the excess flood water of the Kuranji. This scheme is shown in Fig. J-6 and the construction cost is estimated as shown in Table J-5. The result of cost estimate shows that the cost of the diversion measure would be higher than that of the existing channel improvement measure. Therefore this measure is not recommendable.

(5) Existing channel improvement

The other conceivable flood control method is improvement of the existing channel which is the principal flood control measure in the lower reaches. No other measure is to be found in the lower reaches of the objective three rivers. Therefore this method is recommended.

3.2 Alternative Schemes

With regard to river stretches subject to channel improvement of the comprehensive plan, the upstream end of channel improvement is determined in consideration of the results of the fluvial geomorphological study, i.e. the new railway bridge site for the Arau river where the knick point exists, Gunung Nago weir site for the Kuranji river and Koto Tuo weir site for the Air Dingin river. The determined river stretches are as follows :

Name of River	Length (km)	Stretch
1. Arau river	10.6	rivermouth - new railway bridge
2. Jirak river	4.6	confluence to mainstream - new railway bridge
3. Flood relief channel	6.7	whole stretch
4. Kuranji river	13.5	rivermouth - Gunung Nago weir
5. Balimbing river	9.7	confluence to mainstream - 2 km upstream of Lolong Kanan bridge
6. Laras river	4.2	confluence to Balimbing - Kp. Air Pacah
7. Air Dingin river	6.1	rivermouth - Koto Tuo weir

Locations of these stretches are shown in Fig. J-7.

Considering the conditions of the existing channel, channel improvement to increase the carrying capacity is required by means of construction or heightening of dike, excavation of channel and their combination. According to the results of the fluvial geomorphological study, the fluvial action of the rivers is vivid in the stretch between Gunung Nago weir and Kalawi bridge of the Kuranji river and in the middle reaches of the Air Dingin river. The shifting of river course in the said stretches is frequent. Therefore no diking system is adopted for the channel improvement plan in those stretches. The retarding basin in the Laras river basin is considered as one of the alternative schemes. For the drainage in urban area, the outlet structures of drain are considered in the channel improvement. Pumping stations are considered at the outlet of drain in the low-lying area. The conceivable alternative schemes thus set up are as follows (refer to Fig. J-8) :

3.2.1 Arau River

(1) Scheme A-1

a. The middle Arau river (between new railway bridge and Lubuk Begalung weir): The existing channel will not be improved by diking system because the existing channel has sufficient carrying capacity, but bank protection will be required in some reaches.

b. The lower Arau river (between Lubuk Begalung weir and its river mouth): The channel will be subjected to minor improvement to normalize the existing capacity, because houses exist densely on the both banks.

c. The flood relief channel : The channel will be improved as a main floodway for the whole stretch to increase their carrying capacity. For the stretch between Lubuk Begalung weir and the railway bridge, the channel will be widened to the right bank. For the reaches downstream from the railway bridge, the channel will be widened to the both banks. Bank protection will be required over the whole stretch.

d. The Jirak river: The channel will be improved by diking system. Bank protection will be required in some reaches.

e. Lubuk Begalung weir: The Lubuk Begalung weir is to be reconstructed in both the mainstream weir and headwork of the relief channel.

f. Drainage facilities: Major drainage channels will be improved with outlet culvert. Pumping stations will be constructed at the outlets of the Kali Mati, Ujung Gurun and Purus drains.

(2) Scheme A-2

a. The middle Arau river: The same as Scheme A-1.

b. The lower Arau river: The channel will be improved as a main floodway. For the stretch between Lubuk Begalung weir and confluence of the Jirak river, the channel will be improved by excavation of channel to increase its carrying capacity. For the reaches downstream from the confluence, the channel will be widened mainly on the right banks and continuous dike with bank protection will be constructed on the both banks.

c. The flood relief channel: The channel will be subjected to minor improvement such as repair of dike, bank protection and drop structure.

d. The Jirak river: The same as Scheme A-1.

e. Lubuk Begalung weir: The same as Scheme A-1.

f. Drainage facilities: The same as Scheme A-1.

(3) Scheme A-3

a. The middle Arau river: The same as Scheme A-1.

b. The lower Arau river: The channel will be improved on the intermediate scale between Scheme A-1 and A-2.

c. The flood relief channel: The channel will be improved on the intermediate scale between Scheme A-1 and A-2.

d. The Jirak river: The same as Scheme A-1.

e. Lubuk Begalung weir: The same as Scheme A-1.

f. Drainage facilities: The same as Scheme A-1.

3.2.2 Kuranji river

(1) Scheme K-1

a. The middle Kuranji river (between Gunung Nago weir and water supply intake): The channel in the stretch between water supply intake and Kalawi bridge will be improved by diking system, but dike is not necessary in the upstream reaches from Kalawi bridge, because the existing channel has sufficient carrying capacity. Bank protection will be required in some reaches.

b. The lower Kuranji river (between water supply intake and its river mouth): The channel will be improved by compound cross-section with continuous dike. Dredging of low-water channel is to be required in this stretch. Bank protection will also be necessary.

c. The Balimbing and Laras rivers: The channel will be improved by compound cross-section with continuous dike.

d. Drainage facilities: Major drainage channels will be improved with outlet culvert. Pumping stations will be constructed at the outlets of the Ulak Karang and Baung drains.

(2) Scheme K-2

a. The middle Kuranji river: The same as Scheme K-1.

b. Laras retarding basin: A new retarding basin on the right side of the Laras river will be constructed to reduce flood discharge.

c. The lower Kuranji river: The same as Scheme K-1, but the proposed channel in the reaches downstream from the confluence of the Balimbing river will be smaller than that of Scheme K-1 owing to the effect of the retarding basin.

d. The Balimbing and Laras rivers: The same as Scheme K-1, but the proposed channel in the downstream reaches will be smaller than that of Scheme K-1.

e. Drainage facilities: The same as Scheme K-1.

3.2.3 Air Dingin River

(1) Scheme D-1

a. For the whole stretch, the existing channel will be improved by channel excavation and dike construction, but dike is not necessary in the middle reaches since the existing channel has sufficient carrying capacity in some reaches. Bank protection will be required in some reaches.

b. The existing sand spit at the river mouth will be left as it is. The back water effects due to obstruction by the sand spit will be treated by hightening dike.

c. Drainage facilities: Major drainage channels will be improved with outlet culvert. Pumping station will be constructed at the outlet of the Penjalinan drain.

(2) Scheme D-2

a. The channel improvement is the same as Scheme D-1.

b. The sand spit at the river mouth will be removed and the training dike will be constructed to maintain the river mouth.

c. Drainage facilities: The same as Scheme D-1.

4. Design Flood for Alternative Schemes

At present, levels of 20-year to 50-year flood are actually adopted to flood control project in Indonesia as shown in Table J-6. In consideration of the above circumstances, the present situation and future development plan of Padang city, levels of design flood for the comprehensive flood control and drainage plan of the objective rivers are adopted as follows :

River	Return period
a. Arau river, flood relief channel, Kuranji and Air Dingin rivers:	50-year
b. Tributaries such as Jirak, Balimbing and Laras rivers:	25-year
c. Drainage facilities:	10-year

Based on the results of flood runoff analysis described in APPENDIX F, the design flood discharges for each alternative scheme are determined as shown in Fig. J-9.

5. Project Works for Alternative Schemes

5.1 Design Criteria

The following are the criteria applied to design of river channel improvement.

a. A series of the topographic maps of 1/5,000 scale and the aero-photos of 1/5,000 scale are used for design of channel and dike alignments.

b. The river channel cross-sections surveyed by DPU and the Study Team are used for design of river channel.

c. With regard to Manning's coefficient of roughness "n" for design, 0.026 to 0.04 for low-water channel and 0.04 to 0.07 for high-water channel are adopted considering the channel conditions.

d. The following are adopted for design of dike cross-section as standard values.

Design discharge (m^3/s)	Free board (m)	Crest width (m)	Side slope	
			w/o bank protection	w/bank protection
less than 200	0.6	3.0	1 : 2	1 : 1.5
200 to 500	0.8	3.0	1 : 2	1 : 1.5
500 to 2,000	1.0	4.0	1 : 2	1 : 1.5

Fig. J-10 shows the standard dike cross-section.

5.2 Planned River Channel Improvement and Drainage Facilities

Based on the design criteria, the river channel and drainage facilities are designed considering the existing conditions. The outline of the planned river channel and drainage facilities are as follows :

a. Alignment of channel: Since the existing river channel meanders in several locations, it is planned to moderate excessive meandering by means of cutoff to secure the stability of the channel.

b. Profile of channel: The longitudinal profiles of river channel are planned based on the existing profile of river bed and ground slope on river banks. The design high water levels are determined on the basis of the water levels calculated by non-uniform flow method.

c. Cross-section: The compound cross-section of channel consisting of low water and high-water channels is adopted in consideration of large seasonal fluctuation of river water level. For the flood relief channel, the single cross-section with banquettes is adopted considering the existing channel conditions.

d. Urban drainage: The drainage channel in urban area is planned to be improved with regard to 16 major drainage channels. Outlet structures are planned to be constructed at the terminal point of the channel. Pumping stations are planned to be constructed at the outlet of drain in the low-lying area considering the drainage conditions.

5.3 Required Construction Works, Land Acquisition and Compensation

The required construction works, land acquisition and compensation are estimated for each alternative scheme. With regard to land acquisition, the lands on the planned low-water channel, high-water channel and dike sites are planned to be acquired. The required works, land acquisition and compensation are shown in Table J-7.

6. Cost Estimate

6.1 Unit Construction Cost

The unit construction costs are estimated by the unit cost basis which is supported by unit prices of labor, materials, equipment and cost for land acquisition and house compensation. The unit prices of labor, construction materials and unit cost for land acquisition and house compensation for the price level at the beginning of June 1983 are estimated based on the data prepared by DPU West Sumatra Province and the data collected from the other agencies.

6.2 Direct Construction Cost

The Direct construction cost is composed of cost for civil works and costs required for land acquisition and compensation. The cost required for civil works is calculated by multiplying work quantity by unit cost. The estimated construction cost is shown in Table J-8. They are summarized below.

River	Construction cost (Rp.10)		
1. Arau river	Scheme A-1 25,141	Scheme A-2 25,266	Scheme A-3 24,033
2. Kuranji river	Scheme K-1 16,404	Scheme K-2 15,955	
3. Air Dingin river	Scheme D-1 5,579	Scheme D-2 6,278	

7. Comparison of Alternative Schemes

Adopting design flood of 50 year for mainstream, 25 year for tributary and 10 year for drainage channel, seven alternative schemes are studied. The schemes comprised three alternatives for the Arau river, two alternatives for the Kuranji river and two alternatives for the Air Dingin river. The most optimum scheme for comprehensive plan is selected on the basis of the comparative study.

The comparative study on technical and least cost basis makes it clear that (1) for the Arau river, Scheme A-3 indicates lower cost than the other Schemes A-1 and A-2, (2) for the Kuranji river, Scheme K-2 indicates lower cost than Scheme K-1, although the cost difference between the two is a little, and (3) for the Air Dingin river, Scheme D-2 indicates higher cost than Scheme D-1, furthermore Schemes D-2 will be more expensive because much maintenance cost is to be required to maintain the river mouth in addition to the above cost.

Therefore, it is considered reasonable to select Schemes A-3, K-2 and D-1 for the comprehensive flood control and drainage plan.

8. Proposed Comprehensive Plan

8.1 Design Flood Discharge

The design flood discharge distribution for the proposed comprehensive plan is shown in Fig. J-11.

8.2 Proposed Plan

The proposed river channel alignments, longitudinal profiles and cross-sections are shown in Figs. J-12 to J-18. The outline of the proposed comprehensive plan is as follows :

(1) Arau river

The channel improvement plan includes the mainstream of the Arau, the flood relief channel and the Jirak river. The flood relief channel is to be improved as main floodway, while the lower reaches of the mainstream is subject to minor improvement, because the much widening of the channel in this stretch is difficult. The Lubuk Begalung weir is to be reconstructed on both the mainstream weir and headwork of the relief channel as shown in Fig. J-19. Bank protection is to be executed over the whole stretch of the relief channel and some reaches in the other stretches.

(2) Kuranji river

The channel improvement plan includes the mainstream of the Kuranji, Balimbing and Laras rivers. The channel is to be improved by channel excavation and construction of dike in most stretches except the mainstream stretch between Kalawi bridge and Gunung Nago weir. Bank protection is to be executed in some reaches. Laras retarding basin on the right side of the Laras river is to be constructed to reduce the flood discharge.

(3) Air Dingin river

The channel is to be improved mainly by channel excavation for the whole stretch. But dike is to be constructed in the lower reaches. The dike is not to be constructed in the middle reaches since the existing channel has sufficient carrying capacity. Bank protection is to be executed in some reaches. The existing sand spit at the river mouth is to be left.

(4) Urban drainage

The major drainage channels in the urban area are to be improved. At the terminal point of the channel, the outlet structure is to be constructed. Pumping station is also to be constructed at the outlet of drain in the low-lying area. The length of drainage channel to be improved and the proposed capacity of pump are shown in Table J-9.

8.3 Construction Cost

Construction costs are composed of those required for civil works, land acquisition and compensation, contingency and engineering and administration. Cost required for civil works is counted by multiplying work quantity by unit cost. Engineering and administration cost is assumed at 15 % of the sum of the above-mentioned costs. Cost for contingency is assumed at 10 % of the sum of the above costs. The construction cost for the comprehensive plan is estimated at Rp.69,662 $\times 10^6$ as shown in Table J-10.

9. Economic Evaluation

9.1 Economic Cost

Economic construction cost for the comprehensive plan is estimated taking into consideration deduction of tax and contractor's profit from Rupiah currency portion of the construction cost. These tax and contractor's profit to be deducted are assumed to be 4 % and 10 % respectively. The land acquisition and compensation costs are evaluated as a part of construction cost. The economic construction cost for the comprehensive plan is estimated at Rp.67,056 × 10^6 as shown in Table J-11.

9.2 Benefits

Benefits are the expected reduction of flood damages to private properties, farm crops, public facilities and so on, and the expected development effect for the land which has not been utilized during the wet season.

For evaluation of the comprehensive plan, the benefits are estimated under the two conditions, i.e., the present condition provided after completion of the project assuming the execution works of 7 year and the future development condition based on the Master Plan of Padang city.

(1) Benefit under present condition

Based on the estimated flood damages under the present condition described in APPENDIX G, the expected reduction of flood damages by the implementation of the proposed comprehensive plan is estimated as shown below.

Cause of flood	Flood damages caused by flood of:			
	Mainstream	Tributary	Interior water area	Total
Reduction of average annual flood damages (Rp million/yr)	3,548	385	2,782	6,715

Even if the proposed comprehensive plan is implemented, the flood damages of Rp 137 million/yr in the interior water area will not be eliminated, because the improvement of secondary and tertiary drainage channels is not included in the plan as described in APPENDIX I. Therefore, in the present study, the reduction of damages in the interior water area of Rp 2,782 million/yr are estimated by subtracting the damages of Rp 137 million/yr from the amount of flood damages under the present conditions. The expected reduction of the flood damages mentioned above will be given as the most part of flood control benefits.

In addition to the above benefit, by the implementation of the project, the land which has not been utilized due to flooding during the wet season will be used for residential quarter. Such development effects by the project may be counted as enhancement benefit. This enhancement benefits are estimated on the basis of informations obtained from the City Planning Office in Padang city as tabulated below.

River	Arau main stream	Flood relief channel	Jirak river	Kuranji main stream	Balimbing, Laras rivers	Air Dingin river
Area to be enhanced (ha)	18.7	15.8	15.8	52.3	18.5	30.9
Rental value to be increased due to enhancement (Rp/m^2)	4,107	4,114	4,114	4,111	4,124	3,158

The estimated enhancement benefits arising from flood control of mainstreams and tributaries are Rp 1,258 million/yr and Rp 310 million/yr respectively. The enhancement benefit in the interior water area is negligible small so that the benefit is not counted in this study. Therefore, the estimated total benefits under the present conditions are Rp 8,283 million/yr.

(2) Benefit under future development condition

For estimation of the damages under the future development conditions, a number of houses in inundation area should be assumed first. According to Master Plan of Padang City 1983 - 2003, developing area is divided into two categories, i.e. (1) the corridor area along the Arau river and the flood relief channel up to Indarung as a top of triangle area, and (2) the sattelite area along the Kuranji and Air Dingin rivers up to the footline of mountains in hinterland. The average housing densities are estimated at 19 house/ha in the corridor area and at 14 house/ha in the sattelite area.

Based on the above mentioned assumption, and in consideration of a toll road plan, Master Plan, past tendency of population growth during last 10 years as mentioned in APPENDIX C, and densities of houses at the present time as mentioned in APPENDIX G, the number of houses to be located in the inundation area are assumed as shown in Table J-12 for respective return periods. In this case, it is also considered that there would be no any remaining agricultural land along the Arau river in the inundated area according to the Master Plan.

From this result, flood damages under the future development conditions for respective return periods in case of without-project are estimated as shown in Table J-13.

On the basis of these damages, the annual average flood damages are estimated. If the proposed comprehensive plan is implemented under the future development conditions, the amount of damages of Rp 6,329 million/yr for main stream and Rp 915 million/yr for tributaries among them will be eliminated. That is, they will be given as the annual average economic benefit in case of with-project of the proposed comprehensive plan.

In the interior water area, even if the proposed comprehensive plan is implemented, the amount of damages of Rp 72 million/yr will still remain due to the same reason in case of the present conditions. In the same manner under the present conditions, the amount of annual average flood damages to be eliminated is estimated at Rp 4,401 million/yr by subtracting the said remaining damages.

The amount of average annual economic benefit is thus estimated at Rp 11,645 million/yr under the future development conditions in case of with-project of the proposed comprehensive plan.

9.3 Internal Rate of Return

Based on the economic cost and the benefits mentioned above, internal rate of return for the comprehensive plan was calculated under the following assumptions.

a. The project life is assumed to be 50 years after completion of construction works.

b. Operation and maintenance cost is assumed to be 0.5 % annually of the economic construction cost.

c. Facilities made of metal such as pump and gate are to be replaced once in the period of the project life. Concrete lining of the drainage channel is also to be renewed once in the period of the project life. They are considered as replacement cost.

Table J-14 shows the economic cost and benefit flow for the proposed comprehensive plan based on the assumptions mentioned above.

Internal rate of return on the investment, which equalizes the present value of the outlays and return, is graphically calculated for the present and future development conditions. The results show that the project is expected to yield internal rate of return of 10.5 % for the present condition, and 14.7 % for the future development condition.

Table J-1 Construction Cost of Limau Manis Dam Scheme

Discription	Unit	Unit Cost Rp.	Quantity	Amount Rp. 10^6
I. With L. MANIS DAM scheme				
A. Main civil work				
1. Kuranji river				
Excavation	m^3	1,950	434,000	846
Embankment	m^3	1,890	100,000	189
Bank protection	m^2	22,600	33,400	755
Bridge	m^2	458,000	360	165
2. Balimbing, Laras river				
Excavation	m^3	1,950	346,000	675
Embankment	m^3	1,890	145,000	274
Bank protection	m^2	22,600	10,900	246
Bridge	m^2	458,000	438	201
3. Limau Manis Dam				
Diversion tunnel	m	2,400,000	320	768
Dam Fill up	m^3	12,800	1,757,000	22,490
Foundation Treatment	m	1,600,000	250	400
Spill way	m^3	110,000	20,700	2,277
Access road	m	220,000	11,000	2,420
4. Miscellaneous	L.S			3,172
Sub total				34,878
B. Compensation				
Residential area	m^2	5,000	25,000	125
Other area	m^2	1,500	659,000	989
House	nos	700,000	97	68
Sub total				1,182
C. Total				36,060
II. Without DAM scheme				
A. Main civil work				
1. Kuranji river				
Excavation	m^3	1,950	530,000	1,034
Embankment	m^3	1,890	100,000	189
Bank protection	m^2	22,600	33,400	755
Bridge	m^2	458,000	360	165
2. Balimbing, Laras river				
Excavation	m^3	1,950	346,000	675
Embankment	m^3	1,890	145,000	274
Bank protection	m^2	22,600	10,900	246
Bridge	m^2	458,000	438	201
3. Miscellaneous	L.S			354
Sub total				3,893
B. Compensation				
Residential area	m^2	5,000	25,000	125
Other area	m^2	1,500	659,000	989
House	nos	700,000	97	68
Sub total				1,182
C. Total				5,075

Table J- 2 Construction Cost of New Diversion Channel of the Arau River

Description	Unit	Unit Cost Rp.	Quantity	Amount Rp.10^6
I. New diversion channel				
A. Main civil work				
1. New diversion channel				
Excavation	m^3	1,950	606,000	1,182
Embankment	m^3	1,890	48,000	91
Bank protection	m^2	22,600	59,000	1,334
Bridge	m	1,830,000	771,000	1,411
Drop structure /1	m	7,720,000	195	1,505
2. Miscellaneous (10 %)	L.S	-		557
3. Sub-total				6,080
B. Compensation				
Residential area	m^2	5,000	30,000	150
Other area	m^2	1,500	208,000	312
House	nos	700,000	200	140
Sub-total				602
C. Total				6,682
II. Existing river channel				
A. Main civil work				
1. Arau river				
Excavation	m^3	1,950	932,000	1,818
Embankment	m^3	1,890	69,000	131
Bank protection	m^2	22,600	96,000	2,170
Bridge	m	1,830,000	132	242
Drop structure	m	5,520,000	120	663
2. Miscellaneous (10 %)	L.S	-		506
3. Sub-total				5,530
B. Compensation				
Residential area	m^2	5,000	98,300	492
Other area	m^2	1,500	141,000	212
House	nos	700,000	136	96
Sub-total				800
C. Total				6,330

Note : /1 Direct height = 4 m.

Table J-3 Construction Cost of Cutoff Channel of the Arau River

Description	Unit	Unit Cost Rp.	Quantity	Amount Rp.10^6
I. Cutoff channel				
A. Main civil work				
1. Cutoff channel				
Excavation (rock)	m^3	7,890	72,000	568
Timbering	m^3	100,000	6,250	625
Concrete lining	m^3	45,000	13,000	585
Drop structure	m	5,520,000	60	332
2. Miscellaneous	L.S			211
3. Sub-total				2,321
B. Compensation				
Residential area	m^2	5,000	-	-
Other area	m^2	1,500	3,000	5
House	nos	700,000	-	-
Sub-total				5
C. Total				2,326
II. Existing river channel				
A. Main civil work				
1. Arau river				
Excavation	m^3	1,950	212,000	414
Embankment	m^3	1,890	6,000	11
Bank protection	m^2	22,600	9,000	203
2. Miscellaneous (10 %)				62
3. Sub-total				690
B. Compensation				
Residential area	m^2	5,000	69,000	345
Other area	m^2	1,500	2,200	33
House	nos	700,000	25	18
Sub-total				396
C. Total				1,086

Table J-4 Construction Cost of New Diversion Channel of the Balimbing River

Description	Unit	Unit Cost Rp.	Quantity	Amount Rp.10^6
I. Balimbing new diversion channel				
A. Main civil work				
1. Balimbing diversion c.				
Excavation	m^3	1,950	265,000	517
Embankment	m^3	1,890	16,000	31
Bank protection	m^2	22,600	8,000	181
Bridge	m	1,830,000	220	403
Drop structure	m	5,520,000	48	265
2. Kuranji river				
Excavation	m^3	1,950	15,000	30
Embankment	m^3	1,890	21,000	40
Bank protection	m^2	22,600	3,000	68
3. Miscellaneous				155
4. Sub-total				1,690
B. Compensation				
Residential area	m^2	5,000	10,000	50
Other area	m^2	1,500	231,000	347
House	nos	700,000	75	53
Sub-total				450
C. Total				2,140
II. Existing river channel				
A. Main civil work				
1. Balimbing river				
Excavation	m^3	1,950	84,000	164
Embankment	m^3	1,890	33,000	62
2. Kuranji river				
Excavation	m^3	1,950	185,000	361
Dredging	m^3	4,200	48,000	202
Embankment	m^3	1,890	38,000	72
Bank protection	m^2	22,600	6,000	136
3. Miscellaneous				100
4. Sub-total				1,197
B. Compensation				
Residential area	m^2	5,000	1,000	5
Other area	m^2	1,500	272,000	408
House	nos	700,000	35	25
Sub-total				438
C. Total				1,535

Table J-5 Construction Cost of Diversion Channel of the Kuranji River

Description	Unit	Unit Cost Rp.	Quantity	Amount Rp.10^6
I. Kuranji diversion channel				
A. Main civil work				
1. Kuranji diversion				
Excavation	m^3	1,950	350,000	683
Embankment	m^3	1,890	25,000	47
Bank protection	m^2	22,600	21,000	475
Bridge	m	1,830,000	110,000	202
Drop structure	m	5,520,000	110,000	608
2. Flood relief channel				
Excavation	m^3	1,950	130,000	254
Embankment	m^3	1,890	35,000	66
Bank protection	m^2	22,600	17,000	384
Bridge	m	1,830,000	390	714
Drop structure	m	5,520,000	60	332
3. Miscellaneous	L.S			375
4. Sub-total				4,140
B. Compensation				
Residential area	m^2	5,000	46,000	230
Other area	m^2	1,500	215,000	323
House	nos	700,000	310	217
Sub-total				770
C. Total				4,910
II. Existing river channel				
A. Main civil work				
1. Kuranji and Balimbing rivers				
Excavation	m^3	1,950	572,000	1,115
Dredging	m^3	4,200	48,000	202
Embankment	m^3	1,890	100,000	189
Bank protection	m^2	22,600	9,000	204
2. Flood relief channel				
Excavation	m^3	1,950	96,000	187
Embankment	m^3	1,890	8,000	16
Bank protection	m^2	22,600	17,000	385
Bridge	m	1,830,000	55	101
Drop structure	m	5,520,000	40	262
3. Miscellaneous	L.S			221
4. Sub-total				2,882
B. Compensation				
Residential area	m^2	5,000	8,000	40
Other area	m^2	1,500	280,000	420
House	nos	700,000	50	35
Sub-total				495
C. Total				3,377

Table J-6 Design Discharge of Rivers in Indonesia

No.	Name of River	Province	Catchment Area (km^2)	Design Flood (m^3/s)	Return Period (yr)
1.	Sungai Cimanuk	West Jawa	3,006	1,440	25
2.	Kali Serang	Central Jawa	937	900	25
3.	Sungai Citanduy	West Jawa	3,680	1,900	25
4.	Sungai Ular	North Sumatra	1,080	800	30
5.	Kali Pemali	Central Jawa	1,228	1,300	25
6.	Sungai Cipanas	West Jawa	220	385	25
7.	Bengawan Solo	Central/East Jawa	3,320	2,000	40
8.	Kali Madium	East Jawa	2,400	2,300	40
9.	Sungai Wampu	North Sumatra	3,840	1,320	20
10.	Sungai Arakundo	Aceh	5,495	2,100	50
11.	Sungai Kring Aceh	Aceh	1,775	1,960	50
12.	Kali Brantas	East Jawa	10,000	1,500	50
13.	Sungai Bah Bolon	North Sumatra	2,776	1,200	20
14.	Sungai Walanae	South Sulawesi	3,190	2,900	20
15.	Sungai Bila	South Sulawesi	1,368	1,900	20
16.	Sungai Jeneberang	South Sulawesi	729	3,700	50

Data Source : Directorate of Rivers, DGWRD.

Table J- 7 Required Construction Works, Land Acquisition and Compensation for Alternative Schemes

Item	Unit	Arau and Flood R.C.			Kuranji		Air Dingin	
		A - 1	A - 2	A - 3	K - 1	K - 2	D - 1	D - 2
1. Civil Work								
Excavation	10^3m^3	1,112	465	882	925	876	327	308
Transportation	"	1,035	483	932	975	924	362	354
Dredging	"	47	18	50	50	48	35	46
Embankment	"	85	75	79	263	245	66	66
Bank protection								
Stone masonry	10^3m^2	75	111	98	19	19	4	4
Gabion	"	4	3	4	14	14	5	5
Groin	"	-	-	-	11	11	-	-
Drainage culvert								
I	nos	14	14	14	17	17	2	2
II	"	7	7	7	5	5	1	1
III	"	1	1	1	6	6	2	2
Bridge	place	3	3	3	2	2	-	-
Pier protection	m^3	0.5	0.5	0.5	0.6	0.6	1.6	1.6
Drop structure	place	3	3	3	-	-	-	-
Groundsill works	"	1	1	1	1	1	1	1
Diversion weir	"	2	2	2	-	-	-	-
Syphon	"	2	2	2	-	-	-	-
Inspection road	Km	23.3	23.3	23.3	24.8	24.8	8.5	8.5
Disposal of excess soil	10^3m^3	1,031	383	846	785	641	285	266
Training dike	L.s	-	-	-	-	-	1	1
2. Land and House								
Land	10^3m^2	275	242	239	872	684	199	198
House	nos	147	210	136	130	97	20	20

Table J-8 Construction Cost for Alternative Schemes

Item	Construction Cost (Rp.10^6)		
	Scheme A-1	Scheme A-2	Scheme A-3
Arau River	25,141	25,266	24,033
I. River Channel Improvement	12,967	13,088	11,890
Arau	3,757	3,792	3,445
Jirak	830	838	761
Flood relief channel	8,380	8,458	7,684
II. Drainage Channel Improvement	10,698	10,698	10,698
Pumping station	5,800	5,800	5,800
Drainage channel	4,898	4,898	4,898
III. Land acquisition and house compensation	1,476	1,480	1,445
River	721	725	690
Drainage	755	755	755
	Scheme K-1	Scheme K-2	
Kuranji River	16,404	15,955	
I. River channel Improvement	9,216	8,785	
Kuranji	5,845	5,572	
Balimbing	2,440	2,326	
Laras	603	574	
Retarding basin	328	313	
II. Drainage Channel Improvement	6,394	6,394	
Pumping station	5,077	5,077	
Drainage channel	1,317	1,317	
III. Land Acquisition and house compensation	794	776	
River	635	617	
Drainage	159	159	
	Scheme D-1	Scheme D-2	
Air Dingin River	5,579	6,278	
I. River Channel Improvement	2,805	3,476	
Air Dingin river	2,805	3,476	
II. Drainage Channel Improvement	2,503	2,503	
Pumping station	1,953	1,953	
Drainage channel	550	550	
III. Land acquisition and house compensation	271	299	
River	227	255	
Drainage	44	44	

Note : The above construction cost is estimated for main civil works, land acquisition and house compensation.

