4.4 Optimum Flood Control Plan

4.4.1 Project Cost of Each Alternative Flood Control Plan

The estimated project cost for each alternative plan is shown in Table-D.4.26.

Table-D.4.26 Project Cost of Each Alternative Flood Control Plan

Unit: Million Rupiah

Alternative	A: Construction Cost A1: River Improvement, A2: Dam, A3: Diversion Channel, A4: Check Dam					B: Indirect Cost	C: Land Acq. & Comp. C1: Land Acquisition C2: Compensation			Total Project Cost
	A1	A2	A3	A4	Total	Total	C1	C2	Total	
<Ruhu River System>										
FCP-RH1: R/I(30)	23,351	-	-	1,370	24,721	7,416	7,650	5,145	12,795	44,932
FCP-RH2: R/I(5)+Dam	9,323	31,344	-	1,370	42,037	12,611	10,950	1,400	12,350	66,998
FCP-RH3: R/I(10)+Dam	20,932	28,691	-	1,370	50,993	15,298	13,150	5,145	18,295	84,586
FCP-RH4: R/I(5)+Div.	21,332	-	2,833	1,370	25,535	7,661	5,148	5,250	10,398	43,594
FCP-RH5: R/I(10)+Div.	23,465	-	2,502	1,370	27,337	8,201	5,193	6,195	11,300	46,838
<Batu Merah River System>										
FCP-BM1: R/I(30)	29,368	-	-	-	29,368	9,251	3,488	5,600	9,088	47,266
FCP-BM2: R/I(5)+Dam	9,966	21,831	-	-	31,797	9,980	6,058	5,600	11,658	52,994
FCP-BM3: R/I(10)+Dam	23,315	19,818	-	-	43,133	13,381	7,188	9,695	16,883	72,956
FCP-BM4: R/I(5)+Div.	9,966	-	29,055	-	39,021	11,706	158	350	508	51,235
FCP-BM5: R/I(10)+Div.	23,315	-	22,505	-	45,820	14,187	2,138	4,445	6,583	66,149
<Tomu River System>										
FCP-TM1: R/I(30)	18,753	-	-	1,470	20,223	6,067	0	0	0	26,290
FCP-TM2: R/I(5)+Dam	1,328	33,801	-	1,470	36,599	10,980	3,875	0	3,875	51,454
FCP-TM3: R/I(10)+Dam	6,170	24,368	-	1,470	32,008	9,602	2,700	0	2,700	44,310
FCP-TM4: R/I(5)+Div.	3,598	-	12,980	1,470	18,048	5,414	1,238	1,190	2,428	25,890
FCP-TM5: R/I(10)+Div.	6,360	-	9,339	1,470	17,169	5,151	1,181	1,190	2,371	24,691
<Batu Gajah River System>										
FCP-GJ1: R/I(30)	34,584	-	-	1,430	36,014	10,804	2,475	5,145	7,620	54,438
FCP-GJ2: R/I(5)+Dam	6,626	37,188	-	1,430	45,244	13,573	2,700	700	3,400	62,217
FCP-GJ3: R/I(10)+Dam	9,091	32,485	-	1,430	43,006	12,902	2,325	700	3,025	58,933
<Batu Gantung River System>										
FCP-GT1: R/I(30)	20,374	-	-	1,330	21,704	6,511	1,375	2,555	3,930	32,145
FCP-GT2: R/I(5)+Dam	5,147	29,005	-	1,330	35,482	10,645	2,825	0	2,825	48,952
FCP-GT3: R/I(10)+Dam	7,327	24,284	-	1,330	32,941	9,882	2,375	0	2,375	45,198

4.4.2 Identification of Optimum Plan

The alternative flood control plans are summarized in Table-D.4.27, which presents project composition, project costs, land acquisition areas and number of resettlement households.

Table-D.4.27 Summary of Alternative Flood Control Plans

River	Alternative Plan	Project Composition				Project Cost (million Rp.)	Land Acquisition (m^2)	Resettlement (household)
		RImp	Dam	DivC	ChD			
Ruhu	FCP-RH1	O[30]	X	X	O	44,932	50,000	147
	FCP-RH2	O[5]	O	X	O	66,998	445,500	40
	FCP-RH3	O[10]	O	X	O	84,586	389,000	147
	FCP-RH4	O[5]	X	O	O	43,594	44,440	150
	FCP-RH5	O[10]	X	O	O	46,838	44,540	177
Batu Merah	FCP-BM1	O[30]	X	X	O	47,266	7,750	160
	FCP-BM2	O[5]	O	X	O	52,994	236,350	160
	FCP-BM3	O[10]	O	X	O	72,956	206,750	277
	FCP-BM4	O[5]	X	O	O	51,235	1,550	10
	FCP-BM5	O[10]	X	O	O	66,149	5,950	127
Tonu	FCP-TM1	O[30]	X	X	O	26,290	30,000	-
	FCP-TM2	O[5]	O	X	O	51,454	185,000	-
	FCP-TM3	O[10]	O	X	O	44,310	138,000	-
	FCP-TM4	O[5]	X	O	O	25,890	32,480	34
	FCP-TM5	O[10]	X	O	O	24,691	32,360	34
Batu Gajah	FCP-GJ1	O[30]	X	X	O	54,438	21,500	147
	FCP-GJ2	O[5]	O	X	O	62,217	124,000	20
	FCP-GJ3	O[10]	O	X	O	58,933	109,000	20
Batu Gantung	FCP-GT1	O[30]	X	X	O	32,145	2,750	73
	FCP-GT2	O[5]	O	X	O	48,952	119,000	-
	FCP-GT3	O[10]	O	X	O	45,198	101,000	-

Note RImp : River Improvement ([]:Design scale of river improvement)
Dam : Flood Control Dam DivC : Diversion Channel ChD : Check Dam
[ ]: Optimum flood control plan

Mainly taking into account project costs and the number of resettlement households, the optimum flood control plan for each river system was decided as follows:

(1) Ruhu River

The optimum flood control plan for Ruhu River was selected as FCP-RH2 Plan with river improvement and a dam, for which the project cost and resettlement number are Rp. 66,998 million and 40 households.

Out of FCP-RH2/RH3 Plans with a dam, FCP-RH3 Plan is too high in cost and too many on resettlement (147 households) not to be adopted.

FCP-RH1 Plan of river improvement and FCP-RH4/RH5 Plans with a diversion, cost Rp. 44-47 billion, which is 30-34 % cheaper than the selected FCP-RH2 Plan (Rp. 67 billion). However the former plans need resettlement of 147-177 households, which is 107-137 more than the selected plan (40 households).

On the other hand, based on the future water demand and supply projection, the following

two plans meet the future water demand in 2015.

- the water development plan of Batu Gajah Dam and Batu Gantung Dam proposed by the Study Team, with total development discharge of 10,500 m^3/day
- the water development plan of springs, deep wells and Air Besar intake proposed by PDAM, with development discharge of 9,200 m^3/day

However the water supply after 2015 could not meet the demand without additional water development. The development of groundwater and spring water could become critical in/around the center of the city, so that river water development is necessary for future water resources. There are many small rivers in Ambon Island but no large rivers with the exception of Ruhu River near the center of Ambon City. Way Lawa, Way Sikula and Way Hatu Tenga could be found for suitable water development because these rivers have relatively large catchment areas of 25 - 45 km^2. However as these rivers are located in the northern island, water conveyance cost to the center of the city would be very high even if the water resources development could be implemented.

As the result of the above study, the Study Team proposes that development of Ruhu River should be integrated with flood control and water resources development. Therefore FCP-RH2 Plan with a Dam was selected as the optimum flood control plan for Ruhu River.

(2) Batu Merah River

The optimum flood control plan for Batu Merah River was selected as FCP-BM4 Plan with river improvement and a diversion tunnel, for which the project cost and resettlement number are Rp. 51,235 million and 10 households.

The most economical plan is FCP-BM1 with Rp. 47,266 million (92 % of FCP-BM4) and the third economical plan is FCP-BM2 with Rp. 52,994 million (103 % of FCP-BM4). However for these plans it is necessary to resettle 160 households. Therefore, the second economical plan with the least resettlement of 10 households, FCP-BM4 Plan was adopted.

(3) Tomu River

The optimum flood control plan for Tomu River was selected as FCP-TM1 Plan with full scale river improvement, for which the project cost is Rp. 26,290 million with no resettlement.

The most economical plans excluding FCP-TM1 are FCP-TM5 with Rp. 24,691 million (94 % of FCP-TM1) and FCP-TM4 with Rp. 25,890 million (98 % of FCP-TM1). These are the plans with a flood control dam and it is necessary to resettle 34 households. The FCP-TM1 plan is the third economical plan but the project costs of the first and second economic plans are only 2-6 % less than the third. Therefore the FCP-TM1 plan was adopted.

(4) Batu Gajah River

The optimum flood control plan for Batu Gajah River was selected as FCP-GJ3 plan with river improvement and a dam, for which the project cost and resettlement number are Rp. 58,933 million and 20 households.

All the project costs are nearly the same as each other. The most economical plan is FCP-GJ1 with Rp. 54,438 million (92 % of FCP-GT3), but it is necessary to resettle 147 households. It could not be adopted. For the other two plans, it is necessary to resettle only 20 households and the more economical plan of these, FCP-GJ3 was adopted. The dam is planned as a multi-purpose dam as described in Section 3.3.3.

(5) Batu Gantung River

The optimum flood control plan for Batu Gantung River was selected as FCP-GT3 plan with river improvement and a dam, for which the project cost is Rp. 45,198 million with no resettlement household.

The most economical plan is the full scale river improvement plan of FCP-GT1 with Rp. 40,212 million (75 % of FCP-GT3) but it is necessary to resettle 73 households. It could not be adopted although the project cost is 25 % less than FCP-GT3. The other two plans have no resettlement and of these the more economical plan, FCP-GT3 was adopted. The dam is planned as a multi-purpose dam as described in Section 3.3.3.

(6) Features of Flood Control Plan

The optimum flood control plan for each river system is presented in Table-D.4.28 and Figure-D.4.21 to Figure-D.4.25. All the projects were integrated into Figure-D.4.20. Table-D.4.29 presents the integrated features of the flood control master plan of the five target rivers in the Study Area.

Table-D.4.28 Features of Flood Control Plan in the Study Area

Item	Figure	Item	Figure
Project Cost (Million Rp.)	248,654	**Flood Control Dam (RII-1, GJ-2, GT-1)**	
A. Main Construction Cost	177,228	- Construction Cost (Million Rp.)	88,113
B. Indirect Cost	53,609	- Land Acquisition A (m^2)	599,000
C. Land Acquisition/Compensation Cost	18,258	- Resettlement (Household)	20
Land Acquisition A (m^2)	687,057	Dam Type	Rock Fill
Resettlement (Household)	70	Number of Dam	3
River Improvement Plan		**Diversion Channel (Batu Merah River)**	
- Construction Cost (Million Rp.)	54,460	- Construction Cost (Million Rp.)	29,055
- Land Acquisition A (m^2)	1,850	- Land Acquisition A (m^2)	1,200
- Resettlement (Household)	50	- Resettlement (Household)	-
River-bed Formation L (m)	9,950	Type	Tunnel
River-bed Excavation L(m)	8,850	Length L(m)	1,200
Concrete Channel L(m)	4,900	**Check Dam**	
Flood Wall Heightening L(m): Left	1,770	- Construction Cost (Million Rp.)	5,600
: Right	1,520	- Land Acquisition A (m^2)	85,000
River Widening L(m)	370	- Resettlement (Household)	0
Bridge Improvement (Number)	13	Number of Check Dam	4

Table-D.4.29 Optimum Flood Control Plan

Item		Ruhu	Batu Merah	Tomu	Batu Gajah	Batu Ganlung
Code of Alternative Plan		FCP-RH2	FCP-BM4	FCP-TM1	FCP-GJ3	FCP-GT3
Project Cost (Million Rp.)		66,998	51,235	26,290	58,933	45,198
A. Main Construction Cost		42,037	39,021	20,223	43,006	32,941
B. Indirect Cost		12,611	12,147	6,067	12,902	9,882
C. Land Acquisition/Compensation Cost		12,350	508	0	3,025	2,375
- Land Acquisition	A (m^2)	445,500	1,550	30,000	109,000	101,000
- Resettlement	Household	40	10	-	20	-
River Improvement Plan						
- Construction Cost (Million Rp.)		9,323	9,966	18,753	9,091	7,327
- Land Acquisition	A (m^2)	1,500	350	-	-	-
- Resettlement	Household	40	10	-	-	-
Improvement Scale (Return Period)		5-year	5-year	30-year	10-year	10-year
River-bed Formation	Section	0'000-1'600	0'000-1'600	0'000-2'700	0'000-2'600	0'000-1'450
	L (m)	1600	1600	2700	2,600	1,450
River-bed Excavation	Section	0'000-1'600	0'000-1'600	0'000-2'100	0'000-2'100	0'000-1'450
	D (m)	1.00	1.00	0.80	1.00	1.00
	L (m)	1,600	1,600	2,100	2,100	1,450
Concrete Channel	Section	-	0'400-1'600	0'600-2'700	0'200-0'900	0'250-1'150
	L (m)	-	1,200	2,100	700	900
Flood Wall Heightening	Section	0'650-1'550	0'400-1'600	1'800-2'700	0'700-1'600	0'400-0'550
	MnH (m)	3.50-4.00	2.60-3.40	2.40-2.80	2.80-3.80	3.30
: Left	ΔH (m)	0.30	0.20-0.60	0.10-0.40	0.40	0.30
	L (m)	300	1010	130	230	100
: Right	ΔH (m)	0.20-0.60	0.30-0.60	0.10	0.20-0.40	0.40
	L (m)	350 (250)	1070 (1000)	20	150	100
River Widening	Section	0'550-1'000	0'700-0'800	-	-	-
	ΔW (m)	3.0-5.0R	2.0 R	-	-	-
	L (m)	300	70	-	-	-
Bridge Improvement	Location	0'059-1'359	0'386	0'460-1'822	0'750-1'835	0'400-0'769
	Number	B2,B4,B5	B4	B4-B6, B8	B3,B5,B6	B1,B2
Flood Control Dam						
- Construction Cost (Million Rp.)		31,344	-	-	32,485	24,284
- Land Acquisition	A (m^2)	411,000	-	-	93,000	95,000
- Resettlement	Household	-	-	-	20	-
- Dam Type	-	Rock Fill	-	-	Rock Fill	Rock Fill
- Dam Height	H (m)	41.0	-	-	31.8	34.0
- Dam Length	L (m)	103.0	-	-	209.0	132.0
- Dam Volume	V (m^3)	201,000			335,000	174,000
Diversion Channel						
- Construction Cost (Million Rp.)		-	29,055	-	-	-
- Land Acquisition	A (m^2)	-	1,200	-	-	-
- Resettlement	Household	-	-	-	-	-
- Type	-	-	Tunnel	-	-	-
- Length	L (m)	-	1,200	-	-	-
- Standard Section	W (m)	-	5.8	-	-	-
	H (m)	-	5.8	-	-	-
Check Dam						
- Construction Cost (Million Rp.)		1,370	-	1,470	1,430	1,330
- Land Acquisition	A (m^2)	33,000	-	30,000	16,000	6,000
- Resettlement	Household	-	-	-	-	-
- Dam Height	H (m)	10.0	-	7.0	8.0	11.0
- Dam Length	L (m)	50.0	-	110.0	80.0	40.0
- Dam Volume	V (m^3)	2,500	-	2,700	2,600	2,400

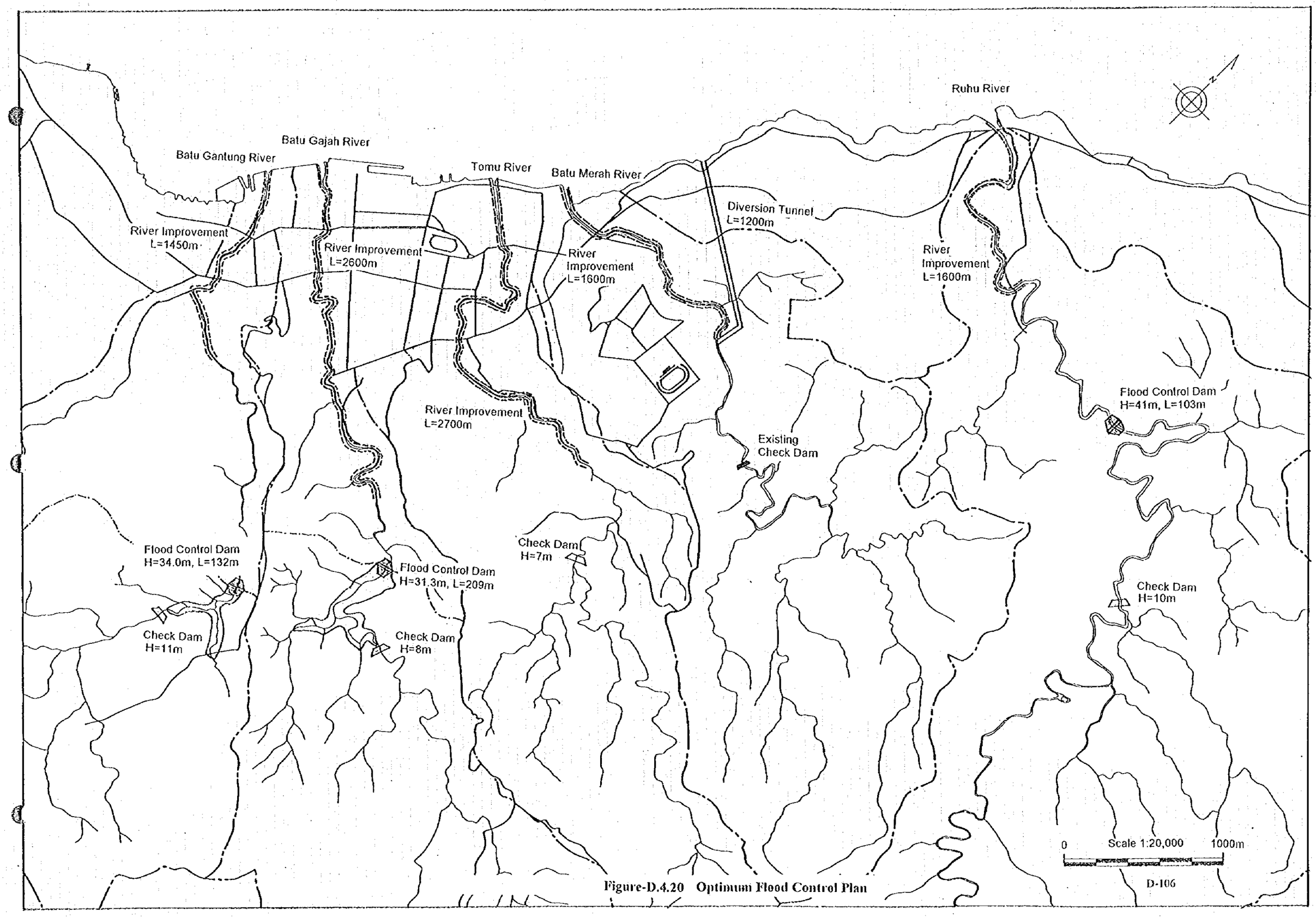
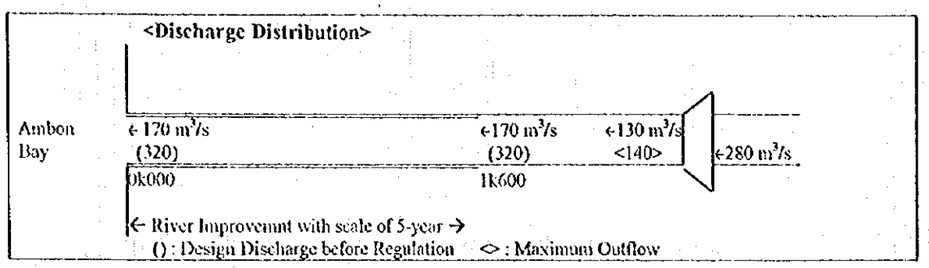
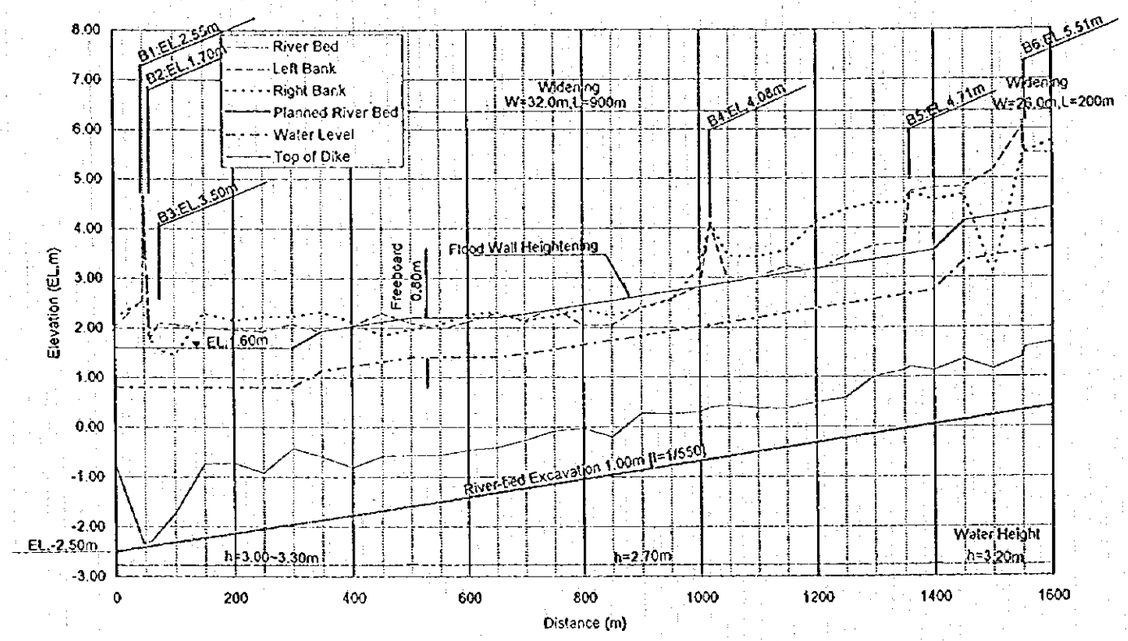


