3.2.2 Alternative Flood Control Plans and Cost Estimate

(1) Alternative Flood Control Plans

After the study of flood control measures such as river improvement, flood control dam, diversion and check dam, alternatives of flood control plans for each river are summarized in Table-I.3.17. These alternative plans are the plans combined each flood control measure.

Table-I.3.17(1) Alternatives of Flood Control Plan

Plan (Ruhu River)		FCP-RH1	FCP-RH2	FCP-RH3	FCP-RH4	FCP-RH5
Components of Plan		R/I, ChD	R/I, Dam ChD	R/I, Dam ChD	R/I, Div ChD	R/I, Div ChD
Total Compensation	Land Acquisition	50,000 m^2	445,500 m^2	389,000 m^2	44,440 m^2	44,540 m^2
	Resettlement	147 houses	40 houses	147 houses	150 houses	177 houses
River Improvement	Design Discharge	320 m^3/sec	170 m^3/sec	230 m^3/sec	170 m^3/sec	230 m^3/sec
	Design Scale	30-year	5-year	10-year	5-year	10-year
Flood Control Dam	Dam Height	-	41.0 m	38.6 m	-	-
	Dam Volume	-	201,000 m^3	172,000 m^3	-	-
Diversion Channel	Design Discharge	-	-	-	150 m^3/sec	90 m^3/sec
	Section Width	-	-	-	7.0 m	6.0 m
	Section Height	-	-	-	3.5 m	3.2 m
Check Dam	Dam Height	10 m	10 m	10 m	10 m	10 m
	Dam Volume	2,500 m^3	2,500 m^3	2,500 m^3	2,500 m^3	2,500 m^3
Plan (Batu Merah River)		**FCP-BM1**	**FCP-BM2**	**FCP-BM3**	**FCP-BM4**	**FCP-BM5**
Components of Plan		R/I	R/I, Dam	R/I, Dam	R/I, Div	R/I, Div
Total Compensation	Land Acquisition	7,750 m^2	236,350 m^2	206,750 m^2	1,550 m^2	5,950 m^2
	Resettlement	160 houses	160 houses	277 houses	10 houses	127 houses
River Improvement	Design Discharge	150 m^3/sec	90 m^3/sec	110 m^3/sec	90 m^3/sec	110 m^3/sec
	Design Scale	30-year	5-year	10-year	5-year	10-year
Flood Control Dam	Dam Height	-	25.0 m	23.1 m	-	-
	Dam Volume	-	115,000 m^3	94,000 m^3	-	-
Diversion Channel	Design Discharge	-	-	-	60 m^3/sec	40 m^3/sec
	Section Diameter	-	-	-	5.8 m	5.1 m
Check Dam	Dam Height	-	-	-	-	-
	Dam Volume	-	-	-	-	-
Plan (Tomu River)		**FCP-TM1**	**FCP-TM2**	**FCP-TM3**	**FCP-TM4**	**FCP-TM5**
Components of Plan		R/I, ChD	R/I, Dam, ChD	R/I, Dam, ChD	R/I, Div, ChD	R/I, Div, ChD
Total Compensation	Land Acquisition	30,000 m^2	185,000 m^2	138,000 m^2	32,480 m^2	32,360 m^2
	Resettlement	-	-	-	34 houses	34 houses
River Improvement	Design Discharge	120 m^3/sec	70 m^3/sec	90 m^3/sec	70 m^3/sec	90 m^3/sec
	Design Scale	30-year	5-year	10-year	5-year	10-year
Flood Control Dam	Dam Height	-	29.2 m	22.8 m	-	-
	Dam Volume	-	271,000 m^3	159,000 m^3	-	-
Diversion Channel	Design Discharge	-	-	-	50 m^3/sec	30 m^3/sec
	Section Diameter	-	-	-	4.2 m	3.5 m
Check Dam	Dam Height	7 m	7 m	7 m	7 m	7 m
	Dam Volume	2,700 m^3	2,700 m^3	2,700 m^3	2,700 m^3	2,700 m^3

Note. R/I : River Improvement Dam : Flood Control Dam Div : Diversion ChD : Check Dam

Table-I.3.17(2) Alternatives of Flood Control Plan

Plan (Batu Gajah River)		FCP-GJ1	FCP-GJ2	FCP-GJ3
Components of Plan		R/I, ChD	R/I, Dam, ChD	R/I, Dam, ChD
Total Compensation	Land Acquisition	21,500 m^2	124,000 m^2	109,000 m^2
	Resettlement	147 houses	20 houses	20 houses
River Improvement	Design Discharge	130 m^3/sec	80 m^3/sec	100 m^3/sec
	Design Scale	30-year	5-year	10-year
Flood Control Dam	Dam Height	-	34.0 m	31.8 m
	Dam Volume	-	406,000 m^3	335,000 m^3
Diversion Channel	Design Discharge	-	-	-
	Section Diameter	-	-	-
Check Dam	Dam Height	8 m	8 m	8 m
	Dam Volume	2,600 m^3	2,600 m^3	2,600 m^3
Plan (Batu Gantung River)		FCP-GT1	FCP-GT2	FCP-GT3
Components of Plan		R/I, ChD	R/I, Dam, ChD	R/I, Dam, ChD
Total Compensation	Land Acquisition	10,750 m^2	137,000 m^2	101,000 m^2
	Resettlement	127 houses	-	-
River Improvement	Design Discharge	150 m^3/sec	90 m^3/sec	110 m^3/sec
	Design Scale	30-year	5-year	10-year
Flood Control Dam	Dam Height	-	37.5 m	34.0 m
	Dam Volume	-	228,000 m^3	174,000 m^3
Diversion Channel	Design Discharge	-	-	-
	Section Diameter	-	-	-
Check Dam	Dam Height	11 m	11 m	11 m
	Dam Volume	2,400 m^3	2,400 m^3	2,400 m^3

Note. R/I : River Improvement Dam : Flood Control Dam Div : Diversion ChD : Check Dam

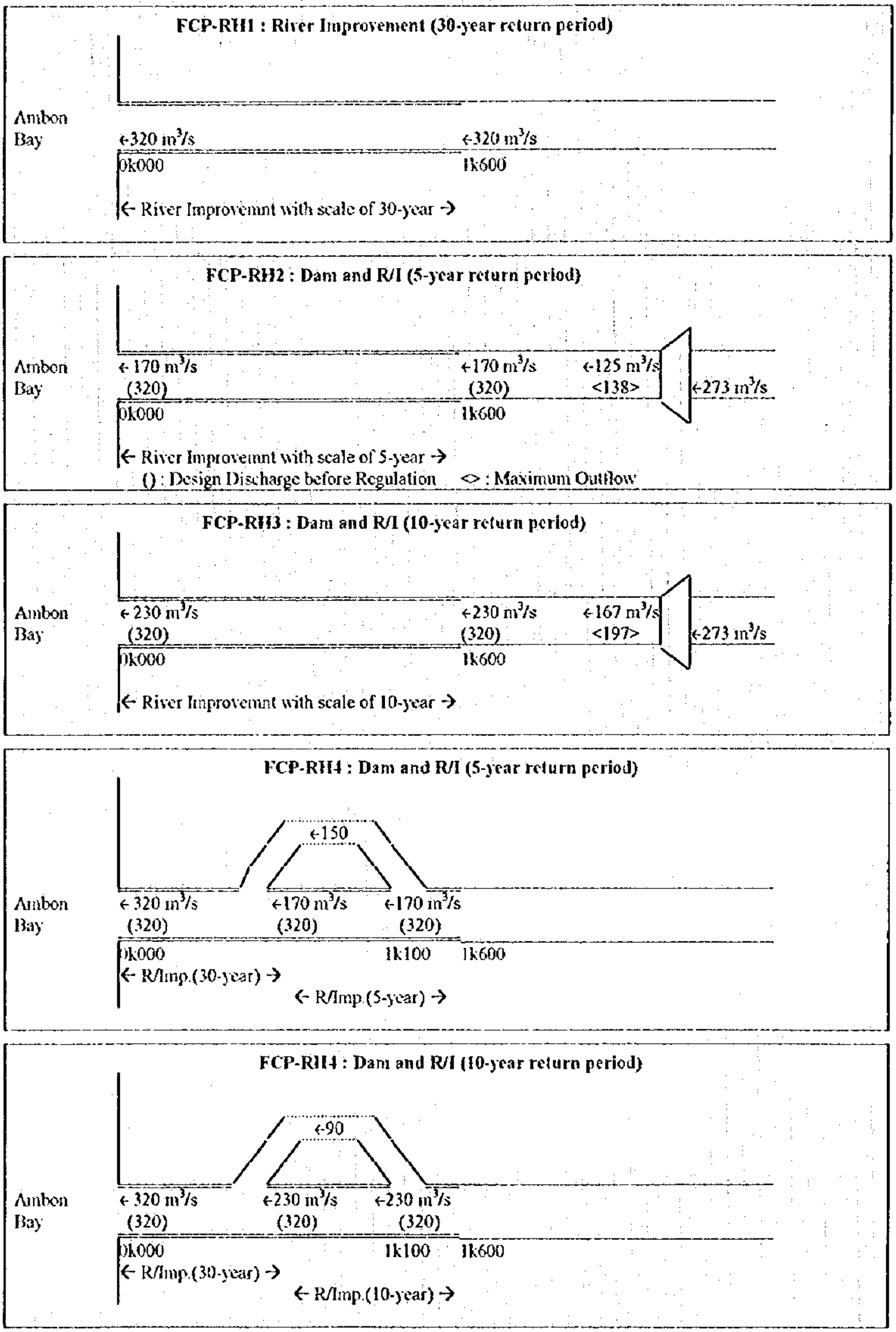


Figure-I.3.9 Distribution of Flood Discharge (Ruhu River)

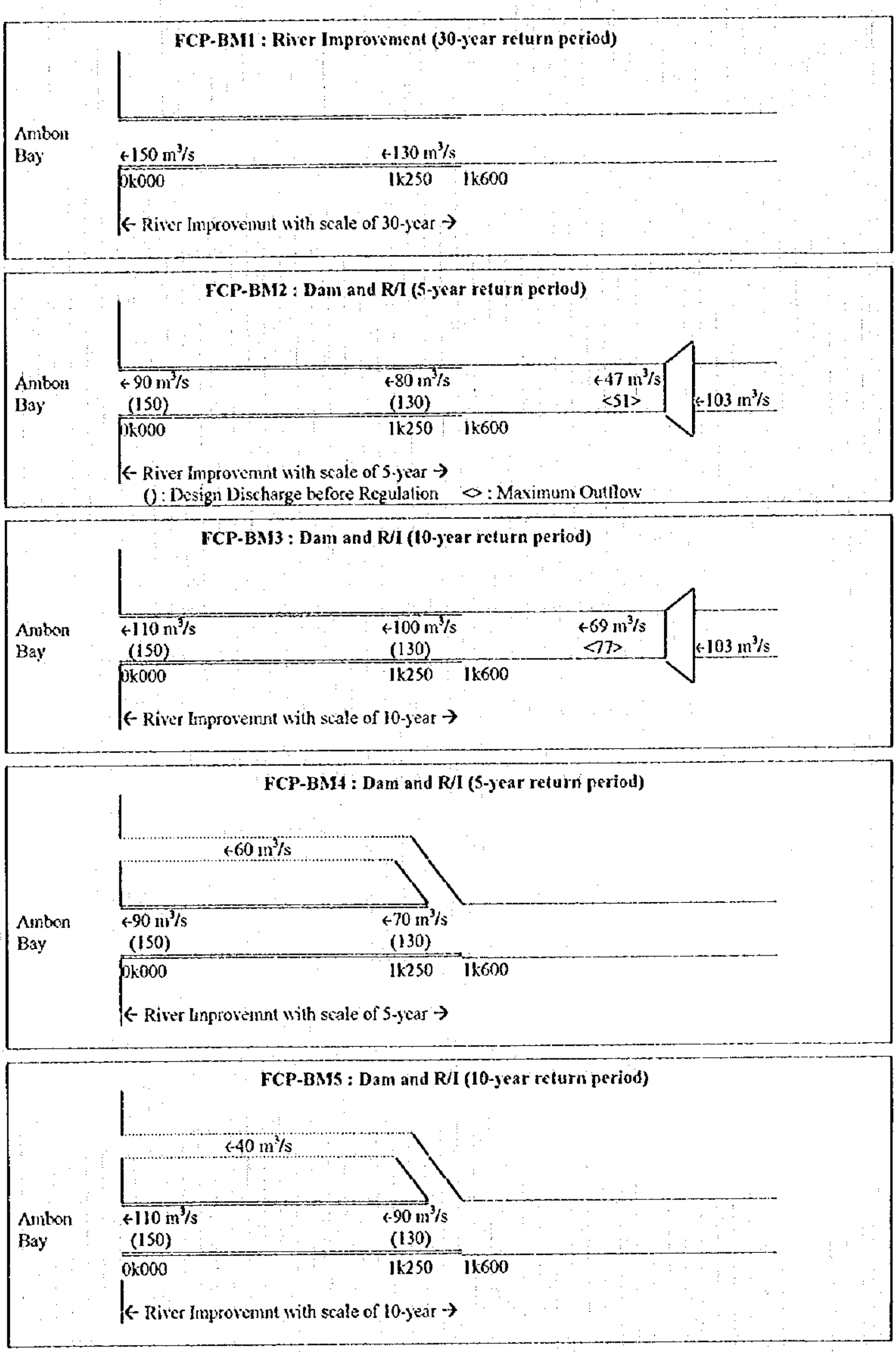


Figure-I.3.10 Distribution of Flood Discharge (Batu Merah River)

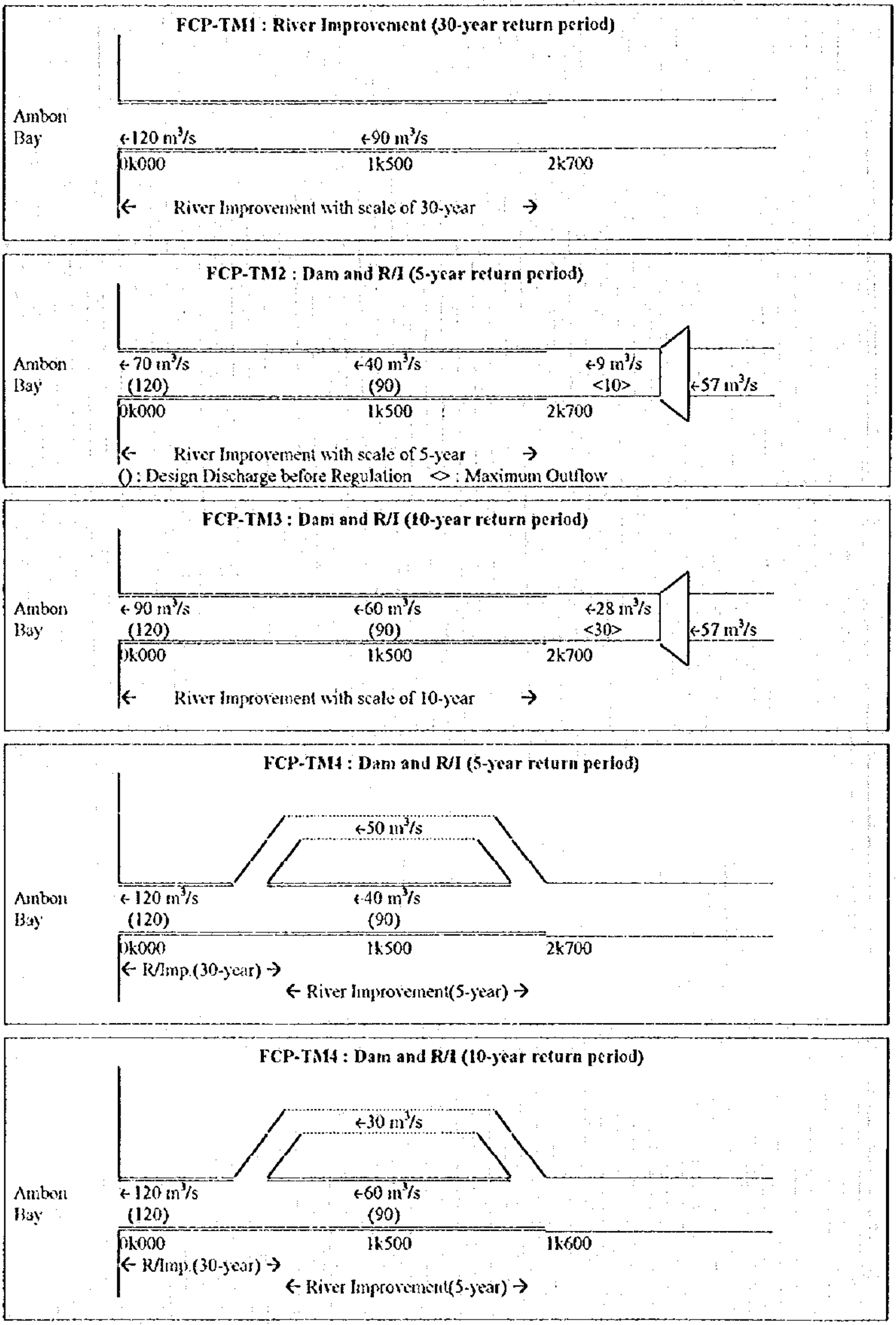


Figure-I.3.11 Distribution of Flood Discharge (Tomu River)

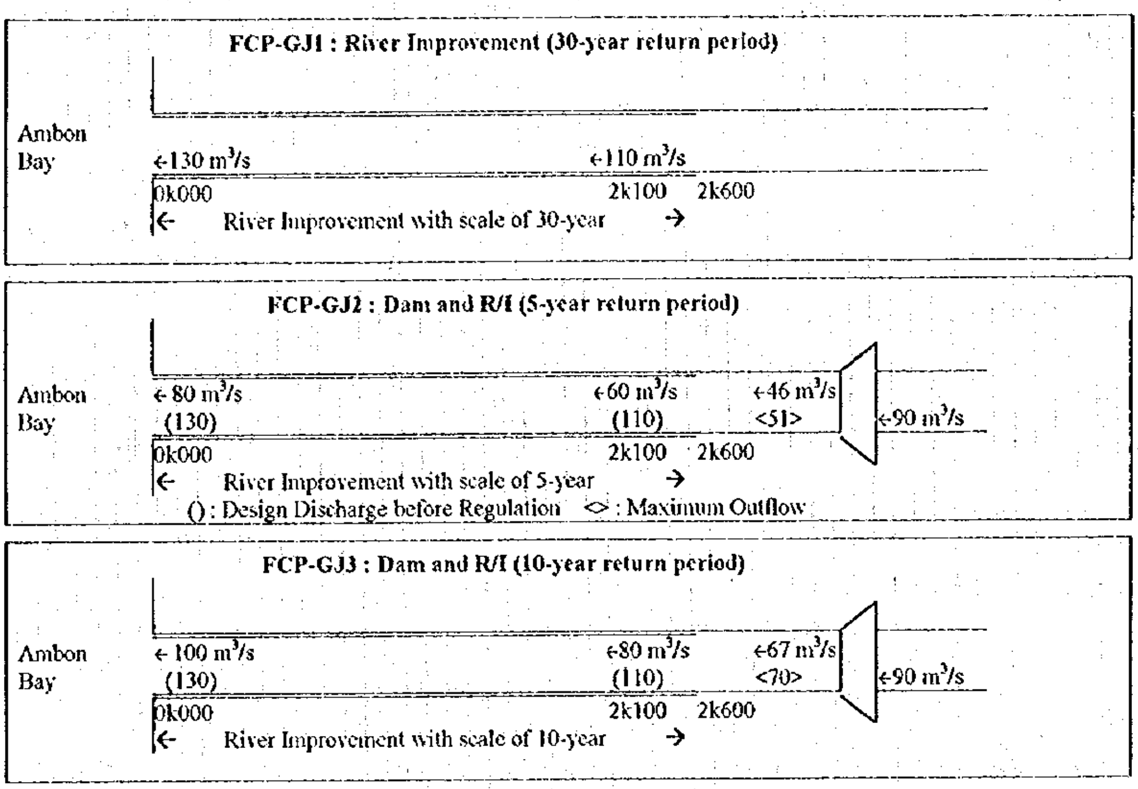


Figure-II.3.12 Distribution of Flood Discharge (Batu Gajah River)

