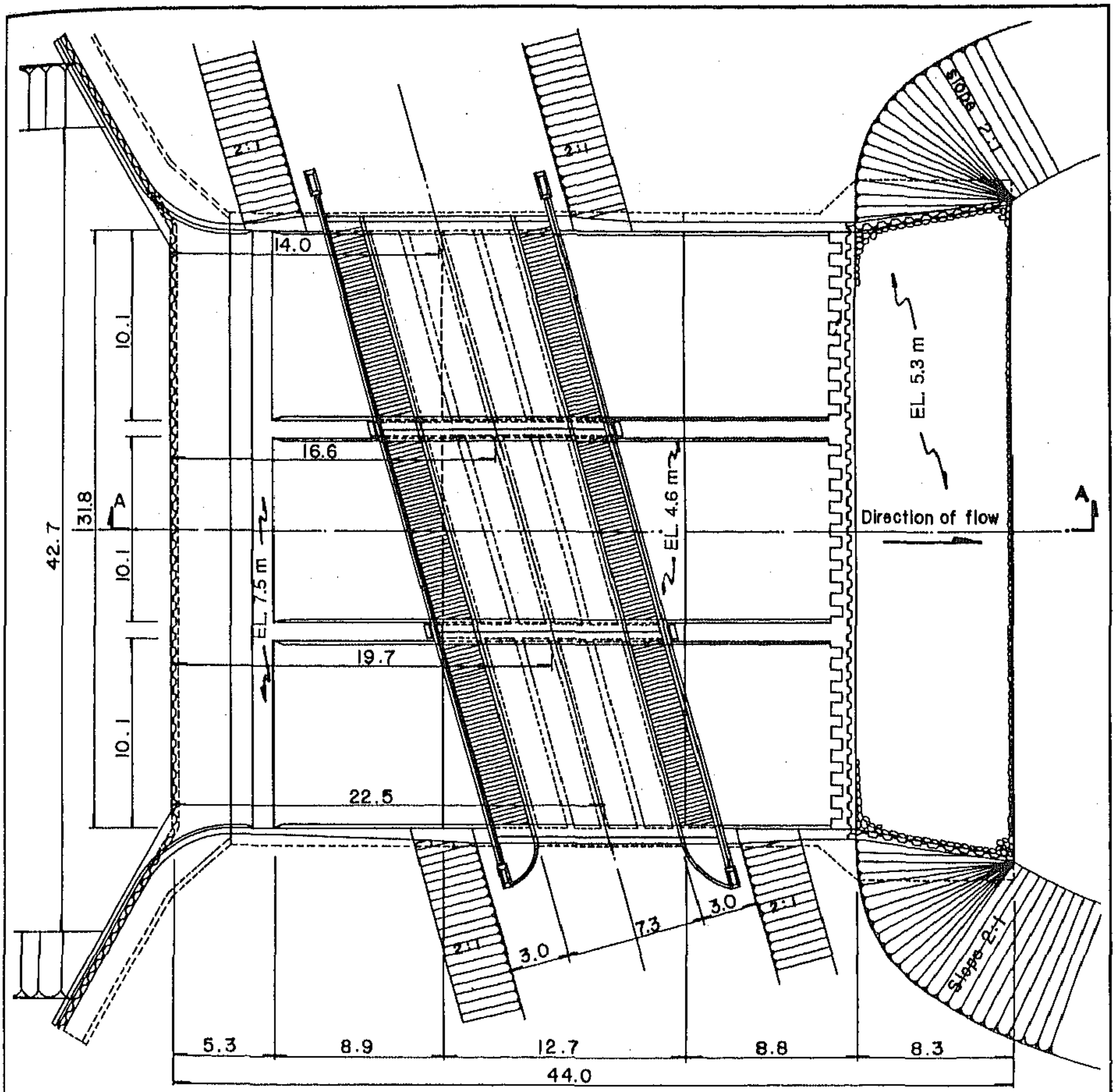


FIG. E-6 **DISCHARGE CAPACITY OF THE BATU RIVER**

THE STUDY ON THE FLOOD MITIGATION OF THE KLANG RIVER BASIN



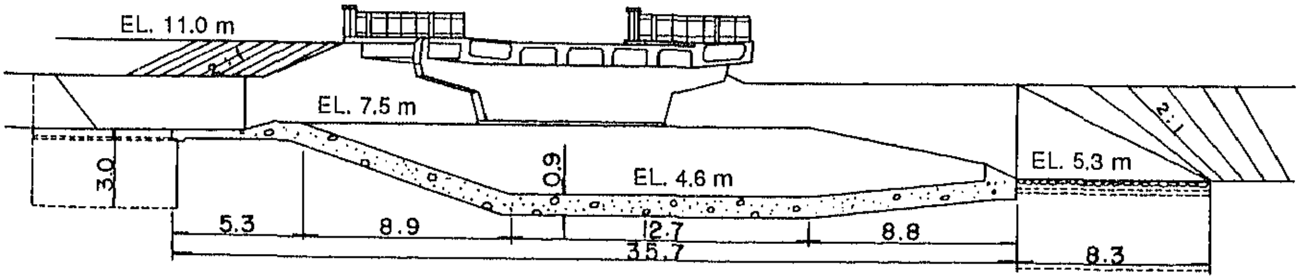


FIG. E-7 **PLAN AND SECTION OF PUCHONG DROP**

THE STUDY ON THE FLOOD MITIGATION OF THE KLANG RIVER BASIN

JICA

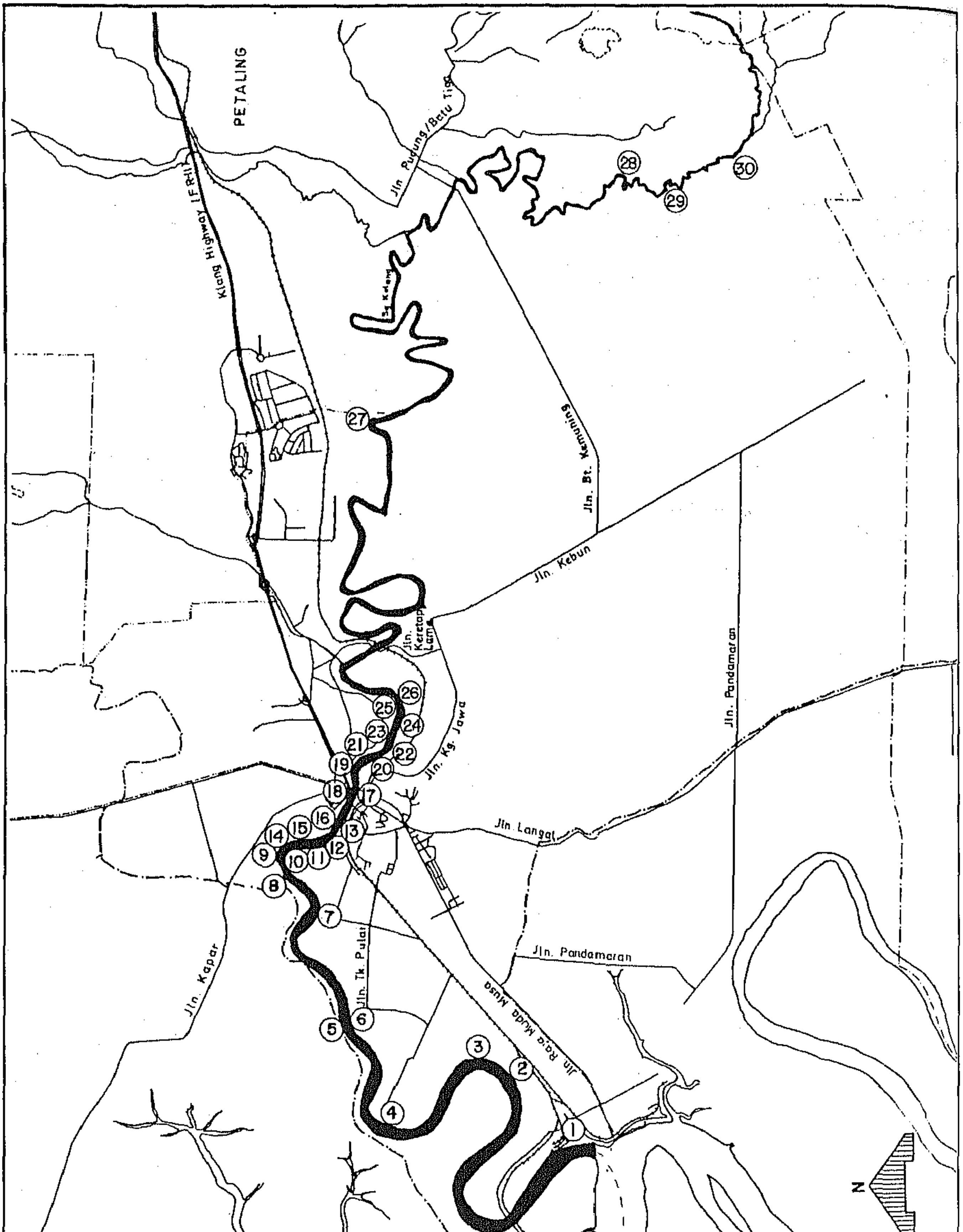


FIG. E-8	LOCATION MAP OF TIDAL GATE

THE STUDY ON THE FLOOD MITIGATION OF THE KLANG RIVER BASIN

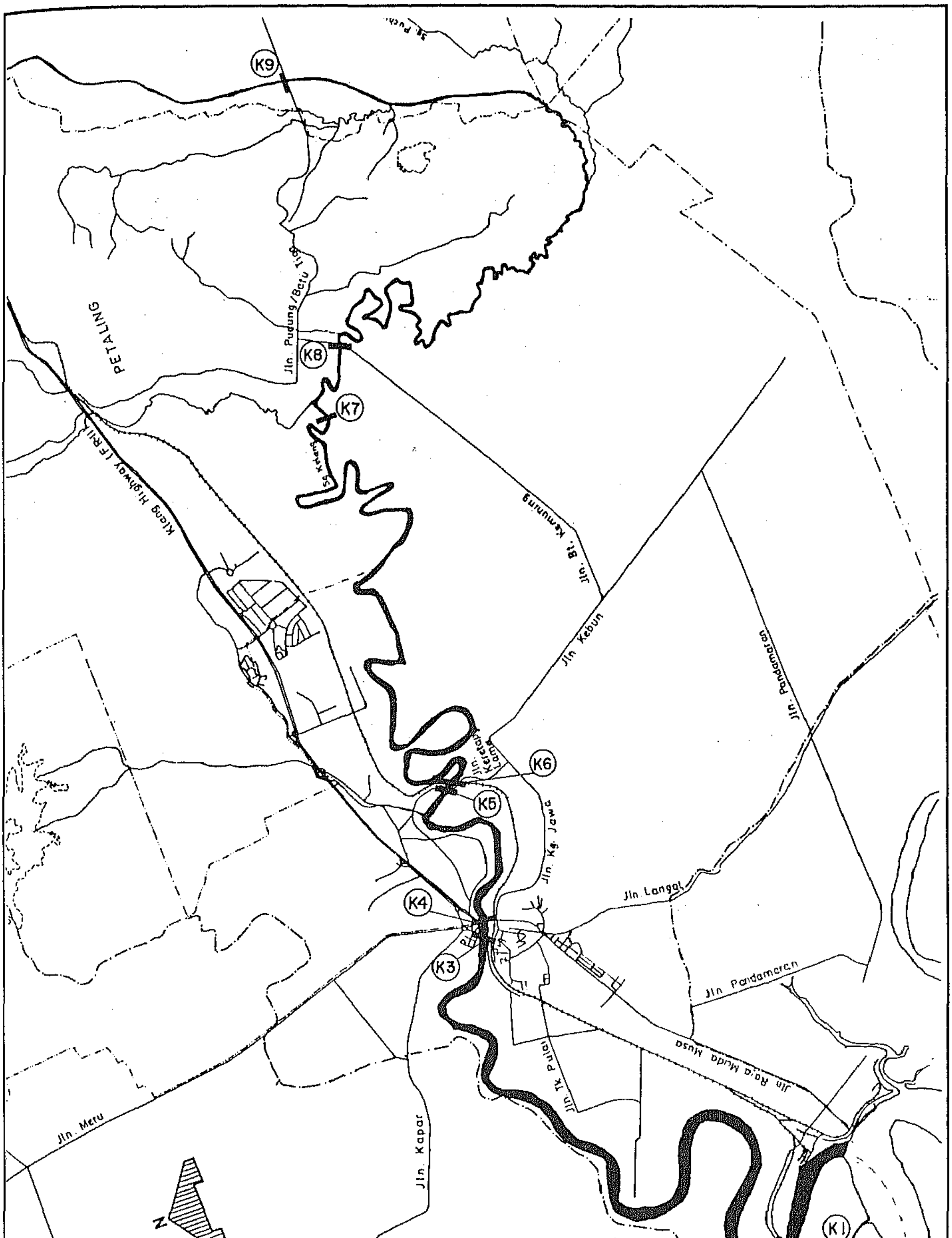


FIG. E-9	LOCATION MAP OF BRIDGE (1/2)

THE STUDY ON THE FLOOD MITIGATION OF THE KLANG RIVER BASIN

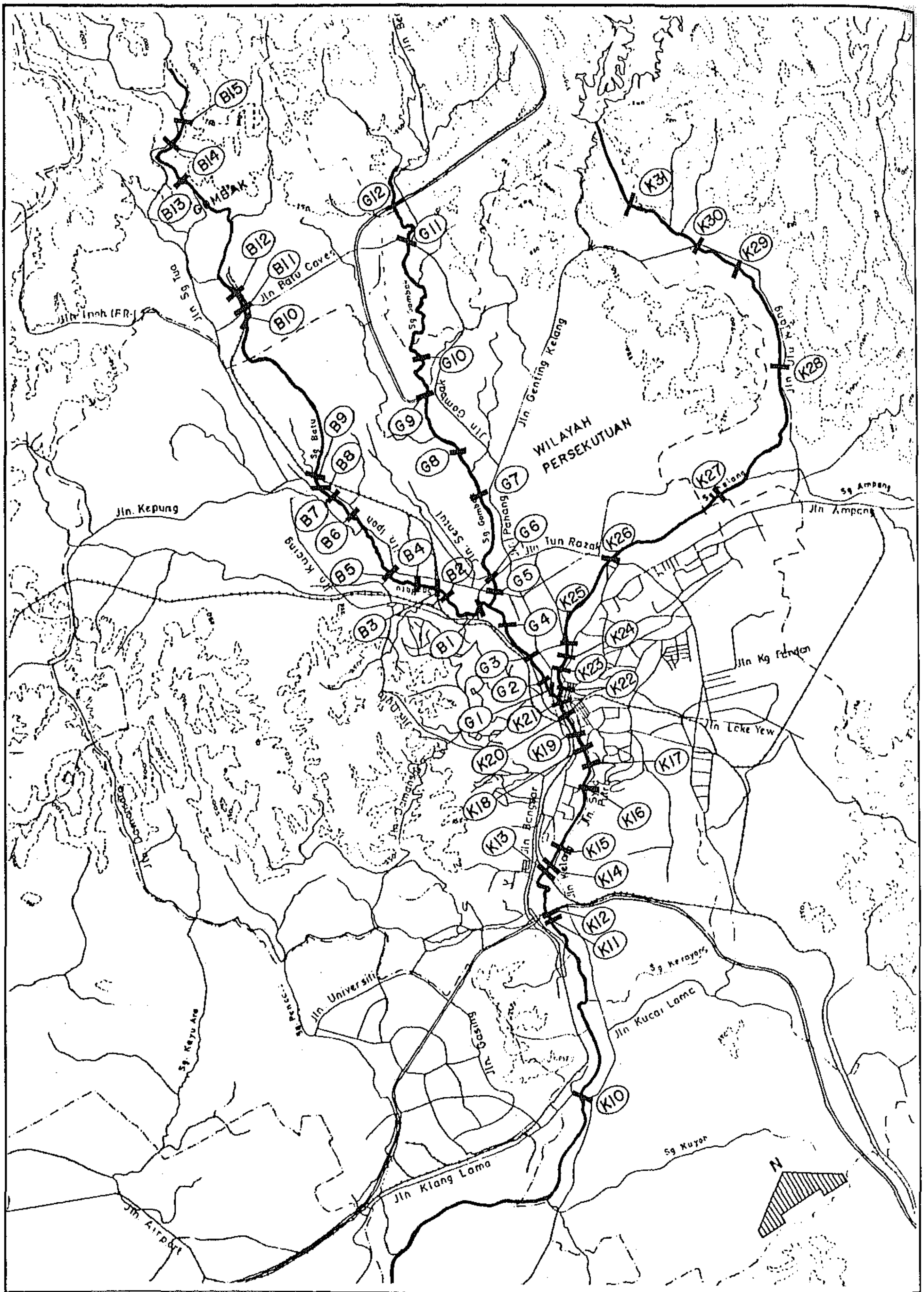


FIG. E-9	LOCATION MAP OF BRIDGE (2/2)

THE STUDY ON THE FLOOD MITIGATION OF THE KLANG RIVER BASIN

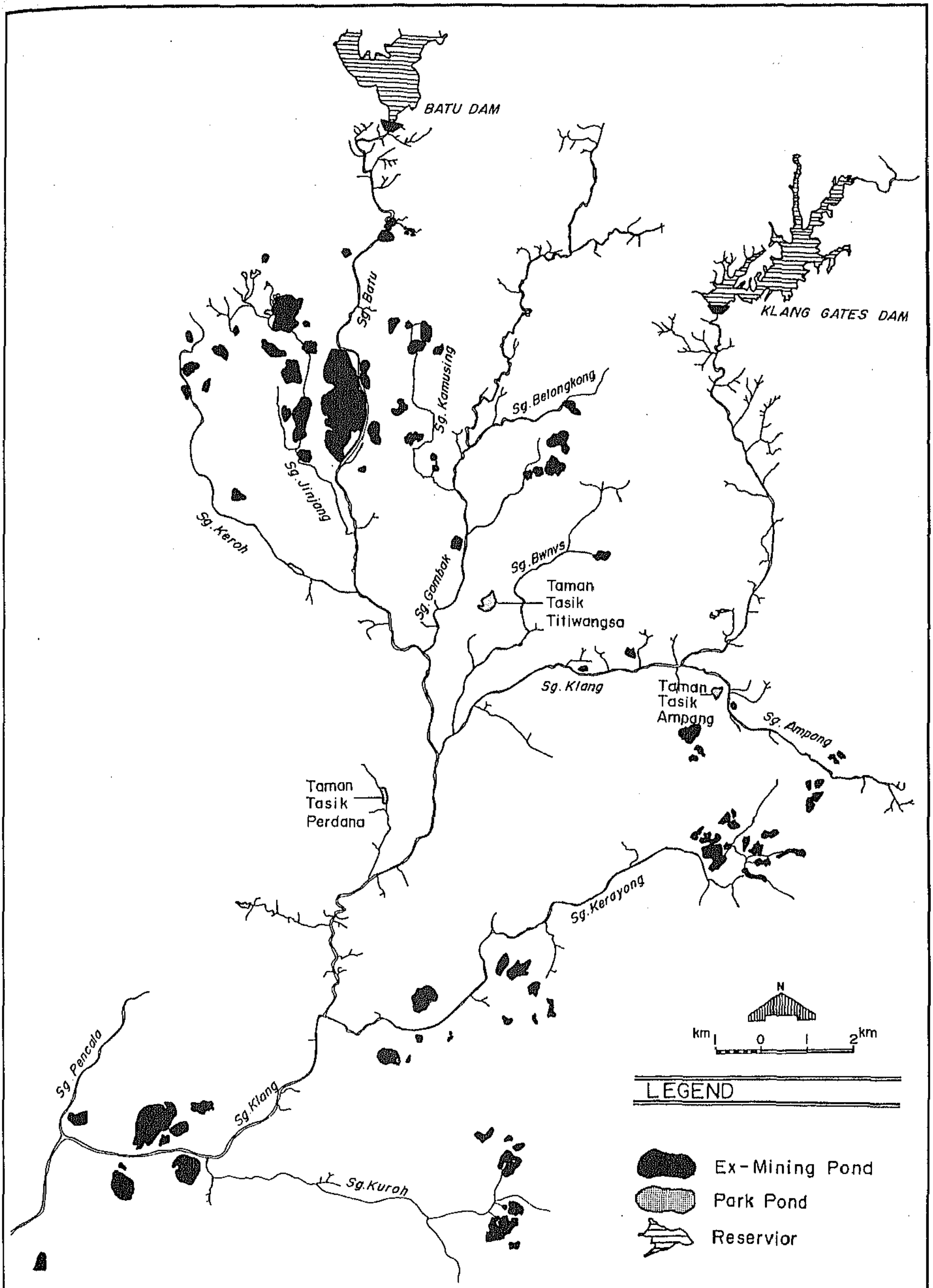
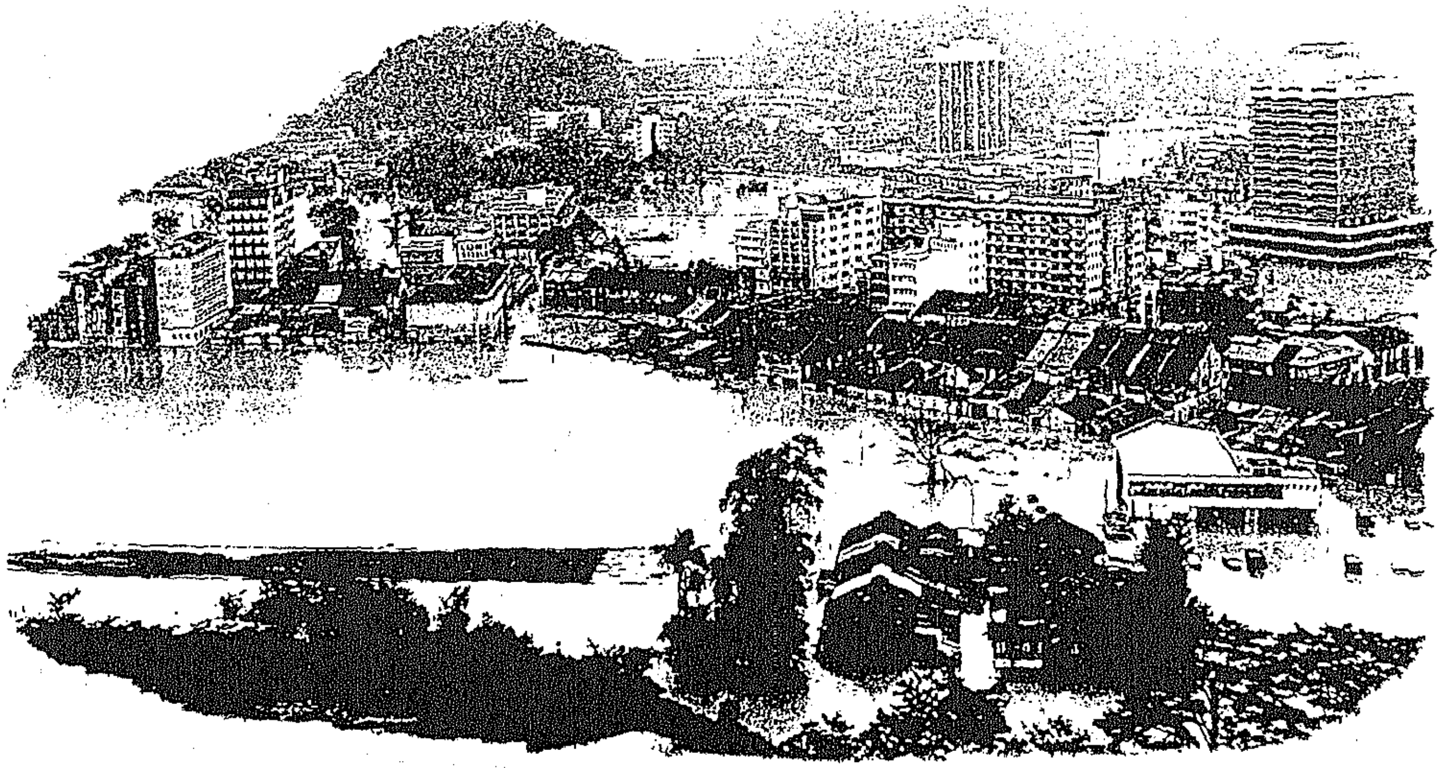


FIG. E-10 **DISTRIBUTION MAP OF EXISTING EX-MINING POND**

THE STUDY ON THE FLOOD MITIGATION OF THE KLANG RIVER BASIN

APPENDIX F: FLOOD RUN-OFF AND FLOODING MECHANISM



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APPENDIX F. FLOOD RUN-OFF AND FLOODING MECHANISM

1. FLOOD RUN-OFF ANALYSIS

1.1 General Procedure

In the Klang River basin, there exists Klang Gates Dam and Batu Dam. Besides, the river improvement works along the reach of Klang River, Batu River and Gombak River are on-going at present.

With due consideration of above conditions, flood run-off analysis aims at the following objects:

- to investigate the retardation effect for flood peak discharge by existing dams, and

- to formulate probable flood discharge distribution under present condition and with flood control works proposed by this Study.

For establishing the above objectives, the following study on flood run-off analysis is needed so as to simulate flood hydrograph at major site in the Basin.

- modelling of the river basin and channel,

- construction of a river system model in which the existing dams and proposed flood mitigation works are linked,

- rainfall analysis for determining the design rainfall duration, rainfall amount and pattern,

- run-off calculation for the present river condition and with proposed flood control works using results of rainfall analysis, and

- prediction of inundated area and depth in the target year.

Fig. F-1 shows the general procedures of flood run-off analysis.

1.2 Methodology

1.2.1 Simulation Model

As mentioned earlier, it is required to calculate the flood hydrograph in order to evaluate the effects for flood mitigation works.

In this Study, the Storage Function Method proposed by Dr. Kimura will be applied for the conversion of areal rainfall to flood hydrograph.

(1) Basic Equation

If flood run-off is assumed to be governed by Manning's formula, the storage amount (S_1) of a river basin or a river channel is expressed as an exponential function of run-off discharge (Q_1).

$$S_1 = K*Q_1^P$$

where, K, P : Constants for a basin or a channel

This equation of motion is combined with the following continuous equation for a river basin or a river channel.

a) For Basin

$$1/3.6*f*R_{ave}*A - Q_1 = d/dtS_1$$

where,
f : Inflow coefficient
Rave : Average rainfall in the basin (mm/hr)
A : Catchment area at the calculated point (km^2)
T_1 : Lag time (hr)
$Q_1(t)$: $Q(t+T_1)$ (m^3/sec)

Constants K, P and lag-time in the equation are initially estimated by means of the following empirical formulas which are described by average river bed slope in sub-basin. These are then calibrated using the flood records.

$$K = 118.84 \cdot i^{0.3}$$

$$P = 0.175 \cdot i^{-0.235}$$

where, i : Average river bed slope

In the study, lag-time in sub-basin is roughly estimated by following empirical formula.

$$TL = 0.047.L - 0.56 \quad (L > 11.9\ km)$$
$$TL = 0 \quad (L < 11.9\ km)$$

where, TL : Basin lag-time (hour)

L : River length (km)

b) For River Channel

$$\sum_{j=1}^{n} f_j I_j - Q1 = d/dt S_1$$

where, I_j : Inflow discharge into the channel from the basin, tributaries and/or upper boundary of the channel (m^3)

f_j : Inflow coefficient

T_1 : Lag time (hr)

$Q_1(t) = Q(t+T_1)$ (m^3/sec)

Discharge at lower boundary of channel after lag time

S_1 : Apparent storage in channel

(2) Run-off Coefficient

Run-off coefficients from the drainage area is referred to DID Standard.

The coefficients used for various types of land use are listed in Table F-1.

(3) Base Flow

Base flow is defined as the discharge just before flooding occurs, and that of probable flood is determined from mean monthly discharge for the wet season.

1.2.2 Rainfall Analysis

(1) Areal Rainfall

Areal rainfall for various duration is estimated by means of Thiessen's method. However, the daily records in the Basin are almost available after 1961. But for the estimation of the areal probable rainfall, it is required to use annual maximum areal rainfall for more than 20 years. Therefore, the correlation analysis is carried out for grasping the relation among the stations, and for filling up the missing data in the Basin. Results of this correlation analysis is applied for estimation of areal rainfall after 1961.

(2) Probable Areal Rainfall

Probable areal rainfall is estimated by means of log-normal method, Iwai method, Ishihara-Takase method and Gumbel method. The most suitable method among the above is applied for the estimation of the probable rainfall comparing the results with the plotting position.

(3) Duration Time and Pattern of Probable Rainfall

Design duration time and pattern of probable rainfall is decided on the basis of the observed rainfall duration time and patterns.

1.2.3 Hydraulic Calculation of the Flooding Area

The inundation area-depth is worked out by hydraulic flooding calculation.

Hydraulic flooding calculation in the Klang River basin is composed of Ida method and modified storage function of the channel.

(1) Ida Method

For numerically calculating the water level of sub-critical flow by non-uniform calculations, the following standard successive calculating method should be used for compound cross sections:

$$\left\{H_2 + \frac{D_2}{2g}\left(\frac{Q_2}{A_2}\right)^2\right\} - \left\{H_1 + \frac{D_1}{2g}\left(\frac{Q_1}{A_1}\right)^2\right\} = h_e$$

$$he = \frac{1}{2}\left\{\frac{N_1^2 Q_1^2}{A_1^2 R_1^{4/3}} + \frac{N_2^2 Q_2^2}{A_2^2 R_2^{4/3}}\right\} \Delta X$$

where, Di : Energy connection coefficient

Ri : Hydraulic radius

Qi : Discharge

Hi : Water level

Ni : Manning's coefficient of roughness

g : Gravity acceleration

If the currents of columnar elements are not affected by each other as shown in the figure below, Ida derived the above formula on the assumption that the energy correction coefficient is constant through the entire section and both the water level and water surface slope are the same throughout the whole width of the section. In this case, D, N and R can be given as follows:

$$D = \alpha \frac{A^2 \int_0^B \frac{h^3}{n^3} d\xi}{\left(\int_0^B \frac{h}{n}^{5/3} d\xi \right)^3}$$

$$N = \frac{\int_0^B h^{5/3} d\xi}{\int_0^B \frac{h^{5/3}}{n} d\xi}$$

$$R = \left(\frac{1}{A} \int_0^B h^{5/3} d\xi \right)^{3/2}$$

(2) Modified Storage Function

Inflow discharge into flooding plain should be retarded by the storage of the plain. Therefore, the storage of the flooding plain is expressed as an exponential function of the outflow discharge (Q) in the modified Storage Function Model.

$$S = K \times Q^P$$

where, K,P : Constants

Q : Outflow discharge in flooding plain

S : Storage volume at water level for outflow discharge (Q)

The constants of K,P should be estimated by least square method, based on the relationship among the water level, discharge and storage volume.

1.3 Result of Study

1.3.1 Basin Division and River System Model

Fig. F-2 shows the river system model for flood analysis. The river system model of the Klang River is modelled by 29 sub-basins, 21 river channels, and the existing Klang Gates Dam and Batu Dam. In addition, the proposed retention pond, retarding basin and diversion channel are linked to the river system model.

Target points are set at Sulaiman bridge and river mouth of the Klang River.

1.3.2 Run-off Coefficient

- Flood run-off coefficient
  Preliminary run-off coefficient for the sub-basins is listed in Table F-2, based on run-off coefficient under various land use condition of DID standard. Maximum limit of rainfall to saturate the ground surface, is set at about 100 mm through the calibration.

1.3.3 Base Flow

Base flow for probable flood discharge is assumed from the average monthly discharge at Batu Sentul gauging station. The specific discharge of 0.05 $m^3/sec/km^2$, which corresponds to the average discharge, is distributed into sub-basins.

1.3.4 Rainfall Analysis

(1) Probable Areal Rainfall

For the estimation of probable areal rainfall, stations should be selected, based on recording period and availability of daily rainfall data (Table F-3).

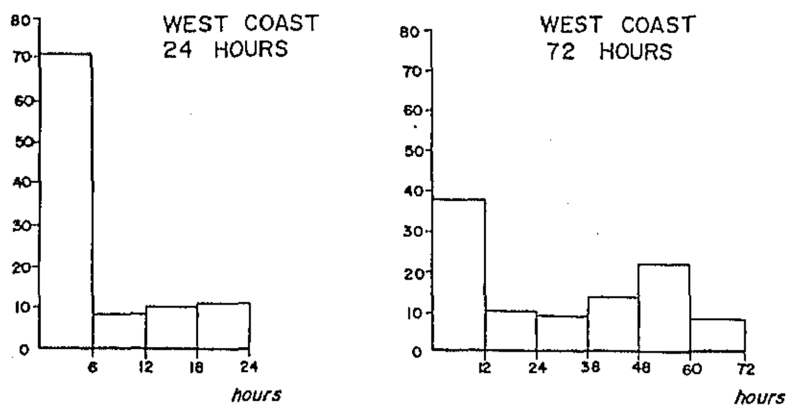
A Thiessen's polygon network based on the stations is shown in Fig. F-3. At some stations, the available daily rainfall records are insufficient from 1961 to 1985. A regression and correlation analysis for 30 stations was carried out to fill up for the value of the missing data. The result of analysis is listed in Table F-4 and then, the annual maximum areal rainfall, that listed in Table F-5, can be obtained using conversion factor of Thiessen's polygon method.

Based on the annual maximum values, frequency analysis was done as listed in Table F-6. The probable areal rainfall (Table F-7) for three target areas is estimated by Gumbel method because the Gumbel method is widely applied for the water resources development projects in Malaysia. Frequency curve of annual maximum are plotted in Fig. F-4.

(2) Storm Pattern

Temporal distribution at annual maximum rainstorms in Peninsular Malaysia has been estimated for selected durations namely 1/2, 3, 6, 12, 24 and 72 hours in Hydrological Procedure 1.

Based on the data from July 1970 to June 1979, temporal distribution in the West Coast Region are illustrated as below.



The following could be seen from the above distribution.

i) 70 percent of 24 hours amount is concentrated in 6 hours.
ii) 50 percent of 72 hours amount is concentrated in 24 hours.

Table lists the date of floods and availability of recording at the stations from 1971 to 1983.

Based on hourly mass curves and hyetograph of actual storm, rainstorm should be divided into 2 types;

i) Monsoon depression type with large amount of rainfall, low intensity and long duration (2-3 days) as caused the 1971 flood.

ii) Flash type with high intensity (30 mm/hr) of short duration (3-4 hrs), and such local distributions as caused flash floods and 1972 flood.

Fig. F-5, F-6 indicate the hourly mass curve and hyetograph of some stations in 1971 flood and 1972 flood.

1.3.5 Calibration of the Model

To calibrate the constant K and P used in the Model, the hydrographs were selected initially with the following considerations:

- Hourly rainfall available from 1970 to 1983
- Large magnitude of floods at Stations
- Floods with annual maximum occurrence at Stations

Initial selected hydrographs are listed below:

1971	Jan.	1	-	5
1972	Nov.	15	-	26
1973	Dec.	7	-	9
1974	Jun.	22	-	24
1975	Dec.	7	-	9
1977	Oct.	6	-	8
1980	July	25	-	29
1981	May	24	-	26
1982	Apr.	2	-	May 1
1983	Jun.	6	-	14

Calibration was done through trial and error in comparison between the calculated flood hydrographs and the hydrographs observed, in Batu River at Sentul Railway Bridge and Gombak River at Circular Road Bridge in Jun. 1974, May 1981, and Apr. 1982. (Fig. F-7)

Finally, constants of sub-basins are taken up by multiplying 0.6 times to the initial values estimated by the empirical formula.

