even in the worst case where the cost is assumed to increase by 20% and the benefit is assumed to decrease by 20%.

9.9.4 *IMPLICATION OF ECONOMIC EVALUATION*

(1) "Present Status"

It is to be noted that the project benefit to be accrued from the saving of the probable direct damage was computed on the basis of the present (as of end 1994) conditions of the Study Area which is being covered partially by lahar deposit. Therefore, in such an area as Mexico municipality where a wide lahar deposit exists, the probable damage counted in the economic analysis is far less than that to be occurred under the pre-eruption conditions. In other words, there are less probable damage remaining in such a heavily damaged area, which worked to reduce the EIRR of the Project.

(2) Evaluation of the Project

More than half of the total Project benefit is expected from the saving of probable building damages to be occurred in the probable inundation area which includes some urban and lowland areas in Mexico municipality. Some lowland areas in Angeles city are attributed to the said saving of probable building damages as well.

Average Annual Damage for 20-Year Return Period (Pesos million)

Building	Crops & Livestock	Infra-structure	Evacuation Cleanup	Loss of GRDP	Total
58.45	23.66	16.39	9.17	7.70	115.37
(51%)	(21%)	(14%)	(8%)	(7%)	(100%)

The agricultural benefit i.e. the savings of damage of agricultural crops occupies more than 20% of the total Project benefit. Lowland farm lands in Mexico and Santa Ana municipalities are expected to be relieved from floods.

(3) Physical Benefit

The Project benefit was estimated by the saving of probable direct and indirect damages caused by the probable flood and/or lahar with a scale of 20 year-return period. The consequent physical benefit will extend to the following :

1) Population to be relieved from inundation : 20,800 (18% of Study Area)
2) Number of household to be relieved : 4,100 (20%)
3) Land area to be saved from inundation : 29.2 square km (23%)
4) Farm land to be saved : 1,500 ha (15%)

In summing up, the Abacan Project will relieve 20,800 persons of 4,100 households from suffering the inundation and will also save 29 square km of land in which 1,500 ha is a farm land

The road traffic will become possible to maintain the normal order, which is absolutely necessary for economic activities of the region and also for the daily life of an ordinary people. With a security of safety from the natural disasters, investments with a longer time span consideration would become possible. The most valuable benefit of the Project seems to be that many people can be free from the risk of losing their lives though it is not included in the benefit computation.

Table 9.1 Present Condition of Bridges in the Abacan River Basin

Bridge (Station)	Route	Condition after Eruption	Present Condition	Remarks
(1) Friendship (25+300)	City Rd.	Heavy damage for access road and foundation	1) Existing RC channel bridge 2) Construction of the temporary sabo dam for protection of bridge foundation 3) Bridge dimensions, L= 209m (19@11m), W= 8.15m (0.7 + 6.75 + 0.7)	1) No construction of transverse stress 2) Insufficient span length of the existing bridge for the Japanese Structural Standard 3) The existing bridge location is no good for malinfluence of two direction turbulent flow from Sapang Bato River and Taug River.
(2) Hensonville (22+600)	City Rd.	Bridge collapse	1) No access road	1) No restoration plan
(3) Abacan (21+600)	Rt.3	Bridge collapse	1) Reconstruction of PC girder bridge 2) Bridge dimensions, L= 230m (4@40m + 2@35m), W= 18.6m (1.5 + 7.3 + 1.0 + 7.3 + 1.5)	
(4) Pandan (19+900)	Rt.313	Bridge collapse	1) No bridge 2) Detailed design under ADB Loan 3) Future bridge dimensions, L= 120m (3@40m) / W= 9.54m (1.11 + 7.32 +1.11)	1) Designed location is no good because bridge wreckage and existing transmission line will be disturb the construction.
(5) Capaya (17+625)	North Luzon Express-way	Damage for abutment on right bank	1) Existing RC slab bridge 2) Bridge dimensions, L= 210m (14@15m), W= 16.9 m (0.25 + 11.9 + 0.25)	
(6) Ninoy Aquino (7+831)	Rt.3	Buried in riverbed	1) Construction of RC slab bridge 2) Bridge dimensions, L= 210m (8@15m), W= 9.54m (1.11 + 7.4 + 1.11)	1) Unfavorable access road alignment on left bank
(7) Mexico (0+611)	Rt.10	Buried in riverbed	1) Construction of Temporary bailey bridge and existing spillway	1) No restoration plan