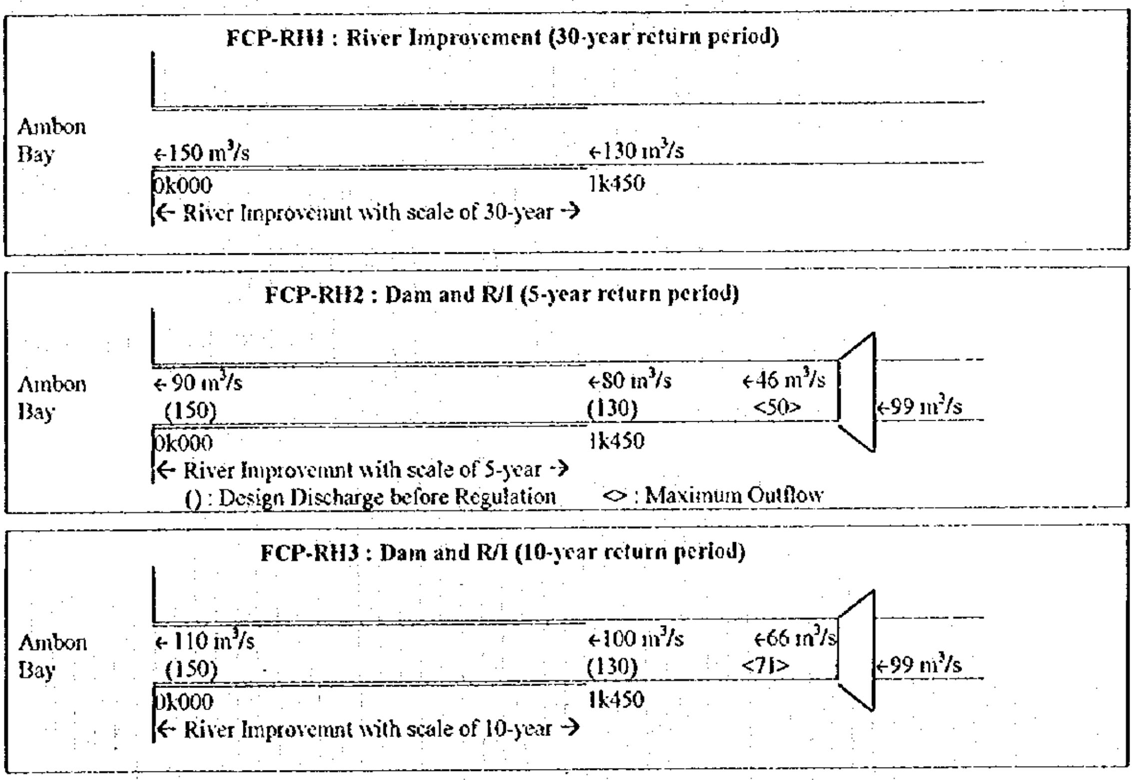


Figure-I.3.13 Distribution of Flood Discharge (Batu Gantung River)

(2) Cost Estimate of Alternative Plans

(a) General Conditions of Cost Estimate

<Standards for Cost Estimate>

The labor and materials allotment for major work items such as excavation, embankment, stone masonry, concrete etc. are based on the following standards used in Indonesia.

1) Construction Cost Estimate Standard
   (Dasar Pengusunan Anggaran Biaya Bangunan)
2) Principal Manual of Works with Machinery
   (Pedomon Pokok Pelaksanaan Pekerjaan dengan Menggunakan Peralatan)

<Composition of Project Cost>

The project cost is generally composed of the following items:

(a) Construction Cost
  - (a1): Main Construction Cost
  - (a2): Preparatory Work Cost

(b) Cost for Land Acquisition and Compensation
  - (b1): Land Acquisition Cost
  - (b2): Compensation Cost

(c) Cost for Engineering Services

(d) Government Administration Cost

(e) Contingency for (a), (b) and (c)

(f) Government Tax (PPN: Value Added Tax)

In the cost estimate for each alternative plan, the project cost is composed of the following items:

1) Main Construction Cost: equivalent to the above item (a1)
2) Cost for Land Acquisition and Compensation, equivalent to the above item (b)
3) Indirect Cost (30% of Main Construction Cost) including:
   - (a2) : Preparatory work cost for construction work
   - (c) : Cost for Engineering Services
   - (d) : Government Administration Cost
   - (e) : Contingency for (a), (b) and (c)
   - (f) : Government Tax (PPN: Value Added Tax)

<Unit Costs and Exchange Rate>

The unit costs are decided based on the current costs of labor, material, equipment cost and so on. The following currency exchange rates (as of November 1996) are employed.

1 US$ = ¥ 115 = Rp. 2,300, ¥ 1 = Rp. 20.0

(b) Project Cost of Alternative Plans

The estimated project cost for each alternative plan is shown in Table-I.3.18.

Table-I.3.18 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	12,147	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

Notes: The shaded alternative plans are selected as the optimum plan for each river.

3.2.3 Identification of Optimum Plan

The alternative flood control plans are summarized in Table-I.3.19, which presents project composition, project costs and number of resettlement households. Mainly taking into account economic feature (project cost), social impact (resettlement) and water development possibility, the optimum flood control plan for each river system was evaluated in the table and the detailed explanation is described 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).

Table-I.3.19 Identification of Optimum Flood Control Plan

Ruhu River Plan	FCP-RH1	FCP-RH2	FCP-RH3	FCP-RH4	FCP-RH5
Project Composition	R/Imp [30] Check Dam	R/Imp [5] F/C Dam Check Dam	R/Imp [10] F/C Dam Check Dam	R/Imp [5] Diversion Check Dam	R/Imp [10] Diversion Check Dam
Project Cost (Rp. Million)	44,932	66,998	84,586	43,594	46,838
Resettlement Households	147	40	147	150	177
Identification Evaluation	△	○	△	△	△
Economical Feature	○	△	X	○	○
Social Impact	X	○	X	X	X
Water Development Possibility	X	○	○	X	X
Remark	FCP-RH2 is only the case to be adopted.				
Batu Merah River Plan	FCP-BM1	FCP-BM2	FCP-BM3	FCP-BM4	FCP-BM5
Project Composition	R/Imp [30]	R/Imp [5] F/C Dam	R/Imp [10] F/C Dam	R/Imp [5] Diversion	R/Imp [10] Diversion
Project Cost (Rp. Million)	47,266	52,994	72,956	51,235	66,149
Resettlement Households	160	160	277	10	127
Identification Evaluation	△	○	△	○	△
Economical Feature	○	○	X	○	△
Social Impact	△	△	X	○	△
Water Development Possibility	X	○	○	X	X
Remark	The dam in FCP-BM2 needs 150 resettlement households.				
Tomu River Plan	FCP-TM1	FCP-TM2	FCP-TM3	FCP-TM4	FCP-TM5
Project Composition	R/Imp [30] Check Dam	R/Imp [5] F/C Dam Check Dam	R/Imp [10] F/C Dam Check Dam	R/Imp [5] Diversion Check Dam	R/Imp [10] Diversion Check Dam
Project Cost (Rp. Million)	26,290	51,454	44,310	25,890	24,691
Resettlement Households	-	-	-	34	34
Identification Evaluation	○	○	○	△	△
Economical Feature	○	X	△	○	○
Social Impact	○	○	○	△	△
Water Development Possibility	X	○	○	X	X
Remark	FCP-RH1 is the most economical plan.				
Batu Gajah River Plan	FCP-GJ1	FCP-GJ2	FCP-GJ3	-	-
Project Composition	R/Imp [30] Check Dam	R/Imp [5] F/C Dam Check Dam	R/Imp [10] F/C Dam Check Dam	-	-
Project Cost (Rp. Million)	54,438	62,217	58,933	-	-
Resettlement Households	147	20	20	-	-
Identification Evaluation	△	○	○	-	-
Economical Feature	○	X	△	-	-
Social Impact	X	○	○	-	-
Water Development Possibility	X	○	○	-	-
Remark	FCP-GJ3 is more economical than FCP-GJ2.				
Batu Gantung River Plan	FCP-GT1	FCP-GT2	FCP-GT3	-	-
Project Composition	R/Imp [30] Check Dam	R/Imp [5] F/C Dam Check Dam	R/Imp [10] F/C Dam Check Dam	-	-
Project Cost (Rp. Million)	32,145	48,952	45,198	-	-
Resettlement Households	73	-	-	-	-
Identification Evaluation	△	○	○	-	-
Economical Feature	○	X	△	-	-
Social Impact	△	○	○	-	-
Water Development Possibility	X	○	○	-	-
Remark	FCP-GT3 is more economical than FCP-GT2.				

Note R/Imp : River Improvement ([]:Design scale of river improvement) F/C Dam : Flood Control Dam

[shaded box] : Optimum flood control plan

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. 1) 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, 2) 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. 32,145 million (71 % of FCP-GT3) but it is necessary to resettle 73 households. It could not be adopted although the project cost is 29 % 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-I.3.21 and Figure-I.3.15 to Figure-I.3.19. All the projects were integrated into Figure-I.3.14. Table-I.3.20 presents the integrated features of the flood control master plan of the five target rivers in the Study Area.

Table-I.3.20 Features of Flood Control Plan in the Study Area

Item	Figure	Item	Figure
Project Cost (Million Rp.)	248,654	**Flood Control Dam (RH-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 (m²)	599,000
C. Land Acquisition/Compensation Cost	18,258	- Resettlement (Household)	20
Land Acquisition A (m²)	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 (m²)	1,850	- Land Acquisition A (m²)	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 (m²)	85,000
River Widening L(m)	370	- Resettlement (Household)	0
Bridge Improvement (Number)	13	Number of Check Dam	4

Table-I.3.21 Optimum Flood Control Plan

Item		Ruhu	Batu Merah	Tomu	Batu Gajah	Batu Gantung
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	-	-	31.3	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

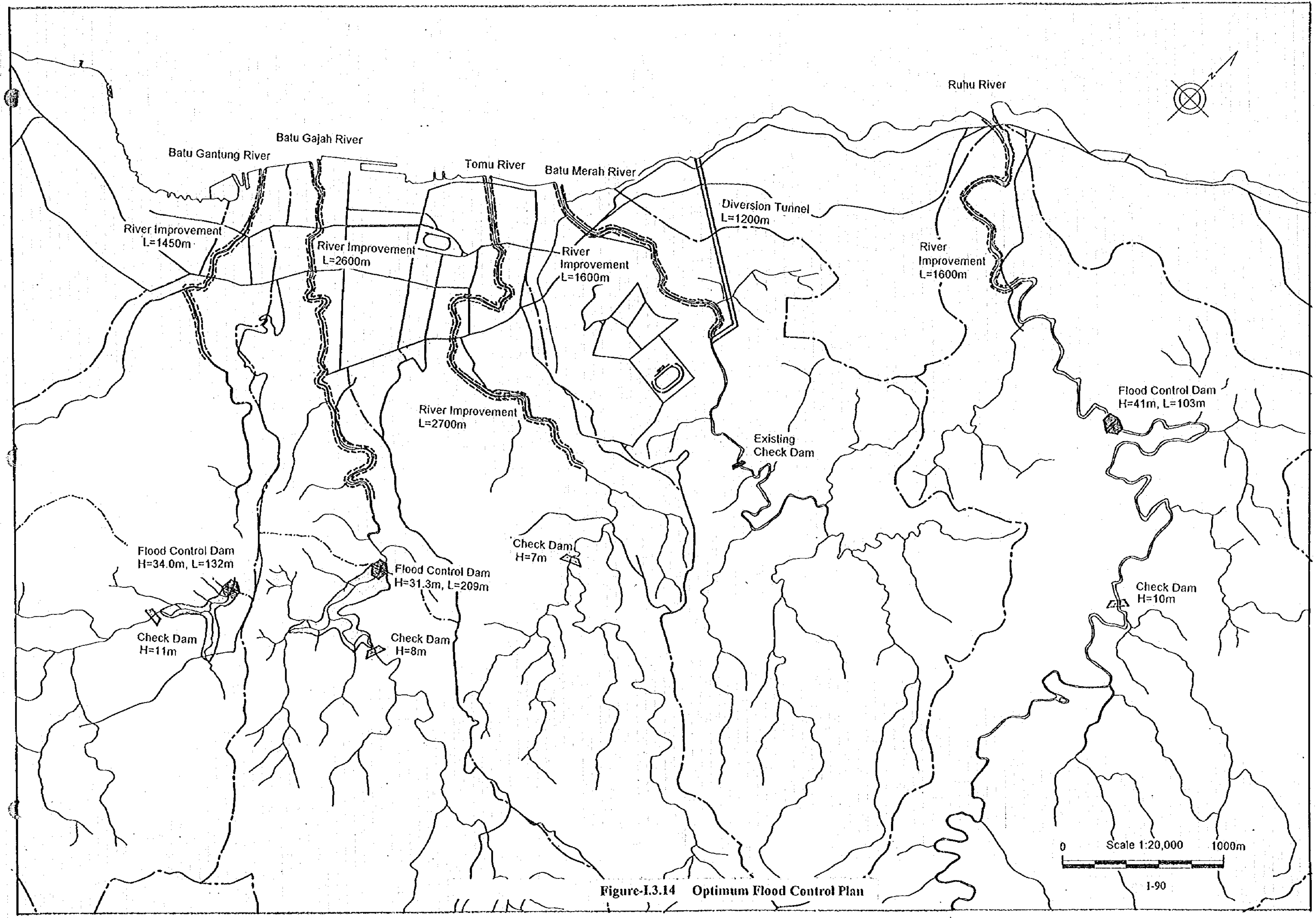
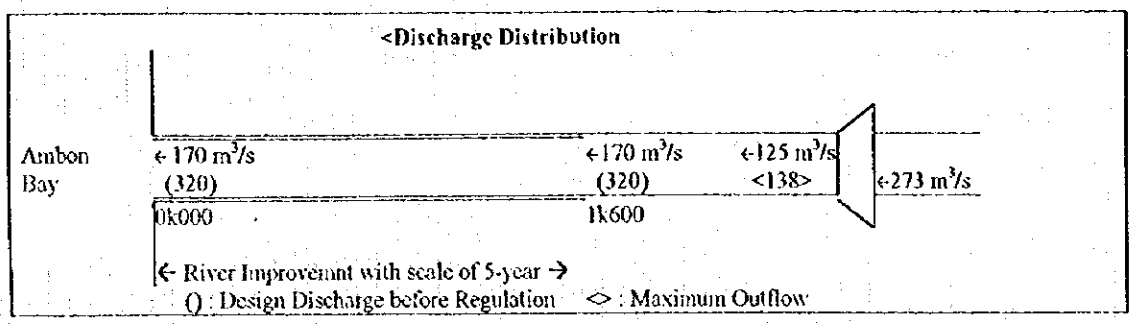
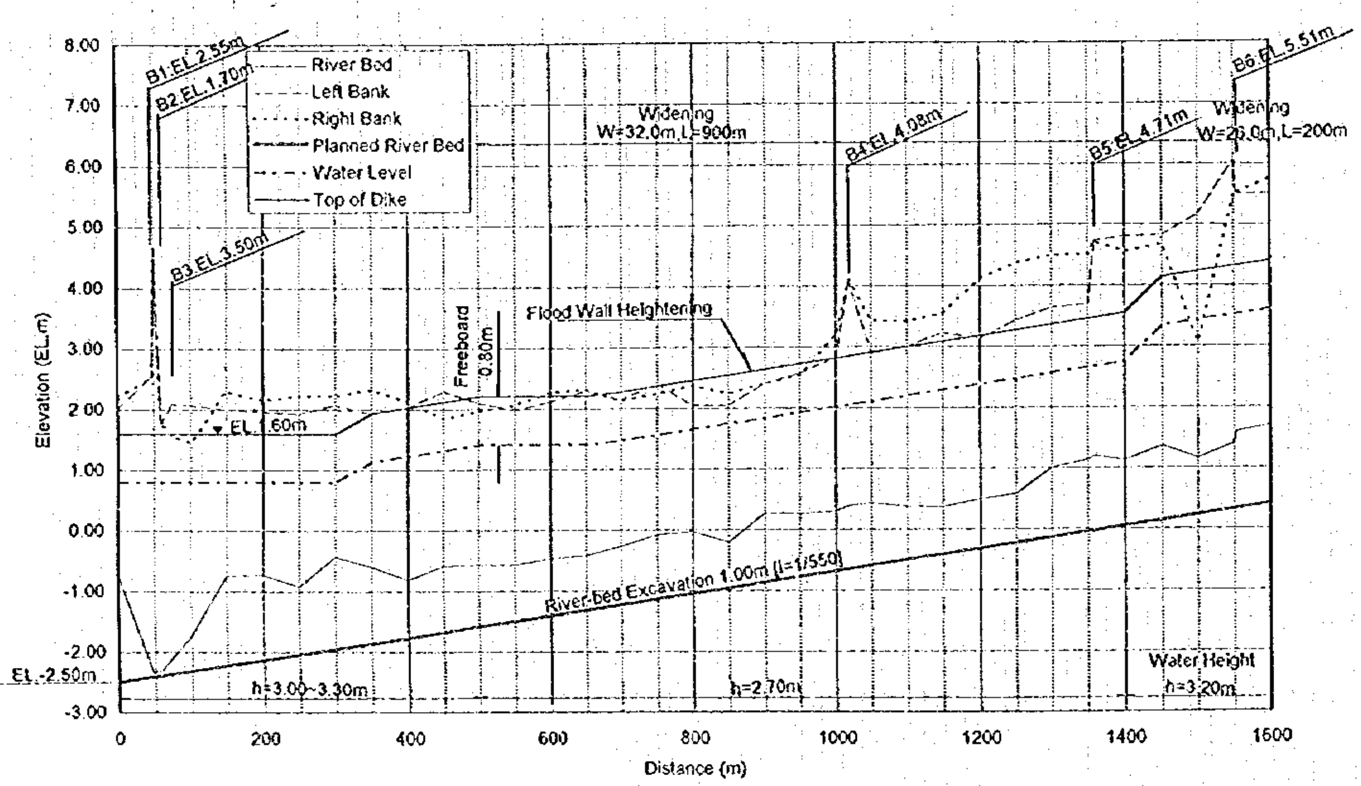