1.3.6 Probable Flood Discharge

Probable flood hydrograph at the target point and the other point are converted from the probable areal rainfall using the model.

The probable floods after Klang Gates and Batu Dams' completion under 2005 land use condition and the completion of river improvement works (2005 years' condition) are studied, resulting in Fig. F-8, F-9.

In addition, flood routing calculation with 2005 year's condition are studied under the following mitigation plan.

i) Klang Gates Dam, Batu Dam, a retention pond, a diversion channel and a natural retarding basin.

ii) Klang Gates Dam, Batu Dam, Gombak Dam, a retention pond and a natural retarding basin.

1.3.7 Design Discharge Distribution

Based on the alternative study, the design discharge distribution was determined as following conditions.

i) 2005 year for the target
ii) After regulation of Klang Gates and Batu Dams
iii) After the completion of the improvement works
iv) With a diversion, a retention pond and a natural retarding basin

Fig. F-10 shows the design flood discharge distribution formulated by the Master Plan Study.

2. INUNDATION ANALYSIS

Inundation analysis was carried out to identify flood areas and inundation depth (or flood water level) under the existing river conditions for the estimation of annual flood damage potential.

2.1 Existing River Discharge Capacity

Bankful discharge capacity of the Klang, Gombak and Batu Rivers were calculated by non-uniform and uniform flow computation methods under the following conditions, for the 2 cases of with and without retention pond and diversion channel.

- Assuming the existing river conditions with a Mannings roughness coefficient of 0.03.

- Assuming the future (2005) conditions for catchment area land use with an equivalent Mannings coefficient of 0.1

Flood run-offs for return period of 10-year, 30-year, 50-year, 80-year and 100-year were computed by the Storage Function method by taking into account flood water retention in the catchment and water storage in the Klang Gates Dam and Batu Dam.

As a result of the above analysis the existing river discharge capacities were evaluated as follows:

- Improved reaches: Approx. 25-year frequency floods
- Non-improved reaches: 5~10-year frequency floods

The detailed computation results are presented in Data Book.

2.2 Inundation Analysis

Inundation analysis was carried out for 6 number frequency floods, ranging from 10 year to 200 year (10, 30, 50, 80, 100, 200 year frequency floods), under the following conditions that remained unchanged:

- River under the existing conditions
- Catchment area under the future (2005) land use conditions
- Without considering the proposed retention pond and diversion channel
- Considering the existing two dams

The analysis of the results are shown in Fig. F-11.

REFERENCE

1. KUALA LUMPUR FLOOD MITIGATION PROJECT, HYDROLOGY APPENDIX, Bureau of Reclamation United States, Department of the Interior, DID, Ministry of Agriculture, Malaysia, 1980

2. HYDROLOGICAL PROCEDURE NO. 11, DESIGN FLOOD HYDROGRAPH ESTIMATION FOR RURAL CATCHMENTS IN PENINSULAR MALAYSIA, Drainage and Irrigation Division, Ministry of Agriculture, Malaysia, 1980

3. HYDROLOGICAL PROCEDURE NO. 16, FLOOD ESTIMATION FOR URBAN AREAS IN PENINSULAR MALAYSIA, Ministry of Agriculture, Malaysia, 1980

4. KUALA LUMPUR FLOOD MITIGATION PROJECT RIVER IMPROVEMENT WORKS, RIVER WORKS MASTER PLAN 1980 VOL. I REPORT AND EXHIBITS, Project Engineer Office, Flood Mitigation Planning, Kuala Lumpur, Drainage & Irrigation Department, Ministry of Agriculture, Malaysia, 1980

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Table F-1 RUN-OFF COEFFICIENT BY DID STANDARD

Type of Drainage Area	Coefficient (C)
Business Areas	0.70 - 0.95
Residential Areas	0.25 - 0.50
Light Industrial Areas	0.50 - 0.80
Unimproved Areas	0.10 - 0.30
Streets	0.70 - 0.95
Lawns:	
Sandy soil, flat 2%	0.05 - 0.10
Sandy soil, av. 2 - 7%	0.10 - 0.15
Sandy soil, steep 7%	0.15 - 0.20
Heavy soil, flat 2%	0.13 - 0.17
Heavy soil, av. 2 - 7%	0.18 - 0.22
Heavy soil, steep 7%	0.25 - 0.35

Hydrological Procedure No. 16
Flood Estimation for Urban Areas in Peninsular Malaysia
1980 Ministry of Agriculture

Table F-2 RUN-OFF COEFFICIENT FOR THE SUB-BASIN

No.	C.A (km2)	Run-off Coe.		No.	C.A (km2)	Run-off Coe.	
		1985	2005			1985	2005
1	76.7	0.30	0.30	16	30.9	0.47	0.50
2	39.8	0.36	0.41	17	28.1	0.41	0.47
3	37.3	0.36	0.39	18	41.0	0.52	0.54
4	17.7	0.53	0.61	19	10.3	0.49	0.51
5	17.5	0.48	0.56	20	75.0	0.36	0.44
6	88.1	0.30	0.30	21	9.3	0.41	0.59
7	6.8	0.35	0.49	22	25.1	0.50	0.52
8	27.1	0.50	0.51	23	34.1	0.35	0.37
9	50.2	0.30	0.32	24	36.1	0.30	0.32
10	16.0	0.34	0.49	25	109.8	0.30	0.30
11	2.5	0.46	0.54	26	57.3	0.31	0.36
12	28.5	0.39	0.42	27	147.6	0.33	0.36
13	6.5	0.60	0.63	28	176.2	0.35	0.42
14	38.5	0.40	0.46	29	49.4	0.37	0.38
15	5.0	0.59	0.52				

Note : Upper Basin (No. 1 ~ 15) 458.2 km2
Middle Basin (No.16 ~ 23) 253.8 km2
Lower Basin (No.24 ~ 29) 576.4 km2

Table F-3 BAR CHART OF AVAILABLE RECORD

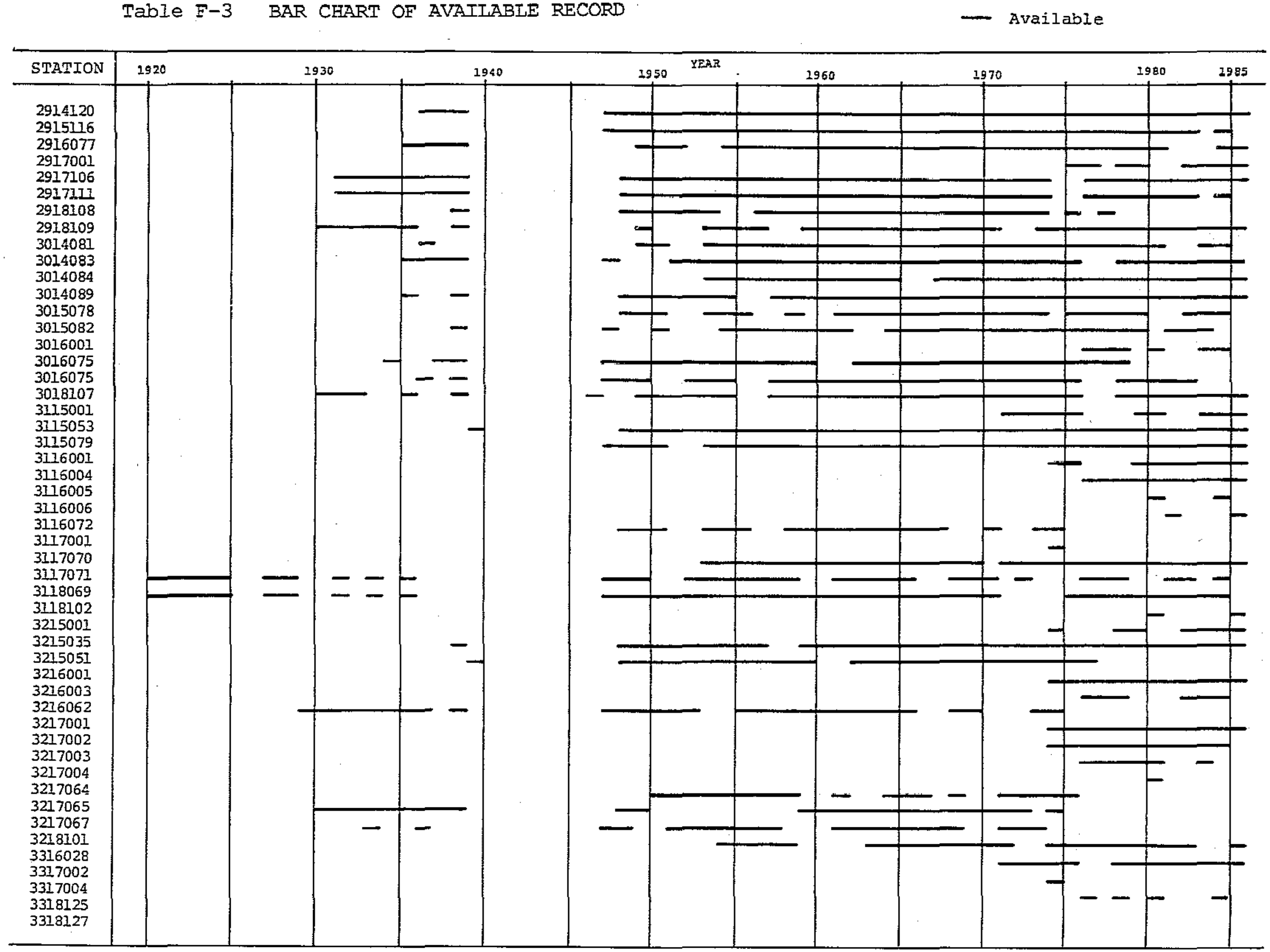


Table F-4

RECORDED HOURLY RAINFALL CONDITION IN PAST FLOODS

0: Available

DATE \ STATION NO.	2917001	2917105	3016001	3116002	3116004	3116005	3116006	3117001	3117070	3118102	3216001	3216002	3216003	3217001	3217002	3217003	3217004	3217067	3317002	3317004	3318126	3416001	3146002
3 JAN 71 – 7 JAN 71	–	0	–	–	–	–	–	–	0	–	0	–	–	–	–	–	–	–	–	–	0	–	–
15 NOV 72 – 18 NOV 72	–	0	–	–	–	–	–	–	0	0	0	–	–	–	–	–	–	0	–	–	0	–	–
23 NOV 72 – 27 NOV 72	–	–	–	–	–	–	–	–	0	0	0	–	–	–	–	–	–	0	–	–	0	–	–
10 APR 73 – 14 APR 73	–	0	–	0	–	–	–	–	0	–	0	–	0	–	0	–	–	0	–	–	–	–	–
6 DEC 73 – 9 DEC 73	–	0	–	0	–	–	–	–	0	0	0	–	0	0	0	–	–	0	–	–	0	–	–
21 JUN 74 – 26 JUN 74	–	0	–	0	–	–	–	–	0	–	–	–	0	0	0	0	–	0	–	–	–	–	–
9 DEC 74 – 13 DEC 74	–	0	–	0	–	–	–	0	0	0	0	0	0	0	0	0	–	0	0	0	0	0	–
6 NOV 75 – 9 NOV 75	0	–	–	–	–	–	–	0	0	–	0	0	0	0	0	0	–	–	0	0	–	0	–
22 DEC 75 – 26 DEC 75	–	–	–	–	0	–	–	0	0	0	0	0	–	0	0	0	–	–	0	0	–	0	–
20 APR 76 – 24 APR 76	0	–	0	0	0	0	–	–	0	0	0	–	0	0	0	0	–	–	0	0	–	0	–
23 APR 77 – 1 MAY 77	0	–	0	0	0	0	0	–	0	0	0	–	0	0	0	0	–	–	–	0	–	0	–
4 OCT 77 – 13 OCT 77	0	–	0	0	0	0	0	–	0	0	0	–	0	0	0	0	–	–	–	0	–	0	–
16 MAR 78 – 23 MAR 78	0	–	0	0	0	0	0	–	0	0	0	–	0	0	0	0	–	–	–	0	–	0	–
14 APR 78 – 22 APR 78	0	–	0	–	0	0	0	–	0	0	0	–	0	0	0	0	–	–	–	0	–	0	–
18 OCT 78 – 22 OCT 78	0	–	0	–	0	0	0	–	0	0	0	–	0	0	0	0	–	–	–	0	–	–	0
14 NOV 78 – 18 NOV 78	0	–	0	0	0	0	0	–	–	0	0	–	0	0	0	0	–	–	–	0	–	–	0
5 JUN 79 – 12 JUN 79	0	–	0	0	0	0	0	–	0	0	0	–	0	0	0	0	0	–	–	0	–	–	0
6 APR 80 – 10 APR 80	0	–	0	0	0	0	0	–	0	–	0	–	0	0	0	0	0	–	–	0	–	–	0
12 MAY 80 – 17 MAY 80	0	–	0	–	–	0	–	–	0	0	0	–	0	0	0	0	0	–	–	0	–	–	0
3 JUN 80 – 8 JUN 80	0	–	0	–	0	0	0	–	0	0	0	–	0	0	0	0	0	–	–	0	–	–	0
12 OCT 80 – 17 OCT 80	0	–	0	–	0	0	0	–	0	0	0	–	0	0	0	–	0	–	–	0	–	–	0
6 APR 81 – 10 APR 81	–	–	0	–	0	–	0	–	0	0	0	–	0	–	0	–	0	–	–	0	–	–	0
22 MAY 81 – 27 MAY 81	0	–	0	–	0	0	0	–	0	0	0	–	0	0	0	0	0	–	–	0	–	–	0
10 SEP 81 – 15 SEP 81	0	–	0	–	0	0	0	–	0	0	0	–	–	–	0	0	0	–	–	0	–	–	0
27 APR 82 – 1 MAY 82	–	–	–	–	0	0	0	–	0	0	0	–	0	0	0	0	0	–	–	0	–	–	0
29 NOV 82 – 1 DEC 82	–	–	0	–	0	0	0	–	0	0	–	–	0	–	0	–	0	–	–	0	–	–	0
5 JUN 83 – 11 JUN 83	–	–	–	–	0	0	0	–	0	0	0	–	0	0	0	0	0	–	–	0	–	–	0

Table F-5 REGRESSION AND CORRELATION FOR 30 STATIONS (1/3)

Base Station	Order of High Regression							
	1)	2)	3)	4)	5)	6)	7)	8)
1) 2914120	3014083	3014084	3014089	2915116	3015082	3015078	3014081	3115053
Reg.Coe	.866	.735	.724	.690	.680	.654	.626	.616
Coe. A	.905	.983	.992	1.049	.965	.933	.908	.917
Coe. B	5.875	3.282	-4.317	-17.431	-15.516	-13.174	1.288	-4.381
Sump.NN	297.	284.	288.	299.	286.	299.	290.	300.
2) 2915116	2914120	3015078	3115053	3014083	3115079	3014084	3015082	3016075
Reg.Coe	.690	.667	.661	.648	.644	.642	.642	.637
Coe. A	.953	.887	.877	.831	.845	.933	.900	.936
Coe. B	16.614	4.982	11.945	27.937	20.783	19.621	5.929	14.030
Sump.NN	299.	298.	299.	296.	299.	283.	285.	287.
3) 2917106	2917111	3016075	3016076	3115079	3116001	3215051	3115053	2918109
Reg.Coe	.875	.779	.753	.730	.729	.715	.712	.692
Coe. A	1.072	1.054	.938	1.034	.871	.886	1.067	.938
Coe. B	-3.616	-15.218	6.324	-2.006	9.462	9.209	-11.032	16.191
Sump.NN	292.	230.	274.	297.	181.	206.	297.	295.
4) 2917111	2917106	3016075	3016076	3116001	3215051	3115079	3115053	2915116
Reg.Coe	.875	.706	.700	.681	.676	.659	.655	.632
Coe. A	.933	.921	.859	.864	.747	.935	.972	1.137
Coe. B	3.372	2.910	12.771	-1.678	30.942	7.153	-2.517	-20.698
Sump.NN	292.	229.	273.	176.	205.	292.	292.	291.
5) 2918109	3018107	2917106	3215051	3016075	3218101	3116001	3118069	3117870
Reg.Coe	.704	.692	.664	.651	.648	.647	.644	.637
Coe. A	.869	1.067	.964	1.154	.946	.918	.910	1.070
Coe. B	9.146	-17.268	-10.226	-37.010	-11.176	-3.629	-8.994	-36.338
Sump.NN	285.	295.	208.	232.	288.	182.	268.	239.
6) 3014081	3014084	3014089	3015082	3014083	3015078	3115053	3115079	2914120
Reg.Coe	.773	.769	.723	.687	.684	.658	.652	.626
Coe. A	1.061	1.071	1.002	.979	1.061	1.026	.974	1.101
Coe. B	6.356	-1.998	-8.365	8.757	-20.924	-8.784	4.039	-1.418
Sump.NN	282.	286.	278.	287.	289.	290.	290.	290.
7) 3014083	2914120	3014084	3014089	3015082	3014081	3015078	2915116	3115053
Reg.Coe	.866	.770	.749	.724	.687	.680	.648	.613
Coe. A	1.105	1.087	1.136	1.084	1.022	1.055	1.203	1.046
Coe. B	-6.493	-3.001	-17.965	-27.114	-8.945	-26.097	-33.618	-17.391
Sump.NN	297.	281.	285.	283.	287.	296.	296.	297.
8) 3014084	3014089	3014081	3014083	2914120	3015082	3015078	2915116	3115053
Reg.Coe	.819	.773	.770	.735	.716	.662	.642	.629
Coe. A	1.006	.943	.920	1.017	.988	.994	1.072	.952
Coe. B	-7.059	-5.993	2.760	-3.338	-18.449	-23.446	-21.031	-11.210
Sump.NN	284.	282.	281.	284.	270.	283.	283.	284.
9) 3014089	3014084	3014081	3014083	2914120	3115079	3015082	3115053	3015078
Reg.Coe	.819	.769	.749	.724	.682	.678	.673	.643
Coe. A	.994	.934	.880	1.008	.912	.989	.948	.984
Coe. B	7.015	1.866	15.807	4.351	5.873	-12.556	-4.427	-15.564
Sump.NN	284.	286.	285.	288.	288.	274.	288.	287.
10) 3015078	3015082	3014081	3014083	2915116	3014084	2914120	3016075	3014089
Reg.Coe	.769	.684	.680	.667	.662	.654	.649	.643
Coe. A	1.038	.943	.947	1.128	1.007	1.072	.975	1.016
Coe. B	-2.307	19.728	24.725	-5.619	23.599	14.125	5.797	15.811
Sump.NN	285.	289.	296.	298.	283.	299.	233.	287.
11) 3015082	3015078	3014083	3014081	3014084	2914120	3014089	3115053	2915116
Reg.Coe	.769	.724	.723	.716	.680	.678	.657	.642
Coe. A	.964	.922	.998	1.012	1.037	1.011	.967	1.111
Coe. B	2.223	25.007	8.348	18.670	16.083	12.700	7.669	-6.590
Sump.NN	285.	283.	278.	270.	286.	274.	286.	285.
12) 3016075	3016076	3116001	2917106	3115079	3215051	3115053	2917111	3215035
Reg.Coe	.922	.814	.779	.776	.743	.742	.706	.661
Coe. A	.947	1.014	.949	.964	.848	.987	1.086	.778
Coe. B	15.766	-2.774	14.439	16.655	22.957	7.981	-3.159	34.248
Sump.NN	231.	118.	230.	233.	207.	233.	229.	233.

Table F-5 REGRESSION AND CORRELATION FOR 30 STATIONS (2/3)

Base Station	Order of High Regression 1)	2)	3)	4)	5)	6)	7)	8)
13) 3016076	3016075	3116001	2917106	3115079	3215051	3115053	2917111	3015078
Reg.Coe	.922	.841	.753	.748	.718	.701	.700	.638
Coe. A	1.056	.985	1.066	1.088	.940	1.127	1.165	.907
Coe. B	-16.649	-9.517	-6.739	-8.410	-1.677	-18.055	-14.873	10.322
Sump.NN	231.	161.	274.	277.	207.	277.	273.	277.
14) 3018107	2918109	3215051	3118069	3117070	3218101	3217002	3117071	3016075
Reg.Coe	.704	.684	.673	.672	.668	.644	.635	.633
Coe. A	1.151	.954	1.043	1.260	1.114	1.592	1.157	1.323
Coe. B	-10.530	-1.541	-21.156	-60.487	-27.060	-77.807	-38.002	-59.024
Sump.NN	285.	203.	255.	234.	283.	69.	276.	227.
15) 3115053	3215035	3115079	3215051	3016075	2917106	3016076	3116001	3014089
Reg.Coe	.848	.775	.747	.742	.712	.701	.689	.673
Coe. A	.848	.973	.857	1.013	.937	.887	.788	1.055
Coe. B	17.906	8.279	13.717	-8.088	10.338	16.021	24.514	4.670
Sump.NN	300.	300.	209.	233.	297.	277.	184.	288.
16) 3115079	3215051	3016075	3115053	3016076	3215035	2917106	3116001	3216001
Reg.Coe	.782	.776	.775	.748	.733	.730	.724	.718
Coe. A	.904	1.038	1.028	.919	.851	.967	.792	.682
Coe. B	2.555	-17.283	-8.511	7.731	14.229	1.940	19.065	37.458
Sump.NN	209.	233.	300.	277.	300.	297.	184.	79.
17) 3116001	3016076	3016075	3215051	2917106	3115079	3117071	3115053	2917111
Reg.Coe	.841	.814	.752	.729	.724	.721	.689	.681
Coe. A	1.015	.986	.860	1.149	1.263	1.040	1.269	1.157
Coe. B	9.664	2.736	9.619	-10.870	-24.075	-14.826	-31.110	1.942
Sump.NN	161.	118.	94.	181.	184.	175.	184.	176.
18) 3116004	3117070	3215051	3117071	3216001	3116001	3118069	3018107	3217064
Reg.Coe	.713	.702	.685	.661	.615	.615	.605	.602
Coe. A	1.447	.757	1.335	.889	1.125	1.432	.807	.952
Coe. B	-94.754	38.443	-73.336	15.739	-34.791	-79.873	23.917	60.786
Sump.NN	66.	36.	63.	66.	66.	64.	60.	24.
19) 3117070	3117071	3118069	3116004	3217002	3215051	3018107	3216001	3217065
Reg.Coe	.772	.724	.713	.698	.676	.672	.671	.671
Coe. A	.962	.856	.691	.923	.902	.793	.826	.713
Coe. B	11.066	24.625	65.505	32.444	23.818	47.993	22.083	63.764
Sump.NN	230.	233.	66.	75.	209.	234.	184.	79.
20) 3117071	3117070	3116001	3217002	3116004	3217001	3216001	3215051	3115079
Reg.Coe	.772	.721	.708	.685	.680	.675	.672	.653
Coe. A	1.039	.961	.992	.749	1.052	.773	.928	1.146
Coe. B	-11.502	14.251	19.233	54.913	-1.014	50.980	15.764	-5.884
Sump.NN	230.	175.	70.	63.	77.	72.	201.	289.
21) 3118069	3216001	3117070	3217001	3217065	3218101	3018107	3217002	2918109
Reg.Coe	.726	.724	.696	.688	.679	.673	.665	.644
Coe. A	.847	1.168	1.132	.957	1.066	.959	1.067	1.099
Coe. B	38.449	-28.756	-15.494	-.857	-5.773	20.283	3.954	9.882
Sump.NN	76.	233.	81.	177.	259.	255.	74.	268.
22) 3215035	3115053	3215051	3115079	3016075	2917106	3016076	3116001	3015077
Reg.Coe	.848	.770	.733	.661	.655	.638	.632	.623
Coe. A	1.179	1.037	1.175	1.285	1.153	1.102	.961	1.265
Coe. B	-21.113	-6.135	-16.719	-44.000	-18.407	-11.376	3.458	-45.164
Sump.NN	300.	209.	300.	233.	297.	277.	184.	299.
23) 3215051	3115079	3215035	3116001	3115053	3016075	3016076	2917106	3116004
Reg.Coe	.782	.770	.752	.747	.743	.718	.715	.702
Coe. A	1.106	.964	1.163	1.167	1.180	1.064	1.129	1.321
Coe. B	-2.825	5.915	-11.187	-16.011	-27.085	1.784	-10.399	-50.765
Sump.NN	209.	209.	94.	209.	207.	207.	206.	36.
24) 3216001	3217001	3118069	3115079	3217002	3117071	3117070	3116004	3115053
Reg.Coe	.768	.726	.718	.694	.675	.671	.661	.650
Coe. A	1.278	1.181	1.467	1.302	1.294	1.403	1.124	1.628
Coe. B	-52.874	-45.421	-54.939	-46.471	-65.984	-89.472	-17.698	-104.837
Sump.NN	79.	76.	79.	75.	72.	79.	66.	79.

Table F-5 REGRESSION AND CORRELATION FOR 30 STATIONS (3/3)

Base Station	Order of High Regression							
	1)	2)	3)	4)	5)	6)	7)	8)
25) 3217001	3217002	3217065	3216001	3217064	3218101	3118069	3318127	3117071
Reg.Coe	.850	.777	.768	.739	.700	.696	.684	.680
Coe. A	.961	.693	.782	.962	.996	.883	1.141	.950
Coe. B	13.406	42.147	41.372	40.234	-.359	13.686	25.825	.964
Sump.NN	75.	28.	79.	42.	84.	81.	84.	77.
26) 3217002	3217001	3217065	3117071	3117070	3216001	3218101	3318127	3118069
Reg.Coe	.850	.840	.708	.698	.694	.690	.681	.665
Coe. A	1.041	.802	1.008	1.084	.768	1.001	1.147	.937
Coe. B	-13.957	8.609	-19.387	-35.169	35.698	-8.232	18.394	-3.706
Sump.NN	75.	20.	70.	75.	75.	75.	75.	74.
27) 3217064	3217001	3217002	3116004	3216001	3218101	3117070	3117071	3118069
Reg.Coe	.739	.616	.602	.560	.519	.456	.456	.450
Coe. A	1.039	.991	1.050	.706	1.015	1.100	1.053	.912
Coe. B	-41.816	-24.989	-63.849	15.196	-49.058	-69.037	-57.238	-38.598
Sump.NN	42.	33.	24.	37.	187.	188.	180.	181.
28) 3217065	3217002	3217001	3118069	3117070	2918109	3018107	3216001	2917106
Reg.Coe	.840	.777	.688	.671	.622	.613	.613	.605
Coe. A	1.247	1.443	1.045	1.211	1.095	1.482	1.134	1.231
Coe. B	-10.737	-60.839	.896	-26.745	19.734	-52.140	5.202	-4.892
Sump.NN	20.	28.	177.	184.	183.	24.	184.	181.
29) 3218101	3217001	3217002	3118069	3318127	3018107	2918109	3117070	3117071
Reg.Coe	.700	.690	.679	.669	.668	.648	.612	.609
Coe. A	1.004	.999	.938	1.368	.898	1.057	1.112	1.024
Coe. B	.361	8.221	5.414	-9.718	24.296	11.816	-25.349	-5.914
Sump.NN	84.	75.	259.	285.	283.	288.	239.	280.
30) 3318127	3217001	3217002	3218101	3216001	3018107	2918109	3115079	3118069
Reg.Coe	.684	.681	.669	.640	.619	.583	.582	.571
Coe. A	.876	.872	.731	.666	.612	.742	.824	.641
Coe. B	-22.628	-16.033	7.104	17.213	34.456	21.594	7.457	22.486
Sump.NN	84.	75.	285.	79.	281.	293.	295.	264.

Table F-6 ANNUAL MAXIMUM AREAL RAINFALL

Unit : mm

1 Day

SULAIMAN BRIDGE		PUCHONG DROP		RIVER MOUTH	
Date	R	Date	R	Date	R
18.NOV 1961	54.4	6.JAN 1961	56.8	6.JAN 1961	66.1
30.OCT 1962	52.1	31.OCT 1962	52.1	30.NOV 1962	61.5
2.DEC 1963	73.8	2.DEC 1963	62.3	13.NOV 1963	54.0
3.MAR 1964	88.3	3.MAR 1964	81.1	3.MAR 1964	64.4
5.APR 1965	47.0	24.DEC 1965	50.0	14.FEB 1965	40.3
25.DEC 1966	38.2	4.DEC 1966	46.5	4.DEC 1966	53.4
17.JUN 1967	39.1	17.JUN 1967	45.5	17.JUN 1967	54.1
12.MAY 1968	46.2	14.DEC 1968	39.1	22.MAR 1968	35.7
30.MAR 1969	54.9	30.MAR 1969	47.9	2.JUN 1969	39.6
2.NOV 1970	77.2	2.NOV 1970	52.9	2.NOV 1970	32.4
4.JAN 1971	117.3	4.JAN 1971	114.2	4.JAN 1971	118.9
16.NOV 1972	40.0	16.NOV 1972	51.0	16.NOV 1972	44.5
24.FEB 1973	67.5	24.FEB 1973	64.6	24.FEB 1973	50.5
8.MAR 1974	61.1	8.MAR 1974	48.2	8.MAR 1974	37.5
10.FEB 1975	35.4	16.APR 1975	37.8	1.NOV 1975	44.3
25.AUG 1976	48.7	25.AUG 1976	47.0	25.AUG 1976	40.5
7.OCT 1977	77.0	7.OCT 1977	74.0	7.OCT 1977	64.7
19.OCT 1978	54.5	19.OCT 1978	38.1	19.SEP 1978	40.6
7.JUN 1979	102.5	7.JUN 1979	87.7	7.JUN 1979	66.9
15.OCT 1980	72.4	15.OCT 1980	56.5	15.OCT 1980	67.5
24.MAY 1981	61.3	24.MAY 1981	55.7	30.APR 1981	41.2
17.MAY 1982	67.2	1.NOV 1982	67.0	11.MAR 1982	50.4
13.NOV 1983	87.8	13.NOV 1983	77.4	13.MOV 1983	51.4
5.NOV 1984	92.0	5.NOV 1984	65.4	5.NOV 1984	49.1
15.NOV 1985	52.6	15.NOV 1985	44.2	3.DEC 1985	34.5

2 Days

SULAIMAN BRIDGE		PUCHONG DROP		RIVER MOUTH	
Date	R	Date	R	Date	R
22-23.MAR 1961	72.5	5-6.JAN 1961	73.6	12-13.JUN 1961	70.5
9-10.OCT 1962	89.8	30-31.OCT 1962	93.7	30-31.OCT 1962	96.7
12-13.NOV 1963	96.1	12-13.NOV 1963	105.8	12-13.NOV 1963	104.4
2-3.MAR 1964	91.9	2-3.MAR 1964	69.6	2-3.MAR 1964	86.2
26-27.SEP 1965	67.7	10-11.OCT 1965	56.1	4-5.APR 1965	63.2
10-11.JUL 1966	81.7	4-5.DEC 1966	65.4	4-5.DEC 1966	59.1
3-4.NOV 1967	60.0	16-17.JUN 1967	64.3	16-17.JUN 1967	56.0
15-16.MAY 1968	54.9	2-3.JUL 1968	64.7	15-16.MAY 1968	53.4
30-31.MAR 1969	79.2	2-3.JUN 1969	57.3	30-31.MAR 1969	65.1
30-31.MAR 1970	97.8	15-16.APR 1970	62.1	30-31.MAR 1970	83.6
4-5.JAN 1971	182.4	4-5.JAN 1971	184.5	4-5.JAN 1971	188.3
2-3.APR 1972	72.8	15-16.NOV 1972	78.6	15-16.NOV 1972	83.7
4-5.APR 1973	100.1	16-17.DEC 1973	72.4	16-17.DEC 1973	88.6
8-9.MAR 1974	76.0	8-9.MAR 1974	55.8	8-9.MAR 1974	65.2
1-2.SEP 1975	63.3	1-2.SEP 1975	66.6	1-2.SEP 1975	63.2
24-25.AUG 1976	60.8	24-25.MAR 1976	54.8	17-18.OCT 1976	59.5
26-27.AUG 1977	104.3	6-7.OCT 1977	76.0	6-7.OCT 1977	90.5
19-20.OCT 1978	102.2	19-20.OCT 1978	57.2	19-20.OCT 1978	74.9
6-7.JUN 1979	122.5	6-7.JUN 1979	81.6	6-7.JUN 1979	107.9
15-16.OCT 1980	96.8	15-16.OCT 1980	80.0	15-16.OCT 1980	74.4
30-1.MAY 1981	84.5	30-1.MAY 1981	69.8	30-1.MAY 1981	82.6
7-8.FEB 1982	109.6	28-29.NOV 1982	73.3	7-8.FEB 1982	84.9
19-20.JUL 1983	108.7	13-14.SEP 1983	64.9	12-13.NOV 1983	94.9
5-6.NOV 1984	108.8	5-6.NOV 1984	63.7	5-6.NOV 1984	85.1
8-9.JUL 1985	79.3	1-2.OCT 1985	49.4	9-10.DEC 1985	71.1

3 Days

SULAIMAN BRIDGE		PUCHONG DROP		RIVER MOUTH	
Date	R	Date	R	Date	R
17-19.NOV 1961	86.2	27-29.APR 1961	89.4	7-9.MAR 1961	79.7
9-11.OCT 1962	104.8	30-1.NOV 1962	107.3	30-1.NOV 1962	102.3
12-14.NOV 1963	109.1	12-14.NOV 1963	114.2	12-14.NOV 1963	123.9
1-3.SEP 1964	104.2	1-3.SEP 1964	96.6	1-3.SEP 1964	80.5
13-15.OCT 1965	83.9	13-15.OCT 1965	69.3	14-16.FEB 1965	70.8
10-12.JUL 1966	97.3	10-12.JUL 1966	87.0	20-22.NOV 1966	82.5
3-5.NOV 1967	80.8	21-23.OCT 1967	73.4	15-17.JUN 1967	81.3
17-19.JUL 1968	78.2	15-17.MAY 1968	82.7	2-4.JUL 1968	69.8
19-21.MAY 1969	87.5	21-23.OCT 1969	75.7	21-23.OCT 1969	68.4
29-31.MAR 1970	117.9	29-31.MAR 1970	99.2	15-17.APR 1970	74.5
3-5.JAN 1971	244.8	3-5.JAN 1971	245.4	3-5.JAN 1971	230.5
2-4.APR 1972	88.7	14-16.NOV 1972	104.0	14-16.NOV 1972	93.7
20-22.OCT 1973	93.6	25-27.MAY 1973	87.6	20-22.OCT 1973	81.8
8-10.MAR 1974	83.0	8-10.MAR 1974	73.4	8-10.MAR 1974	63.5
30-1.SEP 1975	67.5	30-1.SEP 1975	68.7	14-16.APR 1975	75.4
16-18.OCT 1976	75.7	16-18.OCT 1976	74.3	25-27.AUG 1976	66.0
5-7.OCT 1977	167.9	5-7.OCT 1977	142.9	5-7.OCT 1977	111.1
19-21.OCT 1978	117.7	19-21.OCT 1978	89.0	18-20.OCT 1978	64.8
5-7.JUN 1979	126.0	5-7.JUN 1979	111.1	10-12.APR 1979	97.0
15-17.OCT 1980	105.9	23-25.NOV 1980	96.6	22-24.NOV 1980	88.2
1-3.APR 1981	96.0	31-2.APR 1981	12.4	31-2.APR 1981	89.5
6-8.FEB 1982	117.3	6-8.FEB 1982	99.2	27-29.NOV 1982	112.0
18-20.JUL 1983	138.4	11-13.NOV 1983	111.6	12-14.SEP 1983	93.7
21-23.NOV 1984	129.3	21-23.NOV 1984	119.5	9-11.NOV 1984	93.4
13-15.NOV 1985	86.0	9-11.DEC 1985	87.8	9-11.FEB 1985	73.1

Table F-7 PROBABLE RAINFALL UNDER THE VARIOUS METHODS

SULAIMAN BRIDGE

T	RAIN FALL (MM)			1 Day	RAIN FALL (MM)			2 Days	RAIN FALL (MM)			3 Days
	LOG-NORMAL	TAKASE	IWAI	GUMBEL	LOG-NORMAL	TAKASE	IWAI	GUMBEL	LOG-NORMAL	TAKASE	IWAI	GUMBEL
200	147.4	140.2	140.1	151.7	181.3	173.5	215.9	197.1	217.7	230.3	304.5	251.7
100	135.3	129.3	128.7	138.9	168.9	162.3	190.1	181.5	202.5	210.7	253.2	230.6
80	131.1	125.0	124.8	134.7	164.7	158.7	181.8	176.5	197.3	203.3	237.8	223.8
50	122.8	117.5	117.1	125.9	156.1	151.0	166.1	165.9	186.7	190.3	209.7	209.5
30	113.8	109.5	108.8	116.3	146.7	142.4	150.4	154.4	175.2	176.7	183.3	193.8
20	106.6	102.5	102.1	108.7	139.1	135.4	138.7	145.1	165.8	165.1	165.0	181.3
10	94.1	91.1	90.6	95.4	125.6	122.9	120.5	129.1	149.4	146.8	138.8	159.5

PUCHONG DROP

T	RAIN FALL (MM)			1 Day	RAIN FALL (MM)			2 Days	RAIN FALL (MM)			3 Days
	LOG-NORMAL	TAKASE	IWAI	GUMBEL	LOG-NORMAL	TAKASE	IWAI	GUMBEL	LOG-NORMAL	TAKASE	IWAI	GUMBEL
200	117.7	119.2	140.1	131.3	160.8	156.7	227.4	184.6	193.6	189.5	290.9	230.3
100	109.5	110.1	123.8	120.6	150.1	147.0	187.6	169.7	180.9	180.8	236.1	211.3
80	106.7	106.6	118.6	117.1	146.4	143.1	175.8	164.8	176.6	177.2	220.1	205.2
50	101.0	100.4	108.5	109.8	139.0	136.3	154.5	154.6	167.7	170.7	191.5	192.3
30	94.7	93.9	98.4	101.8	130.8	128.8	134.9	143.5	158.0	163.1	165.7	178.2
20	89.7	88.2	90.7	95.5	124.1	122.2	121.5	134.6	150.1	156.1	148.3	166.9
10	80.8	79.1	78.7	84.4	112.4	111.2	102.7	119.1	136.2	143.7	124.6	147.2

RIVER MOUTH

T	RAIN FALL (MM)			1 Day	RAIN FALL (MM)			2 Days	RAIN FALL (MM)			3 Days
	LOG-NORMAL	TAKASE	IWAI	GUMBEL	LOG-NORMAL	TAKASE	IWAI	GUMBEL	LOG-NORMAL	TAKASE	IWAI	GUMBEL
200	109.2	101.2	146.4	122.1	137.9	153.1	216.2	168.8	174.0	176.8	270.4	211.5
100	101.2	95.3	122.9	111.9	129.2	139.7	174.5	154.9	162.7	164.8	218.0	193.8
80	98.5	92.9	115.8	108.6	126.3	134.6	162.4	150.4	158.8	160.1	202.7	188.2
50	93.0	88.7	102.7	101.7	120.2	125.9	140.9	141.0	150.9	151.9	175.6	176.2
30	87.0	84.0	90.2	94.0	113.6	116.9	121.5	130.6	142.2	142.9	151.3	163.0
20	82.1	79.7	81.4	88.0	108.1	109.2	108.6	122.4	135.1	135.1	134.9	152.5
10	73.6	72.6	68.5	77.4	98.5	97.4	91.1	108.0	122.7	122.3	112.8	134.3

Table F-8 PROBABLE AREAL RAINFALL

Unit : mm

T	SULAIMAN BRIDGE		
	1 DAY	2 DAYS	3 DAYS
200	151.7	197.1	251.7
100	138.9	181.5	230.6
80	134.7	176.5	223.8
50	125.9	165.9	209.5
30	116.3	154.4	193.8
20	108.7	145.1	181.3
10	95.4	129.1	159.5

Unit : mm

T	PUCHONG DROP		
	1 DAY	2 DAYS	3 DAYS
200	131.3	184.6	230.3
100	120.6	169.7	211.3
80	117.1	164.8	205.2
50	109.8	154.6	192.3
30	101.8	143.5	178.2
20	95.5	134.6	166.9
10	84.4	119.1	147.2

Unit : mm.