Table 9.2 Project Cost for Abacan River Basin

Unit : Pesos

Work Items	Unit	Quantity	F.C. Portion Unit Cost	F.C. Portion Amount	L.C. Portion Unit Cost	L.C. Portion Amount	Total Unit Cost	Total Amount
1. MAIN CONSTRUCTION COST				407,480,335		272,516,835		679,997,170
1.1 Preparatory Works	l.s.			17,716,536		11,848,558		29,565,094
1.2 Main Works				354,330,726		236,971,161		591,301,887
1.2.1 Reconstruction of Sabo Dams				96,738,420		47,048,016		143,786,436
(1) Sabo Dam No.6				6,661,947		5,943,426		12,605,373
1) Steel Wall and Tie Roads	ton	61	31,000	1,891,000	6,040	368,440	37,040	2,259,440
2) Reinforced Concrete	m3	805	2,735	2,201,675	2,969	2,390,045	5,704	4,591,720
3) Plain Concrete	m3	756	1,620	1,224,720	2,482	1,876,392	4,102	3,101,112
4) Gabion Mattress	m3	432	1,210	522,720	597	257,904	1,807	780,624
5) Others	l.s.			821,832		1,050,645		1,872,477
(2) Sabo Dam No.9	l.s.			64,250,769		27,857,532		92,108,301
1) Steel Sheet piling	m	28,020	1,260	35,305,200	144	4,034,880	1,404	39,340,080
2) Reinforced Concrete	m3	4,426	2,735	12,105,110	2,969	13,140,794	5,704	25,245,904
3) Plain Concrete	m3	1,900	1,620	3,078,000	2,482	4,715,800	4,102	7,793,800
4) Gabion Mattress	m3	3,884	1,210	4,699,640	597	2,318,748	1,807	7,018,388
5) Rubble Concrete type Slope Protection	m3	685	2,559	1,752,915	1,968	1,348,080	4,527	3,100,995
6) Others	l.s.			7,309,904		2,299,230		9,609,134
(3) Sabo Dam TM-1	l.s.			25,825,704		13,247,058		39,072,762
1) Steel Sheet piling	m	11,212	1,260	14,127,120	144	1,614,528	1,404	15,741,648
2) Reinforced Concrete	m3	592	2,735	1,619,120	2,969	1,757,648	5,704	3,376,768
3) Plain Concrete	m3	3,213	1,620	5,205,060	2,482	7,974,666	4,102	13,179,726
4) Gabion Mattress	m3	2,150	432	928,800	597	1,283,550	1,029	2,212,350
5) Others	l.s.			3,945,604		616,666		4,562,270
1.2.2 Bank Erosion Protection Works in Upper Reaches				48,746,553		30,254,827		79,001,380
(1) Gabion Type Slope Protection	m	3,000	13,429	40,285,500	8,062	24,186,600	21,491	64,472,100
(2) Rubble Concrete Type Slope Protection	m	1,510	5,603	8,461,053	4,019	6,068,227	9,622	14,529,280
1.2.3 Training Works in Angeles City	m	7,900	13,512	106,741,184	10,111	79,878,352	23,623	186,619,536
1.2.4 Slope Protection in Lower/Middle Reach	m	12,600	5,258	66,251,700	3,861	48,642,900	9,119	114,894,600
1.2.5 Dike Reinforcement Works	m	18,400	935	17,201,000	905	16,660,800	1,840	33,861,800
1.2.6 Hensonville Bridge Works	m2	1,049	17,780	18,651,869	13,810	14,486,266	31,590	33,138,135
1.3 Miscellaneous Works	l.s.			35,433,073		23,697,116		59,130,189
2. LAND ACQUISITION (Spoil Bank)	ha	100	0	0	75,000	7,500,000	75,000	7,500,000
3. ADMINISTRATION COST				0		34,374,859		34,374,859
4. ENGINEERING SERVICE COST				61,199,745		6,799,972		67,999,717
5. PHYSICAL CONTINGENCY				46,868,008		28,681,681		75,549,689
Total				515,548,088		349,873,346		865,421,434
6. PRICE CONTINGENCY				39,138,000		100,495,000		139,633,000
Ground Total				554,686,088		450,368,346		1,005,054,434
7. MAINTENANCE WORKS (Desilting Works from 1996 to 1999) (Excluding price escalation)	m3	2,000,000			60	120,000,000	60	120,000,000