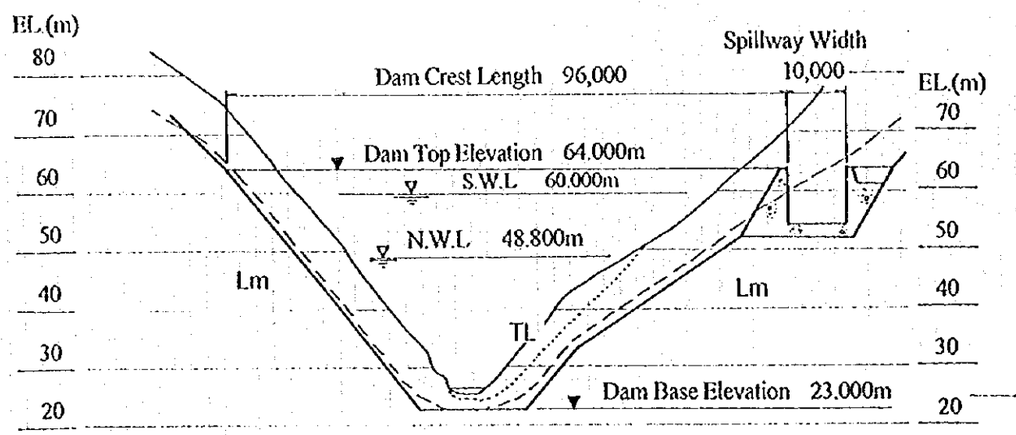
Figure-D.4.20 Optimum Flood Control Plan



Longitudinal Section of River Improvement



View from Downstream of RH-1 Dam S=1:1,000



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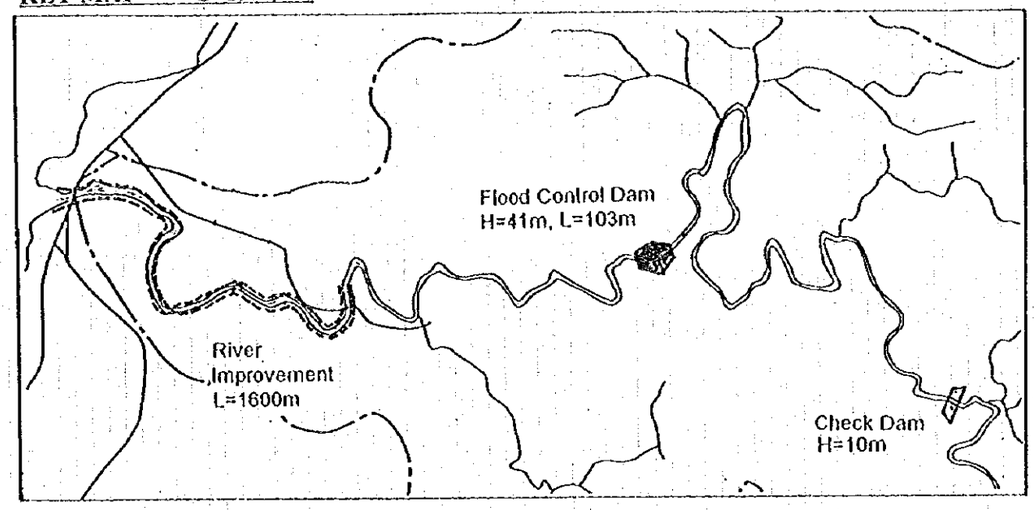
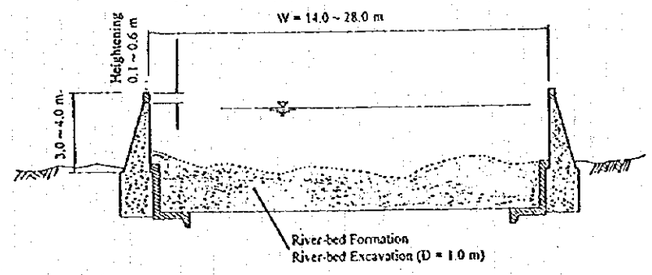
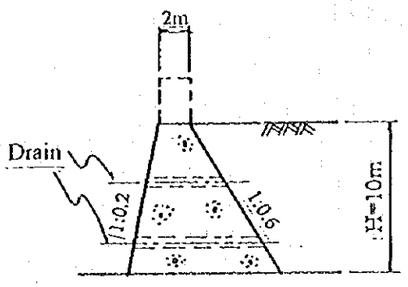


Standard Cross Section of River Improvement S=1:300



Standard Cross Section of Check Dam S=1:400



Standard Cross Section of RH-1 Dam S=1:1,000

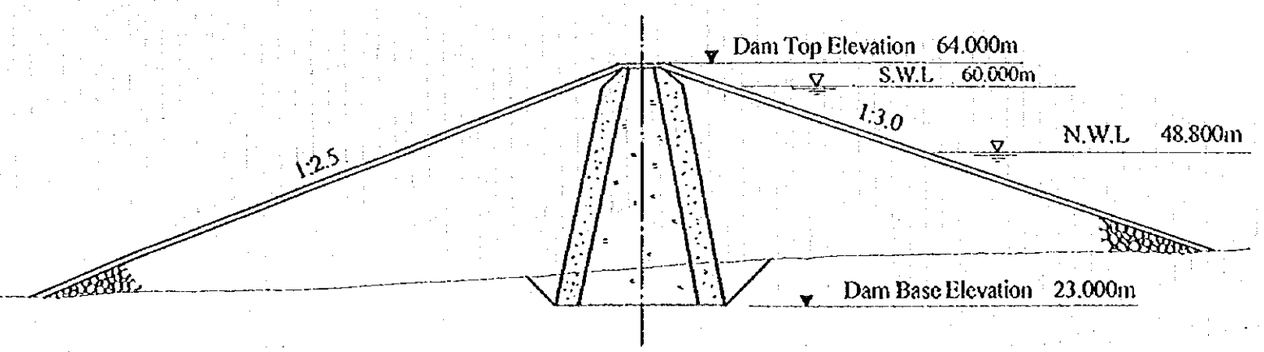
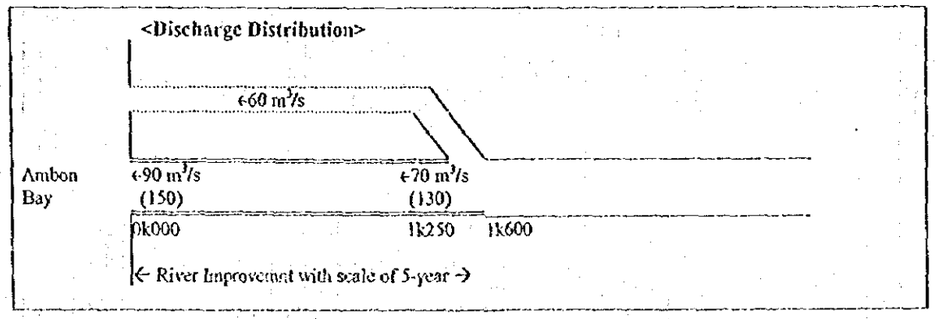
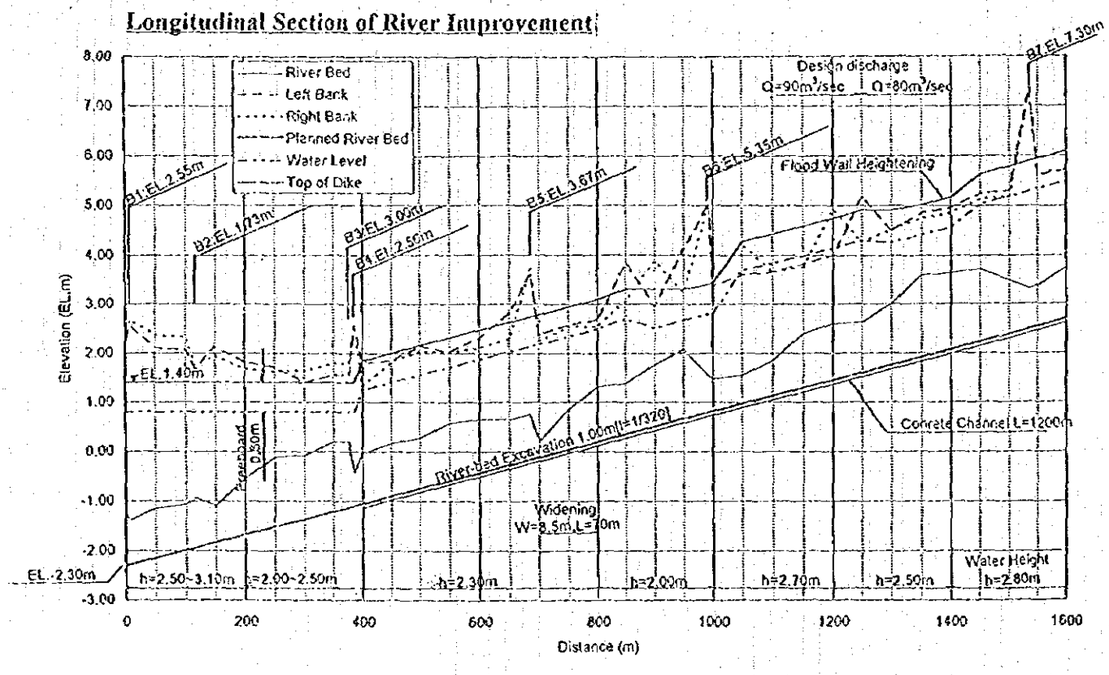


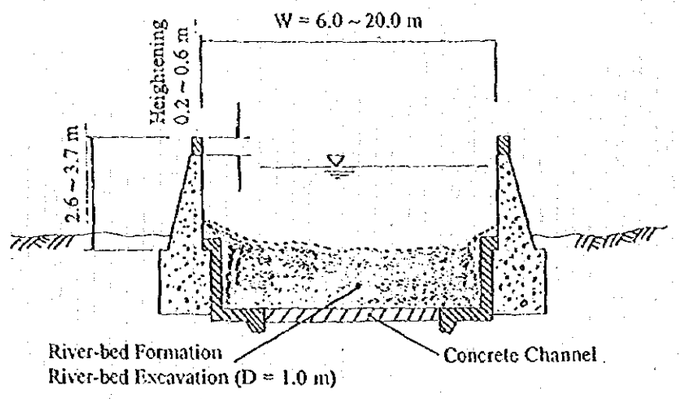
Figure-D.4.21 Optimum Flood Control Plan for Ruhu River



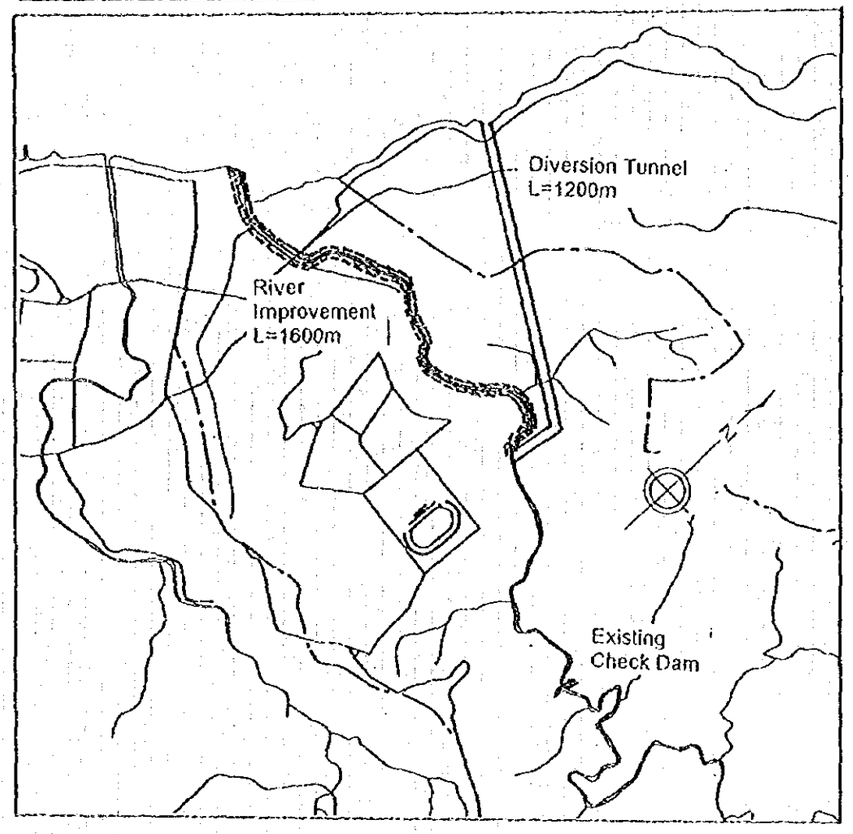
Longitudinal Section of River Improvement



Standard Cross Section of River Improvement S=1:200



KEY MAP S=1:20,000



Standard Cross Section of Diversion Channel S=1:100

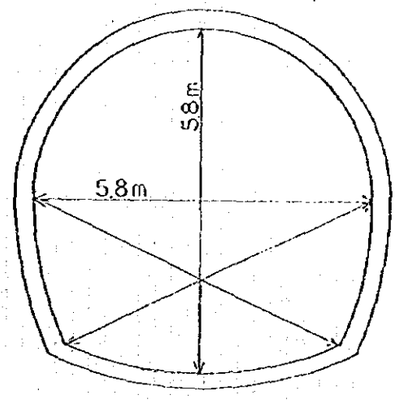
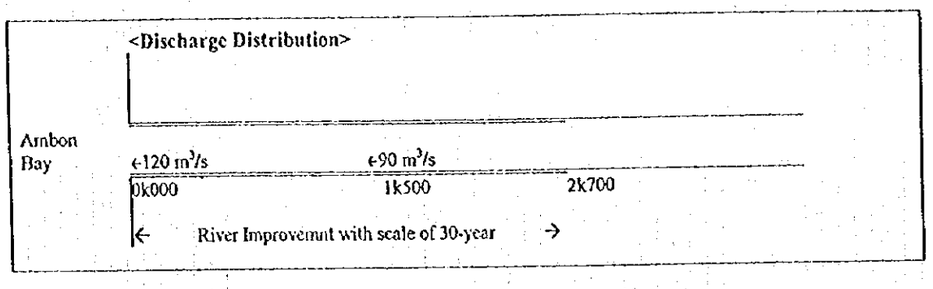


Figure-D.4.22 Optimum Flood Control Plan for Batu Merah River



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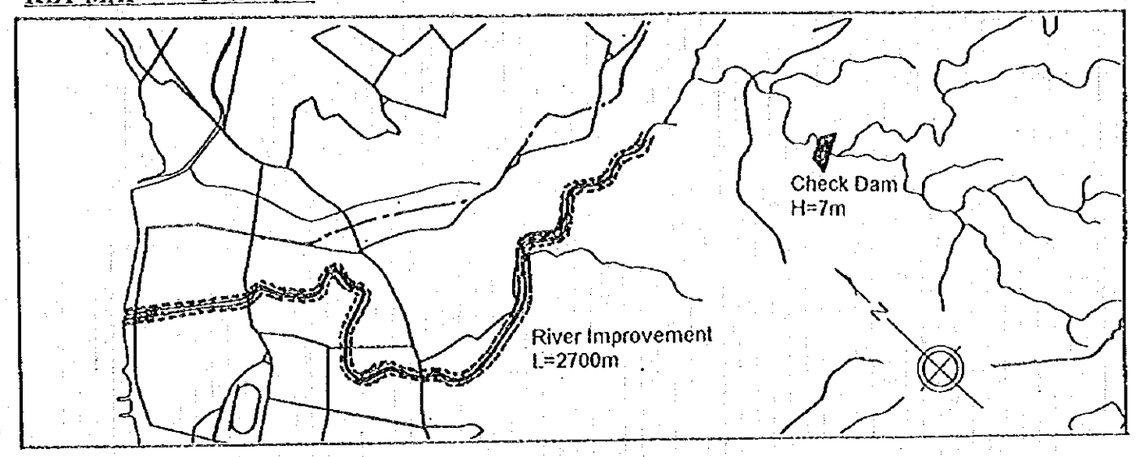
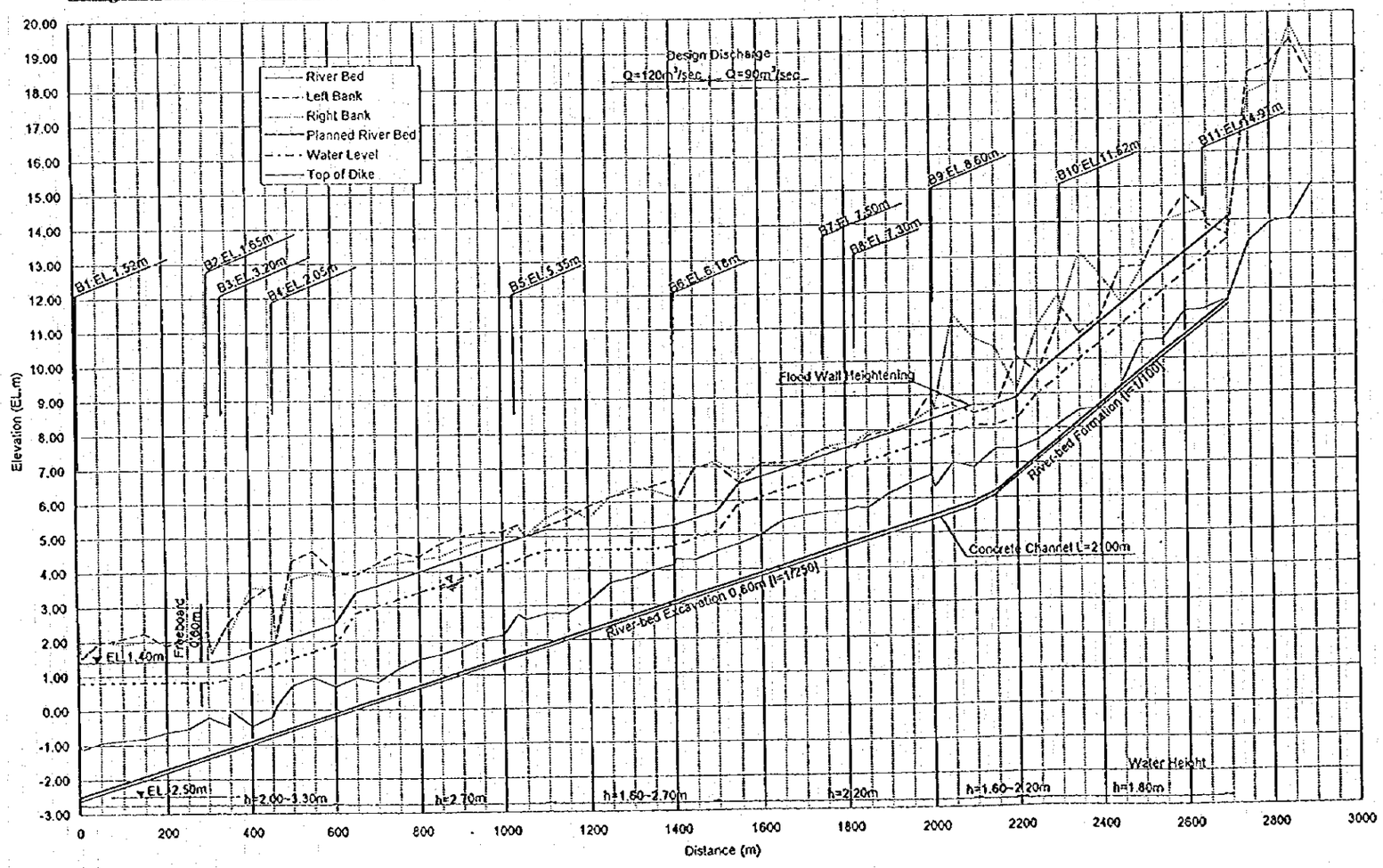


Longitudinal Section of River Improvement



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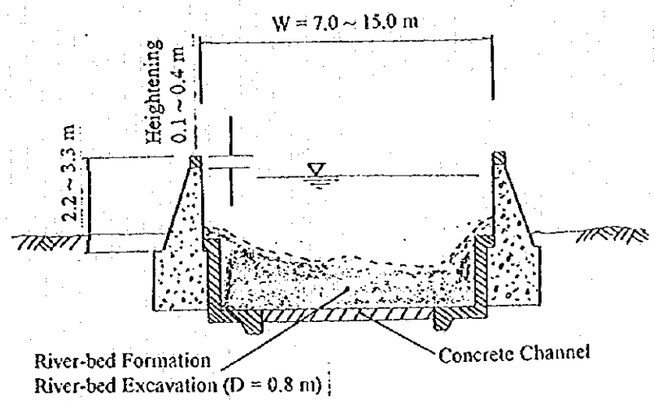


Standard Cross Section of Check Dam S=1:250

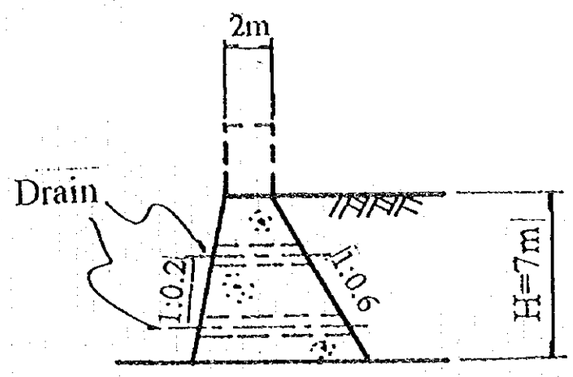
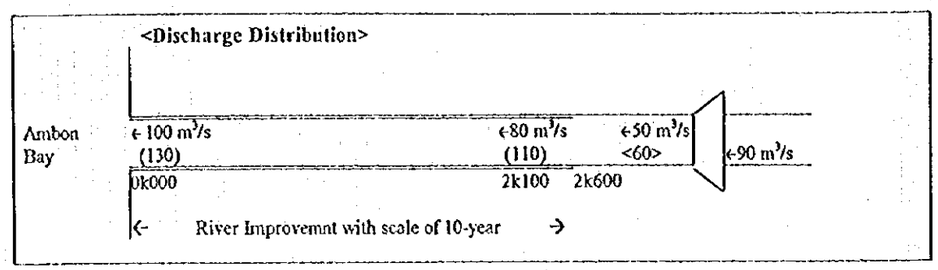
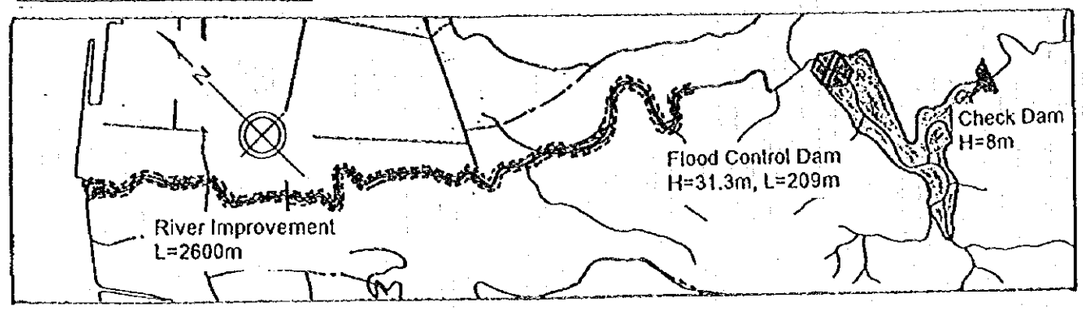