Table J- 9 Length of Drainage Channel to be Improved and Proposed Capacity of Pumping Station

Drainage system	Drainage area (km^2)	Channel length to be improved (km)	Drainage	Capacity of pump (m^3/s)	Terminal	Remarks
Old urban area						
Jati	2.14	4.40	Gravity	-	Arau river	Including 574 m of diversion drain.
Palinggam	0.71	1.35	- do -	-	- do -	
Anak Jati	0.62	2.45	- do -	-	- do -	Including Kelenteng drain.
Olo-Nipah	1.40	5.75	- do -	-	- do -	
Kali Mati	0.21	0.95	Pump	1.0	- do -	Excluding Nipah area.
Damar	1.15	4.00	Gravity	-	Indonesian Ocean	
Ujung Gurun	1.62	5.05	Pump	5.0	Flood relief channel	
Sub-total	7.85	23.95	-	6.0		
New urban area						
Purus	1.06	2.0	Pump	3.5	Flood relief channel	
Lolong	2.65	2.05	Gravity	-	Indonesian Ocean	
Ulak Karang	1.87	3.85	Pump	5.5	Kuranji river	
Lapai	1.42	3.70	Gravity	-	- do -	
Baung	1.82	2.50	Pump	5.5	- do -	
Penjalinan	1.10	1.45	Pump	3.0	Air Dingin river	
Tabing	12.08	3.50	Gravity	-	- do -	
Sub-total	21.46	19.05	-	17.5		
Total	29.41	43.00	-	23.5		

Table J-10(1) Construction Cost for Proposed Comprehensive Plan

Item	Quantity		Local Currency (Rp.)		Foreign Currency (US$)		Equivalent Total (Rp. 10^6)
	Unit	(Amount)	Unit Cost	(Amount) (10^6)	Unit Cost	(Amount) (10^3)	
1. Civil Works				(16,074.4)		(36,874.7)	(51,834.1)
1.1 Arau River				(3,435.2)		(6,551.0)	(9,789.7)
Preparatory /1				231.4		441.2	
(RIVER CHANNEL IMPROVEMENT)							
Excavation I	10^3m^3	144	499	71.9	1.50	216.0	
II	"	215	294	63.3	1.78	382.7	
Dredging	"	32	801	25.7	3.54	113.3	
Transportation	"	391	788	308.2	2.13	832.9	
Embankment I	"	34	425	14.5	1.51	51.4	
Bank protection							
Wet masonry I	m^2	15,574	11,410	177.7	13.74	214.0	
Gabion	m^3	3,712	7,712	28.7	14.49	53.8	
Sod-facing	10^3m^2	23.5	320	7.6	0.17	4.0	
Drainage culvert I	nos	5	15,200,100	76.1	22,726	113.7	
III	"	1	32,120,000	32.2	49,665	49.7	
Bridge (R.C)	m^2	204	173,730	35.5	274.82	56.1	
Pier protection (riprap)	10^3m^3	0.5	13,709	6.9	10.83	5.5	
Groundsill works	m	12	474,462	5.7	424.91	5.1	
Diversion weir	l.s	1	402,442,548	402.5	666,352	666.4	
Inspection road (gravel metaling)	m	9,500	2,422	23.1	3.03	28.8	
Disposal of excess soil	10^3m^3	357	176	62.9	0.81	289.2	
(DRAINAGE CHANNEL IMPROVEMENT)							
Pumping station							
I (1.0 m^3/s)	l.s	1	270,000,000	270.0	1,080,000	1,080.0	
Excavation	10^3m^3	160	2,391	382.6	-	-	
Embankment	"	15	425	6.4	1.51	22.7	
Transportation	"	141	788	111.2	2.13	300.4	
Disposal of soil	"	141	176	24.9	0.81	114.3	
Revetment							
Wet masonry II	m^2	54,000	11,410	616.2	13.74	742.0	
Dry masonry	"	12,000	7,453	89.5	9.32	111.9	

Table J-10(2) Construction Cost for Proposed Comprehensive Plan

Item	Quantity		Local Currency (Rp.)		Foreign Currency (US$)		Equivalent
	Unit	(Amount)	Unit Cost	(Amount) (10^6)	Unit Cost	(Amount) (10^3)	Total (Rp. 10^6)
Inspection road (gravel metaling)	m	19,900	2,422	48.2	3.03	60.3	
Miscellaneous /2				312.3		595.6	
1.2 Flood Relief channel				(5,762.2)		(11,993.0)	(17,395.5)
Preparatory /1				388.1		807.7	
(RIVER CHANNEL IMPROVEMENT)							
Excavation I	10^3m^3	366	499	182.7	1.50	549.0	
II	"	157	294	46.2	1.78	279.5	
Dredging	"	18	801	14.5	3.54	63.8	
Transportation	"	541	788	426.4	2.13	1,152.4	
Embankment I	"	31	425	13.2	1.51	46.9	
II	"	14	456	6.4	1.07	15.0	
Bank protection							
Wet masonry I	m^2	3,100	9,685	30.1	13.31	41.3	
II	"	57,600	11,410	657.3	13.74	791.5	
Dry masonry	"	22,026	7,453	164.2	9.32	205.3	
Sod-facing	10^3m^2	66	320	21.2	0.17	11.3	
Drainage culvert I	nos	9	15,200,100	136.9	22,726	204.6	
II	"	7	22,444,000	157.2	35,023	245.2	
Bridge (R.C)	m^2	812	173,730	141.1	274.82	223.2	
Pier protection (riprap)	10^3m^3	0.2	13,709	2.8	10.83	2.2	
Drop structure	place	3	87,196,000	261.6	129,581	388.8	
Diversion weir	l.s	1	317,914,110	318.0	508,496	508.5	
Syphon	place	2	31,263,100	62.6	45,067	90.2	
Inspection road (gravel metaling)	m	13,760	2,422	33.4	3.03	41.7	
Disposal of excess soil	10^3m^3	489	176	86.1	0.81	396.1	

Table J-10(3) Construction Cost for Proposed Comprehensive Plan

Item	Quantity		Local Currency (Rp.)		Foreign Currency (US$)		Equivalent Total
	Unit	(Amount)	Unit Cost	(Amount) (10^6)	Unit Cost	(Amount) (10^3)	($Rp.10^6$)
(DRAINAGE CHANNEL IMPROVEMENT)							
Pumping station							
I (3.5 m^3/s)	l.s	1	435,300,000	435.3	1,661,000	1,661.0	
II (5.0 m^3/s)	l.s	1	520,000,000	520.0	1,975,000	1,975.0	
Excavation	10^3m^3	140	2,391	334.8	-	-	
Embankment	"	13	425	5.6	1.51	19.7	
Transportation	"	125	788	98.5	2.13	266.3	
Disposal of soil	"	125	176	22.0	0.81	101.3	
Revetment							
Wet masonry II	m^2	48,000	11,410	547.7	13.74	659.6	
Dry masonry	"	11,000	7,453	82.0	9.32	102.6	
Inspection road (gravel metaling)	m	17,500	2,422	42.4	3.03	53.1	
Miscellaneous /2				523.9		1,090.3	
1.3 Kuranji River				(5,107.4)		(13,338.5)	(18,045.8)
Preparatory /1				343.9		898.2	
(RIVER CHANNEL IMPROVEMENT)							
Excavation I	10^3m^3	404	499	201.6	1.50	606.0	
II	"	467	294	137.3	1.78	831.3	
for rock	"	5	1,700	8.5	6.00	30.0	
Dredging	"	48	801	38.5	3.54	170.0	
Transportation	"	912	788	718.7	2.13	1,942.6	
Embankment I	"	245	425	104.2	1.51	370.0	
Bank protection							
Wet masonry I	m^2	5,544	9,685	53.7	13.31	73.8	
II	"	7,588	11,410	86.6	13.74	104.3	

Table J-10(4) Construction Cost for Proposed Comprehensive Plan

Item	Quantity		Local Currency (Rp.)		Foreign Currency (US$)		Equivalent
	Unit	(Amount)	Unit Cost	(Amount) (10^6)	Unit Cost	(Amount) (10^3)	Total (Rp. 10^6)
Dry masonry	m^2	6,270	7,453	46.8	9.32	58.5	
Gabion	m^3	14,424	7,712	111.3	14.49	209.1	
Groin	m	10,500	7,712	81.0	14.49	152.2	
Sod-facing	10^3m^2	96.5	320	30.9	0.17	16.5	
Drainage culvert I	nos	17	15,200,100	258.5	22,726	386.4	
II	"	5	22,444,000	112.3	35,023	175.2	
III	"	6	32,120,000	192.8	49,665	298.0	
Bridge (R.C)	m^2	438	173,730	76.1	274.82	120.4	
" (Metal)	"	360	201,352	72.5	543.82	195.8	
Pier protection (riprap)	10^3m^3	1.3	13,709	17.9	10.83	14.1	
Groundsill works	m	130	474,462	61.7	424.91	55.3	
Inspection road (gravel metaling)	m	24,840	2,422	60.2	3.03	75.3	
Disposal of excess soil	10^3m^3	641	176	112.9	0.81	519.3	
(DRAINAGE CHANNEL IMPROVEMENT)							
Pumping station							
I (5.5 m^3/s)	l.s	1	540,000,000	540.0	2,060,000	2,060.0	
II (5.5 m^3/s)	l.s	1	540,000,000	540.0	2,060,000	2,060.0	
Excavation	10^3m^3	48	2,391	114.8	-	-	
Embankment	"	14	425	6.0	1.51	21.2	
Transportation	"	32	788	25.3	2.13	68.2	
Disposal of soil	"	32	176	5.7	0.01	26.0	
Revetment							
Wet masonry II	m^2	31,000	11,410	353.8	13.74	426.0	
Dry masonry	"	13,000	7,453	96.9	9.32	121.2	
Inspection road (gravel metaling)	"	13,500	2,422	32.7	3.03	41.0	
Miscellaneous /2				464.3		1,212.6	

Table J-10(5) Construction Cost for Proposed Comprehensive Plan

Item	Quantity		Local Currency (Rp.)		Foreign Currency (US$)		Equivalent
	Unit	(Amount)	Unit Cost	(Amount) (10^6)	Unit Cost	(Amount) (10^3)	Total (Rp. 10^6)
1.4 Air Dingin River				(1,769.6)		(4,992.2)	(6,621.1)
Preparatory /1				119.2		336.2	
(RIVER CHANNEL IMPROVEMENT)							
Excavation I	10^3m^3	66	499	33.0	1.50	99.0	
II	"	261	294	76.8	1.78	464.6	
Dredging	"	35	801	28.1	3.54	123.9	
Transportation	"	362	788	285.3	2.13	771.1	
Embankment I	"	66	425	28.1	1.51	99.7	
Bank protection							
Wet masonry I	m^2	3,246	9,685	31.5	13.31	43.3	
II	"	1,076	11,410	12.3	13.74	14.8	
Gabion	m^3	4,875	7,712	37.6	14.49	70.7	
Sod-facing	10^3m^2	29.6	320	9.5	0.17	5.1	
Drainage culvert I	nos	2	15,200,100	30.4	22,726	45.5	
II	"	1	22,444,000	22.5	35,023	35.1	
III	"	2	32,120,000	64.3	49,665	198.7	
Pier protection (riprap)	10^3m^3	1.6	13,709	22.0	10.83	17.4	
Groundsill works	m	150	474,462	71.2	424.91	63.8	
Inspection road (gravel metaling)	m	8,500	2,422	20.6	3.03	25.8	
Disposal of excess soil	10^3m^3	285	176	50.2	0.81	230.9	
(DRAINAGE CHANNEL IMPROVEMENT)							
Pumping station							
I (3.0 m^3/s)	l.s	1	405,000,000	405.0	1,595,000	1,595.0	
Excavation	10^3m^3	14	2,391	33.5	-	-	
Embankment	"	4	425	1.7	1.51	6.1	
Transportation	"	10	788	7.9	2.13	21.3	
Disposal of soil	"	10	176	1.8	0.81	8.1	

Table J-10(6) Construction Cost for Proposed Comprehensive Plan

Item	Quantity		Local Currency (Rp.)		Foreign Currency (US$)		Equivalent
	Unit	(Amount)	Unit Cost	(Amount) (10^6)	Unit Cost	(Amount) (10^3)	Total (Rp. 10^6)
Revetment							
Wet masonry	m^2	15,000	11,410	171.2	13.74	206.1	
Dry masonry	"	4,000	7,453	29.9	9.32	37.3	
Inspection road (gravel metaling)	m	6,200	2,422	15.1	3.03	18.8	
Miscellaneous /2	l.s			160.9		453.9	
2. Land Acquisition and House Compensation				(2,390.4)			(2,390.4)
2.1 Arau River				(860.3)			(860.3)
(RIVER CHANNEL IMPROVEMENT)							
Land	10^3m^2	142.6		440.7			
House	nos	94		41.6			
(DRAINAGE CHANNEL IMPROVEMENT)							
Land	10^3m^2	86.0		376.0			
House	nos	4		2.0			
2.2 Flood Relief channel				(577.2)			(577.2)
(RIVER CHANNEL IMPROVEMENT)							
Land	10^3m^2	96.0		187.8			
House	nos	42		18.9			
(DRAINAGE CHANNEL IMPROVEMENT)							
Land	10^3m^2	78.0		340.0			
House	nos	52		30.5			
2.3 Kuranji River				(683.8)			(683.8)
(RIVER CHANNEL IMPROVEMENT)							
Land	10^3m^2	684.2		492.3			
House	nos	97		36.3			

Table J-10(7) Construction Cost for Proposed Comprehensive Plan

Item	Quantity		Local Currency (Rp.)		Foreign Currency (US$)		Equivalent Total (Rp. 10^6)
	Unit	(Amount)	Unit Cost	(Amount) (10^6)	Unit Cost	(Amount) (10^3)	
(DRAINAGE CHANNEL IMPROVEMENT)							
Land	10^3m^2	58.0		148.0		-	
House	nos	2		7.2		-	
2.4 Air Dingin River				(269.1)			(269.1)
(RIVER CHANNEL IMPROVEMENT)							
Land	10^3m^2	200.0		217.5		-	
House	nos	20		7.6		-	
(DRAINAGE CHANNEL IMPROVEMENT)							
Land	10^3m^2	22.0		44.0		-	
3. Total (1 + 2)				18,464.8		36,874.7	54,233.5
4. Engineering and Administration /3				2,769.8		5,531.3	8,135.2
Contingency /4				2,258.4		5,190.0	7,293.3
Grand Total				23,493.0		47,596.0	69,662.0

Note
1. Price level at the beginning of June '83 is applied
2. Conversion rate : US$ 1 = Rp. 970 = ¥ 240
3. The following lump sum costs are applied for
   - /1 8 % of the direct civil works cost
   - /2 10 % of the civil works cost
   - /3 15 % of the total costs of civil works, and land acquisition and House Compensation
   - /4 10 % of the total costs of civil works, land acquisition and house compensation, and engineering and administration

Table J-11 Economic Cost for Proposed Comprehensive Plan

Item	Construction cost						Economic cost
	L.C				F.C		
	Const. cost	Deduction factor Tax/1 (%)	Deduction factor Profit/2 (%)	Economic cost	Const. cost	Equiv./3 in Rp.	
	($Rp.10^6$)	($Rp.10^6$)	($Rp.10^6$)	($Rp.10^6$)	($US\$10^3$)	($Rp.10^6$)	($Rp.10^6$)
1. Land acquisition	2,390	-	-	2,390	-	-	2,390
2. Civil works							
(1) Earth works	7,073	283	679	6,111	16,962	16,453	22,564
(2) Structure works	9,002	360	864	7,778	19,912	19,315	27,093
Sub-total	16,075	643	1,543	13,889	36,874	35,768	49,657
3. Cost for engineering and administration	2,770	111	-	2,659	5,531	5,365	8,024
4. Contingency	2,258	90	217	1,951	5,190	5,034	6,985
5. Total	23,493	844	1,760	20,889	47,595	46,167	67,056

/1 : rate of tax : 4 %

/2 : rate of contractor's profit : 10 %

/3 : US$ 1 = Rp. 970

Table J-12 Number of Buildings Submerged for Respective Return Periods under Future Development Condition

(Unit : Number)

River/Block			Return period					
			2 - yr	5 - yr	10 - yr	25 - yr	50 - yr	100 - yr
Arau river	Block 1 :	Arau mainstream (Incl. F.R.C)	0	2,903	17,023	21,788	26,572	28,359
	Block 2 :	Jirak river	0	1,299	1,757	2,101	2,400	3,010
	Block 3 :	Interior drainage area	1,546	3,510	8,019	8,761	8,837	9,647
		Sub-total	1,546	7,712	26,799	32,650	37,809	41,016
Kuranji river system	Block 4 :	Kuranji mainstream	425	6,095	9,594	10,728	10,902	11,079
	Block 5 :	Balimbing and Laras rivers	795	1,850	2,478	6,209	8,017	9,683
	Block 6 :	Interior drainage area	1,655	2,256	3,430	3,594	3,727	3,859
		Sub-total	2,875	10,201	15,502	20,531	22,646	24,621
Air Dingin river system	Block 7 :	Air Dingin river	548	3,170	3,784	4,424	5,470	5,745
	Block 8 :	Interior drainage area	26	101	240	407	519	628
		Sut-total	574	3,271	4,024	4,831	5,989	6,373
Grand total			4,995	21,184	46,325	58,012	66,444	72,010

Table J-13 Summarized Flood Damages for Respective Return Periods under Future Development Condition

(Unit : Rp.10^6)

River/Block			Return period					
			2 - yr	5 - yr	10 - yr	25 - yr	50 - yr	100 - yr
Arau river system	Block 1 :	Arau mainstream (Incl. F.R.C)	0	5,528	10,712	17,612	21,734	23,708
	Block 2 :	Jirak river	0	180	347	388	406	662
	Block 3 :	Interior drainage area	1,165	6,316	9,322	10,831	11,436	12,076
		Sub-total	1,165	12,024	20,381	28,831	33,576	36,446
Kuranji river system	Block 4 :	Kuranji mainstream	417	1,450	6,178	7,819	8,574	9,242
	Block 5 :	Balimbing and Laras rivers	344	1,434	2,026	8,429	11,697	14,757
	Block 6 :	Interior drainage area	979	1,916	2,557	2,801	2,815	2,827
		Sub-total	1,740	5,300	10,761	19,049	23,086	26,826
Air Dingin river system	Block 7 :	Air Dingin river	1,469	2,071	4,654	10,476	20,116	20,677
	Block 8 :	Interior drainage area	231	231	247	416	423	423
		Sub-total	1,700	2,302	4,901	10,892	20,539	21,100
Grand total			4,605	19,626	36,043	58,772	77,201	84,372

Table J-14 Economic Cost and Benefit Flow for Comprehensive Plan

(Unit : Rp.10^6)

Year in order	Economic Cost				Benefit	
	Construction Cost	Replacement Cost	O & M Cost	Total	Present	Future
1	2,299	-	-	2,299	-	-
2	2,004	-	-	2,004	-	-
3	10,116	-	-	10,116	-	-
4	14,781	-	-	14,781	-	-
5	16,441	-	41	16,482	1,298	1,941
6	16,441	-	123	16,564	3,892	5,822
7	4,974	-	204	5,178	6,488	9,704
8	-	-	246	246	8,283	11,645
9	-	-	"	"	"	"
10	-	-	"	"	"	"
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31	.	-	246	246	8,283	11,645
32	-	3,420	"	3,666	"	"
33	-	3,420	"	3,666	"	"
34	-	3,420	"	3,666	"	"
35	-	-	"	246	"	"
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57	-	-	246	246	8,283	11,645

Fig. J-1 Location of Planned Limau Manis Dam

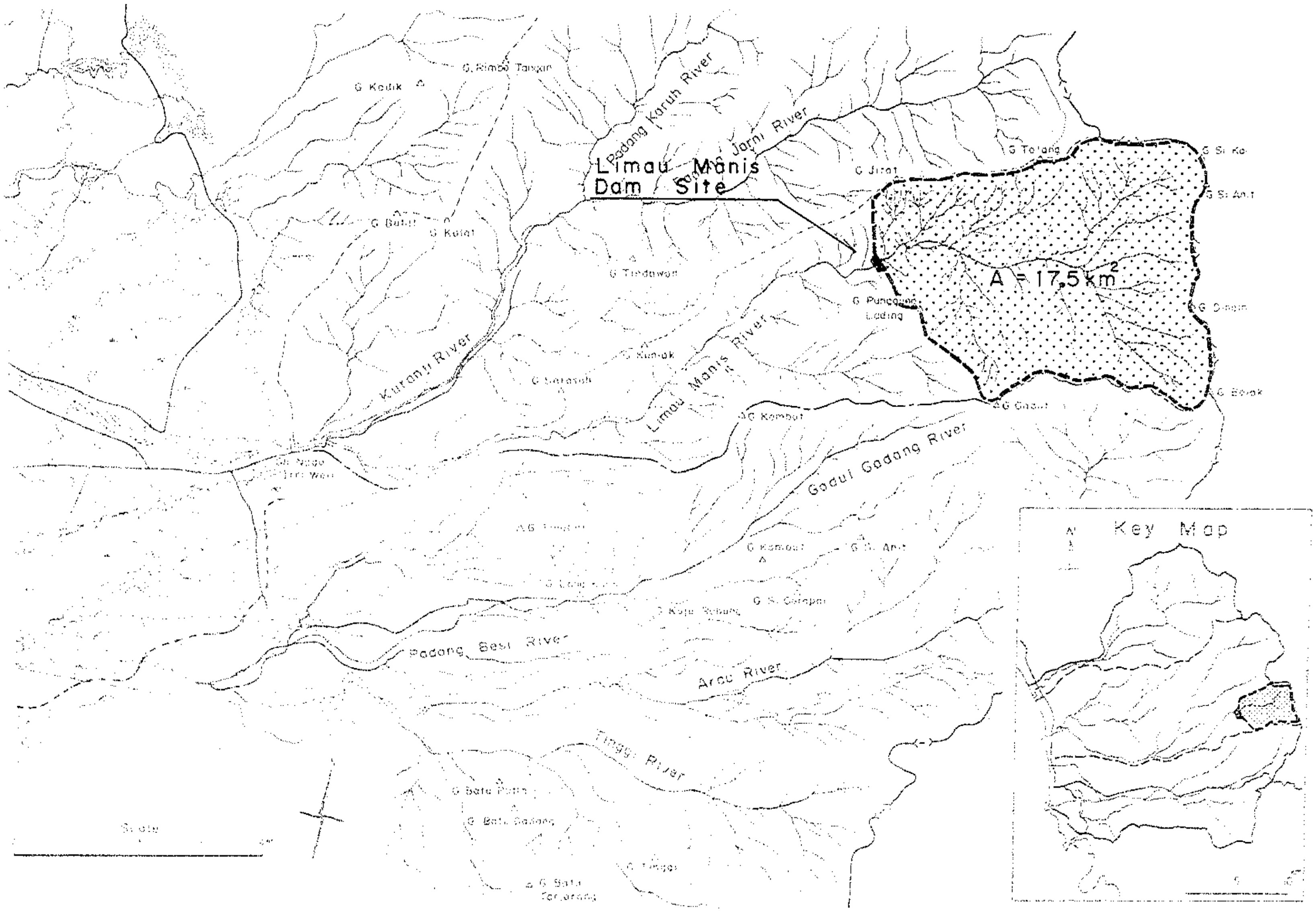
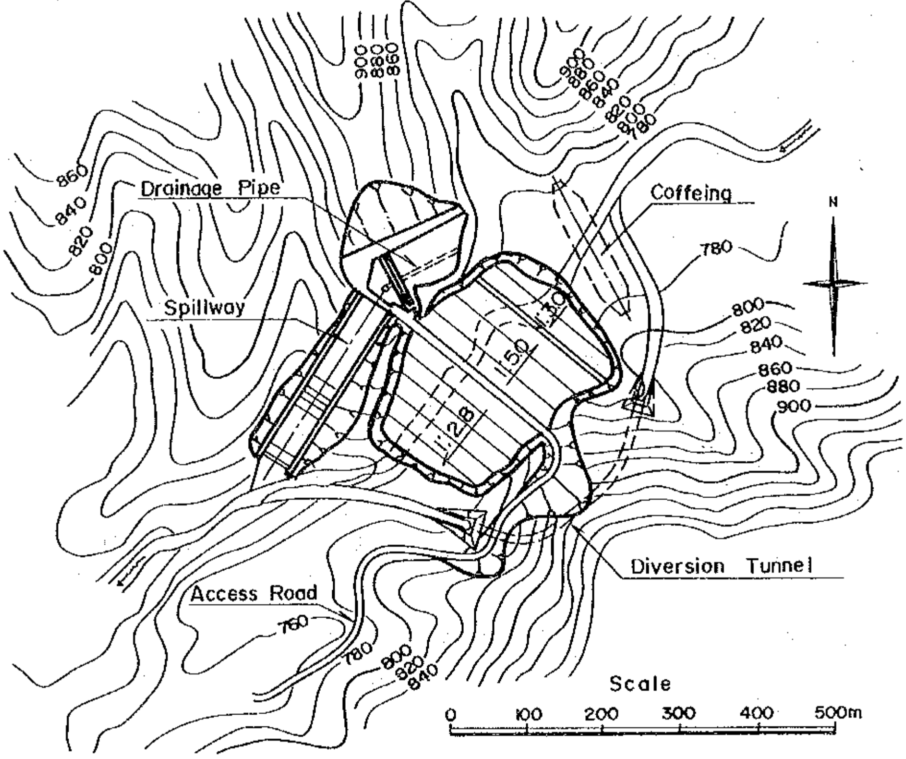
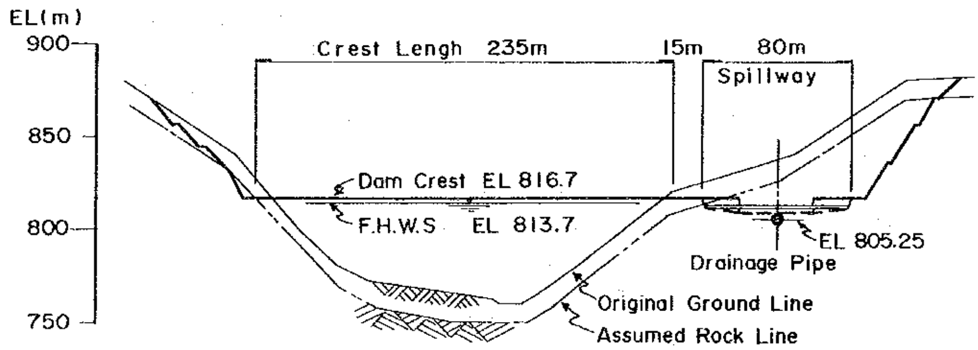


Fig. J-2 General Plan of Limau Manis Dam



Front View



Cross Section

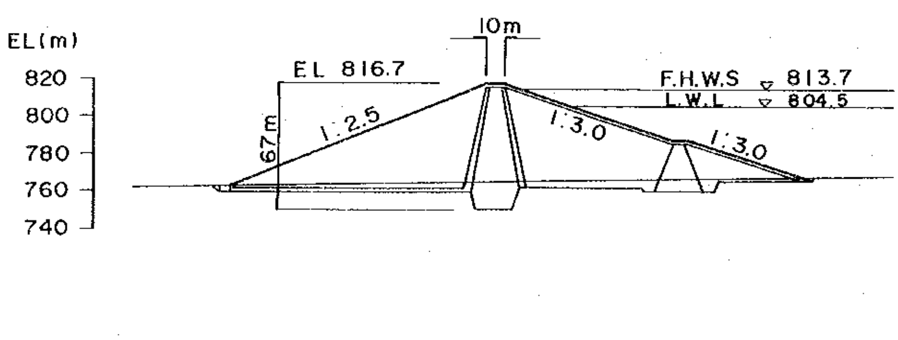
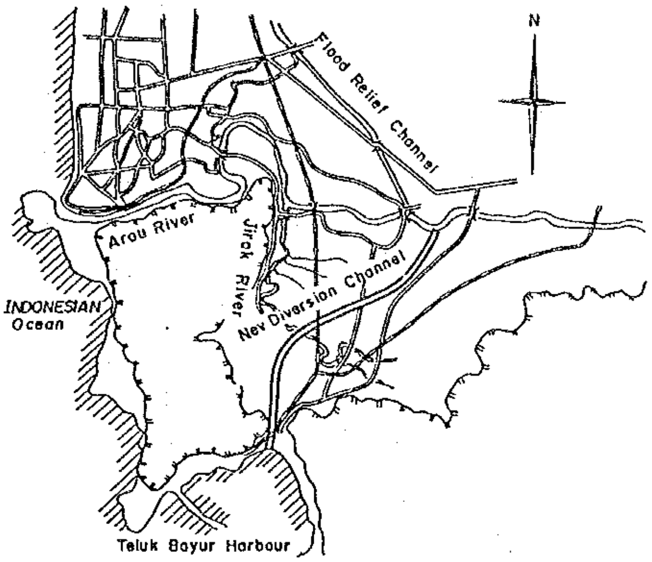
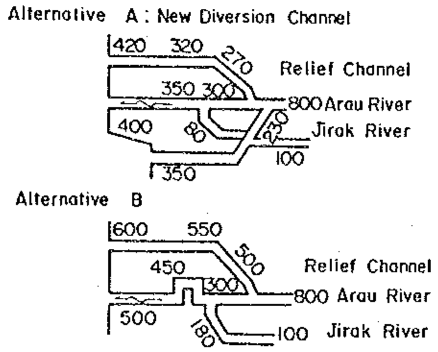