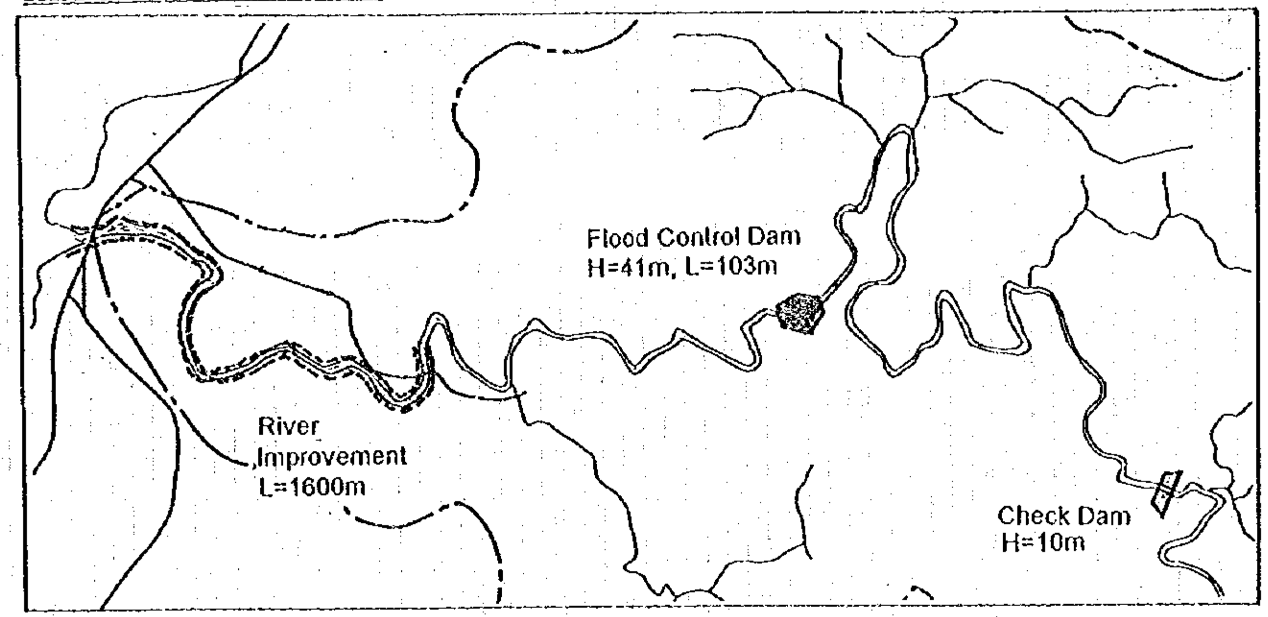
Figure-I.3.14 Optimum Flood Control Plan



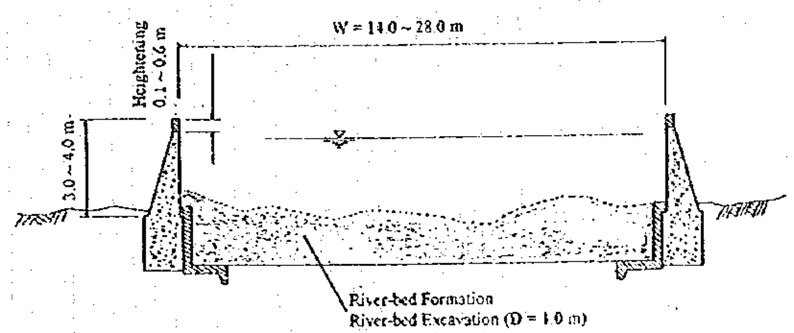
Longitudinal Section of River Improvement



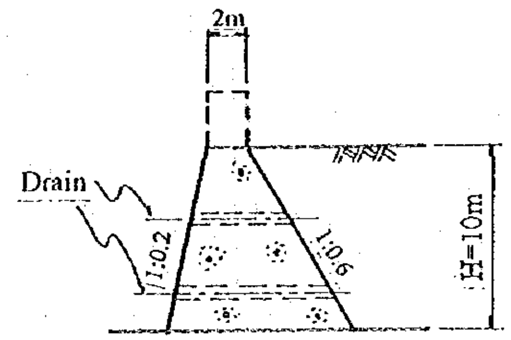
KEY MAP S=1:20,000



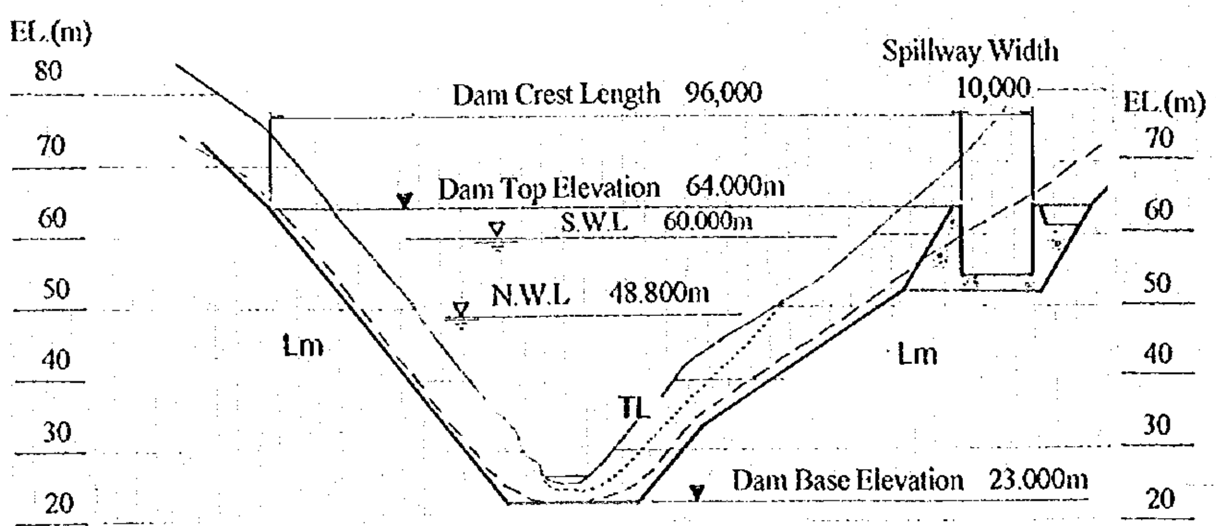
Standard Cross Section of River Improvement S=1:300



Standard Cross Section of Check Dam S=1:400



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



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

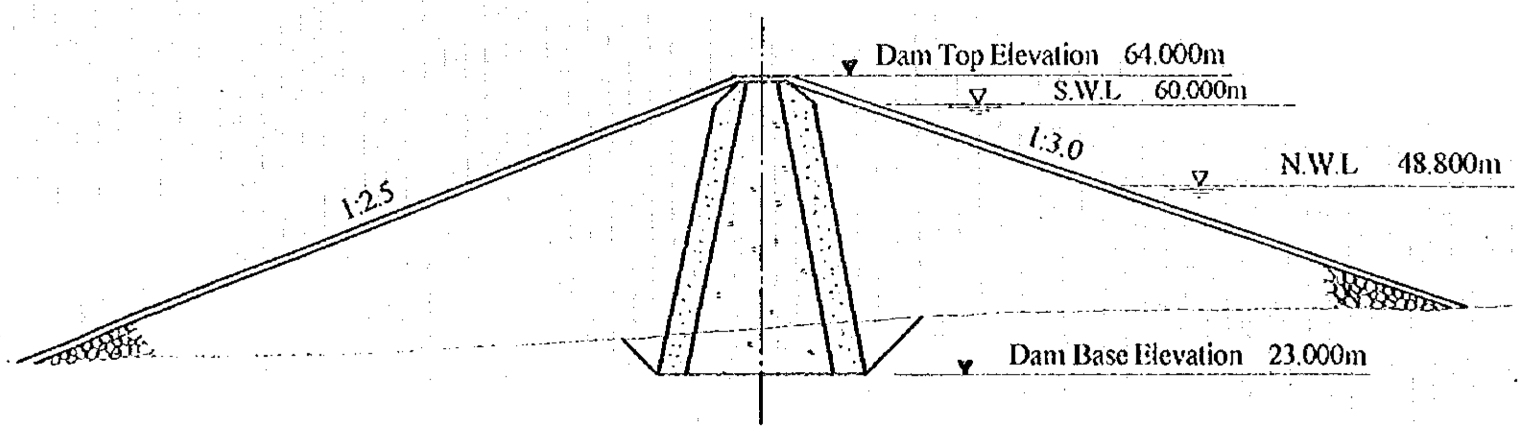
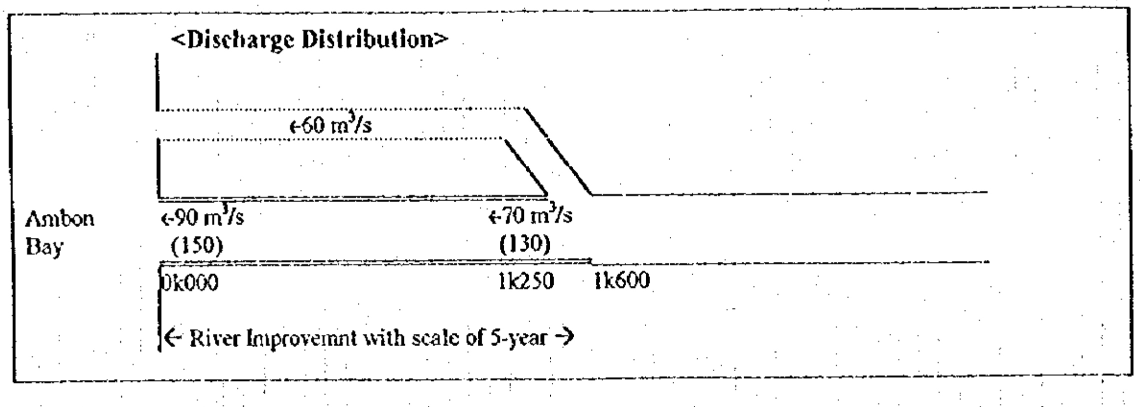
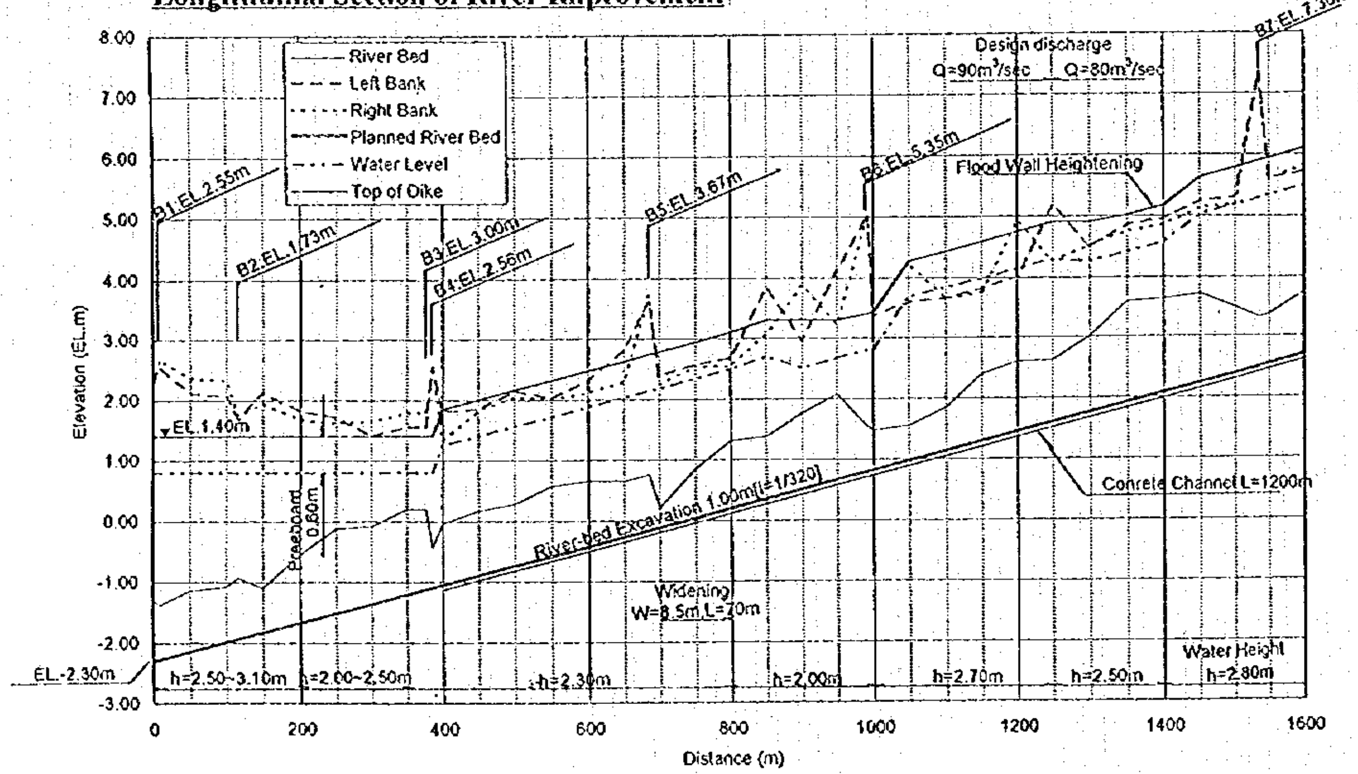


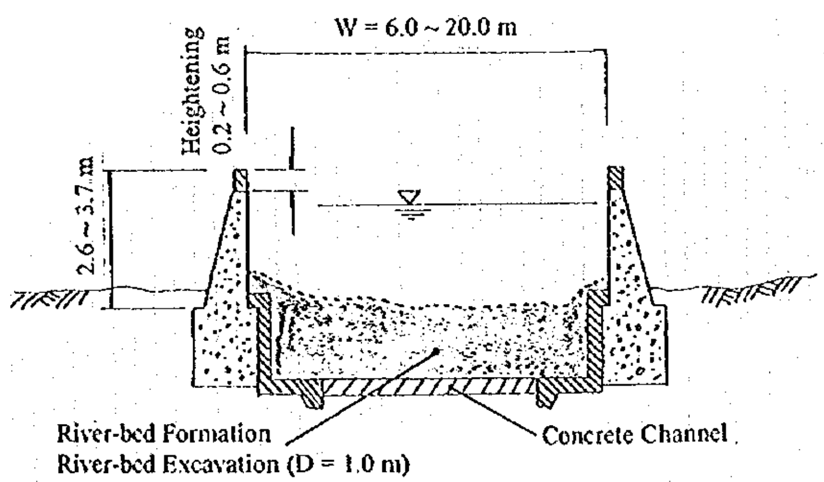
Figure-I.3.15 Optimum Flood Control Plan for Ruhu River



Longitudinal Section of River Improvement



Standard Cross Section of River Improvement S=1:200



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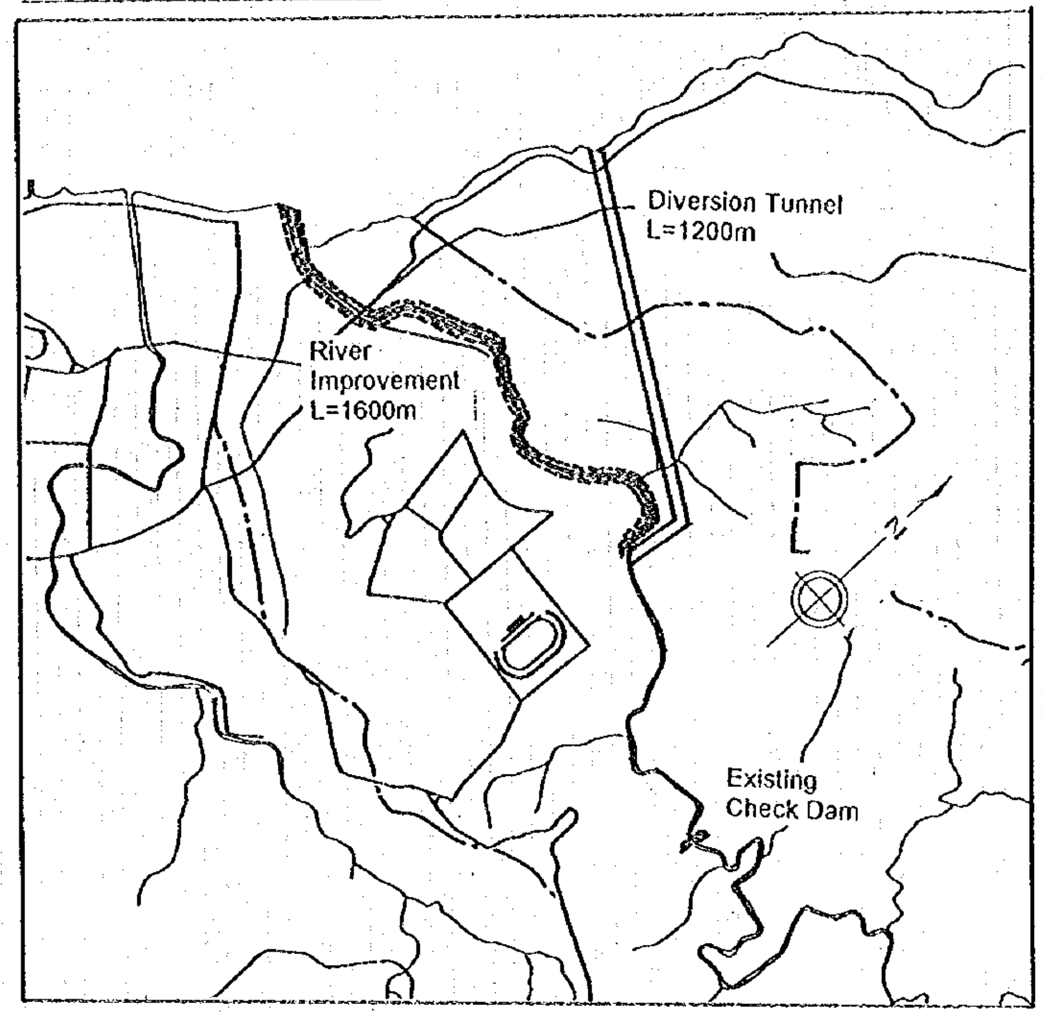


Standard Cross Section of Diversion Channel S=1:100

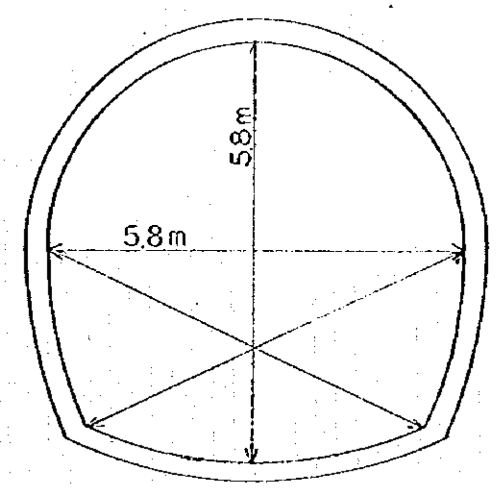
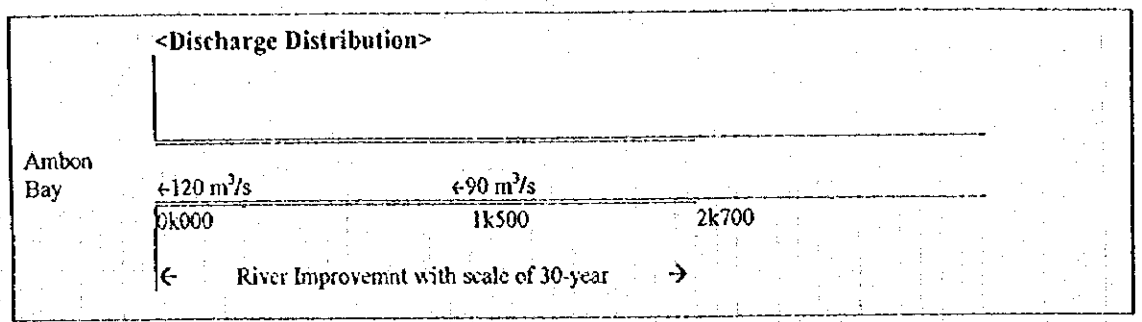