T	RIVER MOUTH		
	1 DAY	2 DAYS	3 DAYS
200	122.1	168.8	211.5
100	111.9	154.9	193.8
80	108.6	150.4	188.2
50	101.7	141.0	176.2
30	94.0	130.6	163.0
20	88.0	122.4	152.5
10	77.4	108.0	134.3

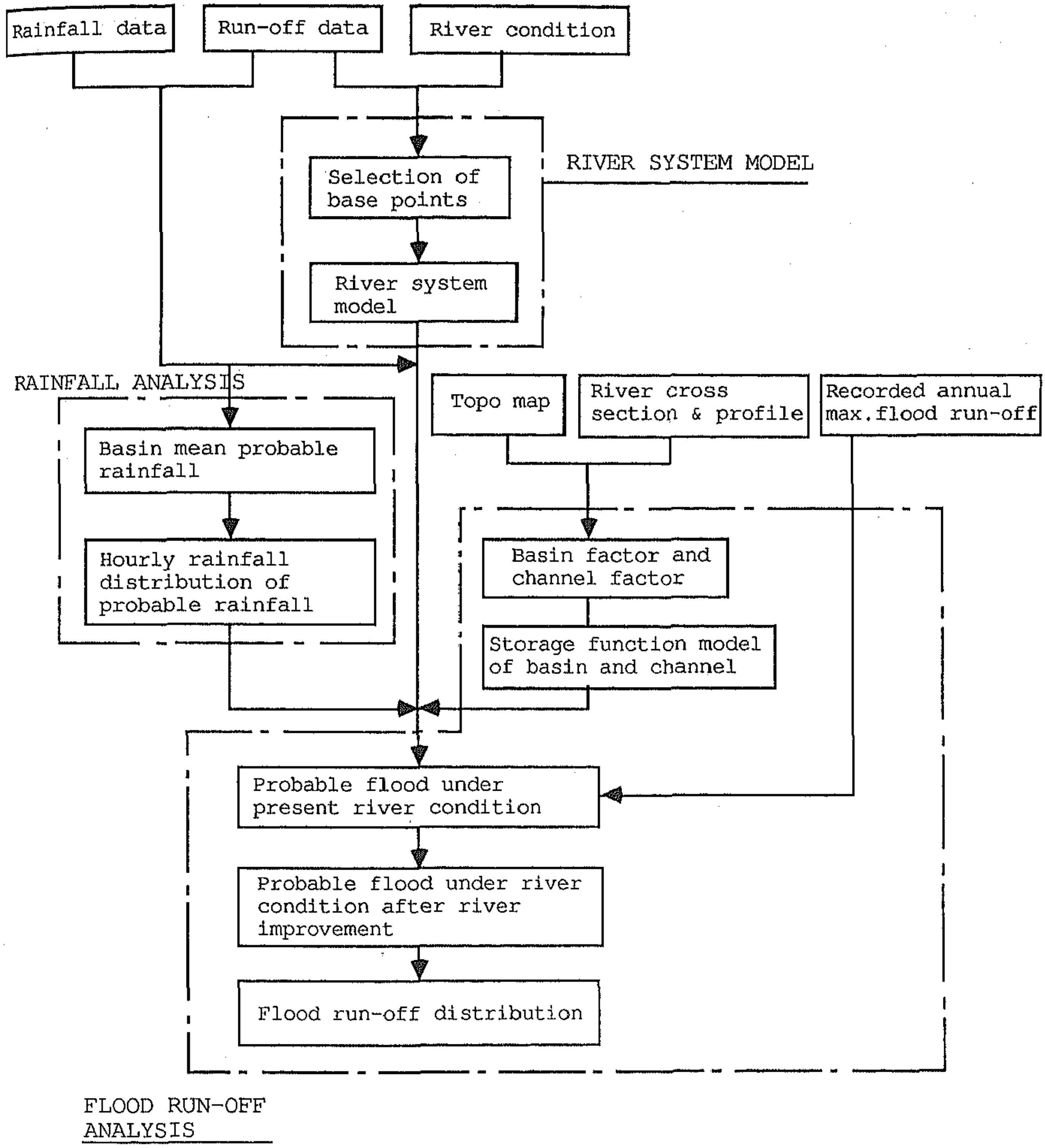
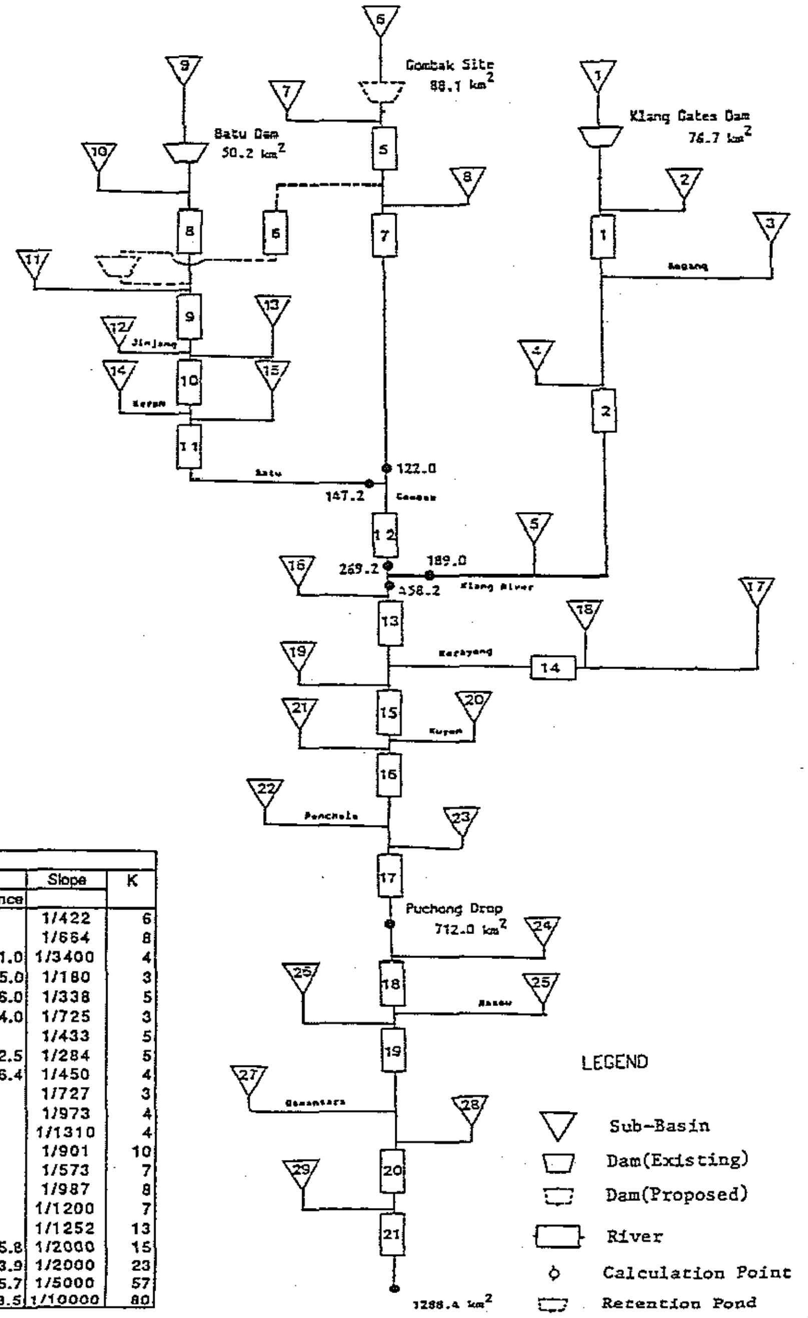


FIG. F-1 GENERAL FLOW CHART OF FLOOD ANALYSIS

THE STUDY ON THE FLOOD MITIGATION OF THE KLANG RIVER BASIN



Dimension and Coefficient of the Basins

No.	C.A. (Km²)	Elevation(m) Upper	Lower	Difference	River Length (Km)	Slope	K 1985	K 2005
1	76.7	1042	86	756	14.0	1/15	32	32
2	39.8	244	48	196	3.8	194	15	11
3	37.3	676	37	639	12.7	20	29	25
4	17.7	107	31	76	1.8	24	28	28
5	17.5	92	26	66	3.8	58	21	11
6	88.1	1430	72	1358	18.4	14	32	32
7	6.8	107	61	46	1.5	33	25	6
8	27.1	153	47	106	4.4	42	23	20
9	50.2	1181	102	1099	14.6	14	42	30
10	16.0	168	52	116	3.5	30	26	8
11	2.5	52	43	9	3.2	356	12	4
12	28.5	476	43	433	12.7	29	26	20
13	6.5	43	38	5	2.5	500	11	11
14	38.5	580	38	542	11.5	21	29	18
15	5.0	122	35	87	3.8	44	23	10
16	30.9	143	25	118	6.3	53	22	18
17	28.1	259	42	217	5.4	25	27	16
18	41.0	107	40	67	2.5	37	24	24
19	10.3	107	19	88	1.3	15	32	22
20	75.0	92	16	76	12.0	158	16	9
21	9.3	46	15	31	2.0	65	20	6
22	25.1	153	15	138	9.6	70	20	18
23	34.1	47	11	36	7.0	194	15	14
24	36.1	31	8	23	7.6	330	13	11
25	109.8	131	5	126	19.1	152	16	16
26	57.3	46	3	43	4.7	109	17	14
27	147.6	96	3	94	18.4	196	14	13
28	176.2	137	3	134	7.7	57	21	15
29	49.4	5	3	2	3.2	1600	8	8

Dimension and Coefficient of Rivers

River No.	River Name		1985 L (Km)	1985 b (m)	1985 Elevation(m) Upper	1985 Lower	1985 Difference	1985 Slope	1985 K	2005 L (Km)	2005 b (m)	2005 Elevation(m) Upper	2005 Lower	2005 Difference	2005 Slope	2005 K
1	Klang	/ Ampang	6.1	24	61.4	39.4	22.5	1/356	6	6.1	29				1/422	6
2	Kl ang	/ Bunus	6.6	25	39.4	26.4	13.0	1/538	7	6.6	34				1/664	8
3		/ Kerayong	3.4		36.0	35.0	1.0	1/3400		3.4		36.0	35.0	1.0	1/3400	4
4		/ Klang	4.2		65.0	60.0	5.0	1/840		4.2		65.0	60.0	5.0	1/180	3
5	Gombak	/ Belongkong	5.4	22	57.1	41.1	16.0	1/338	5	5.4	22	57.1	41.1	16.0	1/338	5
6		CH 48 CH 60	2.9		45.0	41.0	4.0	1/725		2.9		45.0	41.0	4.0	1/725	3
7	Gombak	/ Batu	5.0	23	41.1	27.6	13.5	1/444	5	5.0	30				1/433	5
8	Batu	/ CH 60	6.4	17	67.1	44.6	22.5	1/284	5	6.4	17	67.1	44.6	22.5	1/284	5
9	Batu	/ Jinjang	3.0	17	44.6	38.2	6.4	1/469	4	3.0	33	44.6	38.2	6.4	1/450	4
10	Batu	/ Keroh	2.4	16	38.2	31.5	6.7	1/448	2	2.4	31				1/727	3
11	Batu	/ Gombak	2.4	21	31.5	27.8	3.7	1/649	3	2.4	34				1/973	4
12	Gombak	/ Klang	2.4	31	27.6	24.8	2.8	1/714	3	2.4	30				1/1310	4
13	Klang	/ Kerayong	6.7	39	23.0	17.2	5.8	1/1034	10	6.7	47				1/901	10
14	Kerayong	/ Klang	10.2	7	35.0	17.2	17.8	1/573	7	10.2	7				1/573	7
15	Klang	/ Kuyoh	4.3	53	17.2	13.8	3.4	1/1471	8	4.3	62				1/987	8
16	Klang	/ Penchala	3.7	49	13.8	11.9	1.9	1/1053	6	3.7	68				1/1200	7
17	Klang	/ Puchong	6.5	43	11.9	7.8	4.1	1/1560	13	6.5	71				1/1252	13
18	Klang	/ Rasam	7.0	91	7.8	2.0	5.8	1/1650	15	7.0	80	7.8	2.0	5.8	1/2000	15
19	Klang	/ Damansara	9.0	90	2.0	-1.9	3.9	1/1830	23	9.0	80	2.0	-1.9	3.9	1/2000	23
20	Klang	/ Railmay	19.5	92	-1.9	-7.6	5.7	1/6300	57	19.5	120	-1.9	-7.6	5.7	1/5000	57
21	Klang	/ Mauth	17.0	150	-7.6	-21.1	13.5	1/7100	45	17.0	220	-7.6	-21.1	13.5	1/10000	80

FIG. F-2 RIVER SYSTEM MODEL FOR FLOOD ANALYSIS

THE STUDY ON THE FLOOD MITIGATION OF THE KLANG RIVER BASIN

STATION NUMBER	STATION NAME	GRID REFERENCE
2914120	LADANG GOLDEN HOPE	VJ809300
2916077	LADANG BUKIT HITAM	VK025302
2917106	LADANG WEST COUNTRY BHG. BARAT	VK147293
3014081	LADANG MIDLANDS	VJ882391
3014083	LADANG HIGHLANDS	VJ831322
3014084	PEJABAT JPT KLANG	VJ831362
3014089	LADANG BUKIT RAJAH BHG. BARAT	VJ827420
3015078	LADANG BUKIT KEMUNING	VJ940322
3015082	LADANG HARON	VJ893335
3016076	LADANG KINRARA	VK060377
3115053	LADANG ELMINA	VJ898535
3115079	PUSAT P. GETAH SG. BULOH	VJ959495
3116001	IBU PEJABAT KAJICUACA MALAYSIA	VK055433
3117070	PUSAT PENYELIDIKAN JPT AMPANG	VK171492
3117071	LOJIAIR BUKIT WELD, K.L.	VK123487
3118069	PEMASOKAN AMPANG	VK229495
3215051	PUSAT MENGAWAL KUSTA NEGARA	VJ996568
3216001	KAMPONG SG. TUA (AB)	VK102620
3217001	IBU BEKALAN KM 16 GOMBAK (AB)	VK148615
3217064	JABATAN ORANG ASLI, ULU GOMBAK	VK151644
3217065	LADANG WARDIEBURN	VK159560
3218101	STN. JENALETRIK LLN. PONSOON	VK312552
3318127	JANDA BAIK	VK297681

STATION	SULAIMAN BRIDGE	PUCHONG DROP	RIVER MOUTH
2914120			0.01
3014083			0.02
3014084			0.03
3014089			0.01
3014081			0.06
3015082			0.04
3015078			0.08
2916077		0.01	0.08
3016076		0.11	0.08
2917106		0.04	0.03
3116001	0.01	0.10	0.07
3115079			0.07
3115053			0.01
3215051	0.07	0.04	0.03
3117070	0.06	0.08	0.04
3117071	0.09	0.12	0.07
3216001	0.14	0.09	0.05
3217064	0.24	0.15	0.01
3217001	0.08	0.05	0.03
3217065	0.16	0.10	0.06
3118069	0.08	0.05	0.03
3218101	0.02	0.02	0.01
3318127	0.05	0.04	0.02
TOTAL	1.00	1.00	1.00

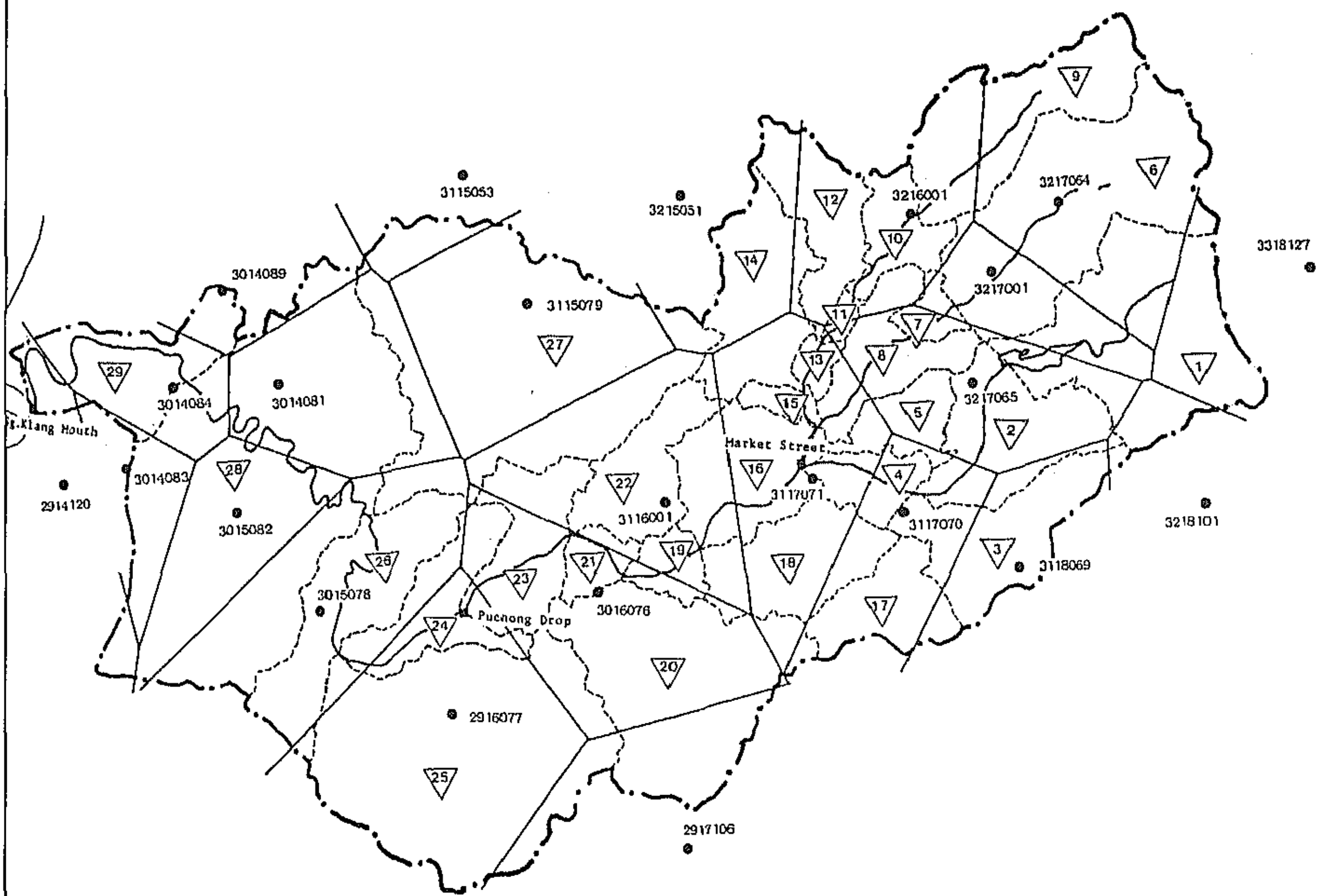


FIG. F-3 THIESSEN POLYGON NETWORK

THE STUDY ON THE FLOOD MITIGATION OF THE KLANG RIVER BASIN

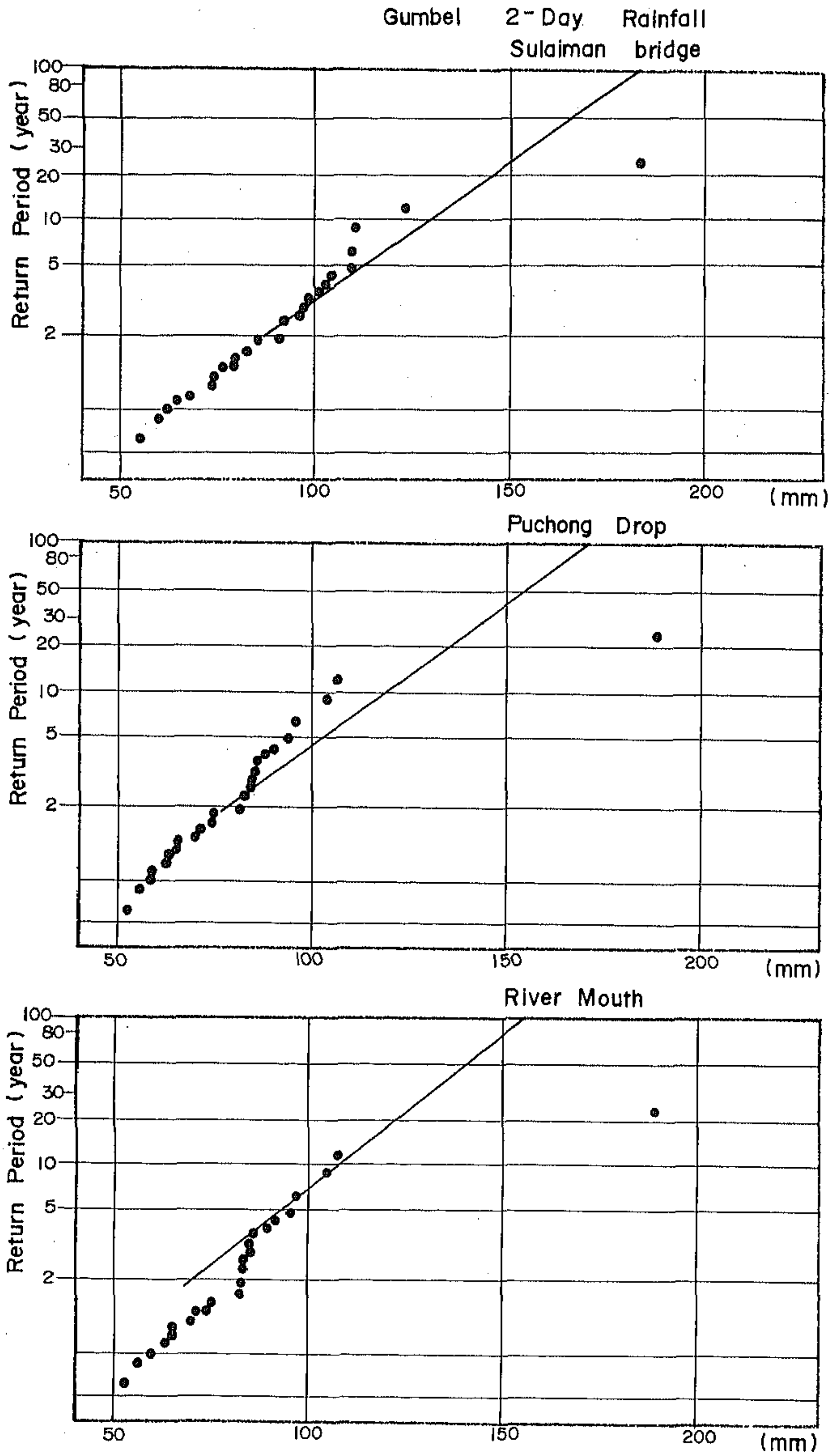


FIG. F-4	FREQUENCY CURVE OF 2 DAYS RAINFALL

THE STUDY ON THE FLOOD MITIGATION OF THE KLANG RIVER BASIN

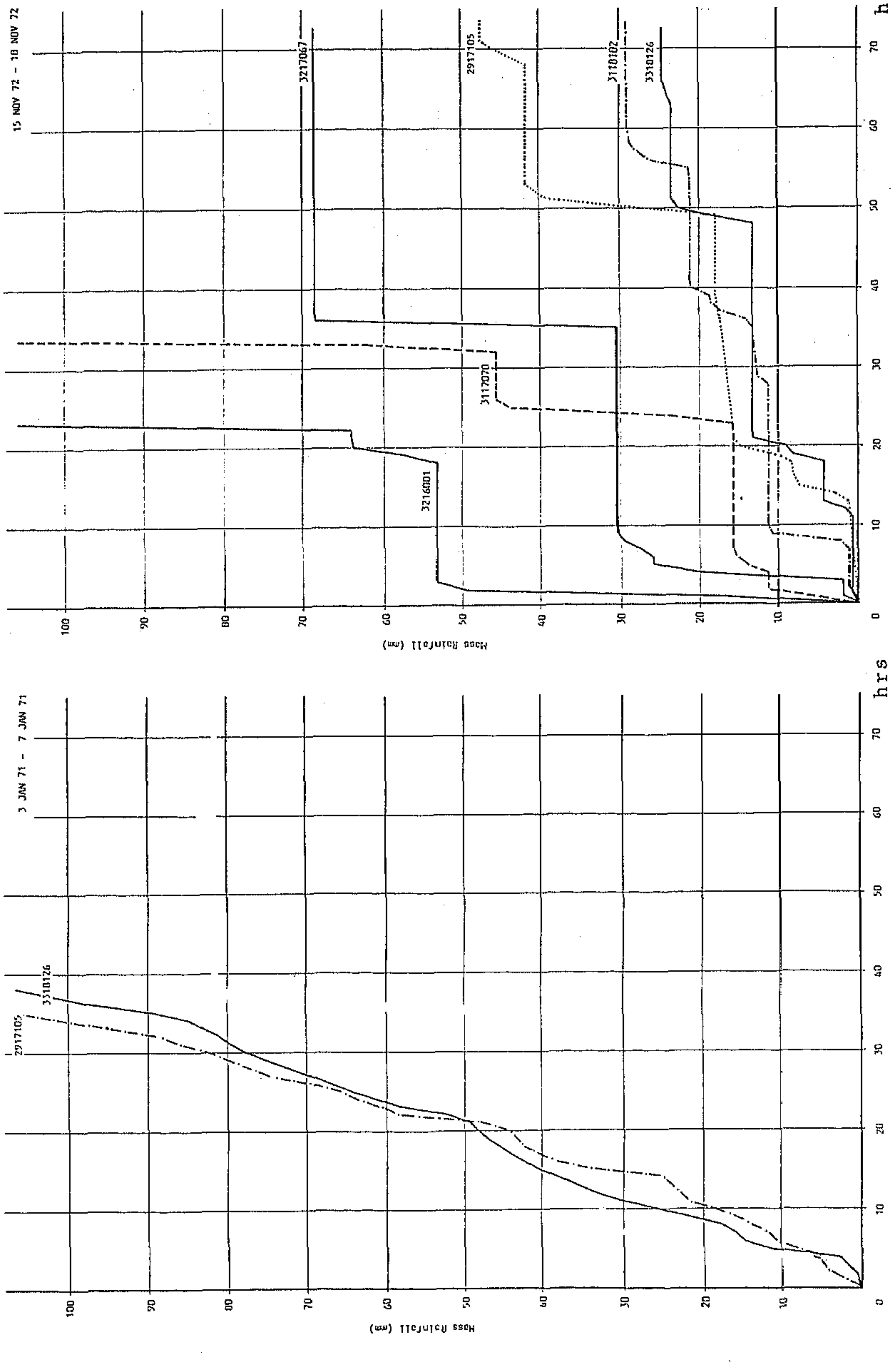
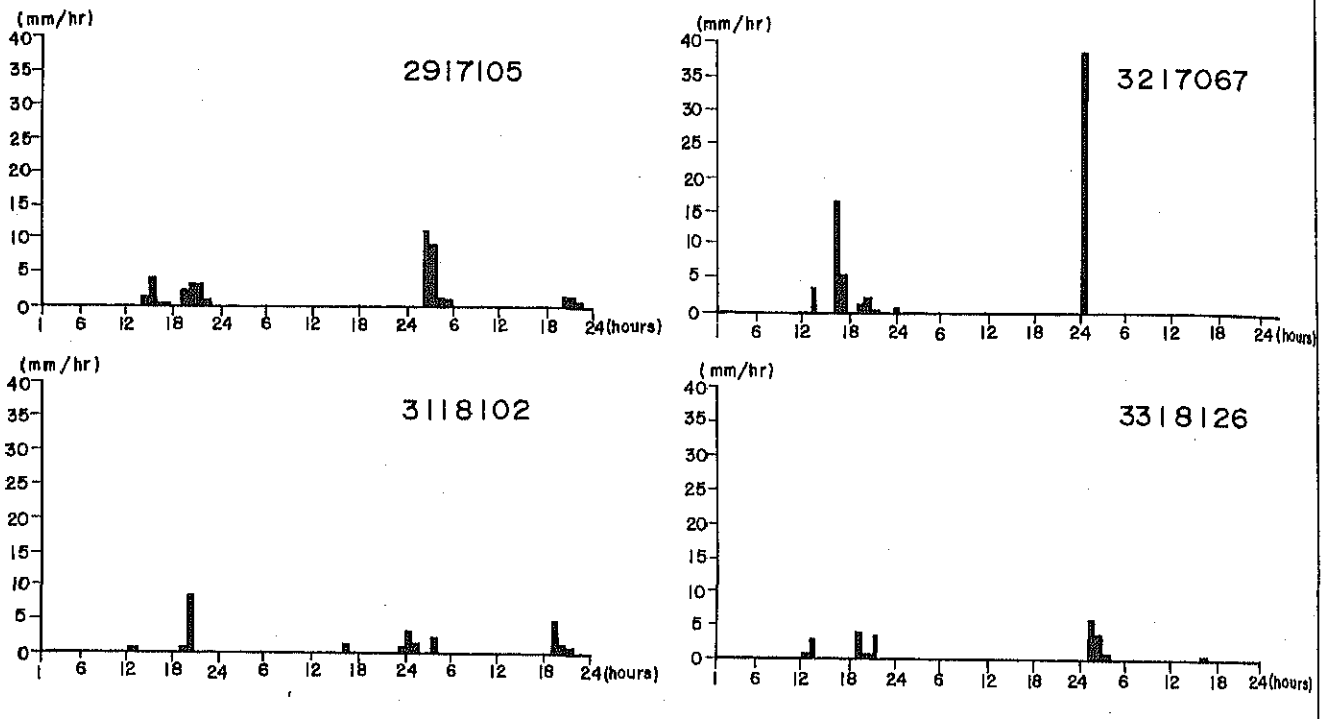
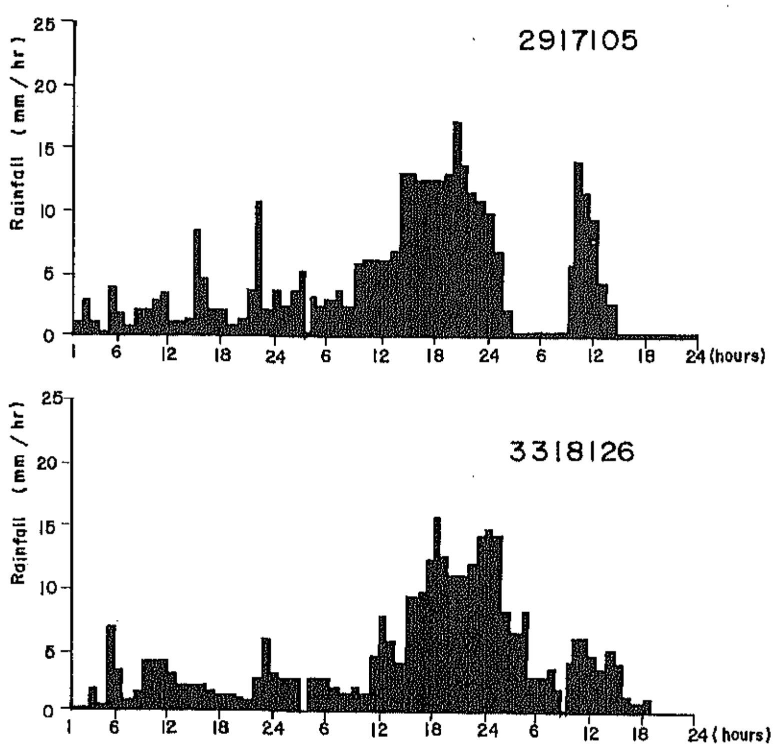