Note:
- (1) Preparatory Works : 5% of Main Works
- (2) Miscellaneous Works : 10% of Main Works
- (3) Administration Cost : 5% of 1. and 2.
- (4) Engineering service Cost : 10% of 1.
- (5) Physical Contingency : 10% of 1., 2., and 4.
- (6) Price Contingency : 2.5% for Foreign Portion and 8.7% for Local Portion
- (7) Exchange Rate : US$ 1.00 = 100 Yen = 25 Pesos

Table 9.3 Annual Disbursement Schedule for Abacan River Basin

(Unit : 1,000 pesos)

Work Items	Total			1996			1997			1998			1999		
	F.C.	L.C.	Total	F.C.	L.C.	Total	F.C.	L.C.	Total	F.C.	L.C.	Total	F.C.	L.C.	Total
1. MAIN CONSTRUCTION COST	407,481	272,516	679,996	23,993	18,775	42,768	59,954	39,932	99,886	188,879	119,975	308,854	134,655	93,834	228,488
1.1 Preparatory Works	17,717	11,849	29,565	1,043	816	1,859	2,607	1,736	4,343	8,212	5,216	13,428	5,855	4,080	9,934
1.2 Main Works	354,331	236,970	591,301	20,863	16,326	37,189	52,134	34,724	86,857	164,243	104,326	268,569	117,091	81,595	198,686
1.2.1 Reconstruction of Sabo Dams	96,739	47,047	143,786	0	0	0	16,063	6,964	23,027	56,310	25,690	82,001	24,366	14,393	38,759
(1) Sabo Dam No.6	6,662	5,943	12,605	0	0	0	0	0	0	1,666	1,486	3,151	4,997	4,457	9,454
(2) Sabo Dam No.9	64,251	27,857	92,108	0	0	0	16,063	6,964	23,027	48,188	20,893	69,081	0	0	0
(3) Sabo Dam TM-1	25,826	13,247	39,073	0	0	0	0	0	0	6,457	3,312	9,768	19,370	9,935	29,305
1.2.2 Bank Protection Works in Upper Reach	48,746	30,255	79,001	0	0	0	0	0	0	24,373	15,128	39,501	24,373	15,128	39,501
(1) Gabion type Slope Protection	40,285	24,187	64,472	0	0	0	0	0	0	20,143	12,094	32,236	20,143	12,094	32,236
(2) Rubble Conc. type Slope Prot.	8,461	6,068	14,529	0	0	0	0	0	0	4,231	3,034	7,265	4,231	3,034	7,265
1.2.3 Training Works in Angeles City	106,741	79,878	186,619	0	0	0	13,343	9,985	23,327	53,371	39,939	93,310	40,028	29,954	69,982
1.2.4 Slope Protection in Lower Reach	66,252	48,643	114,895	16,563	12,161	28,724	16,563	12,161	28,724	16,563	12,161	28,724	16,563	12,161	28,724
1.2.5 Dike Reinforcement Works	17,201	16,661	33,862	4,300	4,165	8,466	4,300	4,165	8,466	4,300	4,165	8,466	4,300	4,165	8,466
1.2.6 Hensonville Bridge Works	18,652	14,486	33,138	0	0	0	1,865	1,449	3,314	9,326	7,243	16,569	7,461	5,794	13,255
1.3 Miscellaneous Works	35,433	23,697	59,130	2,086	1,633	3,719	5,213	3,472	8,686	16,424	10,433	26,857	11,709	8,159	19,869
2. LAND ACQUISITION	0	7,500	7,500	0	7,500	7,500	0	0	0	0	0	0	0	0	0
3. ADMINISTRATION COST	0	34,375	34,375	0	2,513	2,513	0	4,994	4,994	0	15,443	15,443	0	11,424	11,424
4. ENGINEERING SERVICE COST	61,200	6,800	68,000	24,480	2,720	27,200	12,240	1,360	13,600	12,240	1,360	13,600	12,240	1,360	13,600
5. PHYSICAL CONTINGENCY	46,868	28,682	75,550	4,847	2,899	7,747	7,219	4,129	11,349	20,112	12,133	32,245	14,689	9,519	24,209
Total	515,549	349,872	865,421	53,320	34,408	87,728	79,413	50,416	129,829	221,231	148,911	370,142	161,584	116,138	277,722
6. PRICE CONTINGENCY	39,138	100,495	139,634	1,333	2,993	4,326	4,020	9,154	13,174	17,011	42,345	59,356	16,775	46,003	62,777
Ground Total	554,687	450,368	1,005,055	54,653	37,401	92,054	83,434	59,570	143,003	238,242	191,256	429,498	178,359	162,140	340,499
7. MAINTENANCE WORKS(Desilting Works) (Excluding price escalation)		120,000	120,000		30,000	30,000		30,000	30,000		30,000	30,000		30,000	30,000