Figure-I.3.16 Optimum Flood Control Plan for Batu Merah River



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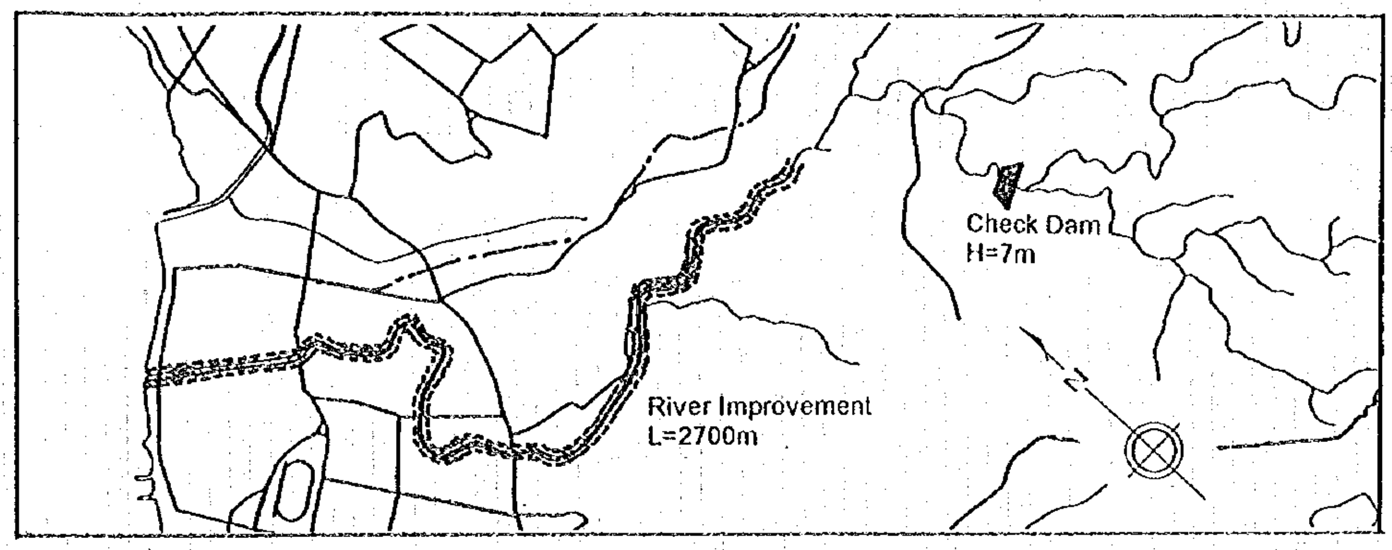
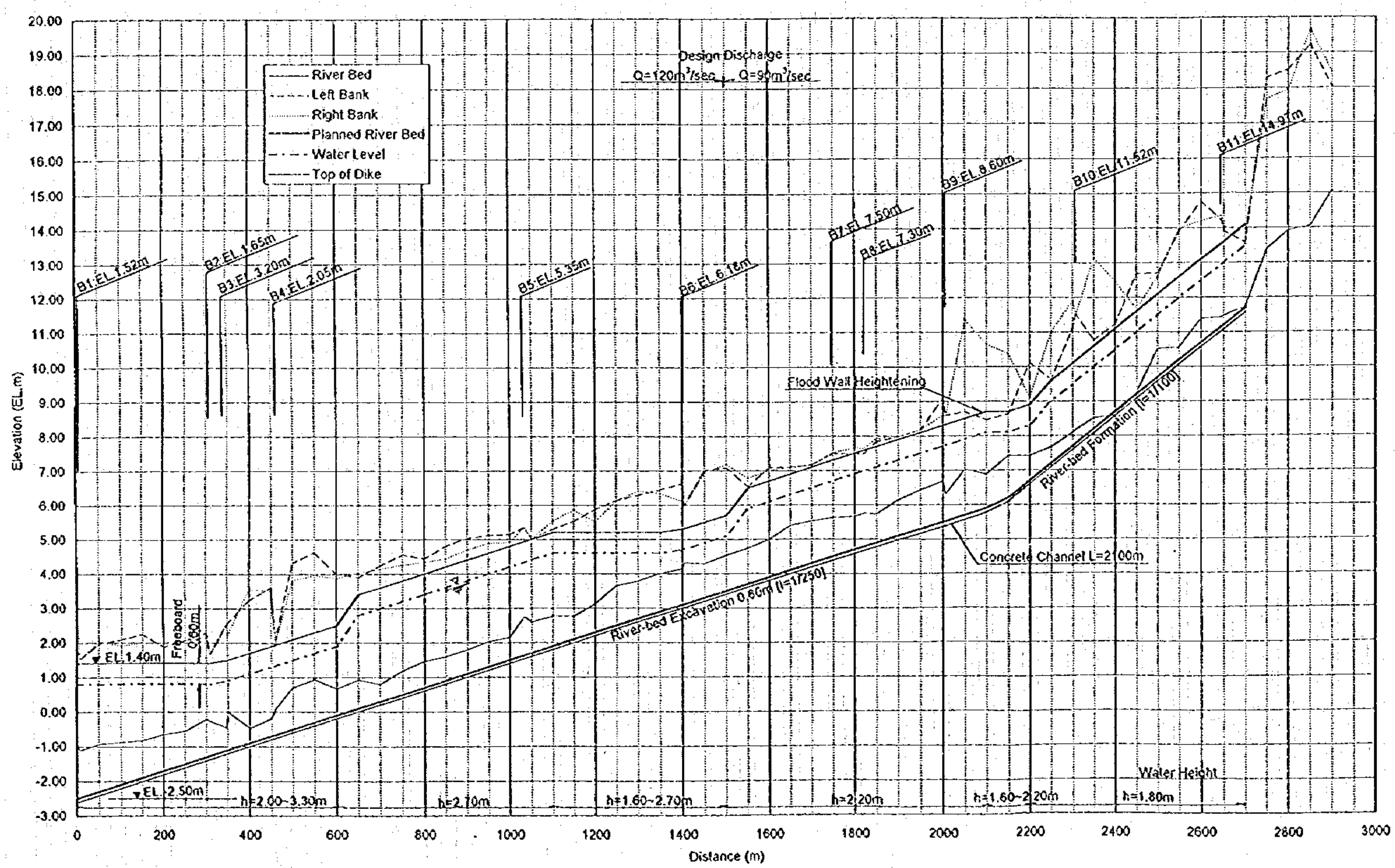
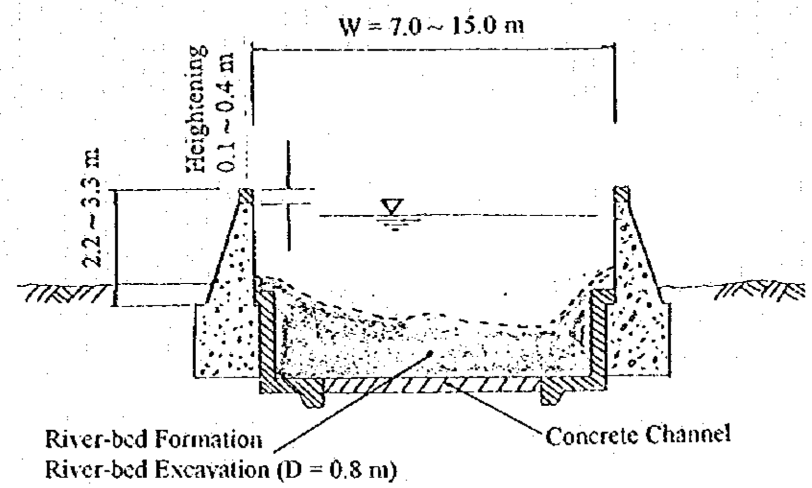


Longitudinal Section of River Improvement



Standard Cross Section of River Improvement S=1:200



Standard Cross Section of Check Dam S=1:250

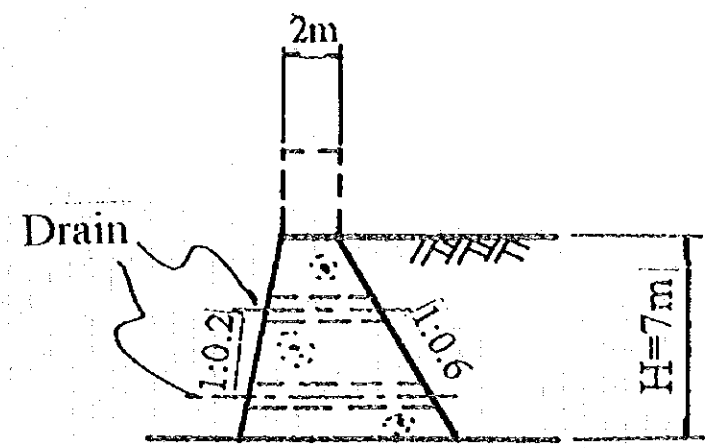


Figure-I.3.17 Optimum Flood Control Plan for Tomu River

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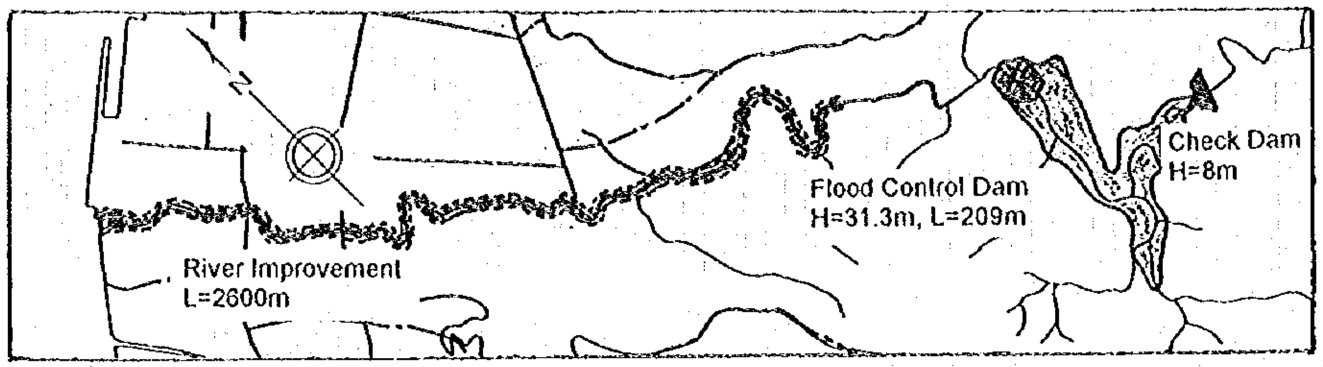
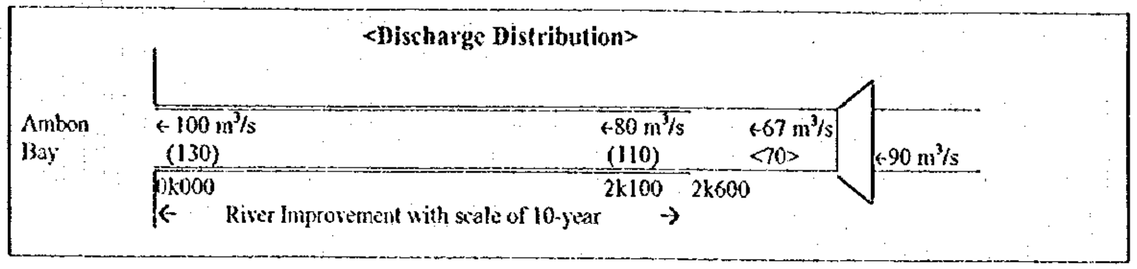
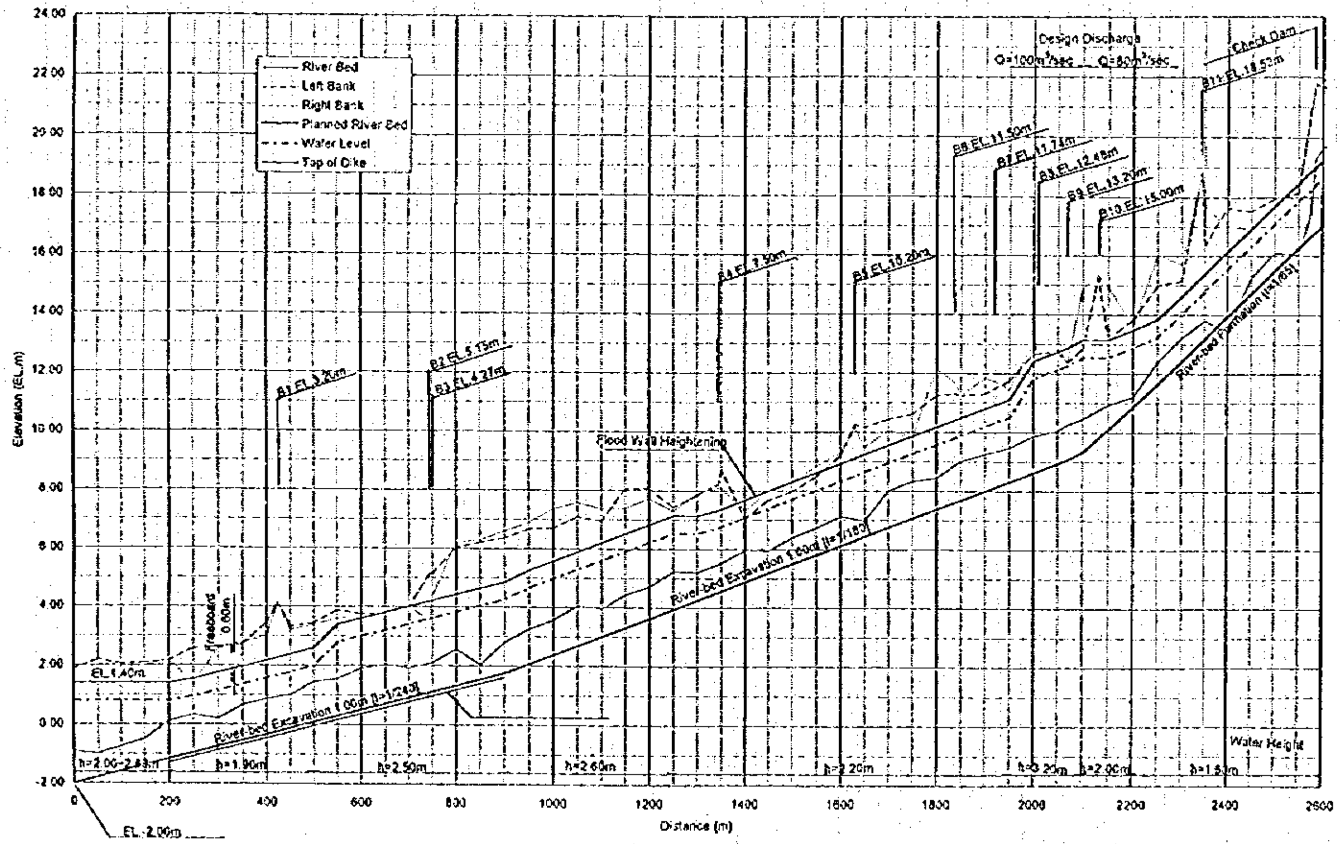
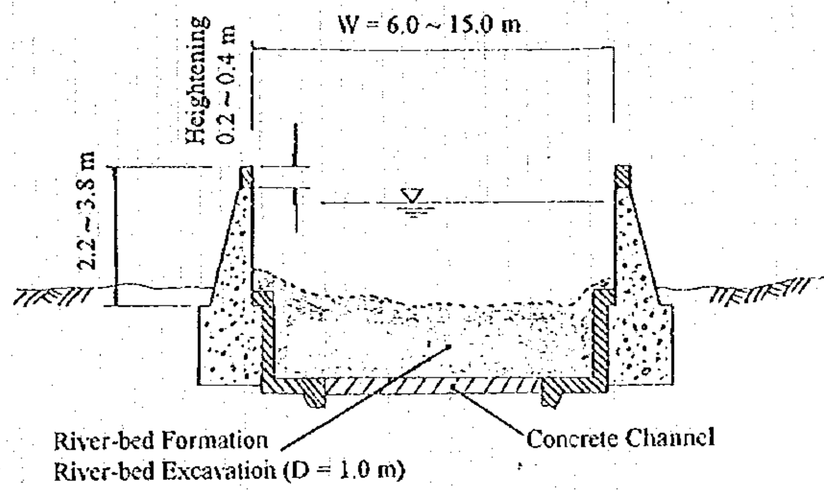




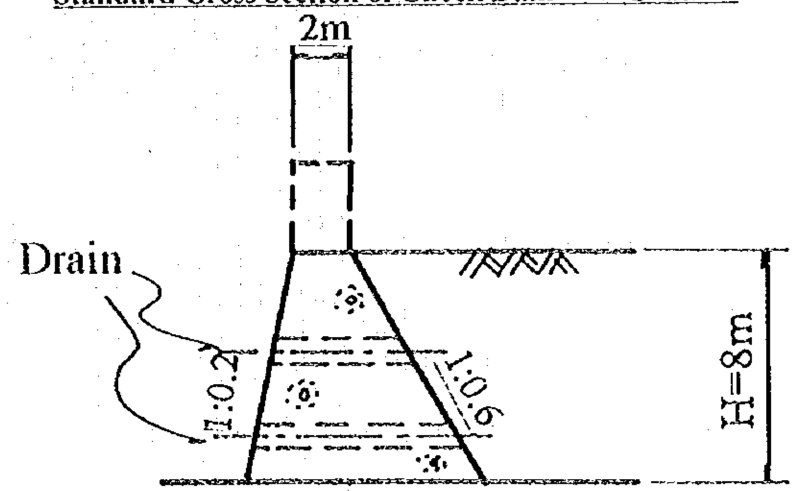
Longitudinal Section of River Improvement