Fig. J-3 Outline of the Scheme for New Diversion Channel of the Arau River

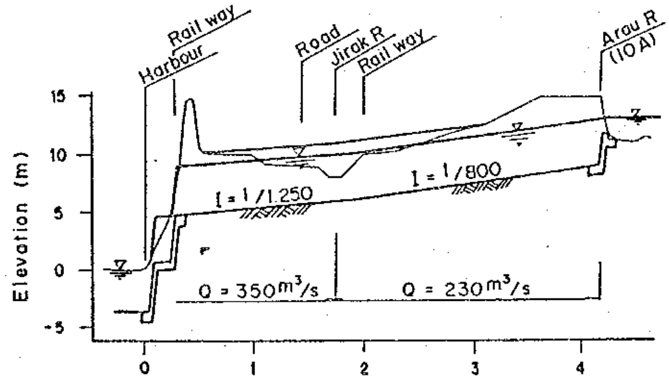
Location of New Diversion Channel



Discharge Distribution



Profile



Cross-section

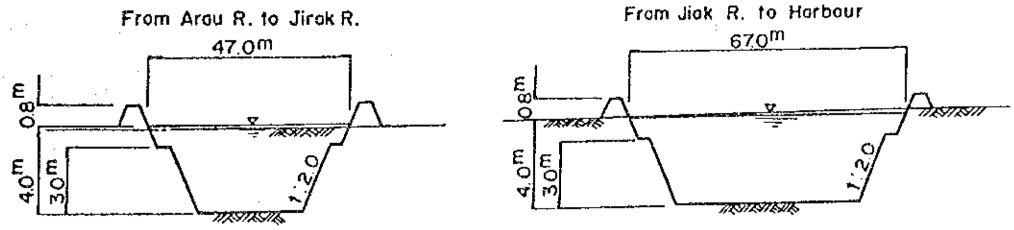


Fig. J-4 Outline of the Scheme for Cutoff Channel of the Arau River

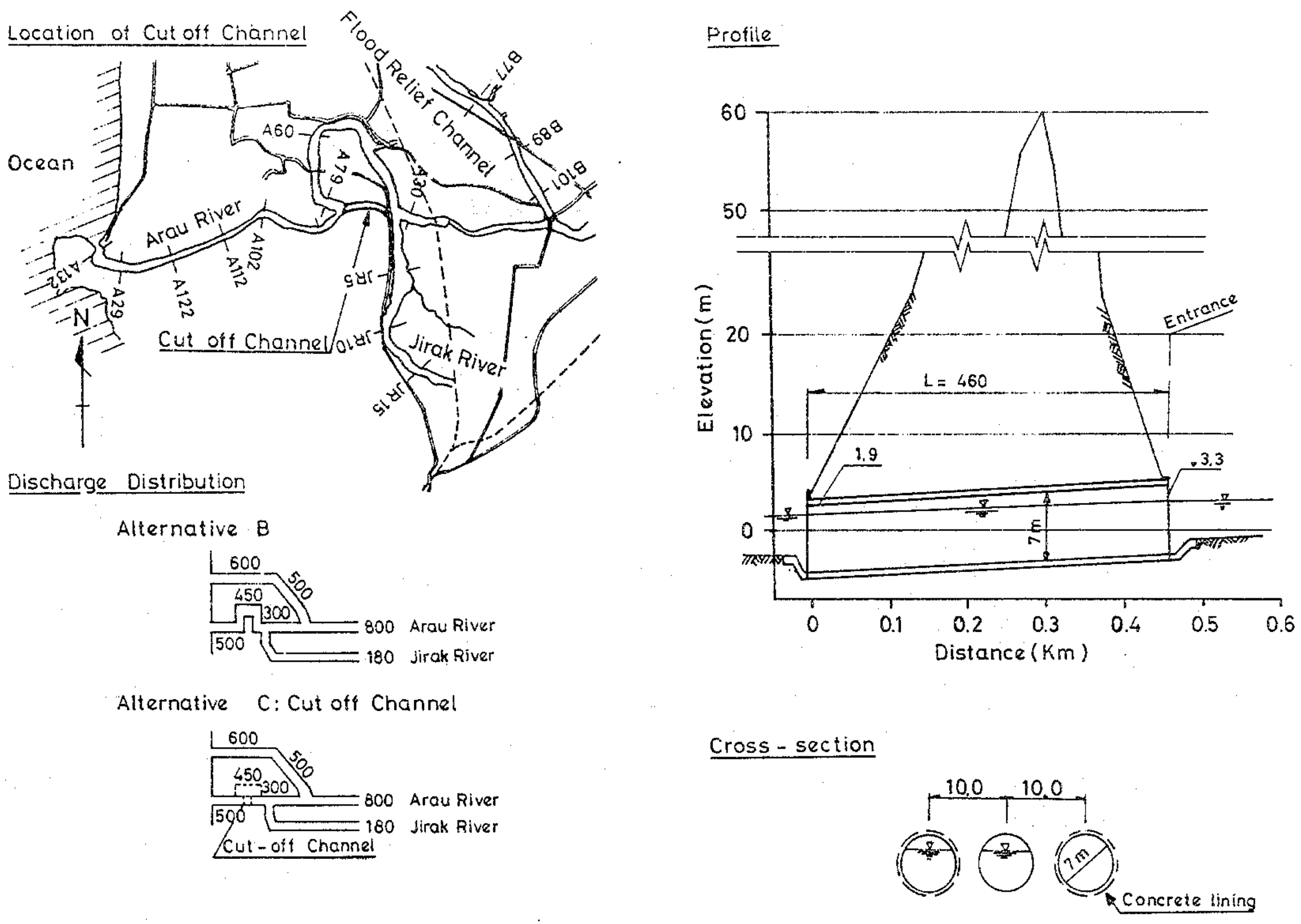


Fig. J-5 Outline of the Scheme for New Diversion Channel of the Balimbing River

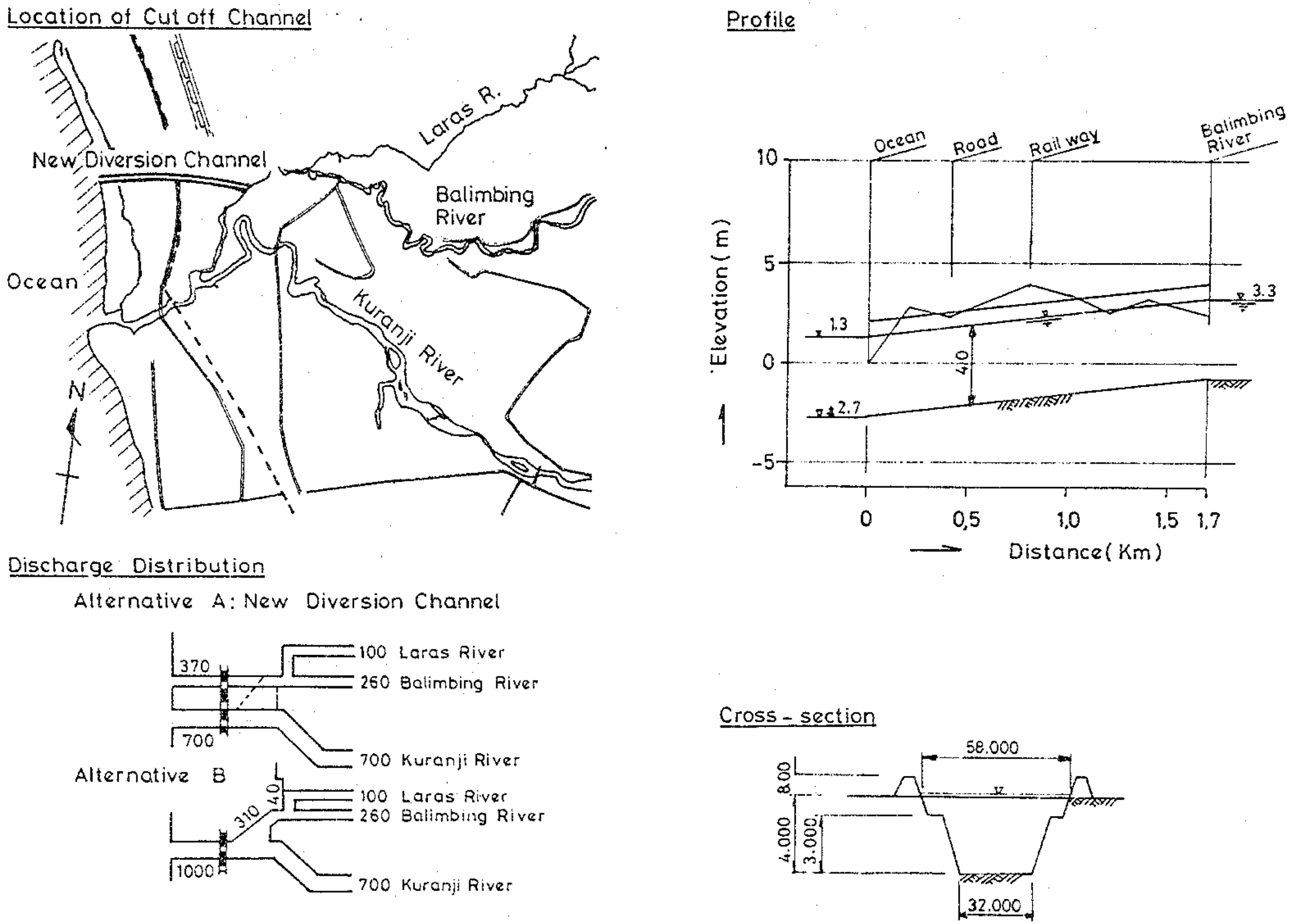
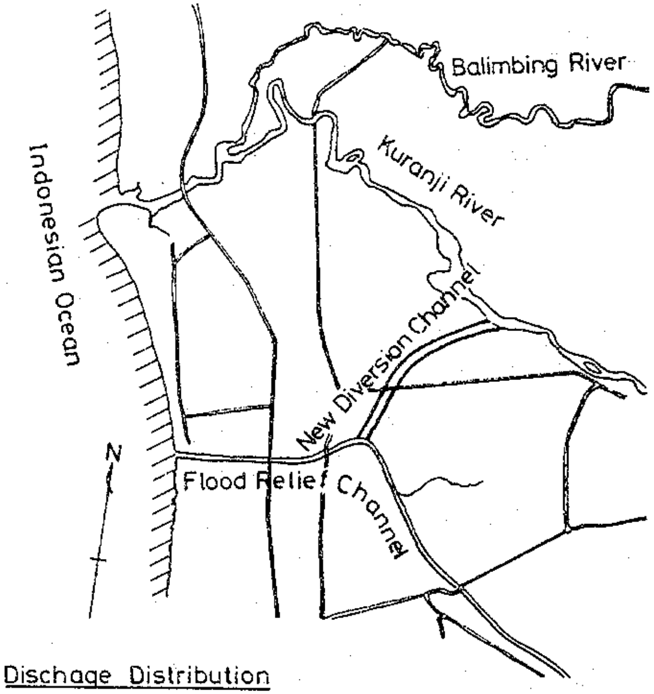


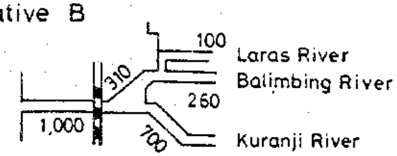
Fig. J-6 Outline of the Scheme for Diversion Channel of the Kuranji River

Location of Cutoff Channel

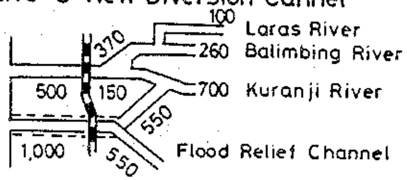


Dischage Distribution

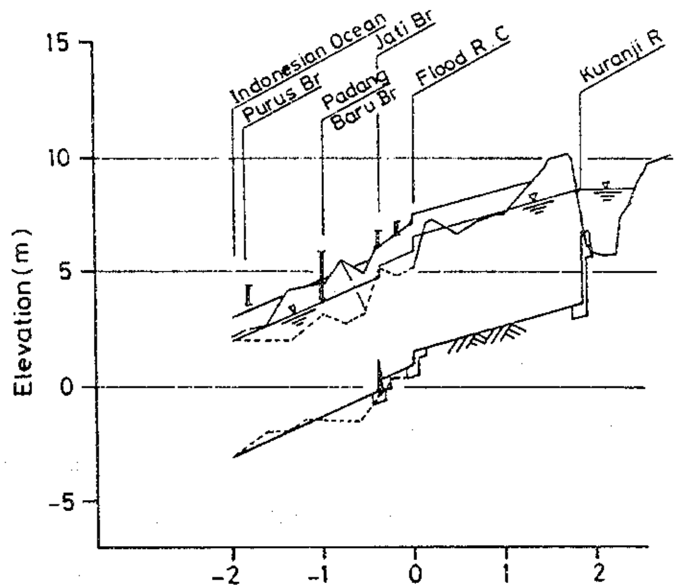
Alternative B



Alternative C: New Diversion Cannel



Profile



Cross section

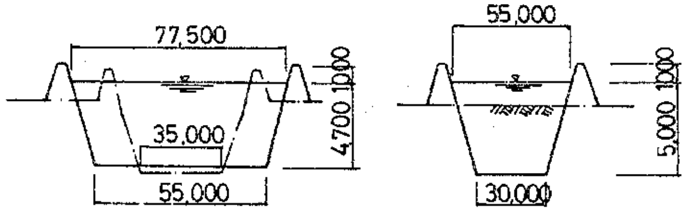


Fig. J-7 Objective River Stretches for Comprehensive Flood Control and Drainage Plan

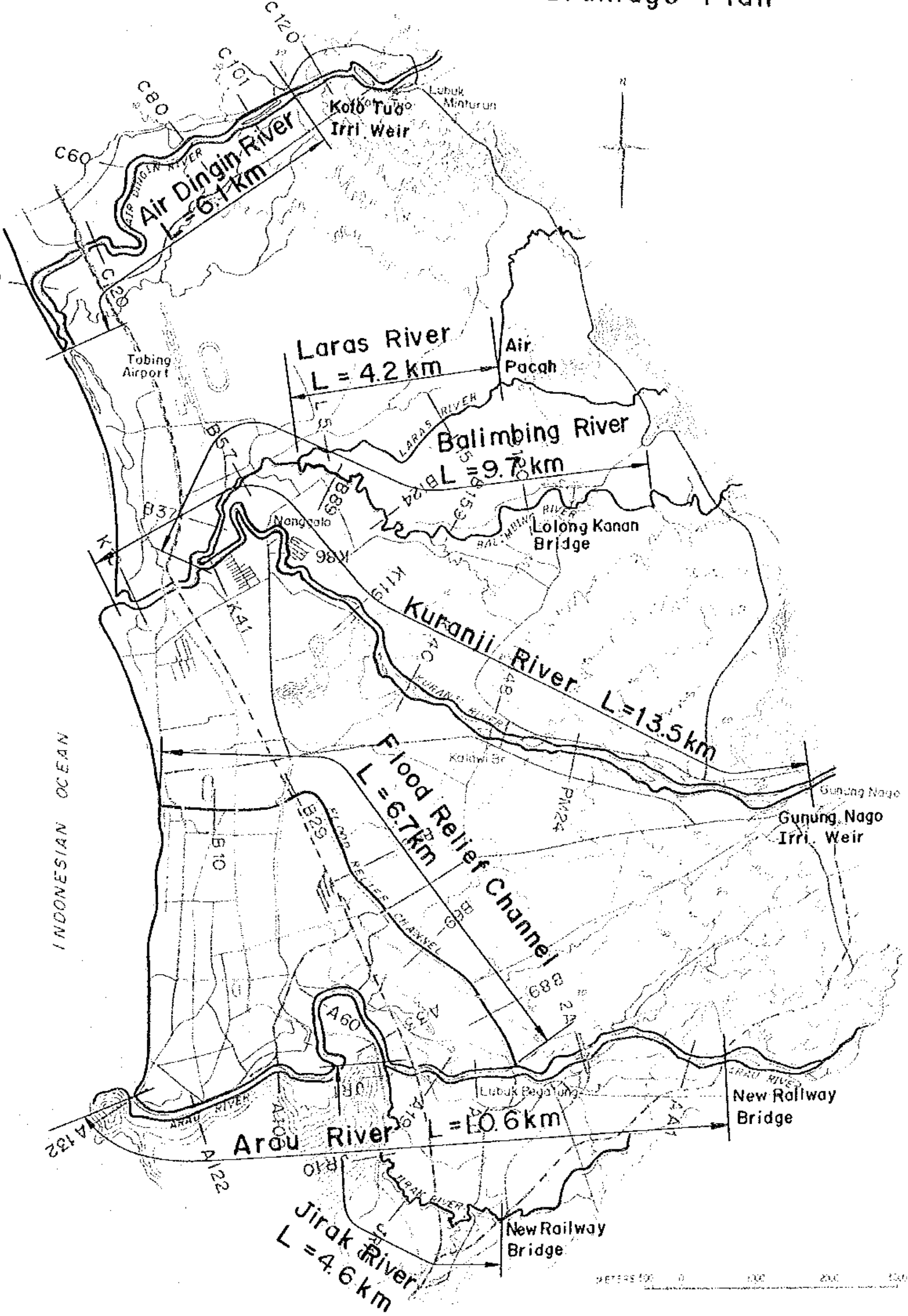


Fig. J-8 Alternative Schemes for Comprehensive Flood Control and Drainage Plan

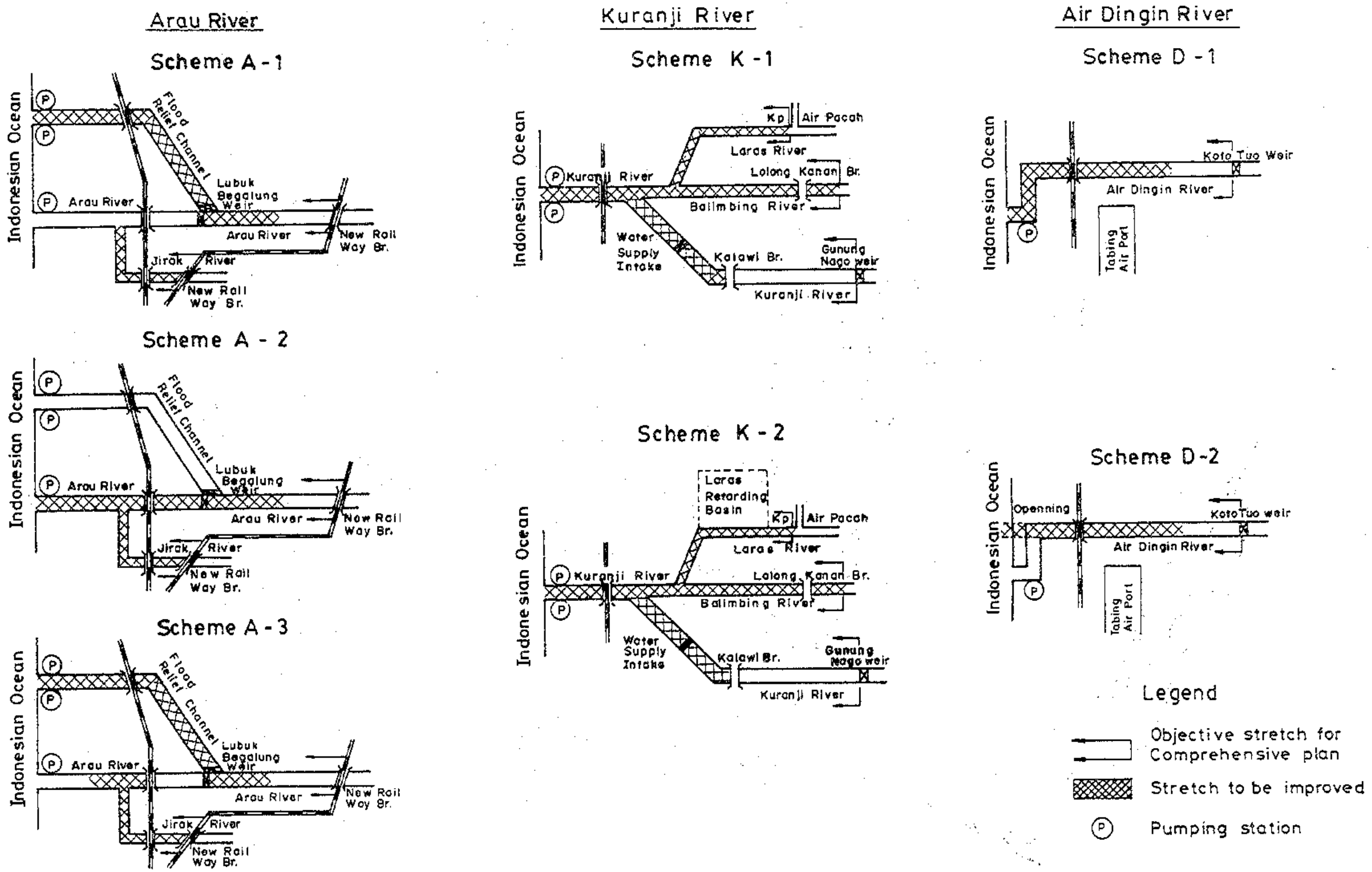


Fig. J-9 Design Flood Discharge for Alternative Schemes

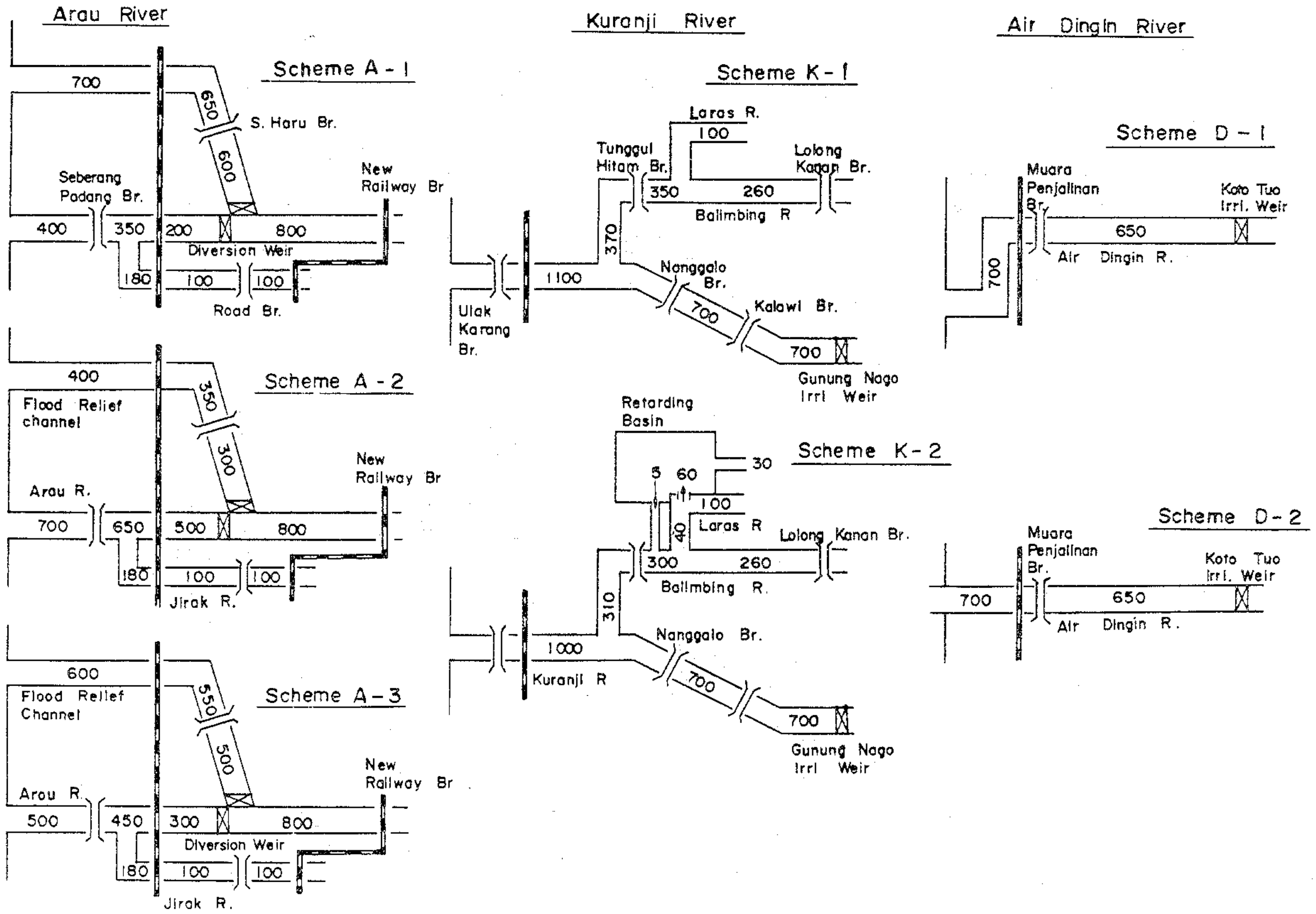
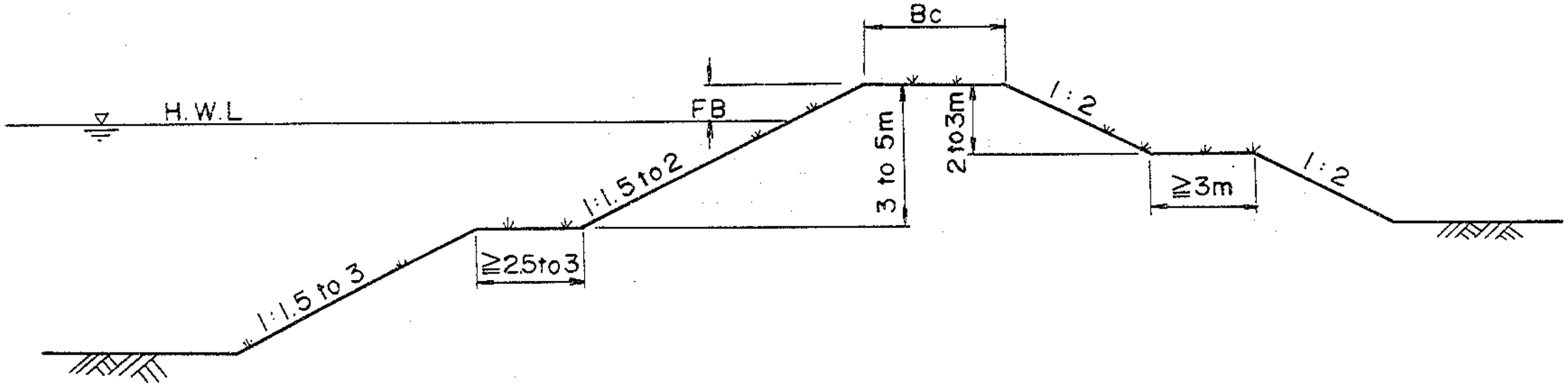


Fig. J-10 Standard Dike Section



Designed Discharge Q (m^3/s)	Free-board FB (m) not less than	Crownwidth Bc (m) not less than
less than 200	0.6	3
200 to 500	0.8	3
500 to 2,000	1.0	4

Fig. J-11 Design Flood Discharge for Proposed Comprehensive Plan

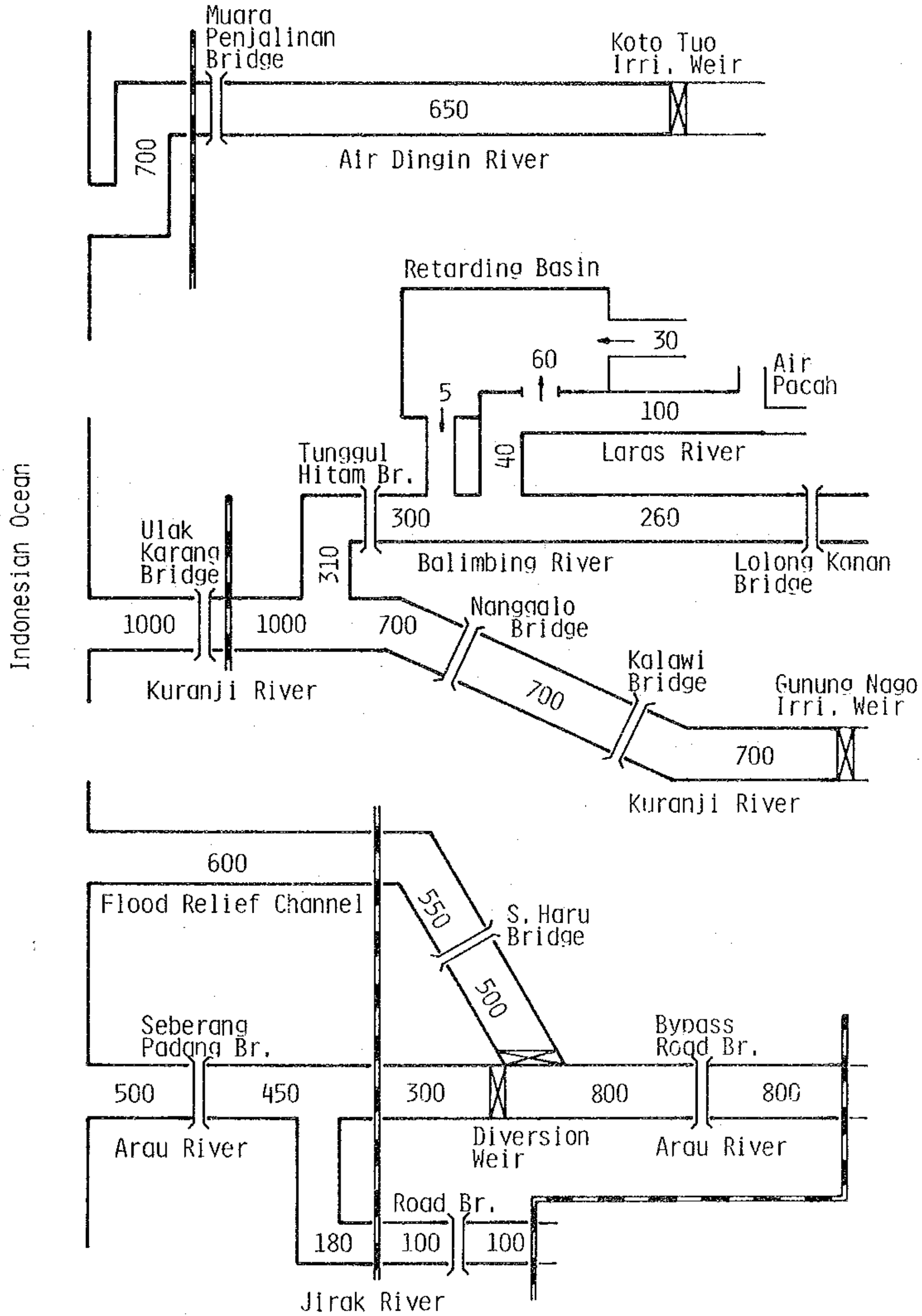


Fig. J-12 Proposed Alignment of River Channel for Comprehensive Plan

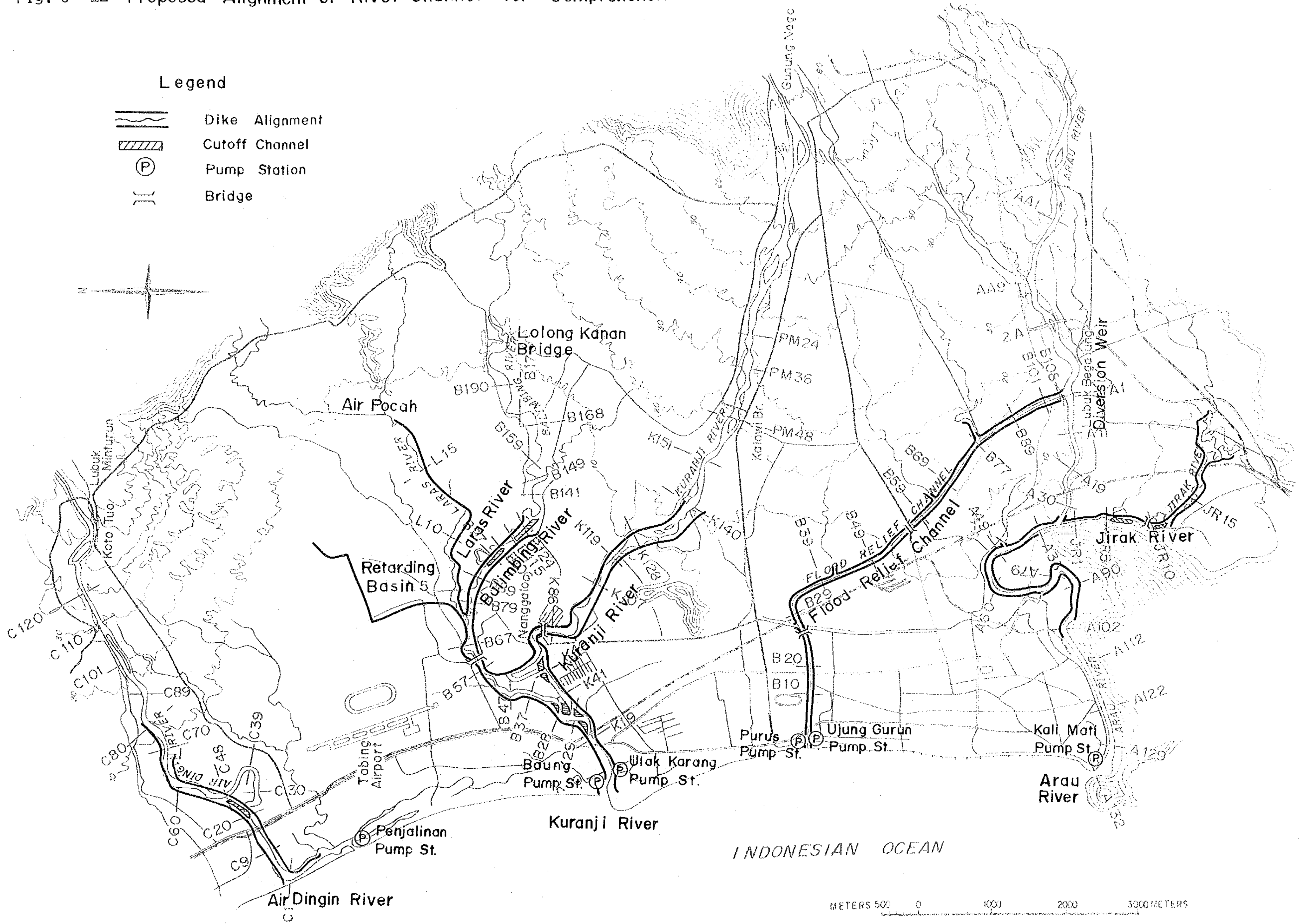
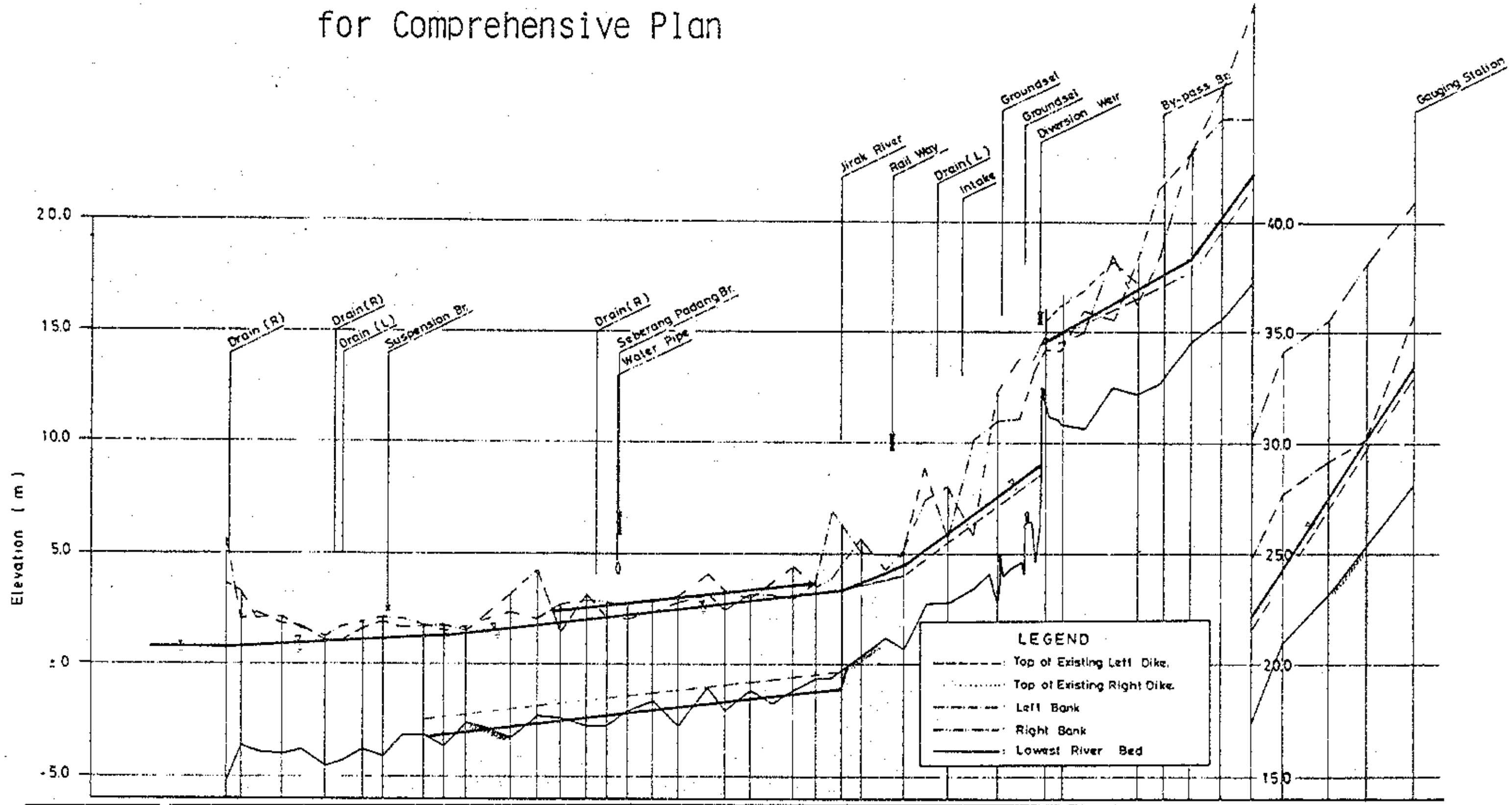