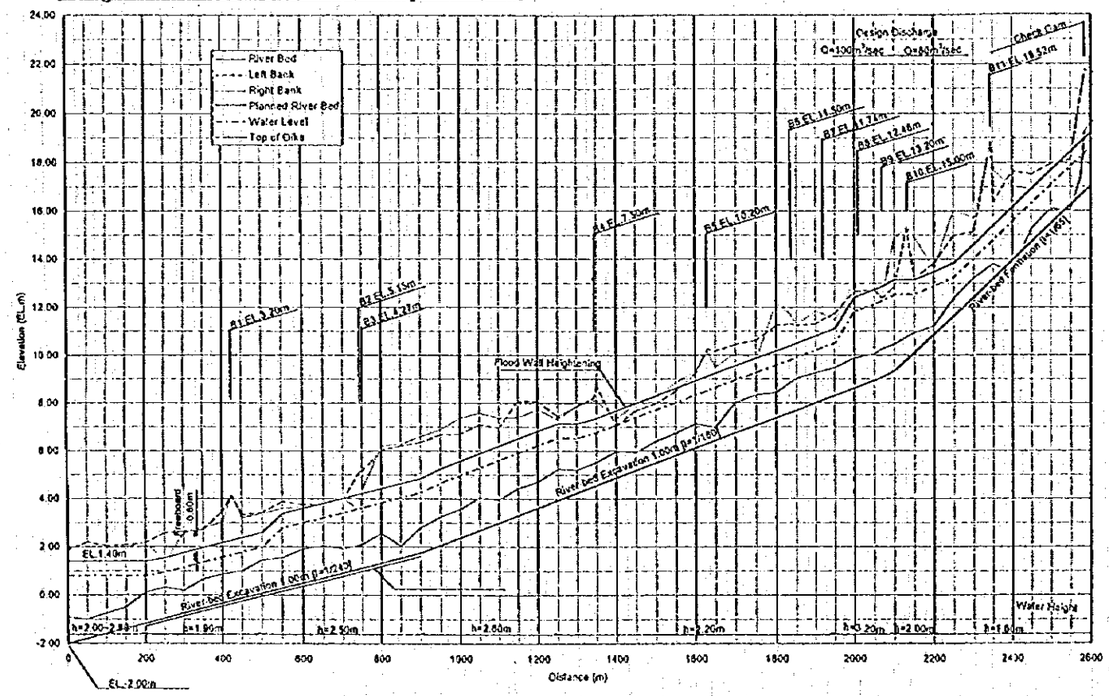
Figure-D.4.23 Optimum Flood Control Plan for Tomu River



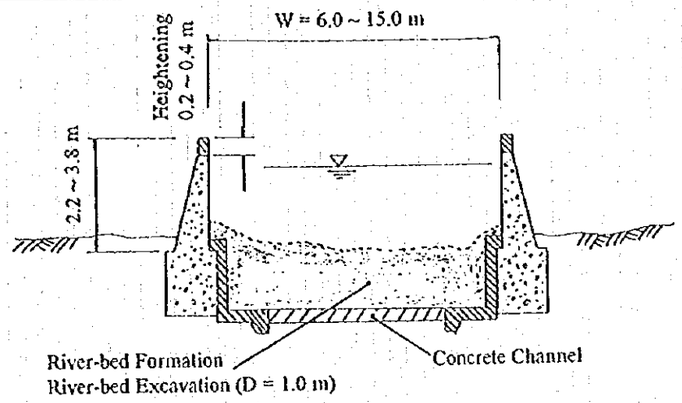
KEY MAP S=1:20,000



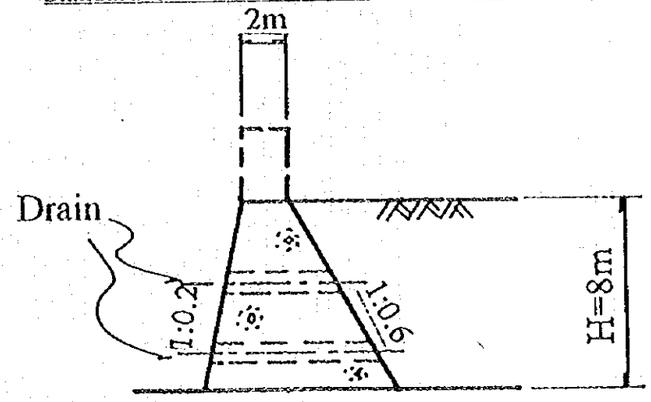
Longitudinal Section of River Improvement



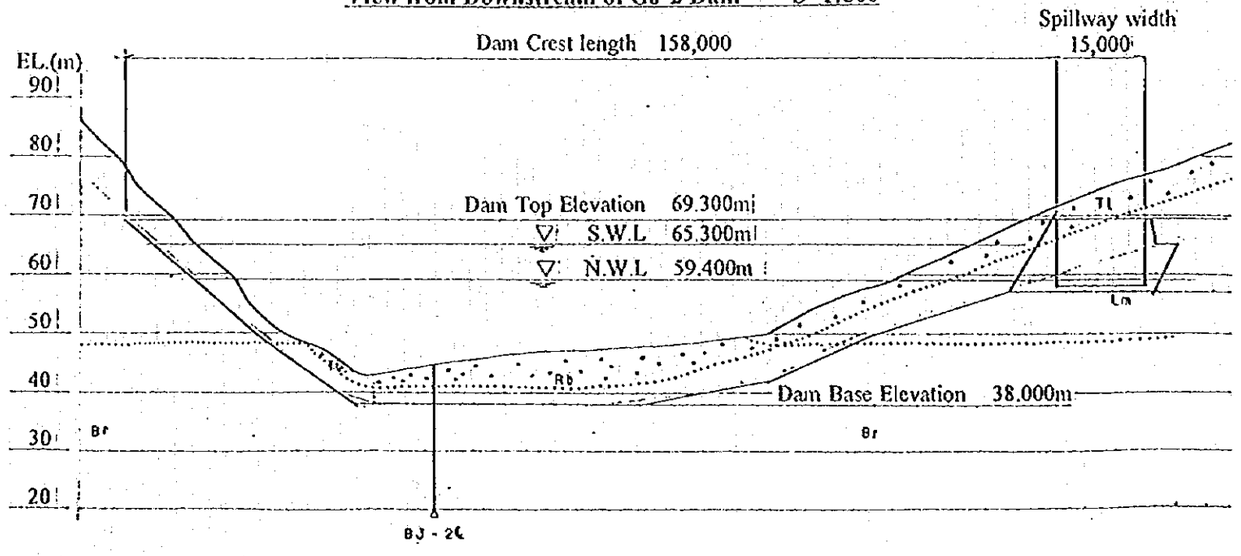
Standard Cross Section of River Improvement S=1:200



Standard Cross Section of Check Dam S=1:250



View from Downstream of GJ-2 Dam S=1:500



Standard Cross Section of GJ-2 Dam S=1:1000

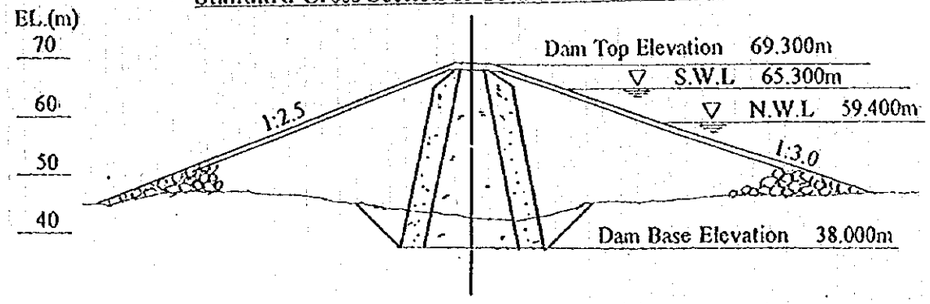
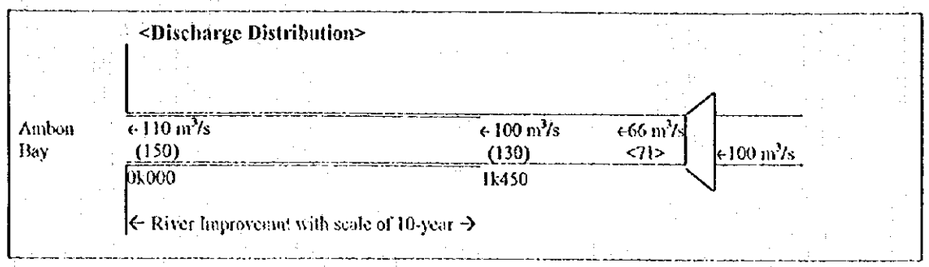
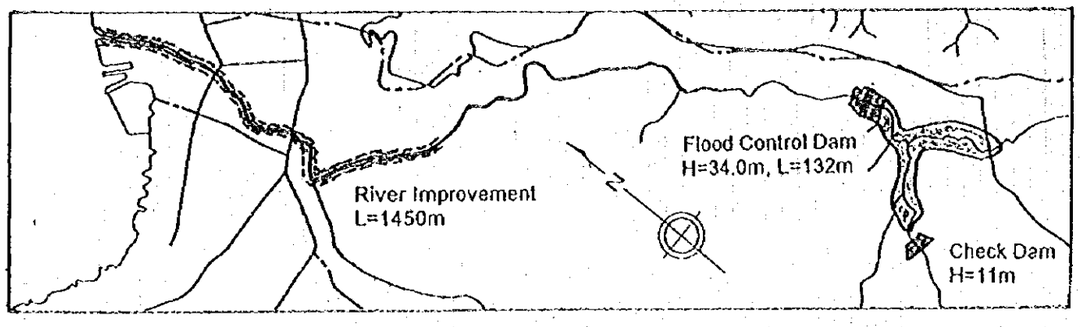


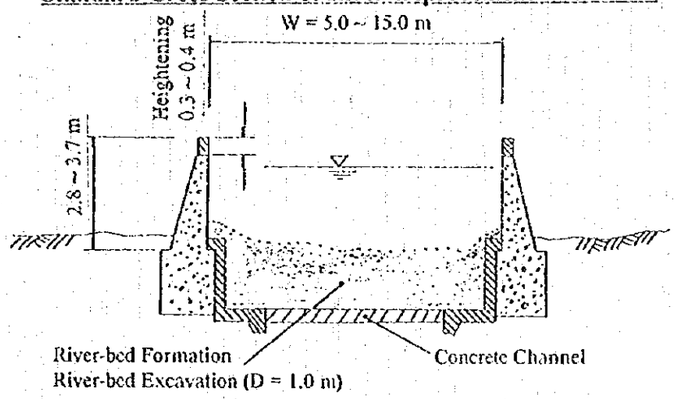
Figure-D.4.24 Optimum Flood Control Plan for Batu Gajah River



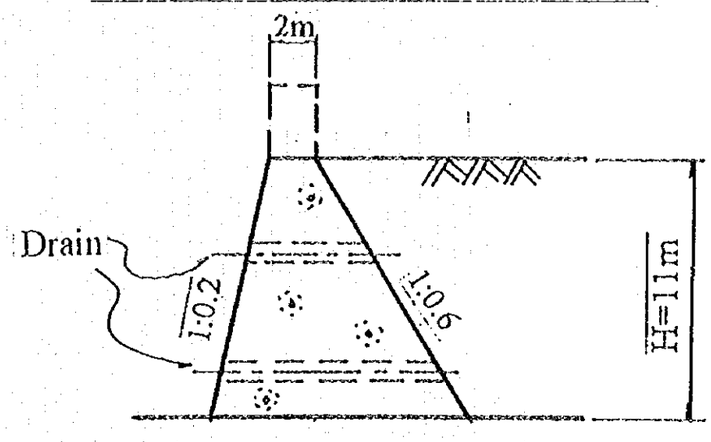
KEY MAP S=1:20,000



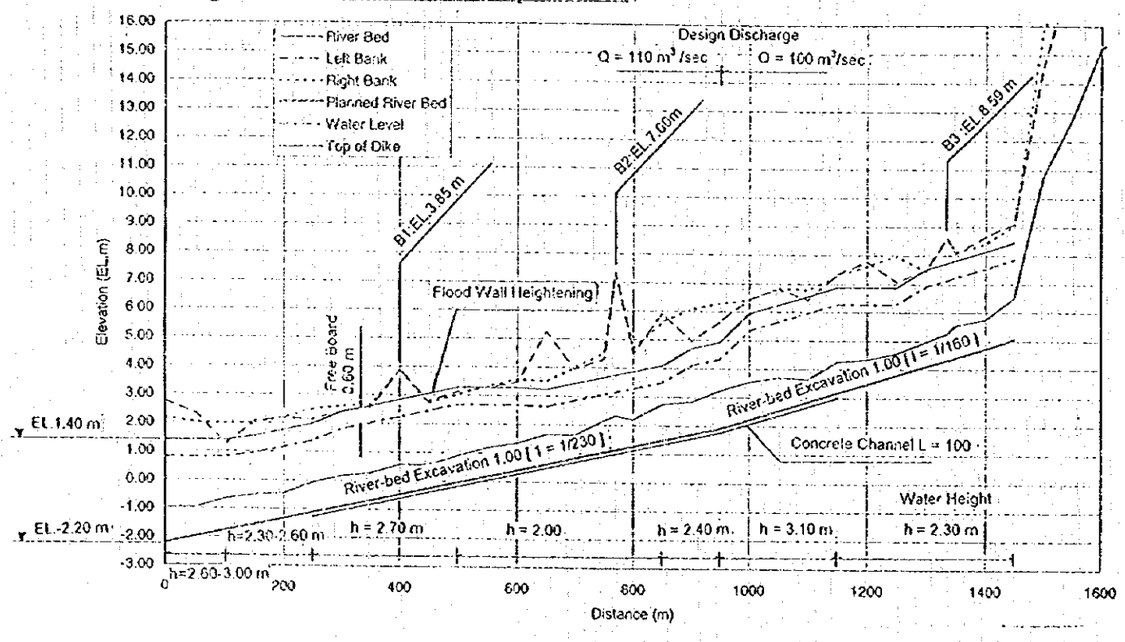
Standard Cross Section of River Improvement S=1:200



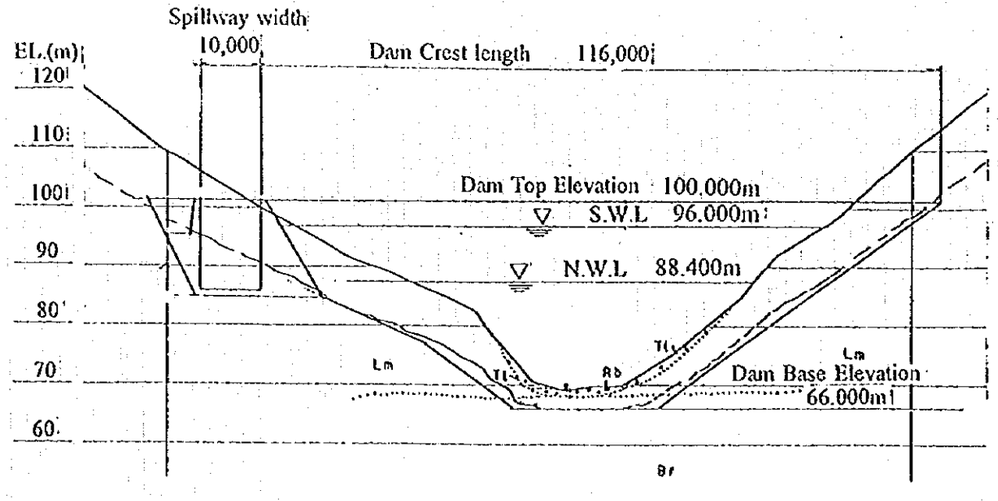
Standard Cross Section of Check Dam S=1:250



Longitudinal Section of River Improvement



View from Downstream of GT-1 Dam S=1:1000



Standard Cross Section of GT-1Dam S=1:1000

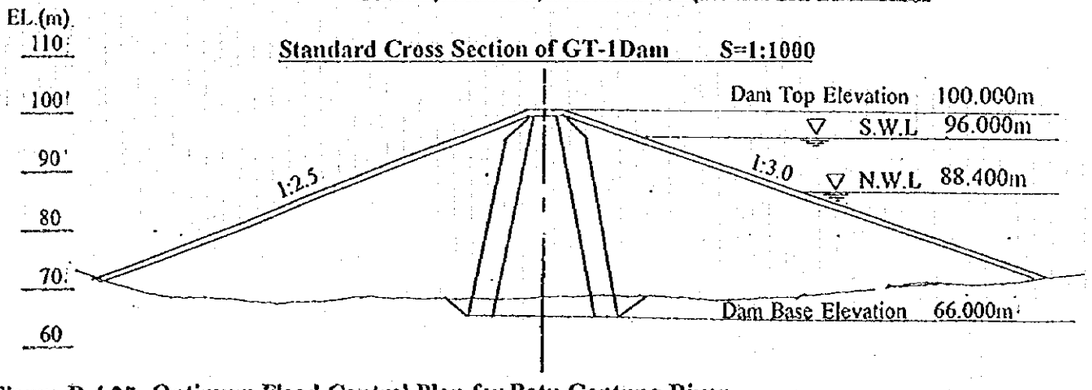


Figure-D.4.25 Optimum Flood Control Plan for Batu Gantung River

4.5 Multi-purpose Dam Plan and Cost Estimate

4.5.1 Plan and Design of Multi-purpose Dams

The flood control dams in Ruhu, Batu Gajah and Batu Gantung Rivers were proposed in Section 4.4 as part of the optimum flood control plan. After consideration of water utilization for domestic use in Ambon central area, RH-1 Dam, GJ-2 Dam and GT-1 Dam were planned and designed as multi-purpose dams. The specification of these dams are presented in Table-D.4.30. These plans are adopted for the Master Plan involved with water utilization. The reservoir storage allocations are presented graphically in Figure-D.4.26.

Table-D.4.30 Specification of Multi-purpose Dams and Reservoirs

Items		Ruhu River	Batu Gajah River	Batu Gantung River
		RH-1 Dam	GJ-2 Dam	GT-1 Dam
Code of Alternative Flood Control Plan		FCP-RH2	FCP-GJ3	FCP-GT3
Design Scale of River Improvements		1/5	1/10	1/10
Catchment Area (km^2)		14.49	4.37	4.76
Unregulated peak discharge (m^3/sec) (30-year return period)	Dam	273	90	99
	River Mouth	314	123	143
Outflow at peak inflow (m^3/sec)	Dam	114	68	67
Regulated peak discharge (m^3/sec)	Dam	136	72	73
	River Mouth	168	100	110
Cut discharge (m^3/sec)	Dam	159	22	32
	River Mouth	146	23	33
Newly Developed Discharge (m^3/day)		16,000	8,000	2,500
Sediment Capacity (1000 m^3)		580	175	191
Water Utilization Capacity (1000 m^3)		1,064	955	639
: River Maintenance Capacity (1000 m^3)		115	20	249
: New Development Capacity (1000 m^3)		949	935	390
Flood Storage Capacity (1000 m^3)		2,763	380	513
Effective Storage Capacity (1000 m^3)		3,827	1,335	1,152
Total Storage Capacity (1000 m^3)		4,407	1,510	1,343
Low Water Level (EL.m)		46.4	57.2	86.4
Normal Water Level (EL.m)		54.3	71.2	97.5
Surcharge Water Level (EL.m)		63.7	74.6	102.9
Dam Top Elevation (m)		67.7	78.6	106.9
Dam Base Elevation (m)		23.0	38.0	66.0
Freeboard (m)		4.0	4.0	4.0
Dam Height (m)		44.7	40.6	40.9
Dam Crest Length (m)		112.0	200.0	139.0
Dam Foundation Length (m)		10.0	54.0	23.0
Conduit		B3.9m*H3.9m	B8.0m*H3.40	B4.1m*H4.1m
Upstream Slope		1:3.0	1:3.0	1:3.0
Downstream Slope		1:2.5	1:2.5	1:2.5
Dam Top Width (m)		5.0	5.0	5.0
Dam Volume (1000 m^3)		235	404	262
Land Acquisition Area (1000m^2)		515,000	148,000	139,000
Resettlement Household (number)		-	30	-
Construction Cost of Multi Purpose Dam (Rp. Mil)		36,646	49,480	35,306
Total Project Cost (Rp. Mil)		76,491	82,751	60,627
A : Construction Cost (Rp. Mil)		47,339	60,001	43,963
B : Indirect Cost (Rp. Mil)		14,202	18,000	13,189
C : Land Acquisition and Compensation Cost (Rp. Mil)		14,950	4,750	3,475

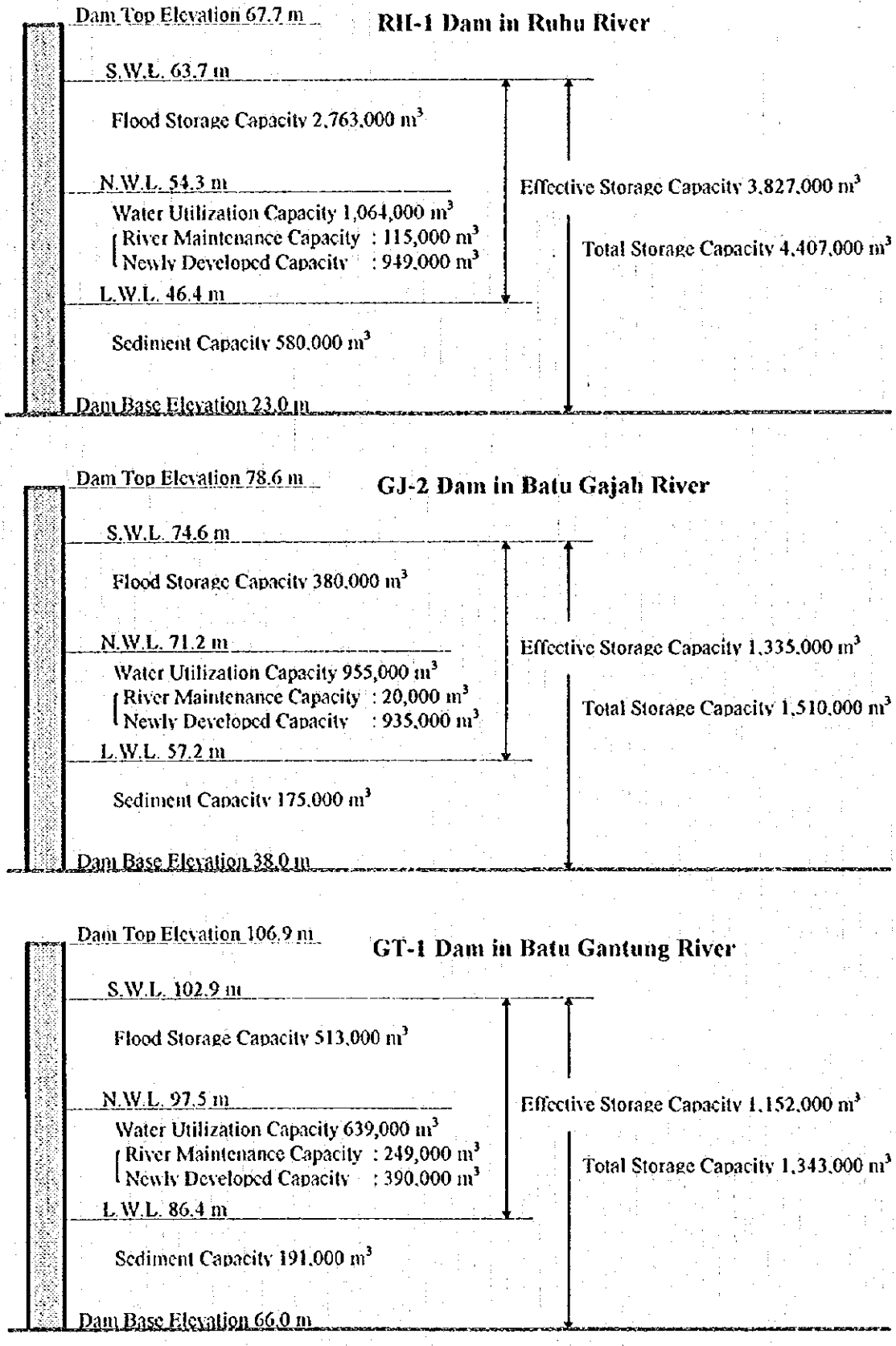


Figure-D.4.26 Reservoir Storage Allocation

4.5.2 Project Cost of the Optimum Flood Control Plan with Multi-purpose Dam

The estimated project cost of the optimum flood control plan and the plans with multi-purpose dams are shown in Table-D.4.31.