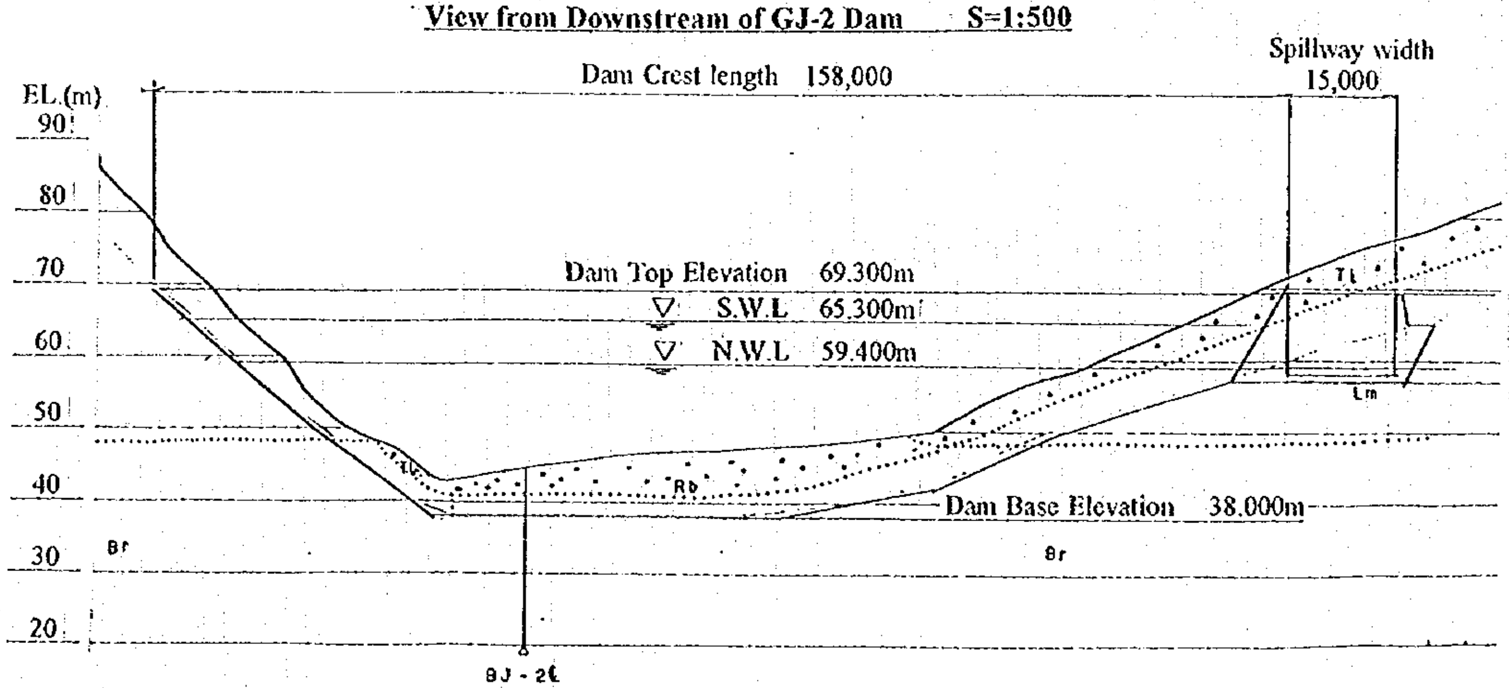
Standard Cross Section of River Improvement S=1:200



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

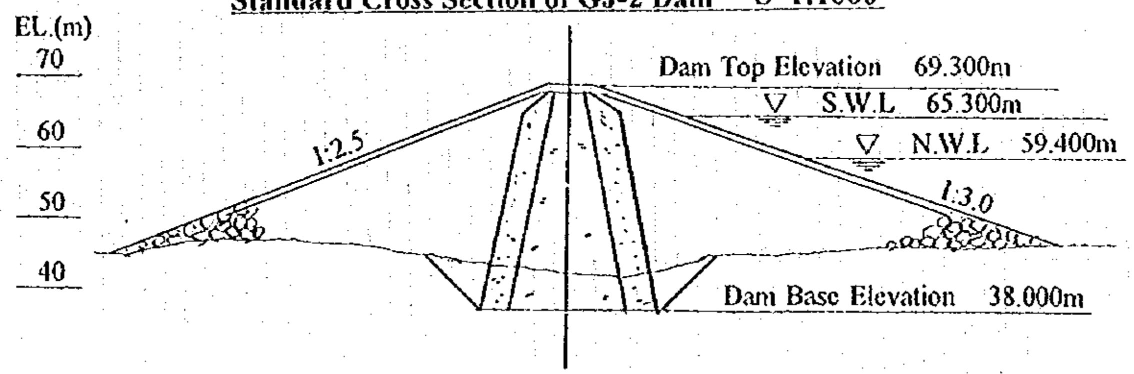
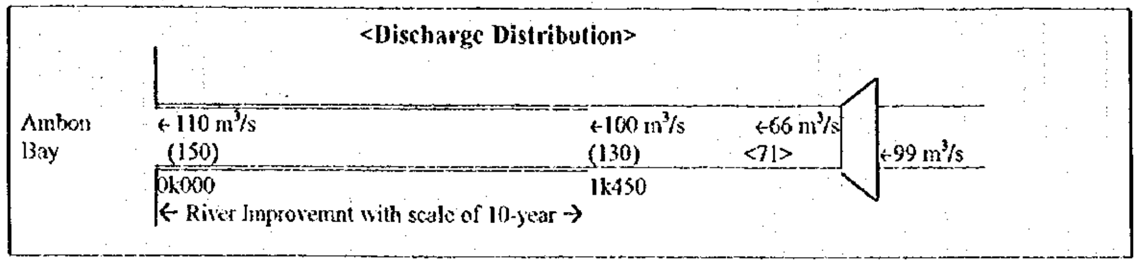


Figure-I.3.18 Optimum Flood Control Plan for Batu Gajah River



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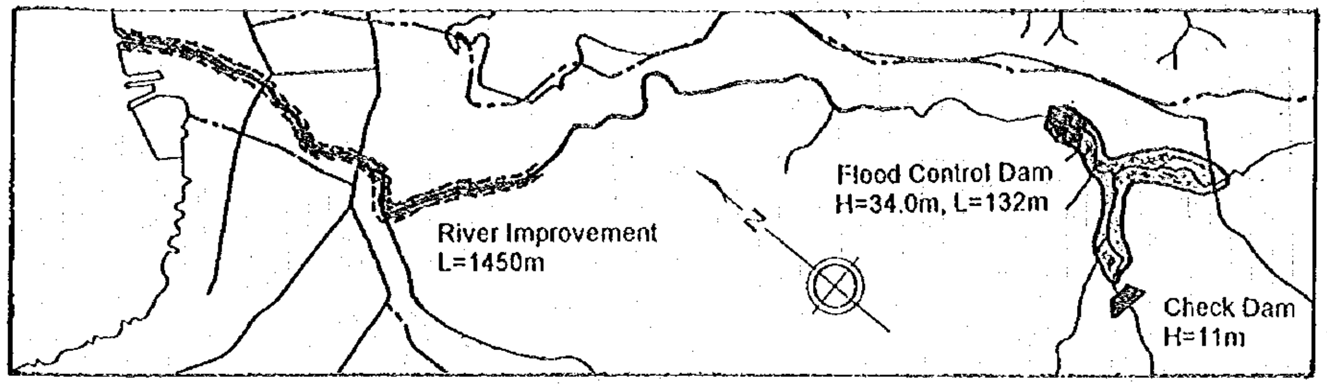
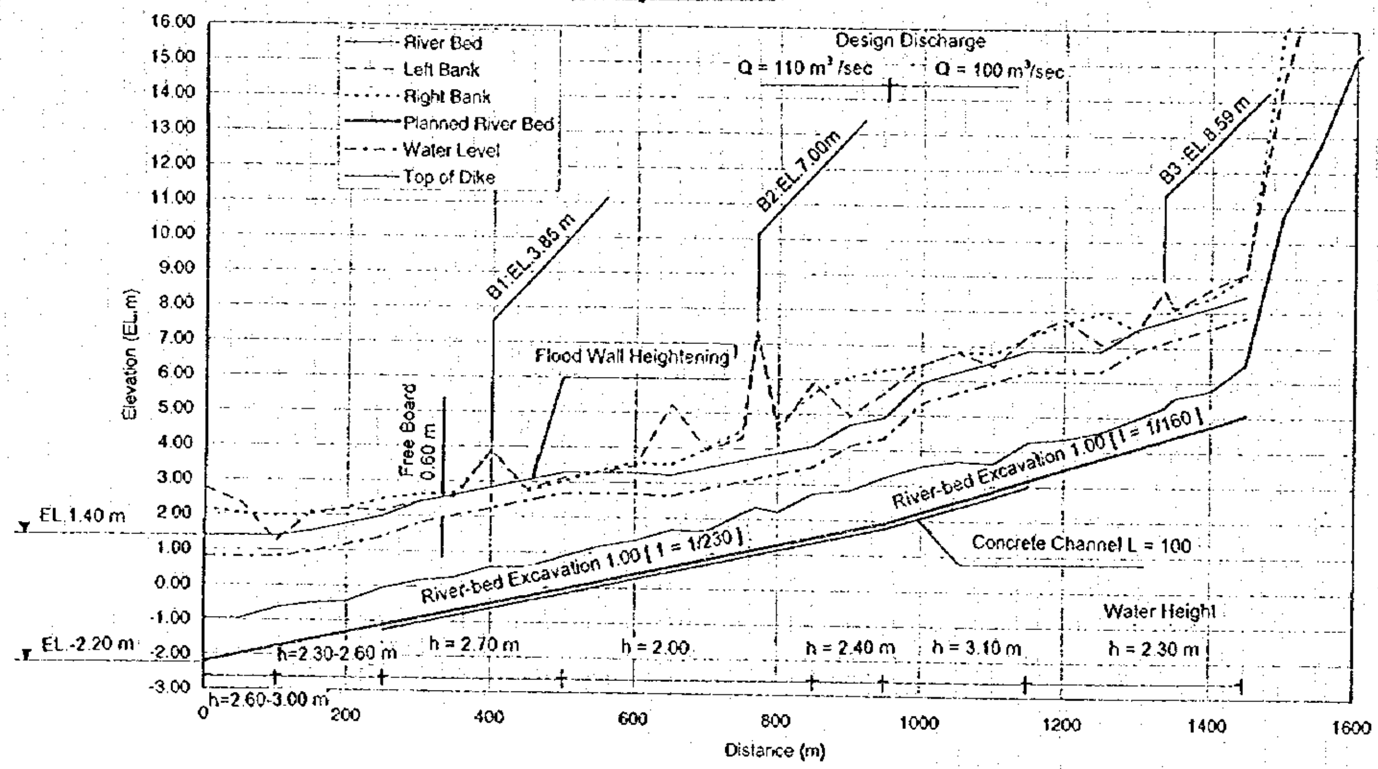
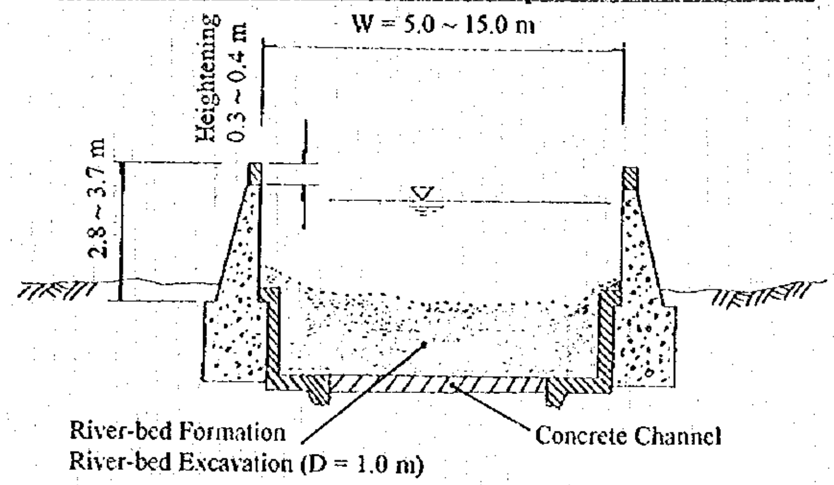


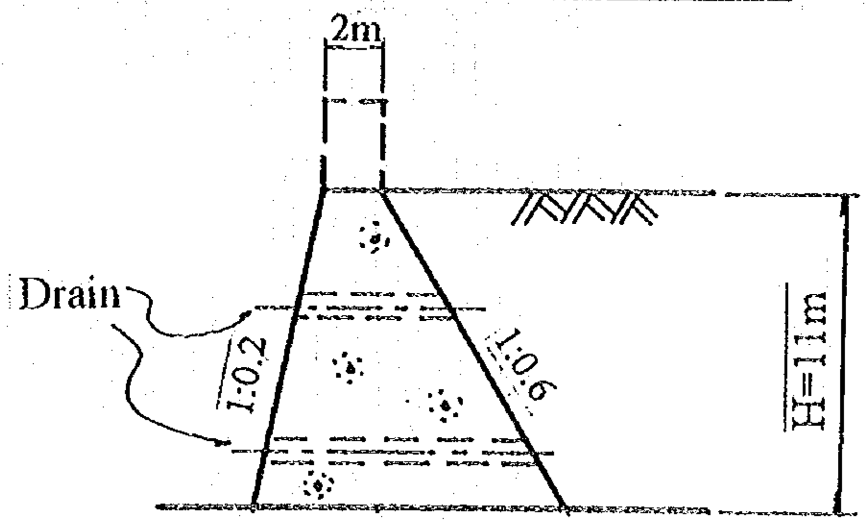
Longitudinal Section of River Improvement



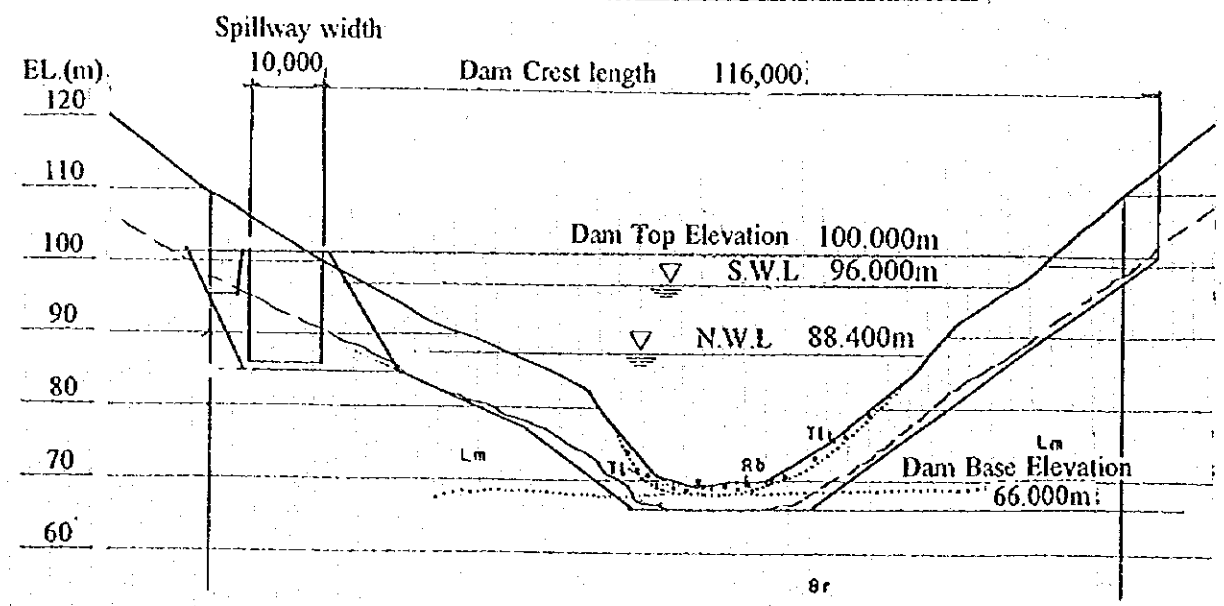
Standard Cross Section of River Improvement S=1:200



Standard Cross Section of Check Dam S=1:250



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



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

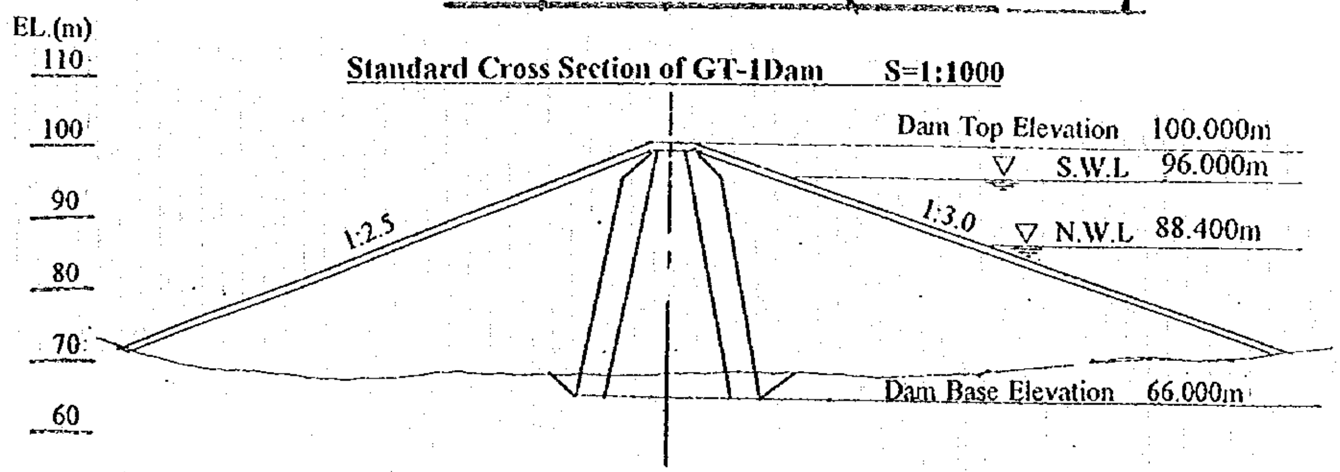


Figure-I.3.19 Optimum Flood Control Plan for Batu Gantung River

3.3 Non-structural Flood Control Measures

3.3.1 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-I.3.22 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-I.3.22 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

3.3.2 Suppression of Flood Runoff

(1) Land Use Regulation

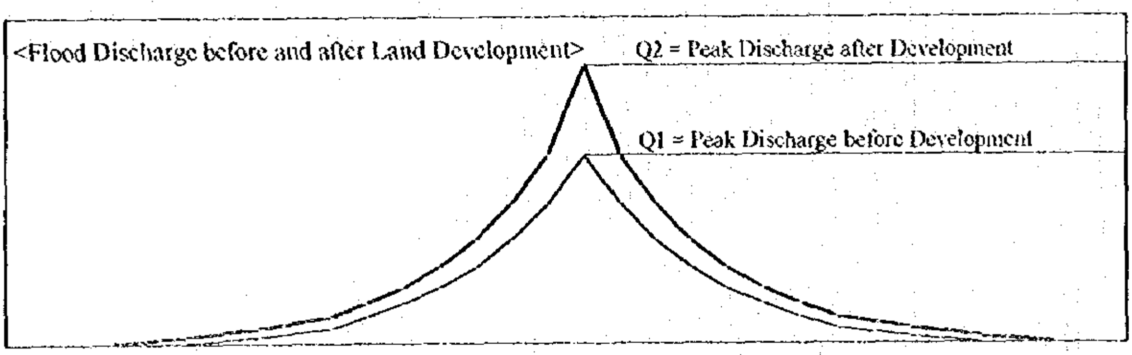
Natural forests and green areas have the advantage of retaining rain water, recharging it into the groundwater reservoir, and decreasing runoff (including sediment runoff) from the areas. To make use of this function, conservation of the existing forests in the upstream areas is important. Land use restrictions 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-I.3.20. It is recommended that the developer shall construct such reservoirs in accordance with a decree issued by the local government.