FIG. F-5	HOURLY MASS CURVE IN 1971 AND 1972 FLOODS

THE STUDY ON THE FLOOD MITIGATION OF THE KLANG RIVER BASIN



Flash Flood Rainfall Pattern 1972. 11. 15



Monsoon Flood Rainfall Pattern 1971. 1. 3

FIG. F-6	HOURLY HYETOGRAPH IN 1971 AND 1972 FLOODS

THE STUDY ON THE FLOOD MITIGATION OF THE KLANG RIVER BASIN

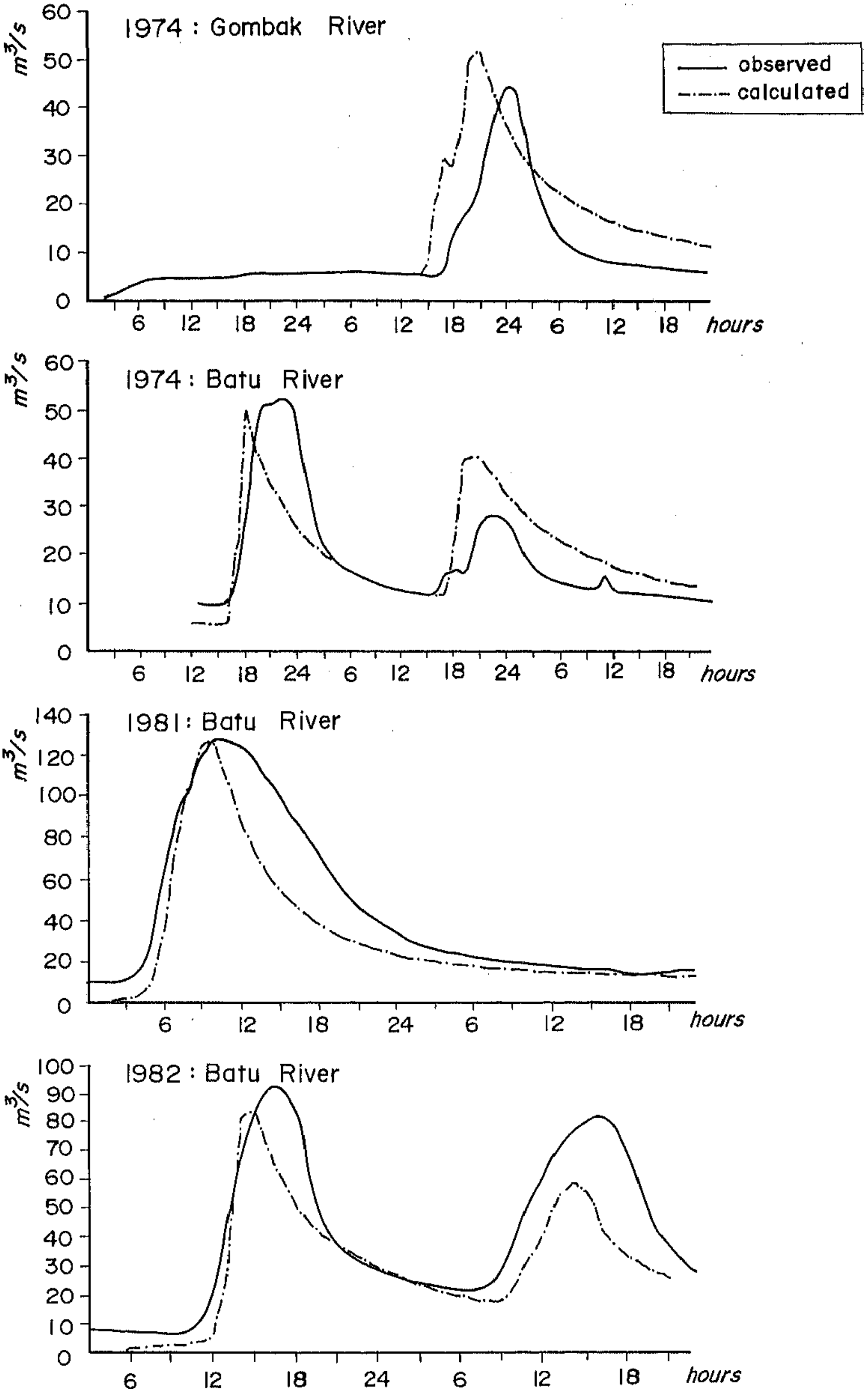


FIG. F-7	OBSERVED AND SIMULATED FLOOD HYDROGRAPH

THE STUDY ON THE FLOOD MITIGATION OF THE KLANG RIVER BASIN

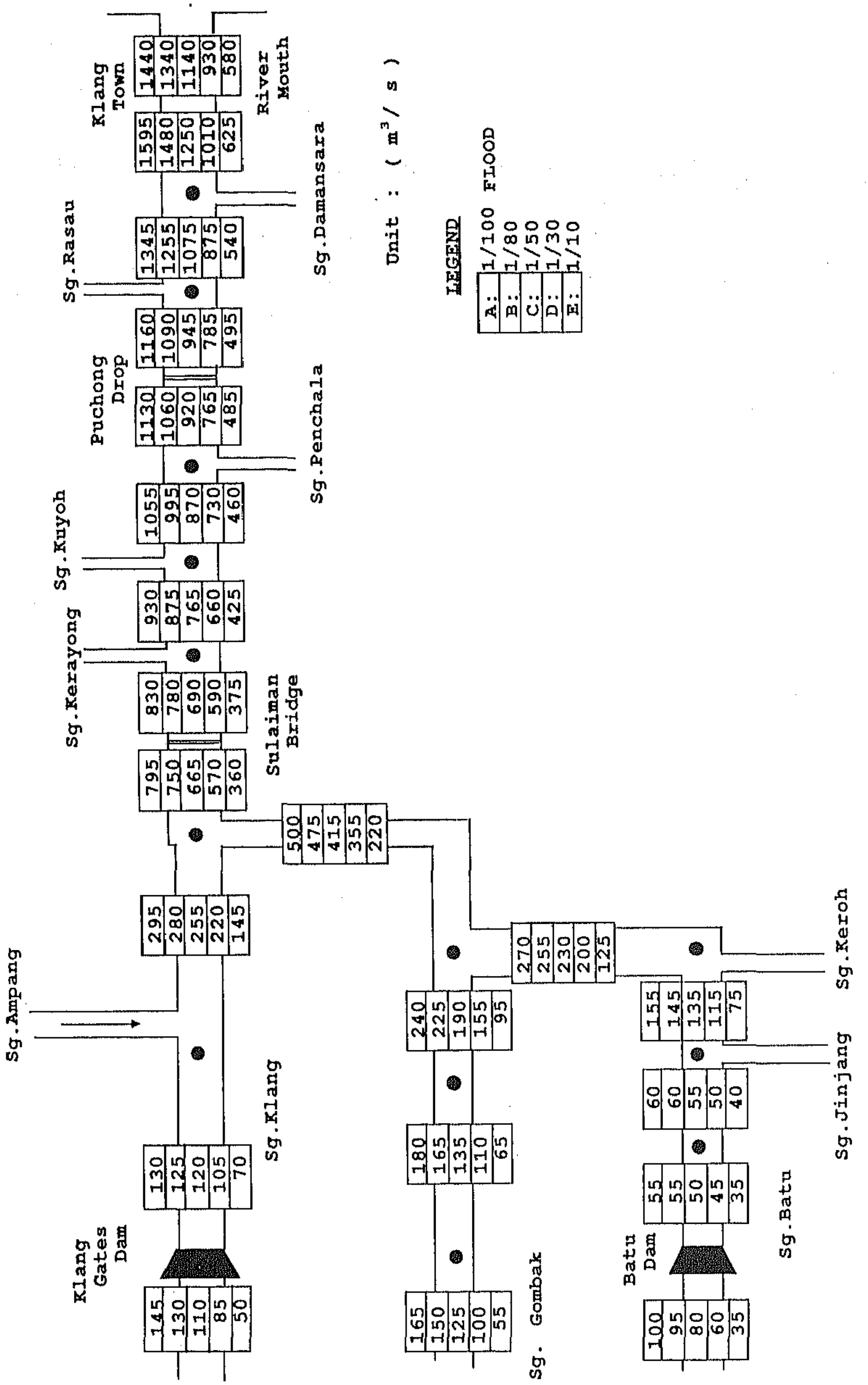
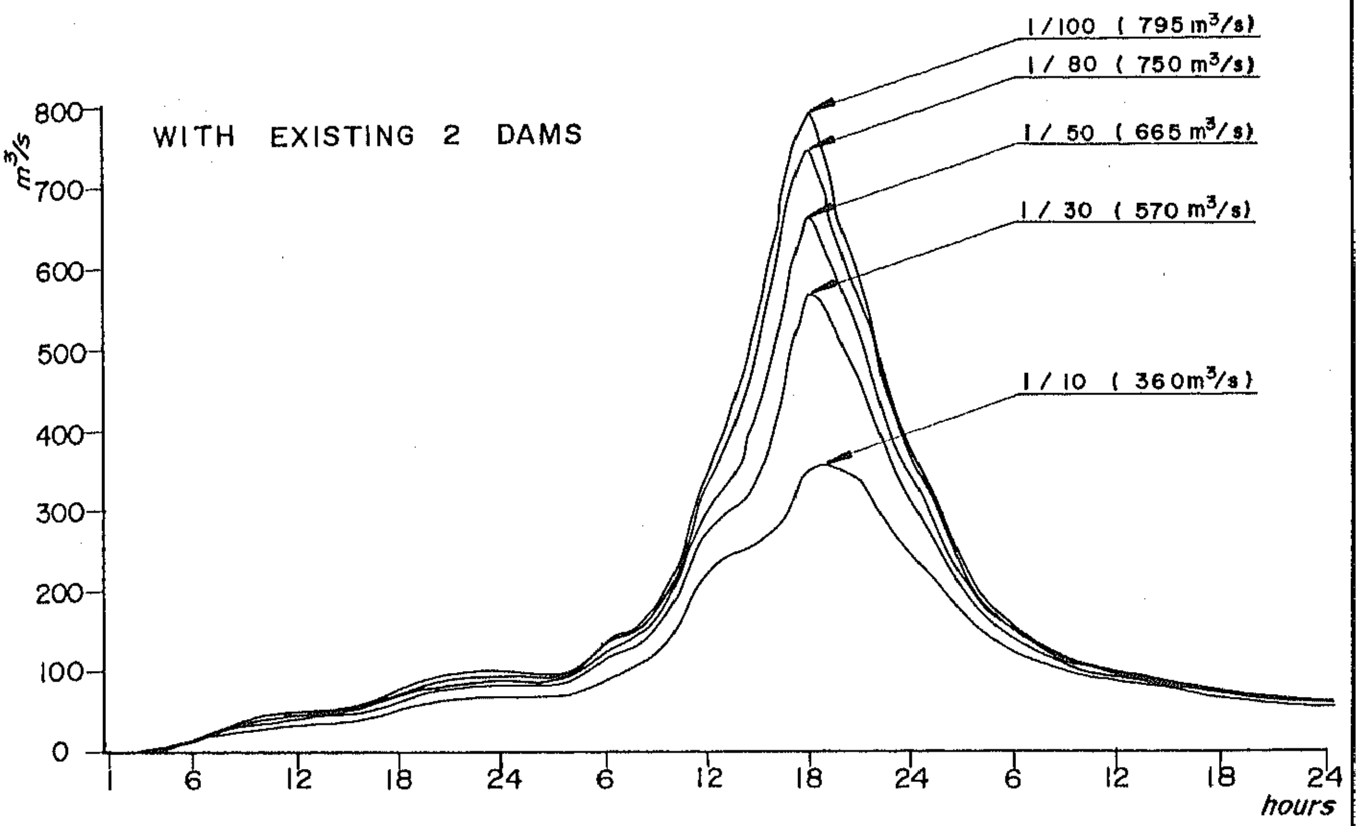


FIG. **F-8** **PROBABLE FLOOD DISCHARGE DISTRIBUTION WITH EXISTING 2 DAMS**

THE STUDY ON THE FLOOD MITIGATION OF THE KLANG RIVER BASIN

JICA



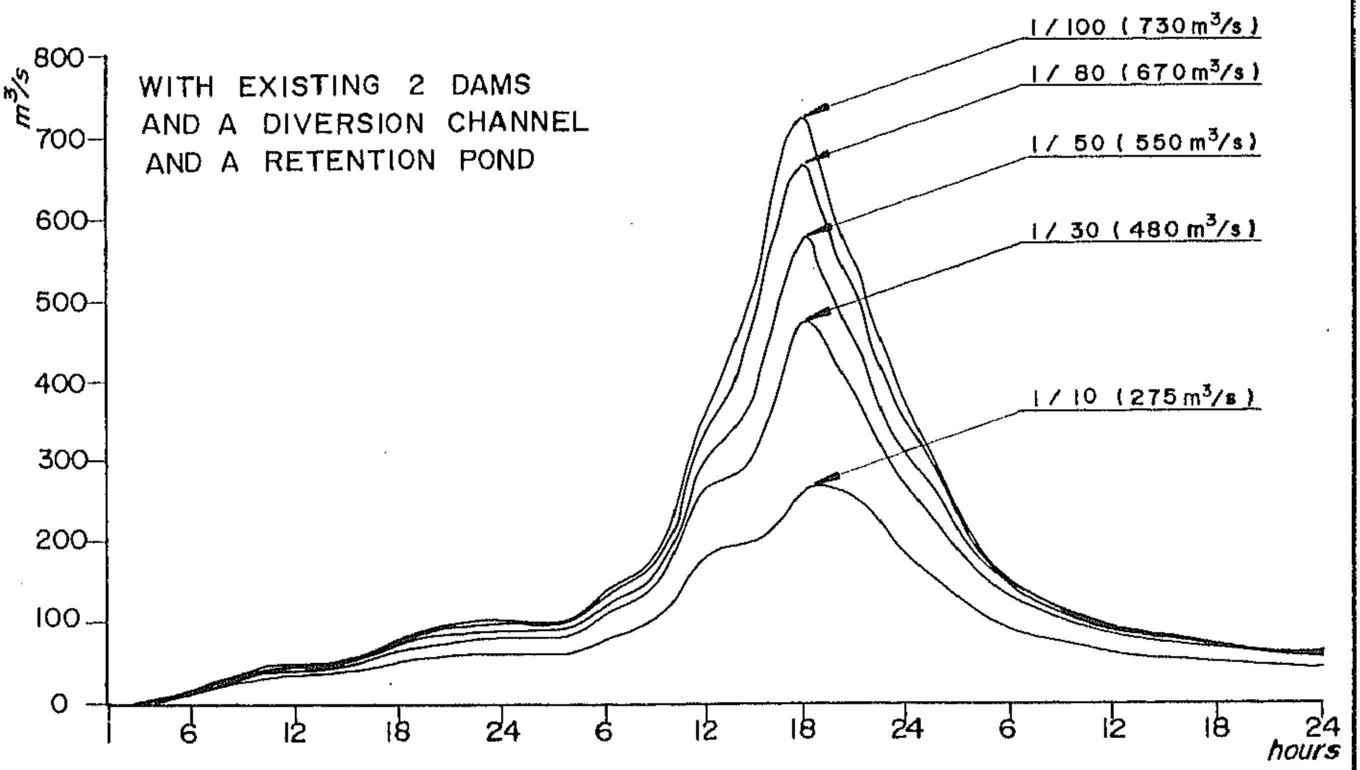


FIG. F-9	PROBABLE FLOOD HYDROGRAPH AT SULAIMAN BRIDGE

THE STUDY ON THE FLOOD MITIGATION OF THE KLANG RIVER BASIN

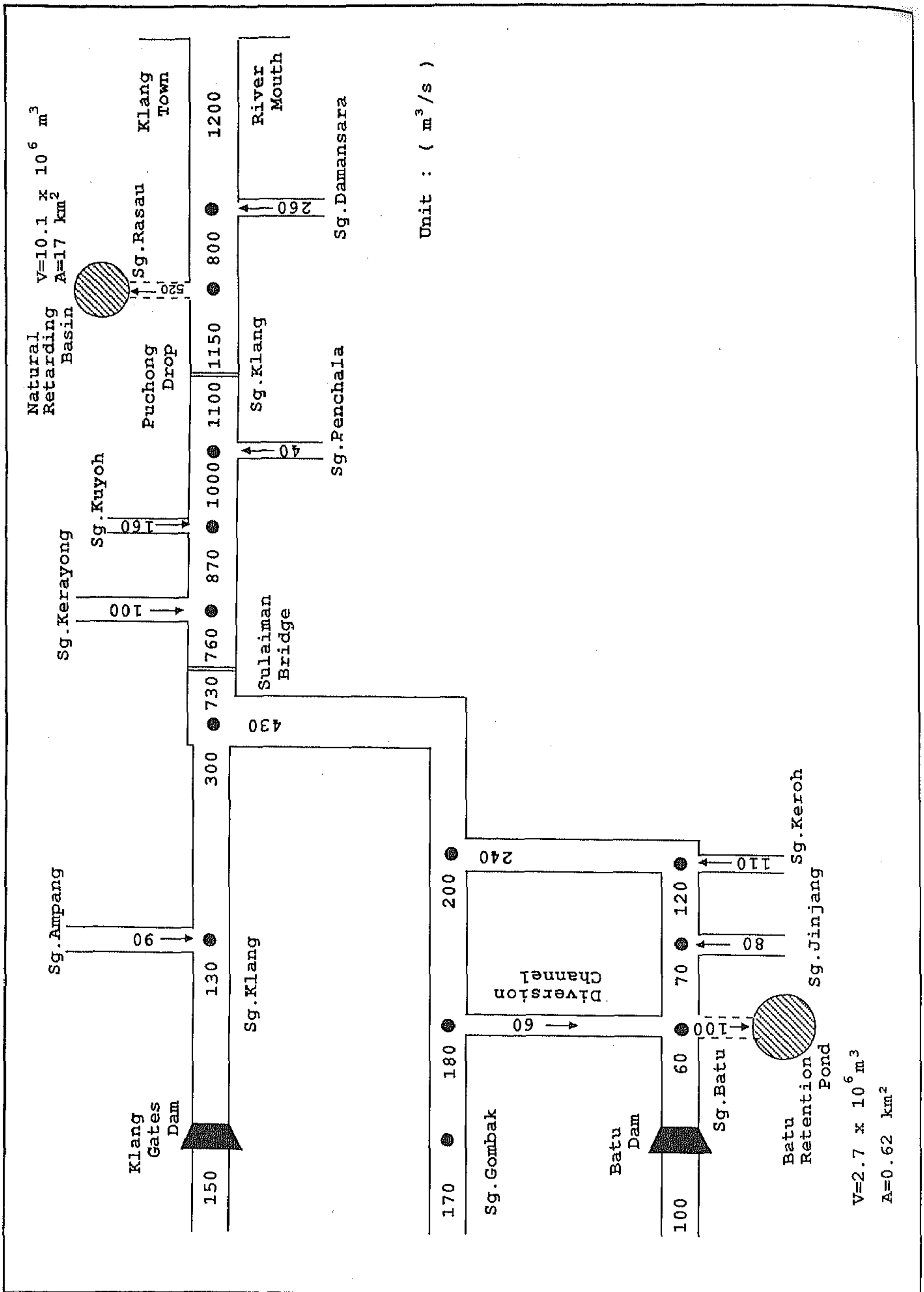


FIG. **F-10** **DESIGN FLOOD DISCHARGE DISTRIBUTION**

THE STUDY ON THE FLOOD MITIGATION OF THE KLANG RIVER BASIN

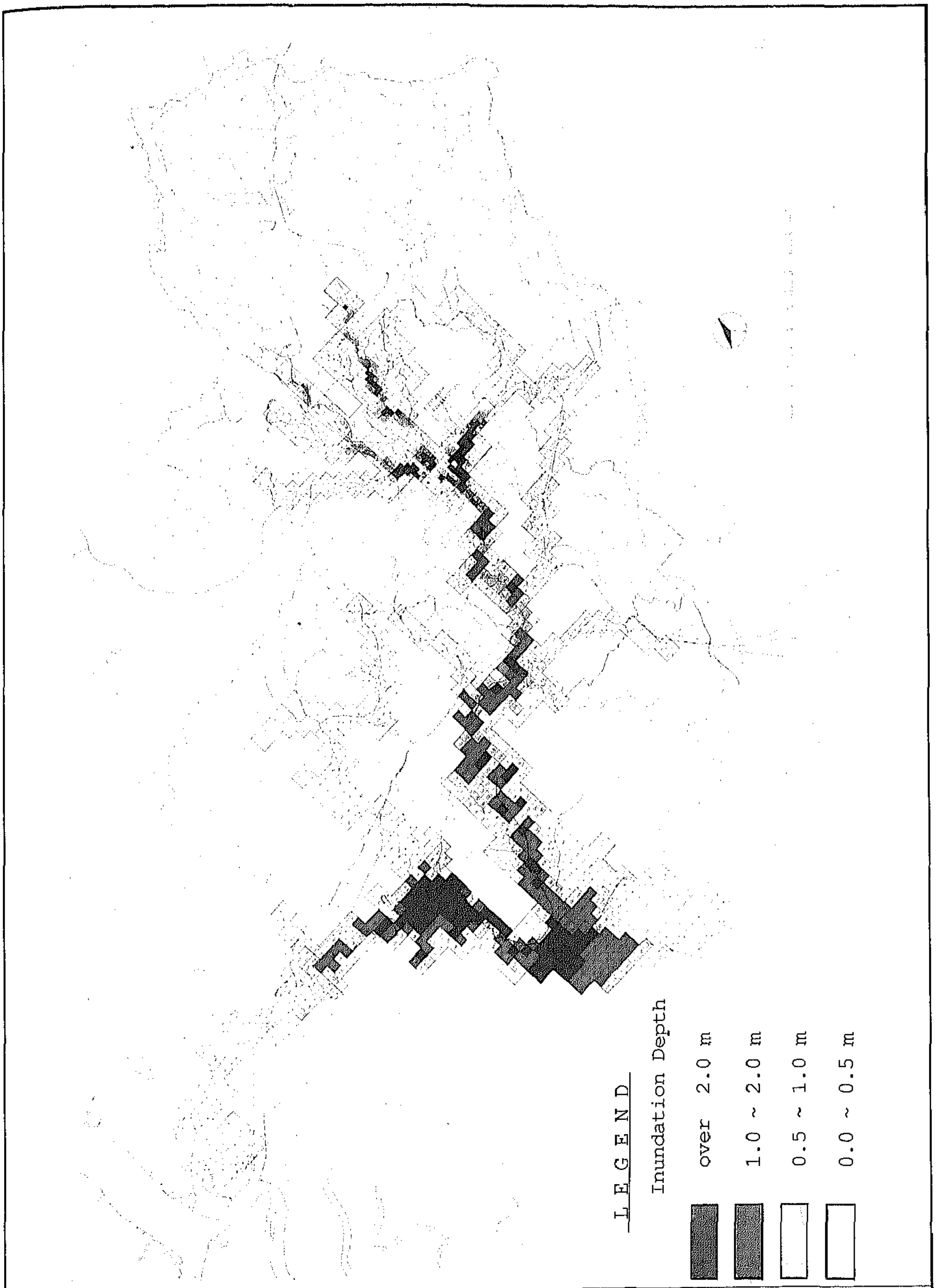


FIG. **F-11** **FLOOD RISK MAP FOR A 100 YEAR RETURN PERIOD**

THE STUDY ON THE FLOOD MITIGATION OF THE KLANG RIVER BASIN

Mark	Depth (m)	
(-)	0	
(1)		<0.25
(2)	0.25<=	<0.50
(3)	0.50<=	<1.00
(4)	1.00<=	<2.00
(5)	2.00<=	<3.00
(6)	3.00<=	

```
                                   Sg. Gombak
         Sg. Batu
                                     4-
   ---                            ---3-
   2--                           --333
  -31-                           --
   2--                           3-
  --2                            31
  -33-                           31
  23                           --3-
  11                           13-
   --                          11
  -3--                         31
  ---                        --43--
  ----                       --43-
   ---                       -433
  ----                       443-
  ----                      -4433 --                 Sg. Klang
  --1                       -34-----
  --21                      144-                        -
  1---                      -2--                       ----
  22                      2223                          ---
  -1                      333-                         --1-
 3221                     244-                           22--
 332                      2251                           1--
  22                       224                           ----
  13                      --23                            ---
  -3--                      44                             --
   1                        34                             -
  -1--                      -4                           ----
  -33-                      --                           ---
  -33-                      --                           ----
  -43-                      --                           ---
  2454---  2-1                                          --
  -4456--333--                                         ----
    -454-343                                           ----
    --64-443                                           ---
      4--344    ------ --                            - ---
      -3-45-  22---2234333                          ------
        --53 233-444444443332--11---- -
         34-2556664543-34----- -----
        -43-4-554444                                -
          4-5444----                                -
          4-6424
          4444--
        -14654
         1541-
        --33
         -44
          44
          43
          33
          43
```

200-year return period

FIG. **F-12** **PREDICTED INUNDATION AREA AND DEPTH (1)**

THE STUDY ON THE FLOOD MITIGATION OF THE KLANG RIVER BASIN

JICA

Mark	Depth (m)	
(-)	0	
(1)		<0.25
(2)	0.25<=	<0.50
(3)	0.50<=	<1.00
(4)	1.00<=	<2.00
(5)	2.00<=	<3.00
(6)	3.00<=	

```
                                                            -1454
                                                            --55
                                                          33443
                                                          554-
                                                          -41-
                                                          2343
                                                          2342
                                             Sg. Klang    3354
                                                          3443
                                                -         233--
                                               ---       223
                                               51       343-
                                             4-5343135455
                                             54355534541-
          Sg. Damansara                    4344-44554432---
                                           4442--13432-2--
------              -             --     -4454441   -31---
------            --33-           -      -144553-   ------
----------221-34333233  --    - -        21323543
----------122134444444  2-    ------     44444413
        --22132444443444--335-4444       33334653
        --32-224333--355-45665444        -3442113
              23    -24455566655         -35432
                    --3245566665         -34453
                        25566666       --112123
                        44546664       --145424
                      454124665-       --3443--
                      -3--256654       -3454---
                          14-455       -45531--
                          ---335       45542---
                            ---5       4542----
                            -245       453-----
                            -443---3443-------
                            14541--444--------
                            134542-55433----
                            -244555554444---
                              555555444443---
                              555555544433222
                                555555433211--
                                55555553211-----
                                4444444111------
                                44444444------
                                  444444--------
                                  3333333-------
                                      ----------
                                      -----------
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                                            ------
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```
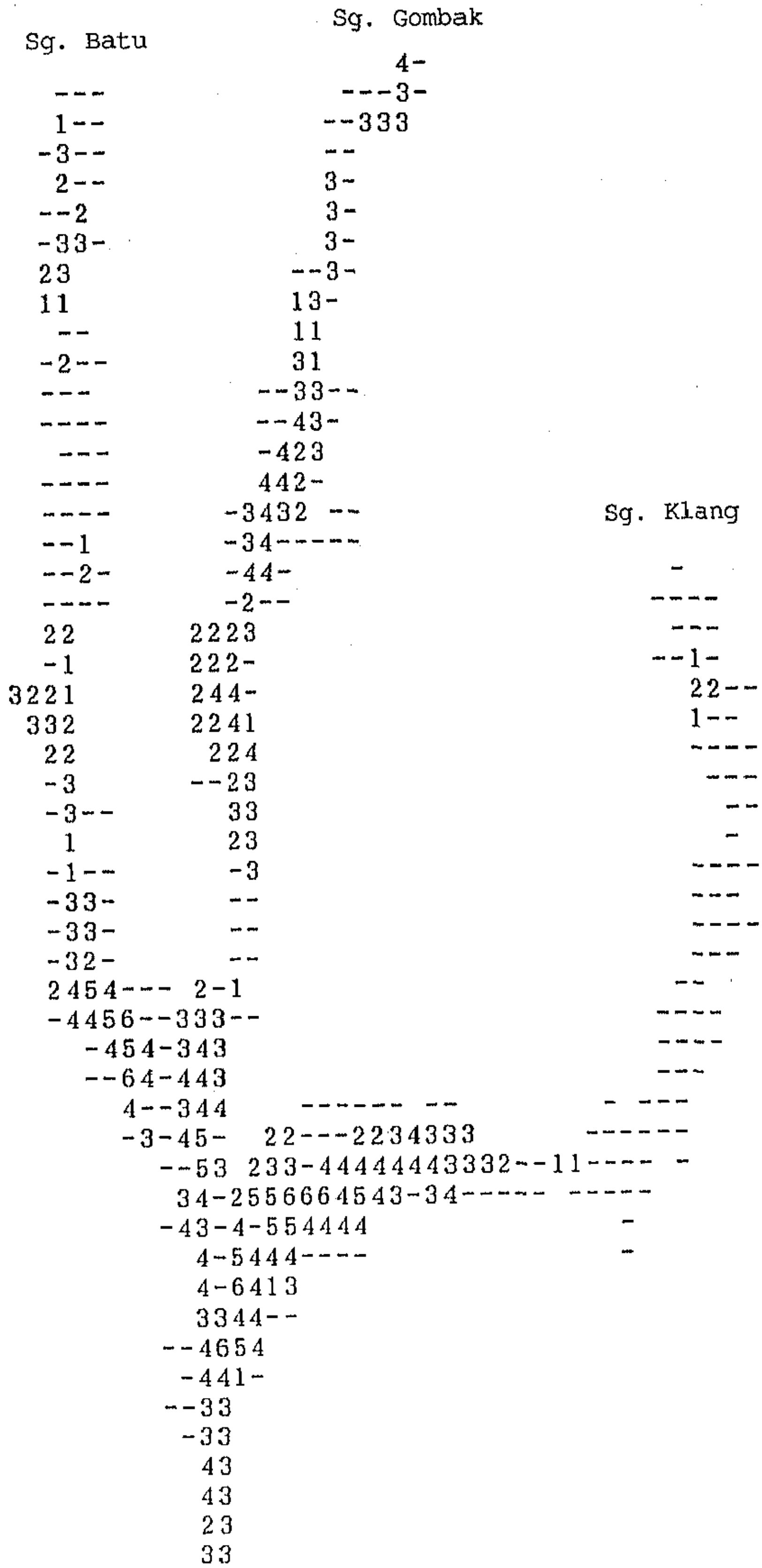

200-year return period

FIG. F-12 PREDICTED INUNDATION AREA AND DEPTH (2)

THE STUDY ON THE FLOOD MITIGATION OF THE KLANG RIVER BASIN

Mark	Depth (m)	
(-)	0	
(1)		<0.25
(2)	0.25<=	<0.50
(3)	0.50<=	<1.00
(4)	1.00<=	<2.00
(5)	2.00<=	<3.00
(6)	3.00<=	



100-year return period

FIG. **F-12** **PREDICTED INUNDATION AREA AND DEPTH (3)**

THE STUDY ON THE FLOOD MITIGATION OF THE KLANG RIVER BASIN

Mark	Depth (m)	
(-)	0	
(1)		<0.25
(2)	0.25<=	<0.50
(3)	0.50<=	<1.00
(4)	1.00<=	<2.00
(5)	2.00<=	<3.00
(6)	3.00<=	

```
                                                          -1444
                                                          --54
                                                        22433
                                                        444-
                                                        -31-
                                                        1333
                                                        2331
                                            Sg. Klang   2354
                                                        3442
                                               -        132--
                                              ---      223
                                              41      343-
                                            4-4343135444
                                            44344534541-
          Sg. Damansara                   3344-44444421---
                                          4431--12431-1--
------        -             --          -3444441  -31---
------      --23-           -           -144553-  ------
----------111-33222222  --  - -         21223532
----------111134444334  2-  ------      33334412
        --21122343433444--334-4333      23324652
        --32-123222--355-45665333       -2441112
              22    -14455556655        -25421
                    --2245566655        -24453
                        15565666    ---11122
                        44446664    ---45413
                      454114665-    --3443--
                      -3--156654    -3444---
                          14-455    -45421--
                          ---335    44532---
                            ---5    4542----
                            -145    443-----
                            -443---3443-------
                            -454---344--------
                            -34542-54433----
                            -244555544444---
                              555555444433---
                              55555554433 2111
                                5555553221----
                                555444421-------
                                4444444---------
                                44444444------
                                  444444--------
                                  3333333-------
                                      ----------
                                      -----------
                                            ------
                                            ------
                                              --
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```

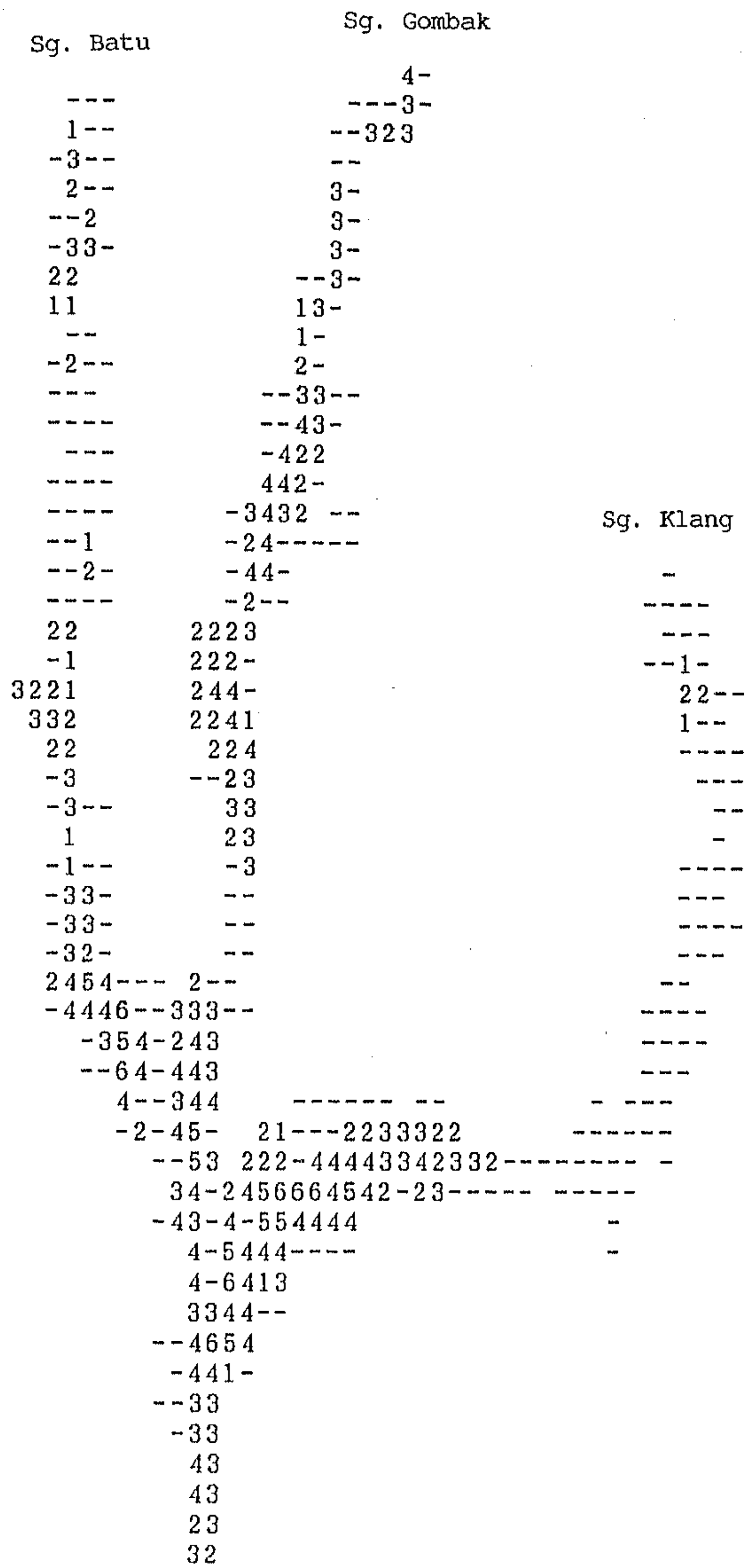
100-year return period

FIG. F-12 PREDICTED INUNDATION AREA AND DEPTH (4)