Fig. J-13(1) Proposed Profile of the Arau River for Comprehensive Plan



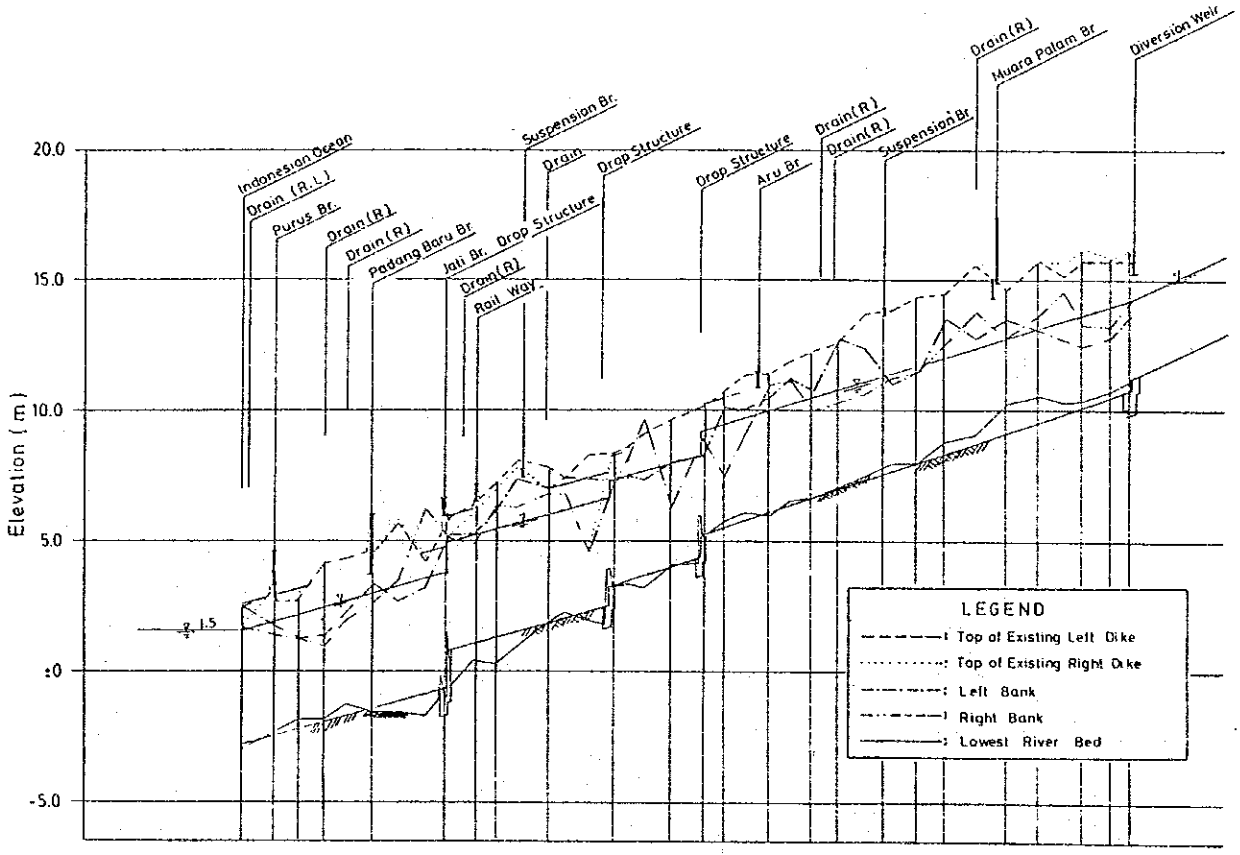
Design Flood Discharge (m^3/s): 500 — 450 — 300 — 600

Gradient of H.W.L: 1/3,900 — 1/1,780 — 1/460 — 1/270 — 1/340 — 1/150 — 1/125

Gradient of Channel Bed: 1/1,780

Section No	Distance (m)	Top of Proposed Levee (El.m)	Proposed H.W.L (El.m)	Proposed Channel Bed (El.m)
A 132	0	-	0.80	-
A 131	137	-	0.84	-
A 127	496	-	0.93	-
A 122	893	-	1.03	-
A 116	1.223	-	1.11	-
A 112	1.403	-	1.16	-
A 105	1.774	1.77	1.26	-3.24
A 102	1.949	1.80	1.30	-3.20
A 98	2.149	-	1.41	-3.09
A 90	2.546	2.12	1.62	-2.88
A 85	2.763	2.22	1.77	-2.73
A 79	2.991	2.38	1.88	-2.62
A 75	3.225	2.51	2.01	-2.49
A 72	3.406	2.62	2.12	-2.38
A 68	3.592	2.72	2.22	-2.28
A 64	3.807	2.84	2.34	-2.16
A 60	4.052	2.98	2.48	-2.02
A 53	4.468	3.21	2.71	-1.79
A 49	4.694	3.34	2.84	-1.66
A 42	5.086	3.56	3.06	-1.44
A 38	5.287	3.67	3.17	-1.33
A 38 +233	5.520	3.80	3.30	-1.20
A 30	5.692	-	3.67	-
A 23	6.077	-	4.50	-
A 15	6.481	-	5.97	-
A 7	6.920	-	7.58	-
14 A	7.352	-	14.49	-
12 A	7.490	-	14.90	-
4 A	8.175	-	16.91	-
4 A +250	8.425	-	17.64	-
4 A +460	8.635	-	18.25	-
AA12	8.920	-	20.10	-
AA12 +290	9.210	-	22.00	-
AA 6	9.485	-	24.18	-
AA 3	9.895	-	27.44	-
AA 0	10.240	-	30.17	-
Kp Ba	10.660	-	33.50	-

Fig. J-13(2) Proposed Profile of Flood Relief Channel for Comprehensive Plan



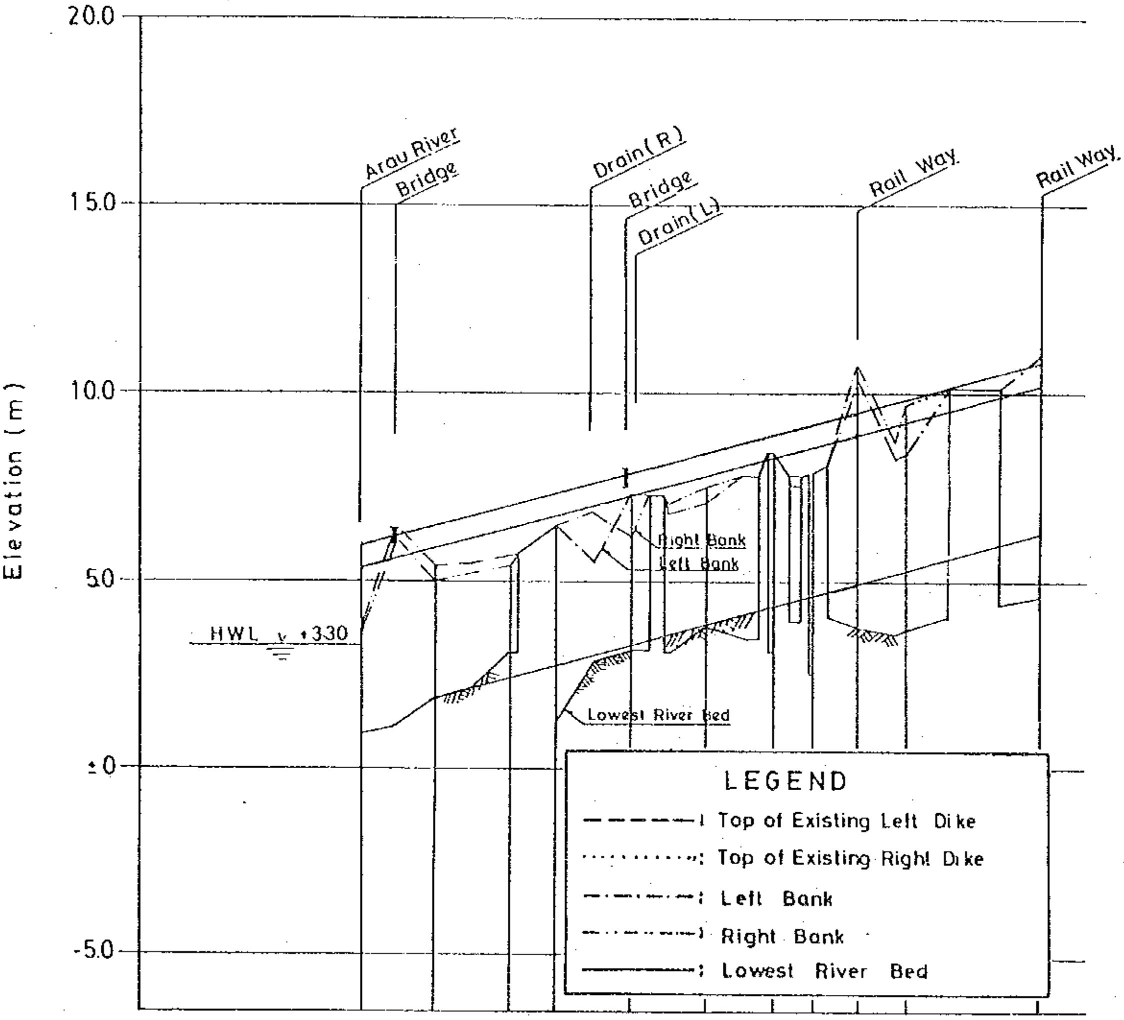
Design Flood Discharge (m³/s): 600 (B 0 – B 10+975); 550 (B 10+975 – B 51+220); 500 (B 51+220 – B 108)

Gradient of H.W.L: 1/720; 1/700; 1/680; 1/660

Gradient of Channel Bed: 1/720; 1/700; 1/680; 1/550

Section No	Distance (m)	Top of Proposed Levee (El.m)	Proposed H.W.L (El.m)	Proposed Channel Bed (El.m)
B 0	0	2.50	1.50	-2.80
B 0+275	275	|	1.88	-2.42
B 7	425	3.09	2.09	-2.21
B 10	630	3.38	2.38	-1.93
B 10+350	980	|	2.86	-1.44
B 10+975	1.605	| |	3.73 / 4.90	-0.57 / 0.80
B 10+1075	1.705	|	5.04	0.94
B 31	1.940	|	5.38	1.28
B 37	2.320	|	5.92	1.82
B 42+150	2.788	7.59 / 8.30	6.59 / 7.30	2.49 / 3.30
B 51	3.273	9.01	8.01	4.01
B 51+220	3.493	9.34 / 10.24	8.34 / 9.24	4.34 / 5.20
B 55	3.683	10.52	9.52	5.46
B 59	4.035	|	10.06	6.06
B 63	4.365	11.56	10.56	6.62
B 69	4.560	11.85	10.85	6.70
B 69+350	4.910	|	11.38	7.54
B 77	5.165	|	11.77	7.98
B 81	5.365	|	12.07	8.31
B 89	5.845	|	12.80	9.13
B 94	6.092	|	13.17	9.55
B 101	6.432	|	13.68	10.12
B 105	6.642	|	14.01	10.48
B 108	6.802	|	14.25	10.80

Fig. J-13(3) Proposed Profile of the Jirak River for Comprehensive Plan



Item											
Design Flood Discharge (m^3/s)	180								100		
Gradient of H.W.L	1/750										
Gradient of Channel Bed	1/750										
Top of Proposed Levee (El. m)	5.90	6.43	6.97	7.29	7.82	8.35	8.83	9.10	9.42	9.87	10.80
Proposed H.W.L (El.m)	5.30	5.83	6.37	6.69	7.22	7.75	8.23	8.50	8.82	9.27	10.20
Proposed Channel Bed (El.m)	-	1.93	2.47	2.79	3.32	3.85	4.33	4.60	4.92	5.37	6.30
Distance (m)	0	400	800	1.040	1.440	1.840	2.200	2.408	2.640	2.980	3.680
Section No.	J 1	J 3	J 5	J 7	J 9	J 13	J 15	J 17	J 19	J 21	J 21 +700

Fig. J-14(1) Proposed Cross Section of the Arau River for Comprehensive Plan

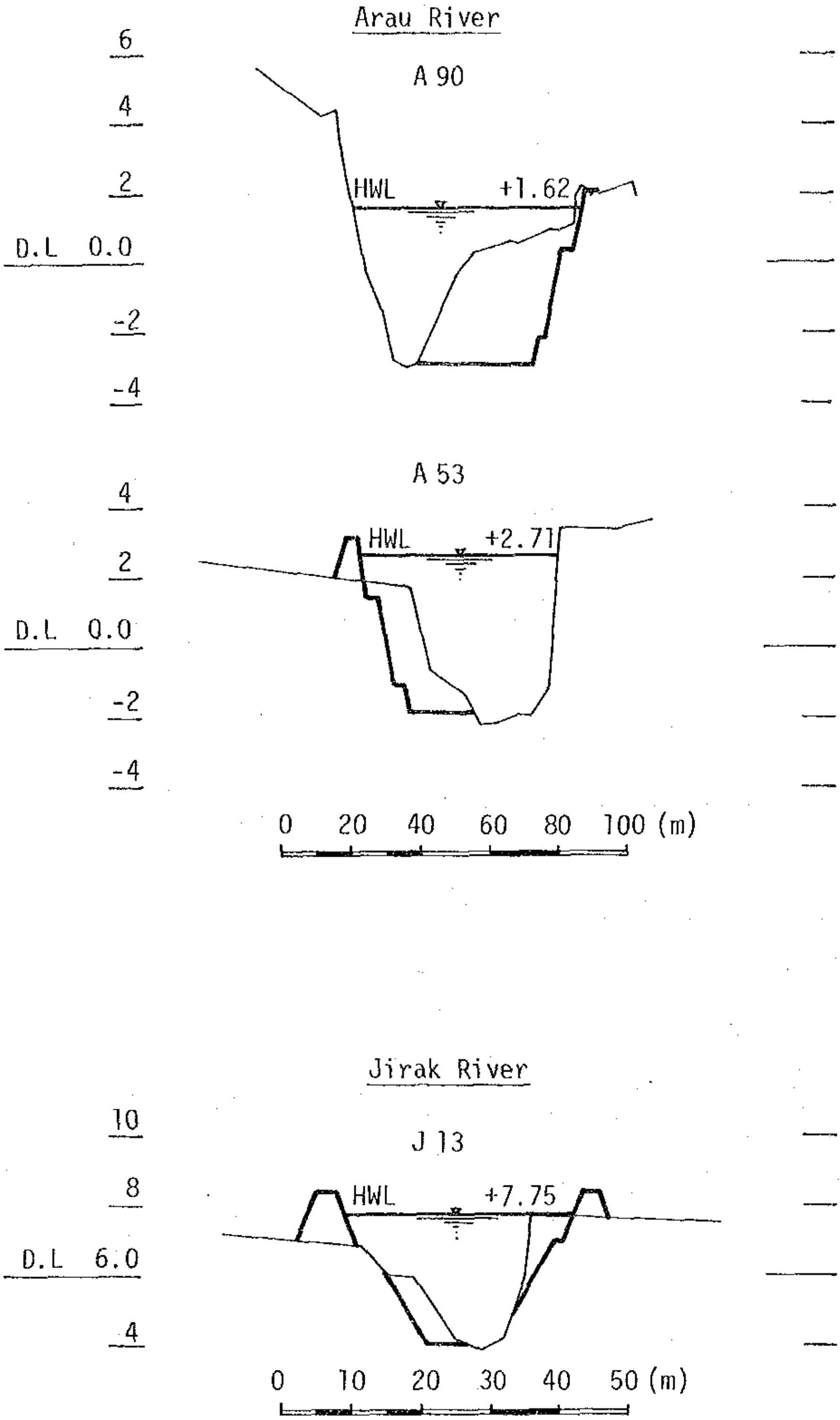


Fig. J-14(2) Proposed Cross Section of Flood Relief Channel for Comprehensive Plan

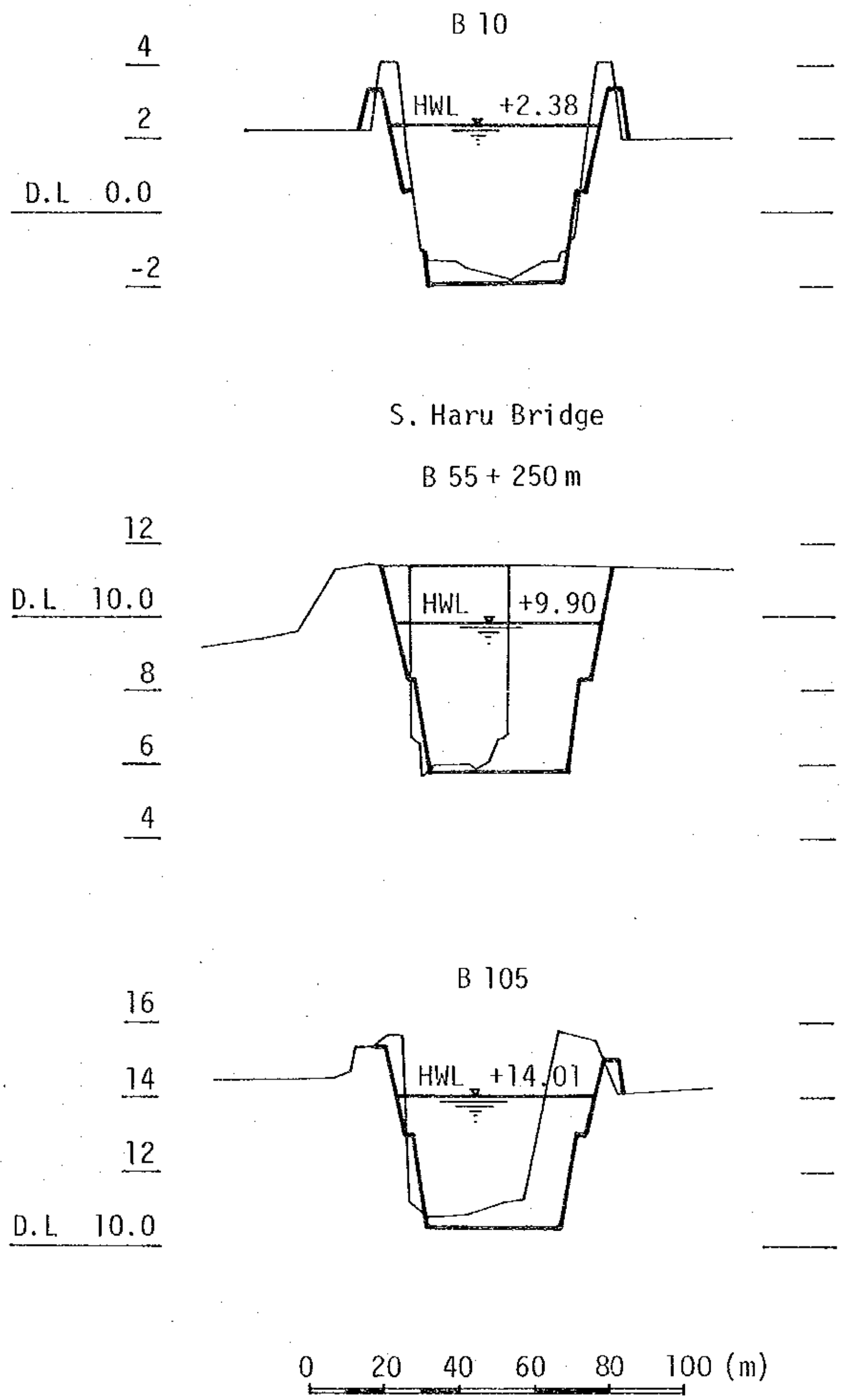
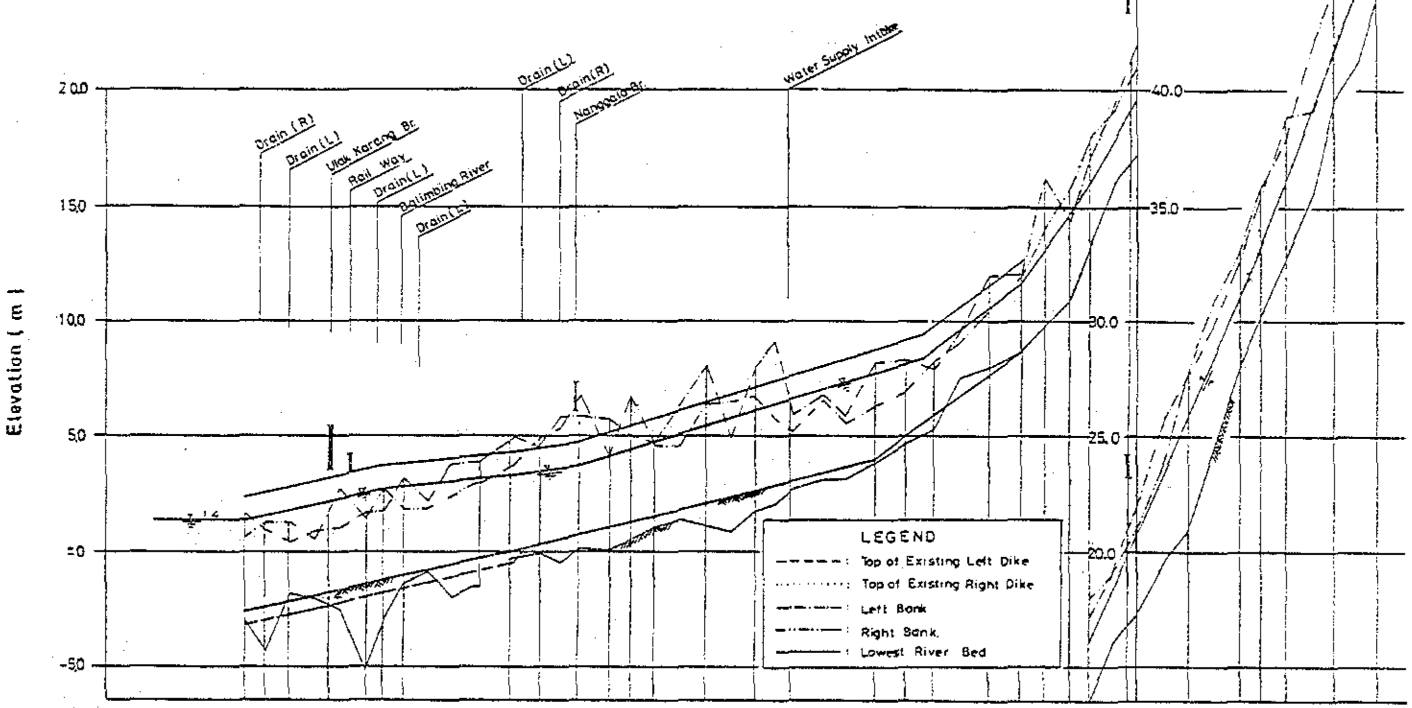


Fig. J - 15 (1) Proposed Profile of the Kuranji River for Comprehensive Plan



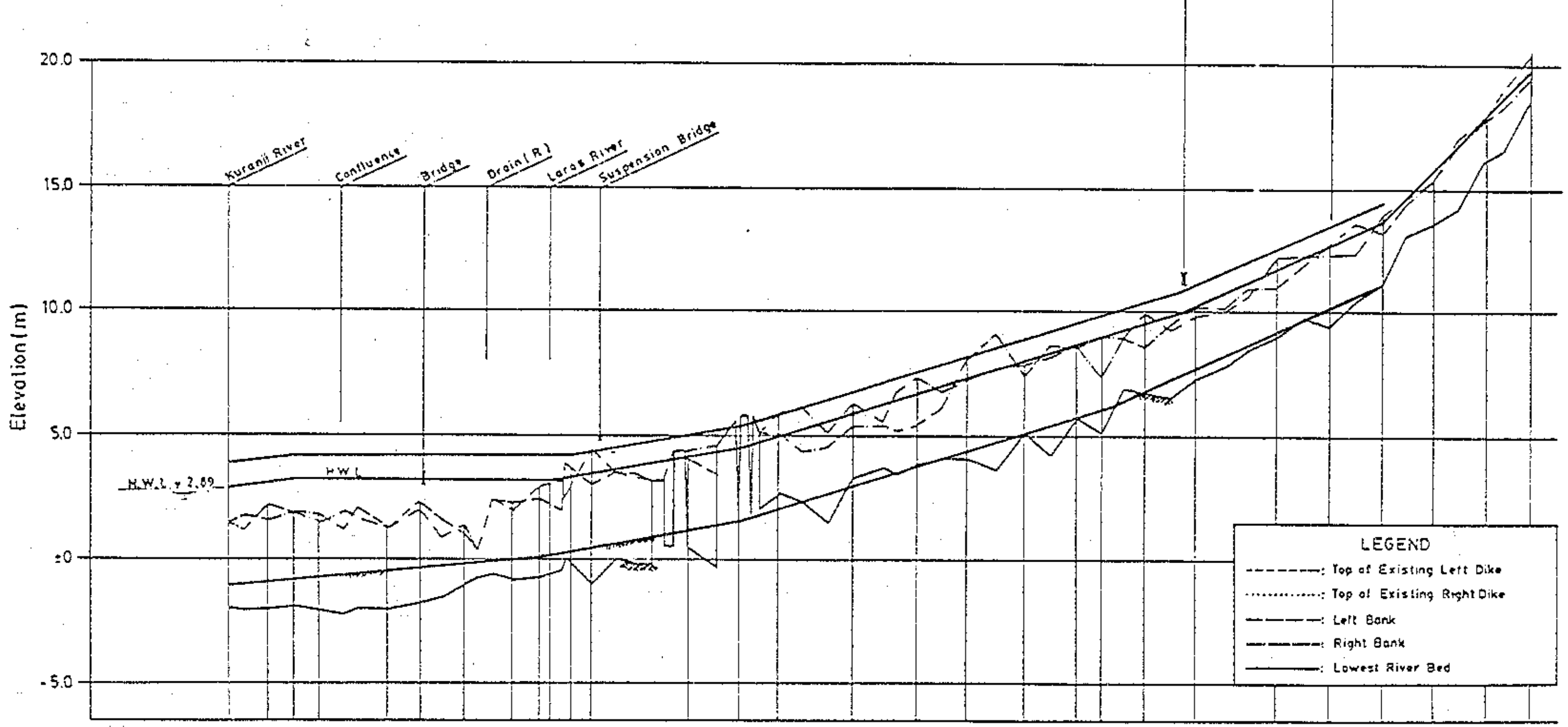
Design Flood Discharge (m3/s): 1000 (K 2 – K 37); 700 (K 37 – PM 3)

Gradient of H.W.L: 1/880 — 1/2000 — 1/400 — 1/770 — 1/260 — 1/130 — 1/85 — 1/80 — 1/75

Gradient of Channel Bed: 1/880 — 1/770 — 1/260

Section No.	Distance	Proposed Channel Bed (El.m)	Proposed H.W.L. (El.m)	Top of Proposed Levee (El.m)
K 2	0	-3.30	1.40	2.40
K 6	173	-2.90	1.60	2.60
K 10	383	-2.66	1.84	2.84
K 10 +350	733	-2.26	2.24	-
K 25	1048	-1.91	2.59	3.59
K 29	1203	-1.73	2.77	3.77
K 37	1368	-1.54	2.85	3.85
K 74	2283	-0.50	3.31	4.31
K 78	2528	0.32	3.91	4.91
K 86	2873	0.77	4.76	5.76
K 91	3118	1.08	5.08	6.08
K 94	3283	1.31	5.31	6.31
K 99	3503	1.58	5.58	6.58
K 107	3933	2.14	6.14	7.18
K 115	4353	2.69	6.69	7.69
K 122	4683	3.11	7.11	8.11
K 134	5388	4.03	8.03	9.03
K 136	5553	5.04	8.37	9.37
K 140	5893	5.96	8.76	9.76
K 147	6363	7.75	10.55	11.55
K 151	6638	8.80	11.60	12.60
K 154	6833	-	13.02	-
PM 51	7063	-	14.70	-
PM 48	7243	-	16.02	-
PM 48 +300	7543	-	19.55	-
PM 32	8020	-	25.82	-
PM 24	8513	-	31.10	-
PM 24 +160	8673	-	33.00	-
PM 17	8913	-	36.09	-
PM 10	9333	-	41.51	-
PM 3	9713	-	46.40	-

Fig. J-15(2) Proposed Profile of the Balimbing River for Comprehensive Plan



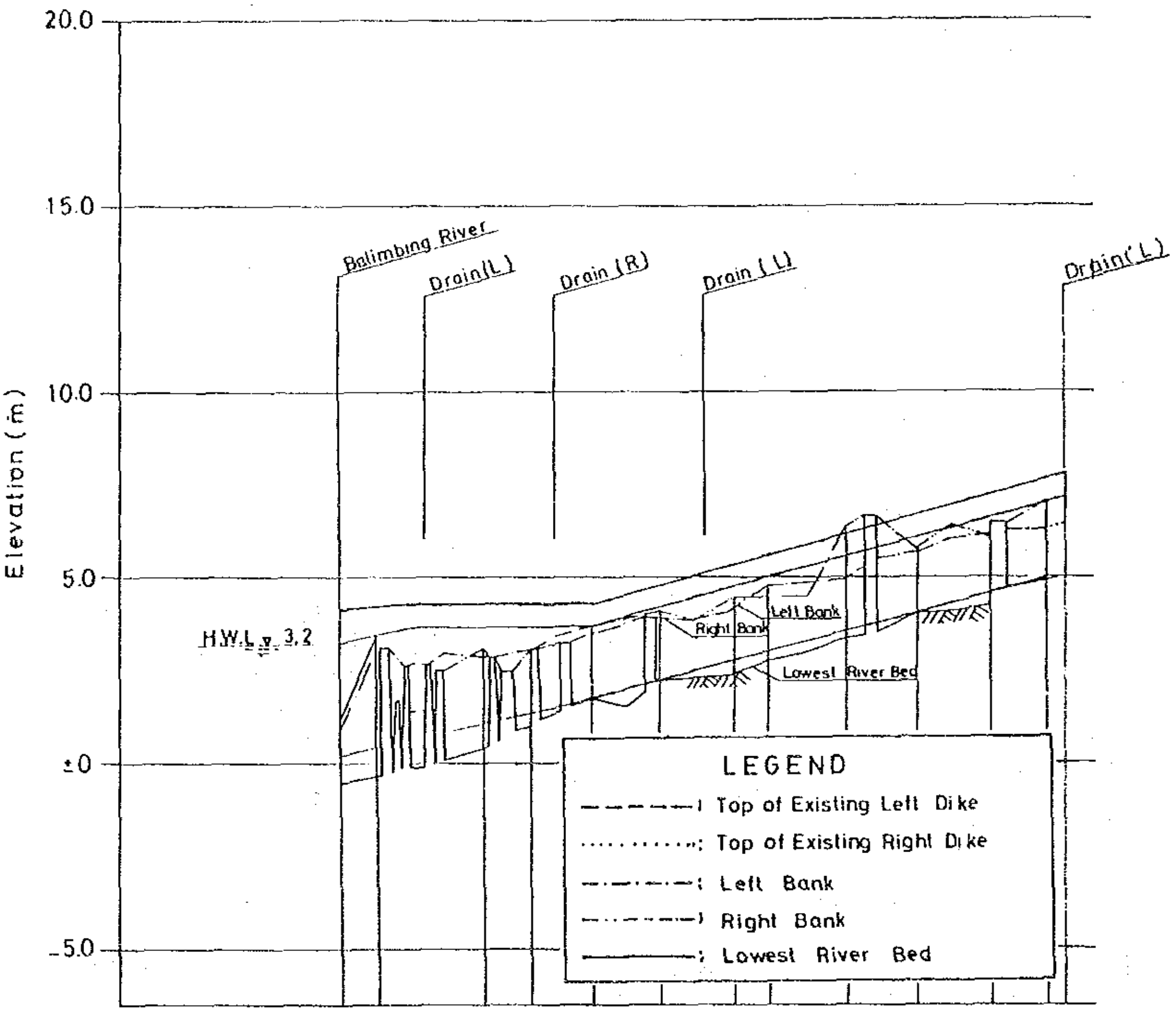
Design Flood Discharge (m³/s): 310 — 300 — 260