Table-D.4.31 Project Cost of the Optimum Flood Control Plan and the Plan with Multi-purpose Dams

Unit: Million Rupiah

Alternative	A: Construction Cost A1: River Improvement, A2: Dam, A3: Diversion Channel, A4: Check Dam					B: Indirect Cost	C: Land Acq. & Comp. C1: Land Acquisition C2: Compensation			Total Project Cost
	A1	A2	A3	A4	Total	Total	C1	C2	Total	
<Ruhu River System>										
FCP-RH2: R/I(5) only	9,323	-	-	-	9,323	2,797	675	1,400	2,075	14,195
FCP-RH2: R/I(5)+Dam (Flood Control Dam)	9,323	31,344	-	1,370	42,037	12,611	10,950	1,400	12,350	66,998
FCP-RH2: R/I(5)+Dam (Multi-purpose Dam)	9,323	36,646	-	1,370	47,339	14,202	13,550	1,400	14,950	76,491
<Batu Merah River System>										
FCP-BM4: R/I(5)+Div.	9,966	-	29,055	-	39,021	11,706	158	350	508	51,235
<Tomu River System>										
FCP-TM1: R/I(30)	18,753	-	-	1,470	20,223	6,067	0	0	0	26,290
<Batu Gajah River System>										
FCP-GJ3: R/I(10)+Dam (Flood Control Dam)	9,091	32,485	-	1,430	43,006	12,902	2,325	700	3,025	58,933
FCP-GJ3: R/I(10)+Dam (Multi-purpose Dam)	9,091	49,480	-	1,430	60,001	18,000	3,700	1,050	4,750	82,751
<Batu Gantong River System>										
FCP-GT3: R/I(10)+Dam (Flood Control Dam)	7,327	24,284	-	1,330	32,941	9,882	2,375	0	2,375	45,198
FCP-GT3: R/I(10)+Dam (Multi-purpose Dam)	7,327	35,306	-	1,330	43,963	13,189	3,475	0	3,475	60,627
Flood Control Plan	54,460	88,113	29,055	5,600	177,228	53,168	15,808	2,450	18,258	248,654
Flood Control Plan with Multi-purpose Dam	54,460	121,432	29,055	5,600	210,547	63,164	20,883	2,800	23,683	297,394

4.5.3 Approximate Cost Estimation of Water Treatment Plant

Costs of water treatment plant and pipelines were estimated assuming the following unit costs :

- Unit cost of treatment plant per cubic meter discharge : Rp. 880,000 /m^3
- Unit cost of pipe line per meter : Rp. 160,000 /m

Water treatment plant and pipe line costs are estimated as shown in Table-D.4.32.

Table-D.4.32 Cost Estimation of Water Treatment Plant

Dam	Developed Disch. (Treated Disch.) (m^3/day)	Pipe Line (m)	Cost of Treatment Facilities (Rp. million)	Cost of Pipe Line (Rp. million)	Total Project Cost (Rp. million)
Ruhu Dam	16,000	800	14,080	128	14,208
Batu Gajah Dam	8,000	2,000	7,040	320	7,360
Batu Gantung Dam	2,500	1,700	2,200	272	2,472
Total	26,500	4,500	23,320	720	24,040

4.6 Non-structural Flood Control Measures

4.6.1 General Outline

Non-structural flood control measures are defined as measures other than structural flood control measures constructed along the river to mitigate flood disasters. The targets of non-structural measures are: 1) to suppress flood runoff (including sediments), 2) to improve flood proofing function and 3) to facilitate flood prevention activities. Non-structural flood control measures selected from those listed in Table-D.4.33 are generally employed to flood prone river basins. On the basis of the current and future forecast conditions of the target river basins, practical non-structural measures are chosen as described in the following sections and entered into the Master Plan.

Table-D.4.33 Non-structural Flood Control Measures for Ambon Area

Objectives	Methods	Contents	Target Area	Priority
Suppression of Flood Runoff	Land Use Regulation	Land use restriction to maintain forest and natural flood retention areas etc. based on Land Use Plan authorized by Local Government	Whole Area	O
	Vegetation Improvement	Aggressive improvement of vegetation to reduce flood and sediment discharge through reforestation and regreening	Upland Area	O
	Off-site Storage	Regulation reservoir to store increasing flood and sediment discharge caused by large scale land development	Whole Area	O
	On-site Storage	Temporary storage system using public facilities (school ground, park etc.) and private house yards	Lowland Area	X
	Infiltration in upland	Trenches and terraces to increase rain water infiltration on hill slopes	Upland Area	X
	Infiltration in lowland	To decrease rain water discharge using permeable sewerage system , infiltration wells and permeable pavement roads	Lowland Area	O
Improvement of Flood Proof Function	Land Use Regulation	To restrict land use in flood prone areas by authorized regulation	Whole Area	O
	Flood Proof Facilities	To promote flood proof public facilities and private buildings by land elevation and water proofing works	Lowland Area	O
	Flood Regulation Facility	Secondary dikes to control flooded and inundated water	Lowland Area	X
Facilitation of Flood Disaster Prevention Activities	Management Organization	Establishment of flood management organization for total flood control system	-	O
	Flood Forecast & Warning System	Establishment of flood forecast and warning system to facilitate flood fighting and evacuation	Lowland Area	O
	Flood Risk Map	To prepare flood risk map and announce officially to inhabitants	Lowland Area	O
	Flood Fighting System	Well organized flood fighting system including soft and hard systems for emergency preparedness	Lowland Area	O
	River Management Zone	Installation of river management zone along the designated reaches	Lowland Area	O
	Public Awareness	Publication of flood control system including flood control measures and implementation schedule	-	O
	Human-source Development	Training for personnel involved with flood control activities	-	O
Insurance	Flood Insurance	Damage insurance fully or partly subsidized by government for inhabitants in the flood risk area	-	X

[Note] Priority O: To be entered in the Master Plan, Priority X: Not to be entered in the Master Plan

4.6.2 Suppression of Flood Runoff

(1) Land Use Regulation

Natural forests and green areas have the advantage of retaining rain water, recharging it into the groundwater reservoir, and decreasing runoff (including sediment runoff) from the areas. To make use of this function, conservation of the existing forests in the upstream areas is important. Land use restrictions to maintain forest and natural flood retention areas shall be implemented in accordance with the land use plan authorized by the local government.

(2) Vegetation Improvement

Positive improvement of vegetation to reduce flood and sediment runoff shall be carried out through reforestation and regreening. Reforestation and regreening projects are not simply flood control projects but are also forest resource development or agricultural development projects. The managing body for flood control shall explain this flood control function to the other sectors and offer cooperation in the implementation of such projects.

(3) Off-site Storage

To meet the recent population expansion in Ambon city, large scale land development for residential areas is currently being carried out in the catchment area. This kind of land development usually causes an increase of runoff and sediment discharge. To maintain former condition of the runoff system, regulation reservoirs to store increasing flood and sediment discharge are essential. Refer to Figure-D.4.27. It is recommended that the developer shall construct such reservoirs in accordance with a decree issued by the local government.

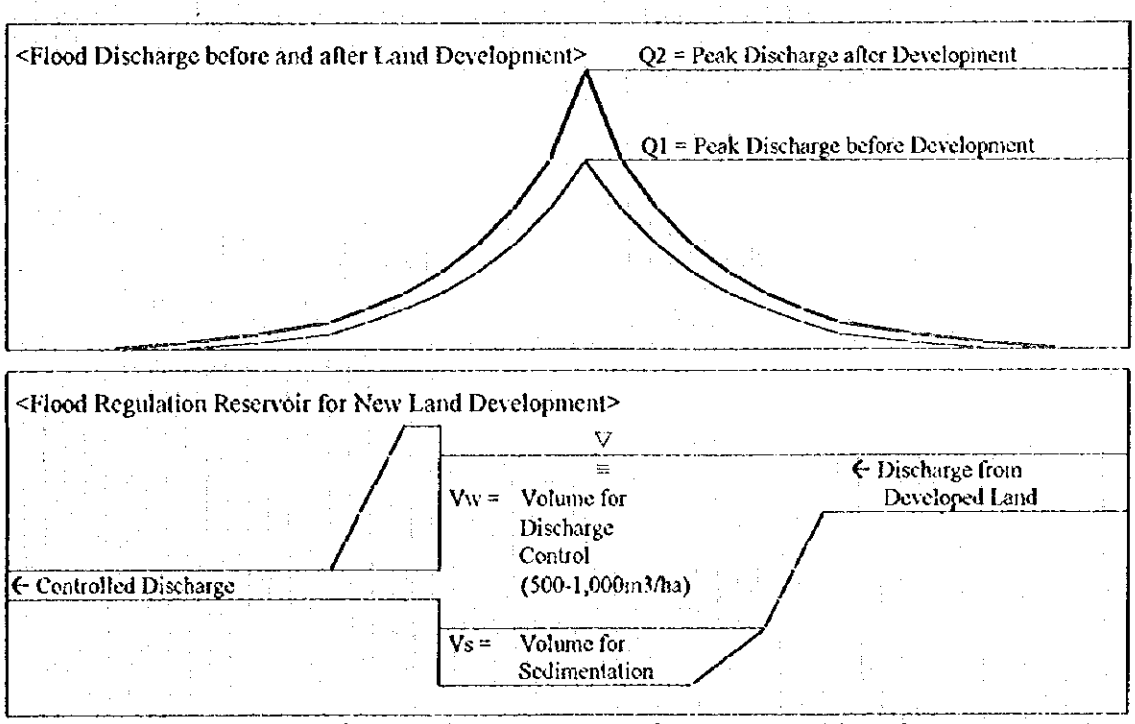


Figure-D.4.27 Off-site Storage System for New Land Development

(4) Lowland Infiltration

In the densely populated lowland areas which are the targets of flood protection, infiltration of rain water using the following methods is useful to decrease rain water discharge. Refer to Figure-D.4.28.

- **Permeable Drainage System :** During heavy rainfall, lowland or town areas suffer from inundation caused by rain water falling on such areas due to shortage of drainage system. Final solution for this problem is to establish an appropriate system. This permeable drainage system is recommended to increase the drainage effect. This system includes underground infiltration trench, infiltration pit, infiltration well and so on.
- **Pervious Pavement Road :** To decrease discharge from roads which are usually paved with impervious materials such as concrete and asphalt, pervious pavement road is effective. Road management body is recommended to employ this type of pavement for new road pavement as well as rehabilitation or improvement.

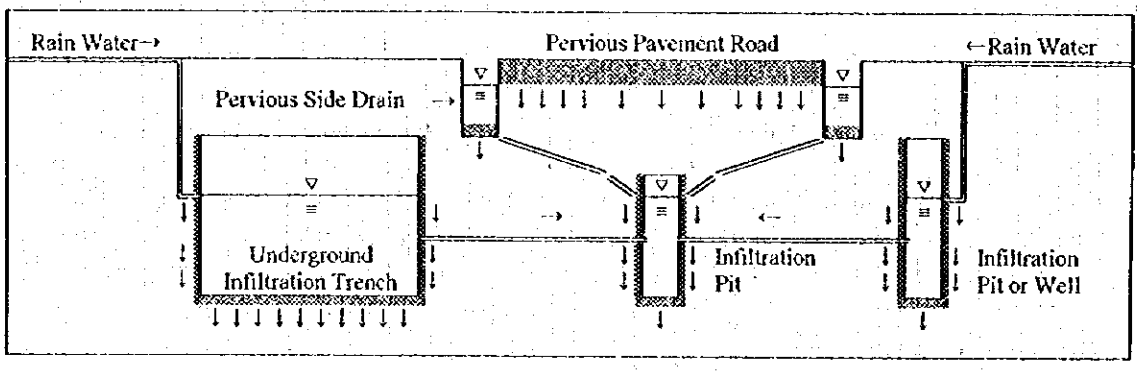


Figure-D.4.28 Infiltration System in Lowland Areas

4.6.3 Improvement of Flood Proof Function

(1) Land Use Regulation

In the upstream flood prone areas where the river improvement work is not yet completed, land use along the river shall be restricted by authorized regulation. Along the river side belt zones, construction of building shall be prohibited. Refer to Figure-D.4.29. To prevent flood damage, soil erosion and water pollution, this regulation shall be implemented completely.

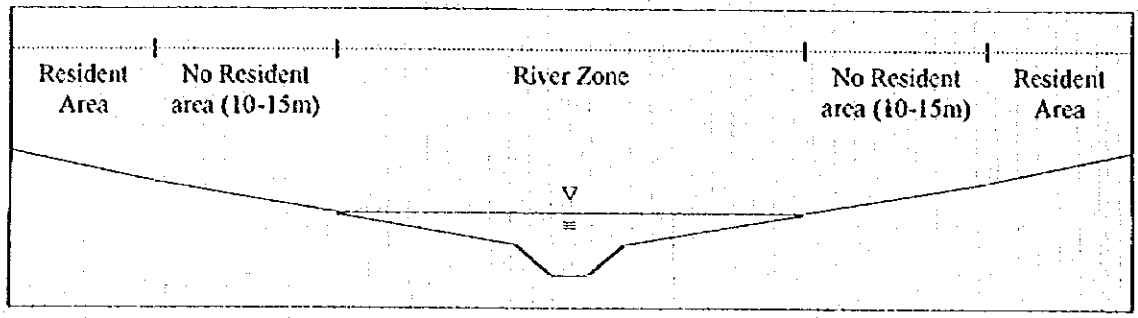


Figure-D.4.29 Land Use Regulation along River Channel

(2) Flood Proof Facilities

To minimize inundation damage to private and public assets during flood time, flood proof facilities such as raised sidewalks and lowered roads, as shown in Figure-D.4.30, are recommendable. Also, important public facilities shall be independently protected against inundation with protecting walls, gates etc., if necessary.

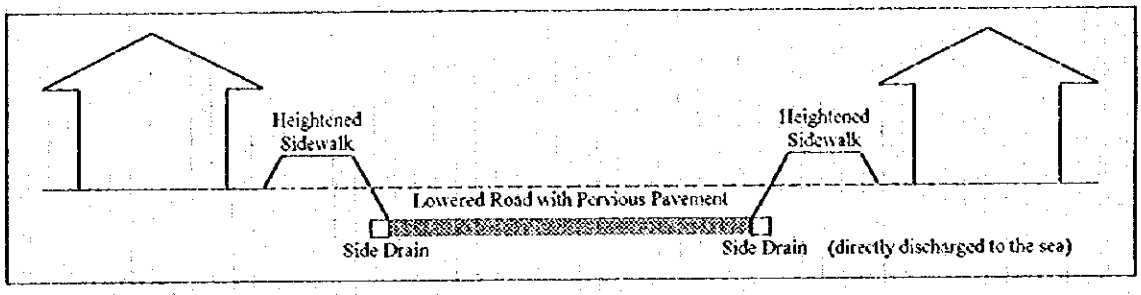


Figure-D.4.30 Flood Proof for Town Street

4.6.4 Facilitation of Flood Disaster Prevention Activities

(1) Management Organization

<Structural Measures>

To implement the flood control project, establishment of a new project office is inevitable. This project office has the supreme function of implementing the flood control project during design, construction and maintenance & operation stages.

<Non-structural Measures>

As for non-structural flood control measures, a special committee lead by BAPPEDA is proposed. This committee should coordinate plans and each organization should have responsibility to implement plans. Responsible organizations of non-structural measures are listed as follows:

- Regional Development Planning Board (BAPPEDA)
- Ministry of Public Works
- Ministry of Forestry
- Ministry of Agriculture
- National Land Agency (BPN)
- Ministry of Education & Culture
- Local Government, Level I & II
- Head of Sub-district
- Ministry of Social Affairs
- Meteorological & Geophysical Agency

(2) Flood Forecast & Warning System

In term of flood forecast for the target areas, floods are characterized by the rapid discharge within almost one hour from the headwaters to the river mouth. Refer to Figure-D.4.31. On the other hand, earlier flood information is useful for flood control management and flood fighting. As illustrated in Figure-D.4.32, rainfall and river water level data are collected by the proposed new observation stations and long term rain forecast data can be obtained from the existing regional meteorological station. These data are transferred to the master station which is proposed to be installed in the Flood Control Project Office. In the master station, the collected rainfall and river water level data are analyzed. The most up-to-date flood and warning information shall be delivered to the related bodies including the disaster relief group (SATLAK) as discussed below.

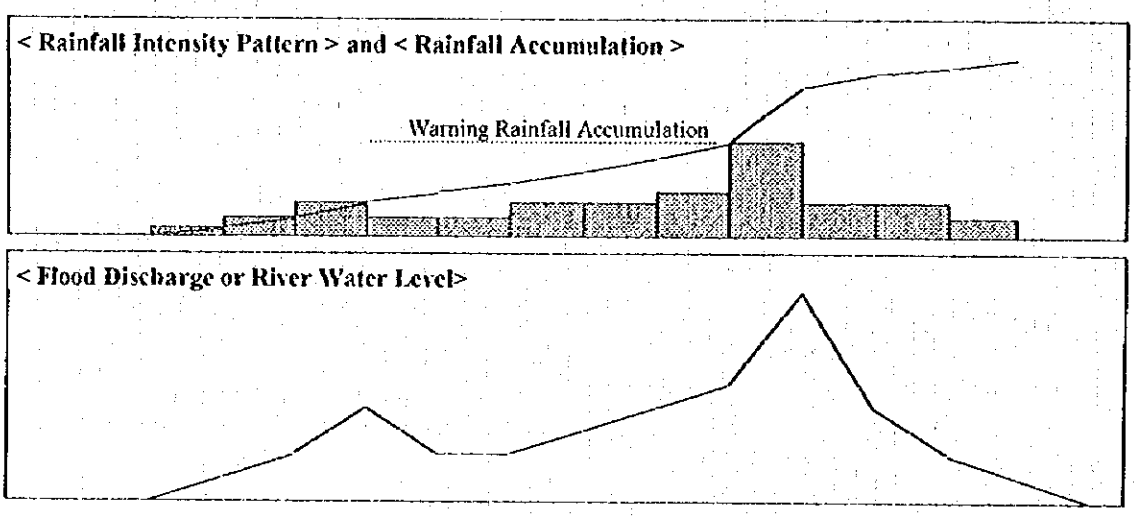


Figure-D.4.31 Rainfall and Runoff Patterns

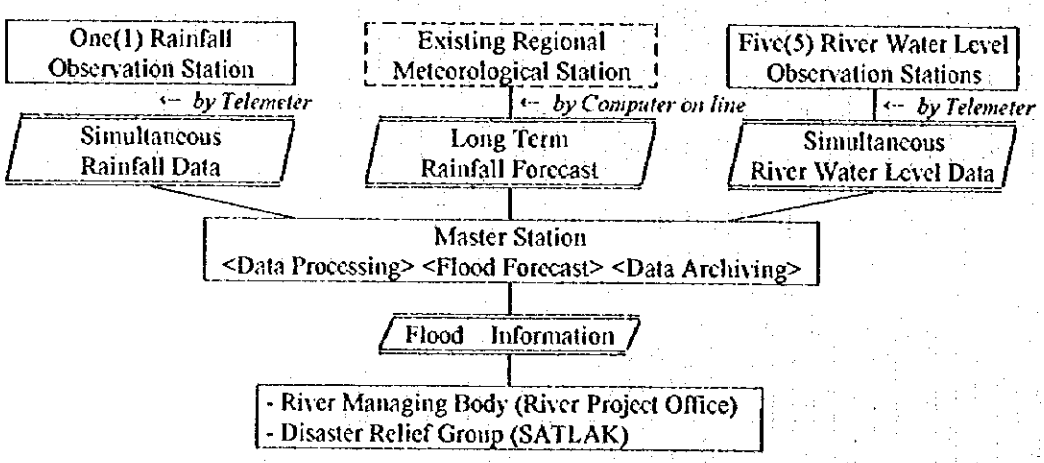


Figure-D.4.32 Transfer System of Flood Information

(3) Flood Risk Map

Flood risk map is an useful information not only for flood control and fighting bodies but also for the inhabitants in flood prone areas. The flood risk map, shown in Figure-D.4.33, illustrates the flood areas of the last biggest flood and the 1/100 year probability flood.