THE STUDY ON THE FLOOD MITIGATION OF THE KLANG RIVER BASIN

JICA

Mark	Depth (m)
(-)	0
(1)	<0.25
(2)	0.25<= <0.50
(3)	0.50<= <1.00
(4)	1.00<= <2.00
(5)	2.00<= <3.00
(6)	3.00<=



80-year return period

FIG. F-12 PREDICTED INUNDATION AREA AND DEPTH (5)

THE STUDY ON THE FLOOD MITIGATION OF THE KLANG RIVER BASIN

Mark	Depth (m)	
(-)	0	
(1)		<0.25
(2)	0.25<=	<0.50
(3)	0.50<=	<1.00
(4)	1.00<=	<2.00
(5)	2.00<=	<3.00
(6)	3.00<=	

```
                                                          -1443
                                                          --54
                                                        22433
                                                        444-
                                                        -3--
                                                        1333
                                                        1331
                                           Sg. Klang    2354
                                                        3442
                                               -        122--
                                              ---      223
                                              4-      343-
                                            4-4243135444
                                            44344524541-
         Sg. Damansara                    3344-44444421---
                                          4431--12431-1--
------        -             --        -3444441  -31---
------      --23-           -         -144553-  ------
----------111-33221222  --  - -       21223532
----------111134444334  2-  ------    33334412
        --21122343433444--334-4333    23224652
        --32-123222--355-45665333     -2441112
              22    -14355556655      -25421
                    --2244566655      -24453
                        15565666    ---11112
                        44446664    ---45413
                      454114665-    --3443--
                      -3--146654    -3444---
                          13-455    -45421--
                          ---335    44431---
                            ---5    4541----
                            -145    443-----
                            -443---3443-------
                            -454---344--------
                            -34542-54433----
                            -244555544444---
                              555555444433---
                              555555444332111
                                5554443221----
                                444444421-------
                                4444444---------
                                44444444------
                                  333333--------
                                  3333333-------
                                      ----------
                                      -----------
                                            ------
                                            ------
                                              --
                                              --
```

80-year return period

FIG. F-12 **PREDICTED INUNDATION AREA AND DEPTH (6)**

THE STUDY ON THE FLOOD MITIGATION OF THE KLANG RIVER BASIN

JICA

Mark	Depth (m)	
(-)	0	
(1)		<0.25
(2)	0.25<=	<0.50
(3)	0.50<=	<1.00
(4)	1.00<=	<2.00
(5)	2.00<=	<3.00
(6)	3.00<=	

```
                          Sg. Gombak
      Sg. Batu
                               3-
         ---                ---2-
         1--               --222
        -3--               --
         1--               2-
        --1                3-
        -22-               3-
        22                --2-
        11                -3-
         --               --
        -2--              2-
        ---             --33--
        ----            --42-
         ---            -422
        ----            432-
        ----           -3422 --
        --1            -24-----               Sg. Klang
        --1-           -44-                      -
        ----           -1--                    ----
        22           2112                       ---
        --           222-                      --1-
      3111           144-                         22--
       332           1141                         1--
        22            114                         ----
        -2           --23                          ---
        -3--           33                           --
          1            23                           -
        -1--           -3                         ----
        -23-           --                         ---
        -33-           --                         ----
        -32-           --                         ---
        2454--- 2--                              --
        -4446--233--                            ----
           -354-243                             ----
           --64-443                             ---
              4--233     ------ --          - ---
              -2-45-  21---2233311         ------
                 --43 222-44443341221-------- -
                   34-2456664542-21----- -----
                  -43-4-554444              -
                     4-5444----             -
                     4-6413
                     3344--
                   --4654
                    -431-
                   --33
                    -33
                     33
                     43
                     12
                     32
```

50-year return period

FIG. F-12 **PREDICTED INUNDATION AREA AND DEPTH (7)**

THE STUDY ON THE FLOOD MITIGATION OF THE KLANG RIVER BASIN

JICA

Mark	Depth (m)
(-)	0
(1)	<0.25
(2)	0.25<= <0.50
(3)	0.50<= <1.00
(4)	1.00<= <2.00
(5)	2.00<= <3.00
(6)	3.00<=

```
                                                          -1443
                                                          --54
                                                        --333
                                                        444-
                                                        -3--
                                                        1233
                                                        1331
                                          Sg. Klang     2343
                                                        3431
                                               -        111--
                                              ---      212
                                              4-      342-
                                            4-4233-35444
                                            4434452453--
           Sg. Damansara                  3344-44444421---
                                          4431--12421-1--
------        -             --        -3444441  -3----
------      --23-           -         -144553-  ------
--------------33111122  --  - -       11113532
------------1-23444233  2-  ------    33334411
        --11121243433444--334-4333    23224651
        --21-112222--344-45665333     -2441--1
              11    -14355556655      -24411
                    --1244566654      -24443
                        14555566    ---11-11
                        34445664    ---45413
                      343113564-    --3443--
                      -2--145553    -3444---
                          13-454    -45421--
                          ---334    34431---
                            ---5    3541----
                            -145    443-----
                            -443---3443-------
                            -444---344--------
                            -34542-44433----
                            -244555444443---
                              555555444332---
                              555555543321111
                                5555553111----
                                444444411-------
                                4444444---------
                                44444444------
                                  333333--------
                                  3333333-------
                                      ----------
                                      -----------
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                                            ------
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```

50-year return period

FIG. F-12	PREDICTED INUNDATION AREA AND DEPTH (8)

THE STUDY ON THE FLOOD MITIGATION OF THE KLANG RIVER BASIN

Mark	Depth (m)
(-)	0
(1)	<0.25
(2)	0.25<= <0.50
(3)	0.50<= <1.00
(4)	1.00<= <2.00
(5)	2.00<= <3.00
(6)	3.00<=

```
                   Sg. Gombak
 Sg. Batu
                       3-
   ---              ---2-
   1--             --112
  -2--             --
   1--             2-
  --1              3-
  -22-             3-
  22             --2-
  11             -3-
   --            --
  -2--           2-
  ---          --33--
  ----         --42-
   ---         -422
  ----         432-
  ----       -3422 --
  --1        -13-----                 Sg. Klang
  --1-       -44-                      -
  ----       -1--                     ----
  22       1112                        ---
  --       221-                       --1-
2111       -44-                         11--
 222       --41                         1--
  11        --3                         ----
  -2       --11                          ---
  -3--       33                           --
   -         23                           -
  ----       -3                         ----
  -23-       --                         ---
  -33-       --                         ----
  -32-       --                         ---
  2453--- 1--                          --
  -4445--222--                        ----
    -243-233                          ----
    --63-442                          ---
      4--233     ------ --          - ---
      -1-35-  11---22233--         ------
        --43 122-4444334-121-------- -
         34-1456664542-2------ -----
        -43-4-554444                  -
           4-5444----                 -
           4-6413
           3344--
         --4654
          -431-
         --33
          ---
           --
           --
           --
           --
```

30-year return period

FIG. F-12 PREDICTED INUNDATION AREA AND DEPTH (9)

THE STUDY ON THE FLOOD MITIGATION OF THE KLANG RIVER BASIN

Mark	Depth(m)	
(-)	0	
(1)		<0.25
(2)	0.25<=	<0.50
(3)	0.50<=	<1.00
(4)	1.00<=	<2.00
(5)	2.00<=	<3.00
(6)	3.00<=	

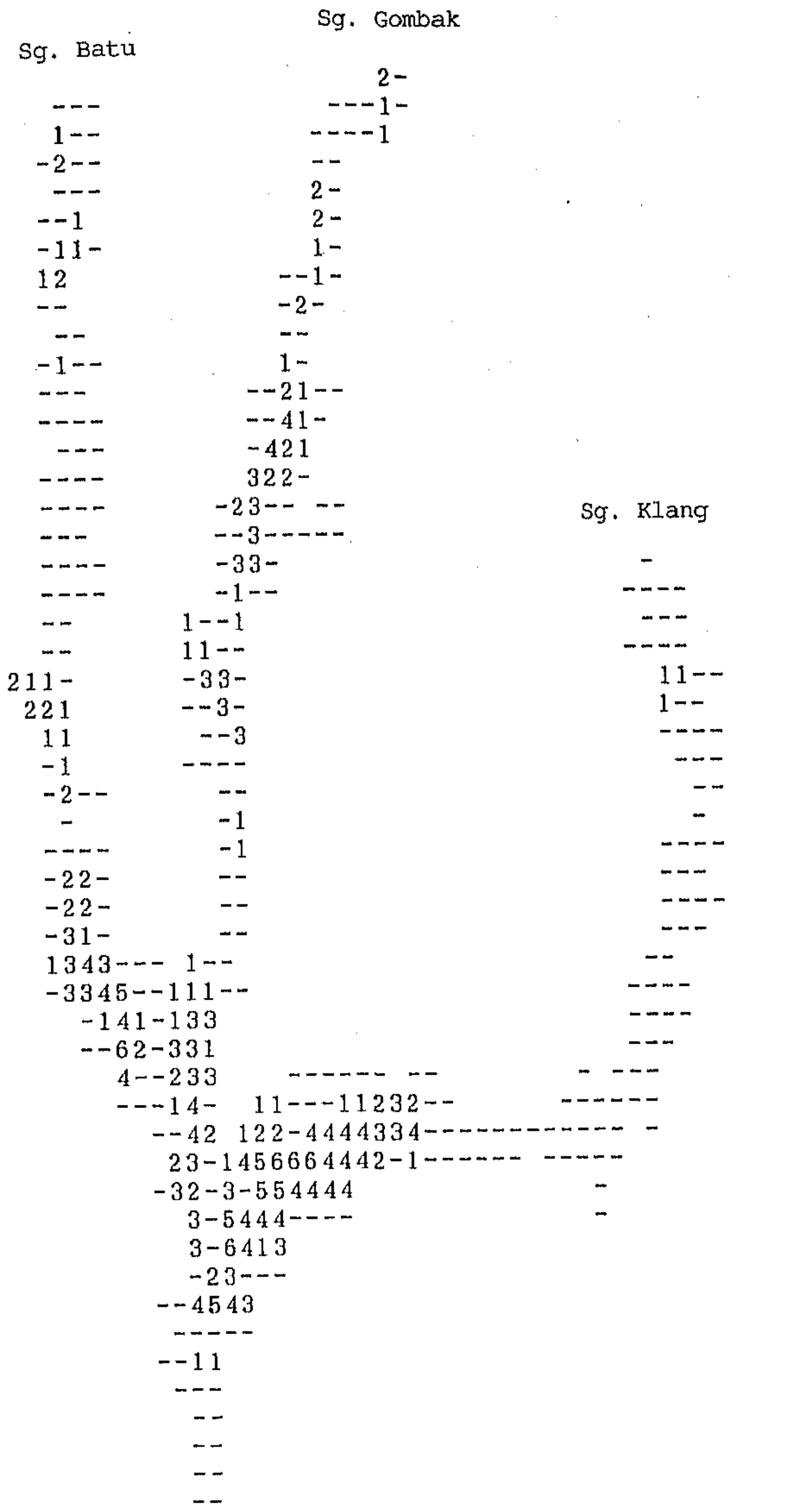
```
                                                                                 --122
                                                                                 --32
                                                                               --121
                                                                               112-
                                                                               -3--
                                                                               ----
                                                                               1221
                                                                               1211
                                                       Sg. Klang               233-
                                                                  -            --1--
                                                                 ---          212
                                                                 2-          132-
                                                               2-2-1--12233
                                                               321333-4321-
                      Sg. Damansara                          2233-333143-----
                                                             321-----1-2----
------              -                   --               --22222-  ------
------            --22-                 -                -111231-  ------
--------------22----11  --   - -                         -23234--
--------------22333122  2-  ------                       ---343--
        --11-11-32312333--224-4222                       -11-232-
        --11-11-111--244-44564222                        --331---
              1-    -13354456644                         --33--
                    --1144456554                         -23221
                        14455555                       -----122
                        34435664                       ---332-2
                      343-13564-                       --2332--
                      -2--145543                       -3343---
                          13-444                       -4441---
                          ---334                       3442----
                            ---5                       3541----
                            -145                       342-----
                            -443---3432-------
                            -444---334--------
                            -34542-44433----
                            -2445544444443---
                              5555554433322---
                              444555433321---
                                555444311-----
                                44444441--------
                                4444444---------
                                44444444------
                                  333333--------
                                  3333333-------
                                      ----------
                                      -----------
                                            ------
                                            ------
                                              --
                                              --
```

30-year return period

FIG. F-12	PREDICTED INUNDATION AREA AND DEPTH (10)

THE STUDY ON THE FLOOD MITIGATION OF THE KLANG RIVER BASIN

Mark	Depth (m)
(-)	0
(1)	<0.25
(2)	0.25<= <0.50
(3)	0.50<= <1.00
(4)	1.00<= <2.00
(5)	2.00<= <3.00
(6)	3.00<=



10-year return period

FIG. F-12 **PREDICTED INUNDATION AREA AND DEPTH (11)**

THE STUDY ON THE FLOOD MITIGATION OF THE KLANG RIVER BASIN

JICA

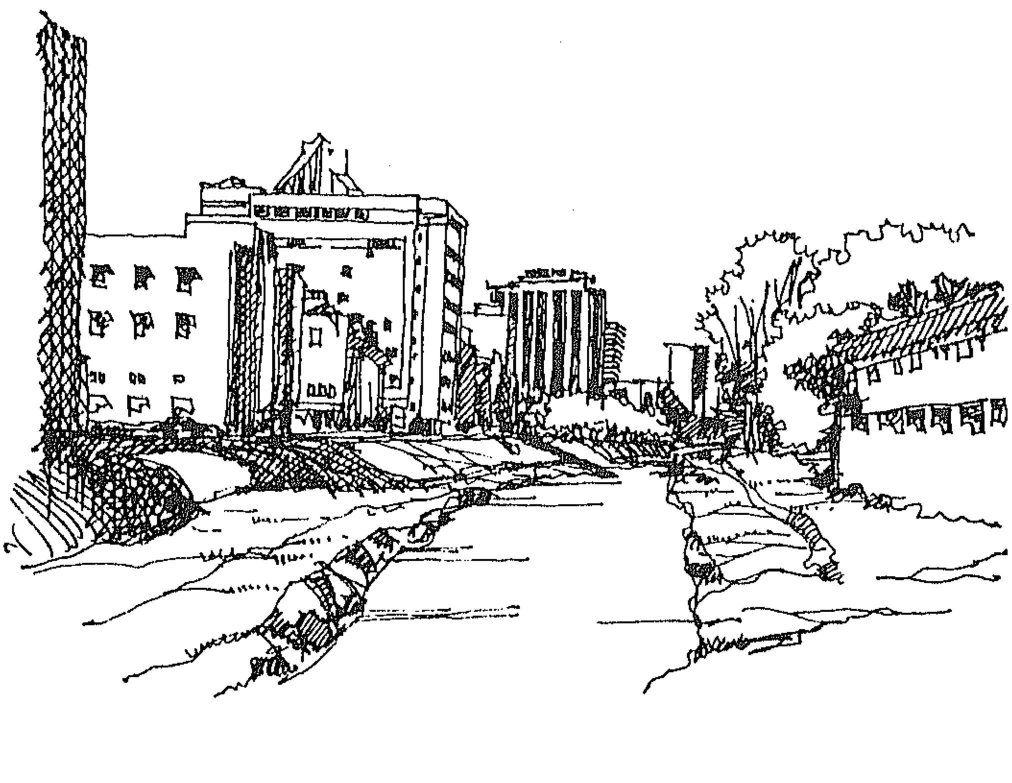
Mark	Depth (m)
(-)	0
(1)	<0.25
(2)	0.25<= <0.50
(3)	0.50<= <1.00
(4)	1.00<= <2.00
(5)	2.00<= <3.00
(6)	3.00<=