Gradient of H.W.L: 1/2425 — Level — 1/1170 — 1/630 — 1/450

Gradient of Channel Bed: 1/2185 — 1/1170 — 1/630 — 1/450

Section No	Distance (m)	Top of Proposed Levee (El.m)	Proposed H.W.L (El.m)	Proposed Channel Bed (El.m)
B 33 -300	0	3.89	2.89	-1.01
B 33	300	4.05	3.06	-0.86
B 37	485	4.16	3.16	-0.77
B 41	650	4.16	3.16	-0.68
B 57	1,230	4.16	3.16	-0.42
B 57 +275	1,505	4.16	3.16	-0.28
B 65	1,835	4.16	3.16	-0.13
B 73	2,210	4.16	3.16	-0.05
B 78	2,435	4.16	3.16	0.16
B78+63	2,515	4.16	3.20	0.20
B78-263	2,702	4.16	3.36	0.35
B 84	2,845	4.28	3.48	0.48
B 115	3,635	4.96	4.16	1.16
B115+400	4,035	5.30	4.50	1.50
B 141	4,355	5.81	5.01	2.01
B 154	4,945	6.75	5.95	2.95
B 164	5,460	7.56	6.76	3.76
B 172	5,860	8.20	7.40	4.40
B 181	6,310	8.91	8.11	5.11
B 189	6,730	9.58	8.78	5.78
+ 200	6,930	9.90	9.10	6.10
A 188	7,220	10.44	9.64	6.85
A 196	7,670	11.05	10.25	7.25
A 209	8,325	12.51	11.71	9.21
A 217	8,745	13.44	12.64	0.14
A 222	9,175	14.40	13.60	11.10
A 234	9,585			
A 243	10,005			
A 245	10,345			

Fig. J-15(3) Proposed Profile of the Laras River for Comprehensive Plan



Section No.	L 1	L 2	+170	L 4	L 6	L 8	L 10	L 12	L 14	L 15	L 17	L 19	L 21	L 23	L 23 +50
Design Flood Discharge (m^3/s)	40		100												
Gradient of H.W.L	1/140		Level				1/800								
Gradient of Channel Bed	1/850						1/800								
Top of Proposed Levee (El.m)	4.16	4.24	4.30	4.30	4.30	4.30	4.30	4.85	5.35	5.60	6.10	6.60	7.10	7.60	7.66
Proposed H.W.L (El.m)	3.20	3.47	3.70	3.70	3.70	3.70	3.70	4.25	4.75	5.00	5.50	6.00	6.50	7.00	7.06
Proposed Channel Bed (El.m)	0.20	0.44	0.64	0.69	1.09	1.38	1.75	2.25	2.75	3.00	3.50	4.00	4.50	5.00	5.05
Distance (m)	0	200	370	420	760	1,000	1,320	1,680	2,080	2,280	2,680	3,040	3,440	3,740	3,790

Fig. J-16(1) Proposed Cross Section of the Kuranji River for Comprehensive Plan

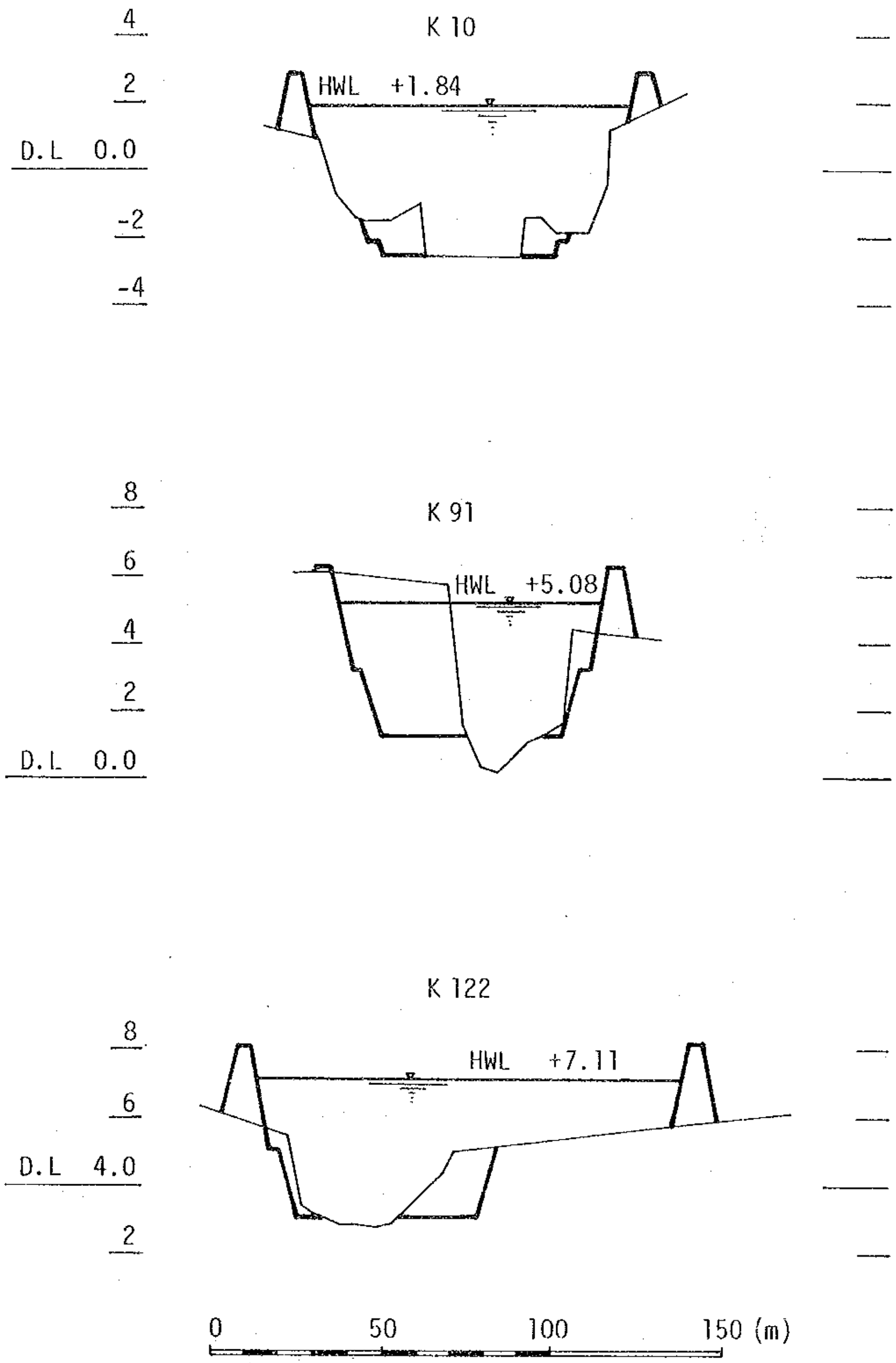


Fig. J-16(2) Proposed Cross Section of the Balimbing River for Comprehensive Plan

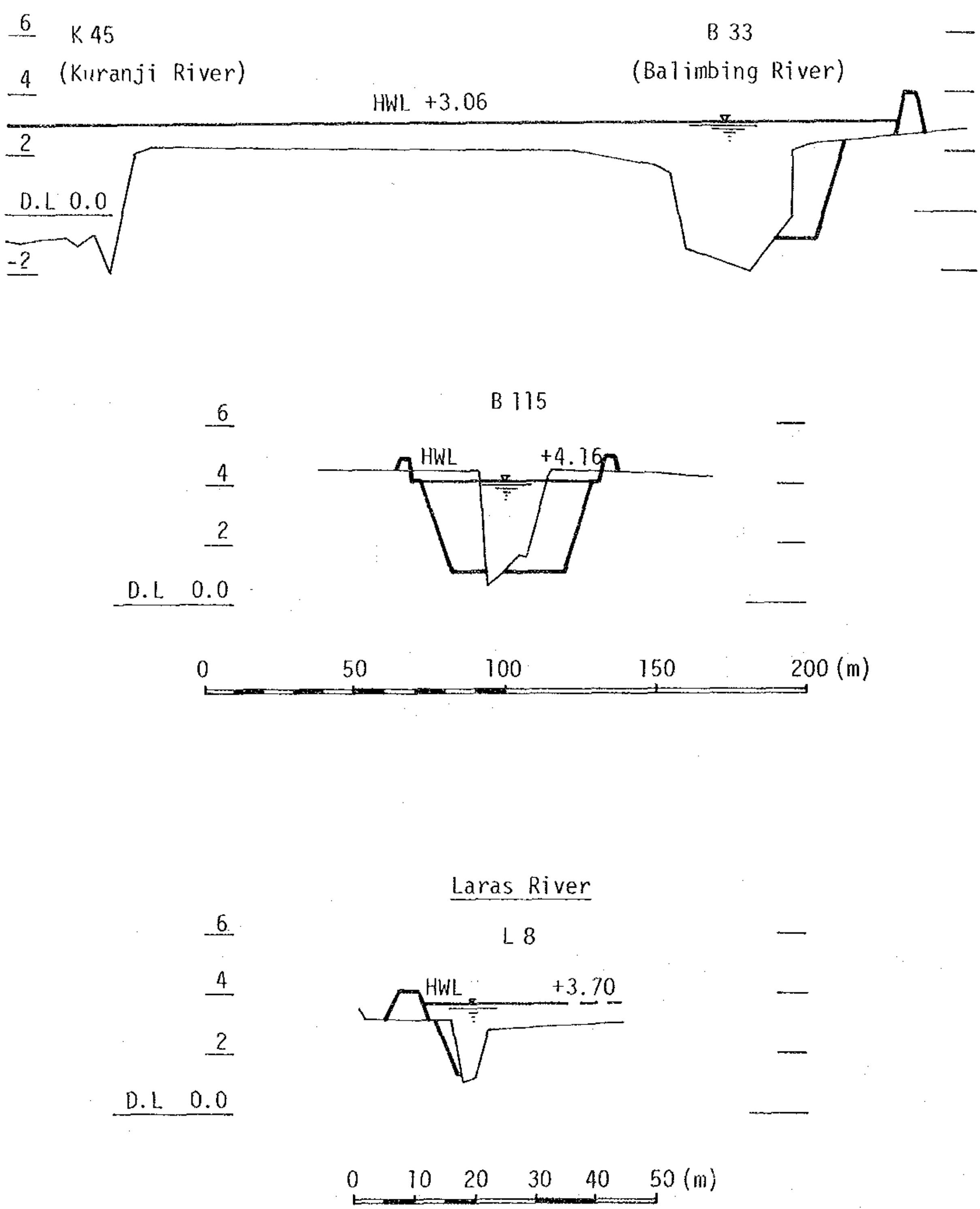
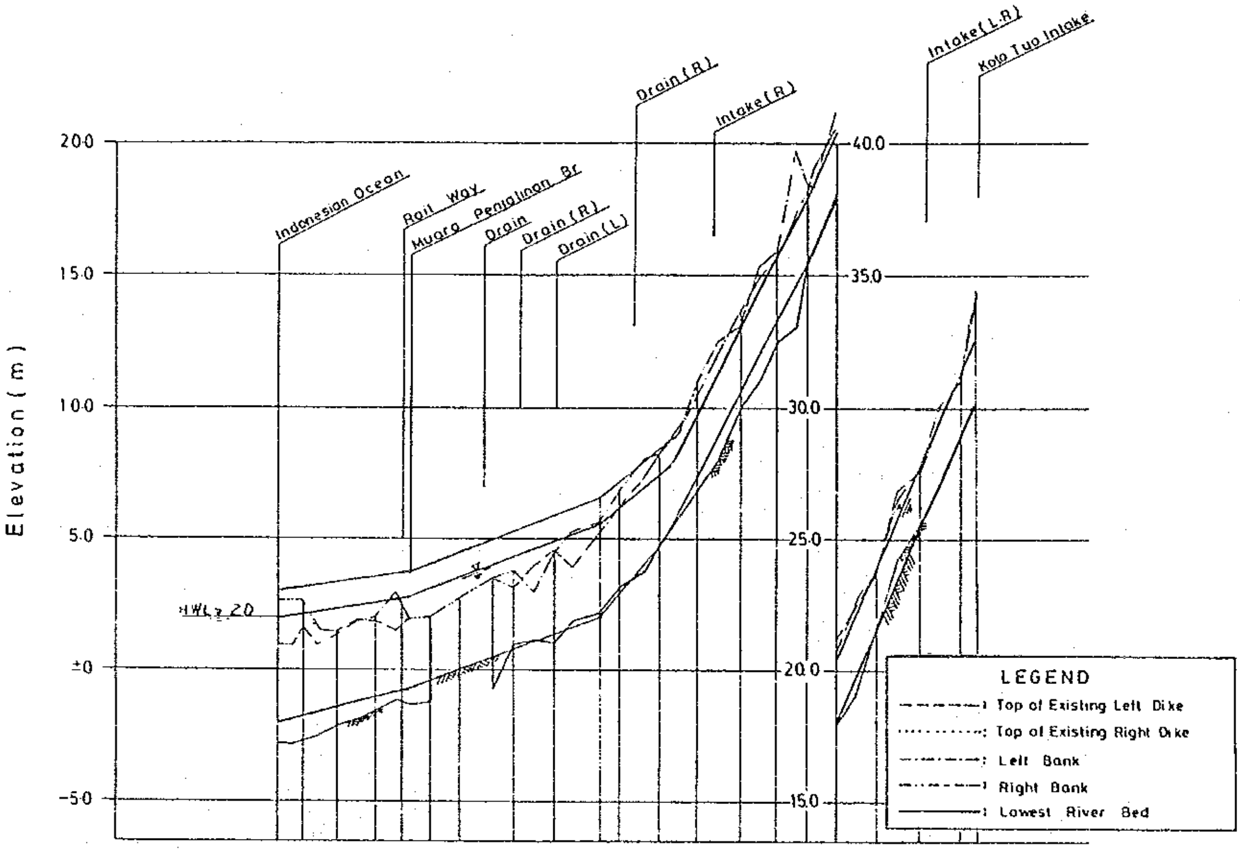


Fig. J-17 Proposed Profile of the Air Dingin River for Comprehensive Plan



Section No	C 0	C 2	C 6	C 12	C 17 +200	C 20	C 20 +225	C 51	C 57	C 64	C 67	C 73	C 80	C 86	C 92	C 97	C 101	C 107	C 114	C 120	C 121
Design Flood Discharge (m^3/s)	700				530																
Gradient of H.W.L	1/1350				1/510					1/225		1/105				1/85					
Gradient of Channel Bed	1/810				1/510					1/150		1/105				1/85					
Top of Proposed Levee (El.m)	3.00	3.15	3.34	3.56	3.75	4.05	3.49	5.26	5.84	6.50	7.11	8.50	-	-	-	-	-	-	-	-	-
Proposed H.W.L (El.m)	2.00	2.15	2.34	2.56	2.75	3.05	3.49	4.26	4.84	5.50	6.11	7.50	10.18	13.30	15.83	17.90	20.43	23.96	27.84	31.43	32.7
Proposed Channel Bed (El.m)	-2.00	-1.76	-1.43	-1.07	-0.75	-0.45	-0.01	0.76	1.34	2.00	2.89	5.90	7.71	10.89	12.41	15.50	18.03	21.56	25.44	29.03	30.3
Distance (m)	0	196	461	751	1.011	1.166	1.391	1.786	2.081	2.421	2.571	2.871	3.156	3.491	3.756	3.976	4.191	4.491	4.821	5.126	5.231

Fig. J-18 Proposed Cross Section of the Air Dingin River for Comprehensive Plan

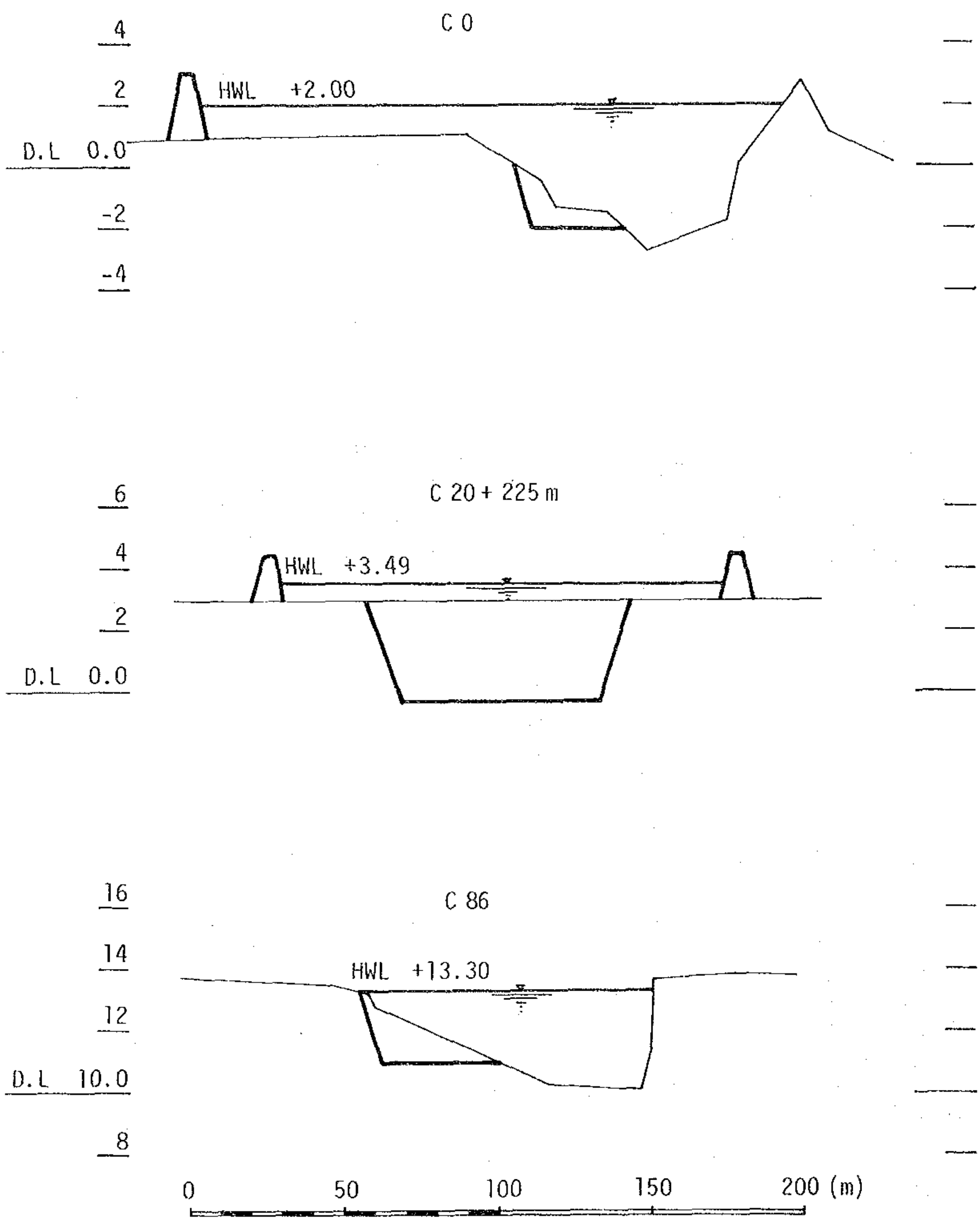
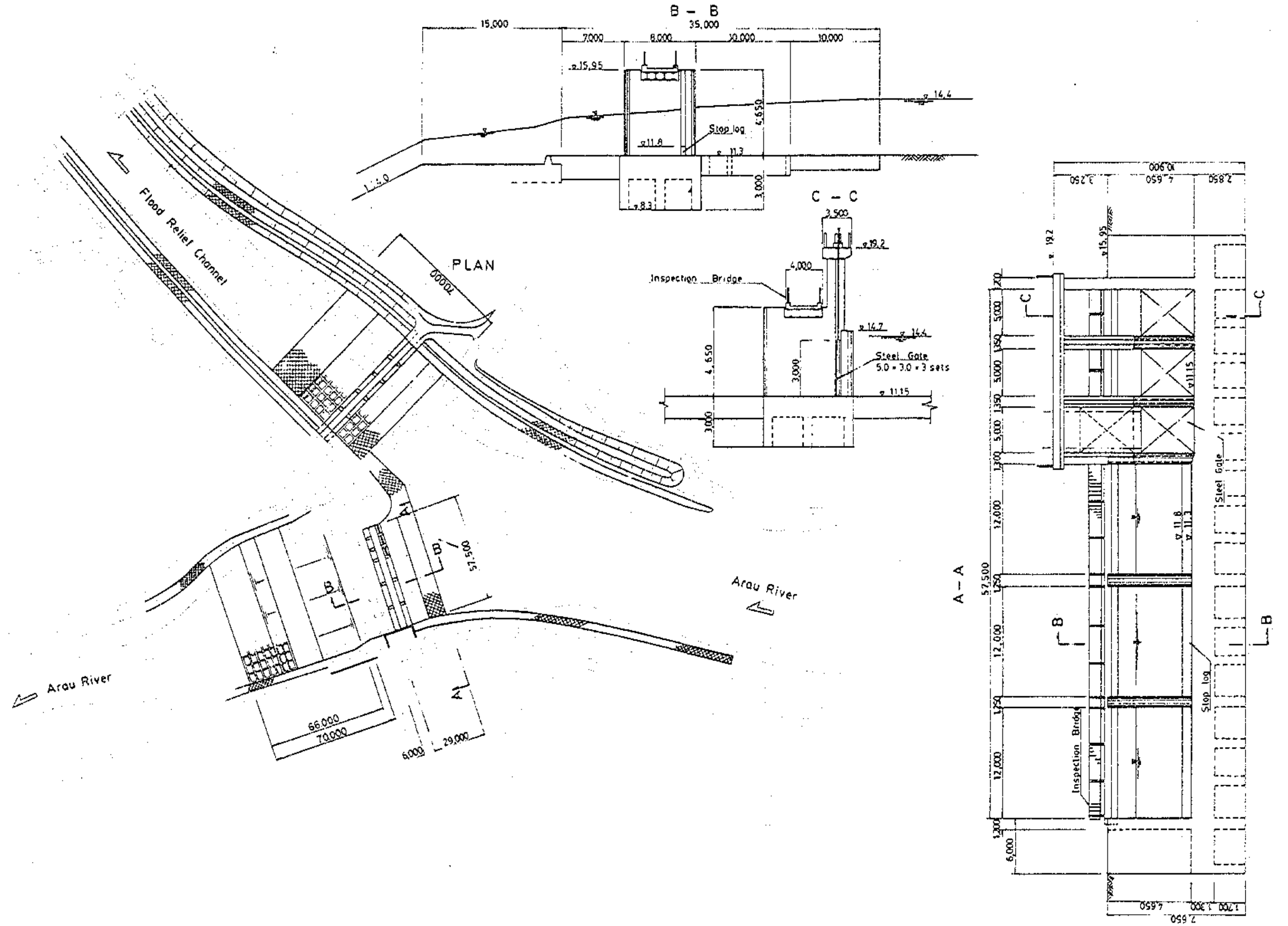


Fig. J-19 Reconstruction of Lubuk Begalung Diversion Weir (Comprehensive Plan)



STUDY ON HYDROLOGICAL EFFECT OF LIMAU MANIS DAN

Storage of flood water due to dam is one of effective flood control methods, which is mainly taken in mountainous area to reduce a peak flood discharge.

An appropriate dam site is recognized in the upper reaches of the Limau Manis river of the Kuranji river basin. The dam site is located at Danau Kering upstream about 11 km away from the Gunung Nago irrigation weir.

According to site inspection conducted by both parties which consists of personnel concerned from DPU and the Study Team, the proposed dam site shows suitable geographical features for dam construction. However, in our judgement it would not be expected to store much volume of flood water because of its comparative small catchment area of 17.5 km^2.

An analytical tool by use of the flood runoff simulation model, which is described in Appendix F, is applied to examine hydrological effect by dam regulation. In calculation it is assumed that stored flood water is discharged from the dam through pipe unartificially. The dam is planned aiming at a probable flood with 50 yr return period. Diameter of the pipe is determined at 1.5 m through a comparative study. Fig. J.1.1 shows that the pipe with 1.5 m in diameter gives the minimum cost among alternatives to yield unit reduction of discharge at Kampung Melayu. Geographical features at the dam site and discharge rating curve at the dam is shown in Fig. J.1.2.

Hydrological effect in terms of reduction of peak flood discharge at major sites is shown in Table J.1.1 with regard to probable floods for five return periods. Comparison of discharge hydrographs with and without the dam for 50 year flood is also shown in Table J.1.2 and Fig. J.1.3. It is recognized that reduction of peak flood discharge at downstream sites is around 10 %.

On the other hand, cost needed to cope with flood with the dam was estimated at Rp.37.8 million while that without the dam amounted to Rp.5.1 million only.

In consideration of the reduction of flood discharge and a huge amount of total cost, alternative taking the Limau Manis dam is not recommendable.

Ten day's mean daily discharge at the dam site is estimated for the referrence. They are shown in Table J.1.3.

Table J.1.1 Reduction of Peak Flood Discharge due to Limau Manis Dam

	Peak flood discharge														
	100 yr. flood			50 yr. flood			25 yr. flood			10 yr. flood			5 yr. flood		
	w/o dam /1	w/dam /2	ΔQ /3	w/o dam	w/dam	ΔQ	w/o dam	w/dam	ΔQ	w/o dam	w/dam	ΔQ	w/o dam	w/dam	ΔQ
Dam site	121	11	110	103	10	93	86	9	77	63	8	55	52	7	45
G. Nago	790	682	108	676	587	89	570	499	71	439	383	56	363	318	45
Kp. Melayu	774	673	101	675	588	87	574	491	83	453	397	56	377	332	45
After confl. of Balimbing R.	1,169	1,096	73	1,055	974	81	926	857	69	768	713	55	639	594	45
River mouth	1,245	1,187	58	1,131	1,046	85	992	916	76	805	750	55	669	625	44

/1 : Without dam

/2 : With dam

/3 : Reduction of peak flood discharge

Table J.1.2 Discharge Hydrograph of 50 year Flood

Date	Time	Limau Manis dam site			Kp. Melayu	
		Inflow (m^3/s)	Outflow (m^3/s)	Storage (10^6 m^3)	Discharge (m^3/s) w/o dam	w/dam
Nov. 23	12	3.09	0.62	0.282	24.32	23.59
	13	3.13	0.64	0.291	24.45	23.70
	14	3.35	0.67	0.300	24.78	23.97
	15	3.34	0.70	0.310	25.58	24.60
	16	3.34	0.73	0.319	26.80	25.57
	17	12.42	0.81	0.345	29.43	27.99
	18	22.68	1.00	0.405	40.93	39.33
	19	42.39	1.35	0.518	93.15	87.14
	20	85.08	2.05	0.741	223.32	201.33
	21	103.22	3.07	1.071	390.47	348.08
	22	81.42	4.07	1.390	596.42	510.16
	23	85.05	4.95	1.674	674.56	588.26
Nov. 24	0	83.30	5.83	1.957	621.35	542.71
	1	82.20	6.69	2.233	609.12	532.99
	2	73.03	7.48	2.487	604.92	528.90
	3	58.65	8.13	2.695	569.97	499.38
	4	45.03	8.62	2.852	504.66	454.42
	5	36.84	8.98	2.968	429.43	382.87
	6	35.39	9.28	3.065	352.85	315.40
	7	29.15	9.54	3.147	299.97	269.51
	8	24.73	9.73	3.209	267.60	241.15
	9	21.47	9.88	3.257	233.66	211.58
	10	18.97	10.00	3.294	199.92	182.67
	11	17.01	10.09	3.323	174.42	160.83
	12	15.43	10.15	3.345	154.18	143.44
	13	14.13	10.21	3.361	138.16	129.67
	14	13.05	10.24	3.373	125.12	118.43
	15	12.14	10.27	3.382	114.35	109.15
	16	11.36	10.29	3.387	105.32	101.35
	17	10.69	10.29	3.390	98.31	96.18
	18	10.10	10.30	3.390	93.37	91.38
	19	9.59	10.29	3.388	88.28	86.79
	20	9.14	10.28	3.385	83.31	82.40
	21	8.74	10.27	3.380	78.73	78.38
	22	8.38	10.25	3.374	74.60	74.76
	23	8.06	10.22	3.367	70.91	71.52
Nov. 25	0	7.77	10.20	3.359	67.60	68.62
	1	7.51	10.17	3.350	64.64	66.00
	2	7.27	10.14	3.340	61.96	63.65
	3	7.05	10.11	3.329	59.54	61.51
	4	6.85	10.07	3.318	57.35	59.56
	5	6.66	10.03	3.306	55.35	57.78
	6	6.50	9.99	3.293	53.52	56.15
	7	6.34	9.95	3.281	51.84	54.65
	8	6.19	9.91	3.267	50.29	53.27
	9	6.06	9.87	3.254	49.15	51.98
	10	5.93	9.83	3.240	48.03	50.79
	11	5.82	9.78	3.226	46.90	49.77
	12	5.71	9.74	3.211	45.79	48.96
	13	5.60	9.69	3.197	44.73	48.10
	14	5.51	9.65	3.182	43.72	47.24
	15	5.42	9.60	3.167	42.77	46.40
	16	5.33	9.55	3.152	41.88	45.59
	17	5.25	9.51	3.137	41.04	44.83
	18	5.18	9.46	3.121	40.26	44.10

Table J.1.3 (1) Mean Daily Discharge at the Dam

LOW WATER FLOW ANALYSIS (LIMAU MANIS DAM SITE) 1979. (1979) - Q -

	1	2	3	4	5	6	7	8	9	10	11	12	
1	3.95	1.82	13.86**	6.35	10.87	-	3.58	2.18	2.78	-	6.72	5.43	
2	3.03	13.86	2.42	3.03	7.27	7.64	2.42	1.57	1.57	-	4.50	3.95	
3	8.39	0.97 *	0.36 *	9.63	6.72	3.58	1.82	1.21	3.95	-	3.58 *	10.13	
4	4.50	-	-	23.54	4.87	2.42	3.58	0.61	0.97	-	6.72	20.10**	
5	7.64	-	0.36 *	31.06**	3.03	8.89	7.27	0.61	-	-	4.50	12.61	
6	6.72	-	1.21	7.64	11.37**	4.50	6.35	0.36 *	3.58	-	8.39	7.64	
7	8.39	8.39	0.97	4.50	8.89	8.89	5.43	1.57	7.64	-	17.91	11.37	
8	6.35	5.43	5.80	3.58	5.43	6.35	2.42	1.57	9.63	-	20.10	8.39	
9	5.43	6.35	2.78	9.63	3.95	4.50	0.97	0.61	5.43	-	11.37	6.35	
10	5.43	3.95	0.36 *	4.87	2.42	4.50	0.36 *	0.61	4.50	-	7.27	4.87	
11	3.95	3.95	-	2.42	1.82	6.35	6.35	-	3.58	10.13	5.43	3.03	
12	3.58	3.58	0.61	3.58	2.18	4.50	3.95	-	1.57	8.39	4.50	1.82	
13	5.43	2.42	-	3.95	1.21	3.03	2.42	-	1.82	4.50	4.50	1.21	
14	5.43	4.50	-	1.82	1.21	3.95	1.57	-	1.57	6.72	6.35	1.21	
15	4.87	4.87	-	1.57 *	0.61	-	0.36 *	-	1.21	3.58	7.27	-	
16	5.80	3.58	-	5.43	0.61	1.57	1.57	-	10.13**	2.18	11.37	-	
17	3.58	2.78	-	3.03	0.61	9.63	0.36 *	-	6.72	0.97	9.63	-	
18	3.03	6.35	-	2.18	-	14.79**	0.97	-	3.95	0.36 *	15.42	-	
19	2.42	4.50	-	1.57 *	-	8.39	-	-	2.18	-	17.91	1.21	
20	13.86**	2.42	-	10.87	-	4.50	0.61	0.36 *	0.97	-	20.10	-	
21	1.82	1.82	-	9.63	-	2.78	2.78	2.18	1.82	10.87	16.98	-	
22	1.21 *	1.21	3.03	7.64	-	1.82	5.43	4.50	3.03	1.57	10.13	-	
23	1.82	1.82	-	2.78	3.03	1.21	2.42	12.61**	1.57	1.57	15.42	-	
24	12.61	1.21	3.03	2.78	0.36 *	0.61	0.61	7.64	0.97	0.61	13.36	-	
25	4.87	12.61	-	5.43	2.18	0.36 *	-	4.87	0.36 *	1.21	13.86	0.61 *	
26	3.58	15.42**	3.03	3.03	0.36 *	-	10.13**	3.03	-	1.57	9.63	-	
27	2.42	5.43	6.35	5.43	-	-	6.35	2.18	-	15.42**	37.66**	-	
28	1.82	3.03	3.95	5.80	0.61	0.36 *	3.03	2.18	-	6.72	13.86	-	
29	2.78		0.97	2.78	-	-	8.89	10.87	-	3.03	9.63	-	
30	1.82		0.36 *	2.42	0.61	2.78	6.35	4.50	-	2.78	7.27	5.80	
31	6.35		6.72		-		3.58	6.35		3.58		0.97	
SUM.	152.84	122.24	56.15	187.97	80.18	117.91	101.91	72.17	81.49	85.76	341.34	106.68	1506.656
MEAN	4.930	4.890	3.120	6.266	3.486	4.716	3.514	3.281	3.396	4.514	11.378	5.927	5.1247
	20	26	1	5	6	18	26	23	16	27	27	4	11 27
MAX.	13.86	15.42	13.86	31.06	11.37	14.79	10.13	12.61	10.13	15.42	37.66	20.10	37.658
	22	3	3	15	24	25	10	6	25	18	3	25	3 3
MIN.	1.21	0.97	0.36	1.57	0.36	0.36	0.36	0.36	0.36	0.36	3.58	0.61	0.363
							Max.	95-Day	185-Day	275-Day	355-Day	Min.	
							37.66	5.80	2.78	0.61	-	-	
1	5.982	5.822	3.125	10.384	6.482	5.697	3.420	1.089	4.451	-	9.107	9.084	
2	5.193	3.896	0.605	3.641	1.176	6.302	2.018	0.363	3.369	4.603	10.249	1.694	
3	3.735	5.316	3.428	4.772	1.190	1.418	4.955	5.538	1.549	4.448	14.778	2.456	
1	5.502	5.546	4.250	14.722	6.553	5.632	3.734	1.234	2.318	-	5.205	10.443	
2	6.462	6.028	2.224	6.046	6.410	5.749	3.106	0.944	6.156	-	13.009	7.725	
3	4.651	3.865	0.605	2.667	1.404	4.457	2.931	-	1.950	6.664	5.611	1.815	
4	5.735	3.927	-	4.615	0.605	7.777	0.877	0.363	4.788	1.170	14.887	1.210	
5	4.465	3.733	3.025	5.653	1.856	1.355	2.809	6.362	1.549	3.167	13.947	0.605	
6	3.127	7.956	3.562	3.890	0.524	1.573	6.386	4.851	-	5.516	15.610	3.382	