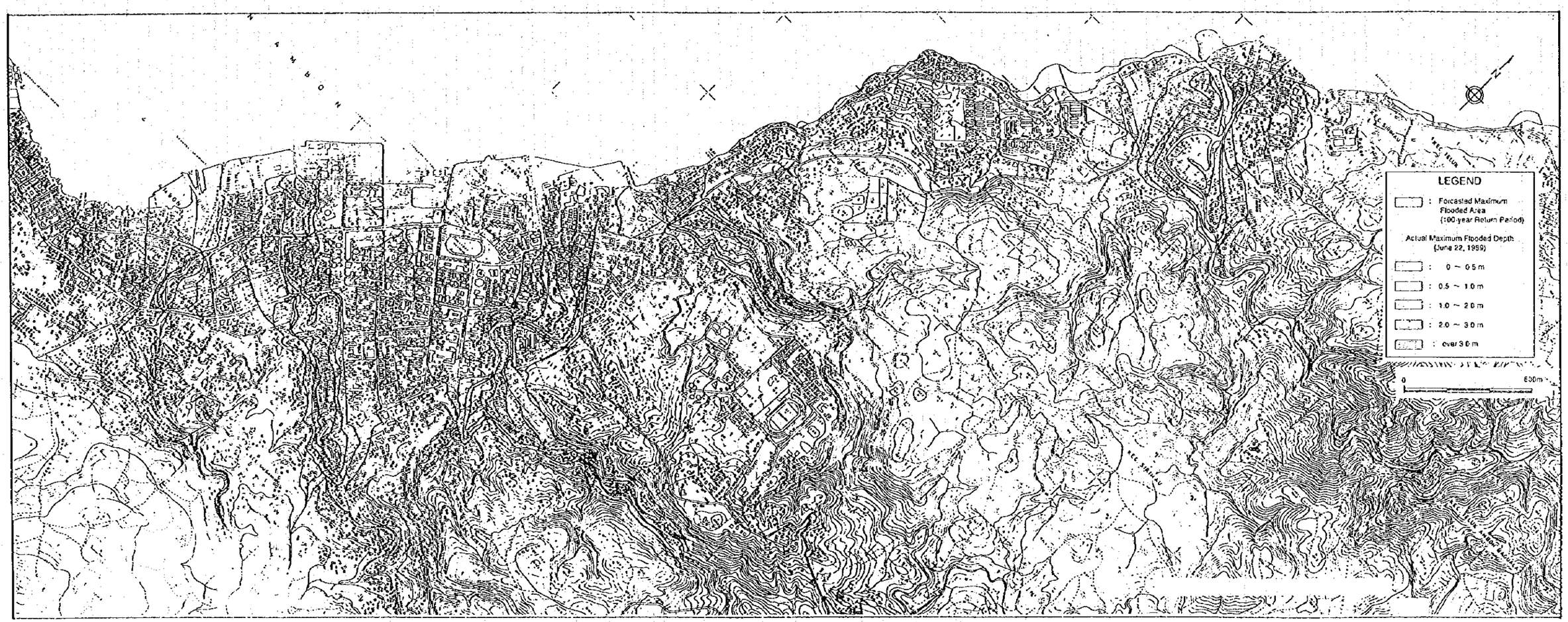


Figure-D.4.33 Flood Risk Map for Ambon Central Area

(4) Flood Fighting System

In Indonesia, the emergency relief system for natural disaster is already well established and functions as shown in Figure-D.4.34 and Figure-D.4.35. In the broad sense, this system is a kind of flood fighting system. However, as shown in Table-D.4.34 which shows the work units of SATLAK (disaster countermeasures of Ambon city), the flood fighting team (or unit) in the narrow sense does not appear. Establishment of the flood fighting team as a work unit under SATLAK is recommended. The targets of the team are: 1) to implement urgent rehabilitation of flood control works during flood time, 2) to monitor constructed flood control works on a regular basis, and 3) to establish evacuation route for each flood prone area and to facilitate services for evacuation of inhabitants. A storage facility for emergency relief is required to store emergency equipment and materials for civil work.

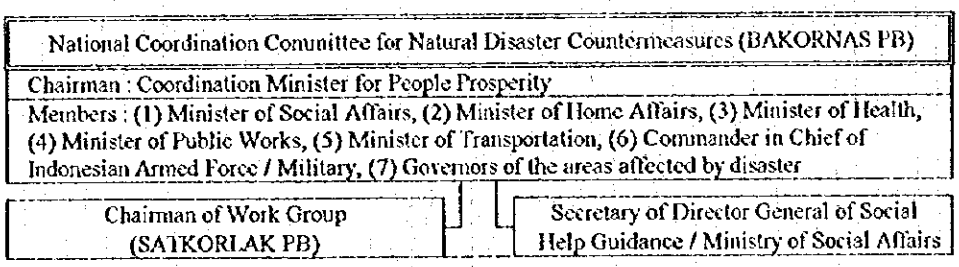


Figure-D.4.34 National Level Organization for Natural Disaster Countermeasures

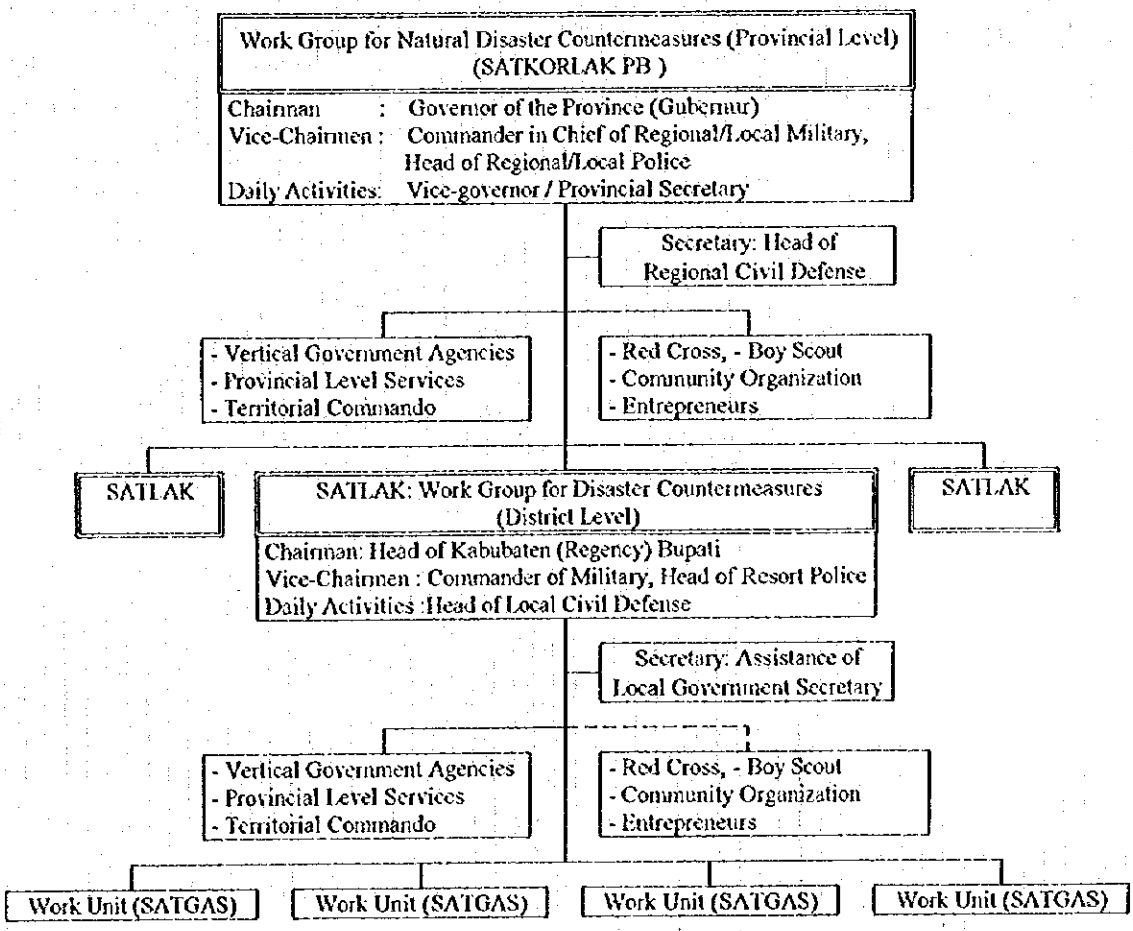


Figure-D.4.35 Local Level Organization for Natural Disaster Countermeasures

Table-D.4.34 Work Units for Disaster Countermeasures of Ambon City

Work Units	M e m b e r
Headquarters	Chairman : Mayor of Ambon Municipality Vice Chairman : Commander of District Military 1504 (KODIM), Ambon Municipality Secretary : Head of Social Affairs Office, Ambon Municipality
(1) Evacuation and Accommodation Unit (SAT EVA AKO)	1. Head of Social & Political Affairs Office, Ambon as a coordinator. 2. Head of Village Development, Ambon 3. Head of K.P.P.P(Coast and Waters Security), Ambon 4. Head of LLAJR (Traffic & Transportation Office), Ambon 5. Head of Civil Defenses Unit, Ambon 6. Head of Resettlement & Environmental Adaptation Section, Regional Office 7. Head of Manpower Office, Ambon 8. Head of Social Affairs Office, Ambon 9. Head of Meteorology & Geophysical Office, Ambon
(2) Security and Defense Assistance Unit (SAT HANKAM)	1. Head of Sabara Unit of Resort Police of Ambon and P.P. Lease as a coordinator. 2. Commander of Navy, Ambon 3. Military Intelligence Officer 1504, Ambon Island 4. Head of Civil Defense unit, Ambon 5. Head of Security and Order Subsection, Ambon 6. Head of Fire Fighting Office, Ambon
(3) Logistic Assistance Unit (SAT BANGLOK)	1. Head of People Prosperity Section, Ambon 2. Head of Social Affairs Office, Ambon 3. Head of Management & Procurement Section, Logistic Office, Ambon 4. Head of BAPPEDA (Regional Development Planning Agency) Ambon 5. Head of Traffic & Transportation Office (LLAJR), Ambon 6. Head of Health Office, Ambon 7. Head of Red Cross, Ambon branch Office. 8. Commander of Army Transport and Logistic No. VIII - 44, Ambon 9. Head of Den Kesyah, Ambon 10. Head of Dis Dekes of Local Police, Ambon 11. Head of Public Works Office, Ambon
(4) Communal Kitchen Unit (SAT PEL DAM)	1. Head Peoples Prosperity Section, Ambon 2. Head of Social Office, Ambon 3. Commander of Army Transport and Logistic No. VIII - 44, Ambon 4. Head of Red Cross, Ambon Branch Office. 5. Head of Den Kesyah Ambon
(5) Medical Care Unit (SAT WATDIS)	1. Head of Health Office, Ambon as a coordinator. 2. Head of Den Kesyah Ambon 3. Head of Red Cross Ambon Branch Office 4. Head of RAPI, Ambon Office 5. Head of Radio Communication Association (ORARI) Ambon 6. Head of Amateur Radio Station, Ambon
(6) Public Relations Unit (SAT HUBMAS)	1. Secretary of Ambon Municipality as coordinator 2. Head of Public Relation Section, Ambon Municipality 3. Head of Radio Station (RRI), Ambon 4. Chairman of Non-Government Radio (RAPI), Ambon Municipality 5. Chairman of Amateur Radio Organization (ORARI), Ambon Municipality 6. Chief of Amateur Radio Station, Ambon Municipality
(7) Special Unit (SAT SUS)	1. Secretary of Ambon Municipality as coordinator 2. Head of Police Intelligence for Ambon and Lease Islands 3. Commander of Military Rayon of Sirimau Sub-district, Ambon 4. Commander of Military Rayon of Baguala, Ambon 5. Commander of Military Rayon of Nusaniwe, Ambon 6. Head of Public Prosecutor Office, Ambon 7. Head of SAR(Search & Rescue) / SOS (sea, land, air) 8. Chief Section of Governmental Administration, Ambon Municipality 9. Head of Health Office, Ambon 10. Head of Public Works Office, Ambon 11. Head of Education & Culture Office, Ambon 12. Head of Sea Transportation (ADPEL) 13. Head of Electricity, Ambon branch Office 14. Head of Road Transportation Traffic Office, Ambon 15. Commander of Den Zipura Dam No. VIII Trikora 16. Head of Religious Affairs Office, Ambon 17. Head of City Planning Office, Ambon 18. Head of BPD / Bank Pembangunan Daerah (Local Development Bank), Maluku Province 19. Head of Fire Fighting Office, Ambon 20. Head of Sirimau Sub-district Area, Ambon 21. Head of Baguala Sub-district Area, Ambon 22. Head of Nusaniwe Sub-district Area, Ambon

Decree of Major of Ambon City No. Kep.188.45.1022/KMA, dated May, 25, 1993

(5) River Management Zone

To maintain the flood control facilities along the river channel, the establishment of river management zone(s) of width 5 - 10 meters is recommended. This river management zone shall be implemented simultaneously with the construction of river improvement works. However, it will be carried out step by step according to authorized city planning, including land use plan and road plan, as land acquisition along the densely populated river side is currently very difficult.

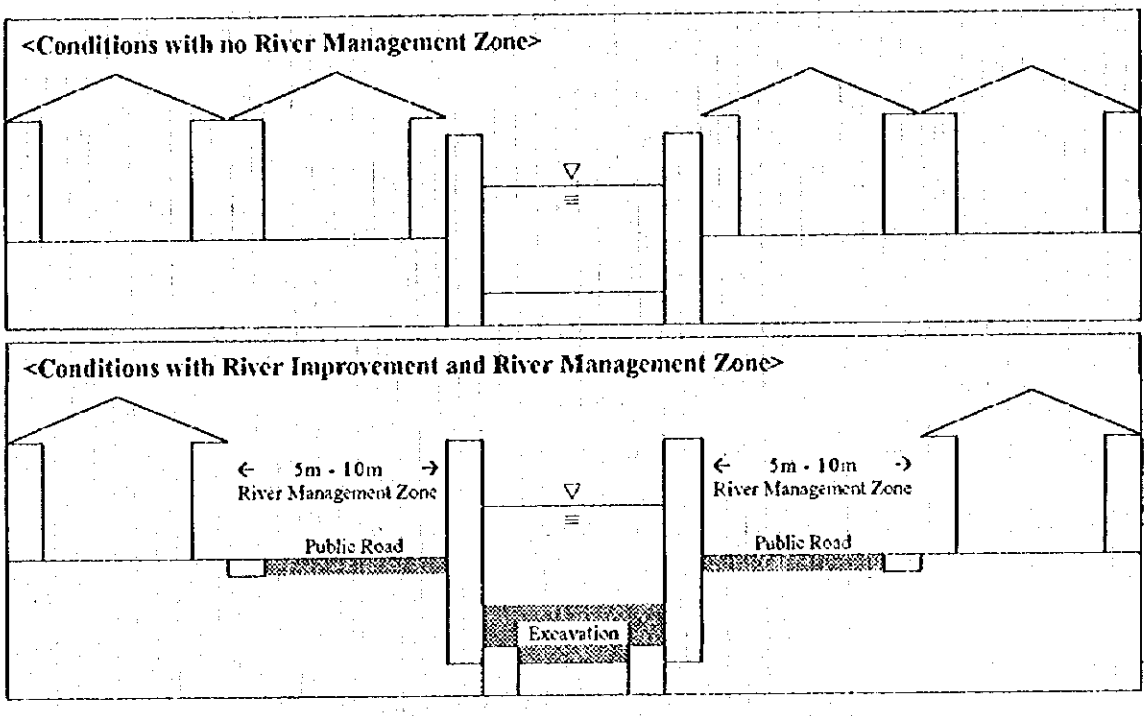


Figure-D.4.36 River Management Zone

(6) Public Awareness

The flood control project can not be implemented without the understanding and cooperation of inhabitants. The structural counter measures require a lot of land owned by the residents in the flood prone areas. Non-structural counter measures also involve the participation of the inhabitants. As the flood control project will be implemented for public welfare or on behalf of the inhabitants, the Project Office shall promote positive public awareness through existing communication systems such as publications, TV and radio. The Project Office should explain the outline of the master plan as general information and the outline of those counter measures which require inhabitants' recognition, cooperation and participation.

(7) Human Resource Development

For the proposed new organization or the Flood Control Project Office, an important first step is to gather talented key personnel who are assigned to the project manager and his staff. The personnel appointed to this project shall be trained at similar project offices or at government training facilities. During the design and construction stage, relevant overseas training to experienced countries will be applicable.

4.7 Implementation Schedule and Organization

4.7.1 Implementation Schedule

Implementation schedule of the Master Plan is proposed as shown in Table-D.4.35 based on the following considerations :

- Total implementation period is 15 years, consisting of Phase-1 (the first 10 years) and Phase-2 (the second 10 years). Projects of both phases should be implemented parallel during the 5 years in the middle of the 15 years
- The projects in Phase-1 is the priority projects and consist of the former four years of preparation (Procurement of a consultant and contractors, Detail design) and the last six years of construction (including water storage test). Project composition of Phase-1 is 1) river improvement works of the five rivers, 2) check dams for Ruhu, Tomu Batu Gajah and Batu Gantung rivers, 3) diversion tunnel for Batu Merah River, 4) Batu Gajah multi-purpose dam and 5) Batu Gantung multi-purpose dam.
- The project in Phase-2 is Ruhu Multi-purpose Dam Project, which consists of the former four years of preparation and the last six years of construction as same as Phase-1.

4.7.2 Implementation Organization

(1) Implementation Organization for Structural Measures

To implement the flood control project, establishment of a new project office is inevitable. This project office has the supreme function of implementing the flood control project during design, construction and maintenance & operation stages. Implementation organization for structural flood control measures is proposed as shown in Figure-D.4.36.

(2) Implementation Organization for Non-structural Measures

As for non-structural flood control measures, a special committee lead by BAPPEDA is proposed as shown in Figure-D.4.37. This committee should coordinate plans and each organization should have responsibility to implement plans.

In the Master Plan, non-structural flood control measures were proposed and responsible organizations of the measures are listed as follows:

- Regional Development Planning Board (BAPPEDA)
- Ministry of Public Works
- Ministry of Forestry
- Ministry of Agriculture
- National Land Agency (BPN)
- Ministry of Education & Culture
- Local Government, Level I & II
- Head of Sub-district
- Ministry of Social Affairs
- Meteorological & Geophysical Agency

Table-D.4.35 Implementation Schedule for the Master Plan

Items \ Fiscal Year	(1) 1998 99	(2) 1999 00	(3) 2000 01	(4) 2001 02	(5) 2002 03	(6) 2003 04	(7) 2004 05	(8) 2005 06	(9) 2006 07	(10) 2007 08	(11) 2008 09	(12) 2009 10	(13) 2010 11	(14) 2011 12	(15) 2012 13
Structural Measures															
<<< Phase-1 >>>															
1-1 **Preparation**															
(a) Procurement															
- Consultant	XX														
- Contractor			XX	XX											
(b) Detailed Design		XX	XX												
1-2 **Consulting Services**															
(a) Survey and Design		XX	XX												
(b) Tender Assistance			XX	XX											
(c) Supervision					XX	XX	XX	XX	XX	XX					
1-3 **Construction**															
5 Rivers' Improvement					XX	XX	XX	XX							
4 Check Dams					XX	XX									
Merah Diversion					XX	XX									
Gajah Dam					XX	XX	XX	XX	XX	XX					
Gantung Dam					XX	XX	XX	XX	XX	XX					
<<< Phase-2 >>>															
2-1 **Preparation**															
(a) Procurement															
- Consultant						XX									
- Contractor								XX	XX						
(b) Detailed Design							XX	XX							
2-2 **Consulting Services**															
(a) Survey and Design							XX	XX							
(b) Tender Assistance								XX	XX						
(c) Supervision										XX	XX	XX	XX	XX	XX
2-3 **Construction**															
Ruhu Dam										XX	XX	XX	XX	XX	XX
Non-Structural Measures															
- Management Organization	XX														
- Forecast/Warning System		XX	XX	XX	XX										
- Flood Risk Map		XX	XX												
- Flood Fighting System		XX	XX	XX	XX										
- Public Awareness		XX	XX												
- Human Development		XX	XX	XX	XX	XX	XX	XX	XX						
- Land Use Regulation		ZZ	ZZ	==	==	==	==	==	==	==	==	==	==	==	==
- Vegetation Improvement		ZZ	ZZ	==	==	==	==	==	==	==	==	==	==	==	==
- Off site Storage		ZZ	ZZ	==	==	==	==	==	==	==	==	==	==	==	==
- Infiltration in Lowland		ZZ	ZZ	==	==	==	==	==	==	==	==	==	==	==	==
- Land Use Regulation		ZZ	ZZ	==	==	==	==	==	==	==	==	==	==	==	==
- Flood Proof Facility		ZZ	ZZ	==	==	==	==	==	==	==	==	==	==	==	==
- River Management Zone		ZZ	ZZ	==	==	==	==	==	==	==	==	==	==	==	==

[Note] XX : Mainly dealt by Flood Control Project Office
ZZ : Planned by Special Committee
== : Implemented by each Related Organization

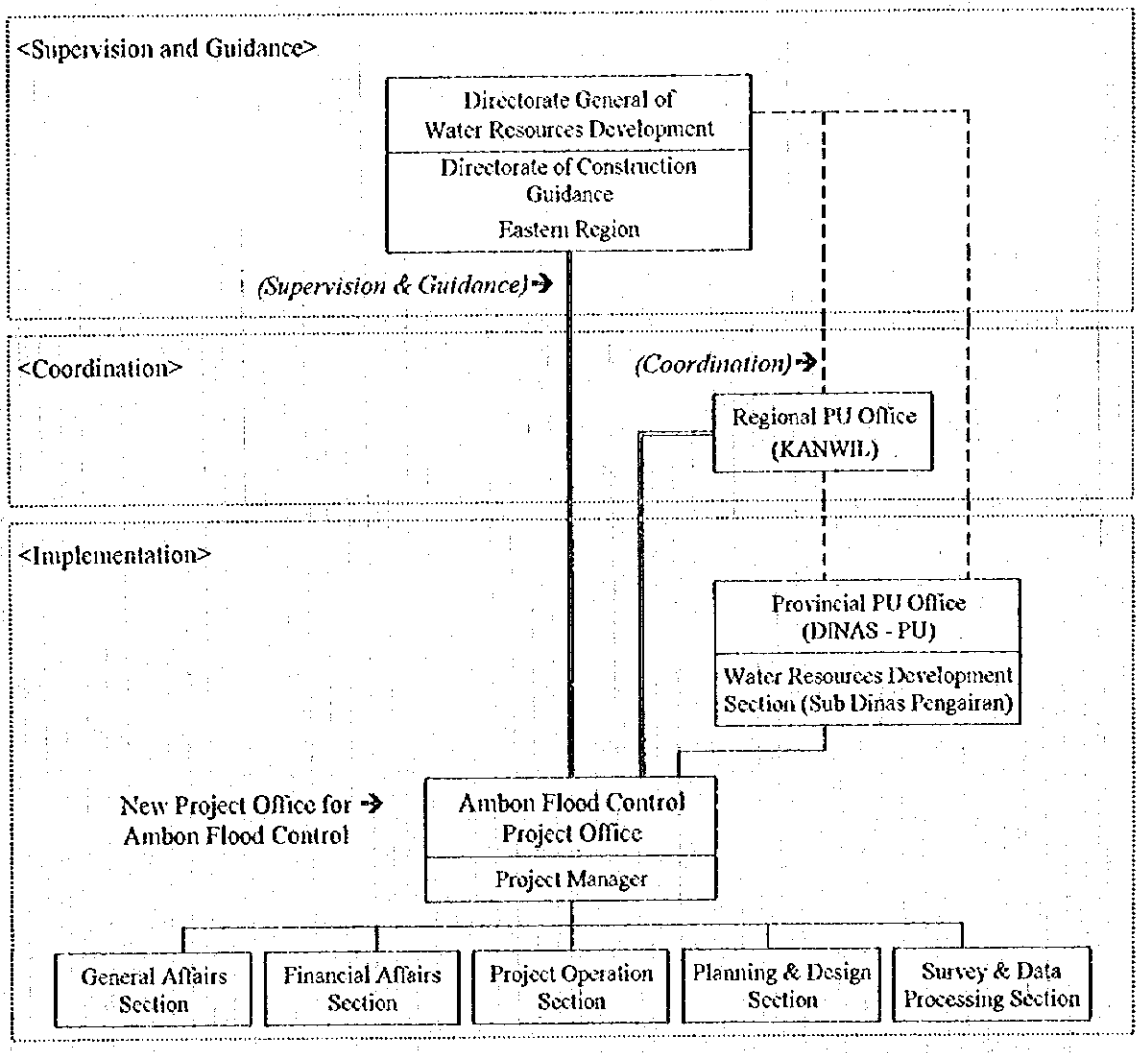


Figure-D.4.37 Organization Structure of Ambon Flood Control Project Office for Structural Measures