```
                                                           -----
                                                           --11
                                                         -----
                                                         ----
                                                         ----
                                                         ----
                                                         11--
                                            Sg. Klang    11--
                                                         -22-
                                                -        -----
                                               ---      1--
                                               1-      121-
                                             1-1----11221
                                             221322-322--
          Sg. Damansara                    2133-322-32-----
                                           211--------1----
------        -             --          --12112-  ------
------      --11-            -          ----121-  ------
--------------12------   --  - -        ----23--
--------------11222---   1-  ------     ----12--
        --11--1-212-1123--224-3---      ----132-
        --11---------134-34554---       --22----
              --    --2244445544        --22--
                    ---133455544        -2221-
                        -4454555      ------11
                        33325664      ---231-1
                      343--2564-      --1222--
                      -2---45543      -2233---
                          -3-344      -3431---
                          ---224      3441----
                            ---4      343-----
                            -145      342-----
                            -343---2332-------
                            -444---333--------
                            -34542-44322----
                            -244544443332---
                              555555333211---
                              44455443211----
                                4444441-------
                                4444444---------
                                4444444---------
                                44444444------
                                  333333--------
                                  2222222-------
                                      ----------
                                      -----------
                                            ------
                                            ------
                                              --
                                              --    10-year return period
```

Fig. F-12	PREDICTED INUNDATION AREA AND DEPTH (12)

THE STUDY ON THE FLOOD MITIGATION OF THE KLANG RIVER BASIN

APPENDIX G: FLOODS AND FLOOD DAMAGE



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APPENDIX G. FLOODS AND FLOOD DAMAGE

1. INTRODUCTION

For the purpose of estimating the flood conditions and flood damage, past records of floods and property damage were investigated in the flood prone areas. Information on these floods was obtained by interviewing residents at the sites. In addition to this field investigation, records and data related to flood and flood damage were obtained from the agencies concerned such as Drainage and Irrigation Department (DID) Head Quarters, DID Federal Territory, DID Selangor, City Hall and etc.

Three kinds of field investigations, viz. flood conditions, flood damage and building surveys were carried out during the field survey period. Among these surveys, the building survey was executed especially in the flood prone areas along the Klang, Gombak and Batu Rivers, and Sg. Kerayong in Kuala Lumpur.

To obtain the past records of flood conditions, the following information was collected through interviewing;

- Inundation depth
- Inundation duration
- Causes of floods
- Type of house/building
- Flood flow direction
- Flood frequency
- Thickness of sediment after flood has subsided

A sample of interview questionnaire is shown in Table G-1.

With regard to the flood damage survey, the following information was collected;

- Type and area of house/building
- Construction material and cost of house/building
- Repair or replacement cost
- Assets value and damage loss
- Stock value to be sold and damage loss
- Sales loss owing to flood/inundation
- Income loss due to flood

Interview questionnaire is shown in Table G-2.

The building survey is a kind of quantity survey for property conducted by collecting basic information to estimate number of buildings in the flood prone area. Following information were collected;

- Number of buildings in the survey areas
- Type of main use of building
- Lot size and building area

These survey results were adopted as basic data for evaluation of flood damage potential and in calculating expected average annual flood damage.

2. PAST RECORD OF FLOOD CONDITION

2.1 General

In the Klang River Basin, floods occur usually between August and January, mostly in November, but flash floods occur throughout the year. One of the most severe floods ever recorded occurred in January 1971 and inundated approximately 122 km^2 or 9.5% of the Klang River catchment area (1,288.4 km^2). Nearly 180,000 people were affected by this flood.

Numerous streams often overflow during or after a downpour even in off-flood seasons. The unimproved drainage system in the city and towns tends to exacerbate the worst flood conditions. This kind of flash flood damages household properties in the low lying areas, hampers economic activities, and causes traffic jam.

The discharge capacity in an unimproved river stretch of the Batu, Gombak and Klang Rivers is small compared with that in the improved river stretch in Kuala Lumpur. In addition to this, the river discharge capacity at some bridge sites is so small that the flood flow is dammed up causing the river to overflow at the upstream reaches of those bridge sites.

In this basin, especially in the surrounding areas of Kuala Lumpur, urban development such as large-scale housing schemes has encroached on to the abandoned tin mining sites and slopes of mountains. The change of land uses from reserved land to housing schemes and other uses gives rise to the following problems;

- Reduction of retention capacity of water and the increase of flood peak run-off from a downpour.

- Increase of erosion, and decrease of flow capacity of river and drain due to sedimentation.

Under the present conditions, the intensity and probability of floods are increasing year by year.

For the purpose of estimating the flood conditions, past records of floods were collected from agencies concerned such as DID Headquarters, DID Federal Territory, DID Selangor, City Hall, etc., and from field surveys.

2.2 January 1971 Floods

On January 4th and 5th, 1971, severe flooding occurred and the basin was severely damaged especially along the Klang, Gombak and Batu Rivers between Kuala Lumpur and Klang Town. The damage was much more extensive and severe than the floods of 1926 and 1931. The communication systems such as telephone, roads, and radio were cut off for a short duration, and the Federal Capital was isolated from the rest of the country. Damage to property was severe as the flood peak occurred at night when many people were unaware of the extent of the damage. Although the flood lasted approximately one day in the center of Kuala Lumpur, the cleaning operation in restoring and rehabilitating the public and private services, flood victims, etc. lasted for weeks.

Continuous rain began on January 1st, 1971 when a severe tropical depression which originated in the South China Sea moved westwards and crossed the southern half of Peninsular Malaysia. The Upper Klang River Basin experienced heavy and continuous rainfall. A total rainfall of 320.3 mm was recorded for this storm period between January 1st to 5th, 1971 at DID Ampang. Rainfall on January 4th was especially heavy when 171.5 mm rainfall was recorded at the same station. This precipitation was directly translated into a peak discharge, as the catchment was already saturated with rainfall occurred previously.

Flooding in the town center of Kuala Lumpur was for a short duration of approximately one day. However, low lying areas such as Tiong Nam, Datuk Keramat, Kampung (Kg.) Kasipillay, Kg. Haji Abdullah Hukom, Kg. Baru, Puchong and etc. were inundated for up to 5 days. As shown in Fig. G-1, the total area inundated by this flood was estimated to be approximately 122 km^2 which corresponds to about 9.5% of the Klang River catchment area (1,288.4 km^2). In addition to this, inundated depths at each area was estimated from the interview survey results and available topo-map. As shown in Fig. G-2, some low lying areas in the central part of the Kuala Lumpur, approximately 5 hectares, were inundated more than 3 m. Inundated area corresponding to varions range of inundation depths are summarized below, and more detail relationships are shown in Table G-3 for each river stretch.

INUNDATED AREA AND DEPTH

Inundated Depth (m)	Inundated Area (km^2)
0 ~ 1	73.58
1 ~ 2	46.10
2 ~ 3	2.23
Over 3	0.05
Total	121.96

The main causes of flooding other than heavy rainfall were:

- Insufficient flow sections and obstruction by piers etc. at bridges,
- Rubbish from houses in flood plains accumulated at bridges and river crossings,
- Overflow of banks along unimproved sections,
- Backwater from main river, and
- Insufficient flow capacity at Puchong Drop.

2.3 Flash Floods

In addition to the January 1971 flood, which is caused by depression-type monsoon storm, many areas are often flooded as a result of a flash rainfall throughout the year in the Klang River Basin. This kind of flash flood also damages household properties and causes heavy traffic jam.

Outline of major flash floods are as follows;

(1) December 10, 1985 Floods

On December 10, 1985, several districts in Kuala Lumpur were under water because of flooding of the Klang River and its tributaries. More than 6,000 people were affected by this flood. This floods is one of the worst floods since the 1971 floods and caused heavy traffic jam, and damage to bridges, houses, roads and etc.

On December 9, there was a heavy rainfall in Kuala Lumpur. The DID Ampang raingauge station recorded a rainfall of 80 mm between 2:00 pm to 3:00 pm.

On December 10, heavy rainfall occurred again in the eastern area of the Upper Klang River Basin between 3:00 am to 7:00 am. Total rainfall recorded at the DID Ampang raingauge station reached 165 mm between 2:00 pm December 9 to 8:00 am December 10.

At Sulaiman Bridge across the Klang River, a water level of 26.82 m was recorded at 10:00 am. This was only 0.2 m lower than danger water level of 27.0 m.

At the Pekeliling station, in the Gombak River, water level reached its danger level of 31.50 m at 11:00 am and highest level of 31.67 m was recorded at 11:30 am.

About 7:30 am, several districts in Kuala Lumpur were inundated. The areas affected were Kg. Baru, Kg. Cendana, Brickfields, Kg. Selamat, Kg. Limau, Kg. Bakti, Kg. Pasir Dalam, Kg. Pantai Dalam, Kg. Pasir, Kg. Petaling Bahagia and Kg. Sentosa. These areas are located mainly along the Klang River and were inundated by the overflow from its river banks or bunds.

About 8:00 am, the Klang River was choked by rubbish brought down by the flood water at the Tun Razak Bridge and caused inundation of the upstream low lying areas such as Datuk Keramat. The flood water also overflowed Jln. Tun Razak (Pekeliling) and it reached Yap Kwan Seng area and inundated it. The peak discharge at this point of the Klang River was about 105 m^3/s.

Low lying areas along the Sg. Kerayong, a tributary of the Klang River, was also inundated, which included the following areas; Jln. Cheras 3-1/2 miles, Jln. Sungai Besi 3-1/2 miles, Jln. Klang Lama 4-1/2 miles and Kuala Lumpur - Seremban Highway (TUDM). These areas were inundated due to the overflow of the Sg. Kerayong except last area which was due to insufficient drainage system.

About 8:00 am, Jln. Tun Razak (Pekeliling) near Balai Datuk Harun was inundated due to the overflow from the Sg. Bunus. The flood water then flowed back into the downstream of old Sg. Bunus. The new trash screen at the entrance of the by-pass channel was completely clogged with rubbish.

About 8:00 am, the Klang River breached its protection dyke near Jln. Raja Ali footbridge in Kampung Baru area. Flood water then gushed into Kampung Baru in large amount and inundated it to a depth of 2 m. This flood water and the overflowed water from the Sg. Bunus merged downstream at Jln. Raja Muda Bridge and resulted in a more severe floods in that area. The people affected by this floods were evacuated to flood relief centers.

Other inundated areas were Bamboo Garden, Segambut Industrial Estate and Kampung Kassipillay along Batu River, and Sentul Pasar along Sg. Untut.

(2) May 8, 1986 Flood

In the early morning of May 8, 1986, a localized torrential rainfall hit Kuala Lumpur for about three hours. All rainfall stations recorded more than 50 mm until 8:00 am.

Three hours later, i.e. at 11:00 am, flood water level of the Klang River reached 27.29 m at Sulaiman Bridge. Low lying areas were already flooded to about 1 m deep. Flood water overflowed from the Klang River and inundated Kg. Sentosa, Kg. Pasir and Kg. Bohol.

At the same time, the Batu River and Sg. Keroh also overflowed its banks. As a result, Segambut Industrial Estate, Kg. Railway Gate, Segambut Dalam and Kg. Kasipillay were inundated to a depth of 0.3 m to 1 m.

Flood water subsided three hours later in both areas. In the central part of Kuala Lumpur, a large number of people ready to go to offices or schools were delayed by about three hours because of traffic congestion.

(3) October 25, 1986 Flood

A heavy rainfall hit the eastern upstream areas of the Klang River from 3:00 pm to 5:00 pm. Rainfall amount of 71 mm and 75 mm were recorded at DID Ampang rainfall station and Empangan Genting Klang respectively.

Flood water level at the Sulaiman Bridge rose rapidly from 24.81 m to 27.75 m between 3:00 pm to 5:00 pm and reached 28.31 m at 7:00 pm. On the other hand, flood water level at Sentul on the Batu River rose from 29.94 m to 31.39 m, which was the peak water level recorded between 3:00 pm to 5:00 pm.

As a result of this floods, the following areas were inundated for approximately 7 hours to a depth of 1 m: Kg. Baru, Kg. Periok, Jln. Tun Razak (Pekeliling), Kg. Pasir, Kg. Bakti, Kg. Pantai Dalam, Kg. Selamat, Kg. Sentosa and Jln. Klang Lama 4-1/2 miles.

(4) May 13, 1988 Floods

On May 13, 1988, several areas in downstream reaches within Kuala Lumpur were under water because of floods from the Klang River and Sg. Kerayong.

Heavy rainfall hit the central area of Kuala Lumpur from 7:00 am. Rainfall amount recorded were 105 mm and 75 mm at DID Federal Territory and DID Ampang rainfall stations, respectively. However, very little rainfall was recorded in the Gombak River basin. Therefore, it appears that most of the rainfall was concentrated within the Klang River basin and around the city center. This storm pattern caused the flood level to rise very rapidly.

The flood water level at Sulaiman gauging station responded almost immediately after rain began falling with practically no time lag. The flood water rose at a rate of 2.6 m/hr between 8:00 am to 8:30 am. The water level reached the danger level of 27.0 m at about 8:15 am and a peak of 28.74 m was recorded at 9:30 am. At the confluence of the Klang and Gombak Rivers, the peak flood water level reached 28.85 m at about 10:30 am and slightly above the flood protection wall of Masjid Jamek. The upstream soffit of the Jln. Tun Perak Bridge was submerged and a very high flood discharge velocity was observed under the bridge.

As a result, several areas were flooded. Location, inundation depth and duration and causes of the floods are summarized as below:

MAY 13, 1988 FLOOD INFORMATION

Location	Inundated Depth (m)	Inundated Duration (hrs)	Causes
Kg. Baru	1.5	5	Inner water and intrusion from Klang River
Brickfields	1.5	3	Overflow from Klang River
Kg. Pasir Baru	2.0	8	Inner water and intrusion from Klang River
Kg. Pasir Lama	1.0	3	Overflow from Klang River
Kg. Sentosa	2.0	8	Backwater from Klang River
Kg. Bakti	1.0	3	Overflow from Klang River
RSGC	0.5 (max. 2.0)	5	Insufficient culvert and drainage capacity
Kg. Pantai Dalam	1.5	3	Backwater from Klang River
Kg. Limau	1.5	3	Backwater from Klang River
TUDM	1.0	3	Insufficient culvert capacity
Jln. Cheras 3-1/2 miles	1.0	3	Overflow from Sg. Kerayong
Jln. Sg. Besi 3-1/2 miles	1.0	3	Overflow from Sg. Kerayong

Source: Flood Information Report by DID Federal Territory

In addition to the major flash floods described above, many streams often overflow as a result of a downpour throughout the year in the Klang River Basin. In the Federal Territory, fifty (50) flash flood prone areas are identified. Most of these areas are located along the banks or in the vicinity of the Klang, Gombak and Batu Rivers, and Sg. Kerayong as shown in Fig. G-3.

Past flood records at each area in the Federal Territory are obtained from the "Flood Information Report" which were prepared by DID Federal Territory. This report records flood period, location, duration, causes, hydrological information such as rainfall and water level, inundation depth and others. Based on this report and field survey results, inundation duration, depth, frequency and causes are summarized in Table G-4 and illustrated in Fig. G-4 for each flash flood prone area. From these results, it is found out that flash flood was occurred with high frequency at the flood prone area along the Sg. Kerayong. Inundated period at upstream flood prone areas are approximately 2 to 4 hours and other areas are 5 to 8 hours.

Outside the Federal Territory, in the Klang River Basin, which lies in the Selangor State is also affected by flash floods. According to the Selangor State Annual Flood Report (Laporan Banjir/Kemarau Tahunan Negeri Selangor), 47 flooded areas were recorded between 1984 to 1986 as shown in Fig. G-5. Based on these reports and field survey results, phenomena of flash flood are summarized in Table G-5 for each flooded area. Among these areas, lower reaches of the Klang River are flooded basically due to the effect of high tide.

The main causes of these flash floods are as follows:

- Insufficient depth or width of river or canal due to sedimentation and heavy vegetation growth on its banks.
- Rapid housing development which causes heavy silting and increase in peak discharge.
- Drainage channels, culverts, bridges etc. clogged or choked with rubbish and other waste materials.

- Overflowing of mining pools.
- Breaching of river banks/dykes.
- Absence of retaining wall to prevent floods.
- The settlements are situated in low lying areas with insufficient or without any drainage systems.
- Occurrence of tide which impedes the discharge of drains into the downstream reaches of the river as well as the smooth discharge of the river into the sea.

3. PREVIOUS FLOOD DAMAGE

3.1 Flood Damage Estimation for January 1971 Floods

Unlike the physical flood conditions, past records of flood damage in monetary terms are not available except for the case of the January 1971 floods. This estimation was carried out as a part of the Study of Kuala Lumpur Flood Mitigation Project. A field survey of flood damage for the January 1971 floods was performed by the United States Bureau of Reclamation and the Malaysian Drainage and Irrigation Department, the government of Malaysia in June 1976. The summary of the results is shown below.

Estimated flood damage

Houses	- M$3,710,900
Shops	- M$10,001,200 (*)
Banks	- M$3,063,000 (*)
Government Department	- M$17,492,100
Total (1977 price level)	M$34,267,200

Note: (*) 10% of direct damage is added as sales loss.

3.2 Estimation of Potential Direct Annual Average Damage

In view of the lack of historic information, a survey was carried out by Dingle Smith (Australian National University) in 1985 and a part of the results were reported recently.

The data were gathered in Kuala Lumpur and analyzed to estimate the "Potential Direct Annual Average Damage" to the commercial and residential sectors.

Table G-6 presents the estimates for the eight (8) areas into which the flood-prone area was divided. This table shows the interim study results.

4. FLOOD DAMAGE ESTIMATE

4.1 General

The benefit of a flood mitigation project is defined as the monetary value of the difference in damage with and without project implementation. The estimation of flood damage presented here is made assuming no project implementation. In other words, the flood damage estimate is based on a "do nothing" scenario.

The many parameters needed for the estimation of flood damage were obtained through the results of field surveys and from the agencies concerned. For a clarification of the relationships among the subtasks in this study, the reader is referred to Figure G-7.

4.2 Flood Damage Survey and Building Survey

4.2.1 Flood Damage Survey

The Study Team carried out a field survey and collected information on actual damage with regard to various types of properties.

a) Surveyed Areas

The survey covered the flood prone areas in the Klang River Basin from Gombak district to Klang district including Federal Territory and Petaling.

b) Items Surveyed

The survey forms used are presented in Table G-2. Two types of interview questionnaires have been designed; one is for use with households and the other for shops, factories and institutions.

c) Sample Size

The sample size was 582 for residential houses, 146 for shops, factories and 22 for institutions.

d) Method

A home interview method was adopted in this survey.

4.2.2 Building Survey

(1) Objectives

A building survey was also carried out in addition to the above-mentioned flood damage survey. The aim of this survey was not to examine flood damage, but to collect the basic data necessary to identify estimation parameters for the number of housing units, shops, factories, and buildings for public use in flood prone areas.

Typical areas were selected by referring to the present land use map and all the buildings in those areas were surveyed on the items mentioned below.

(2) Surveyed Items

All the buildings in the selected areas were identified by referring to the maps of 1:1,584 scale and the following items were surveyed.

- Number of stories
- Types of usage of ground floor (residential, commercial, industrial, public facility) and number of units included in the ground floor corresponding to the type of usage
- Type of primary usage of upper floors
- Lot size and building area
- Number of buildings located in the area

(3) Selection of Building Survey Areas

Typical survey areas were selected so as to represent each land use category prevalent in the flood prone areas. The location map covering the survey areas is given in Figure G-6 and explained below:-

a) Residential Area

The residential districts in flood prone areas are considered to be classified into the following four (4) types, and survey areas were selected for each type.

- The high density residential area located within the central urban area bounded by Jln. Pekeliling (from which, 3 survey areas were selected as marked with K, L, M in Figure G-6).

- The housing estates located in the environs of the central urban area (N, O).

- The low density residential areas scattered in the suburbs (P).

- The riverside areas occupied by squatter settlement (Q).

b) Commercial and Service Area

The commercial and business areas in Kuala Lumpur spread along predominantly North-South direction from the confluence of the Klang and Gombak Rivers and along the main roads outside the central business district.