Note:

(1) Preparatory Works = 5% of Main Works
(2) Miscellaneous Works = 10% of Main Works
(3) Administration Cost = 5% of 1. and 2.
(4) Engineering Service Cost = 10% of 1.
(5) Physical Contingency = 10% of 1., 2. and 4.
(6) Price Contingency = 2.5% for Foreign Portion and 8.7% for Local Portion
(7) Exchange Rate : US$ 1.00 = 100 Yen = 25 Pesos

Table 9.4 Probable Flood Damage for each Return Period

Unit : Pesos 10^3

	Buildings	Crops & Livestock	Infrastructure	Total
Value of Assets	880,645	127,610	267,403	1,275,658
Return Period				
2 years	60,587	25,729	17,759	104,076
5	67,125	28,505	18,763	114,393
10	83,414	27,815	21,382	132,611
20	108,345	30,071	25,195	163,611
50	168,873	33,695	33,675	236,242
100	233,827	38,165	32,726	304,718

Table 9.5 Estimated Average Annual Damage under without-Project Conditions

(A) Return Period	(B) Average Annual Probability of Exceedance for Return Period	(C) Events within Intervals	(D) Flood Damage up to Indicated Return Period (Pesos 10^6)	(E) Average Flood Damage (Pesos 10^6)	(F) Flood Damage within Intervals (Pesos 10^6)	(G) Average Annual Flood Damage up to Indicated Return Period (Pesos 10^6)
2	0.5		104.08			0.00
		0.3		160.20	48.06	
5	0.2		216.33			48.06
		0.1		282.63	28.26	
10	0.1		348.94			76.32
		0.05		430.75	21.54	
20	0.05		512.55			97.86
		0.03		630.67	18.92	
50	0.02		749.79			116.78
		0.01		901.15	9.01	
100	0.01		1053.51			125.79