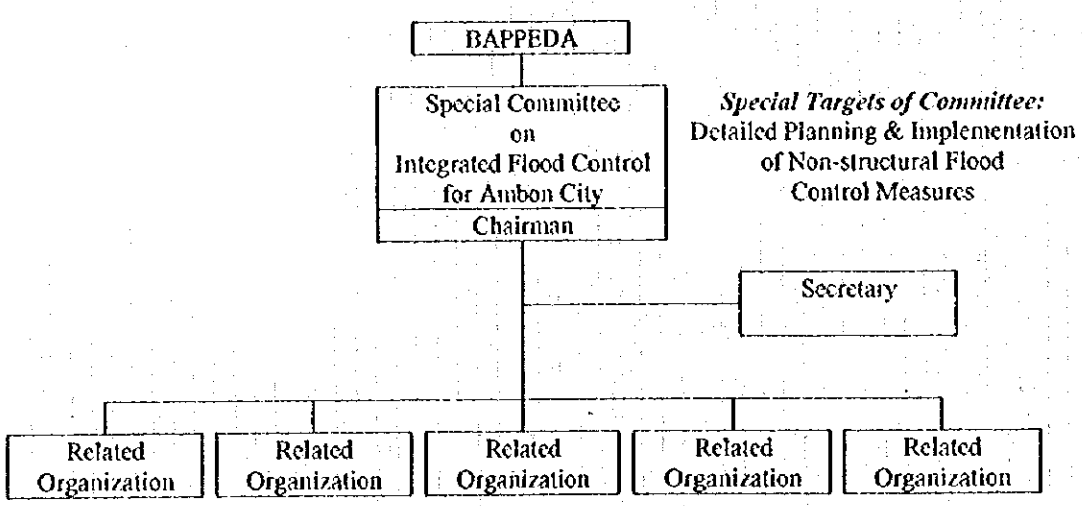


Figure-D.4.38 Organization of Special Committee for Non-structural Measures

4.8 Selection of Priority Project

4.8.1 Criteria for Selecting Priority Projects

Priority projects to be studied further in the Feasibility Study should be selected from the Flood Control Master Plan under the following criteria :

- **Economic Feasibility** : To realize earlier benefit, projects with high economic feasibility should be selected.
- **Urgent Requirement** : Projects with urgent requirement for flood damage protection should be selected.
- **Less Social and Environmental Impact** : Projects with less social and environmental impact should be selected.

Taking into account social, economic and flood damage conditions in the Study Area, the following detailed criteria standards are proposed for selecting priority projects :

1) **Small Scale River Improvement Measures** : River improvement works should be small scale measures as follows :
   - Flood water level should as far as possible not become higher than the current level and landside water should be able to drain to rivers.
   - River widening should be kept to the minimum necessary, and large scale river widening should not be planned. Partial widening of particularly narrow sections should be applied.
2) **Less Resettlement** : Dam sites should be selected considering not only engineering advantages but also social impacts. Resettlement should be kept to the minimum possible. As diversion channels have the advantage of avoiding resettlement if designed as tunnels, social impact as well as engineering possibilities and economic efficiency of diversion should be taken into account.
3) **Sediment Measures** : As river bed sedimentation is one of the causes of flooding, sediment load measures should be taken into account and should be included in the flood control project.
4) **Water Resources Development** : In order to fully utilize dams being planned for multipurpose use, namely water resources development, the flood control plan should also contribute to the improvement of water supply rates and living standards in Ambon City.
5) **River Utilization** : The rivers in the Study Area are necessary and indispensable for the inhabitants to live / cook / bathe. Although these are the main cause of poor river water quality, such access for utilization of the rivers should be taken into account in the flood control plan.

Although these detailed criteria include the criteria contrary to each other, priority projects should be proposed based on engineering judgment, taking into account the balance between economic efficiency and social impacts.

4.8.2 Composition of Priority Projects

The results of the economic evaluation of all the projects integrated in the Flood Control Master Plan Project, shows IRR of 16.0 %, B/C of 2.2 and NPV of Rp. 179,576 million. Of all the projects included, the projects for Batu Merah River have the highest economic viability. Its indicators show IRR of 21.8 %, B/C of 3.6 and NPV of Rp. 90,614 million. The order of economic viability by river, according to IRR, is as follows:

1) Batu Merah River : EIRR=21.8%, B/C=3.6, NPV=Rp.90,614 million
2) Tomu River : EIRR=19.7%, B/C=3.1, NPV=Rp.36,514 million
3) Batu Gajah River : EIRR=14.4%, B/C=1.7, NPV=Rp.45,628 million
4) Ruhu River : EIRR=12.1%, B/C=1.24, NPV=Rp.18,965 million
5) Batu Gantung River : EIRR=10.9%, B/C=1.1, NPV=Rp.6,256 million

Non structural measures and structural measures were proposed as part of the flood control master plan. Non structural measures are as important as structural measures and the priority is also high. For instance, land use regulation or vegetation improvement is said to be effective to mitigate flood peak discharge. Establishment of management organization, flood forecast and warning system or flood fighting system is also effective for reducing flood damage. However, it is difficult to estimate the quantitative effectiveness of these non-structural flood control measures.

In this study, priority projects were selected from the structural flood control measures. The first stage projects were selected as priority projects. It mean that the priority project is as same as the flood control master plan project excluding Ruhu Multi-purpose Dam.

CHAPTER 5 PLAN OF PRIORITY PROJECT

5.1 General

5.1.1 Composition of Priority Project

The priority projects, which were selected from 'Flood Control Master Plan', consist of the components described in Table-D.5.1.

Table-D.5.1 Composition of Priority Projects

River	Target of Planning Scale in Priority Projects	Component
Ruhu River	5-year return period	- River Improvement (5-year return period) - Check Dam
Batu Merah River	30-year return period	- River Improvement (5-year return period) - Diversion Channel
Tomu River	30-year return period	- River Improvement (30-year return period) - Check Dam
Batu Gajah River	30-year return period	- River Improvement (10-year return period) - Multi-purpose Dam - Check Dam
Batu Gantung River	30-year return period	- River Improvement (10-year return period) - Multi-purpose Dam - Check Dam

5.1.2 Objectives of Priority Project

The objectives of the priority projects are set as follows :

- To mitigate flood damage which occurs annually along the five rivers (Ruhu, Batu Merah, Tomu, Batu Gajah and Batu Gantung) in the central part of Ambon City;
- To supply raw water for domestic and industrial use in Ambon City;
- To improve the river environment by appropriate facilities and to improve water quality and quantity by developed maintenance flow.

5.1.3 Basic Conditions

(1) Target Year for Planning

The target year for planning is set at 2015, same as the Flood Control Master Plan. This target year is utilized to determine water demand and supply in the future. However water demand and supply in the following 15 years, i.e. until the year 2030, is also taken into account for the long term water utilization plan.

(2) Target Completion Year

The target year for completion of priority projects is set at 2007/08 starting from the year of 1998/99. An implementation period of 10 years (1998/99 - 2007/08) is deemed appropriate by the feasibility study.

(3) Planning Scale in the Priority Projects

Planning scale is set at 30-year return period for the four rivers in the center of the city, namely Batu Merah River, Tonu River, Batu Gajah River and Batu Gantung River. The planning scale of Ruhu River, which is out of the center of the city, is also set at 30-year return period but river improvement works as a priority project is planned with 5-year return period.

(4) Design Rainfall and Hyetograph

Design rainfall and design hyetograph of all the target rivers are set the same as each other and are shown as follows:

Design Rainfall : 422 mm (30-year return period)
Design Hyetograph : 1990/6/6 Flood (Figure-D.5.1)
- Actual Daily Rainfall : 214.2 mm
- Enlarging Ratio : 1.970

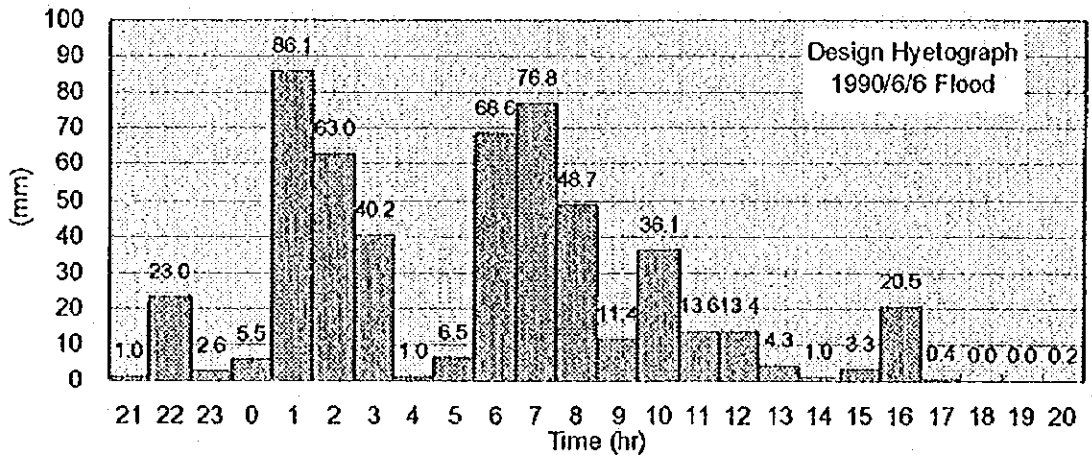


Figure-D.5.1 Design Hyetograph : 1990/06/06 Flood

(5) Bridge Improvement

Bridges should be improved in the following cases :

- Bridge underside elevation is lower than the elevation of flood wall (no clearance)
- The bridge has piers and excavation work is planned
- The length of the bridges is shorter than the planned river width

(6) Estuary Condition

The estuary condition of the five target rivers is shown in Figure-D.5.2. In addition, the study team surveyed the estuary condition near Ruhu River Mouth around Tantui and Wai Nitu area.

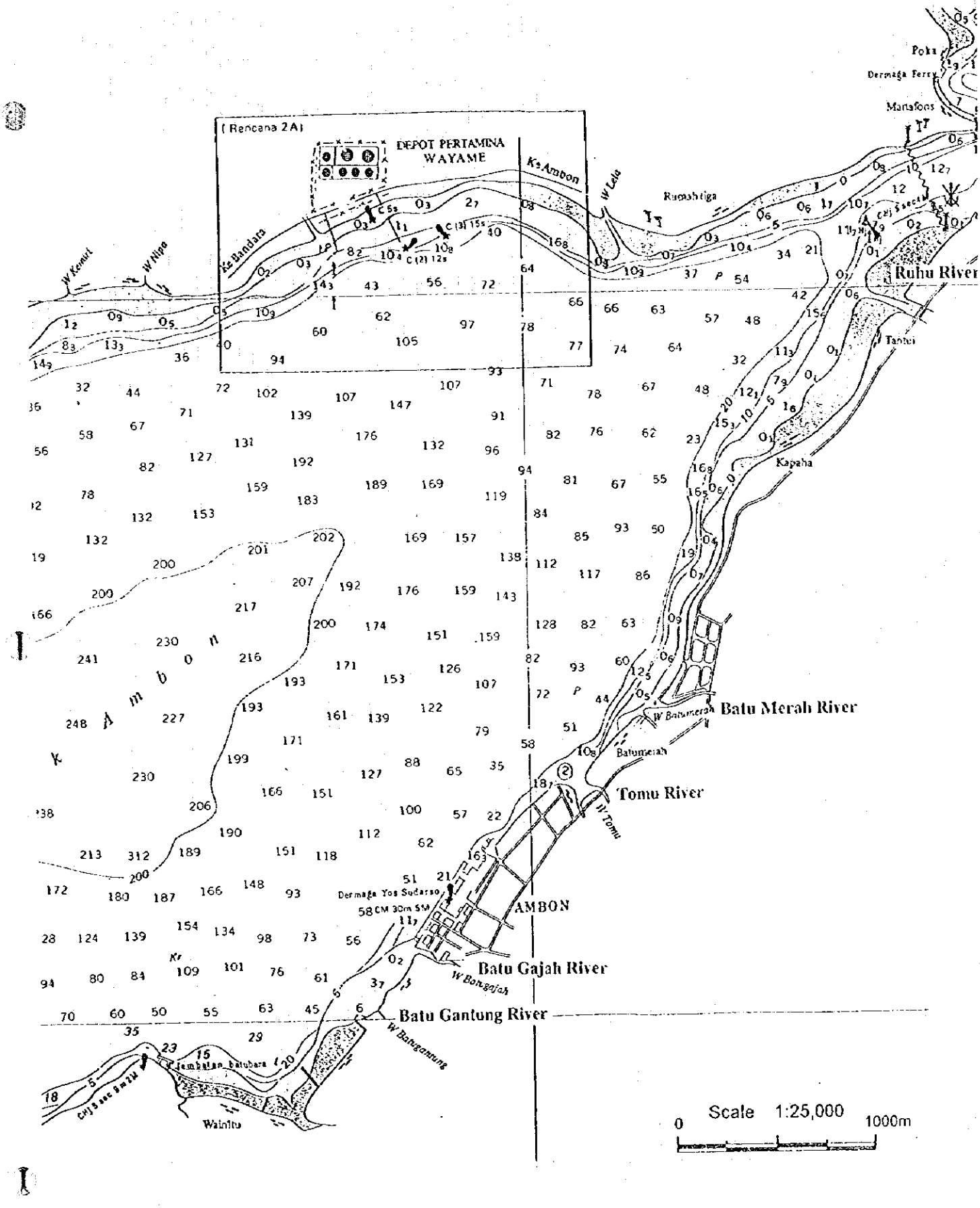


Figure-D.5.2 Estuary Condition of the Five Target Rivers
(Source : Bathymetric Map of Ambon Bay No.398, Ambon in 1982, Wayame in 1996)

5.2 Ruhu River Project

5.2.1 Basic Policy

(1) Basic Concept of the Project

The downstream of Ruhu River is improved with the design discharge equivalent to 5-year return period. In order to achieve the security against flood with 30-year return period, a multi-purpose dam is planned to be constructed at 3k000 from the river mouth. From the fact that sedimentation is progressing around the estuary, large sediment is expected to flow down to the sea during flooding and is also one of flood causes. Therefore, a check dam is planned at 6k100 from the river mouth, located at the end of the reservoir. Refer to Figure-D.5.3.

- 0k000 - 1k600 : River improvement with 5-year return period
- 3k000 : Multi-purpose dam
- 6k100 : Check dam

(2) Staged Construction Plan

In the Master Plan, the following staged construction plan was adopted:

- First Stage (1998/99-2007/08) (Priority Project) : River improvement with 5-year return period Check dam
- Second Stage (2003/04-2012/13) : Multi-purpose dam

In this Chapter, river improvement works and a check dam selected as priority projects are to be studied.

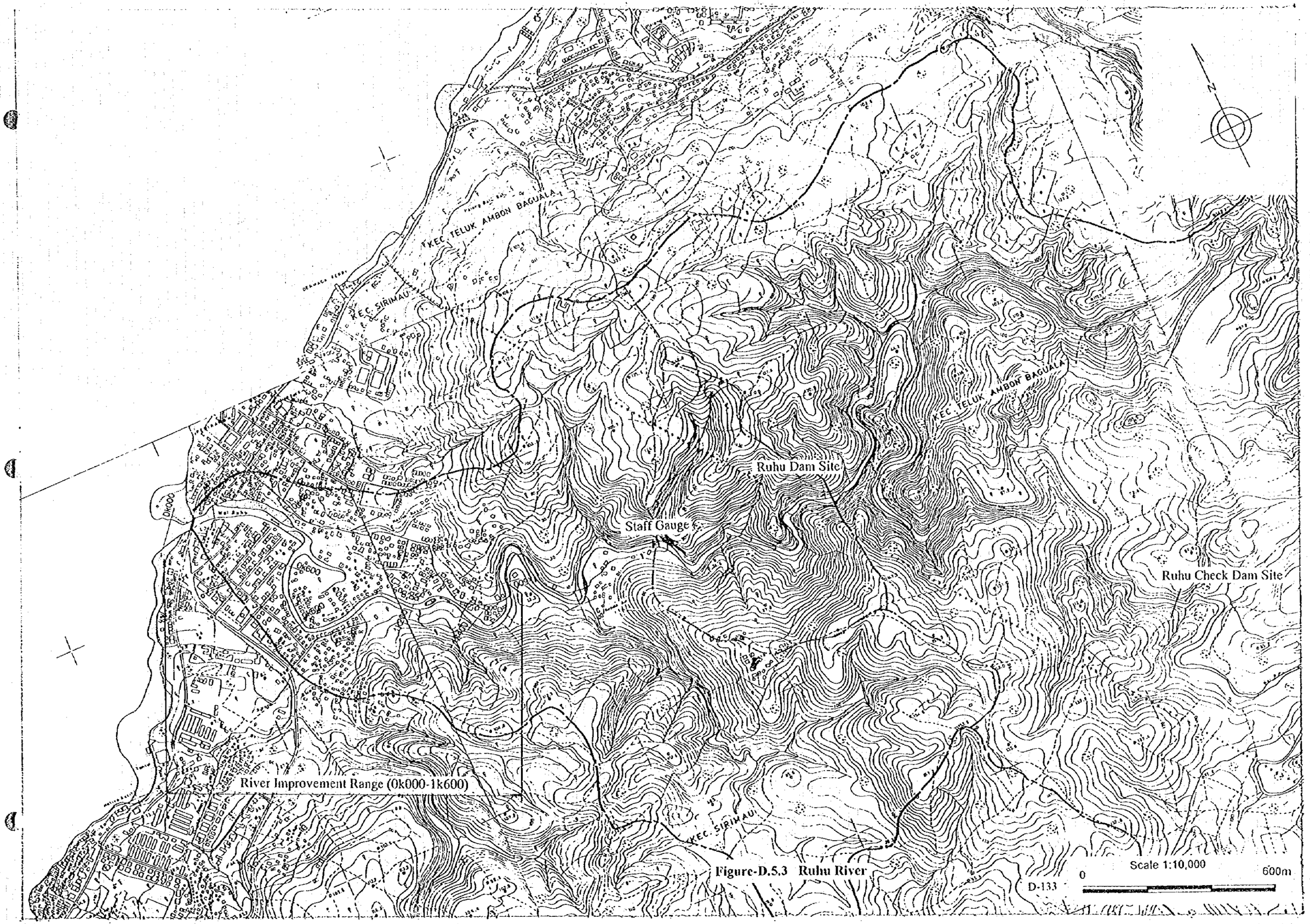


Figure-D.5.3 Ruhu River

5.2.2 Planning Criteria

(1) Design Scale

5-year return period for the first stage
30-year return period for the second stage (out of F/S)

(2) Reference Point, Basin Division and Runoff Model

Reference points are set as shown in Table-D.5.2 and the basin division is shown in Figure-D.5.5. The runoff model is shown in Figure-D.5.4.