One survey area (G) was selected within the central area with a high density of various commercial facilities and another two (H, I) were from areas comprising a mix of commercial-residential development.

Additional survey area (J) was for the area where commercial facilities are located along the main road.

c) Industrial Area

As medium or large scale industries are considered to be located in Taman Segambut and Sungai Besi, 6 survey areas (A~F) were selected from these areas.

4.3 Procedure and Conditions for Estimating the Potential Cost of Damage

4.3.1 Scheme for Flood Damage Estimate

The total scheme for flood damage estimation is shown in Figure G-7 and explained briefly below:

i) Present and future land use are categorized on a fine grid map based on the land use study.

ii) Building density (Number of buildings/ha) by land use category is obtained through the analysis of Building Survey.

iii) Quantities of properties (Number of houses, commercial buildings, industrial buildings and indoor movables in these buildings) are calculated by applying the building density to each grid area.

iv) Unit values of various kinds of property are estimated from the results of the Flood Damage Survey and from the information provided by the agencies concerned.

v) The unit values of each type of property times the quantity of that type of property summed over all types of property is equal to the total damageable properties in each cell of the grid.

vi) A hydrological analysis is carried out to establish the relationship between the amount of rainfall and the level of river flooding. Results of this analysis are attached to each cell of the grid.

vii) The relationship between inundation depth and flood damage is obtained through the analysis of the Flood Damage Survey and is applied to the various kinds of properties according to the information of probable inundation depth.

viii) Probable flood damages for different magnitude of floods are calculated by aggregating the damage of each cell of the grid.

ix) Average annual damage is obtained by applying the probabilities of occurrence of different magnitude of floods.

4.3.2 The Grid Method

The width of one cell of the grid is 500 m for the flood prone area located in downstream area from the Sulaiman Bridge and 250 m for upperstream area. The reasons of this treatment are as follows:

- The upperstream area contains the central business district and its environs in which there is dense commercial, residential and public development. Therefore, a 250 meter grid is selected to capture the dense detail of the variegated land uses.

- The fine grid is also required for upperstream area for the calculation of average ground elevation. As the ground elevation at upperstream tend to be more variable in short distance from riverside than downstream, 250 m cell width is adapted instead of 500 m width.

The layout of the grid is based on the Rectified Skew Orthomorphic (R.S.O.) Grid.

4.3.3 Types of Properties in Flood Prone Area

Since flood damage in monetary terms is dependent on property value, the property survey was a crucial part of the investigation. In this flood damage study, the types of properties are classified as follows.

a) General Properties

- Various kinds of crops on agricultural land
- Livestock
- Various types of buildings for household, retail and wholesale, private services, manufacturing industry
- Indoor movables in buildings specified above

b) Public Properties

- Infrastructure such as roads, bridges, railway, electricity, and telecommunication facilities and other public facilities (including public buildings).

4.3.4 The Conditions and Parameters for Flood Damage Estimate

(1) Land Use in Flood Prone Area

Present and future land use in flood prone area are the most basic information for a flood damage study. The characteristics of land use in the whole Klang River Basin and in the flood prone area with 500 m width grid are explained in the part of Socioeconomic and Land Use Study. However, the cells of 500 m width in the upperstream from the Sulaiman Bridge are subdivided into 250 m width cells for the purpose of detailed flood damage estimation.

The flood prone areas in the Upper Klang River had been estimated on the basis of areas inundated by the worst flood on record which occurred in 1971.

A present land use map of the flood prone areas was prepared in 250 m x 250 m grid cells on the basis of the topographic maps of a scale of 1:10,000 and aerial photographs taken in 1987, as well as using data collected during site inspection. The land use is classified into the following categories: Residential; Commercial; Industrial; Institutional and Public Facilities; Park and Cemetery; Pond; Agricultural and Vacant Land. Furthermore, to incorporate additional details into the residential areas they were sub-divided into the following three categories:

i) Existing housing areas: existing housing areas having high and middle densities located inside urban area as well as new housing estates.

ii) Squatter areas: high density immigrant settlements erected illegally. These areas are normally deficient in basic amenity and infrastructure.

iii) Village areas: low density farm land and housing outside the urban area.

Based on the above landuse classification, the present land use pattern in the flood prone areas is tabulated below.

PRESENT LAND USE COMPOSITION IN THE FLOOD PRONE AREAS

	No. of Meshes	Ha	%
Housing	153	956	44.8
Squatter	16	100	4.7
Village	47	294	13.8
Commercial	42	263	12.3
Industrial	17	106	5.0
Public Facilities	27	169	7.9
Pond	4	25	1.2
Park/Cemetery	2	13	0.6
Vacant Land/Agriculture	33	206	9.7
Total	341	2,132	100.0

Of the total area of 2,132 ha in the flood prone areas of the Upper Klang River Basin, 1,000 ha or 88.6% of the total area is occupied by urban facilities which consist of residential, commercial, industrial and public installations. The residential occupancies can be further broken down as follows: existing housing areas with 956 ha or 44.8%, squatter areas with 100 ha or 4.7% and village areas with 294 ha or 13.8%.

As for the distribution of these residential areas, most of the village areas in the flood prone area are located along the upper stretch of the Gombak River and squatter areas are concentrated on the river reservations of the Gombak and Klang Rivers.

The commercial area and public facilities in the flood prone areas are concentrated in the central area with 263 ha and 169 ha respectively.

The industrial area, with 106 ha or 5.0% of the total flood prone areas, is located within Taman Segambut along the Batu River and Ulu Klang along the Klang River.

Other non-urban usages, such as pond, park and cemetery, agricultural and vacant land, account for some 244 ha or 11.4% of the total flood prone areas. These areas are mostly distributed along the upper stretch of the Gombak River, while some 25 ha of ex-mining land are mostly located along the Batu River.

The future land use information is prepared for the year 2005.

(2) Agro-Economic Indicator

a) Unit Yield of Main Crops

Yield per hectare of main crops are shown in Table G-7. These figures are the average in Selangor state and are considered to be applicable.

b) Economic Prices of Crops

Economic prices of main crops are available from various sources according to the kind of crops. The detailed information is shown in Table G-8 to Table G-10. A summary of these information is given in Table G-11.

c) Unit Value of Livestock

The value of livestock per hectare is shown in Table G-12 as the average of each district.

The future unit values of each crop and livestock per hectare are assumed to remain the same as those at present.

(3) Number of Buildings

Number of buildings for household, commercial and manufacturing industry are estimated applying the building density per hectare obtained from the result of the Building Survey conducted by the Study Team.

Building density by type of building and by land use category is shown in Table G-13.

(4) Unit Value of Building

Present unit value for each type of building is estimated based on building cost per m^2 (excluding land value), standard size of building, and its salvage value. The detailed data on unit cost of building are shown in Table G-14.

Future unit values of each type of building for the year 2005 are obtained by applying the rate of increase of per capita GDP from 1988 to 2005 (1.21).

(5) Value of Indoor Movables per Building

The types of indoor movables surveyed are as follows:

Residential house - Household articles such as clothes, furniture, kitchen commodities, bicycle, car, etc.

Commercial sector - Indoor assets such as machines, lamps, display equipment, etc. and stock of goods to be sold.

Industrial sector - Indoor assets, raw material and stock to be sold.

The present unit values of above mentioned indoor movables were calculated using the data collected through the Flood Damage Survey conducted by the Study Team and shown in Table G-15. As household articles were valued at present price level, they were re-estimated to reflect the actual values in consideration of salvage value.

Future unit value of indoor movables were estimated by applying the rate of increase in per capita GDP from 1988 to 2005 (1.21).

(6) Damage Rate

The flood damage rates for buildings, household articles, commercial and industrial sectors' assets were obtained by the Flood Damage Survey conducted by the Study Team.

The Japanese experience, on the other hand, was applied to the damage rate for stock to be sold because the reliable data were not obtained with regard to the amount of stock damages.

The damage rates applied in this Study are shown in Table G-16.

4.4 Probable and Annual Average Flood Damage

4.4.1 Results of Flood Damage Estimate

The estimated probable flood damage is classified into following three types.

- General property damage
- Public property damage
- Indirect flood damage

Among these, general property damage was estimated through the procedure mentioned above. Rest of two types of flood damage were estimated with the method explained below:

a) Public Property Damage

This category includes the damages for public facilities and utilities such as roads, railway, electricity and telecommunication (including public buildings).

According to the previous study conducted by JICA (National Water Resources Study, Malaysia), flood damages of public sector were estimated as 30% of private sector. The same rate was applied in this Study.

b) Indirect Flood Damage

Damage under this category involves wage loss, commercial trade loss, industrial production loss. The indirect damage can be usually estimated by multiplying a factor to direct damage. The United States Bureau of Reclamation and Drainage and Irrigation Department (DID), Malaysia applied the rate of 10% to commercial direct damage for estimating indirect damage as business loss in the 1971 flood. This rate was applied in this study to commercial and industrial sector as well.

In this study, six (6) cases of return period of flood, i.e. 10-year, 30-year, 50-year, 80-year, 100-year and 200-year return period of flood damage were estimated on the basis of the present (the year 1988) and future (the year 2005) land use conditions as shown in Table G-17 and G-18 respectively. Flood damage of 100-year return period by each river stretch is shown in Table G-19. Figures G-8 and G-9 illustrate flood damage potential.

4.4.2 Annual Average Flood Damage

The Annual Average Damage (A.A.D.) is calculated by using the following equation:

$$D = \sum[(N_{m-1} - N_m) \times (L_{m-1} + L_m)/2]$$

where D : Annual average damage

N_m : Excess probability for discharge level (m)

L_m : *Amounts of probable damage at applicable discharge* level (m)

m : Ordinal number for discharge level corresponding to return period

The results of the estimation are shown below:

D_{1988} = (1/5*-1/10) x (0 + 415.0)/2
+ (1/10 - 1/30) x (415.0 + 593.1)/2
+ (1/30 - 1/50) x (593.1 + 821.8)/2
+ (1/50 - 1/80) x (821.8 + 944.0)/2
+ (1/80 - 1/100) x (944.0 + 995.0)/2
+ (1/100 - 1/200) x (995.0 + 1069.6)/2
= 77.9 (million M$)

D_{2005} = (1/5*-1/10) x (0 + 956.7)/2
+ (1/10 - 1/30) x (956.7 + 1342.5)/2
+ (1/30 - 1/50) x (1342.5 + 1929.0)/2
+ (1/50 - 1/80) x (1929.0 + 2190.1)/2
+ (1/80 - 1/100) x (2190.1 + 2286.5)/2
+ (1/100 - 1/200) x (2286.5 + 2502.7)/2
= 179.1 (million M$)

Note (*): The maximum frequency of existing flood mitigation facilities is assumed to be 5-year return period.

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Table G-1 INTERVIEW SHEET FOR FLOOD CONDITION SURVEY

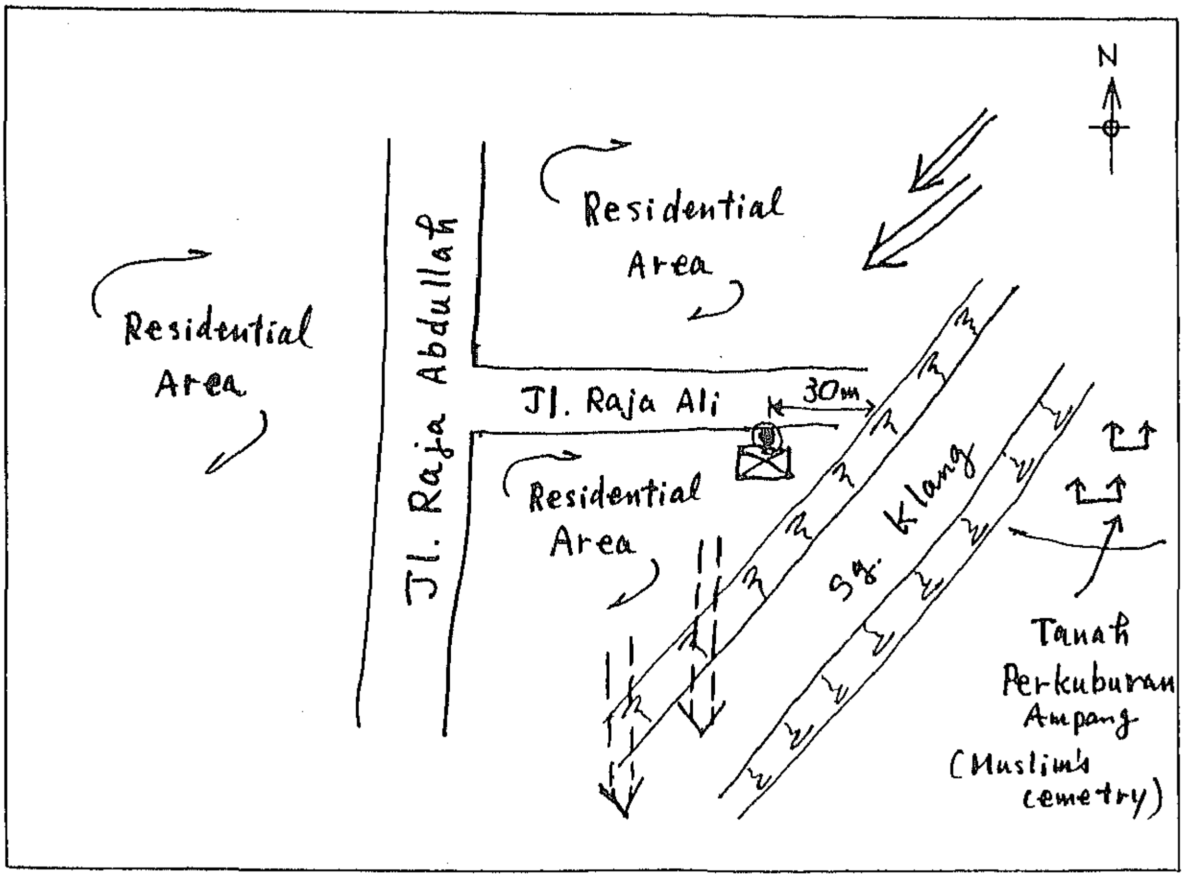
THE STUDY ON FLOOD MITIGATION
OF
THE KLANG RIVER BASIN

No. H-16-02

Subject; Flood/inundation survey in Klang River Basin
Executive agency; JICA Study Team in cooperation with DID

Survey date;	(Oct) Nov. 16, 1987
Interviewer's name;	Abc. D. Efgh
Interviewer's ID No.;	123456
Address;	9, Jl. Raja Ali, Kg. Baru, K.L.
	(Name of building)

Location;



Note; ⟹ Flood flow during flood water level is increasing.
⇢ Flood flow during flood water level is decreasing.

Has your house/building ever flooded? (Yes) No
If Yes. [ ] times per year (houses/buildings on flood plain).
or [3] times in [20] years (houses/buildings away from flood plain).

(To be continued)

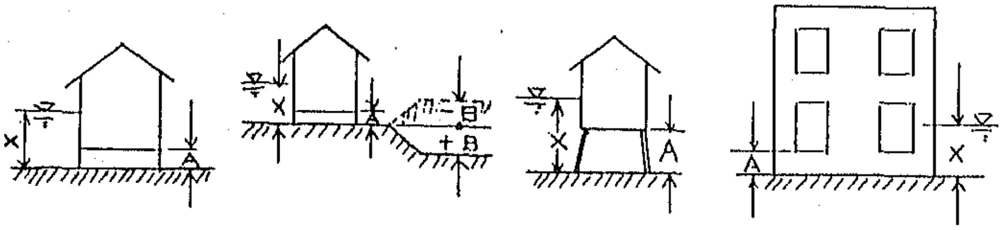
(1) Flooded;

Case		Causes	
Worst	O	Overflow of bank	O
2nd		Backwater from river or canal	
3rd		Others; Much rubbish at pier	
Flash flood			
Average			

(2) Year and month of above case; | 1971 | Jan |

(3) Type of house/building

(1)	2	3	4



(4) Height of floor from the ground; | (A) 0.2 m |

(5) Height of the elevated ground; | (B) — m |

(6) Inundation depth; | (X) 3.0 m |

(calculation) | (X-A) 2.8 m |

(7) Inundation duration

(i) On the floor

From begining to peak;	3	(Hours)	Day
From peak to end;	10	(Hours)	Day
Total;	1	Hours	(Day)

(ii) On the ground

From begining to peak;	3	(Hours)	Day
From peak to end;	12	(Hours)	Day
Total;	1	Hours	(Day)

(8) Rainfall duration at that flood; | 24 Hours |

Period between begining of inundation and begining of rainfall; | 6 Hours |

(9) Thickness of sediment on floor/ground after flood had subsided;

| Average 2 cm |

(10) Can you remember the flood flow direction? | (Yes) | No |

If Yes. Please show the flood flow direction on map of Page 1.

(11) Is there the FLOOD MARK on wall or something? | (Yes) | No |

(12) Others;

Table G-2(1) INTERVIEW SHEET FOR FLOOD DAMAGE SURVEY FOR HOUSEHOLD

Sample No.	

THE STUDY ON FLOOD MITIGATION

OF

THE KLANG RIVER BASIN

Subject: Flood/inundation damage survey in Klang River basin.

Executive agency: JICA STUDY TEAM in cooperation with DID

Date	Oct. Nov. ,1987
Interviewer's Id No.	
Area code	

Interviewees' Address

ZA. When did flood/inundation water come to the maximum depth?

Worst case year

A. Water Depth

A-1 Was your house submerged in the year of the worst case? What about the average case?

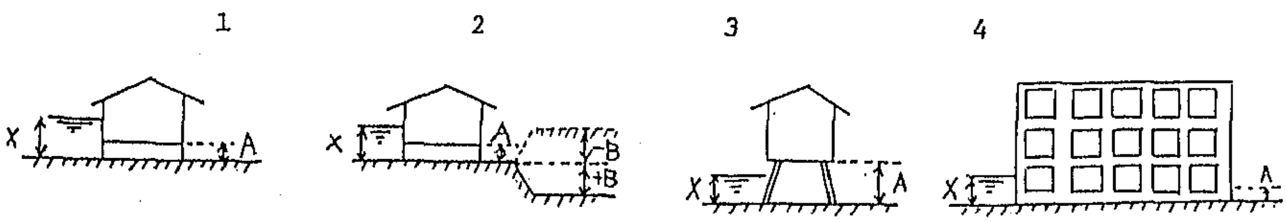
Worst Case		Average Case	
Yes	No	Yes	No

(To be continued)

A-2 Check the items below:

	Worst Case	Average Case Occurs once in average year
(H) Type of house/building → (see below) *	1 2 3 4	1 2 3 4
(A) Height of the floor from the ground →	(A) M	(A) M
(B) Height of the elevated ground →	(B) M	(B) M
(X) Inundation depth →	(X) M	(X) M
(Calculation) →	(X-A) M	(X-A) M
(D) Duration day (on the floor) →	(D) days	(D) days

* Type of house/building



(To be continued)

B. House area & building value

	Questions		Answers
B-1	How large is your housing area?	Total lot (including garden)	( ) M x ( ) M = ( ) sq.M
		Housing/ground floor (excluding garden)	( ) M x ( ) M = ( ) sq.M
B-2	How many stories does your house have?		stories
B-3	By what material is your house's wall constructed?		1. Bamboo/straw 2. Wood 3. Tin 4. Brick 5. Cement
B-4-1	How many years ago was your house constructed?		years ago
B-4-2	How much does your house cost you at construction time? (Original cost)		M$
	------------ or ------------		
B-4-3	If you reconstruct this house now, how much does it cost?		M$

C. Damage

C-1 Did the items below submerged?

	The Worst Case	Average Case
House	Yes No	Yes No
Household articles	Yes No	Yes No

(To be continued)

C-2. Damaged items and their value

			Replacing/repairing cost	
			Worst Case	Average Case
C-2-1A	House	Was your house repaired or newly constructed?	. Repair . New Const.	. Repair . New Const.
C-2-1B		How much did it cost?	M$	M$
C-2-2A	Household articles	Were any household articles damaged by flood/inundation?	Yes No	Yes No
C-2-2B		Which items below were damaged? How much did they cost in repair/replacement?		
		Carpet	M$	M$
		Desk, chair, wardrobe, buffet	M$	M$
		Clothes, dresses	M$	M$
		Kitchen commodities	M$	M$
		Electric equipments	M$	M$
		Others	M$	M$
		Total	M$	M$
C-2-3	Others	How much did you expend in repairing/replacing the items below?		
		Vehicle/bicysle	M$	M$
		Livestock (chicken, duck, cow sheep, etc.)	M$	M$

(To be continued)

D. Wage Lost

D-1 How many families are living in this house?

D-2 How many members of your family are getting incomes?

D-3 How much is their income per month or per day?

D-4 How many days do you work per month?

D-5 How many days couldn't you work due to flood or inundation?

D-6 How much was your income reduced owing to flood/inundation?

No. of family members	Persons	Average income per month	Average income per day	Total working days per month	Total days which you couldn't work due to flood/inundation		Income loss due to flood/inundation	
					Worst case	Average	Worst case	Average
	1	M$	M$	days/month	days/month	days/month	M$/month	M$/month
	2							
	3							
	4							
	5							
TOTAL								

(To be continued)

Check the number of the items below which interviewee have now.

Item	Sub-item			Number	Average Price (M$)
Household Articles	Floor mat				
	Carpet				
	Curtain				
	Clothes	Overcoat			
		Jacket			
		Suit			
		Trousers			
		Shirts (long, short)			
		Longies			
		Sari			
		Blouse			
		Skirt			
		Socks			
		Shoes			
	Furniture	Chairs, sofa			
		Table, desk			
		Ward roke, buffet, bookshelf, plate shelf			
		Bed			
		Mattress			
		Blanket			
	Kichen	Plate, cup, bowl	(China)		
			(Steel, aluminium)		
			(Plastic)		
		Pot	(China)		
			(Steel, aluminium)		
			(Plastic)		
		Gas equipment			
		Refrigerator			
		Radio			
		Tape recorder			
		TV set			
		Lamp	(Table lamp)		
			(on the wall/ciel)		
		Bicycle			
		Car			
	Other luxuries				

Table G-2(2) INTERVIEW SHEET FOR FLOOD DAMAGE SURVEY FOR SHOP, FACTORY AND ESTABLISHMENT

Sample No.	

THE STUDY ON FLOOD MITIGATION
OF
THE KLANG RIVER BASIN

Subject: Flood/inundation damage survey in Klang River basin.

Executive agency : JICA STUDY TEAM in cooperation with DID

Date	Oct. Nov. ,1987
Interviewer's ID No.	
Area code	

Interviewees' Address & Name of Building

	Were your shop/factory flooded/inundated in the past?		Yes No
	When was the severest flood/inundation in the area? (The year of the worst case)		
	The Average Case	Water depth from the floor?	meter
		Duration days of flooding/ inundation?	days/year
	The Worst Case	Water depth from the floor?	meter
		Duration days of flooding/ inundation on the floor?	days/year
	How large is your shop/factory area? (excluding garden)		( ) M x ( ) M = ( ) sq.M
	How many people are working here?		persons

(To be continued)

Asset	How much is the value of this shop factory's assets? (assets includes machine, lamp, display equipment, etc. but excluding land & building)	M$/
	Can you estimate the value of this building in 1987?	M$/
	How seriously damaged your asset by flood/ inundation in average case?	M$/
Stock	How much was the total value of your shop/factory's stock in 1987 ?	M$/
	How seriously damaged your stock by flood/inundation in average case?	M$/
Sales loss (1)	How many days did you close your store/ factory owing to flood/inundation in average case?	days/year
Average Case	How much is the sales value per day or per month? (in 1987)	M$/day or M$/month
	What was percent loss of sales?	%
Sales loss (2)	How many days did you close your store/ factory/owing to flood/inundation?	days
The year of the worst case	How seriously did your sales value decrease in the worst year in comparison with the average sales value?	%

Table G-3 INUNDATED AREAS AND AVERAGE INUNDATED DEPTH IN 1971 FLOODS FOR EACH RIVER STRETCH

No.	River	River Stretch	Inundated Area					Average Inundated Depth (m)
			Depth 0 - 1m (km2)	Depth 1 - 2m (km2)	Depth 2 - 3m (km2)	Depth Over 3m (km2)	Total (km2)	
1	Klang	U/S Klang R. - Sg. Ampang confluence	0.501	0	0	0	0.501	0.50
2	Ampang	U/S Sg. Ampang - Klang R. confluence	0.210	0	0	0	0.210	0.50
3	Klang	Sg. Ampang confluence - Jln. Tun Razak	0.538	0.255	0	0	0.793	0.82
4	Klang	Jln. Tun Razak - Gombak R. confluence	0.459	0.677	0.497	0.015	1.648	1.54
5	Gombak	U/S Gombak R. - Jln. Kg. Bandar Dalam	1.414	0.740	0	0	2.154	0.84
6	Gombak	Jln. Kg. Bandar Dalam - Batu R. confluence	0.818	0.386	0.201	0.005	1.410	1.07
7	Batu	U/S Batu R. - Jln. Duta Segambut	0.788	0.072	0.005	0	0.865	0.59
8	Keroh	U/S Sg. Keroh - Jln. Duta Segambut	0.135	0.006	0	0	0.141	0.54
9	Batu	Jln. Duta Segambut - Gombak R. confluence	0.123	0.303	0.340	0.022	0.788	1.83
10	Gombak	Batu R. confluence - Klang R. confluence	0.094	0.267	0.198	0.006	0.565	1.71
11	Klang	Gombak R. confluence - Jln. Kinabal	0.114	0.143	0	0	0.257	1.06
12	Klang	Jln. Kinabal - 3rd Miles Railway bridge	0.537	0.321	0.010	0	0.868	0.89
13	Klang	3rd Miles Railway bridge - Sg. Kerayong confluence	0.415	0.459	0.428	0	1.302	1.51
14	Kerayong	U/S Sg. Kerayong - Klang R. confluence	0.665	0.452	0.140	0	1.257	1.08
15	Klang	Sg. Kerayong confluence - Jln. Klang bridge	0.409	0.711	0.189	0	1.309	1.33
16	Klang	Jln. Klang bridge - Sg. Puncala confluence	3.549	4.141	0.182	0	7.872	1.07
17	Klang	Sg. Pencala confluence - Puchong Drop	6.390	6.580	0	0	12.970	1.01
18	Klang	Puchong Drop - Sg. Damansara confluence	38.650	24.700	0	0	63.350	0.89
19	Damansara	U/S Sg. Damansara - Klang R. confluence	4.870	2.690	0.040	0	7.600	0.86
20	Klang	Sg. Damansara confluence - Klang Town	12.900	3.200	0	0	16.100	0.70
		Total	73.579	46.103	2.230	0.048	121.960	0.92

Note: U/S means upstream.

Table G-4 FLASH FLOOD AREAS IN FEDERAL TERRITORY

No.	Location	Inundation Ave.Duration (hrs)	[hrs]	Ave.Depth (m)	[m]	Frequency <1	[Times]	Causes and Other Information
1	Datuk Keramat	5	[5]	0.8	[0.8]	5	[4/Yr]	Klang River overflow. Insufficient drainage Capacity. Intrusion through drain from Klang River. Rubbish clogged drain. Increase sediment from upstream housing area.
2	Jln. Yap Kwan Seng	6	[4]	0.7	[0.8]	1	[1/Yr]	Klang River overflow.
3	Kg. Baru	5	[5]	0.8	[0.9]	25	[10/Yr]	Intrusion through culverts from Klang River. Insufficient drainage capacity. Klang River breached its protection dike on December 10, 1985.
4	Kg. Cendana	6	[6]	1.0	[1.0]	14	[9/Yr]	Instrusion through culbert from Klang River. Klang River overflow.
5	Pulapol		[3]		[0.5]		[2/Yr]	Bunus River overflow. Rubblish clogged drain.
6	Jln. Pekeliling	5	[4]	0.5	[0.8]	8	[4/Yr]	Bunus River overflow. Intrusion through drain from Bunus River. Rubbish accumulate at trash screen.
7	Kg. Periok/Kg. Doraisamy	5	[5]	1.1	[1.0]	7	[11/Yr]	Bunus River overflow. Instrusion through drain from Bunus River. Rubbish clogged drain. Insufficient drainage capacity because of sedimentation.
8	Taman Ibu Kota	2	[2]	0.5	[0.4]	1	[15/Yr]	Belongkong River overflow. Insufficient flow capacity at bridge. Insifficient river capacity because of sedimentation. Flood frequency increase recently.
9	Taman Setapak	2	[4]	0.5	[0.4]	1	[5/Yr]	Belongkong River overflow. Rubbish clogged drain. Flood frequency increase recently.
10	Kg. Bandar Dalam	4	[2]	0.5	[0.4]	1	[4/Yr]	Gombak River overflow. Intrusion through drain from Gombak River.
11	Kg. Sg. Mulia	3	[5]	1.2	[0.3]	1	[8/Yr]	Gombak River overflow. Intrusion through drain from Gombak River.
12	Kg. Cempedak	14	[8]	0.8	[0.8]	1	[10/Yr]	Gombak River overflow. Intrusion through drain from Gombak River.