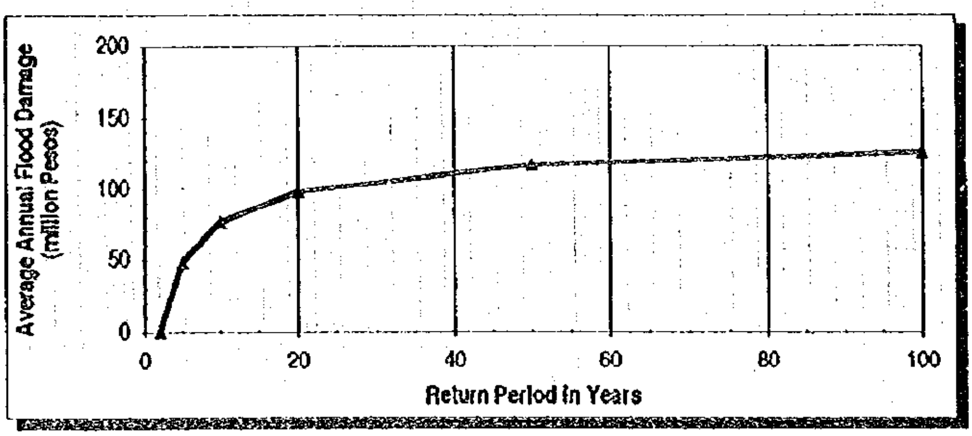


Table 9.6 Probable Indirect Damage by Flood Return Period

Unit: Pesos million

Flood Return Period	Evacuation & Clean-up Costs	Loss of GRDP	Total
2 years	10.30	8.64	18.94
5	10.52	8.83	19.35
10	10.72	9.03	19.75
20	12.45	10.45	22.90
50	14.99	12.58	27.57
100	23.22	19.49	42.71

Table 9.7 Average Annual Indirect Damage in Abacan River Basin

(A) Return Period	(B) Average Annual Probability of Exceedance for Return Period	(C) Events within Intervals	(D) Evacuation and Clean-up Costs up to Indicated Return Period (Pesos 10^6)	(E) Estimated Loss of GRDP up to indicated Return Period (Pesos 10^6)	(F) Average Value (Pesos 10^6)	(G) Average Value within Intervals (Pesos 10^6)	(H) Average Annual Value up to Indicated Return Period (Pesos 10^6)
2	0.5		10.30	8.64			0.00
		0.3			44.18	13.25	
5	0.2		20.82	17.47			13.25
		0.1			74.35	7.43	
10	0.1		31.54	26.50			20.69
		0.05			107.26	5.36	
20	0.05		43.99	36.95			26.05
		0.03			146.21	4.39	
50	0.02		58.98	49.53			30.44
		0.01			200.46	2.00	
100	0.01		82.20	69.02			32.44

Table 9.8 Cost-benefit Analysis of Abacan Flood/Mudflow Control Project

Unit : Pesos million

No	Year	Economic Cost		Cost Total	Benefit		Benefit Total	B - C
		Capital	O & M		Flood Control	Indirect Damage		
1	1995	73.04	23.99	97.03	0.00	0.00	0.00	-97.03
2	1997	115.90	24.18	140.08	0.00	0.00	0.00	-140.08
3	1998	328.81	24.62	353.43	0.00	0.00	0.00	-353.43
4	1999	245.46	25.98	271.44	0.00	0.00	0.00	-271.44
5	2000		3.00	3.00	157.29	30.51	187.80	184.80
6	2001		3.00	3.00	170.23	32.00	202.23	199.23
7	2002		3.00	3.00	184.24	33.57	217.61	214.61
8	2003		3.00	3.00	199.40	35.21	234.61	231.61
9	2004		3.00	3.00	215.82	36.93	252.75	249.75
10	2005		3.00	3.00	233.58	38.74	272.31	269.31
11	2006		3.00	3.00	252.80	40.63	293.43	290.43
12	2007		3.00	3.00	273.61	42.62	316.22	313.22
13	2008		3.00	3.00	296.12	44.70	340.83	337.83
14	2009		3.00	3.00	320.49	46.89	367.38	364.38
15	2010		3.00	3.00	346.87	49.18	396.05	393.05
16	2011		3.00	3.00	375.42	51.59	427.01	424.01
17	2012		3.00	3.00	406.32	54.11	460.43	457.43
18	2013		3.00	3.00	439.75	56.76	496.51	493.51
19	2014		3.00	3.00	475.95	59.53	535.48	532.48
20	2015		3.00	3.00	515.12	62.44	577.56	574.56
21	2016		3.00	3.00	557.51	65.50	623.01	620.01
22	2017		3.00	3.00	603.39	68.70	672.09	669.09
23	2018		3.00	3.00	653.05	72.06	725.11	722.11
24	2019		3.00	3.00	706.80	75.58	782.38	779.38
25	2020		3.00	3.00	764.97	79.28	844.25	841.25
26	2021		3.00	3.00	827.93	83.15	911.08	908.08
27	2022		3.00	3.00	896.07	87.22	983.29	980.29
28	2023		3.00	3.00	969.81	91.49	1061.30	1058.30
29	2024		3.00	3.00	1049.63	95.96	1145.59	1142.59
30	2025		3.00	3.00	1136.01	100.65	1236.66	1233.66
		548	90	637	1563	223	1786	1149
					(87.5%)	(12.5%)	(100)	
							EIRR=	24.05%
							NPV(12%)=	1149