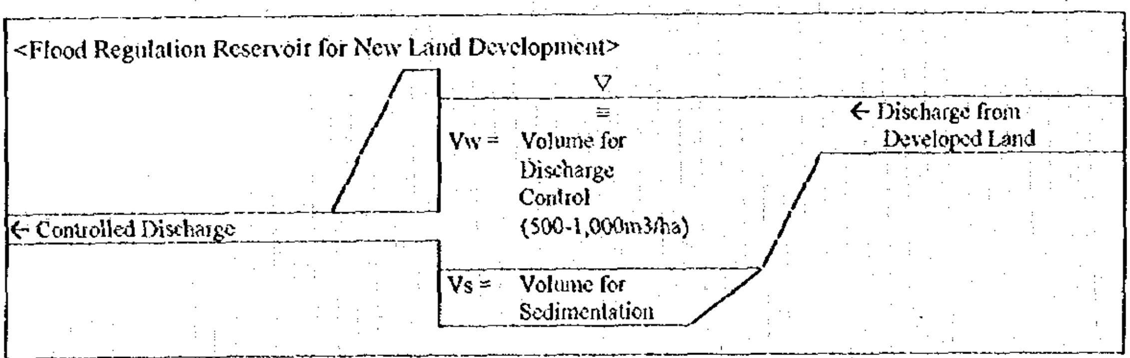


Figure-I.3.20 Off-site Storage System for New Land Development

(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-I.3.21.

- **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.

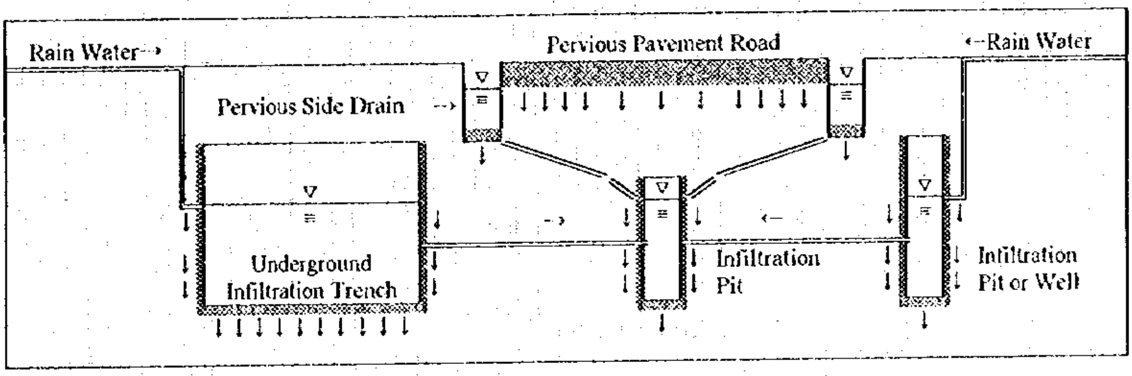


Figure-I.3.21 Infiltration System in Lowland Areas

3.3.3 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-I.3.22. To prevent flood damage, soil erosion and water pollution, this regulation shall be implemented completely.

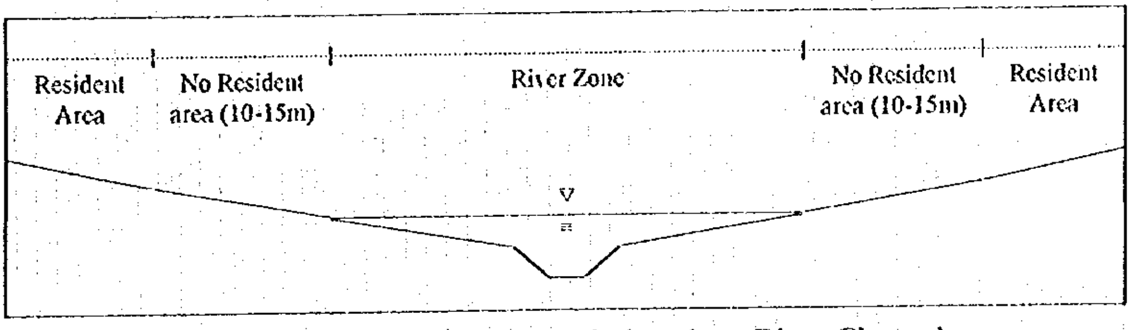


Figure-I.3.22 Land Use Regulation along River Channel

(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-I.3.23, are recommendable. Also, important public facilities shall be independently protected against inundation with protecting walls, gates etc., if necessary.

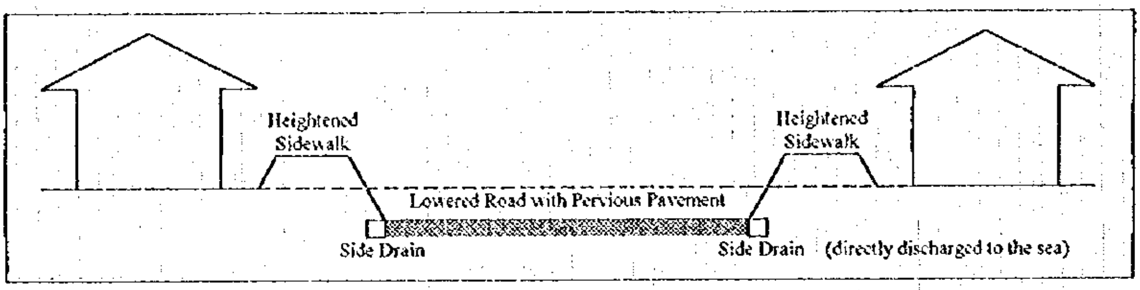


Figure-I.3.23 Flood Proof for Town Street

3.3.4 Facilitation of Flood Disaster Prevention Activities

(1) Management Organization

The management organization is explained in the section "3.6.2 Implementation Organization".

(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-I.3.24. On the other hand, earlier flood information is useful for flood control management and flood fighting. As illustrated in Figure-I.3.25, 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.

(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-I.3.26, illustrates the flood areas of the last biggest flood and the 1/100 year probability flood.

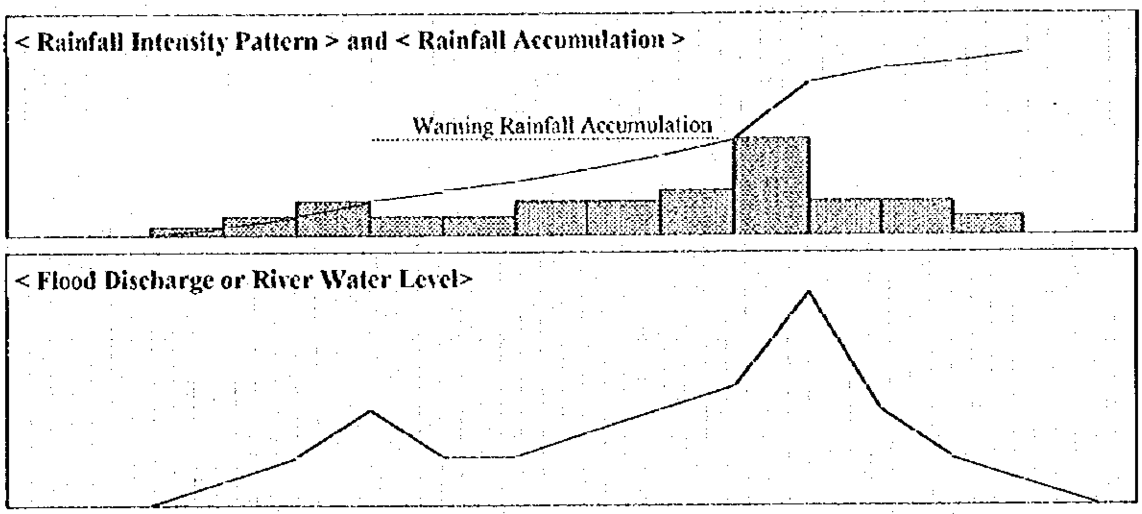


Figure-I.3.24 Rainfall and Runoff Patterns

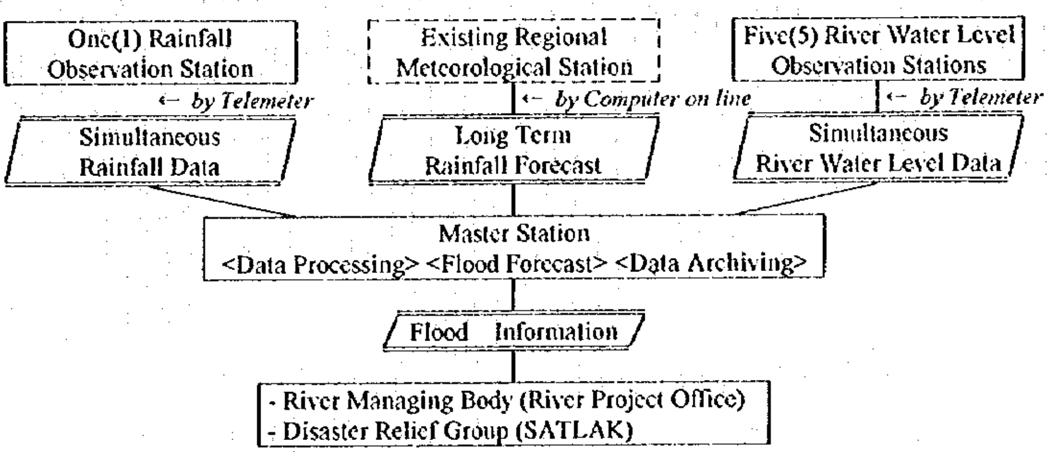


Figure-I.3.25 Transfer System of Flood Information

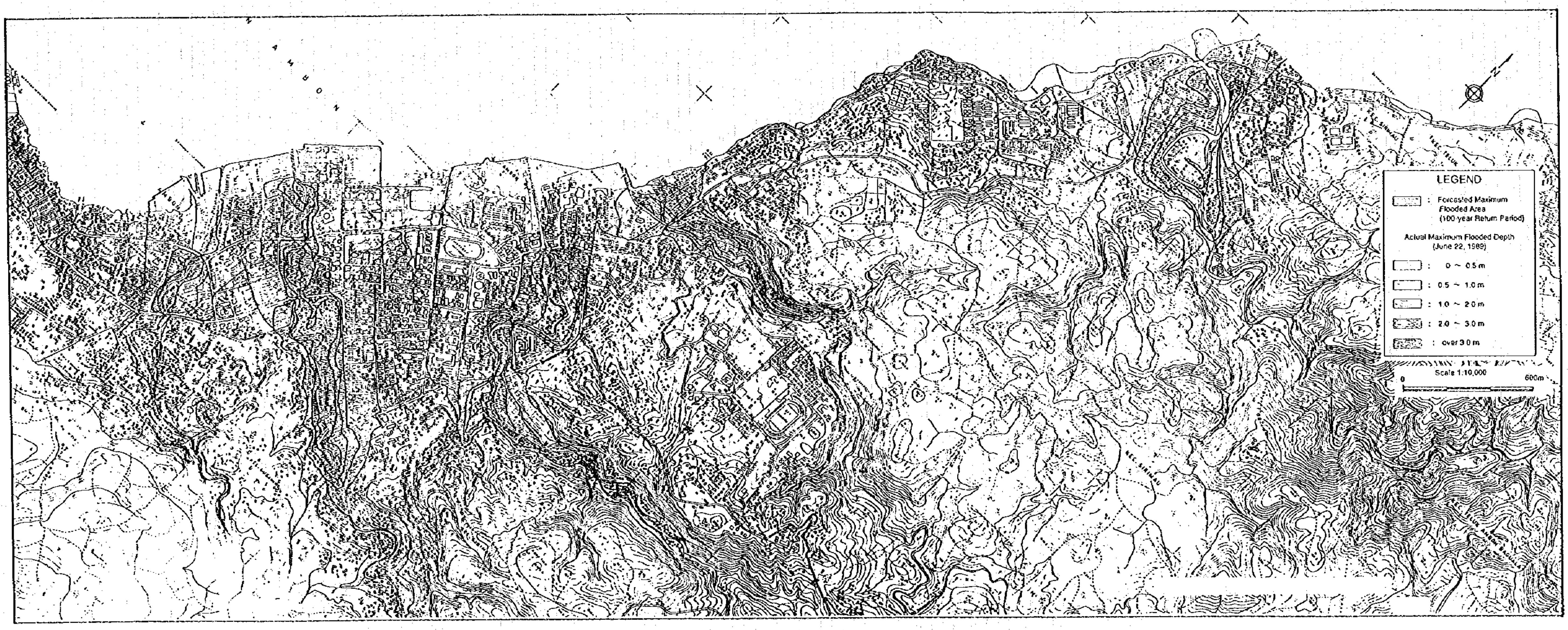


Figure-I.3.26 Flood Risk Map for Ambon Central Area

(4) Flood Fighting System

In Indonesia, the emergency relief system for natural disaster is already well established and functions as shown in Figure-I.3.27 and Figure-I.3.28. In the broad sense, this system is a kind of flood fighting system. However, as shown in Table-I.3.23 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.

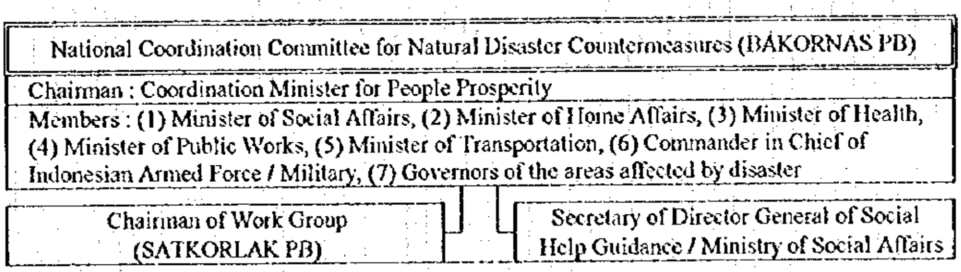


Figure-I.3.27 National Level Organization for Natural Disaster Countermeasures

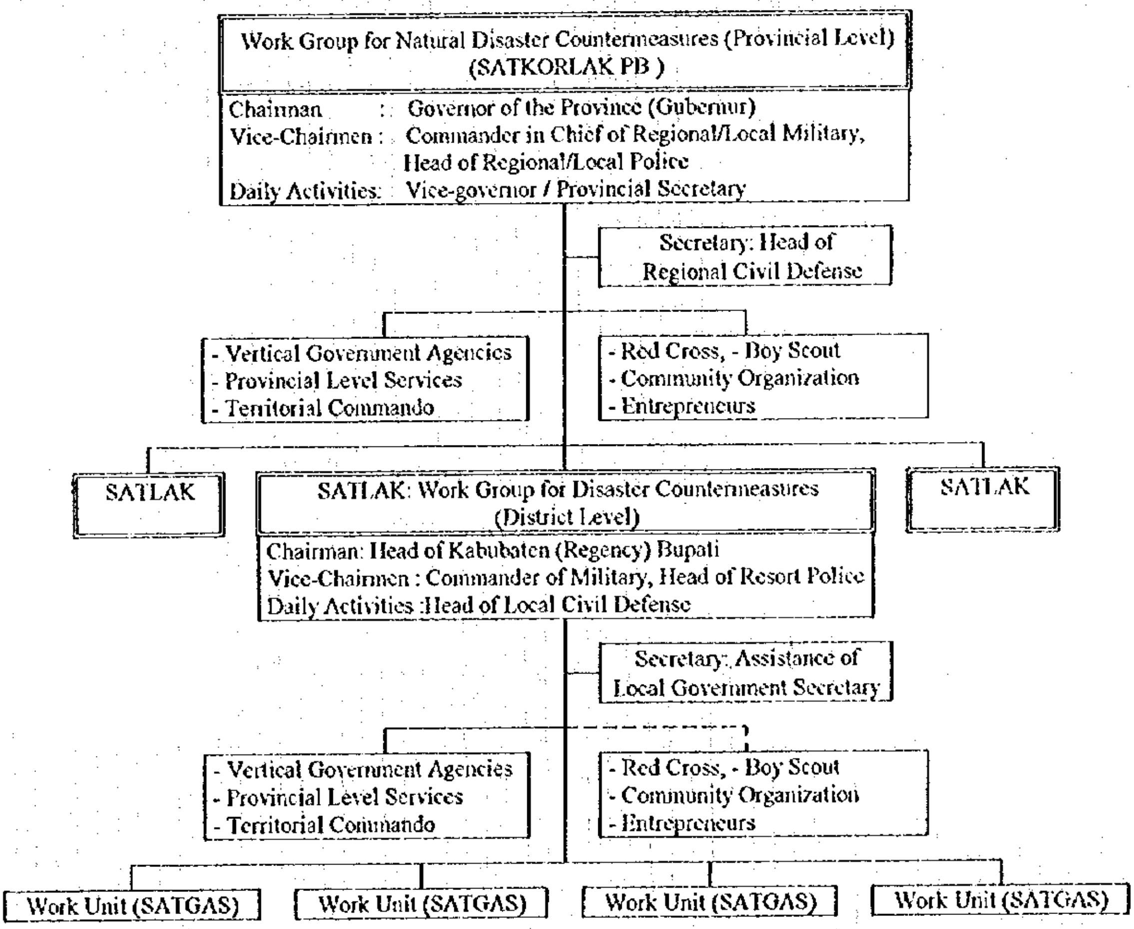


Figure-I.3.28 Local Level Organization for Natural Disaster Countermeasures

Table-I.3.23 Work Units for Disaster Countermeasures of Ambon City

Work Units	Member
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.

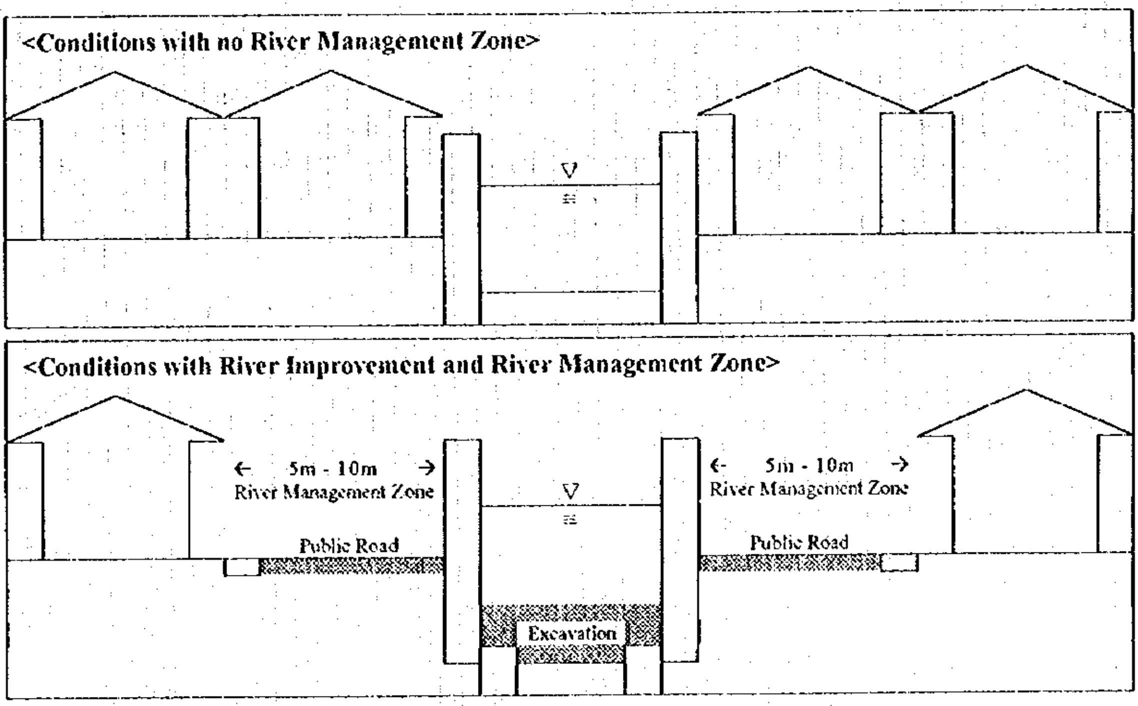


Figure-I.3.29 River Management Zone

(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.