Table-D.5.2 Reference Point and Basin Division

Basin Name	Catchment Area (km^2)	Reference Point	Catchment Area (km^2)
[1] Upper Basin (Dam)	14.49	Staff Gauge	14.91
[2] Upper Basin (Remaining)	0.42	River Mouth	16.84
[3] Lower Basin	1.93		
Total	16.84		

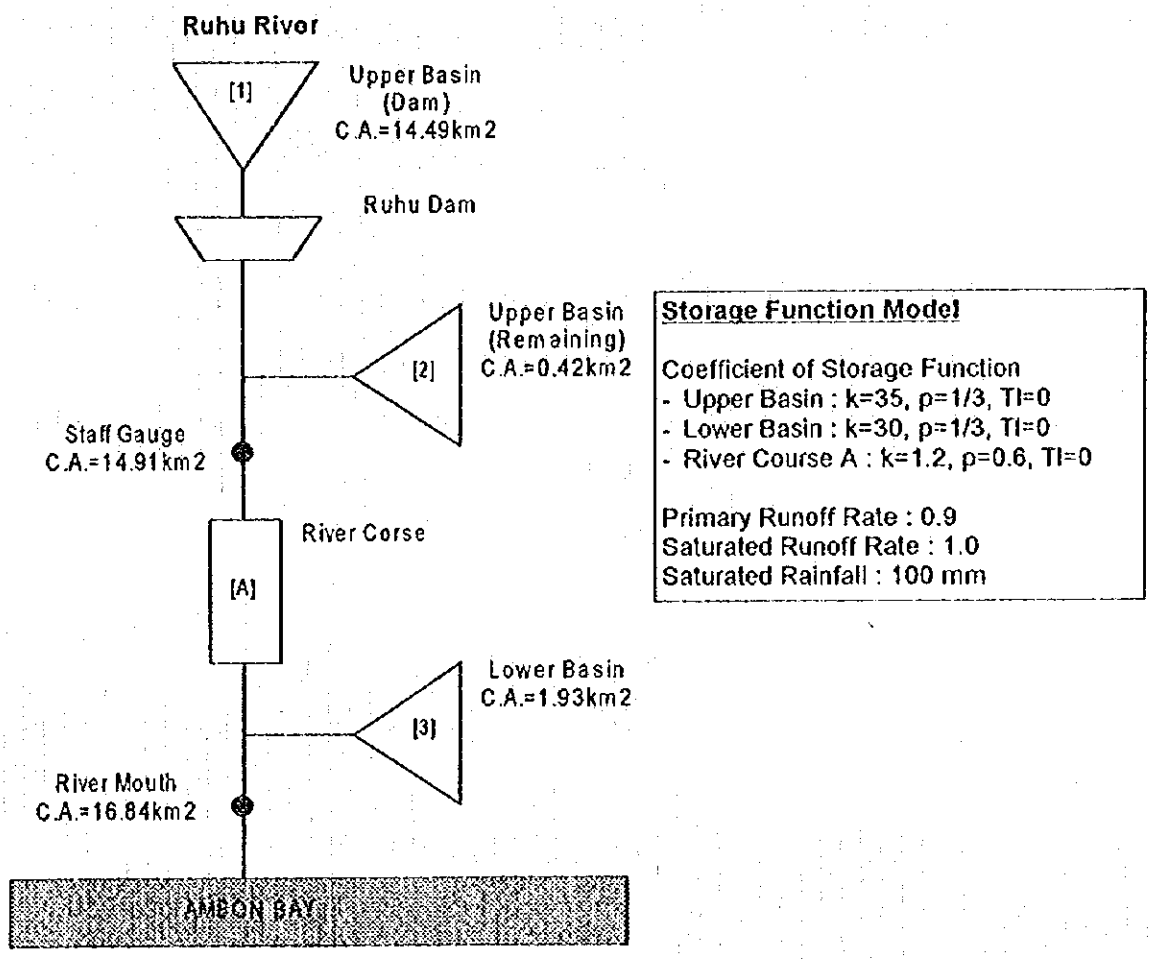


Figure-D.5.4 Runoff Model of Ruhu River

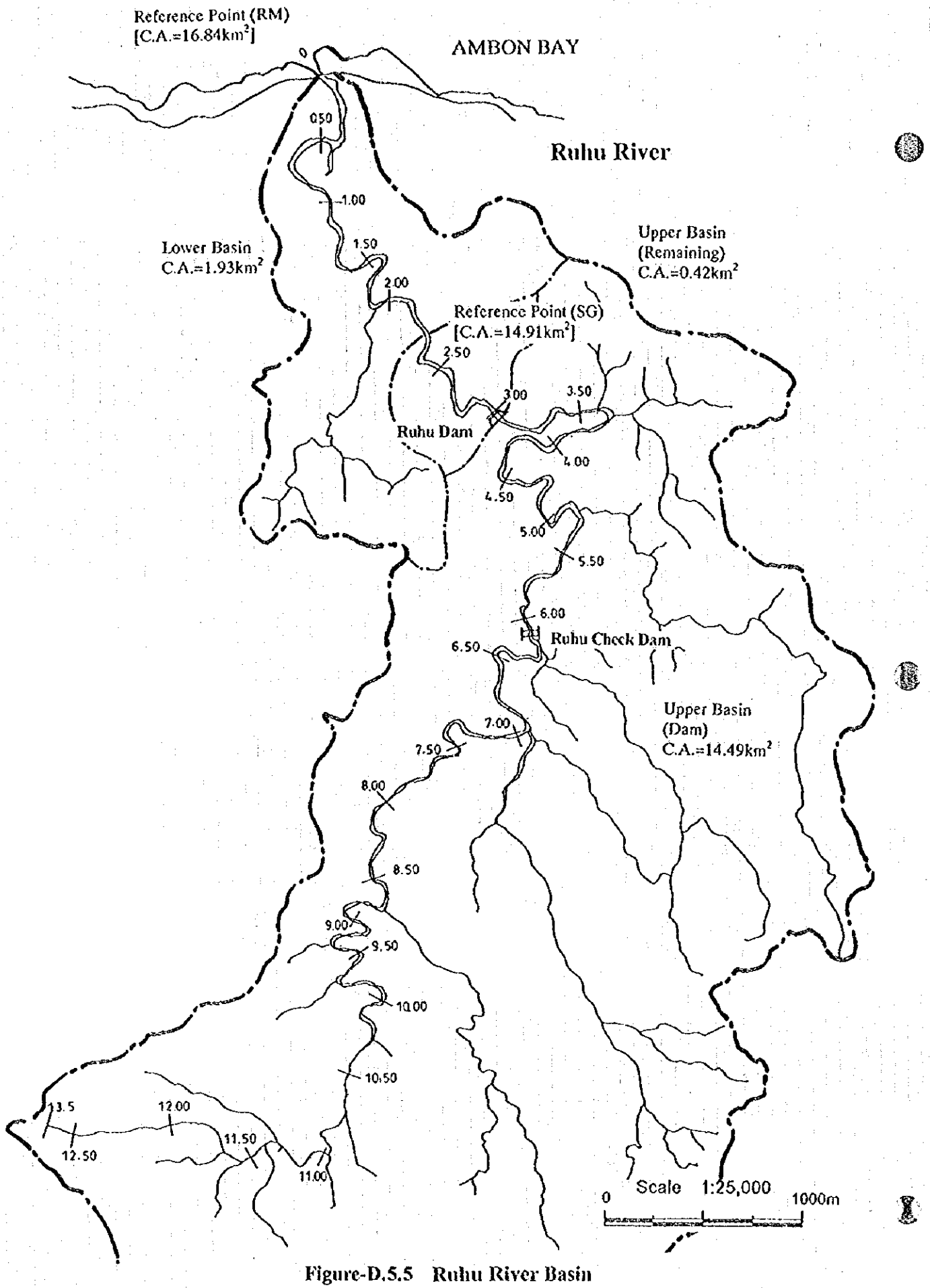


Figure-D.5.5 Ruhu River Basin

(3) Design Flood Discharge and Design Hydrograph

Design Flood Discharge

		5-year Return Period	30-year Return Period
- Staff Gauge Reference Point	:	150 m^3/sec	290 m^3/sec
- River Mouth Reference Point	:	170 m^3/sec	320 m^3/sec

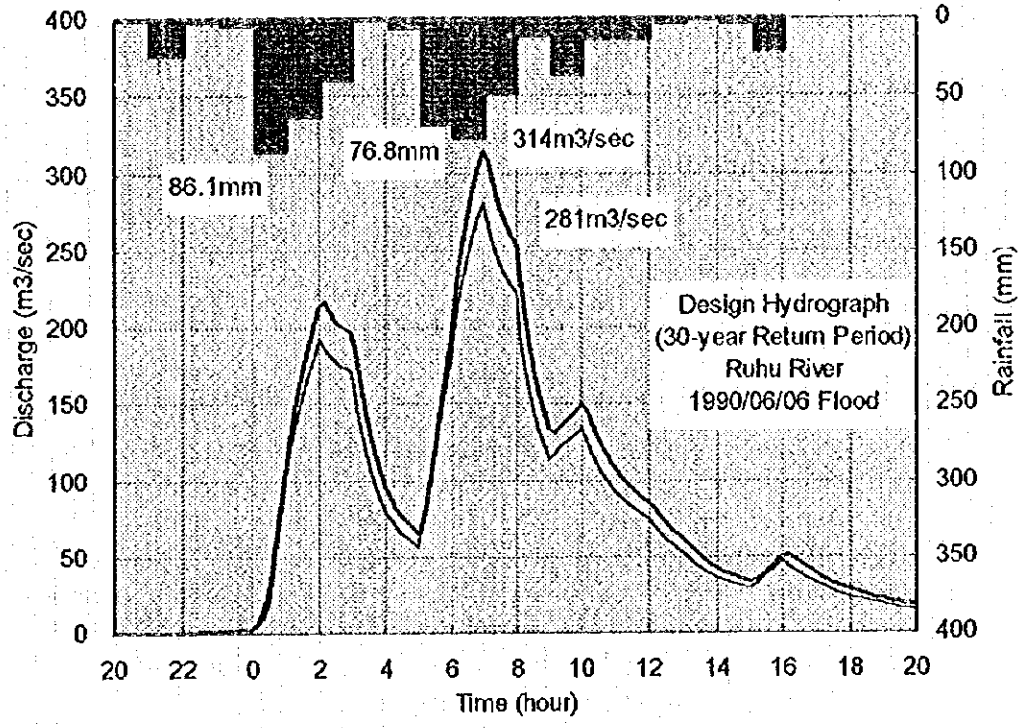


Figure-D.5.6 Design Hydrograph at Reference Points (Ruhu River)

(4) Design Discharge Distribution

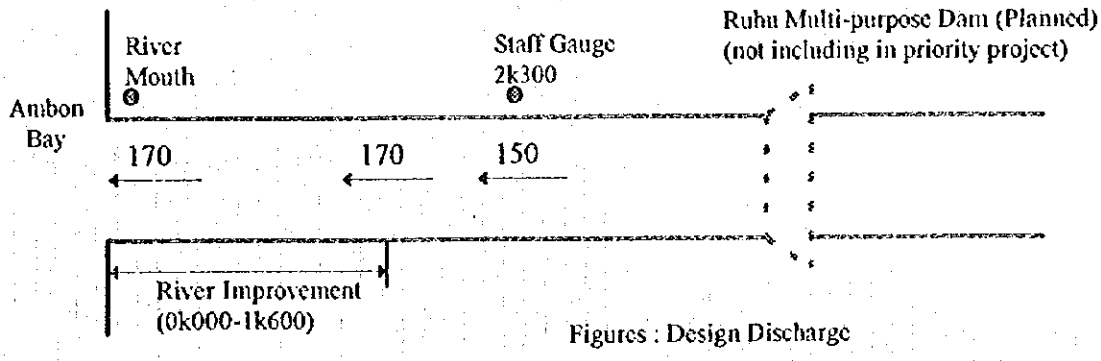


Figure-D.5.7 Design Discharge Distribution (Ruhu River)

5.2.3 River Improvement Plan

River improvement plan of Ruhu River is summarized in Table-D.5.5 and Figure-D.5.8 based on the following study:

(1) River Improvement Range

River improvement range is set from river mouth to 1k600 i.e. 1,600m length. There are currently no flood walls constructed to the upstream of 1k600, which is like a natural river. The houses upstream are located in relatively higher place and no flood damages were reported. Then the upstream river from 1k600 is judged not to be necessary to be improved.

River Improvement Range : 0k000 - 1k600 (Length 1,600m)

(2) River Course Alignment

River course alignment followed current river course with no new channel.

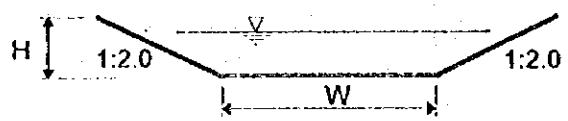
(3) Planned River Bed (Slope, Excavation)

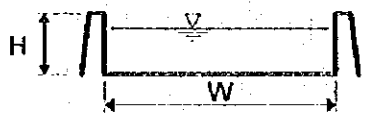
Planned riverbed slope of the downstream from 0k000 to 0k525 was set level at EL.-1.00m, which is the nearly current deepest river bed level. Because there are much sedimentation along the estuary, of which area would be necessary to be excavated if deeper river bed excavation would be applied.

Planned riverbed of the upstream from 0k525 was set at I=1/420 in line with the current upstream riverbed slope. Three cases of excavation depth, 1.0m, 0.5m and 0.0m below the deepest riverbed, were studied. Of these cases the shallowest excavation case was adopted because of economical reason, even though river bed excavation has advantage for enlarging discharge capacity and facilitating inner water drainage.

(4) Standard Cross Section (Heightening, Widening)

The planned standard cross section was set trapezoid in the downstream and rectangular in the upstream as follows:





0k000-0k450 : W=28.0m, H=2.4-3.3m

0k500 : W=28.0m, H=3.3m
0k550-1k400 : W=17.0m, H=3.2m
1k450-1k600 : W=15.0m, H=3.4m

Based on uniform and non-uniform flow calculation on the design discharge 170 m^3/sec equivalent to 5-year return period, the following flood wall heightening and section widening were planned. Three-sided concrete channel was not planned because of relatively wide river width

- The river section from 0k000 to 0k500 is relatively wide and excavation works is enough for the design discharge. The planned river width is set at 28.0 m there.

- The sections from 0k850 to 0k950 and 1k050 were planned to be widened to 17.0 m on the right side, because of following reasons:
  ⇒ This section is very narrow with 13.8 - 16.0 m width.
  ⇒ Water level raising would be affected 400m upstream without widening
  ⇒ The left side of these sections is utilized for pig/chicken farms or no households.
- The flood walls from 0k250 to 1k350 were planned to be heightened by 0.1-0.7m of right side (0.4m on average) and 0.1-0.9m of left side (0.4m on average).

(5) Bridge Improvement

The list of bridges in Ruhu River is shown in Table-D.5.3. The clearance between bridge underside elevation and H.W.L. is judged to be enough (more than 0.6m) but the bridges of No.4 and No.6 are necessary to be improved.

Table-D.5.3 List of Bridges in Ruhu River

No.	Distance (m)	Bridge Underside Elevation (EL.m)	Bridge Pier		Bridge Width (m)	*1 Objec-tives	Clearance (m)		Depth of *2 Excavation at Pier (m)		Remarks
			Number	Width (m)							
1	0k047	3.346	-	-	7.00	VR	2.31	O	-	O	Truss bridge
2	0k059	1.703	2	2.00	8.00	VR	0.61	O	1.40	X	Old bridge (not in use)
3	0k074	3.900	-	-	-	WP	2.79	O	-	O	Pipe line
4	1k018	4.350	1	25.00	2.00	FPB	1.59	O	0.50	X	Suspension bridge
5	1k359	4.800	1	25.00	2.00	FPB	1.22	O	0.20	O	Suspension bridge
6	1k554	5.950	-	-	4.00	VR	1.76	O	1.90	X	Concrete bridge

*1 Objectives (Vehicle Road, Foot Path Bridge, Water Pipe, Others)
*2 Excavation Depth below Deepest Riverbed

(6) Drainage Improvement

The list of drainage in Ruhu River is shown in Table-5.2.3. The method of drainage improvement will be studied in the chapter of facility design.

Table-D.5.4 List of Drainage in Ruhu River

No.	Distance (m)	Side	Bottom Elevation (EL.m)	Section		Objectives	Remarks
				Width (m)	Height (m)		
1	0k433	L	0.440	1.00	0.50	HD	
2	0k481	L	0.680	1.00	0.50	HD	Covered by garbage
3	0k533	R	0.500	1.20	1.50	CD	Covered by garbage
4	0k638	L	1.220	1.00	0.50	CD	
5	0k647	L	1.070	1.00	0.50	CD	
6	0k747	R	0.924	0.90	0.50	HD	
7	0k788	R	1.240	0.90	0.50	HD	
8	0k798	R	1.350	0.90	0.50	HD	
9	0k886	R	1.420	1.00	0.50	HD	
10	0k058	R	2.900	0.90	0.50	HD	Covered by tree
11	1k108	R	1.990	0.90	0.60	HD	
12	1k158	R	1.550	0.90	0.40	HD	
13	1k213	R	1.070	1.00	0.50	Toilet	
14	1k305	R	3.150	1.00	0.50	HD	Covered by tree
15	1k361	L	3.670	-	-	HD	
16	1k506	L	2.380	1.40	2.00	HD	New drainage

* Objectives (City Drainage, Home Drainage, Toilet, Others)

Table-D.5.5 Ruhu River Improvement Plan

Section No.	Profile No.	Cumulative Distance (m)	Current Condition: Dpst. Bed Level (EL.m)	Current Condition: Ave. Bed Level (EL.m)	Current Condition: River Width (m)	Current Condition: Left Bank (EL.m)	Current Condition: Right Bank (EL.m)	Planning Condition: Riverbed Level (EL.m)	Planning Condition: Water Level (EL.m)	Planning Condition: Top of Dike (EL.m)	Planning Condition: Design Qp (m3/s)	Planning Condition: River Width (m)	Planning Condition: Water Height (m)	Planning Condition: Slope I	Planning Condition: R.bed at Wall Left (EL.m)	Planning Condition: R.bed at Wall Right (EL.m)	Dike Height (m)	Excavation Depth: Ave. (m)	Excavation Depth: Deepest (m)	Excavation Depth: R.bed at Wall L (m)	Excavation Depth: R.bed at Wall R (m)	Heightening Left (m)	Heightening Right (m)	Widening Length (m)	Concrete Channel
1	RH0	0.00	-0.73	-0.42	160.25	2.02	2.29	-1.00	0.80	1.40	170	28.00	1.80	-	-0.75	-0.15	2.40	0.58	0.27	0.25	0.85	-	-	-	-
2	B1	47.10	-2.36	-0.92	79.40	2.55	2.54	-1.00	1.03	1.63	170	28.00	2.03	-			2.63	0.08	-			-	-	-	-
3	RH0A	50.00	-2.31	-0.23	81.29	4.63	4.69	-1.00	1.04	1.64	170	28.00	2.04	-	-2.10	-0.50	2.64	0.77	-	-	0.50	-	-	-	-
4	B2	58.70	-2.31	-0.32	63.65	3.27	3.20	-1.00	1.06	1.66	170	28.00	2.06	-			2.66	0.68	-			-	-	-	-
5	B3	74.40	-2.09	-0.65	48.90	2.09	1.56	-1.00	1.11	1.71	170	28.00	2.11	-			2.71	0.35	-			-	0.15	-	-
6	RH1	100.00	-1.74	-0.35	28.00	2.07	1.46	-1.00	1.17	1.77	170	28.00	2.17	-	0.25	1.45	2.77	0.65	-	1.25	2.45	-	0.31	-	-
7	RH1A	150.00	-0.74	-0.04	41.25	2.00	2.30	-1.00	1.28	1.88	170	28.00	2.28	-	-0.20	-0.20	2.88	0.96	0.26	0.80	0.80	-	-	-	-
8	RH2	200.00	-0.73	0.00	44.41	1.96	2.15	-1.00	1.36	1.96	170	28.00	2.36	-	-0.45	0.25	2.96	1.00	0.27	0.55	1.25	0.00	-	-	-
9	RH2A	250.00	-0.92	0.03	44.26	1.93	2.23	-1.00	1.44	2.04	170	28.00	2.44	-	-0.60	0.20	3.04	1.03	0.08	0.40	1.20	0.11	-	-	-
10	RH3	300.00	-0.43	0.12	41.58	2.08	2.23	-1.00	1.50	2.10	170	28.00	2.50	-	-0.60	0.40	3.10	1.12	0.57	0.40	1.40	0.02	-	-	-
11	RH3A	350.00	-0.60	0.18	38.21	1.92	2.33	-1.00	1.56	2.16	170	28.00	2.56	-	0.15	0.90	3.16	1.18	0.40	1.15	1.90	0.24	-	-	-
12	RH4	400.00	-0.81	0.03	38.30	2.04	2.13	-1.00	1.61	2.21	170	28.00	2.61	-	0.35	-1.00	3.21	1.03	0.19	1.35	0.00	0.17	0.08	-	-
13	RH4A	450.00	-0.58	0.16	37.65	2.29	1.85	-1.00	1.66	2.26	170	28.00	2.66	-	0.95	-0.50	3.26	1.16	0.42	1.95	0.50	-	0.41	-	-
14	RH5	500.00	-0.57	0.00	29.60	2.10	1.96	-1.00	1.66	2.26	170	28.00	2.66	-	0.55	0.15	3.26	1.00	0.43	1.55	1.15	0.16	0.30	-	-
15	RH5A	550.00	-0.57	0.22	22.29	1.98	2.06	-0.94	1.66	2.26	170	17.00	2.60	420	0.30	0.75	3.20	1.16	0.37	1.24	1.69	0.28	0.20	-	-
16	RH6	600.00	-0.47	0.01	17.80	2.12	2.27	-0.82	1.66	2.26	170	17.00	2.48	420	0.25	0.25	3.08	0.83	0.35	1.07	1.07	0.14	-	-	-
17	RH6A	650.00	-0.42	0.03	17.05	2.29	2.31	-0.70	1.81	2.41	170	17.00	2.51	420	0.05	0.80	3.11	0.73	0.28	0.75	1.50	0.12	0.10	-	-
18	RH7	700.00	-0.27	0.06	17.25	2.14	2.13	-0.58	1.97	2.57	170	17.00	2.55	420	0.15	0.30	3.15	0.64	0.31	0.73	0.88	0.43	0.44	-	-
19	RH7A	750.00	-0.08	0.22	19.68	2.40	2.24	-0.46	2.10	2.70	170	17.00	2.56	420	0.15	0.80	3.16	0.68	0.38	0.61	1.26	0.30	0.46	-	-
20	RH8	800.00	-0.03	0.30	22.10	2.05	2.37	-0.34	2.22	2.82	170	17.00	2.57	420	-0.40	1.25	3.17	0.64	0.31	-	1.59	0.77	0.45	-	-
21	RH8A	850.00	-0.20	0.08	13.80	2.05	2.24	-0.23	2.35	2.95	170	17.00	2.57	420	0.75	0.75	3.17	0.31	0.03	0.98	0.98	0.90	0.71	3.20	-
22	RH9	900.00	0.27	0.24	15.59	2.41	2.40	-0.11	2.47	3.07	170	17.00	2.58	420	2.20	2.20	3.18	0.35	0.38	2.31	2.31	0.66	0.67	1.41	-
23	RH9A	950.00	0.26	0.38	16.00	2.57	2.55	0.01	2.59	3.19	170	17.00	2.58	420	2.75	2.75	3.18	0.37	0.25	2.74	2.74	0.62	0.64	1.00	-
24	RH10	1000.00	0.30	0.65	20.08	2.83	3.19	0.13	2.71	3.31	170	17.00	2.58	420	1.20	0.45	3.18	0.52	0.17	1.07	0.32	0.48	0.12	-	-
25	B4	1018.10	0.39	0.63	20.30	4.08	4.09	0.17	2.76	3.36	170	17.00	2.59	420			3.19	0.46	0.22			-	-	-	-
26	RH10A	1050.00	0.43	0.82	15.00	2.91	3.43	0.25	2.83	3.43	170	17.00	2.58	420	1.35	1.35	3.18	0.57	0.18	1.10	1.10	0.52	0.00	2.00	-
27	RH11	1100.00	0.38	0.89	20.15	3.01	3.42	0.37	2.95	3.55	170	17.00	2.58	420	1.65	0.80	3.18	0.52	0.01	1.28	0.43	0.54	0.13	-	-
28	RH11A	1150.00	0.37	0.86	19.00	3.23	3.55	0.49	3.08	3.68	170	17.00	2.59	420	1.10	1.45	3.19	0.37	-	0.61	0.96	0.45	0.13	-	-
29	RH12	1200.00	0.49	1.16	19.83	3.14	4.12	0.61	3.21	3.81	170	17.00	2.60	420	1.50	1.75	3.20	0.55	-	0.89	1.14	0.67	-	-	-
30	RH12A	1250.00	0.58	1.38	29.65	3.43	4.37	0.73	3.32	3.92	170	17.00	2.59	420	1.20	0.25	3.19	0.65	-	0.47	-	0.49	-	-	-
31	RH13	1300.00	1.01	1.48	22.50	3.64	4.49	0.85	3.44	4.04	170	17.00	2.59	420	1.95	0.90	3.19	0.63	0.16	1.10	0.05	0.40	-	-	-
32	RH13A	1350.00	1.14	1.39	17.60	3.69	4.51	0.96	3.55	4.15	170	17.00	2.59	420	1.20	1.50	3.19	0.43	0.18	0.24	0.54	0.46	-	-	-
33	B5	1359.20	1.20	1.44	18.00	4.73	4.71	0.99	3.58	4.18	170	17.00	2.59	420			3.19	0.45	0.21			-	-	-	-
34	RH14	1400.00	1.13	1.56	17.30	4.80	4.55	1.08	3.67	4.27	170	17.00	2.59	420	1.60	2.25	3.19	0.48	0.05	0.52	1.17	-	-	-	-
35	RH14A	1450.00	1.36	1.65	15.20	4.82	4.67	1.20	3.67	4.27	170	15.00	2.47	420	2.50	3.75	3.07	0.45	0.16	1.30	2.55	-	-	-	-
36	RH15	1500.00	1.16	1.40	21.00	5.16	3.06	1.32	4.01	4.61	170	15.00	2.68	420	0.80	3.00	3.28	0.08	-	-	1.68	-	1.55	-	-
37	RH15A	1550.00	1.40	2.25	22.35	6.06	5.47	1.44	4.18	4.78	170	15.00	2.74	420	3.45	1.80	3.34	0.81	-	2.01	0.36	-	-	-	-
38	B6	1553.50	1.60	2.33	20.90	5.51	5.51	1.45	4.19	4.79	170	15.00	2.74	420			3.34	0.88	0.15			-	-	-	-
39	RH16	1600.00	1.70	2.84	22.95	5.51	5.77	1.56	4.34	4.94	170	15.00	2.78	420	3.60	2.05	3.38	1.28	0.14	2.04	0.49	-	-	-	-
Average																	3.09	0.68	0.25	1.09	1.15	0.39	0.38	1.90	