Table 9.9 Sensitivity Analysis of Abacan Flood/Mudflow Control Project

(%)

Benefit / Cost	-20%	-10%	Normal	+10%	+20%
-20%	24.05	25.90	27.67	29.38	31.02
-10%	22.31	24.05	25.70	27.29	28.82
Normal	20.86	22.49	24.05	25.54	26.97
+10%	19.62	21.16	22.64	24.05	25.40
+20%	18.53	20.01	21.41	22.76	24.05

Table 9.10 Analysis of Economic Benefit in Abacan River System

Probable Flood Damage for each Flood Return Period in Abacan River Basin

	Buildings	Crops & Livestock	Infrastructure	Evacuation & Cleanup Cost	Loss of GRDP	Total
Return Period						
2 years	60,587	25,729	17,759	10,300	6,640	121,016
5	67,125	28,505	18,763	10,520	8,830	133,743
10	83,414	27,815	21,382	10,720	9,030	152,361
20	108,345	30,071	25,195	12,450	10,450	186,511
50	168,873	33,695	33,875	14,990	12,580	263,912
100	233,827	38,165	32,728	23,220	19,490	347,428

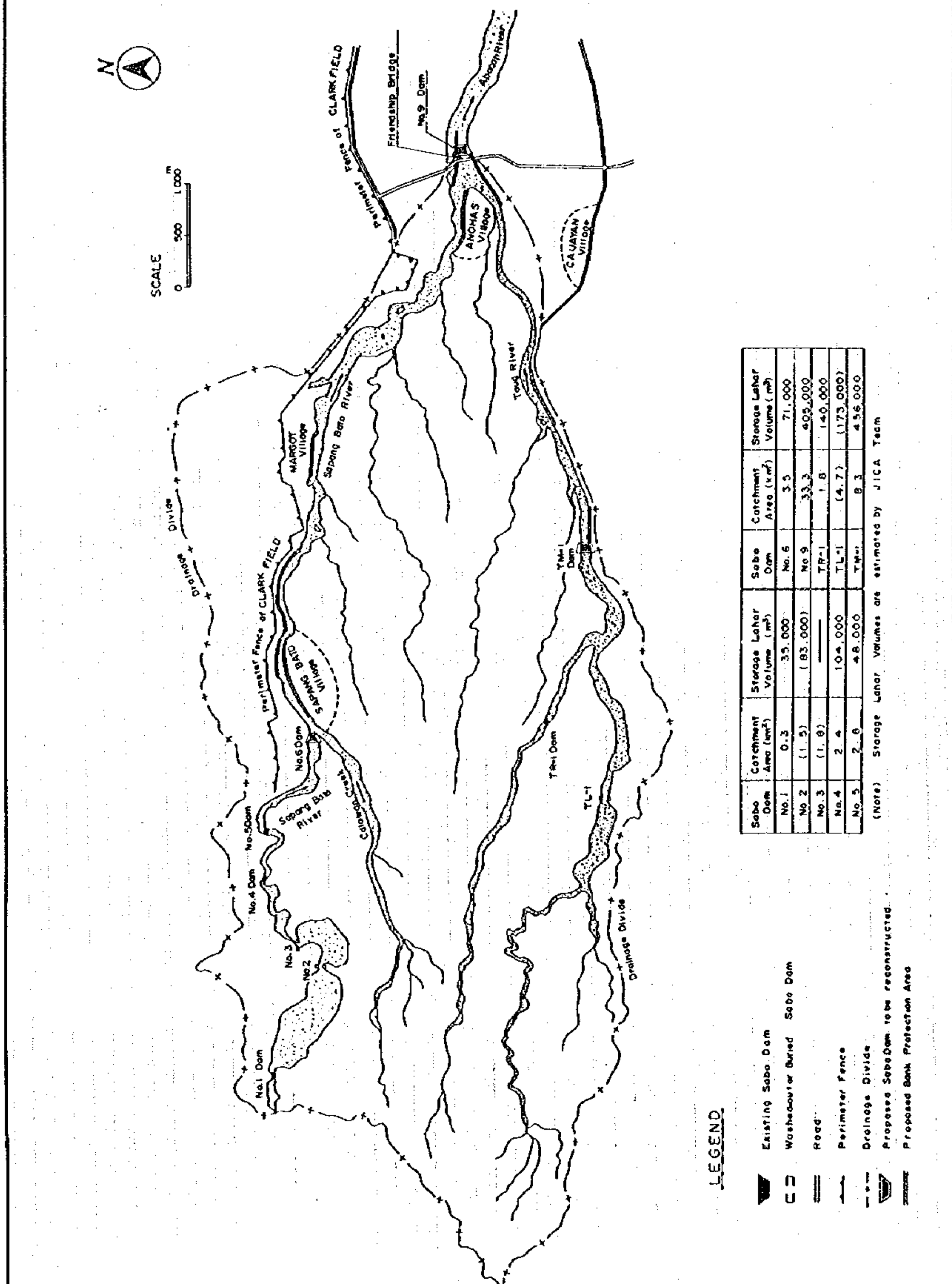
	Buildings	Crops & Livestock	Infrastructure	Evacuation & Cleanup Cost	Loss of GRDP	Total
Return Period						
2 years	49.25%	20.82%	14.44%	8.37%	7.02%	100
5	50.19%	21.31%	14.03%	7.87%	6.60%	100
10	54.75%	18.26%	14.03%	7.04%	5.93%	100
20	58.09%	16.12%	13.51%	6.68%	5.60%	100
50	64.01%	12.77%	12.79%	5.68%	4.77%	100
100	67.30%	10.99%	9.42%	6.68%	5.61%	100