3.4 Water Utilization Plan

3.4.1 Planning Condition

In order to mitigate city water supply shortages in the future, it is proposed to utilize the flood control dams described in the optimum flood control plan in Chapter 3.2 as a source of water supply for Ambon central city area. The proposed dams on Ruhu, Batu Gajah and Batu Gantung rivers, namely RH-1, GJ-2 and GT-1, will therefore be utilized as multi-purpose dams and the water utilization plan is outlined below.

Water from the dam reservoirs will be used to maintain the river discharge at an acceptable level during the dry season for environmental and other purposes (maintenance discharge) and also to supplement other water sources to meet the future water demand in the Ambon Study area (newly developed discharge). The necessary reservoir volume required to meet the shortfall in future supply has been calculated.

It was found that the available discharge from the two dams on Batu Gajah and Batu Gantung rivers will be sufficient to satisfy the future deficit in the medium term (until 2015), assuming that PDAM develop and improve existing water sources as proposed in their Water Supply System Development Plan. The discharge developed by the construction of Dam RH-1 on Ruhu river will satisfy demand in the longer term until beyond 2030.

(1) Compensation Discharge

Compensation discharge is the river discharge necessary to be maintained downstream of a dam in order to ensure the normal function of the river (maintenance discharge) and to provide water to existing water users (water use discharge).

Compensation Discharge = Maintenance Discharge + Water Use Discharge

(a) Maintenance Discharge

The maintenance discharge is the discharge required downstream of a dam to maintain the normal function of the river. This maintenance discharge usually includes the requirements of river transportation, fishing, prevention of salt water intrusion, prevention of estuary sedimentation, maintenance of groundwater levels, preservation of river plants and wildlife, and maintenance or improvement of river water quality. For the five target rivers in Ambon, the problem of river water quality is the most important.

In this water utilization plan, the specific maintenance discharge has been set as 1.0 $m^3/sec/100km^2$ for Ruhu and Batu Gajah rivers, and the maintenance discharge required at each dam site calculated based on the catchment area. For Batu Gantung river, a value of 0.5 $m^3/sec/100km^2$ was used because there is currently no flow in this river during the dry season and therefore such a high level of maintenance discharge is not necessary. The catchment area and maintenance discharge Q_m at the three proposed dam sites and corresponding staff gauges are given in Table-I.3.24.

Table-I.3.24 Maintenance Discharge at Proposed Dam Sites

River & Dam Site	Specific Maint. Discharge $m^3/sec/100km^2$	Dam Site C.A. km^2	Dam Site Qm m^3/sec	Reference Point - Staff Gauge C.A. km^2	Qm m^3/sec	Slope	Depth cm *
Ruhu RH-1	1.0	14.49	0.145	14.91	0.149	1/550	15
Batu Gajah GJ-2	1.0	4.27	0.043	4.92	0.049	1/160	8
Batu Gantung GT-1	0.5	4.76	0.024	5.89	0.024	1/160	5

* assuming 1m channel width

(b) Water Use Discharge

There is currently no water abstraction from the rivers in Ambon for consumptive use. This situation is not expected to change and it is not recommended to commence using river water for consumption. Water developed for domestic and other uses in Ambon city should be abstracted directly from the dam reservoir. However, river water is sometimes used for washing and bathing. Table-I.3.24 shows the water depth calculated at an assumed 1m wide channel at each reference point - this depth is thought to be adequate for use for washing and bathing. Therefore, the maintenance discharge described above is sufficient for water use discharge downstream of the potential dam sites.

(2) Necessity for City Water Development

(a) Future Water Demand

As described in Chapter 1.4, total water demand in Ambon municipality is calculated to increase from the current level of 16,750 m^3/day to around 58,600 m^3/day by the medium term target year of 2015. In the longer term, total demand will increase to nearly 100,000 m^3/day by the year 2030. In the Study area, corresponding to the central Ambon area, demand is expected to increase from 11,200 m^3/day (130 l/sec) to almost 30,600 m^3/day (354 l/sec) by the year 2015, and to 45,470 m^3/day (526 l/sec) by the year 2030. In order to meet these increased demands, it is essential that the responsible agencies take positive action to identify and implement new sources of city water for Ambon city.

(b) Planned Water Resources by PDAM

The regional water supply authority (PDAM) and the government agency responsible for water supply (Cipta Karya) have undertaken studies to identify and plan for future water resources development. Implementation of small projects, including drilling of deep wells and improvements to the water distribution network, has been carried out using government funds but, up to now, less than 30% of Ambon's population is served by piped water supply.

The IBRD (World Bank) funded "Master Plan and Feasibility Study for Ambon Water Supply" completed by the US consultant James M. Montgomery in September 1977 for Cipta Karya identified water resources that needed to be developed in order to meet demand up to the year 2000. In the central city area, improvement and expansion of the existing springs at Air Keluar, Air Besar, Batu Gajah and Wai Nitu and construction of new reservoirs and distribution pipes were recommended. For the longer term, the report proposed the development of a river intake and water treatment plant at Wai Lela to the north of Ambon Bay with a submarine pipeline beneath the bay to bring water to the central city. The report also clearly states that the geology of Ambon can not support the number of deep wells necessary to satisfy water demand because of the risk of saltwater intrusion.

However, during the twenty years since that report, Ambon has done little to develop surface water resources and has, in fact, proceeded to sink deep wells in direct contradiction to the report's recommendations. In a subsequent report as part of the Eastern Islands Urban Development Project, the Water Supply System Development Plan adopted by PDAM includes plans to develop supplies from springs and boreholes to the east and north of Ambon, including Tulehu spring, deep wells at Poka and Rumah Tiga in addition to the proposed abstraction from Wai Lela river. These new water resources will mainly serve the northern and eastern sides of Ambon Bay, including Poka, Rumah Tiga, Paso and Lateri.

In the central Ambon area, according to the PDAM Development Plan, there are plans to sink additional deep wells and to increase production from existing springs and boreholes, as well as to abstract water from a free intake on Air Besar, a tributary in the upper catchment of Ruhu river. However, as outlined above, it is not considered that further development of groundwater is recommendable because of the problems of fluctuating groundwater levels and possible saltwater intrusion.

PDAM is currently undertaking a revised Water Supply Master Plan with the assistance of the Dutch water supply company WMD. This master plan includes future water demand forecasts and shortfalls in supply of a similar scale to those presented in this report. The proposed short term solutions include development of existing resources, including the small river intake on Air Besar and the Wai Pompa and Wai Nitu springs. In the longer term, the developed water from the proposed multi-purpose dams at Ruhu, Batu Gajah and Batu Gantung is included as is the possible free intake at Wai Lela to the north of Ambon Bay. However, it must be noted that no flow measurement or hydrological study has been carried out by PDAM for the proposed intake at Wai Lela. Also, it is understood that the master plan makes no recommendations for funding or implementation of the projects needed, with the exception of initial investment to improve the existing water supply network.

Based on the existing PDAM Water Supply System Development Plan and discussions with PDAM regarding the new water supply master plan, the assumed increase in water resources for the central Ambon area is shown in Table-I.3.25.

(c) Required Newly Developed Discharge

The timescale of the PDAM Development Plan assumes that the above increases can be achieved by the year 2010. Given that initial investment is likely to be provided by the Dutch water supply company, this current Study also assumes that the increases shown in Table-I.3.25 can be achieved by 2010. However, the production capacities quoted above have not been verified but are taken from the PDAM report for planning purposes.

Even if production capacity is increased in line with the PDAM plan, the total supply capacity will not be sufficient to meet the increased demand. It can be seen that there will be a shortfall in supply of nearly 9,500 m^3/day (110 l/sec) in the central Ambon area by the year 2015 and over 24,000 m^3/day (282 l/sec) by the year 2030. In order to satisfy this shortfall, developed water from the proposed multi-purpose dams should be utilized. The following section explains the calculation of the water resources developed by the dams on Ruhu, Batu Gajah and Batu Gantung rivers.

Table-I.3.25 Assumed Water Resources (Central Ambon Area)

No.	Planned Water Source	Location	Source Capacity (l/s)	Production Capacity (l/s) 1995	2000	2005	2010
A	SPRING SOURCES						
1	Wainitu Spring	Wainitu	80	34	40	50	50
2	Air Keluar Spring	u/s Batu Gantung	13	10	13	13	13
3	Batu Gajah Spring	u/s Batu Gajah	18	13	16	16	18
4	Air Besar Spring	u/s Ruhu	18	18	21	21	23
5	Air Panas / Wainiuw Springs	u/s Ruhu	13	10	6	6	8
6	Wai Pompa Spring #	Halong	40	15	20	24	30
	Sub-Total Springs (l/sec)		182	100	116	130	142
			(m^3/d)	8,640	10,020	11,230	12,270
B	DEEP WELL SOURCES						
1	AP / 1	Ambon City	17	17	13	17	17
2	AP / 3	Ambon City			10	10	10
3	AP / 4	Hative Kecil	15	11	10	10	15
4	AP / 4A (Planned 1997)	Hative Kecil			5	5	10
5	AP / 1A	Ambon City		5	5	10	10
6	AP / 1B	Ambon City		5	5	10	10
	Sub-Total Wells (l/sec)		42	38	48	62	72
			(m^3/d)	3,280	4,150	5,360	6,220
C	RIVER WATER SOURCES						
1	Air Besar *	u/s Ruhu			30	30	30
	Sub-Total Rivers (l/sec)				30	30	30
			(m^3/d)		2,600	2,600	2,600
	TOTAL CAPACITY (l/sec)		214	138	194	222	244
			(m^3/d)	11,920	16,770	19,190	21,090

Notes : # Operated by Ambon Municipality (not PDAM)
* Pipeline under construction (PU - Cipta Karya)

3.4.2 City Water Development Plan

(1) Daily Discharge at Dam Sites

The daily discharge at the proposed dam sites on Ruhu and Batu Gajah rivers was calculated from the flow regime compiled using measured daily water level data. As there are only two years of actual data (October 1994 to September 1996), ten years' daily discharge data was generated by applying the 1995/96 data multiplied by the ratio of total annual rainfall for each year to that in 1995/96. Of the two years' available data, the 1995/96 data was chosen as the more extreme case, in that the daily discharge in the dry season was much lower than that for 1994/95, while the flow in the rainy season was considerably higher. Based on the calculated daily discharge data, the lowest flow condition occurred in 1993, with total rainfall equal to approximately two thirds of the ten year mean value. In the case of Ruhu river, the proposed abstraction by PDAM from Air Besar (a tributary of Ruhu) was deducted from the flow data at the start of the calculation.

A similar method was used for Batu Gantung, although there is no available daily discharge data for Batu Gantung river. The Batu Gajah data was used for the rainy season (May to October), increased in proportion to the larger catchment area. However, during the dry season, the base flow in Batu Gantung was taken as zero based on the data collected since installation of the JICA staff gauge.

(2) Developed Discharge and Required Reservoir Capacity

The developed discharge is the discharge available for water use developed by the construction of a dam and reservoir. Using the assumed 1993 daily discharge data, the necessary reservoir capacity for water development was calculated for a range of values of potential developed discharge for Ruhu, Batu Gajah and Batu Gantung dam sites. The variation of reservoir capacity required with increasing developed discharge is given in Figure-I.3.230.

Considering the optimum reservoir size based on hydrological, geological and socio-economic considerations, the developed discharge for city water development from each of the three dams was determined as follows :

Ruhu RH-1	16,000 m^3/day	(0.185 m^3/sec)
Batu Gajah GJ-2	8,000 m^3/day	(0.093 m^3/sec)
Batu Gantung GT-1	2,500 m^3/day	(0.029 m^3/sec)

The reservoir volumes necessary to ensure that maintenance discharge of Q_m = 0.145 m^3/sec for Ruhu Dam RH-1, 0.043 m^3/sec for Batu Gajah Dam GJ-2 and 0.024 m^3/sec for Batu Gantung Dam GT-1 is provided downstream, even under the 10 year drought condition, and newly developed discharge as described above can be attained from each dam, are given in Table-I.3.26.

Table-I.3.26 Required Reservoir Volume for City Water Development

River	Developed Discharge (m^3/sec)			Newly Dev. Q	Required Reservoir Volume (m^3)		
	Maint.	Dev.	Total	m^3/day	Maint.	Newly Dev.	Total
Ruhu RH-1	0.185	0.145	0.330	16,000	115,000	949,000	1,064,000
Batu Gajah GJ-2	0.043	0.093	0.136	8,000	20,000	935,000	955,000
Batu Gantung GT-1	0.024	0.029	0.053	2,500	249,000	390,000	639,000

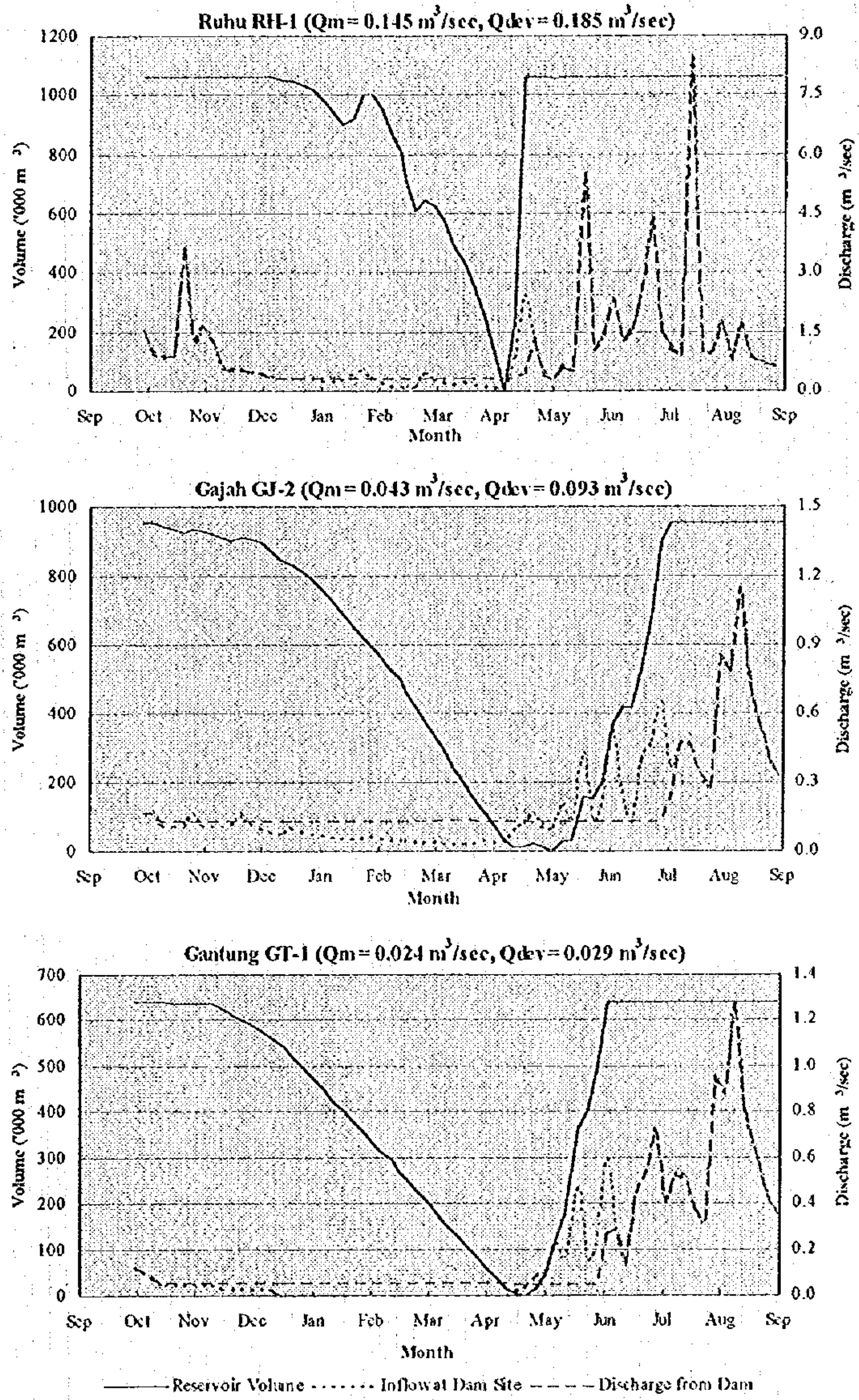


Figure-I.3.30 Variation in Reservoir Volume with Daily Discharge (Dry Year)

(3) City Water Development Plan

In order to meet the shortfall between demand and supply in the years up to 2015 and on to 2030, newly developed discharge of 16,000 m^3/day can be provided from Ruhu RH-1, 8,000 m^3/day from Batu Gajah GJ-2 and 2,500 m^3/day from Batu Gantung GT-1. This will be more than sufficient to satisfy the shortfall assuming that PDAM improve and develop other water sources in accordance with the Water Supply Systems Development Plan.

Developed discharge from the multi-purpose dams, constructed in accordance with the proposed implementation schedule, has been incorporated in the city water development plan, as shown in the following Table-I.3.27 and Figure-I.3.31. It is strongly recommended that PDAM adopt this city water development plan and suggested implementation schedule in order to seek funding as part of an integrated flood control and water resource development project.

Table-I.3.27 City Water Development Plan - Ambon Central Area

Year		1996	2000	2005	2010	2015	2020	2025	2030
Future Demand (m^3/day)		11,211	15,594	20,163	26,665	30,559	36,001	40,603	45,470
Springs		8,640	10,020	11,230	12,270	12,270	12,270	12,270	12,270
Wells		3,280	4,150	5,360	6,220	6,220	6,220	6,220	6,220
Rivers :	Air Besar		2,600	2,600	2,600	2,600	2,600	2,600	2,600
	Gajah GJ-2				8,000	8,000	8,000	8,000	8,000
	Gantung GT-1				2,500	2,500	2,500	2,500	2,500
	Ruhu RH-1					16,000	16,000	16,000	16,000
Total Supply (m^3/day)		11,920	16,770	19,190	31,590	47,590	47,590	47,590	47,590

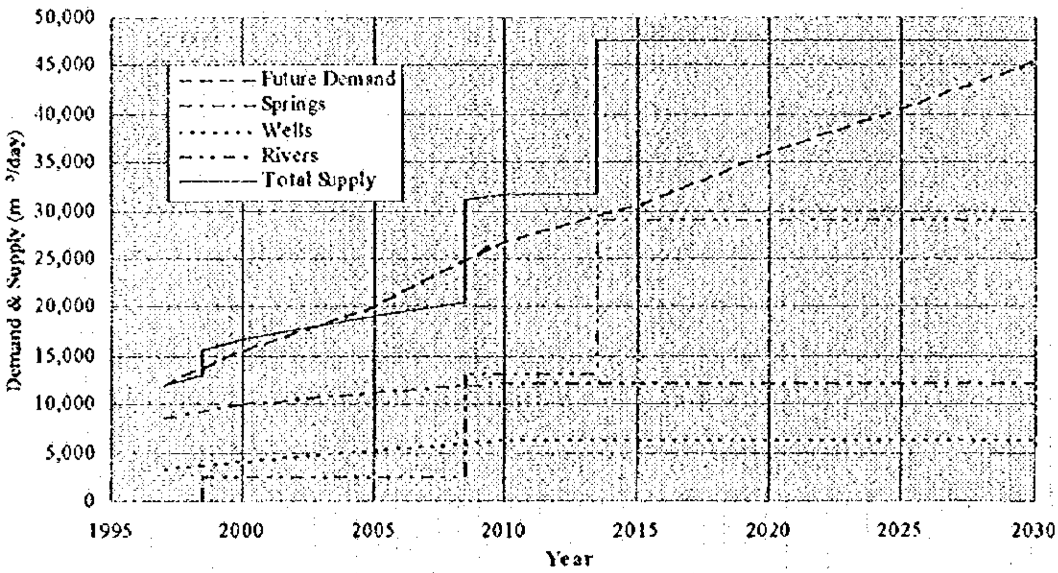


Figure-I.3.31 City Water Development Plan - Ambon Central Area

3.4.3 Small Scale Hydropower Generation

(1) Basic Policy

Small scale hydropower generation was studied for Batu Gajah and Batu Gantung dams based on dam outflow discharge and reservoir water level. Reservoir type should be applied as hydropower generation type, although reservoir volume specifically for hydropower purposes was not considered.