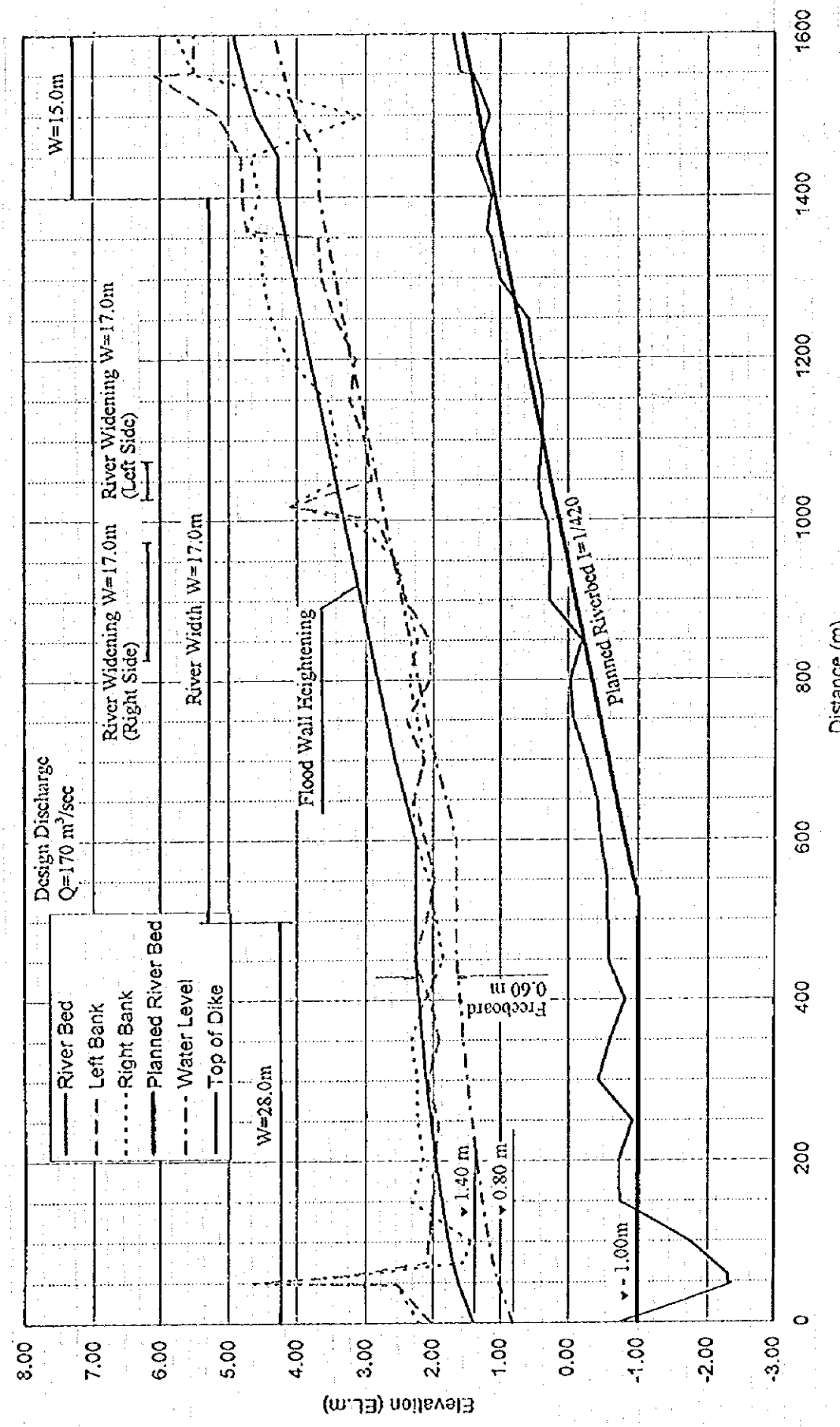


Figure-D.5.8 Longitudinal Section of Ruhu River Improvement Plan

5.3 Batu Merah River Project

5.3.1 Basic Policy

The downstream of Batu Merah River is improved with 5-year return period. In order to achieve the security against flood with 30-year return period, a diversion tunnel is planned to be constructed at 1k400 from the river mouth. As the existing check dam is located at 2k500 from the river mouth, no check dam is planned in Batu Merah River. Refer to Figure-D.5.9.

- 0k000 - 1k500 : River improvement with 5-year return period
- 1k400 : Diversion tunnel

5.3.2 Planning Criteria

(1) Design Scale

30-year return period

(2) Reference Point, Basin Division and Runoff Model

Reference points are set as shown in Table-D.5.6 and the basin division is shown in Figure-D.5.11. The runoff model is shown in Figure-D.5.10.

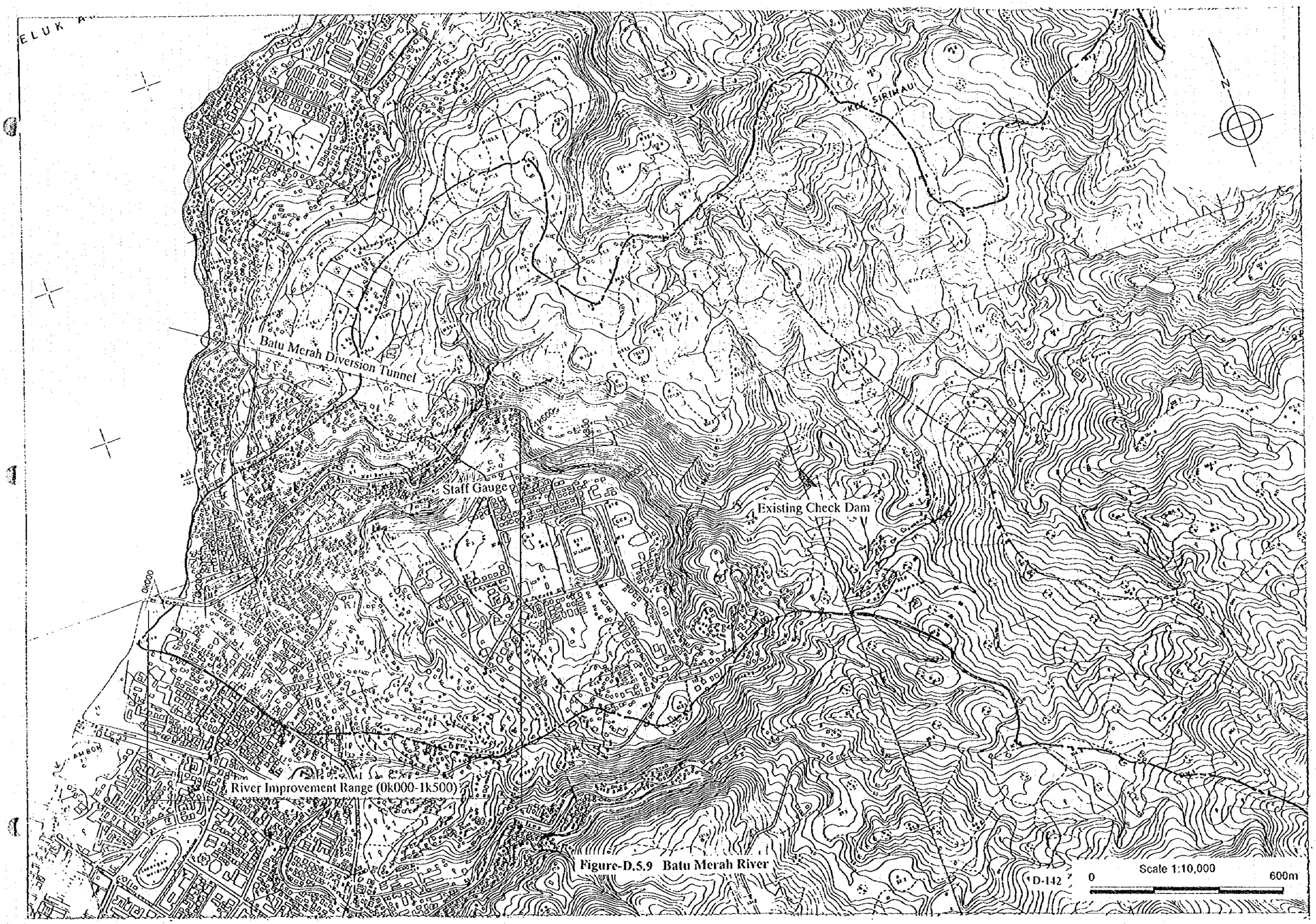


Figure-D.5.9 Batu Merah River

Table-D.5.6 Reference Point and Basin Division

Basin Name	Catchment Area. (km^2)	Reference Point	Catchment Area (km^2)
[1] Upper Basin	4.23	Staff Gauge	6.14
[2] Middle Basin	1.91	River Mouth	7.03
[3] Lower Basin	0.89		
Total	7.03		

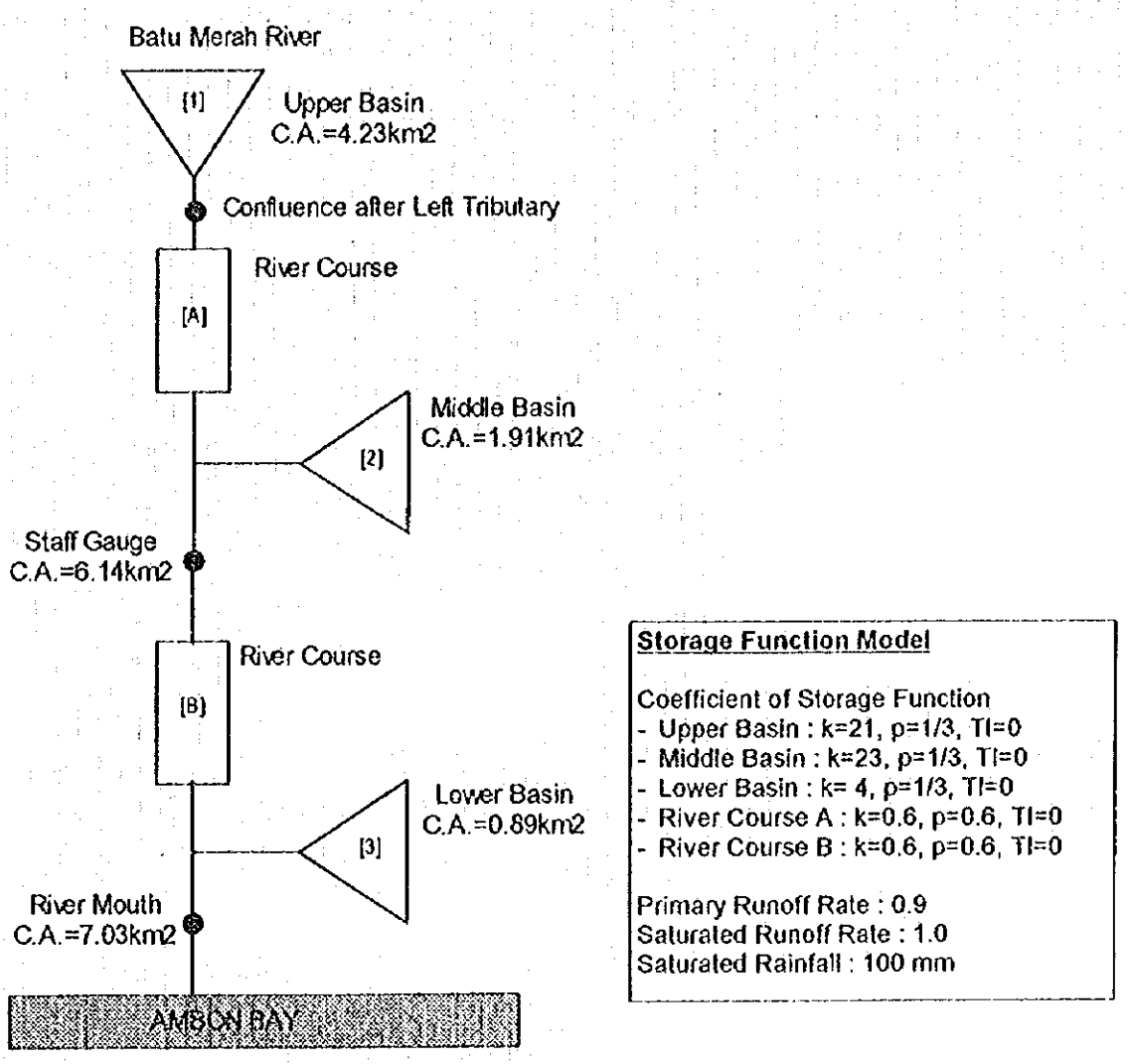


Figure-D.5.10 Runoff Model of Batu Merah River

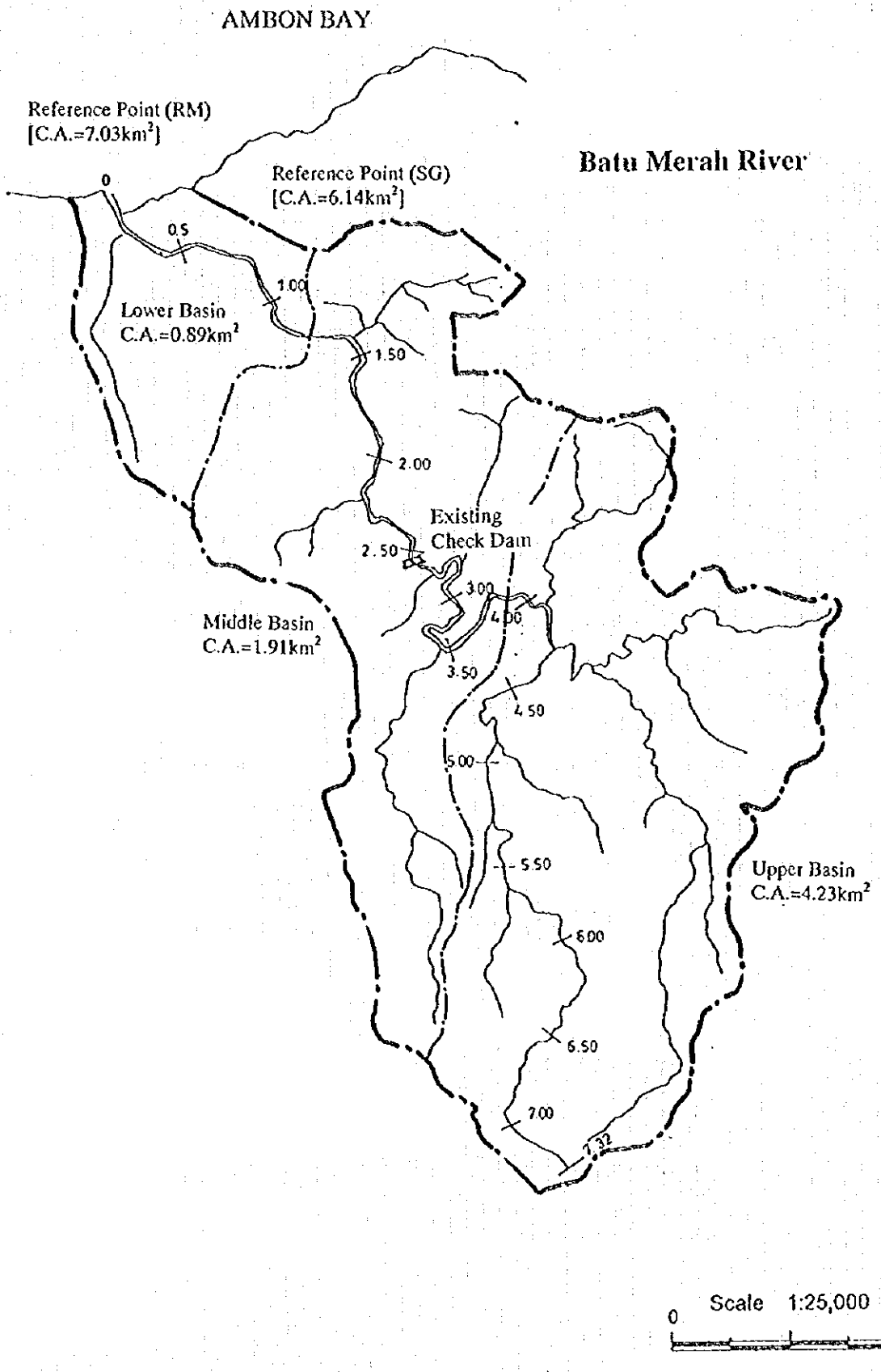


Figure-D.5.11 Batu Merah River Basin

(3) Design Flood Discharge and Design Hydrograph

Design Flood Discharge

		5-year Return Period	30-year Return Period
- Staff Gauge Reference Point	:	80 m^3/sec	130 m^3/sec
- River Mouth Reference Point	:	90 m^3/sec	150 m^3/sec

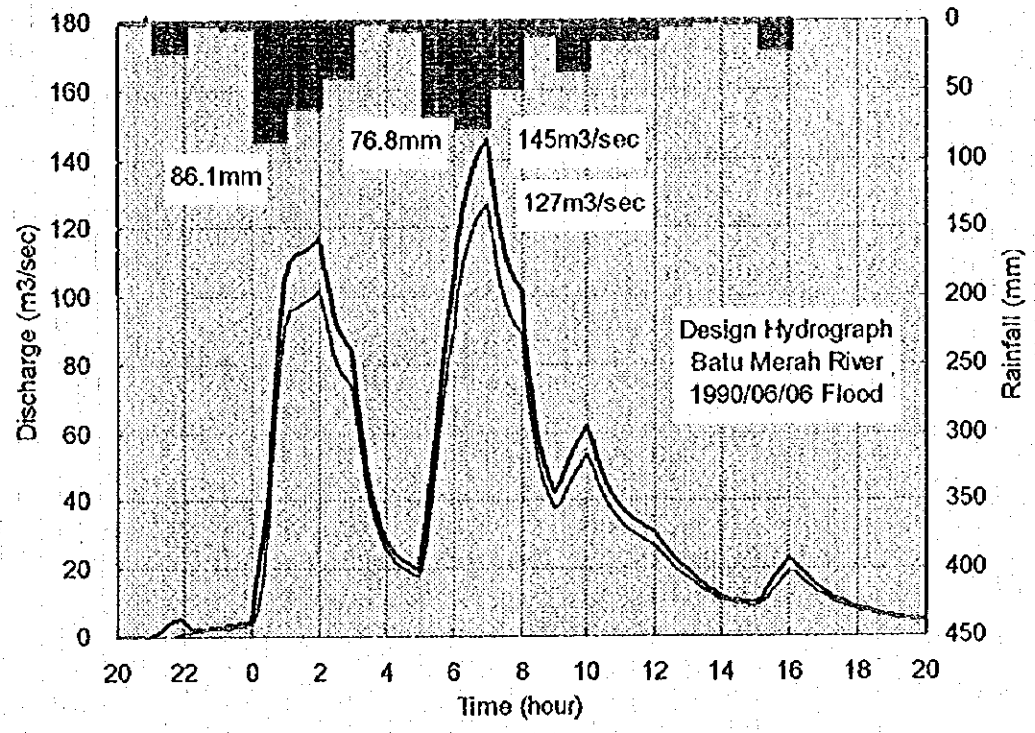


Figure-D.5.12 Design Hydrograph at Reference Points (Batu Merah River)

(4) Design Discharge Distribution

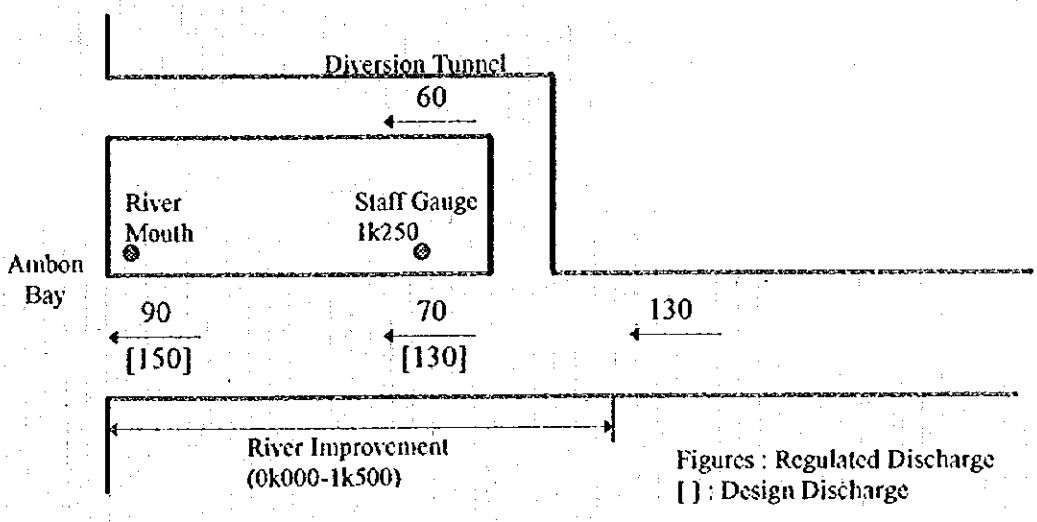


Figure-D.5.13 Design Discharge Distribution (Batu Merah River)