	No. of Affected Buildings	Affected Agricultural Land(sq.m)	Total Affected Area(sq.km)	Affected Household	Affected Urban Population
2 years	2,852			3,355	9,404
5	2,922			3,438	9,608
10	2,988			3,515	9,825
20	3,450	15.40	28.21	4,059	11,373
50	4,163			4,898	13,688
100	6,449		61.15	7,587	21,204

Note: (1) "Affected Household" is computed at "No. of Affected Buildings" divided by 0.85.
(2) "Affected Urban Population" = "Affected Househod" * Urbanization Ratio * Family Size

Average Annual Damage for 20-Year Return Period (Pesos million)

Building	Crops & Livestock	Infrastructure	Evacuation & Cleanup Cost	Loss of GRDP	Total
58.45	23.68	15.39	9.17	7.70	115.37
51%	21%	14%	8%	7%	100%

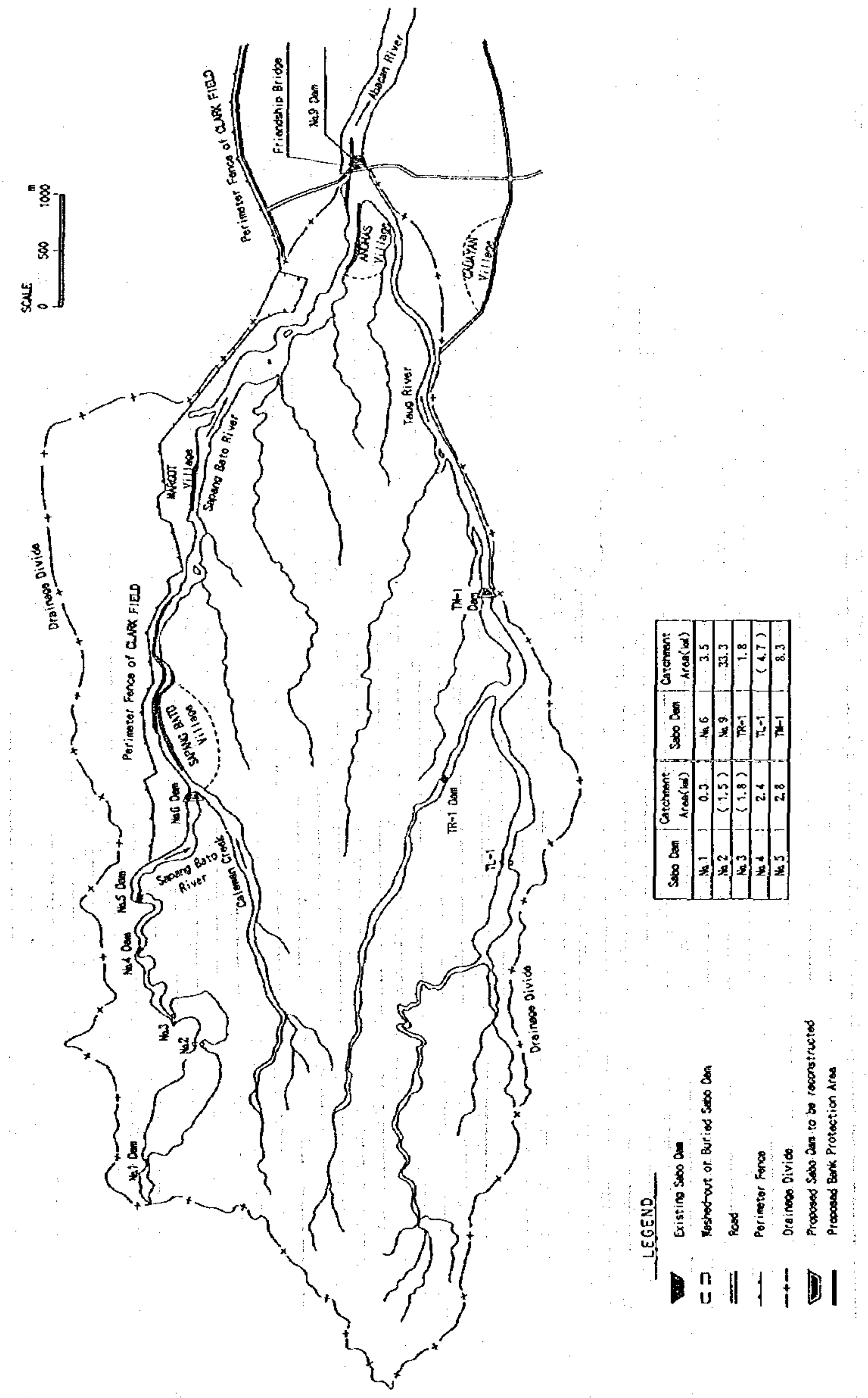


Sabo Dam	Catchment Area (km^2)	Storage Lahar Volume (m^3)	Sabo Dam	Catchment Area (km^2)	Storage Lahar Volume (m^3)
No.1	0.3	35,000	No.6	3.5	71,000
No.2	(1.5)	(83,000)	No.9	33.3	405,000