(2) Basic Condition

Basic condition of hydropower for Batu Gajah and Batu Gantung dams is shown in Table-I.3.28. Suitable type of hydropower turbine was selected, based on maximum utilization discharge and available water head. From this point of view, it is concluded that Crossflow type turbine is suitable for Batu Gajah Dam. However, no suitable turbine is available for Batu Gantung Dam because both the total water head and discharge are too small. It was therefore decided that small scale hydropower generation plan would be studied for Batu Gajah Dam, but not for Batu Gantung Dam.

Table-I.3.28 Basic Condition for Hydropower Generation Plan

Item	Batu Gajah Dam	Batu Gantung Dam
Reservoir Water Level	EL.65.6 m - 51.6 m	EL.96.7 m - 85.9 m
Down Stream River Level	EL.30.2 m	EL.74.3 m
Total Water Head	35.4 m - 21.4 m	22.4 - 11.6 m
Range of Utilization Discharge (m^3/sec)	0.13 - (0.25 - 0.57)	0.05 - (0.09 - 0.30)
Suitable Type of Hydro Turbine	Crossflow Turbine Type	Not Available

(3) Hydropower Production and Economic Evaluation for Batu Gajah Dam

Five study cases of hydropower generation were studied, considering the range of maximum utilization discharge. Calculation results of hydropower production are shown in the following Table-I.3.29. As the table indicates, maximum hydropower corresponds to maximum utilization discharge, but annual hydropower production has a peak at 0.5 m^3/s of maximum utilization discharge. Approximate costs of hydropower station in Batu Gajah Dam are also shown in Table-I.3.29. As the prime production cost of hydropower is almost the same as the existing cost of diesel generated electricity, it was decided that small scale hydropower generation would not be included in the proposed priority project. However, small scale hydropower generation could be considered in detail again in the future.

Table-I.3.29 Approximate Cost of Hydropower Station [Batu Gajah Dam]

Item	Unit	Study Case				
		1	2	3	4	5
Maximum Utilization Discharge	m^3/sec	0.2	0.3	0.4	0.5	0.6
Maximum Hydropower [Pmax]	kW	37	53	62	68	70
Annual Hydropower Production [A.H.P.]	MWh	305	390	437	462	446
Total Construction Cost	Mil.Rp	1,215	1,484	1,649	1,747	1,811
Specific Cost 1 (Total Cost) / (Pmax)	Mil.Rp/kW	32.8	28.0	26.6	25.7	25.9
Specific Cost 2 (Total Cost) / (A.H.P.)	Rp/kWh	3,984	3,805	3,774	3,781	4,061
Prime Production Cost	Rp/kWh	316	302	299	300	322

Note: Construction cost is calculated using relationship between several cost items and maximum hydropower, effective water head, etc. This relationship is based on example of hydropower station in Japan.

3.4.4 Multi-purpose Dam Plan and Cost Estimate

(1) Specification of Multi-purpose Dams

The flood control dams in Ruhu, Batu Gajah and Batu Gantung Rivers were proposed in Section 3.2 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-I.3.30. These plans are adopted for the Master Plan involved with water utilization. The reservoir storage allocations are presented graphically in Figure-I.3.32.

Table-I.3.30 Specification of Multi-purpose Dams and Reservoirs

Items		Ruhu River RH-1 Dam	Batu Gajah River GJ-2 Dam	Batu Gantung River 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
Spillway (Conduit / Overflow)		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

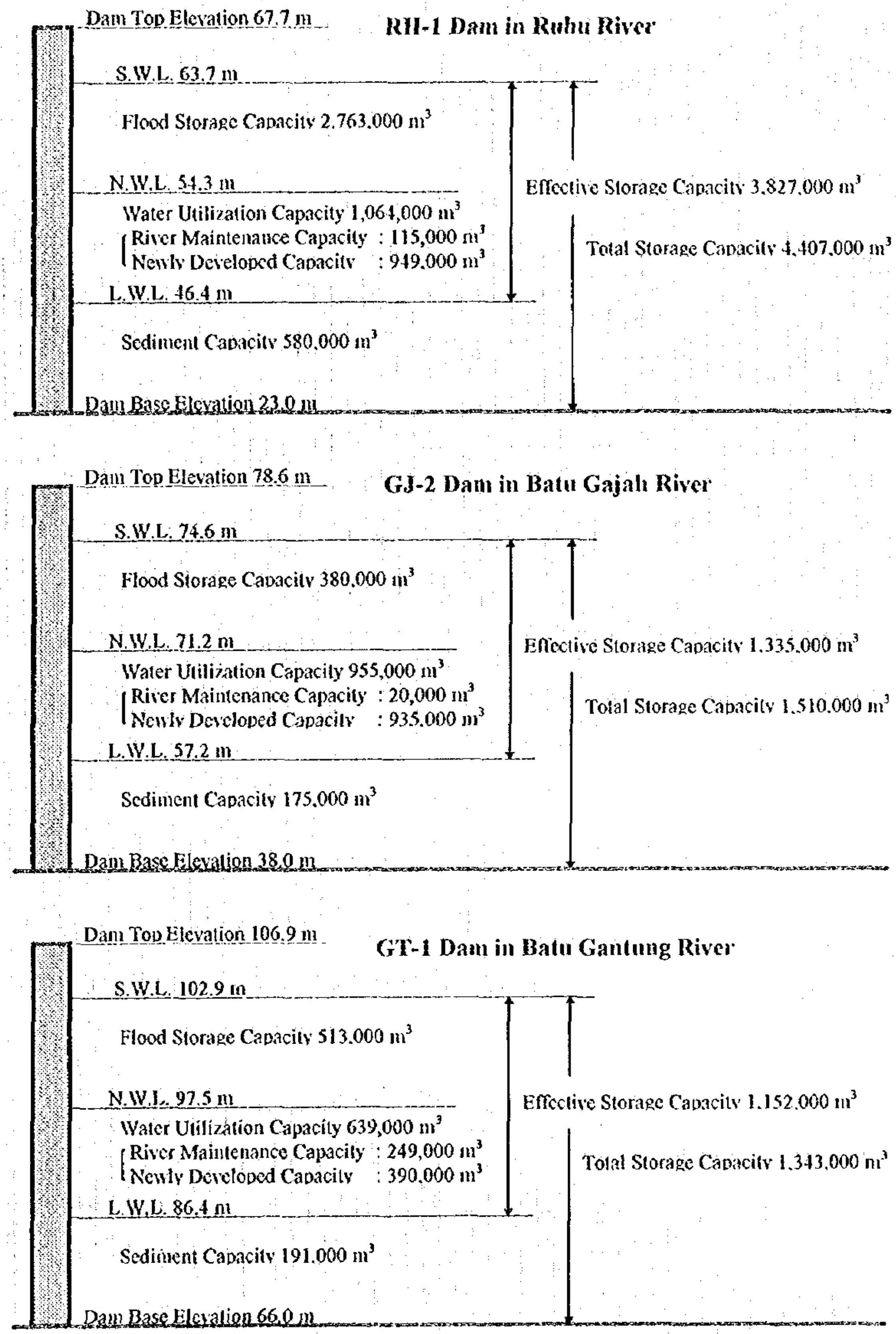


Figure-I.3.32 Reservoir Storage Allocation

(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-I.3.31.

Table-I.3.31 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 Gantung 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

(3) Approximate Cost Estimation of Water Treatment Plant and Pipelines

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-I.3.32.

Table-I.3.32 Cost Estimation of Water Treatment Plant and Pipelines

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

3.5 River Environment Management

3.5.1 Necessity for River Environment Management

(1) Current Condition of River Water Pollution

It is understood from pollution analysis for the five rivers that if all the domestic BOD is discharged into these rivers, it will result in a river water BOD concentration as high as more than 100 mg/l under a condition of low flow which is often considered as the condition for sewerage system design. The river water BOD corresponding to the flow rate measured in the dry season is also calculated. It ranges from about 40 to 170 mg/l except for Batu Gantung River where the flow rate was too low for a reliable flow measurement result to be acquired.

The self-purification factor is also estimated. Since all these rivers flow through a very short distance before entering the sea, no more than 10% BOD removal can be achieved by self-purification. Besides domestic wastewater, dumping of solid wastes into the river is also a problem resulting in river water pollution.

(2) Necessity for River Environment Management

River environment management generally aims at the following objectives: 1) Biological environment conservation for aquatic flora and fauna; 2) Water resource conservation for its utilization and development; 3) Living environment conservation for people in the river basin.

For the five rivers in the Study Area, they do not provide a suitable environment for aquatic life, since they have the characteristics of urban rivers, i.e. usually low flow but high discharge in the flood season, and flow through the densely populated central city area. At present, there is almost no direct use of river water for industries, agriculture or domestic water supply. Therefore, conservation of the living environment for the people in the river basin should be the main objective. However, after the construction of the multi-purpose dams, water stored in the reservoirs shall be used for water supply. Water resource conservation shall also be required for the reservoirs and their upstream areas.

3.5.2 River Environment Improvement Program

From the result of pollution analysis mentioned above, it is clear that the pollutant load generated from each of the river basin areas has already been at a level to cause serious pollution of river water. Generally speaking, construction of sewerage system should be the most effective measure for a reduction of pollutant load to improve river water quality. However, according to the present condition of socio-economy and the function of the five rivers in the Study Area, it is not considered realistic to recommend sewerage system construction in this flood control master plan. Instead, possible measures are proposed for river environment management in accordance with the objectives of water utilization.

(1) Programs for Dam-Reservoir and Upper Stream Area

For all the multi-purpose dams proposed in the master plan, their reservoirs and upper stream areas can be put into one category with the following objectives of water utilization and river environment management: 1) Purpose of water utilization: source water for water supply; 2) Objective of water quality grade B or higher according to the Government Regulation No. 20/1990. The measures to be taken shall include the following :

- Remove all toilets from the river and promote the use of septic tanks;
- Prevent all sewers from discharging sewage directly into the river or reservoir by building small scale infiltration basins;
- Strengthen garbage collection and prevent any solid waste form being dumped into the river or reservoir;
- Prevent people from washing and bathing in the reservoir area.

Since the dam-reservoir and its upstream area are not so densely populated as the downstream area and most of the residents are farmers, it is expected that water quality can be improved to a level to meet grade B or higher.

(2) Programs for Other Areas

For the areas downstream of the multi-purpose dams and the rivers without dam construction, the objectives of water utilization and river environment management are as follows: 1) Purpose of water utilization: washing and bathing for the residents living by the river; 2) Objective of water quality: free from fecal pollutants, garbage and concentrated discharge of any sewage water. These objectives are set under a consideration that the river water will not be used for any purpose other than washing and bathing as the residents living by the river are currently doing. Since there is no available regulation regarding water quality for this kind of use, and an improvement of river water quality to a level as high as grade A or B is not realistic within the framework of this master plan, a minimum objective of water quality is proposed from a viewpoint of sanitation. Accordingly, the following measures can be recommended:

- Remove all toilets from the river and promote the use of septic tanks;
- Strengthen garbage collection and prevent any solid waste from being dumped into the river;
- Carry out an inspection of all the drainage outlets to the river. At places where large quantities of sewage water are discharged into the river from a business, workshop or office building, installation of wastewater treatment facilities must to be required.

By the above mentioned measures, at least about half of the BOD load can be reduced and significant improvement in river water quality can be expected.

(3) Sanitary Education

For an effective river environment management, sanitary education is indispensable for raising public awareness of the importance of environment protection and water quality improvement. The habit of using rivers as receivers for all kinds of wastes should be completely abandoned, and creation of a comfortable and beautiful environment should become the target of all the residents in the river basin areas. This needs a long term education program for people of all ages and also strong administrative measures such as proposing new regulations including strict penalties for environmental contamination. Sanitary education should be incorporated with the measures mentioned above for water quality improvement.

3.6 Implementation Schedule and Organization

3.6.1 Implementation Schedule

Implementation schedule of the Master Plan is proposed as shown in Table-I.3.33 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.

3.6.2 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-I.3.33.

Following implementation of the project and completion of the flood control measures, the Ambon Flood Control Project Office could be handed over to Dinas PU as a Basin Water Operation Unit (BWOU) or Balai. In accordance with the Ministry of Home Affairs Decree No. 179 of 1996, the Balai is responsible for collection of data, water management and conservation in addition to operation and maintenance of flood control facilities.

(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-I.3.34. 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 Forestry
- National Land Agency (BPN)
- Local Government, Level I & II
- Ministry of Social Affairs
- Ministry of Public Works
- Ministry of Agriculture
- Ministry of Education & Culture
- Head of Sub-district
- Meteorological & Geophysical Agency

Table-I.3.33 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

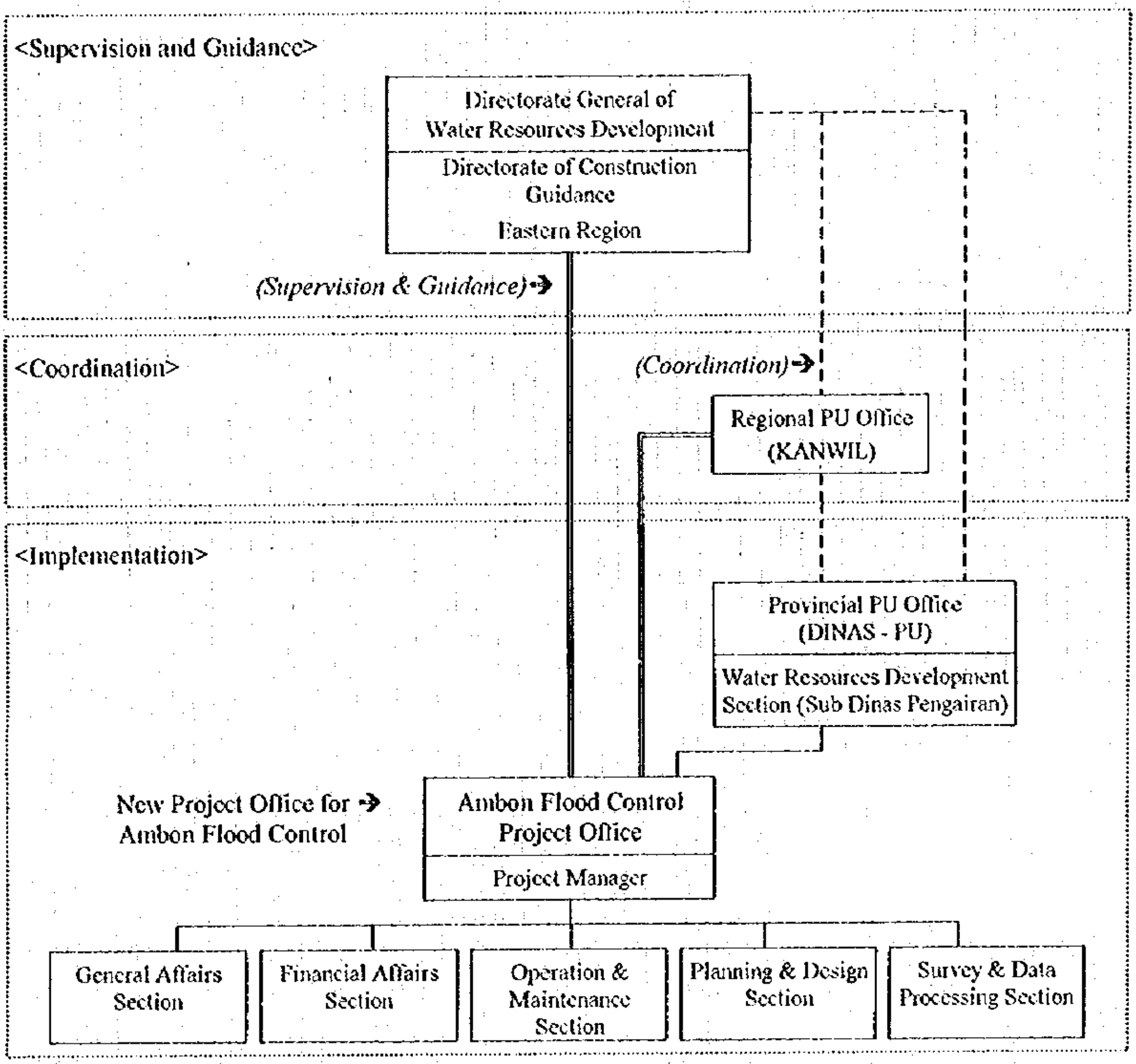


Figure-I.3.33 Organization Structure of Ambon Flood Control Project Office for Structural Measures

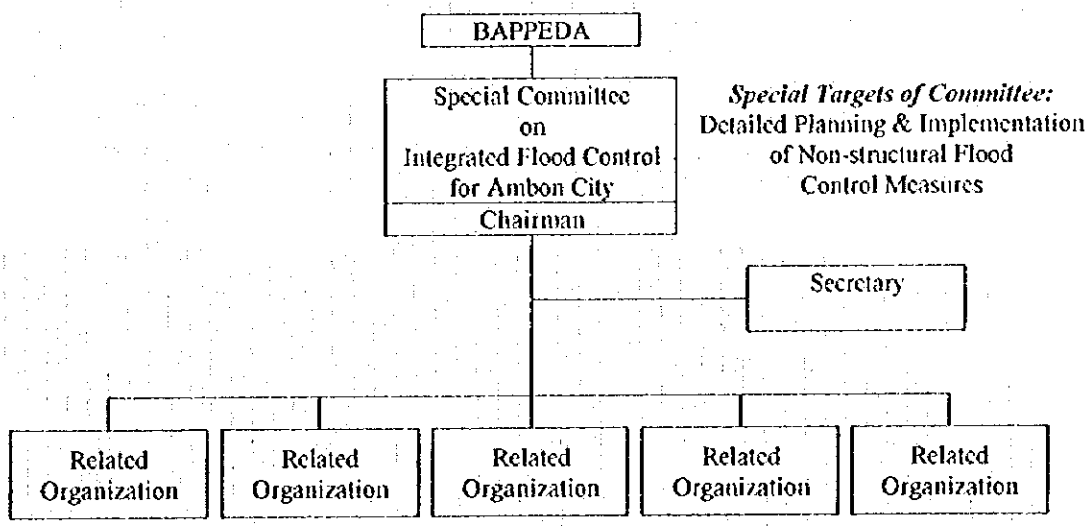


Figure-I.3.34 Organization of Special Committee for Non-structural Measures