Table J.1.3 (2) Mean Daily Discharge at the Dam

LOW WATER FLOW ANALYSIS (LIMAU MANIS DAM SITE) 1980. (1980) - Q -

	1	2	3	4	5	6	7	8	9	10	11	12	
1	-	-	0.61	3.95	7.27	1.57	-	-	0.00 *	1.57	-	-	
2	3.58	-	0.36 *	2.78	6.72	1.82	-	-	0.00 *	2.42	-	-	
3	1.82	-	-	1.21 *	4.50	3.58	-	0.97	0.00 *	7.27	-	-	
4	0.97	0.97	-	3.58	3.03	4.87	-	0.61	0.00 *	6.72	-	-	
5	2.42	-	2.42	4.87	9.63**	13.86**	-	-	0.00 *	5.43	-	-	
6	0.61 *	-	0.61	2.42	8.89	8.89	-	-	-	4.50	-	-	
7	3.95	-	6.72**	1.57	5.80	5.43	-	-	3.03	2.18	-	-	
8	1.57	-	6.72**	4.87	4.50	3.95	-	21.66**	5.80**	3.58	-	-	
9	0.61 *	-	2.42	10.87	3.58	2.18	-	21.66**	5.80**	4.50	-	-	
10	0.97	-	-	12.61**	6.72	1.21	-	5.80	2.78	7.27	-	-	
11	0.61 *	-	-	8.89	6.72	1.21	-	3.03	1.21	3.95	-	-	
12	-	-	-	4.87	3.95	0.61 *	-	2.78	0.61	3.58	-	-	
13	10.13	-	1.82	9.63	3.03	0.97	-	2.18	0.00 *	2.78	-	-	
14	1.21	-	-	7.64	4.87	0.61 *	-	2.18	0.00 *	3.03	-	-	
15	-	-	-	8.89	4.50	-	-	0.61	0.00 *	4.87	-	-	
16	-	-	-	6.35	3.03	-	-	0.61	0.00 *	3.95	-	-	
17	-	-	-	8.39	2.18	-	1.21	0.97	0.00 *	2.78	-	-	
18	-	-	-	6.35	1.82	-	1.57	0.36 *	0.00 *	3.58	-	-	
19	-	-	-	3.58	1.21	-	-	0.61	-	2.18	-	-	
20	-	-	-	5.43	0.61	-	-	0.61	-	1.21	-	-	
21	-	-	-	5.80	0.61	-	1.21	0.61	0.97	0.97	-	-	
22	-	0.36 *	-	6.72	0.61	-	6.72	0.61	2.42	0.61 *	-	-	
23	12.12**	-	-	6.35	0.36 *	-	6.35	0.36 *	0.97	0.61 *	-	-	
24	8.39	0.61	3.95	6.35	-	-	-	-	0.00 *	0.61 *	-	-	
25	2.42	-	-	5.43	4.87	1.21	7.64**	0.61	0.00 *	3.58	-	-	
26	2.42	-	3.58	3.58	2.42	3.03	6.35	0.97	1.82	4.87	-	-	
27	0.61 *	1.21	0.97	3.03	0.61	-	4.50	-	0.97	6.72	-	-	
28	-	-	0.61	3.95	0.61	-	3.03	-	2.42	8.89	-	-	
29	-	2.18**	4.87	2.42	0.36 *	-	3.58	-	4.87	8.89	-	-	
30	-		1.82	6.35	-	-	0.97	-	1.82	29.18**	-	-	
31	-		1.57		-		0.36 *	0.97		11.37		-	
SUM.	54.38	5.32	39.03	168.72	102.98	54.97	43.49	68.72	35.46	153.64	-	-	726.713
MEAN	3.199	1.065	2.602	5.624	3.678	3.436	3.625	3.273	1.313	4.956	-	-	3.5976
MAX.	23 12.12	29 2.18	7 6.72	10 12.61	5 9.63	5 13.86	25 7.64	8 21.66	8 5.80	30 29.18	-	-	10 30 29.181
MIN.	6 0.61	22 0.36	2 0.36	3 1.21	23 0.36	12 0.61	31 0.36	18 0.36	16 0.00	22 0.61	-	-	9 16 0.000
							Max. 29.18	95-Day 2.78	185-Day 0.36	275-Day -	355-Day -	Min. -	
1	1.831	0.968	2.836	4.875	6.063	4.734	-	10.138	1.933	4.545	-	-	
2	3.981	-	1.815	7.001	3.190	0.847	1.392	1.392	0.227	3.191	-	-	
3	5.190	1.089	2.480	4.997	1.305	2.118	4.071	0.686	1.625	6.934	-	-	
1	2.196	0.968	1.129	3.279	6.230	5.139	-	0.787	0.000	4.683	-	-	
2	1.540	-	4.116	6.470	5.897	4.330	-	16.373	4.350	4.407	-	-	
3	3.981	-	1.815	7.983	4.614	0.847	-	2.154	0.363	3.642	-	-	
4	-	-	-	6.019	1.767	-	1.392	0.629	0.000	2.740	-	-	
5	7.641	0.484	3.949	6.128	1.611	1.210	5.481	0.545	0.871	1.273	-	-	
6	1.513	1.694	2.236	3.865	0.998	3.025	3.131	0.968	2.378	11.652	-	-	

Table J.1.3 (3) Mean Daily Discharge at the Dam

LOW WATER FLOW ANALYSIS (LIMAU MANIS DAM SITE) 1981. (1981) - Q -

	1	2	3	4	5	6	7	8	9	10	11	12	
1	3.95	0.00 *	1.57**	1.57	3.95	6.90**	0.00 *	6.17**	0.00 *	0.97	10.62	2.42	
2	5.80**	0.00 *	1.57**	1.82	3.95	3.39	0.00 *	3.39	0.00 *	0.61	7.09	9.38	
3	5.80**	0.00 *	0.24	2.66	1.45	2.42	0.00 *	2.42	0.00 *	0.00 *	5.24	12.61**	
4	5.43	0.00 *	0.00 *	2.66	2.66	4.87	0.00 *	1.82	0.00 *	0.00 *	4.32	10.62	
5	3.58	0.00 *	0.00 *	16.98**	2.06	3.95	1.82	1.45	0.00 *	3.03	2.66	8.89	
6	2.66	0.00 *	0.36	9.38	1.57	3.03	1.45	1.21	0.00 *	1.82	1.82	5.80	
7	3.58	0.00 *	0.36	7.64	1.21	1.82	0.61	0.61	0.00 *	2.66	1.21	4.87	
8	3.39	0.00 *	0.36	5.24	0.61 *	1.57	0.00 *	0.00 *	3.39	5.80	1.21	3.95	
9	2.42	0.00 *	0.24	5.80	1.57	2.06	0.00 *	0.00 *	7.09	6.17	0.61	2.78	
10	2.06	-	0.00 *	8.14	1.82	6.17	0.00 *	0.00 *	3.39	10.62	0.61	1.21	
11	1.21	0.00 *	0.00 *	7.09	2.66	2.78	0.00 *	0.00 *	4.50	9.63	0.61	2.18	
12	0.36	0.00 *	0.00 *	4.32	4.32	2.06	0.00 *	0.00 *	4.32	9.63	0.36	1.45	
13	0.00 *	0.00 *	0.00 *	2.78	3.58	1.57	0.00 *	0.00 *	9.63	7.64	0.36	0.97	
14	0.00 *	0.00 *	0.00 *	2.66	3.95	2.66	1.21	0.00 *	5.80	16.98	0.85	3.95	
15	0.00 *	0.00 *	0.00 *	1.57	2.66	2.06	0.00 *	0.00 *	4.87	29.18**	0.36	1.45	
16	0.00 *	0.00 *	0.00 *	1.21	1.45	1.21	1.45	0.00 *	10.62**	15.42	0.24	0.97	
17	0.00 *	0.00 *	0.00 *	1.82	2.06	1.21	0.85	0.00 *	5.80	9.63	0.00 *	2.06	
18	0.00 *	0.00 *	0.00 *	1.45	0.61 *	1.21	4.32	0.00 *	4.32	7.64	0.00 *	3.03	
19	0.00 *	0.00 *	0.00 *	0.85	4.50	1.45	4.32	0.00 *	2.06	6.17	0.00 *	1.21	
20	0.00 *	1.45	0.00 *	0.61	1.21	1.45	1.45	0.00 *	6.35	7.09	9.63	0.61	
21	0.00 *	0.00 *	-	0.85	0.61 *	0.61	0.24	0.00 *	6.17	7.64	12.12	0.61	
22	2.18	2.66	0.00 *	0.61	0.61 *	0.00 *	1.82	0.00 *	4.87	6.53	6.17	0.00 *	
23	0.97	1.21	0.00 *	0.00 *	0.61 *	0.00 *	9.63	0.00 *	6.17	7.09	5.24	0.00 *	
24	0.00 *	4.87	0.00 *	0.00 *	5.43	0.00 *	3.39	0.00 *	4.87	8.14	7.27	0.00 *	
25	0.00 *	5.24**	0.00 *	8.39	4.50	0.00 *	1.45	0.00 *	2.66	5.80	9.63	0.00 *	
26	0.00 *	3.58	0.00 *	6.72	4.32	0.00 *	1.21	0.00 *	5.43	6.17	18.54**	0.00 *	
27	0.00 *	1.45	0.00 *	4.50	4.50	0.00 *	1.45	0.00 *	7.09	5.80	7.09	0.00 *	
28	0.00 *	0.24	0.00 *	3.03	7.27**	0.00 *	6.72	0.00 *	3.95	4.87	5.24	0.00 *	
29	0.00 *		0.36	1.82	3.39	0.00 *	10.13**	0.00 *	1.82	13.36	4.32	0.00 *	
30	1.45		0.00 *	3.95	2.18	0.00 *	8.39	0.00 *	1.21	8.89	2.78	0.61	
31	1.45		0.00 *		3.39		9.38	0.00 *		5.24		0.85	
SUM.	46.28	20.71	5.08	116.10	84.65	54.45	71.29	17.06	116.37	230.19	126.19	82.46	970.844
MEAN	1.493	0.767	0.169	3.870	2.731	1.815	2.300	0.550	3.879	7.425	4.206	2.660	2.6745
	2	25	1	5	28	1	29	1	16	15	26	3	10 15
MAX.	5.80	5.24	1.57	16.98	7.27	6.90	10.13	6.17	10.62	29.18	18.54	12.61	29.181
	20	5	18	24	8	29	4	28	7	4	19	29	8 28
MIN.	0.00	0.00	0.00	0.00	0.61	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.000
							Max.	95-Day	185-Day	275-Day	355-Day	Min.	
							29.18	3.95	1.45	0.00	0.00	-	
1	3.866	0.000	0.472	6.189	2.085	3.618	0.387	1.706	1.388	3.166	3.538	6.254	
2	0.157	0.145	0.000	2.436	2.700	1.767	1.360	0.000	5.827	11.901	1.241	1.787	
3	0.550	2.408	0.036	2.985	3.346	0.061	4.892	0.000	4.423	7.229	7.840	0.187	
1	4.909	0.000	0.678	5.138	2.814	4.308	0.363	3.050	0.000	0.920	5.987	8.785	
2	2.823	0.000	0.266	7.241	1.355	2.927	0.411	0.363	2.776	5.413	1.089	3.722	
3	0.315	0.000	0.000	3.685	3.434	2.227	0.242	0.000	5.824	14.613	0.508	2.000	
4	0.000	0.290	0.000	1.186	1.966	1.307	2.478	0.000	5.829	9.189	1.775	1.573	
5	0.629	2.797	0.000	1.968	2.349	0.121	3.307	0.000	4.947	7.040	[illegible]	0.121	
6	0.484	1.758	0.061	4.002	4.177	0.000	6.213	0.000	3.898	7.386	[illegible]	0.242	

Table J.1.3 (4) Mean Daily Discharge at the Dam

LOW WATER FLOW ANALYSIS (LIMAU MANIS DAM SITE) 1982. (1982) - Q -

	1	2	3	4	5	6	7	8	9	10	11	12	
1	0.97	0.00 *	4.50	0.97	6.72**	0.61	0.00**	0.00**	0.00 *	0.00 *	0.00 *	7.09	
2	1.21	0.00 *	3.95	0.97	5.80	0.00 *	0.00**	0.00**	0.00 *	0.24	0.00 *	4.87	
3	0.85	0.00 *	2.06	0.97	5.43	0.00 *	0.00**	0.00**	0.00 *	0.00 *	0.00 *	3.95	
4	0.85	0.00 *	2.76	0.61	3.95	0.00 *	0.00**	0.00**	0.00 *	0.00 *	0.00 *	4.32	
5	0.97	0.00 *	6.17	0.36 *	3.03	0.00 *	0.00**	0.00**	0.00 *	1.57	-	4.87	
6	0.61	0.00 *	11.37	1.57	2.18	0.85	0.00**	0.00**	0.00 *	0.85	2.06	6.72	
7	0.00 *	0.00 *	8.39	1.57	3.39	0.97**	0.00**	0.00**	0.00 *	0.00 *	3.58	4.32	
8	0.00 *	0.36	7.27	0.97	3.39	0.00 *	0.00**	0.00**	0.00 *	0.00 *	3.03	2.18	
9	0.00 *	0.00 *	3.39	2.06	3.95	0.00 *	0.00**	0.00**	0.00 *	0.00 *	4.32**	1.82	
10	0.00 *	0.97	1.82	2.18	2.66	0.00 *	0.00**	0.00**	0.00 *	3.03**	2.18	1.45	
11	4.50**	0.61	1.57	0.61	1.45	0.00 *	0.00**	0.00**	0.00 *	2.42	2.06	1.45	
12	2.78	2.06	2.66	0.97	1.21	0.00 *	0.00**	0.00**	0.00 *	-	1.21	1.57	
13	0.85	3.39	5.24	1.45	2.06	0.00 *	0.00**	0.00**	0.00 *	0.61	0.85	1.21	
14	1.82	0.85	3.95	1.57	4.50	0.00 *	0.00**	0.00**	0.00 *	0.24	0.24	0.85	
15	0.61	1.57	3.58	0.97	1.82	0.00 *	0.00**	0.00**	0.00 *	-	-	1.57	
16	0.00 *	0.85	3.39	0.97	1.82	0.00 *	0.00**	0.00**	0.00 *	0.24	-	2.78	
17	0.00 *	0.24	2.18	1.57	0.97	0.00 *	0.00**	0.00**	0.00 *	0.00 *	-	1.45	
18	0.00 *	0.00 *	3.39	0.97	1.21	0.00 *	0.00**	0.00**	0.00 *	0.24	0.36	1.21	
19	0.00 *	3.03	4.32	1.57	5.24	0.00 *	0.00**	0.00**	0.00 *	0.36	0.00 *	0.61	
20	0.00 *	1.57	3.95	2.78	6.17	0.00 *	0.00**	0.00**	0.00 *	-	0.85	0.36	
21	0.00 *	3.58**	2.18	3.39	5.80	0.00 *	0.00**	0.00**	0.00 *	0.00 *	0.36	0.85	
22	0.00 *	1.82	5.43	9.63	3.03	0.00 *	0.00**	0.00**	2.06**	0.00 *	0.85	-	
23	0.00 *	1.21	13.11**	8.39	2.06	0.00 *	0.00**	0.00**	0.00 *	0.00 *	0.00 *	0.00 *	
24	0.00 *	0.61	6.72	3.95	1.45	0.00 *	0.00**	0.00**	0.00 *	0.00 *	0.00 *	0.00 *	
25	0.00 *	0.24	6.17	7.64	0.97	0.00 *	0.00**	0.00**	0.00 *	0.00 *	0.00 *	0.00 *	
26	0.00 *	0.00 *	4.50	10.13	-	0.00 *	0.00**	0.00**	0.00 *	0.00 *	-	10.13**	
27	0.00 *	0.00 *	3.39	7.27	0.00 *	0.00 *	0.00**	0.00**	0.00 *	0.00 *	3.39	6.17	
28	0.00 *	0.00 *	2.42	6.72	1.21	0.00 *	0.00**	0.00**	0.00 *	0.00 *	2.06	3.03	
29	0.00 *		1.82	6.17	0.97	0.00 *	0.00**	0.00**	0.00 *	0.00 *	2.06	3.39	
30	0.00 *		1.21 *	11.37**	0.61	0.00 *	0.00**	0.00**	0.00 *	0.00 *	3.03	2.06	
31	0.00 *		2.66		0.85		0.00**	0.00**		0.00 *		2.18	
SUM.	16.00	22.95	135.54	100.32	83.86	2.42	0.00	0.00	2.06	9.80	32.47	82.45	487.868
MEAN	0.516	0.820	4.372	3.344	2.795	0.081	0.000	0.000	0.069	0.350	1.299	2.748	1.3743
	11	21	23	30	1	7	3	12	22	10	9	26	3 23
MAX.	4.50	3.58	13.11	11.37	6.72	0.97	0.00	0.00	2.06	3.03	4.32	10.13	13.110
	22	2	30	5	27	28	1	1	4	1	4	24	1 22
MIN.	0.00	0.00	1.21	0.36	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.000
							Max.	95-Day	185-Day	275-Day	355-Day	Min.	
							13.11	1.82	0.00	0.00	0.00	-	
1	0.545	0.133	5.170	1.222	4.049	0.242	0.000	0.000	0.000	0.569	1.684	4.158	
2	1.055	1.416	3.424	1.343	2.644	0.000	0.000	0.000	0.000	0.588	0.795	1.307	
3	0.000	0.931	4.510	7.466	1.693	0.000	0.000	0.000	0.206	0.000	1.305	2.780	
1	0.968	0.000	3.892	0.774	4.983	0.121	0.000	0.000	0.000	0.363	0.000	5.020	
2	0.121	0.266	6.448	1.670	3.116	0.363	0.000	0.000	0.000	0.774	3.032	3.297	
3	2.111	1.695	3.401	1.113	2.208	0.000	0.000	0.000	0.000	1.089	1.087	1.331	
4	0.000	1.138	3.447	1.573	3.080	0.000	0.000	0.000	0.000	0.212	0.403	1.283	
5	0.000	1.490	6.720	6.601	2.660	0.000	0.000	0.000	0.411	0.000	0.242	0.212	
6	0.000	0.000	2.668	8.331	0.726	0.000	0.000	0.000	0.000	0.000	2.434	4.491	

Fig. J.1.1 Cost-Discharge Reduction Rate for Alternatives of Limau Manis Dam

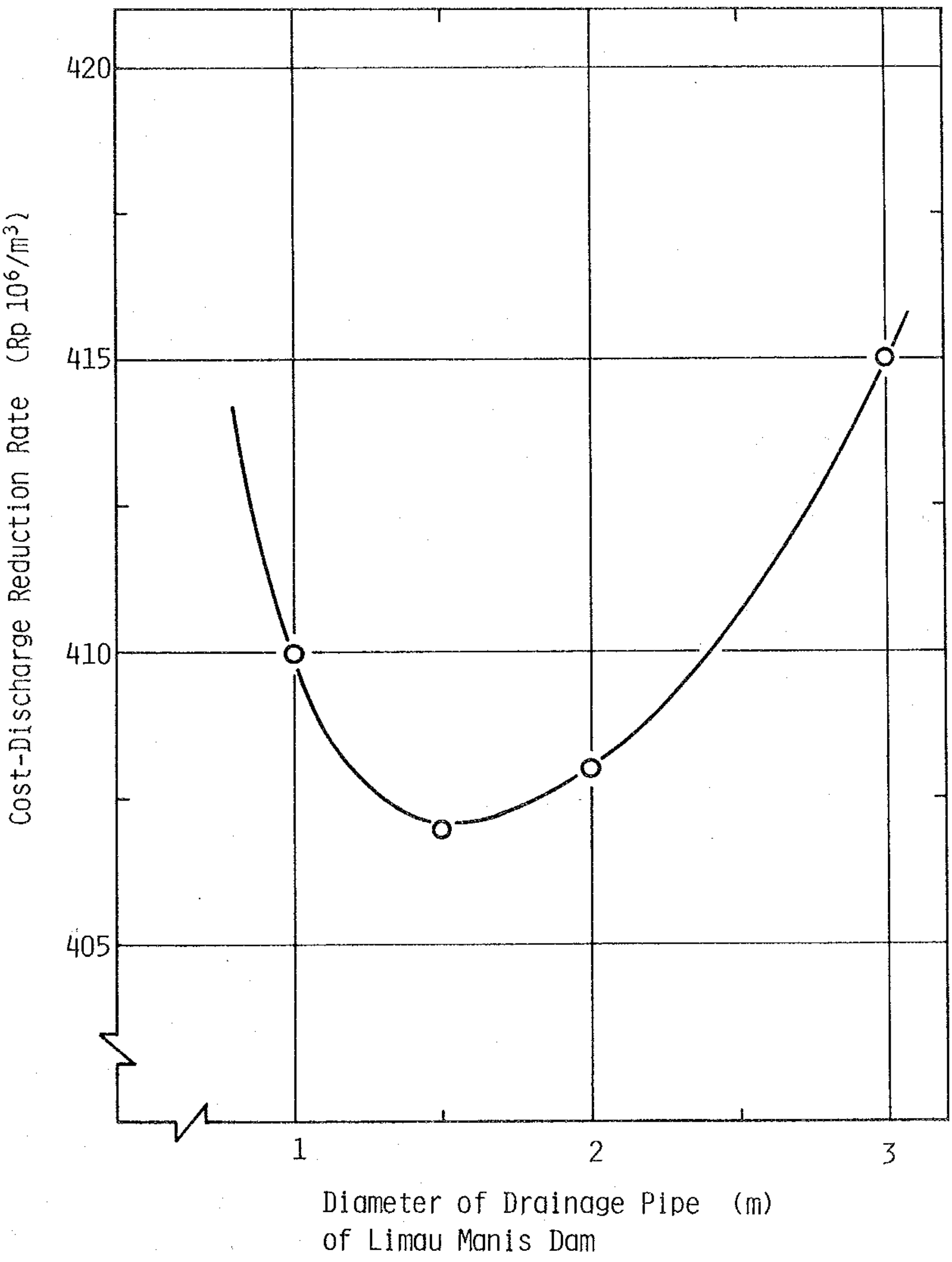
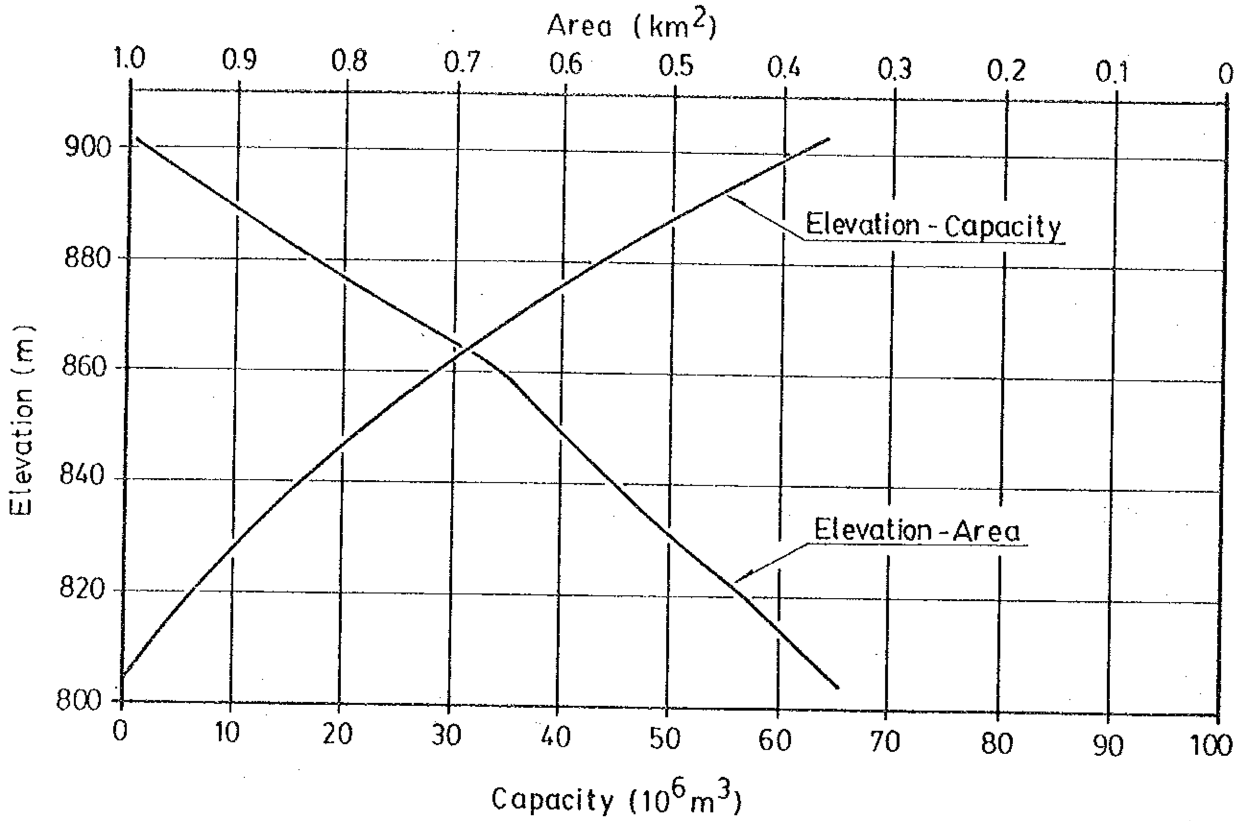


Fig. J.1.2 Elevation-Area-Capacity Relation Curve and Discharge Rating Curve at Dam Site



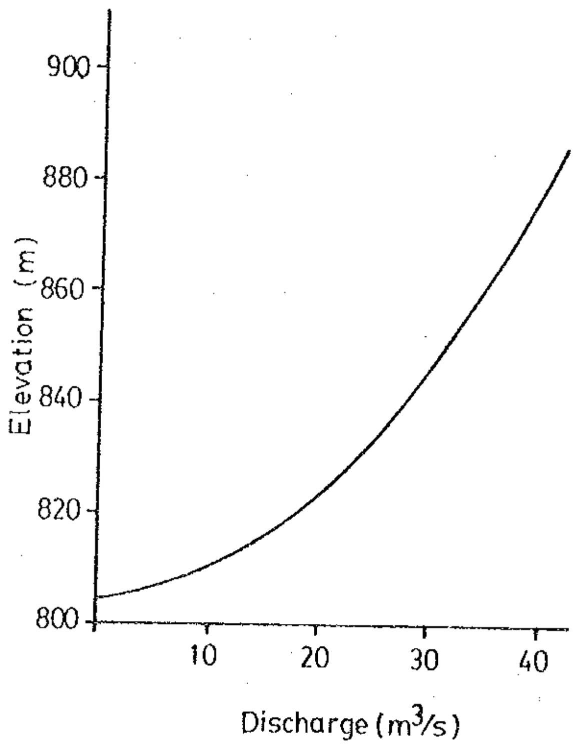
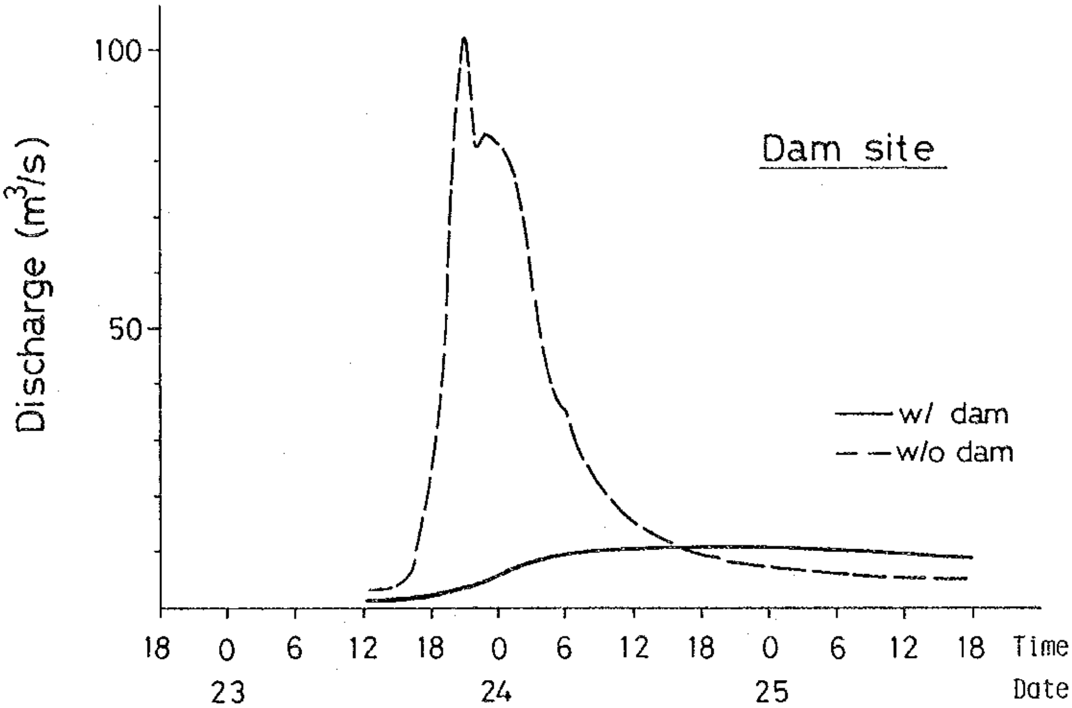
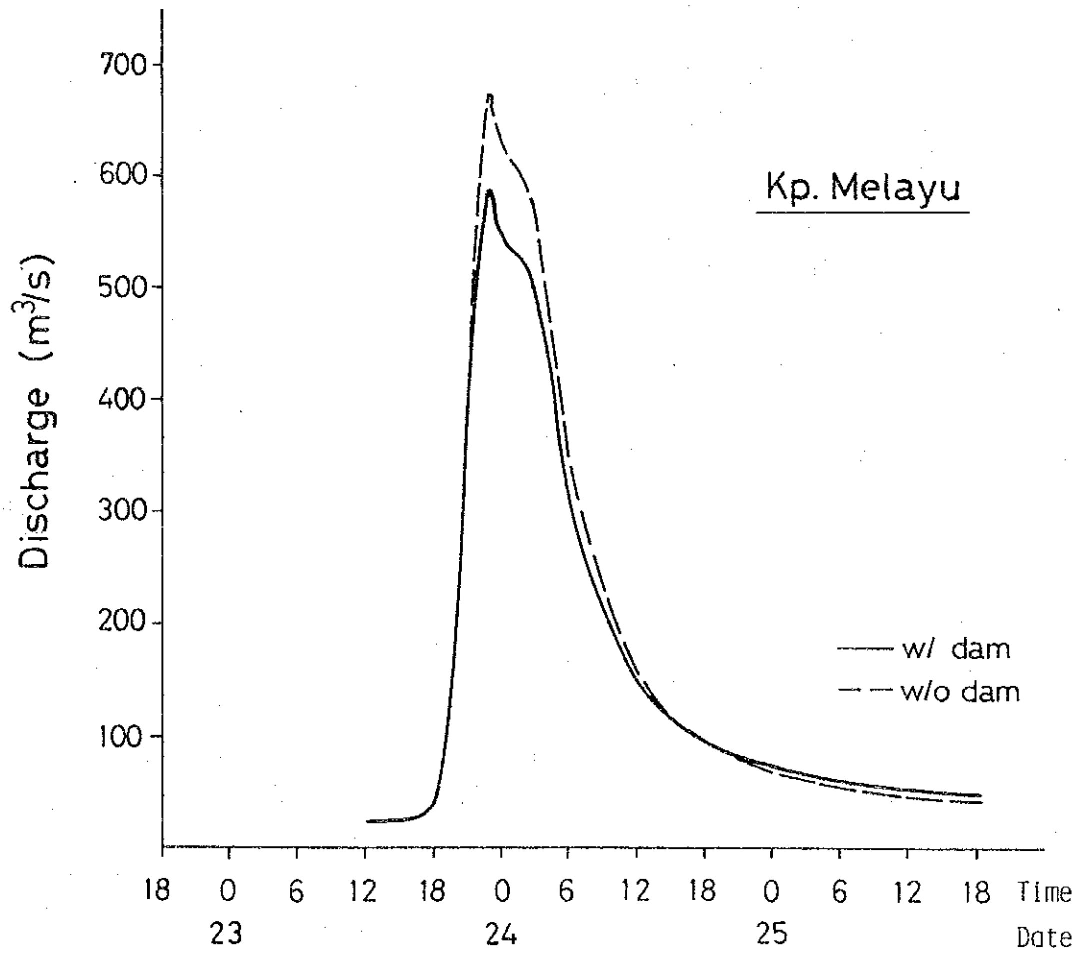


Fig. J.1.3 Comparison of Discharge Hydrographs with and without Limau Manis Dam





STUDY ON EFFECT OF PEAK DISCHARGE REDUCTION BY STEPPED DAMS

For the purpose of knowing the effect to reduce a peak flood discharge by means of a series of stepped dams construction in the upper basins which was proposed in the previous study by P.T. Indah Karya, the Study Team checked the reduction of peak discharge by the stepped dams by calculation using the flood runoff simulation model described in APPENDIX F. The idea of stepped dams construction is as follows.