13	Kg. Cubadak Tambuhan	10	[4]	0.9	[0.3]	2	[6/Yr]	Gombak River overflow. Intrusion through drain from Gombak River.
14	Kg. Puah Seberang	7	[3]	1.6	[0.7]	3	[2/Yr]	Gombak River overflow. Intrusion through drain from Gombak River.
15	Sentul Pasar		[4]		[0.8]		[9/Yr]	
16	Kg. Tanah Lapang		[3]		[0.5]		[5/Yr]	
17	Batu View		[5]		[0.2]		[3/Yr]	
18	Taman Kok Lian	8	[4]	0.6	[0.6]	1	[6/Yr]	Batu River overflow. Insufficient drainage capacity.
19	Taman Ipoh Road		[4]		[0.6]		[6/Yr]	Insufficient drainage capacity.
20	Bamboo Garden	7	[4]	0.8	[0.6]	15	[6/Yr]	Batu River overflow. Intrusion through drain from Batu River.
21	Segambut Industrial Estate	8	[7]	0.8	[0.6]	28	[10/Yr]	Batu River overflow. Intrusion through drain from Batu River.
22	Kg. Benteng		[4]		[1.2]		[1/Yr]	Keroh River overflow.
23	Segambut Dalam	6		0.6		4		Tributary of Keroh River overflow.
24	Kg. Railway Gate	8	[5]	0.9	[0.6]	13	[Many/Yr]	Keroh River overflow. Intrusion through drain from Keroh River.
25	Kg. Kassipillay	7	[6]	0.7	[0.6]	20	[6/Yr]	Batu River overflow. Intrusion through drain from Batu River.
26	Brickfields	4	[5]	0.8	[0.7]	8	[7/Yr]	Klang River overflow. Intrusion through drain from Klang River. Rubbish clogged drain.
27	Kg. Haji Abdullah Hukom	5	[4]	0.9	[0.8]	5	[6/Yr]	Klang River overflow. Intrusion through drain from Klang River. Insufficient drainage capacity.
28	Kg. Selamat	5	[3]	1.0	[0.9]	10	[6/Yr]	Klang River overflow. Intrusion through drain from Klang River.
29	Kg. Limau	6	[6]	1.0	[1.3]	10	[8/Yr]	Klang River overflow. Rubbish clogged drain.
30	Kg. Ponnudurai	12	[3]	1.0	[0.9]	1	[10/Yr]	Klang River overflow. Intrusion through drain from Klang River.
31	Kg. Bakti	5	[6]	0.9	[0.6]	6	[5/Yr]	Klang River overflow. Kerayong River overflow.
32	Kg. Pasir Dalam	6	[7]	1.0	[1.0]	1	[6/Yr]	Klang River overflow.
33	Kg. Pantai Dalam	6	[7]	0.9	[0.8]	9	[7/Yr]	Klnag River overflow. Intrusion through drain from Klang River
34	Jln. Klang Lama 4 1/2 miles	6	[7]	0.9	[0.6]	7	[9/Yr]	Klang River overflow. Kerayong River overflow.
35	Kg. Pasir Baru	5	[7]	0.9	[1.1]	14	[15/Yr]	Klang River overflow. Intrusion through drain from Klang River.
36	Kg. Pasir Lama	6	[7]	0.8	[0.9]	8	[5/Yr]	Klang River overflow. Intrusion through drain from Klang River.
37	Kg. Sentosa	6	[9]	1	[0.8]	9	[6/Yr]	Klang River overflow. Intrusion through drain from Klang River. Rubbish clogged drain.
38	Kg. Petaling Bahagia		[5]		[0.8]		[8/Yr]	Klang River overflow. Intrusion through drain from Klang River. Rubbish clogged drain.
39	Kg. Bohol	6	[5]	1.2	[0.7]	4	[5/Yr]	Intrusion through Kuyoh River from Klang River. Overflow from mining pond. Kuyoh River overflow.
40	Pudu Ulu		[2]		[0.9]		[12/Yr]	Insufficient drainage capacity.
41	Jln, Cheras 3 1/2 miles	4	[4]	0.7	[0.6]	6	[12/Yr]	Kerayong River overflow.
42	Chan Sow Lin	11	[6]	0.5	[1.0]	2	[10/Yr]	Kerayong River overflow. Rubbish clogged drain. Insufficient drainage capacity.
43	Jln. Sg. Besi 3 1/2 miles	4	[5]	0.8	[1.1]	12	[20/Yr]	Kerayong River overflow. Insufficient drainage capacity.
44	TUDM	3	[3]	0.7	[0.6]	2	[20/Yr]	Insufficient culvert capacity under Highway.
45	Kg. Sungai Penchala		[5]		[0.5]		[5/Yr]	Kayu Ara River Overflow.
46	Kg. Cubadak Hilir		[2]		[0.6]		[2/Yr]	Insufficient drainage capacity.
47	Jln. Kepong 4 miles		[4]		[0.2]		[6/Yr]	Rubbish cologged drain.
48	Kg. Delima		[3]		[0.5]		[1/Yr]	Jinjang River overflow.
49	Bukit Bintang Plaza		[2]		[0.3]		[10/Yr]	Insufficient drainage capacity. Overflowed water run into underground car parking area.
50	Royal Selangor Golf Club		[5]		[0.6]		[5/Yr]	Insufficient drainage capacity.

Table G-5 FLOODED AREA IN SELANGOR STATE BETWEEN 1984 TO 1986

No.	Location	Recorded Year 1984	1985	1986	Inundation Duration		Depth (m)		Area (ha)	Frequency (Times/year)	Causes and Other Information
1	Kg. Pasir, 8 miles		*			[4 hrs]	1.0	[0.8]	2	[5]	Klang River overflow.
2	Kg. Pasir	*	*		1-2 days		1.1		3.1		Insufficient drainage capacity.
3	Kg. Selamat	*			3 days	[3 hrs]	0.9	[0.6]	2	[4]	Instrusion through drain from Klang River. Rubbish accumulation in canal/river.
4	Jln. Ulu Klang 7 miles	*			1-2 days		0.6		800m		
5	Jln. Gombak 7 1/2 miles		*			[6 hrs]	0.1	[0.6]	2	[1]	Gombak River overflow.
6	Jln. Gombak 7 miles	*			3 days	[3 hrs]	0.1	[0.6]	8	[5]	Insufficient river capacity because of siltation. Gombak River overflow. Instrusion through drain from Gombak River.
7	Jln. Gombak 7 miles		*				0.1		100m		
8	Kg. Tengah/Kg. Kerdas	*	*		1-3 days	[9 hrs]	0.6	[0.4]	8	[2]	Drain overflow mainly because of siltation due to housing development at upstream reaches and also the drain is too small to cater for the increased runoff.
9	Jln. Gombak 6 miles		*		1-2 days	[9 hrs]	0.6	[0.4]	2	[2]	Gombak River overflow mainly because of situation.
10	Kg. Setia	*	*		2 days	[3 hrs]	0.3-0.5	[0.4]	0.8-2	[10]	Belongkong River overflow. Increase sediment from housing development at upstream reaches. Insufficient drainage capacity. Flood frequency increases recently.
11	Kg. Nakhoda		*		1-3 days		0.6		3.5		No outlet drain and no reserve provided for it.
12	Kg. Laksamana	*	*			[3 hrs]	0.6	[0.5]	0.1-0.8	[2]	No reserve for outlet drain.
13	Kg. India Settlement Batu Cave			*	1 day	[1 hrs]	0.3	[0.2]		[4]	Insufficient outlet drain capacity.
14	Jln. Ipoh 8 miles	*	*				0.6		90m		
15	Kg. Selayang Pandang		*				0.6		8		Jinjang River overflow.
16	Cheshire Home	*	*				0.6		1.2		Outlet drain always silted.
17	Jln. Sg. Tua	*	*	*			0.6		90-500m		
18	FRI Staff Office	*					0.6		2		Increase sediment from upstream reaches.
19	Kg. Sentosa			*	0.5 day	[2 hrs]	1.5	[0.5]	50	[7]	Intrusion through drain from Klang River. Rubbish and undergrowth clogged drain.
20	Universiti Pertanian Malaysia			*	1-2 hrs		0.2				Flood flow was clogged at main canal due to laying of G.I. telephone duct across Kuyoh River.
21	Taman Sri Serdang			*	1-2 hrs		0.3				Main canal was clogged by bridge under construction.
22	Serdang Jaya			*	1-2 hrs		0.3				Tributary of Rekah River heavily silted. Triple pipe culvert at downstream of this tributary obstructed flood flow.
23	Kg. Muhibbah		*		2-3 hrs		0.6		100		Shallow river bed because of siltation.
24	Seri Kembangan Petaling	*	*		3 hrs		0.6		130		Sediment and rubbish obstructs drainage capacity.
25	Kg. Tun Ismail			*	1 day	[5 hrs]	2.0	[1.5]	20	[3]	No proper drainage system.
26	Kg. Kenangan, Kg. Tengah and Kg. Baru Sri Puchong			*	1-2 hrs	[4 hrs]	0.5	[0.4]	50	[3]	Main canal from Kg. Kenangan through Kg. Tengah to Klang River was filled with sediment and undergrowth. Main drain at Kg. Baru Sri Puchong was also filled with them.
27	Secondary School Jln. Puchong 14 miles			*	1-2 hrs	[4 hrs]	0.5	[1.4]	20	[5]	Flood flow in outlet drain at school was obstructed by sediment and undergrowth.
28	Dengkil Country			*	2 days		1.2-1.8		100		Obstruction of Rasau River.
29	Jln. Puchong 17 miles			*	1-2 hrs		0.5		20		Air Hitam River was closed by Hong Kong Tin.
30	Jln. Air Hitam 16 miles Mukim Dengkil	*			5 days		2.0		16		
31	Kg. Air Hitam Mukim Dengkil	*			5 days	[2 days]	0.4	[1.8]	16	[3]	Silting due to tin mining.
32	Kg. Pulas	*		*	1-10 days	[6 days]	1.0-1.5	[1.0]	50-60	[2]	Intrusion through Hitam River from Klang River. Insufficient drainage capacity because of undergrowth.
33	Kg. Bt. Lanchong	*			3 days		1.0		60		Heavy undergrowth and water could not flow smoothly.
34	Kg. Melayu Subang			*	1-2 hrs		0.5	[0.5]	20	[1]	Insufficient river capacity because of undergrowth.
35	Kg. Chempaka	*	*	*	2-3 hrs	[2 hrs]	0.8-2.0	[0.5]	20-100	[2]	Insufficient culvert and drainage capacity because of sediment from upstream housing development. No dike along river. Much rubbish from squatters and industrial areas.
36	Kg. Lembah Subang	*	*		4 days	[2 hrs]	1.0	[0.7]	30-32	[10]	Damansara River overflow. No dike along river.
37	Kg. Apoi	*	*		4 days	[2 days]	1.0	[0.3]	33		Damansara River overflow. No dike along river.
38	Padang Jawa	*	*		2 days	[1.5 days]	0.1-0.4	[0.4]	50	[5]	Insufficient railway culvert, JKR drainage and JPT outlet capacity. High tide obstructs drainage.
39	Taman Maznah	*	*		1.5 days	[2.5 days]	0.1-0.3	[0.2]	23	[2]	Insufficient drainage capacity. High tide obstructs drainage. Rubbish obstructs flood flow.
40	Bkt. Kuda	*			6 hrs	[2 hrs]	0.2	[0.5]	2	[4]	Insufficient sluice gate capacity. Insssufficient drainage system. High tide obstructs drainage.
41	Kg. Shah Bonder Raya	*	*		4 hrs-2 days		0.2-0.4	[0.4]	124	[3]	Insufficient railway culvert and drainage capacity. High tide obstructs drainage. Rubbish clogged drain.
42	Jln. Sireh	*			6 hrs		0.2		25		Insufficient culvert and drainage capacity.
43	Melawis and Bunga Rose Area	*	*		3-6 hrs	[3 hrs]	0.1-0.3	[0.5]	49	[5]	Insufficient railway culvert and drainage capacity.High tide obstructs drainage.
44	Jln. Tepi Sungai	*			8 hrs		0.4		64		No proper drainage system.
45	Telok Pulai	*			1 day		0.4		64		Insufficient drainage capacity.
46	Kg. Raja Uda	*			8 hrs		0.5		23		Insufficient railway culvert and drainage capacity.
47	Jln. Pelabuhan Utara	*	*		4-8 hrs		0.2-0.4		69		Insufficient railway culvert and drainage capacity.

Note: Value in parenthesis are obtained through field investigation in this study.

Table G-6 POTENTIAL DIRECT ANNUAL AVERAGE DAMAGE

Area	Commercial		Residential		
	No. of Properties	AAD Contents	No. of Properties	AAD Contents	AAD (1) Structure
1. Brickfields	405	137,283	988	61,804	7,475
2. Hukum	25	15,165	360	47,701	16,490
3. Keramat	95	12,071	983	16,628	661
4. Kasipillay	56	5,483	923	17,471	2,294
5. Bahru	135	241,651	960	135,972	11,918
6. Bunus	26	34,680	221	25,251	3,731
7. Central	941	513,774	186	13,080	1,592
8. Sentul	230	206,249	341	51,122	2,204
Total	1,913	1,166,356	4,962	369,029	46,365

Source : Urban River Flooding in Kuala Lumpur, Dingle Smith March 1985
All values in M$ at 1985 prices.
AAD : Average Annual Damage.
(1) Structural damage only included for wooden buildings.

Table G-7 YIELD PER HECTARE OF MAIN CROPS

Crops	Selangor & W. Persekutuan			Peninsular Malaysia		
	Planted Area (hectares)	Production (tonnes)	Yield per hectare (ton/ha)	Planted Area (hectares)	Production (tonnes)	Yield per hectare (ton/ha)
Paddy *	35,620	127,337	3.57	465,510	1,680,789	3.61
Rubber 2*	104,985 (46,239)	102,122 (48,679)	0.97 (1.05)	1,684,600 (443,569)	1,487,411 (509,687)	0.88 (1.15)
Oil Palm 3* [Fresh Fruit Bunches]	121,947 (89,332)	1,878,315 (1,764,444)	15.40 (19.75)	1,215,592 (691,874)	16,472,682 (10,827,952)	13.55 (15.65)
Cocoa 3*	– (6,380)	– (3,419)	– (0.54)	106,932 (33,533)	19,161 (17,819)	0.18 (0.53)

Source : * Paddy Statistics Malaysia 1985
2* Statistical Handbook, Agriculture, Malaysia 1984
3* Oil Palm, Cocoa, Coconut and Tea Statistics Handbook Malaysia 1985

Note : Figures in parenthesises indicate the case of estates

Table G-8 DERIVATION OF FARM GATE PRICE FOR RUBBER

Items	1986 Financial	1986 Economic
US$/mt		
1. RSS1, spot, New York	1000	
2. Less Ocean freight, insurance and handling, Klang to New York	-150	
3. F.O.B. Port Klang M$/mt (US$1 = M$2.40)	850	
4. F.O.B. Port Klang	2040	2040
5. Port handling($2) & transport($8)(a)	-13	-10
6. Export duty (b)	-198	-
7. Ex-factory price	1829	2030
8. Processing cost (c)	-160	-142
9. Farm gate price for RSS1	1669	1888
10. Quality discount Less 15% of RSS1 price for grade differential	-250	-283
11. Farm gate price	1419	1605

Source: IBRD, Commodity Price Forecasts, in constant 1983 dollars (introduced in "Tumboh Block Regional Integrated Development Project (Annex 14)". Ministry of Agriculture, Malaysia, 1986. A few adjustments were added in above table by JICA Study team)

Note: (a) A CF of 0.68 applied for port handling + CF of 0.79 for transport of approx. 50km at M$0.20 ton/km

(b) The research and replanting cess was assessed at M$138/ton; export duty on rubber is assessed as follows: On the gazetted value listed below, a duty is calculated in cents per kilogramme to the nearest 1/8 of a sen according to the rates shown -
On the first 180 sen per kg.................ad valorem Nil
plus on the next 11 sen per kg.............ad valorem 20%
plus on the next 11 sen per kg.............ad valorem 25%
plus on the next 11 sen per kg.............ad valorem 30%
plus on the next 11 sen per kg.............ad valorem 35%
plus on the next 11 sen per kg.............ad valorem 40%
plus on the next 11 sen per kg.............ad valorem 45%
plus on the balance.......................ad valorem 50%

(c) A CF of 0.89 applied for processing cost

Table G-9 DERIVATION OF FARM GATE PRICE FOR PALM OIL, PALM KERNEL AND FRESH FRUIT BUNCH

Item	1986		
	Financial		Economic
Palm Oil US$/mt			
Malaysian, 5% bulk c.i.f., Rotterdam		555	
Ocean freight, bunker surcharge, insurance and handling		-63	
f.o.b. Port Klang		492	
M$/mt (US$1 = M$2.40)			
f.o.b. Port Klang	1180		1180
Export duty (a)	-340		-
Port charges ($3) & Transport ($10) (b)	-13		-9
Ex-mil price	827		1171
Palm Kernel US$/mt			
Nigerian palm kernels, c.i.f., Rotterdam		365	
Ocean freight and insurance		-60	
f.o.b. Port Klang		305	
M$/mt (US$1 = M$2.40)			
f.o.b. Port Klang	732		732
Export duty (5%)	-37		-
Port charges and Transport (b)	-40		-28
Ex-mill price	655		704
Fresh Fruit Bunch M$/mt			
Value per ton			
20% of oil plus 4% of kernel (c)	192		262
Processing cost (d)	-24		-22
Manufacturing margin (e)	-34		-23
Ex-mill price	134		218
Less transport cost to mill (20km)	-4		-3
Farm-gate price	130		214

Source : IBRD Commodity Price Forecasts, in constant 1983 dollars (Introduced in "Tumboh Block Regional Integrated Development Project (Annex 14)". Ministry of Agriculture, Malaysia, 1986. A few adjustments were added in above table by JICA Study team.

Note : (a)-The export duty on palm oil is based on the following: On the gazetted value listed below, a duty is calculated in ringgit per tonne to the nearest cent, according to the rates shown -

On the first $500 per tonne.................. ad valorem Nil
plus on the next $49.21 per tonne............ ad valorem 30%
plus on the next $49.21 per tonne............ ad valorem 35%
plus on the next $49.21 per tonne............ ad valorem 40%
plus on the next $49.21 per tonne............ ad valorem 45%
plus on the balance.............. ad valorem 50%

(b)-A CF of 0.72 applied for port handling + CF of 0.66 for transport of 50 km at M$0.20 ton/km
(c)-Actual prices vary with the year of harvest of FFB
(d)-A CF of 0.90 applied for processing cost
(e)-15% of output cost; a CF of 0.68 for trade applied

Table G-10 AVERAGE PRICE AND PRODUCTION COST OF VEGETABLE, FRUITS

Item	Vegetables	Fruits
Yield (ton/ha)	15.1	14.8
Price (M$/ton)	680.1	633.3
Production cost (M$/ton)	261.6	116.7

Source : Originally depends on "Tumboh Block Regional Integrated Development Project (Annex 14)", Ministry of Agriculture, Malaysia 1986.
Note : Figures concerning vegetables are the simple average of 12 types vegetables, and six kinds of fruit are averaged.

Table G-11 SUMMARY OF AGRO-ECONOMIC DATA

Item	Yield (tonne/ha)	Price (M$/tonne)
Paddy	3.57	*504
Rubber	0.97	1,605 (1,619)
Oil Palm (FFB)	15.40	214 (217)
Cocoa/Coconut		*M$2,819/ha
Vegetable	15.10	680 (685)
Fruit	14.80	633 (638)

Source : * "Production Cost Estimation and Return of Multi-Crops for Selangor and Negeri Sembilan". Peninsular Malaysia Agriculture Department, Jun. 1987.
Others are from previous tables.

Note : Prices and costs at 1985 or 1986 level are adjusted by the change or price index in order to indicate the current 1988 price level, which are shown in parenthesises.

Table G-12 DATA RELATED TO LIVESTOCK

District	*Quantity (Head 1981)						2* Pasture & Grassland (ha)	4* Value (M$/ha)
	Buffaloes	Cattle	Goats	Sheep	Swine	Total		
GOMBAK	345	1,867	642	-	12,867	15,721	1,798.9	2,675
KLANG	29	3,914	2,050	47	8,896	14,936	2,142.3	3,325
PETALING	398	4,483	2,299	-	8,241	15,421	3,662.0	2,243
ULU LANGAT	-	3,488	2,831	514	10,292	17,125	4,138.9	1,823
(3*) Price (M$/kg)	$11.0/kg	$11.0/kg	$14.0/kg	$7.0/kg	$3.0/kg			

Source : * Livestock Statistics, Malaysia, 1981
2* Department of Agriculture 1981
3* "Warta Barangan" (Listed Commodities), January to December 1985

Note : 4* $\sum$(*Price x Head x Weight Per Head*)/*Pasture & Grassland Area*

In this calculation, weights of buffaloes and cattle are assumed to be 100 kg/Head and rest of livestock 50 kg/Head.

Table G-13 BUILDING DENSITY PER HECTAR BY TYPE OF BUILDING AND LAND USE

(units/ha)

Landuse	Type of Building			
	General Residential House	Squatter House	Commerce	Industry
Housing Area (Kuala Lumpur and Klang District)	25.5	-	-	-
Housing Area (other Districts)	20.0	-	-	-
Village Area	14.7	-	-	-
Squatter Area	-	37.9	-	-
Commercial & Service Area	18.6	-	13.8	-
Industrial Area	5.6	-	-	6.1

Source : The Building Survey by the Study Team

Table G-14 PRESENT UNIT COST PER EACH TYPE OF BUILDING

Item	House		Squatter house [5*]	Commerce	Industry
	Wooden	Permanent			
Unit cost per s.g.m (M$/m2) [*]	M$ 270	M$ 290	M$ 194	M$ 350	M$ 270
Average floor area (m2) [2*]	220		50	460	1,000
Unit cost per building (M$)	61,600		9,700	161,000	270,000
Salvage value [3*]	10% of unit cost per building				
Average unit cost per building (M$) [4*]	33,880		5,300	88,500	148,500

Source : [*] Building Cost Information Centre, Institution of Surveyors, Malaysia.
[2*] By interviewing to quantity surveyors and construction cost consultants, and to a private construction company.

Note : Types of building shown above are categorized as medium class.
[3*] Salvage value of building is assumed to be 10% of original cost.
[4*] Average unit cost indicates the mean cost between original cost and salvage value.
[5*] Wooden low cost house information was applied to squatter house.

Table G-15 PRESENT UNIT VALUE OF INDOOR MOVABLES (1988)

Type of building	Indoor property	Stock, Raw material
General house	M$ 10,700	-
Squatter house (*)	M$ 2,400	-
Commerce (Service)	M$ 165,000 (M$ 165,000)	M$ 28,900 (-)
Industry	M$ 344,000	M$ 300,000

Source ; Flood Damage Survey by the Study Team

Note ; (*) It is reported in "Kuala Lumpur Structure Plan (1984)" that the mean monthly income are M$ 317 per household for squatter family and M$ 1,447 for whole Kuala Lumpur. The ratio of 0.22 (=317/1,447) was applied to the value of indoor property of general house and obtained the value of M$ 2,400 for squatter house (0.22 x M$ 10,700).

Table G-16 DAMAGE RATE

(1)

Inundated depth W(m)	Damage rate for buildings	Damage rate for household articles	Damage rate for assets	Damage rate for stock (*)
1. W<0.5m	0.053	0.057	0.052	0.127
2. 0.5<W<1.0m	0.132	0.096	0.121	0.276
3. 1.0<W<2.0m	0.158	0.135	0.161	0.379
4. 2.0<W<3.0m	0.278	0.336	0.208	0.479
5. 3.0<W	0.425	0.687	0.243	0.562

Source: Flood Damage Survey by the Study Team
(*) Japanese experience (Ministry of Construction, Japan.)

(2) (**)

Depth W(m)	Property				
	Rubber	Oil Palm	Cocoa /Coconut	Fruit	Vegetable
0.25m≤W	0.05	0.10	0.18	0.18	0.18

(3) (**)

Depth W(m)	Property Livestock
W<2.0m	0.0
2.0≤W	1.0

Source: (**) "National Water Resources Study, Malaysia" Sectoral Report Vol.5 JICA

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Table G-17 FLOOD DAMAGE IN 1988 BY RETURN PERIOD

(Unit : million M$ 1988 price)

Items	Return period					
	10-yr.	30-yr.	50-yr.	80-yr.	100-yr.	200-yr.
(1) General property						
1) Houses	86.2	129.0	186.6	217.0	224.5	243.8
2) Commercial Buildings	34.6	50.0	57.8	60.3	62.6	65.3
3) Industrial Buildings	14.6	19.2	25.0	34.1	35.2	39.2
4) Household articles	22.0	36.2	53.2	64.3	67.0	75.0
5) Commercial assets	53.2	76.4	91.6	94.8	101.6	105.9
6) Commercial stocks	10.9	15.6	18.6	19.3	20.8	21.7
7) Industrial assets	26.8	35.0	55.4	66.7	71.5	76.7
8) Stocks & raw materials of industry	54.7	72.5	114.2	136.1	146.6	157.1
9) Agricultural products	0.9	1.2	1.2	1.3	1.3	1.4
10) Livestock	0.3	0.4	0.6	0.6	0.6	0.8
Subtotal	304.2	435.5	604.2	694.5	731.7	786.9
(2) Public property	91.3	130.7	181.3	208.4	219.5	236.1
(3) Indirect damage	19.5	26.9	36.3	41.1	43.8	46.6
Grand total	415.0	593.1	821.8	944.0	995.0	1,069.6

Table G-18 FLOOD DAMAGE IN 2005 BY RETURN PERIOD

(Unit : million M$ 1988 price)

Items	Return Period					
	10-yr.	30-yr.	50-yr.	80-yr.	100-yr.	200-yr.
(1) General property						
1) Houses	189.0	273.9	392.9	447.1	463.4	508.1
2) Commercial Buildings	45.1	64.4	74.9	78.0	80.8	84.1
3) Industrial Buildings	47.2	61.6	88.0	110.0	113.5	131.1
4) Household articles	48.5	76.5	112.1	131.2	137.9	159.4
5) Commercial assets	69.9	99.8	119.0	122.9	131.0	136.3
6) Commercial stocks	14.3	20.4	24.2	25.1	26.8	27.9
7) Industrial assets	93.3	126.1	197.2	227.1	237.4	259.6
8) Stocks & raw materials of industry	192.7	260.8	405.0	463.5	484.6	527.9
9) Agricultural products	0.3	0.4	0.4	0.5	0.5	0.6
10) Livestock	0.1	0.1	0.3	0.3	0.3	0.4
Subtotal	700.4	984.0	1,414.0	1,605.7	1,676.2	1,835.4
(2) Public property	210.1	295.2	424.2	481.7	502.9	550.6
(3) Indirect damage	46.2	63.3	90.8	102.7	107.4	116.7
Grand total	956.7	1,342.5	1929.0	2,190.1	2,286.5	2,502.7

Table G-19 FLOOD DAMAGE BY RIVER STRETCH (100-YEAR RETURN PERIOD)

(Unit : 1000 M$ 1988 price)

River stretch	Flood Damage Potential		Flood Damage Per Ha		Inundated Area (Ha)
	1988	2005	1988	2005	
K-1	0	0	0.0	0.0	-
K-2	4,585	8,219	18.2	32.6	252.50
K-3	199,149	319,855	104.5	167.9	1,905.00
K-4	100,536	542,603	53.6	289.4	1,875.00
K-5	1,135	17,104	0.4	5.6	3,075.00
K-6	75,837	604,692	37.5	298.6	2,025.00
K-7	131,810	166,318	251.1	316.8	525.00
K-8	154,803	187,309	193.5	234.1	800.00
Sub total (1)	667,855	1,846,100	63.9	176.5	10,457.50
K-9	132,733	178,635	518.0	697.1	256.25
K-10	14,546	17,782	116.4	142.3	125.00
K-11	660	800	26.4	32.0	25.00
Sub total (2)	147,939	197,217	364.2	485.5	406.25
K-Total (1+2)	815,794	2,043,317	75.1	188.1	10,863.75
B-1	24,806	30,013	496.1	600.3	50.00
B-2	61,566	75,099	340.1	414.3	181.25
B-3	497	2,059	19.9	82.4	25.00
B-4	6,137	11,793	89.3	171.5	68.75
B-Total (3)	93,006	118,964	286.2	366.0	325.00
G-1	63,190	76,460	561.7	679.6	112.50
G-2	5,896	8,163	94.3	130.6	62.50
G-3	7,861	17,254	59.9	131.5	131.25
G-4	6,172	13,718	65.8	146.3	93.75
G-5	2,222	6,351	25.4	72.6	87.50
G-6	1,166	2,188	37.3	70.0	31.25
G-Total (4)	86,507	124,134	166.8	239.3	518.75
Sub total (2+3+4)	327,452	440,315	262.0	352.3	1,250.00
Grand total (1+2+3+4)	995,307	2,286,415	85.0	195.3	11,707.50

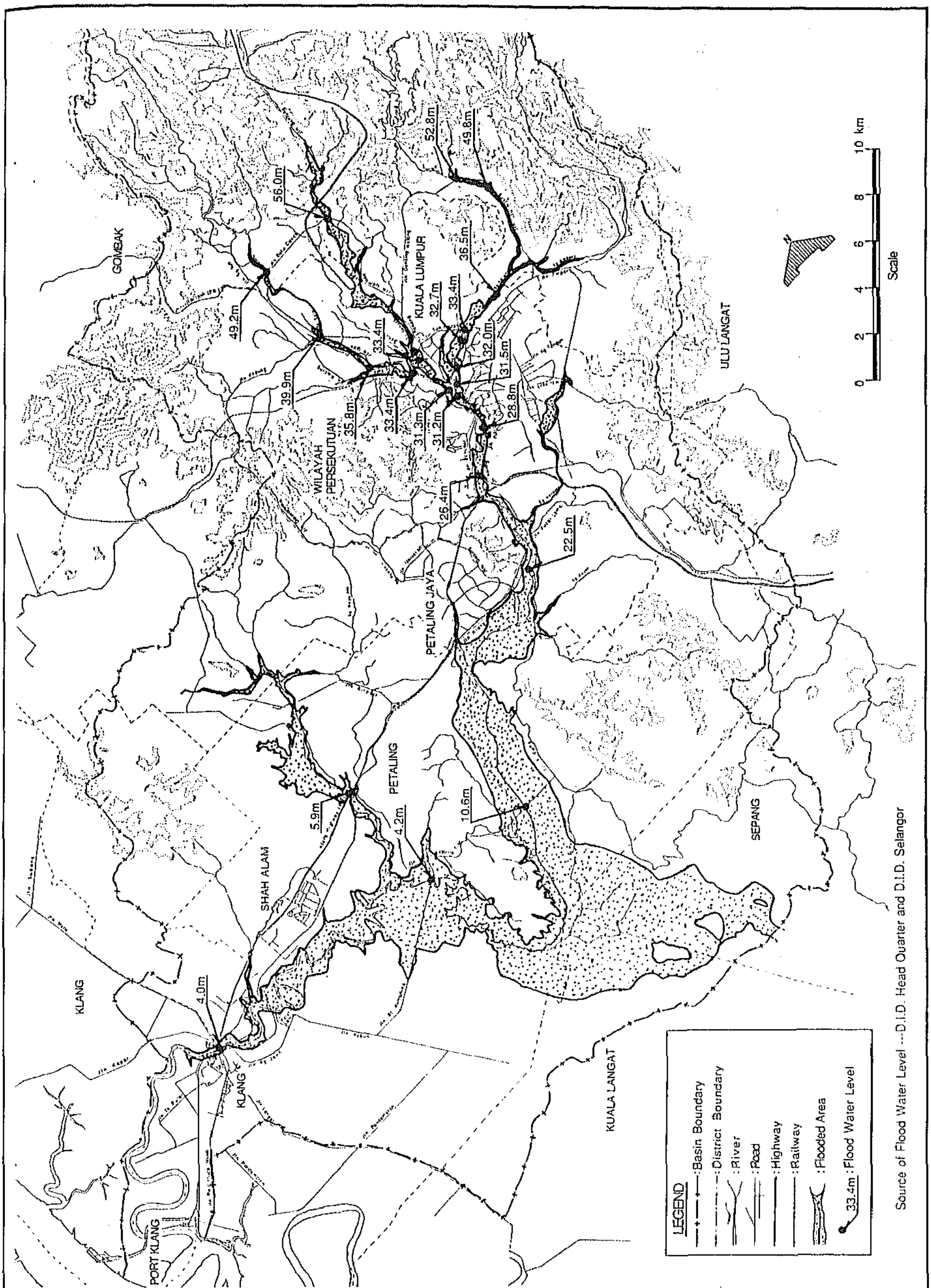

FIG. G-1	FLOOD AREA IN JANUARY 4 & 5, 1971 FLOODS

THE STUDY ON THE FLOOD MITIGATION OF THE KLANG RIVER BASIN

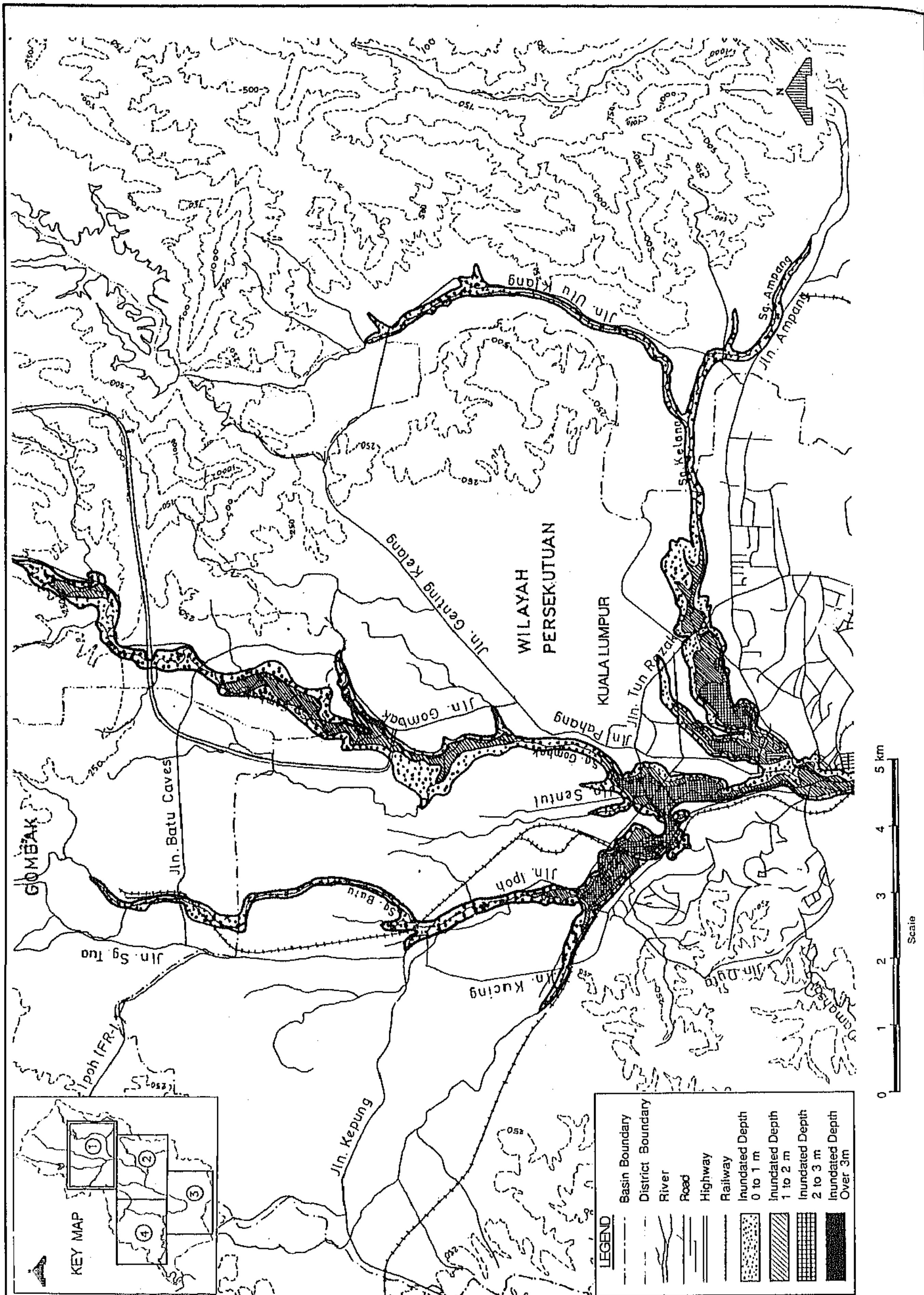

FIG. G-2 **INUNDATED DEPTH MAP IN JANUARY 4 & 5, 1971 FLOODS (1/4)**

THE STUDY ON THE FLOOD MITIGATION OF THE KLANG RIVER BASIN

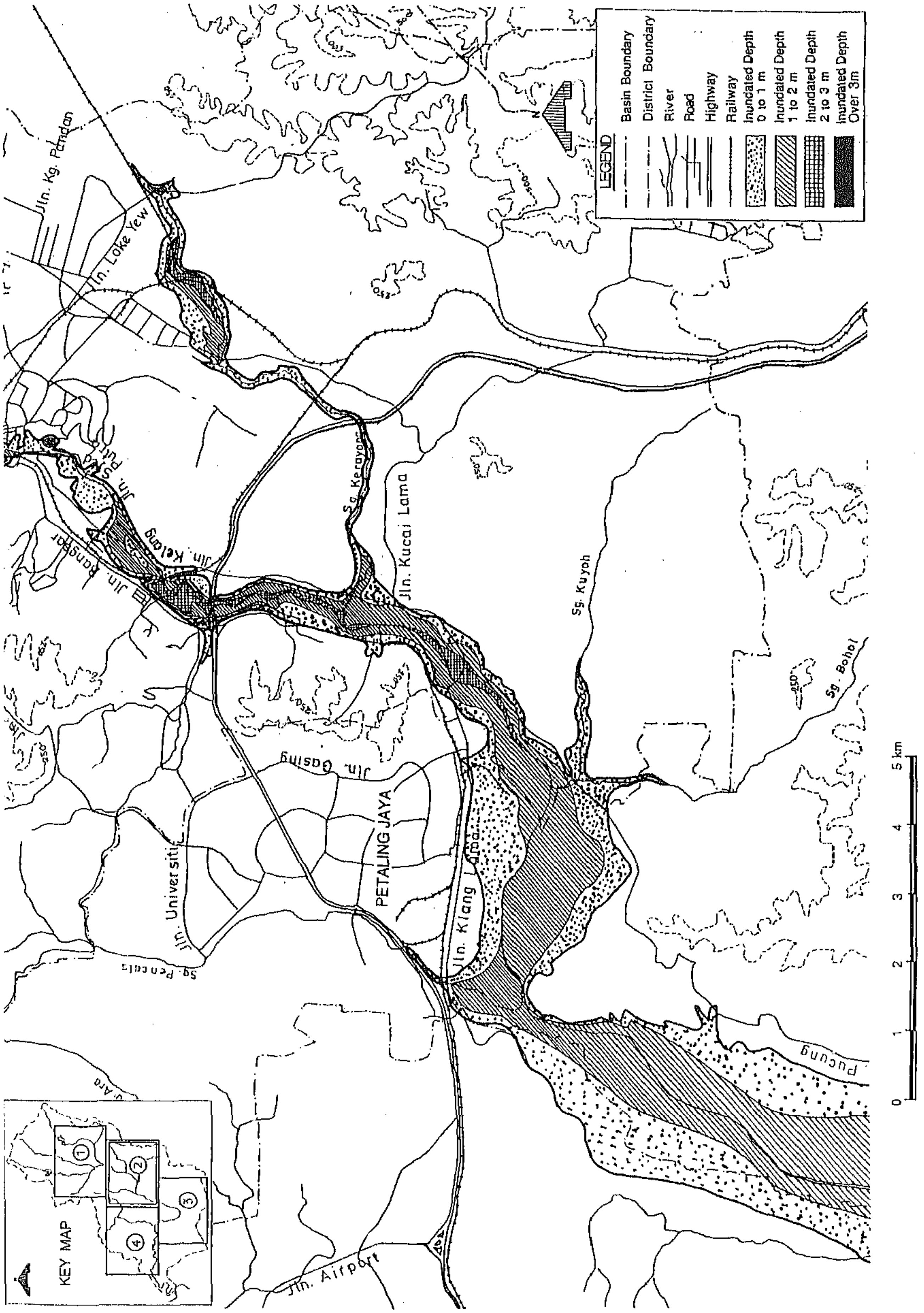

FIG. G-2	INUNDATED DEPTH MAP IN JANUARY 4 & 5, 1971 FLOODS (2/4)

THE STUDY ON THE FLOOD MITIGATION OF THE KLANG RIVER BASIN

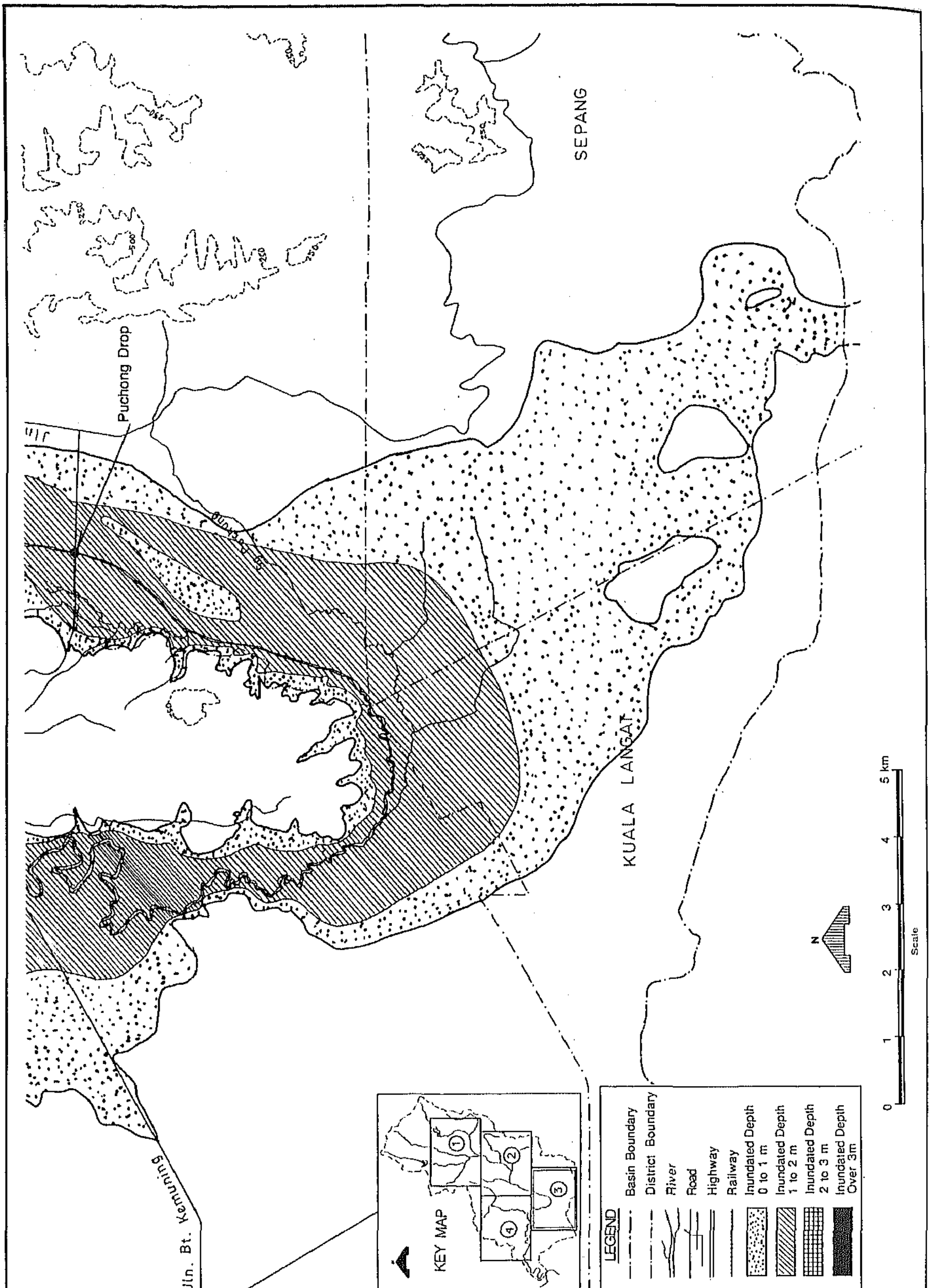

FIG. G-2 **INUNDATED DEPTH MAP IN JANUARY 4 & 5, 1971 FLOODS (3/4)**

THE STUDY ON THE FLOOD MITIGATION OF THE KLANG RIVER BASIN

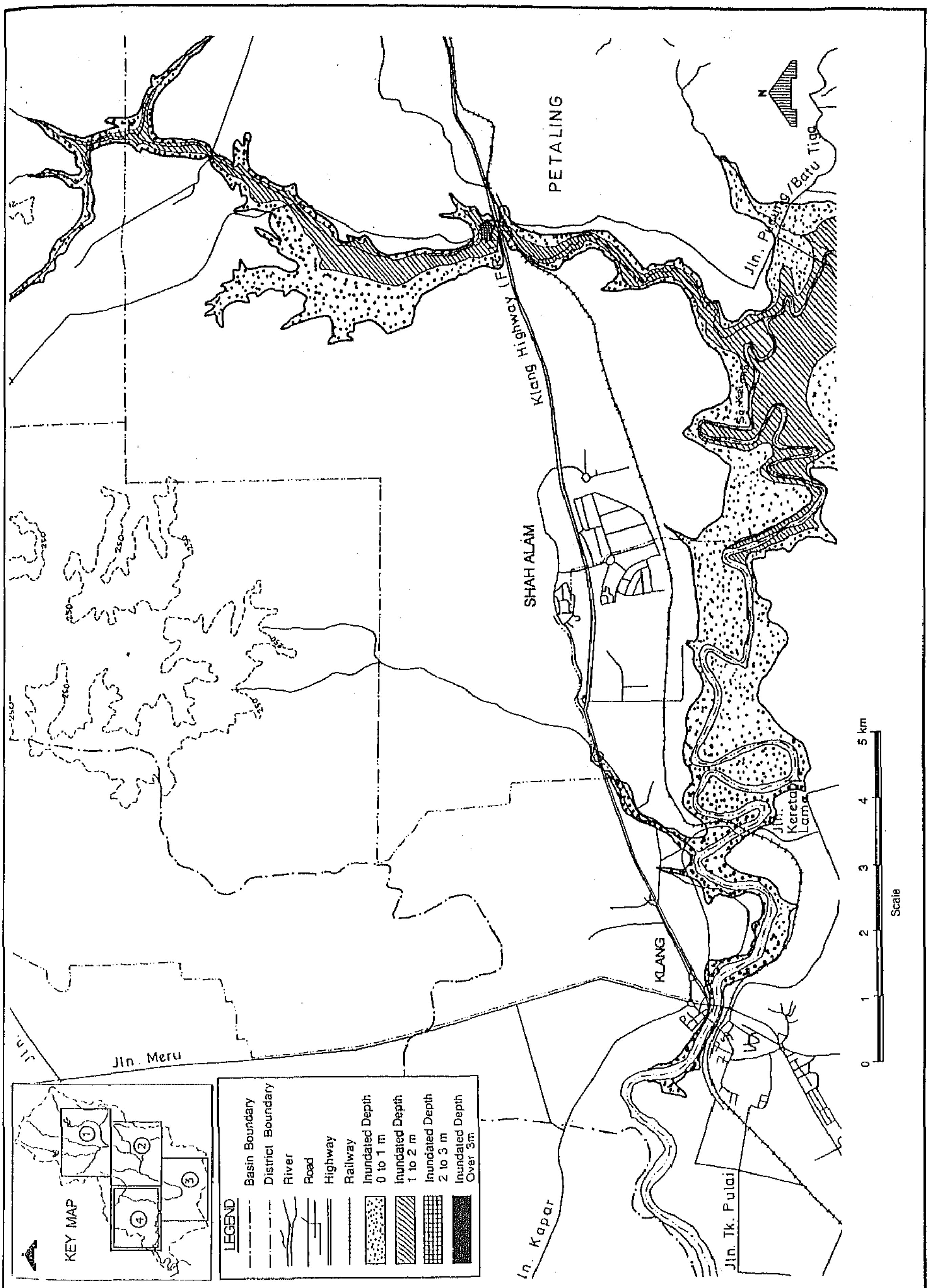

FIG. G-2 **INUNDATED DEPTH MAP IN JANUARY 4 & 5, 1971 FLOODS (4/4)**

THE STUDY ON THE FLOOD MITIGATION OF THE KLANG RIVER BASIN

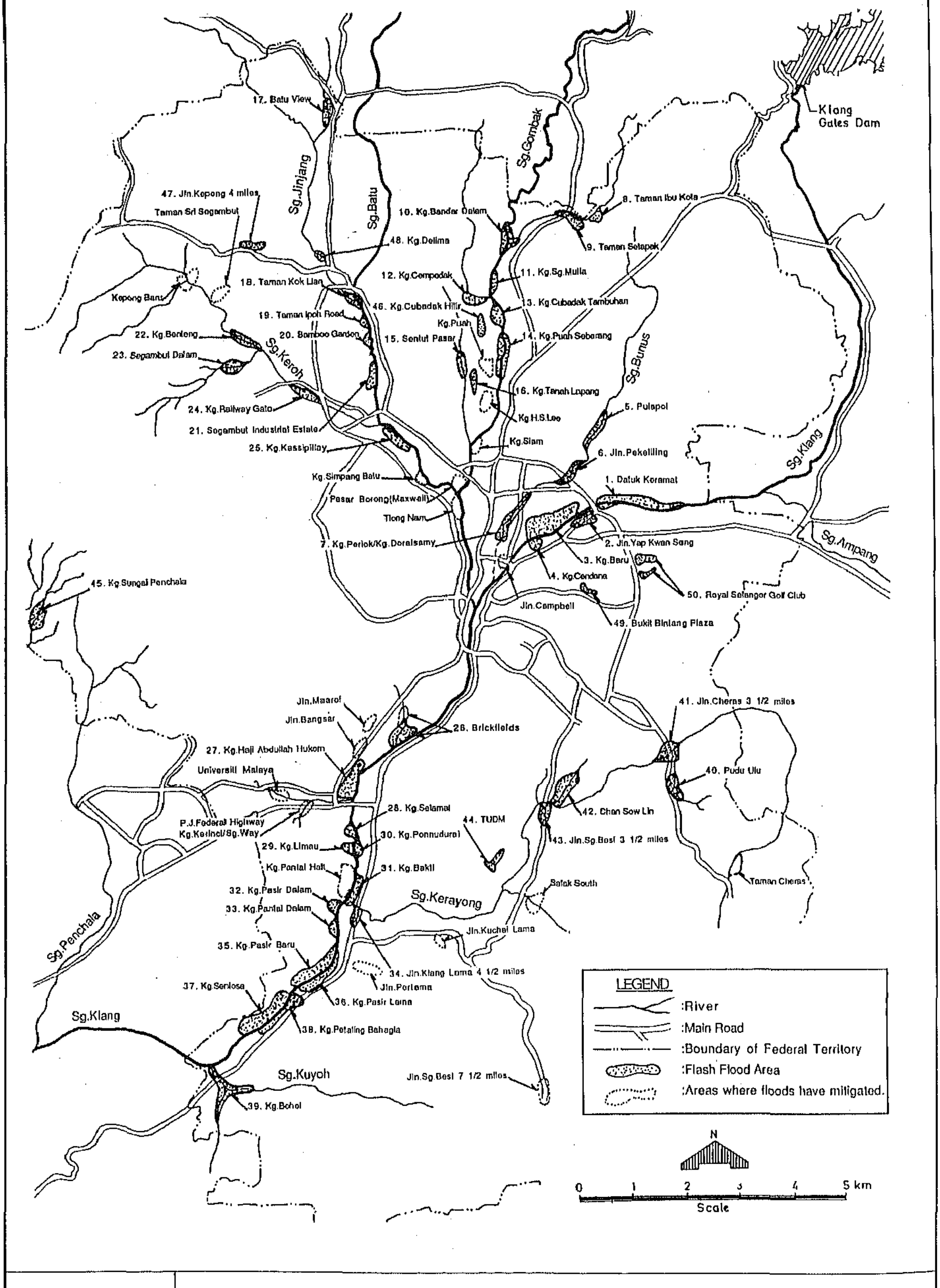

FIG. G-3 LOCATION OF FLASH FLOOD AREAS IN FEDERAL TERRITORY

THE STUDY ON THE FLOOD MITIGATION OF THE KLANG RIVER BASIN

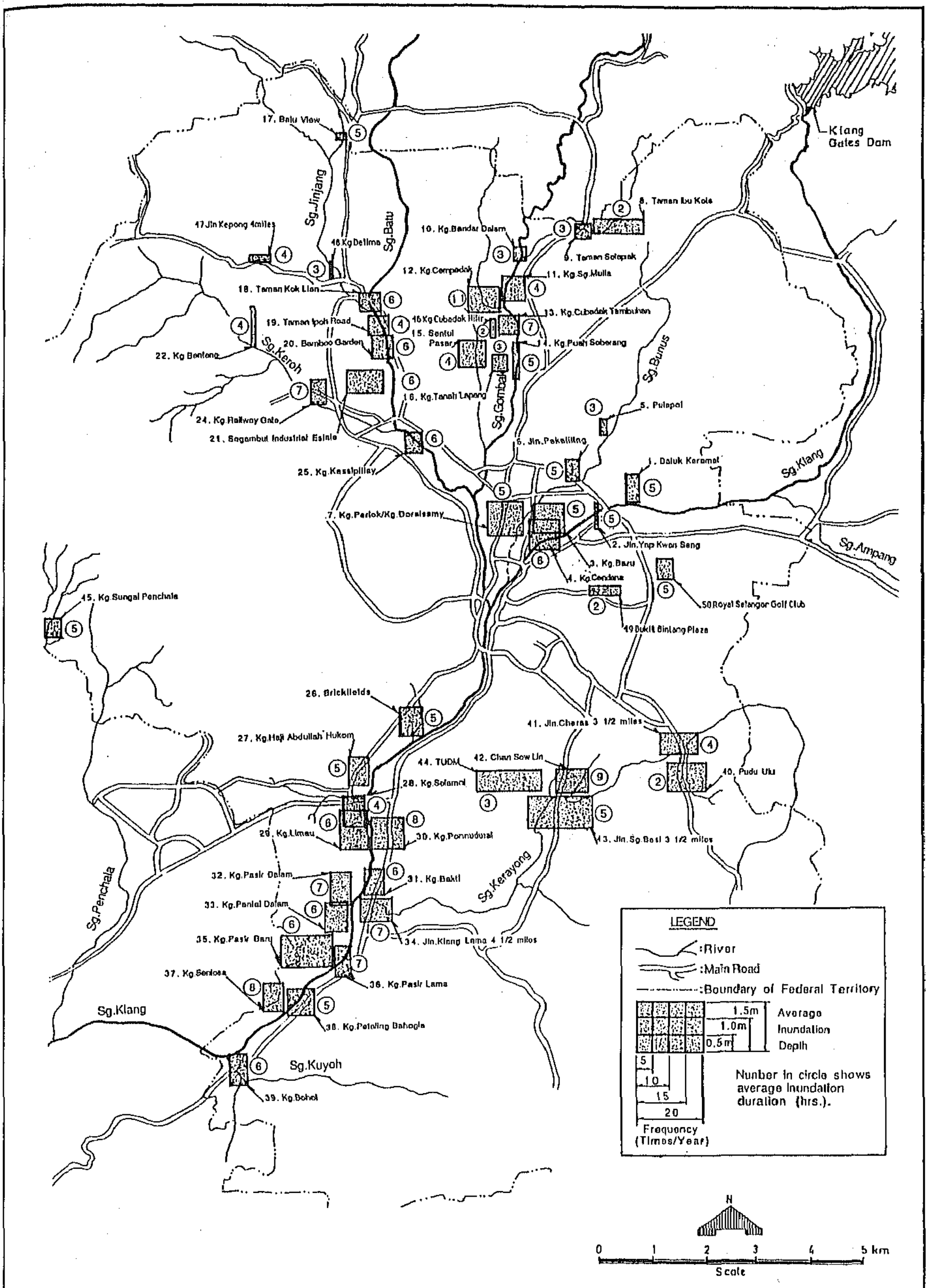

FIG. G-4	AVERAGE INUNDATION DEPTH, DURATION AND FREQUENCY OF FLASH FLOODS IN FEDERAL TERRITORY

THE STUDY ON THE FLOOD MITIGATION OF THE KLANG RIVER BASIN

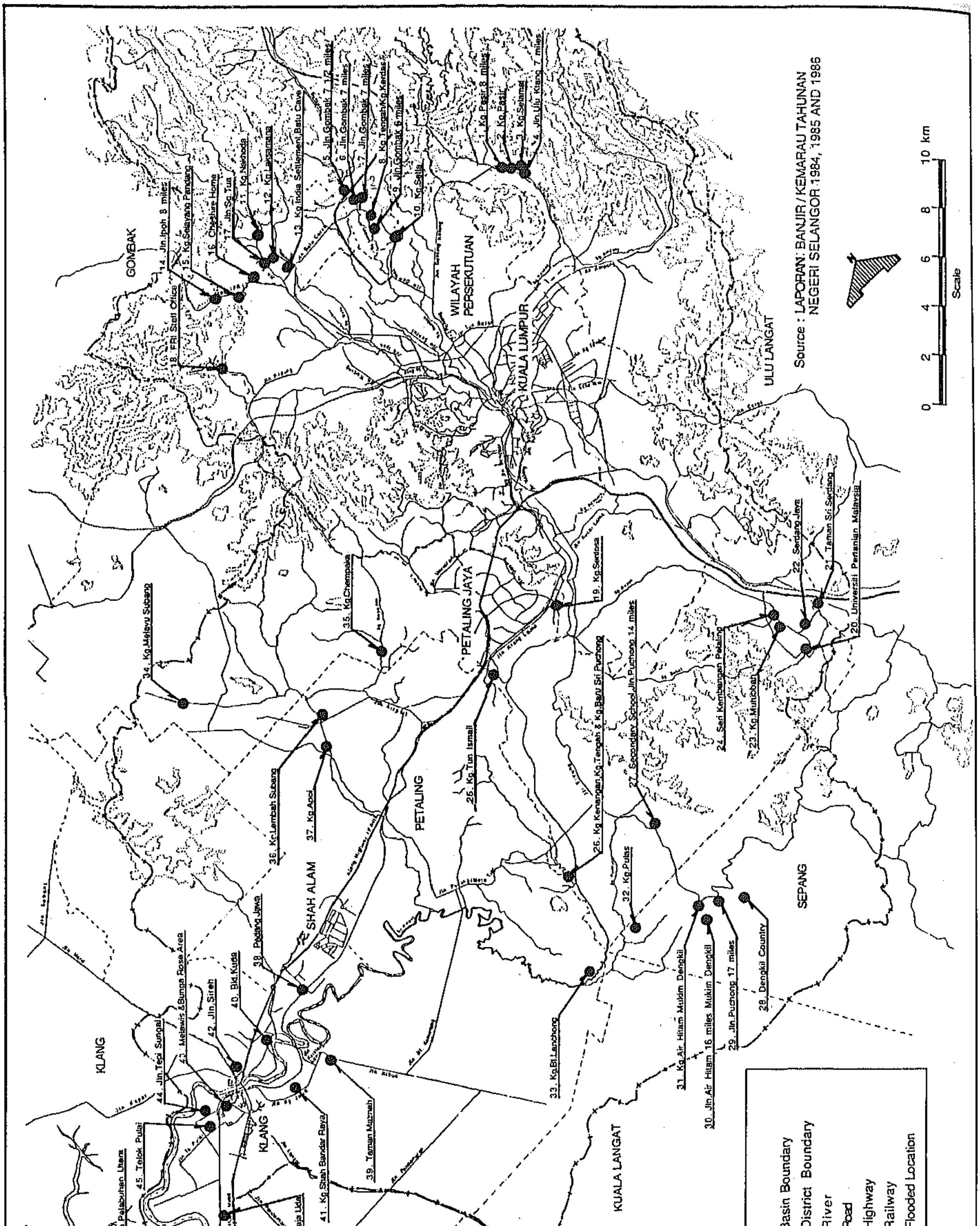

FIG. G-5 **LOCATION OF FLOODED AREAS IN SELANGOR STATE BETWEEN 1984 TO 1986**

THE STUDY ON THE FLOOD MITIGATION OF THE KLANG RIVER BASIN

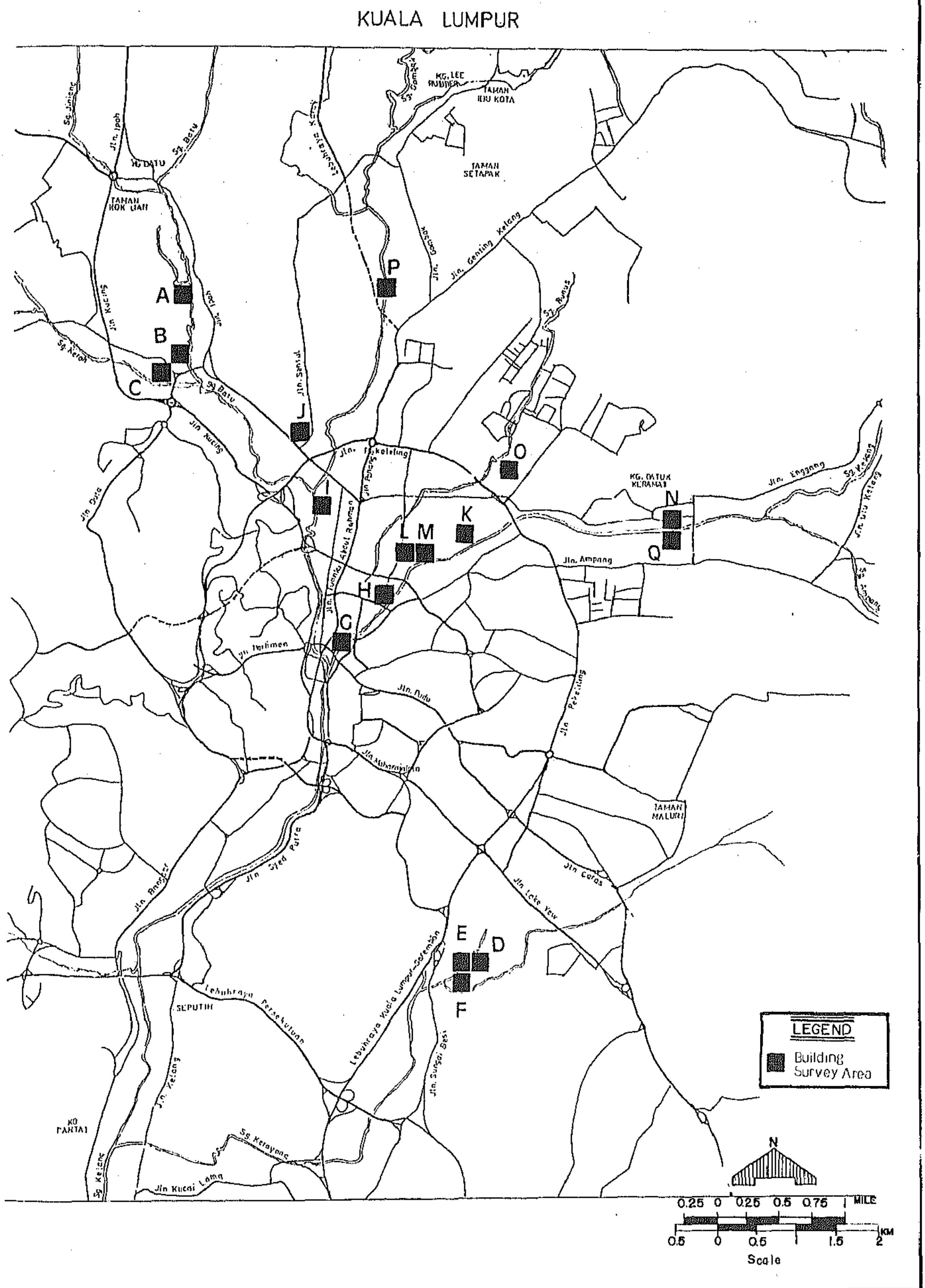

FIG. G-6	LOCATION MAP OF BUILDING SURVEY AREAS

THE STUDY ON THE FLOOD MITIGATION OF THE KLANG RIVER BASIN

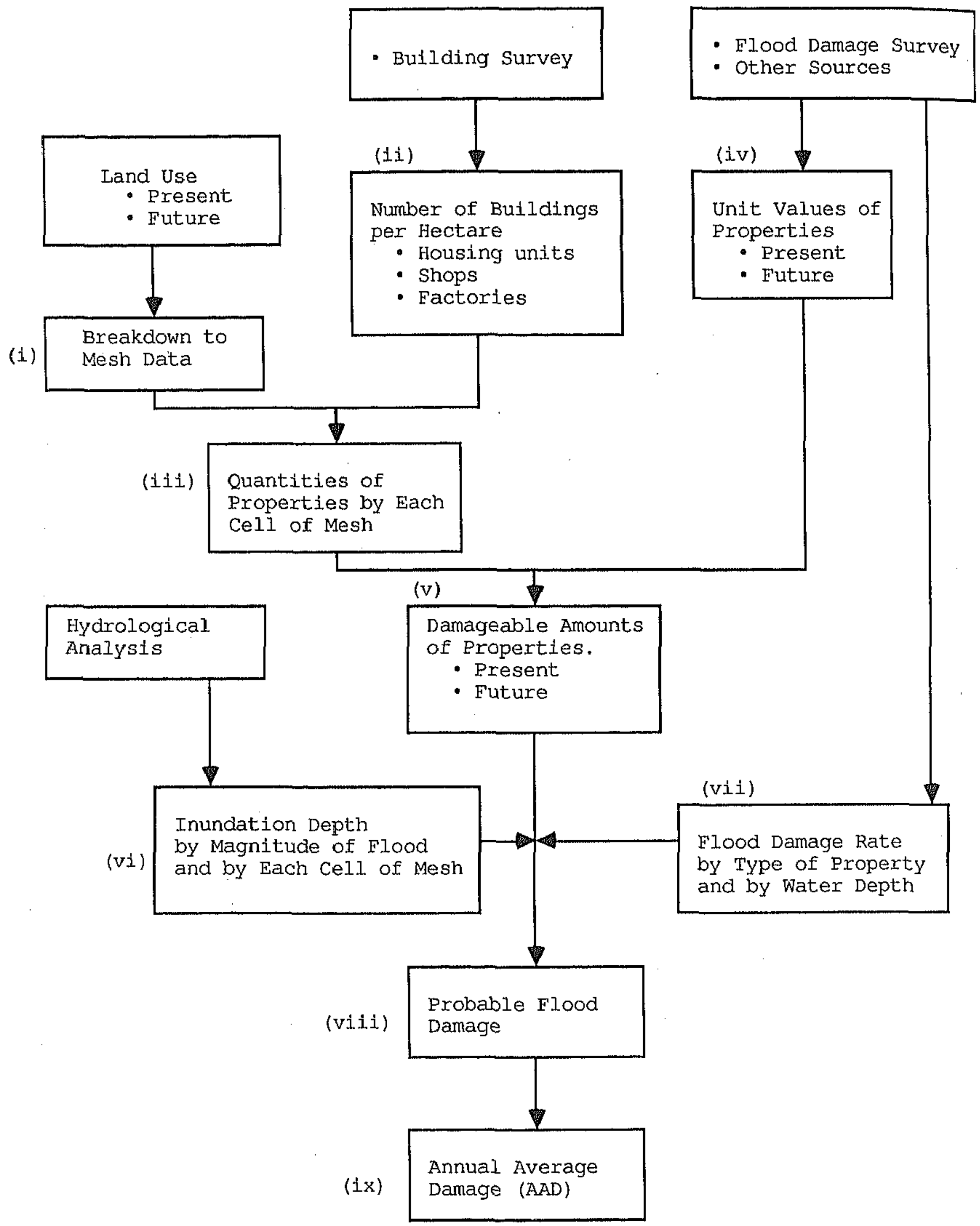

FIG. G-7 FLOW CHART FOR FLOOD DAMAGE ESTIMATE

THE STUDY ON THE FLOOD MITIGATION OF THE KLANG RIVER BASIN

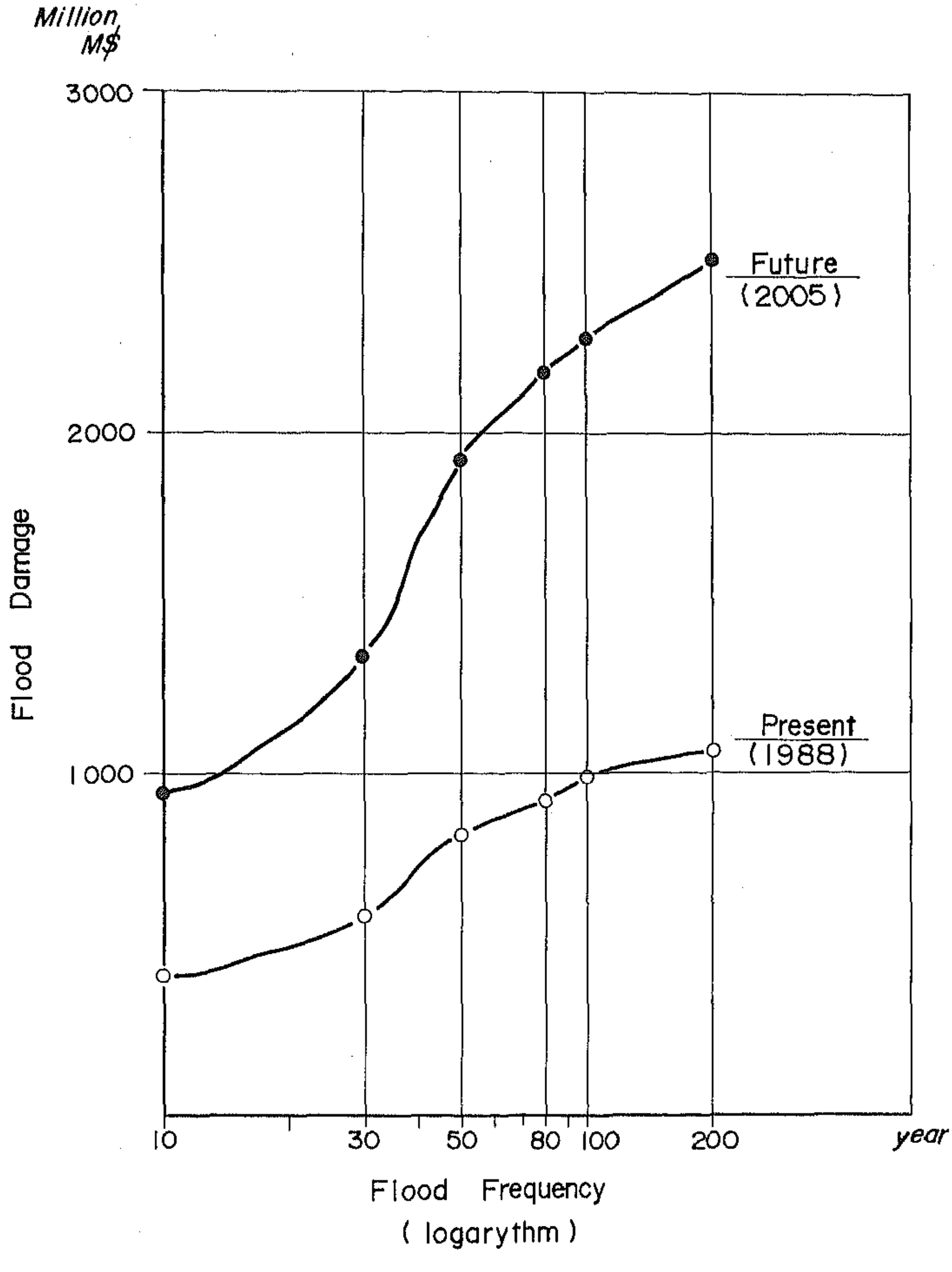

FIG. G-8	RELATION BETWEEN THE FLOOD FREQUENCY AND FLOOD DAMAGE POTENTIAL

THE STUDY ON THE FLOOD MITIGATION OF THE KLANG RIVER BASIN

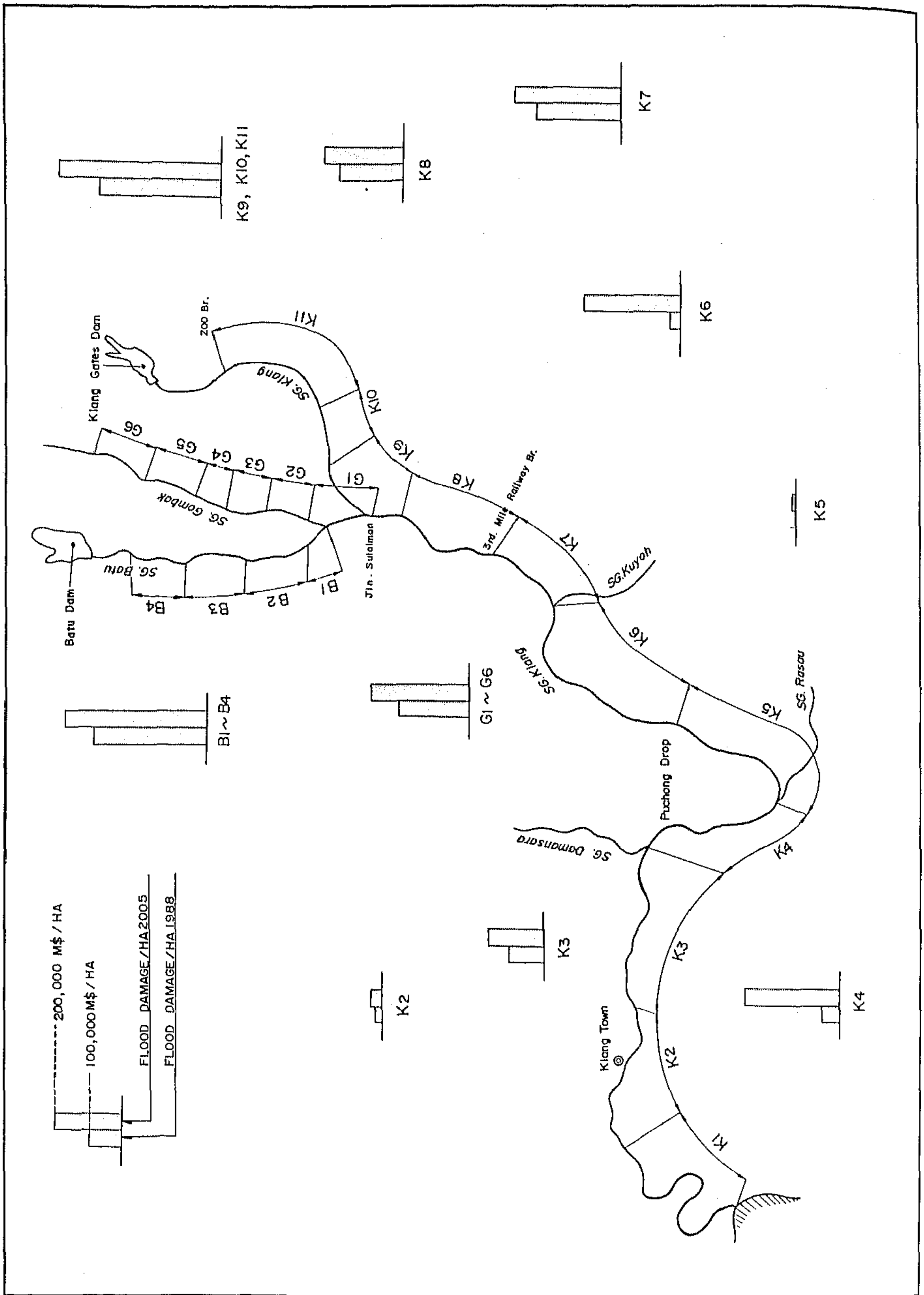

FIG. G-9 **FLOOD DAMAGE POTENTIAL PER HECTARE (100-YEAR RETURN PERIOD)**