It is expected to reduce a peak flood discharge by constructing stepped dams in the upstream reaches of river basin. When the stepped dam is constructed, the increased storage effect of channel which is associated with the decrease of gradient in the upstream of the dam will appear. That will bring the direct reduction of a peak flood discharge. In addition, a time of concentration upstream of the dam will be delayed to some extent by the stepped dams.

1) Location of Stepped Dams

For calculation, stepped dams are planned in the upstream reaches of the Arau and Kuranji rivers. The planned sites are shown in Fig. J.2.1. Actually conceivable sites of stepped dams to be built are picked up through site inspection by both the personnel concerned from D.P.U. and the Study Team taking into consideration circumstances such as a scale of drainage area of the dam, land use and accessibility. The both parties concerned also agreed that a series of dams are assumed to be built continuously in 3 m high and 2 km through 5 km long as the conditions of calculation.

2) Profile and Hydrological Effect of Dams

In calculation of storage effect, it is assumed that the river bed upstream of the dam would show a gradient of i/2 due to sedimentation, that is, a half of original channel bed. The assumption is based on the experiments through construction of sabo dams. They are shown in Fig. J.2.2. Hydrological effect of dams is estimated with regard to 5-yr and 50-yr discharge hydrographs. The result is shown in

Table J.2.1. It shows that reduction of the peak discharge is extremely small. The delay of a time of concentration at Lb. Begalung and Kp. Melayu is less than half an hour.

Table J.2.1 Hydrological Effect by Stepped Dams

(Unit: m^3/s)

Site	Peak flood discharge					
	5yr. flood			50yr. flood		
	Without dams	With dams	Reduction	Without dams	With dams	Reduction
<u>Arau river</u>						
Lb. Sarik	222	221	1	424	409	15
Kp. Baru	384	381	3	740	724	16
Lb. Begalung	427	424	3	773	761	12
<u>Kuranji river</u>						
G. Nago	363	362	1	676	672	4
Kp. Melayu	377	376	1	675	675	0

Fig. J.2.1 Location of Stepped Dam

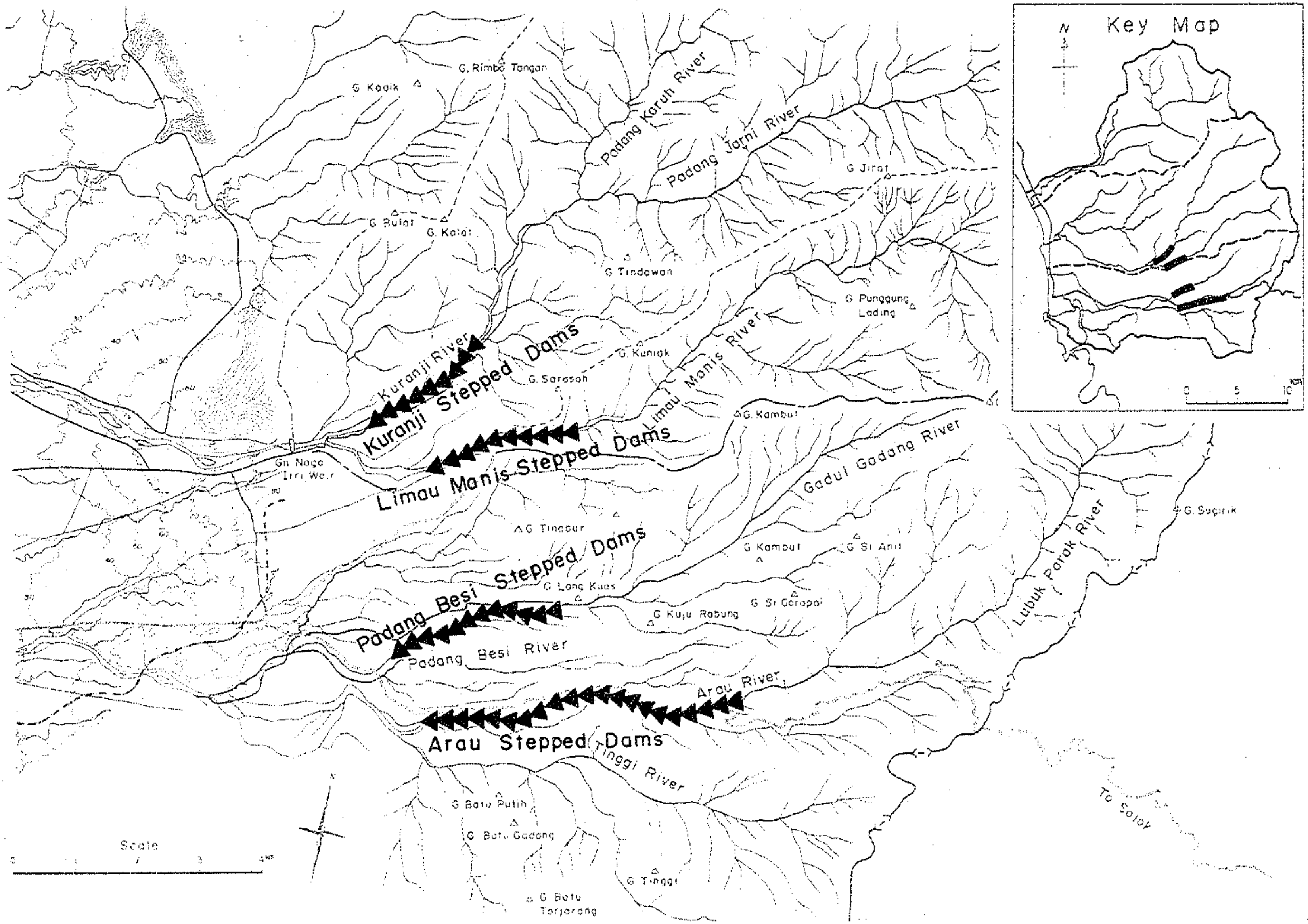
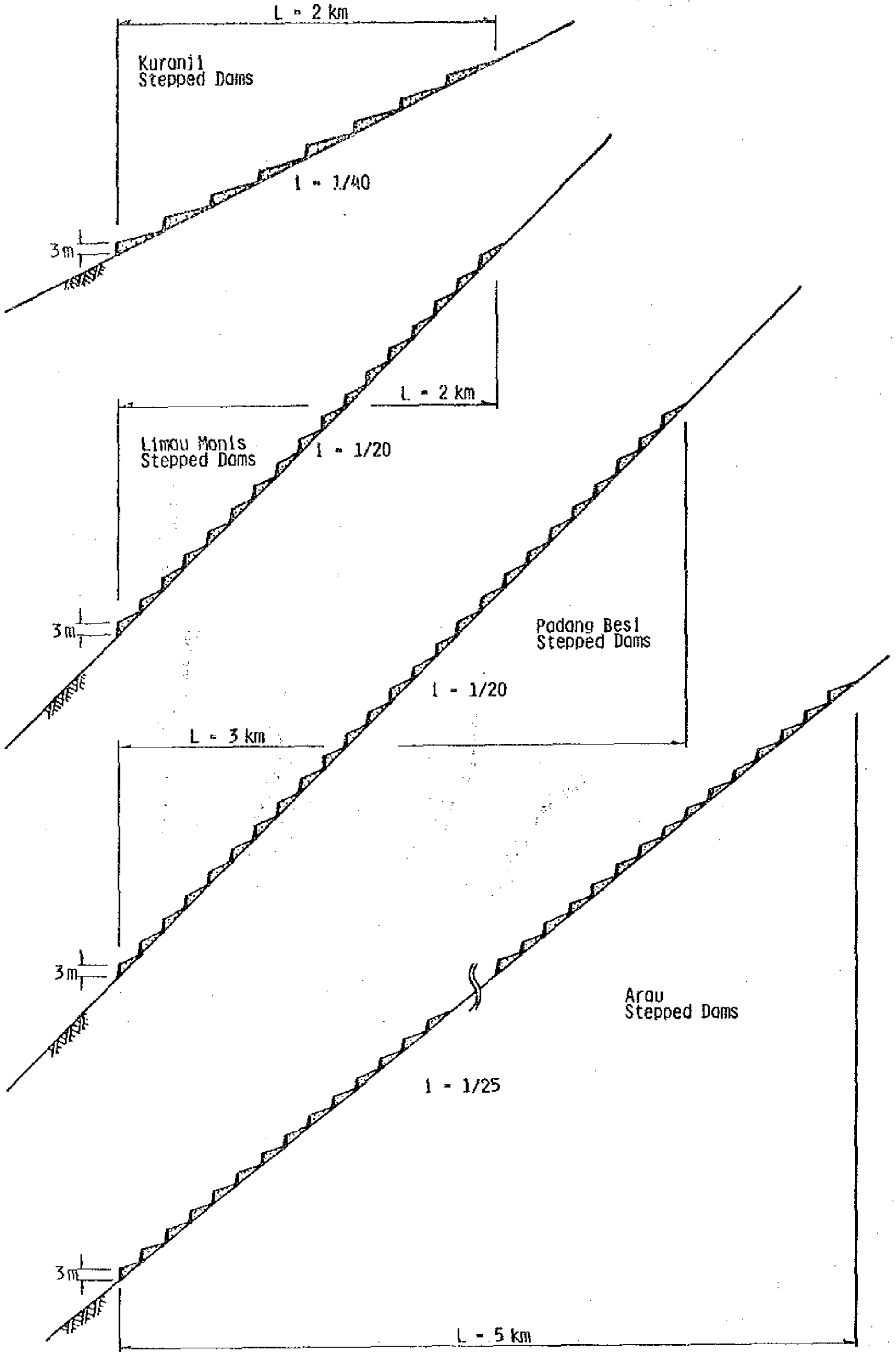


Fig. J.2.2 Profile of Stepped Dams



APPENDIX K

URGENT FLOOD CONTROL PLAN

APPENDIX K

URGENT FLOOD CONTROL PLAN

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1. General

The comprehensive flood control and drainage plan is formulated aiming at mitigation of flood damage not only in the existing urban area but also in future urban area. The economic viability of the plan under the present development stage is not so high, and also much fund will be required to implement such a big project. Therefore, the time has not come yet to implement the comprehensive plan at present. However, as mentioned in the APPENDIX G, the existing urban area of Padang city suffers from habitual flood damage which can not be overlooked any longer. Realization of an urgent flood control countermeasures is required aiming at mitigation of flood damage in the existing urban area. For this reason, urgent flood control plan based on the comprehensive plan is studied to formulate a priority project for immediate implementation in consideration of the urgency of countermeasures, as well as the technical and economical effectiveness of the project under the present conditions. The urgent flood control plan aims at mitigation of flood damage in the existing urban area and area to be developed as residential quarter in the near future.

2. Necessity of Urgent Flood Control Project

The city of Padang and its surrounding alluvial lands formed by the Arau, Kuranji and Air Dingin rivers suffer from habitual inundation damage due to the insufficient capacity of flood control and drainage facilities. In fact, the area was subjected to large flood damage five times in these last ten years. Especially the damages by floods in 1972 and 1980 were serious.

On the other hand, urban area of Padang city is expanding rapidly and new settlements are developing even in the low-lying land surrounding the existing urban area. The social and economic damage due to flooding in these areas are increasing. In order to mitigate the flood damage, implementation of urgent measure of flood control is required.

3. Design Flood

In order to select a level of design flood for urgent project, three alternative plans are examined by the scale of the following design floods.

River	Return period of design flood (yr)		
	Plan-A	Plan-B	Plan-C
1. Mainstream	10	25	50
2. Tributary	5	10	25
3. Drainage channel	2	5	10

The result of comparative study using economic cost shown in Table K-1 and economic benefit based on the study results in APPENDIX G and APPENDIX M are summarized below.

Alternative plan	Benefit ($Rp.10^6$)	Economic cost ($Rp.10^6$)	B/C with discount rate of 12 %
1. Plan-A	5,694	37,383	1.19
2. Plan-B	7,415	43,678	1.24
3. Plan-C	8,320	66,500	0.90

The above table shows that Plan-B has high economic value of B/C as compared with those of the other alternatives. In the above table, flood control benefits are estimated taking into account reduction of flood damages under present situation for private properties, farm crops, public facilities and the development effect to be expected for land with the project.

The plan with 25 year design flood is therefore proposed as urgent flood control project from the standpoint of high economic value and socio-economic conditions in the area.

On the other hand, according to the flood damage survey, the past remarkable floods in Padang city were the floods of May 1972, October 1976, April 1979, November 1980 and November 1981. Among them, the flood of May 1972 was the biggest since 1960 of which return period corresponds to about 23 years. The river channel to be improved by the urgent flood control project will have capacity to carry the said flood. The determined design flood discharge is shown in Fig. K-1.

4. Proposed Urgent Flood Control Plan

4.1 River stretches for Proposed Urgent Flood Control Project

Considering the flood prone area and carrying capacity of the existing river channel, river stretches as the object of planning for the urgent flood control works are determined. The upstream end of the objective stretch for channel excavation and embankment is determined based on the comparison of proposed high-water level with river bank elevation. The river stretches for the proposed urgent flood control works are shown in Table K-2.

4.2 Improvement Plan of River Channels and Related Structures

4.2.1 Design Criteria

The following are the criteria applied to design of river channel improvement.

a. A series of the topographic maps of 1/5,000 scale and the aerophotos of 1/5,000 scale are used for design of channel and dike alignments.

b. The river channel cross-section surveyed by DPU and the Study Team are used for design of river channel.

c. With regard to Manning's coefficient of roughness "n" for design, 0.026 to 0.04 for low-water channel and 0.04 to 0.07 for high-water channel are adopted considering the channel conditions.

d. The following are adopted for design of dike cross-section as standard values.

Design discharge (m^3/s)	Free board (m)	Crest width (m)	Side slope	
			W/o bank protection	W/bank protection
less than 200	0.6	3.0	1 : 2	1 : 1.5
200 to 500	0.8	3.0	1 : 2	1 : 1.5
500 to 2,000	1.0	4.0	1 : 2	1 : 1.5

e. Standard cross-section of inspection road is shown in Fig. K-2.

f. Higher high tide level of 0.78 m at Teluk Bayur is adopted for the high-water level at river mouth.

4.2.2 Improvement Plan of River Channel and Related Structures

Based on the design criteria, the river channels and its related structures are designed considering the existing condition and the proposed comprehensive plan. The proposed alignments of river channel are shown in Fig. K-3, and the detailed drawings of the proposed alignments, longitudinal profiles and cross-sections of river channel and their related structures are compiled in "DRAWINGS".

The outline of the plan of river channels and related structures is as follows :

(1) Mainstream of Arau river

The existing alignment is adopted for the improvement plan. No cut-off channel is planned. The high-water levels of the proposed channel are planned to be lower as much as possible by excavation of channel, since houses exist densely on both banks in the downstream reaches from the confluence of the Jirak river.

Rivermouth - Suspension Br.

No channel improvement is planned in this stretch, because the existing channel has sufficient capacity to carry the design discharge.

Suspension Br. - Confluence of Jirak river

a. The channel is to be widened to the left bank, because houses on the right bank exist densely compared with those on the left bank.

b. The design high-water levels are determined to be lowered or to be the same as ground elevation of river banks for drainage. The design river bed is determined on the basis of the existing lowest river-bed.

c. Low dike construction is planned in some places. Free board of

0.5 m is adopted for stretch with no dike.

d. Bank protection by means of wet masonry is planned to protect bank slope on lower part than low-water level. Protection of the both banks at Seberang bridge site is planned to protect the bridge by means of wet masonry up to high-water level.

Confluence of Jirak river - Lubuk Begalung Weir

No channel improvement is planned in this stretch, because the existing channel has sufficient capacity to carry the design discharge.

(2) Jirak river

a. Alignment of channel is planned to moderate excessive meanders by means of cutoff, since the existing channel meanders in several locations.

b. Construction of dike is planned on the right bank in the downstream reaches from Kp. Koto Kecil and on the both banks in the upstream reaches from there.

c. A bridge at Sec. No. J.9 is planned to be reconstructed due to widening of the channel.

(3) Flood relief channel

The whole stretch of the channel is planned to be improved to increase their carrying capacity. The proposed high-water levels are designed to be lower than those of the existing. To avoid much widening of the channel, the proposed channel-bed is planned to be lower as much as possible by excavation. Bank protection by means of wet masonry is planned in the whole stretch.

River mouth - Railway Br.

a. The channel is to be widened to the both banks. The slope of banks of 1 : 1.5 is adopted.

b. Jati bridge, the drop structure and the siphon are to be reconstructed. The other existing bridges are not reconstructed, but the piers and abutments of bridges are to be protected.

Railway Br. - Lubuk Begalung weir

a. The channel is to be widened to the right bank. The outlets of drain on the right side are to be treated by back-water dike method.

b. The dike crown with 5 m width is planned on the left bank in order to utilize the dike as public road.

c. Aru bridge, the siphon and the two drop structures are to be reconstructed.

(4) Lubuk Begalung weir

Although Lubuk Begalung weir is planned to be reconstructed on both the mainstream and relief channel weirs in the proposed comprehensive plan, only the relief channel weir is planned in the urgent plan to be reconstructed in order to increase the design discharge of the flood relief channel. The mainstream-weir is not to be reconstructed in the urgent plan, because the weir body is judged to be still structually strong enough based on the stability analysis described in APPENDIX E. But some works such as repairing of bridge, reinforcement of downstream apron and closing two openings to decrease discharge diverted to the mainstream are planned to be carried out in the urgent plan.

The location of the new relief channel weir is planned to be built at the downstream side of the existing weir considering diverting function of the weir during the period of construction and the existing channel conditions at the weir site.

New relief channel weir of 60 m width with 6 openings is preliminarily designed as shown in Fig. K-4. However it is recommended that the dimension of the weir should be determined by hydraulic model test.

(5) Kuranji river

a. The stretch between the river mouth and 1.4 km upstream from the water supply intake will be improved by compound cross-section with continuous dike.

b. The cutoff channels are planned to moderate excessive meanderings in the stretches the railway to Nanggalo Br. and water supply intake to Kalawi Br.

c. In the stretch between the river mouth and Ulak Karang Br., single section is adopted as cross-section, because houses exist densely on the both banks. Dredging of channel-bed will be carried out to increase the channel capacity.

d. In the stretch between the railway bridge and the confluence of the Balimbing river, the channel alignment is planned to be shifted to the right side in order to moderate river course, and stone groin is planned to be set on the left side.

e. The side slope 1 : 3 is adopted for the low-water channel except the stretches of bank protection.

f. In order to protect the pier of the railway bridge and Ulak Karang Br., the foot of the pier will be reinforced by riprap.

g. The Nanggalo bridge will be expanded by one more span to the left side due to widening of the channel.

(6) <u>Balimbing river</u>

a. Since the existing river channel meanders in several locations, it is planned to moderate excessive meandering by means of cutoff.

b. To protect residential quarter on the left bank in the stretch between the confluence of the Laras river and Kp. Padjang, the dike will be constructed only on the left bank. In the stretch between the confluence to the Kuranji river and Tunggul Hitam bridge, the dike will be constructed only on the right side. In the stretch between the Tunggul Hitam bridge and the confluence of the Laras river, the dike is to be constructed on the both banks.

c. Tunggul Hitam bridge will be reconstructed due to widening of the channel.

(7) Laras river

a. Since the Laras retarding basin is adopted to reduce the flood of the Laras river, the excess flood over the existing channel capacity will overflow from the right bank, and they will be stored in the retarding basin. The dike is planned on the left bank in the stretch from the confluence of the Balimbing river to 1.5 km upstream in order to stop overtopping on the left bank. On the right bank in the reaches from the confluence of the Balimbing river to 350 m upstream, the dike will be constructed connected to the dike of the retarding basin.

b. The profile of the proposed high-water levels and river-bed are determined on the basis of the existing profile. The back-water dike is also planned in the lower reaches.

(8) Laras retarding basin

a. The Laras retarding basin on the right side of the Laras river will be constructed to reduce the flood discharge of the Kuranji river in the lower reaches. The excess flood discharge of the Laras and Merah rivers will be stored temporarily by the retarding basin. The excess flood of the Balimbing river is not controlled by the retarding basin owing to topographic condition.

b. The area of the retarding basin is to be about 1.5 km^2 and the storage capacity is to be about 1×10^6 m^3 with 1 m depth in average. On the boundary of the retarding basin, small dike and drainage channel will be constructed to show the boundary line and to store flood water.

c. Fig. K-5 shows the location of the Laras retarding basin, and Fig. K-6 shows flood inflow and water level hydrographs for design flood. Table K-3 shows the result of calculation.

d. Although a housing development plan named "PROYEK PERUMAHAN PT. PEMBANGUNAN SUMBAR" is proposed in the location of the retarding basin, the location of houses to be built is recommended to be changed to the area between the Laras and Balimbing rivers or the west area, out of the retarding basin.

(9) Air Dingin river

a. Since the Air Dingin river has comparatively steep slope of 1/800 - 1/100, the river channel is to be improved mainly by excavation of channel. The compound cross-section consisting of low-water and high-water channels with low height dike is adopted in the lower reaches from the river mouth to 3 km upstream. The channel upstream from there will be improved by channel excavation. The bank slopes of the channel 1 : 3 for low-water channel and 1 : 2 for high-water channel are adopted.

b. Excessive meanders of the existing channel upstream of the Muara Penjalinan Br. is to be shorten by means of cutoff to make smooth alignment.

c. The existing sand spit at the river mouth will be left as it is.

d. To protect river-bed at upper end of cutoff channel, the river-bed will be protected by ground sill.

e. Since the channel near the railway and Muara Penjalinan bridges is narrow compared with that in the upstream and downstream reaches, the abutment and pier of the bridges will be protected by ground sill and other protection method.

4.3 Improvement Plan of Urban Drainage Channel and Related Structures

4.3.1 Improvement plan of major drainage channels

Within the comprehensive plan, the stretches of major drainage channels to be urgently improved are selected considering existing urbanization, flooding conditions and priority order in old urban area proposed by the Cipta Karya.

Stretches subject to the improvement and their design discharges are as follows :

Drainage channel	Length to be improved (m)	Design discharge (m^3/s)
1. Olo-Nipah	590	25 - 14
2. Ujung Gurun	810	18 - 10
3. Purus	580	13
4. Ulak Kanang	1,030	6.5 - 2.5

Stretches to be improved are shown in Fig. K-7.

4.3.2 Plan of terminal drainage facilities

At the terminals of the Ujung Gurun, Purus and Ulak Karang drains, pumping stations are planned to be constructed urgently. The required capacities of pumps are estimated based on hydraulic analysis and the study on economic aspects. The study results are described in APPENDIX I. The capacities of pumps are determined below.

Pumping station :	Ujung Gurun	Purus	Ulak Karang
Pump capacity (m^3/s) :	3.5	2.0	3.5

4.4 Proposed Urgent Flood Control Works

Based on the proposed river channel mentioned above, the following major works are proposed for the urgent flood control project in this study.

(1) Mainstream of Arau river including Jirak river

a. Excavation/dredging of channel and embankment of dike.
b. Bank protection by means of wet masonry and gabion.
c. Construction of outlet culvert.
d. Reconstruction of bridge.
e. Ground sill on river bed.

(2) Flood relief channel

a. Excavation/dredging of channel and embankment of dike.
b. Bank protection by means of wet masonry and dry masonry.
c. Construction of outlet culvert and drainage pumping station.
d. Reconstruction of drop structure on channel bed, bridge, siphon and diversion weir.
e. Drainage channel improvement.

(3) Kuranji river including Balimbing and Laras rivers and Laras retarding basin

a. Excavation/dredging of channel and embankment of dike.
b. Bank protection by means of wet masonry, dry masonry, gabion and groin.
c. Construction of outlet culvert and drainage pumping station.
d. Reconstruction of bridge.
e. Ground sill on river bed.
f. Drainage channel improvement.

(4) Air Dingin river

a. Excavation of channel and embankment of dike.
b. Bank protection by means of wet masonry and gabion.
c. Construction of outlet culvert.
d. Ground sill on river bed.

The proposed work quantities are shown in Table K-4, and they are summarized below.

River channel improvement

Excavation/dredging	$1,789 \times 10^3$ m^3
Embankment	310×10^3 m^3
Bank protection	
Wet masonry	83,700 m^2
Dry masonry	28,300 m^2
Gabion	14,200 m^3
Groin	10,500 m

Reconstruction of diversion weir	1 place
Reconstruction of bridge	5 bridges
Reconstruction of drop structure	3 places
Reconstruction of siphon	2 places
Ground sill	3 places
Construction of drainage culvert	52 places

Drainage channel improvement

Construction of pumping station	3 places
Drainage channel improvement	3,000 m

The location of the drainage culvert is listed in Table K-5.

4.5 Land Acquisition and Compensation

Land acquisition and house compensation are required prior to the execution of the construction works. The quantity is shown in Table K-6. Number of houses to be compensated in each river stretch is listed in Table K-7.

The quantities of land acquisition and compensation are summarized below :

Land acquisition	
River channel improvement	$1,057 \times 10^3$ m^2
Drainage channel improvement	90×10^3 m^2
House compensation	
River channel improvement	244 nos
Drainage channel improvement	58 nos

Table K-1 Economic Cost for Alternatives on Urgent Flood Control Project

Item	L.C Construction cost (Rp10⁶)	L.C Tax/1 (%)	L.C Profit/2 (%)	L.C Economic cost (Rp10⁶)	F.C Construction cost (US$10³)	F.C Equiv. in Rp. (Rp10⁶)	Economic cost
Plan-A							
1.Land acquisition	1,510	-	-	1,510	-	-	1,510
2.Civil works							
(1) Earth works	4,583	183	394	4,006	12,097	11,734	15,740
(2) Structure works	3,071	123	263	2,685	8,067	7,825	10,510
Sub-total	7,654	306	657	6,691	20,164	19,559	26,250
3.Cost for engr'g & administration	1,720	65	-	1,655	4,711	4,570	6,225
4.Contingency	1,127	45	97	985	2,488	2,413	3,398
5.Total	12,012	416	754	10,841	27,363	26,542	37,383
Plan-B							
1.Land acquisition	1,820	-	-	1,820	-	-	1,820
2.Civil works							
(1) Earth works	5,391	216	518	4,657	13,212	12,816	17,473
(2) Structure works	4,236	169	407	3,660	9,568	9,281	12,941
Sub-total	9,627	385	925	8,317	22,780	22,097	30,414
3.Cost for engr'g & administration	2,085	83	-	2,002	5,681	5,511	7,531
4.Contingency	1,354	54	130	1,170	2,846	2,761	3,931
5.Total	14,886	522	1,055	13,309	31,307	31,369	43,678
Plan-C							
1.Land acquisition	2,280	-	-	2,280	-	-	2,280
2.Civil works							
(1) Earth works	10,353	414	888	9,051	22,014	21,354	30,405
(2) Structure works	5,944	238	511	5,195	14,680	14,240	19,435
Sub-total	16,297	652	1,399	14,246	36,695	35,584	49,840
3.Cost for engr'g & administration	2,305	90	-	2,215	6,309	6,120	8,335
4.Contingency	2,169	85	210	1,874	4,300	4,171	6,045
5.Total	28,051	827	1,609	20,615	47,304	45,885	66,500

Remarks: /1 : rate of tax : 4 %

/2 : rate of contractors profit : 10 %

Table K-2 Objective River Stretches for Proposed Urgent Flood Control Works

River	Whole Stretch/1		Stretch for Main Works/2	
	Stretch	Length (km)	Stretch	Length (km)
1. Mainstream of Arau river	River mouth - bypass road Br.	8.5	Suspension Br.-confluence of Jirak river	1.9
2. Flood relief channel	River mouth - Lubuk Begalung weir	6.7	River mouth - Lubuk Begalung weir	6.7
3. Jirak river	Confluence to mainstream - railway Br.	2.5	Confluence to mainstream - railway Br.	2.5
4. Mainstream of Kuranji river	River mouth - Kalawi Br.	7.5	River mouth - Kalawi Br.	7.5
5. Balimbing river	Confluence to mainstream of Kuranji - Kp. Padjang	4.2	Confluence to mainstream of Kuranji - Kp. Padjang	4.2
6. Laras river	Confluence to Balimbing river - Kp. Blantikan	1.2	Confluence to Balimbing river - Kp. Blantikan	1.2
7. Air Dingin river	River mouth - Koto Tuo weir	5.2	River mouth - Koto Tuo weir	5.2

Remarks /1 : Whole stretch subject to improvement works including bank protection and ground sill works

/2 : Stretch subject to main works such as channel excavation and embankment works.

Table K-3 Effect by Laras Retarding Basin

(Unit; m^3/s)

Date/Time		Without Retarding Basin				With Retarding Basin		
		Merah R.	Laras R.	Balimbing R.	Kuranji R.	Merah R. + Laras R.	Balimbing R.	Kuranji R.
23/	18	4.5	18.7	50.0	81.3	17.9	44.7	76.0
	19	6.4	31.4	92.6	158.9	25.6	80.5	146.8
	20	6.8	42.5	150.6	302.4	29.3	130.6	282.4
	21	7.9	58.7	224.3	487.8	33.0	190.7	454.2
	22	9.2	68.9	262.9	725.0	35.2	220.0	682.1
	23	12.8	74.9	277.3	887.5	37.8	227.4	837.6
24/	0	18.9	80.3	305.8	926.5	40.8	247.4	868.1
	1	20.3	79.9	313.2	920.7	43.0	256.0	863.5
	2	19.9	78.7	301.5	921.6	45.1	248.0	868.1
	3	19.7	73.3	275.3	884.0	47.1	229.4	838.1
	4	18.6	65.2	237.1	805.9	48.6	202.0	770.8
	5	17.8	56.3	201.8	698.6	49.9	177.6	674.4
	6	16.9	48.9	179.1	588.3	50.0	163.3	572.5
	7	16.2	42.9	159.8	506.7	50.0	150.8	497.7
	8	15.5	37.3	140.7	442.3	50.0	138.0	439.6
	9	14.8	31.4	122.9	383.6	50.0	126.8	387.5
	10	14.1	23.1	104.8	334.9	50.0	117.6	347.7
	11	13.6	20.1	93.8	291.6	50.0	77.4	308.0
	12	13.0	18.1	85.1	260.4	50.0	66.4	279.1
	13	12.5	16.4	77.9	235.3	50.0	57.8	255.4
	14	12.0	15.1	71.8	213.9	48.2	50.7	235.0
	15	11.5	13.9	67.1	195.9	47.2	45.3	217.7
	16	11.1	13.0	63.1	181.2	46.3	40.8	203.5
	17	10.6	12.1	59.3	169.4	45.4	36.6	192.1
	18	10.3	11.4	55.8	159.6	44.6	32.8	182.6
	19	9.9	10.7	52.6	150.7	43.8	29.4	173.9
	20	9.5	10.1	49.7	142.3	42.9	26.5	165.5
	21	9.2	9.6	47.1	134.4	41.9	24.0	157.5
	22	8.9	9.2	44.8	127.4	41.0	21.8	150.4
	23	8.6	8.9	42.7	121.0	40.1	19.9	143.8
25/	0	8.3	8.4	40.8	115.2	38.9	18.6	137.4

Table K-4(1) Required Construction Works

Item	Unit	Quantity				Total
		Arau river	Flood R.C	Kuranji R.	Air Dingin R.	
River Channel Improvement						
Excavation I (high water channel)	10^3m^3	96	366	279	50	791
II (low water channel)	"	155	157	373	199	884
for rock	"	-	-	3	-	3
Dredging	"	24	18	39	30	111
Transportation	"	275	541	682	279	1,777
Embankment I (new dike)	"	31	31	168	66	296
II (strengthening)	"	-	14	-	-	14
Bank protection						
Wetmasonry I (high water channel)	m^2	504	1,992	2,112	1,076	5,684
II (low water channel)	"	10,362	57,600	6,760	3,246	77,968
Drymasonry	"	-	22,026	6,270	-	28,296
Gabion	m^3	3,093	-	8,525	2,484	14,102
Groin	"	-	-	10,500	-	10,500
Sod facing	10^3m^2	21.5	66.0	46.1	29.6	163.2
Drainage culvert type I	nos	5	9	16	2	32
type II	"	-	7	5	1	13
type III	"	1	-	4	2	7
Bridge (R.C)	bridge	1	2	2	-	5
(Metal)	"	-	-	1	-	1

Table K-4(2) Required Construction Works

Item	Unit	Quantity				Total
		Arau river	Flood R.C	Kuranji R.	Air Dingin R.	
Pier protection (riprap)	10^3m^3	0.5	0.2	0.6	1.6	2.9
Drop structure	place	-	3	-	-	3
Groundsill works	m	12	-	130	150	292
Diversion weir	l.s	1	1	-	-	2
Syphon	place	-	2	-	-	2
Inspection road	m	8,500	13,760	21,090	8,500	51,850
(gravel metaling)						
Disposal of excess soil	10^3m^3	241	487	507	202	1,437
<u>Drainage Channel Improvement</u>						
Pump plant ($Q = 3.5\ m^3/s$)	l.s	-	1	1	-	2
($Q = 2.0\ m^3/s$)	"	-	1	-	-	1
Excavation	10^3m^3	12.0	48.3	7.4	-	67.7
Embankment	"	-	2.8	1.8	-	4.6
Transportation	"	12.0	45.0	5.3	-	62.3
Disposal of excess soil	"	12.0	45.0	5.3	-	62.3
Bank protection						
Wet masonry	10^3m^2	8.8	6.0	0.3	-	15.1
Dry masonry	"	-	1.0	2.2	-	3.2
Inspection road	m	-	2870	1450	-	4320

Table K-5 Location and Quantity of the Proposed Drainage Culvert

Name of River	Location	Left or Right side	Type
Arau	A.131	R	III
	A.98+170^m	L	I
	A.79+ 50^m	L	I
Jirak	J.5+50	R	I
	J.9	R	I
	J.12	L	I
Flood Relief channel	B.0	R	I
	B.0+100	L	II
	B.7+100	R	I
	B.17	L	II
	B.17	R	I
	B.24	L	I
	B.31+50^m	R	I
	B.33	R	II
	B.37	R	I
	B.49+100^m	R	II
	R.55	R	II
	R.75+60^m	R	I
	R.77+80^m	R	II
Flood Relief channel	B.89	R	II
	B.96	R	I
Kuranji	K.6	R	II, III
	K.10	L	III
	K.14	L	I
	K.19	L	I

Name of River	Location	Left or Right side	Type
	K.19	R	I
	K.25+130^m	L	I
	K.45+100^m	L	I
	K.71	R	I
	K.86	R	I
	K.99-150^m	R	I
	K.99	L	I
	K.119+100^m	R	I
	K.128	R	I
	K.132+100^m	L	II
Balimbing	B.28+50^m	R	I
	B.45+200^m	R	II
	B.26	L	I
	B.65+150^m	R	II
	B.65+150^m	L	I
	B.92+100^m	L	III
Laras	L.4	L	II
Retarding Basin			I, III
Air Dingin	C.0-850^m	L	III x 2
	C.6	R	I
	C.20+150^m	L	II
	C.48+170^m	R	I

Note : Remarks : I : 1.5^m x 1.5^m x 1

II : 2.0^m x 2.5^m x 1

III : 2.0^m x 2.5^m x 2

Table K-6 Required Land Acquisition and House Compensation

Item	Unit	Quantity				Total
		Arau river	F.R.C.	Kuranji river	Air Dingin river	
I. River Channel Improvement Works						
Land I (residential area)	$10^3 m^2$	84.8	12.5	22.9	10.0	130.2
Land II (agricultural land & others)	"	46.8	83.5	606.3	190.0	926.6
House I (permanent house)	nos	-	-	-	-	-
House II (semi permanent house)	"	5	4	-	-	9
House III (small house)	"	52	17	58	13	140
House IV (temporary house)	"	33	21	34	7	95

Item	Unit	Quantity				Total
		Olo-Nipah	Ujung Guran	Purus	Ulak Karang	
II. Drainage Channel Improvement Works						
Land I (residential area)	$10^3 m^2$	4.0	37.0	9.0	2.0	52.0
Land II (agricultural land and others)	"	-	32.0	-	6.0	38.0
House I (permanent house)	nos	-	2	1	2	5
House II (semi permanent house)	"	-	4	2	-	6
House III (small house)	"	4	6	1	-	11
House IV (temporary house)	"	-	6	30	-	36

Note: House I ; Deluxe house which is constructed by concrete or brick structures with more than 100 m^2 of floor area in average.

House II ; Ordinary house which is constructed by concrete or brick structures with 60 m^2 of floor area in average.

House III ; Wooden house with 40 m^2 of floor area in average.

House IV ; Temporary house which is constructed by bamboo or nipah with 30 m^2 of floor area in average.

Table K-7 Number of House to be Relocated

River	Stretches	Number of Houses	
		Left side	Right side
Arau	Suspension Br. (A 112)		
	to Seberang Padang Br. (A 68)	21	8
	Seberang P. Br. to Jirak River	11	9
Jirak	Confluence to Railway Br.	29	12
Flood Relief Channel			
	River Mouth to Aru Br. (B 59)	16	25
	Aru Br. to Diversion Weir	0	18
Kuranji			
	River Mouth to Railway Br. (K.19)	12	1
	Railway Br. to Kalawi Br. (PM.40)	33	13
Balimbing			
	Confluence to Kp. Sungai Sapiah (B.141)	12	19
Laras	Confluence to Kp. Blantikan (L.11)	2	0
Air Dingin	River Mouth to Muara Penjalinan (C.17)	3	5
	M. Penjalinan to Koto Tuo	7	5
Total		146	115

Fig. K-1 Flood Discharge Distribution for Urgent Flood Control Project

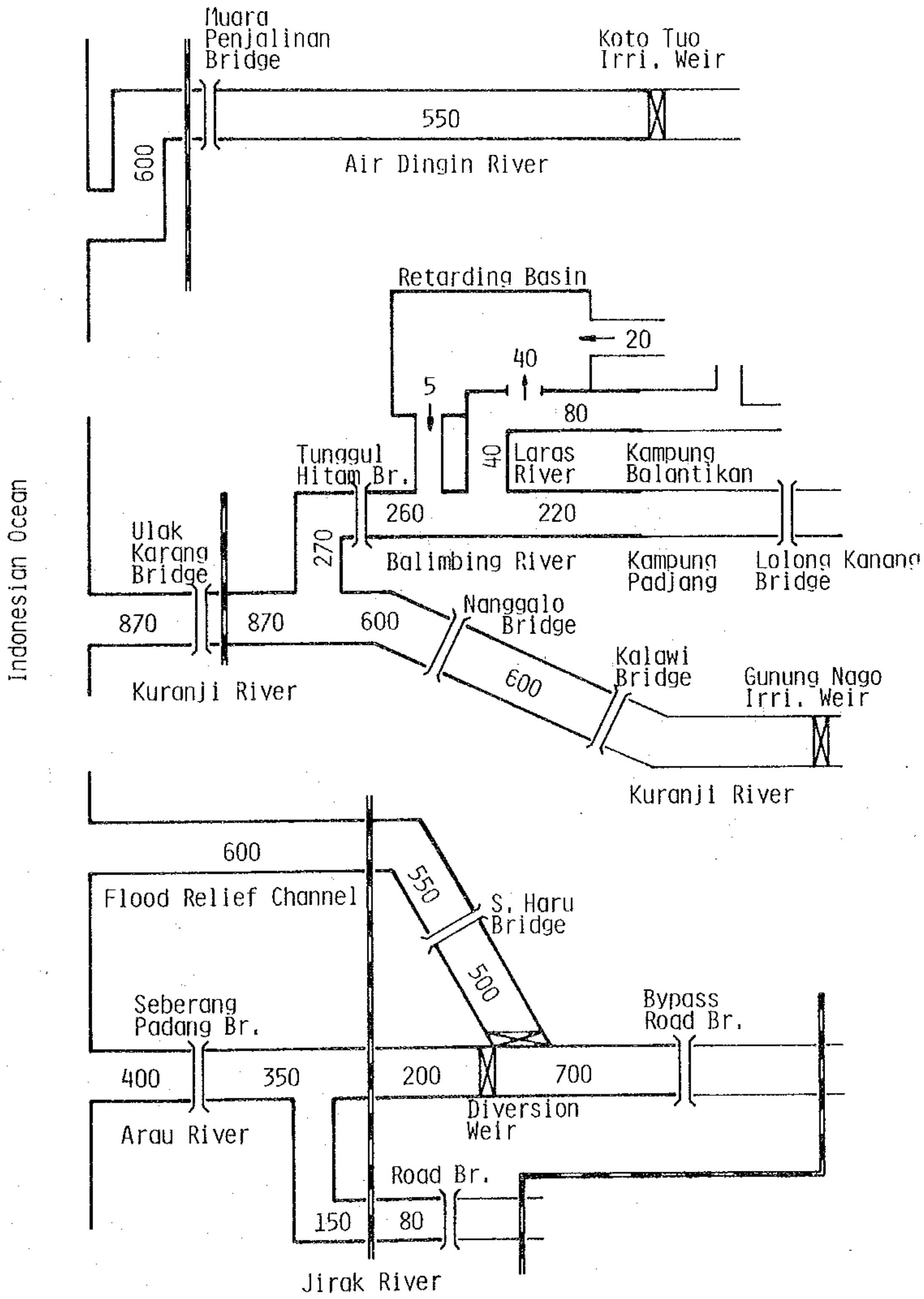


Fig. K-2 Standard Section of Inspection Road

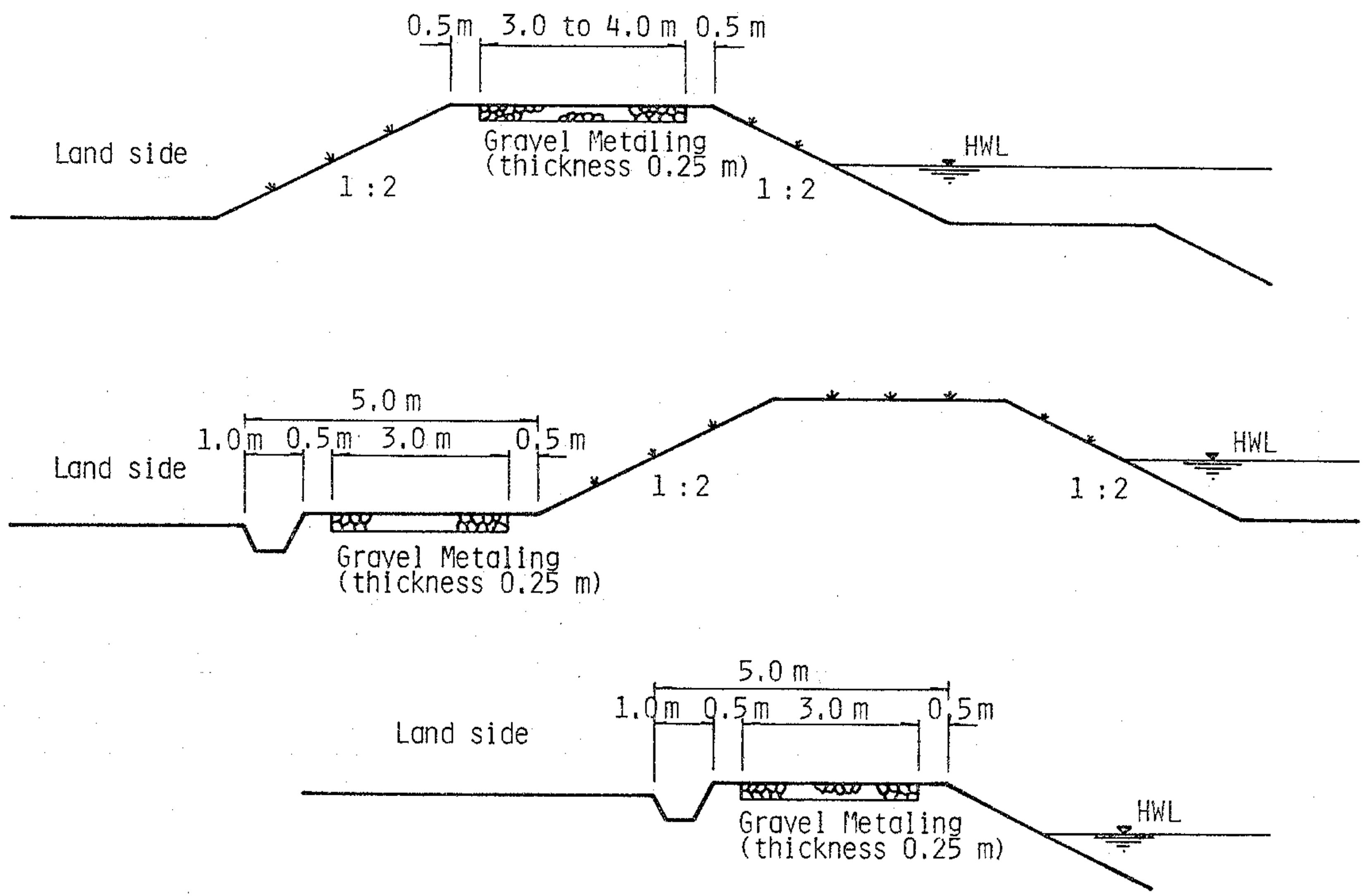


Fig. K-3 Alignment of River Channel for Flood Control Project

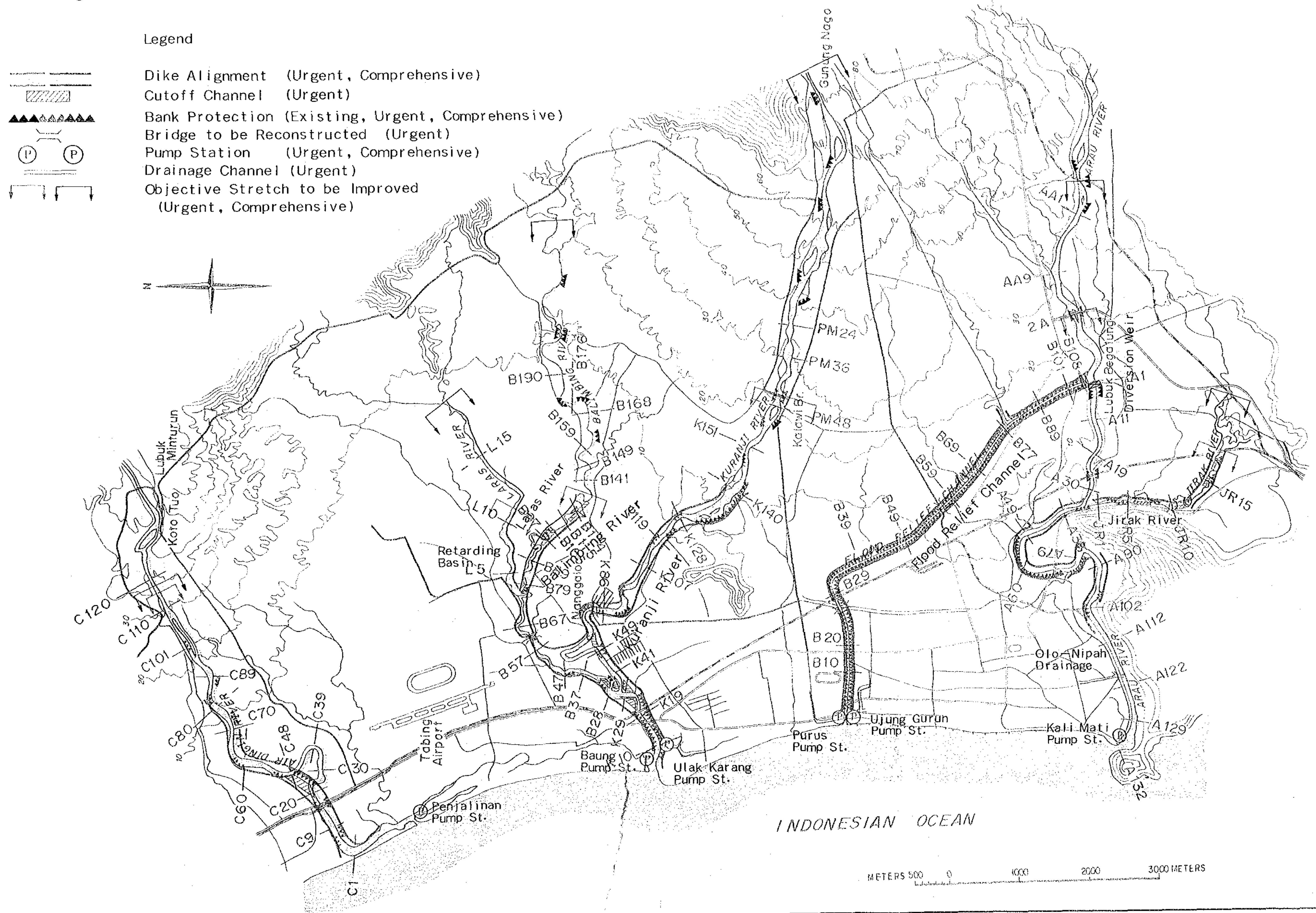


Fig. K-4 Lubuk Begalung Weir to be Reconstructed by Urgent Flood Control Project

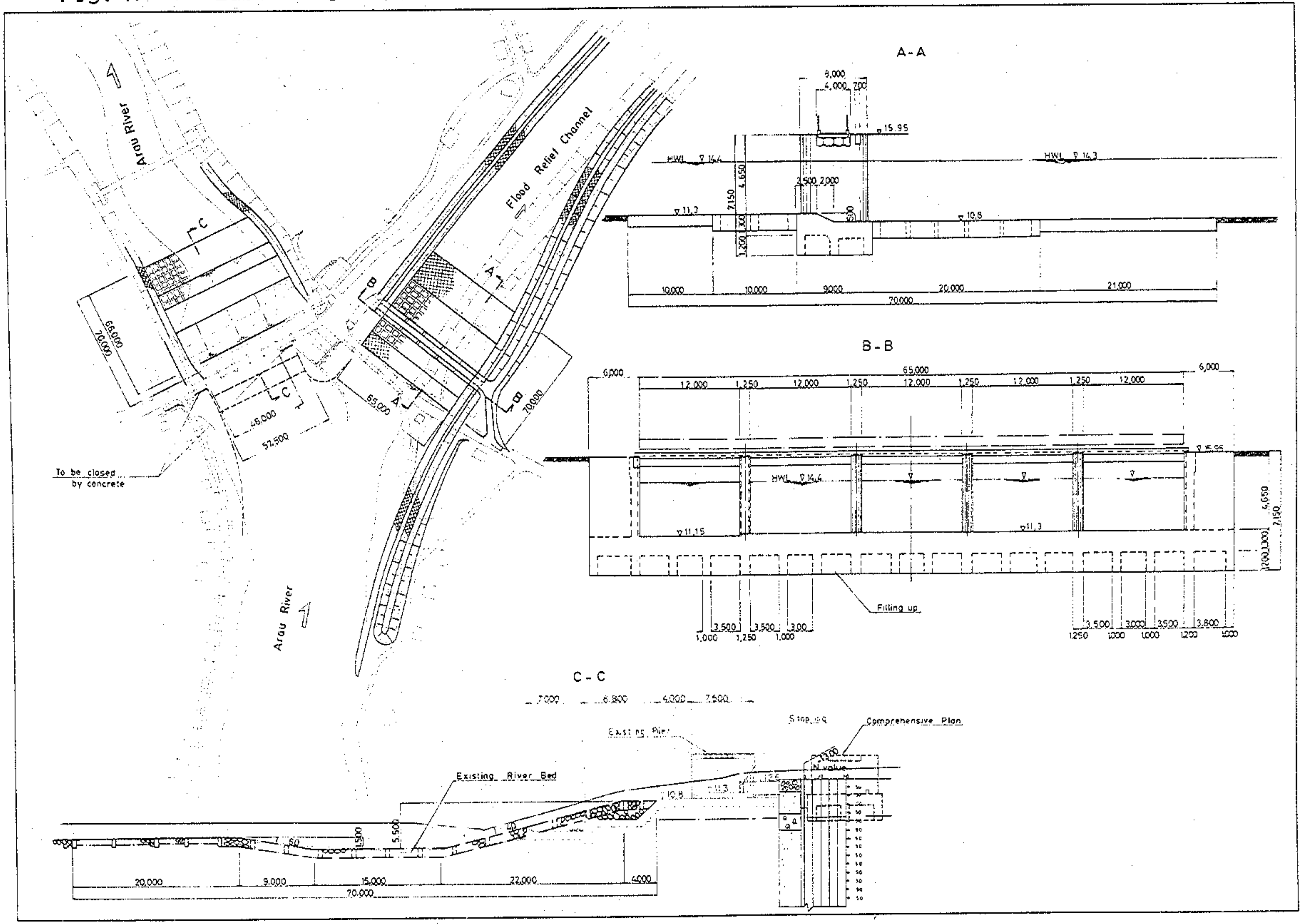


Fig K-5 Proposed Retarding Basin

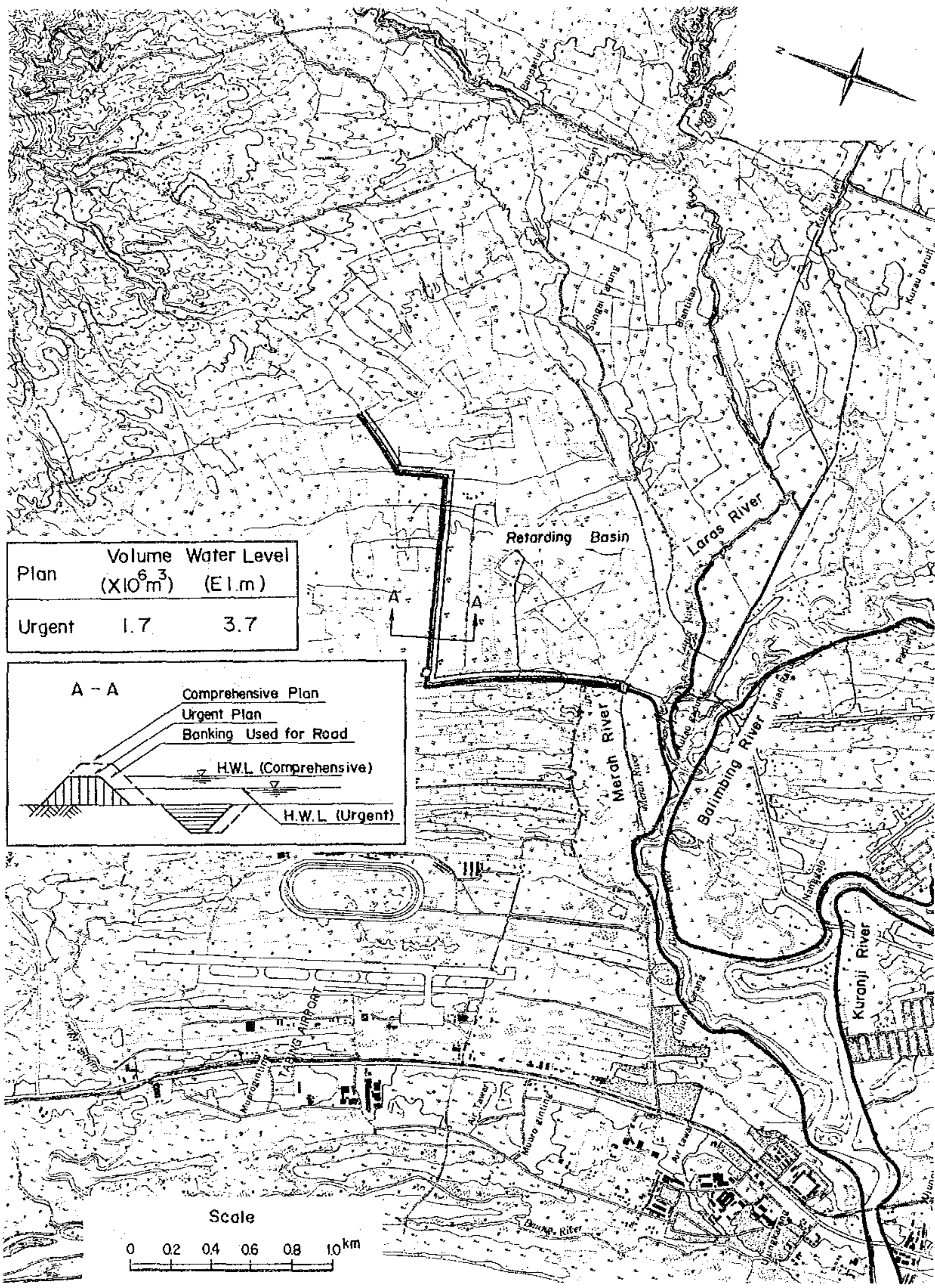
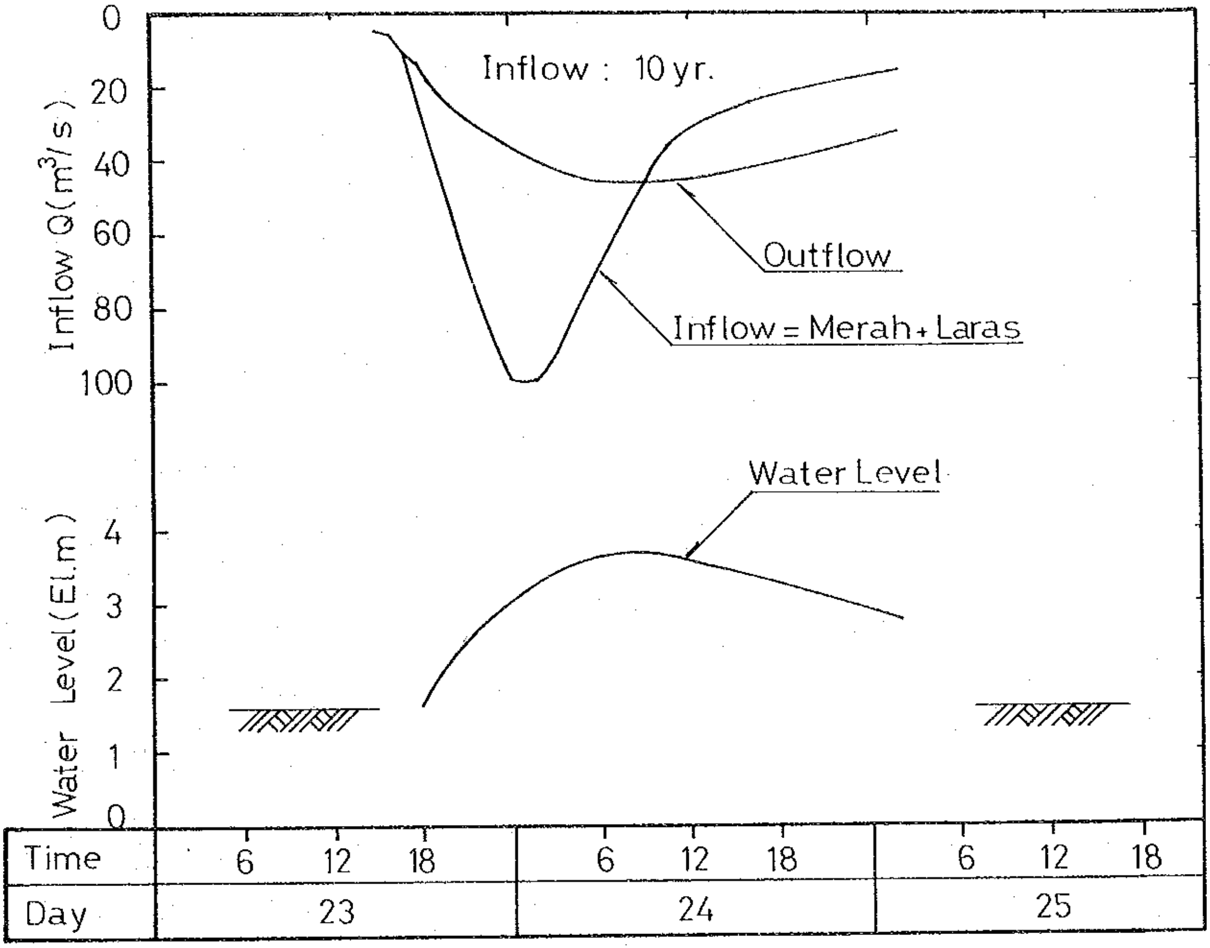


Fig. K-6 Hydrograph of Retarding Basin



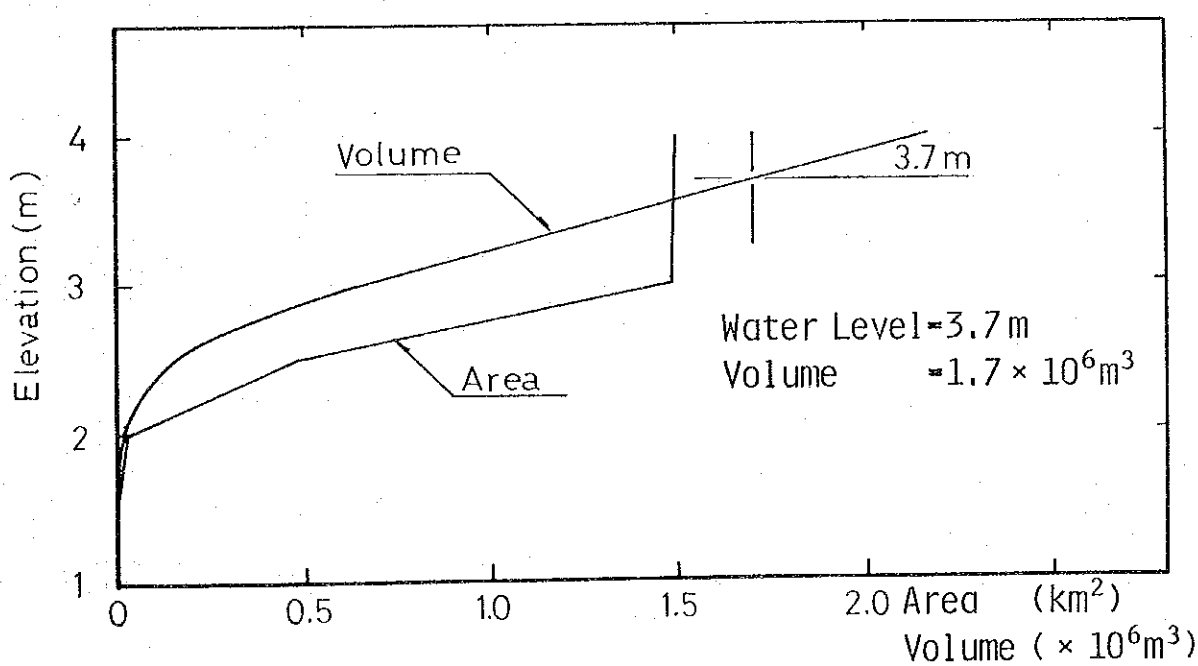


Fig. K-7 Proposed Layout of Urban Drainage