No.3	(1.8)	—	TR-1	1.8	140,000
No.4	2.4	104,000	TL-1	(4.7)	(173,000)
No.5	2.8	48,000	TM-1	8.3	456,000

(Note) Storage Lahar Volumes are estimated by JICA Team

Figure 9.1 Location of Sabo Dams and Proposed Works for Upper Reach

THE GOVERNMENT OF THE PHILIPPINES
THE DEPARTMENT OF PUBLIC WORKS AND HIGHWAYS
THE STUDY ON FLOOD AND MUDFLOW CONTROL FOR SACOBIA-BAMBAN/ABACAN RIVER DRAINING FROM MT.PINATUBO
JAPAN INTERNATIONAL COOPERATION AGENCY



Sabo Dam	Catchment Area(km²)	Sabo Dam	Catchment Area(km²)
No.1	0.3	No.6	3.5
No.2	(1.5)	No.9	33.3
No.3	(1.8)	TR-1	1.8
No.4	2.4	TL-1	(4.7)
No.5	2.8	TM-1	8.3

Figure 9.2 Location of Sabo Dams and Proposed Works in Medium Term Plan for Abacan River

THE GOVERNMENT OF THE PHILIPPINES
THE DEPARTMENT OF PUBLIC WORKS AND HIGHWAYS
THE STUDY ON FLOOD AND MUDFLOW CONTROL FOR SACOBIA-BAMBAN/ABACAN RIVER DRAINING FROM MT.PINATUBO
JAPAN INTERNATIONAL COOPERATION AGENCY

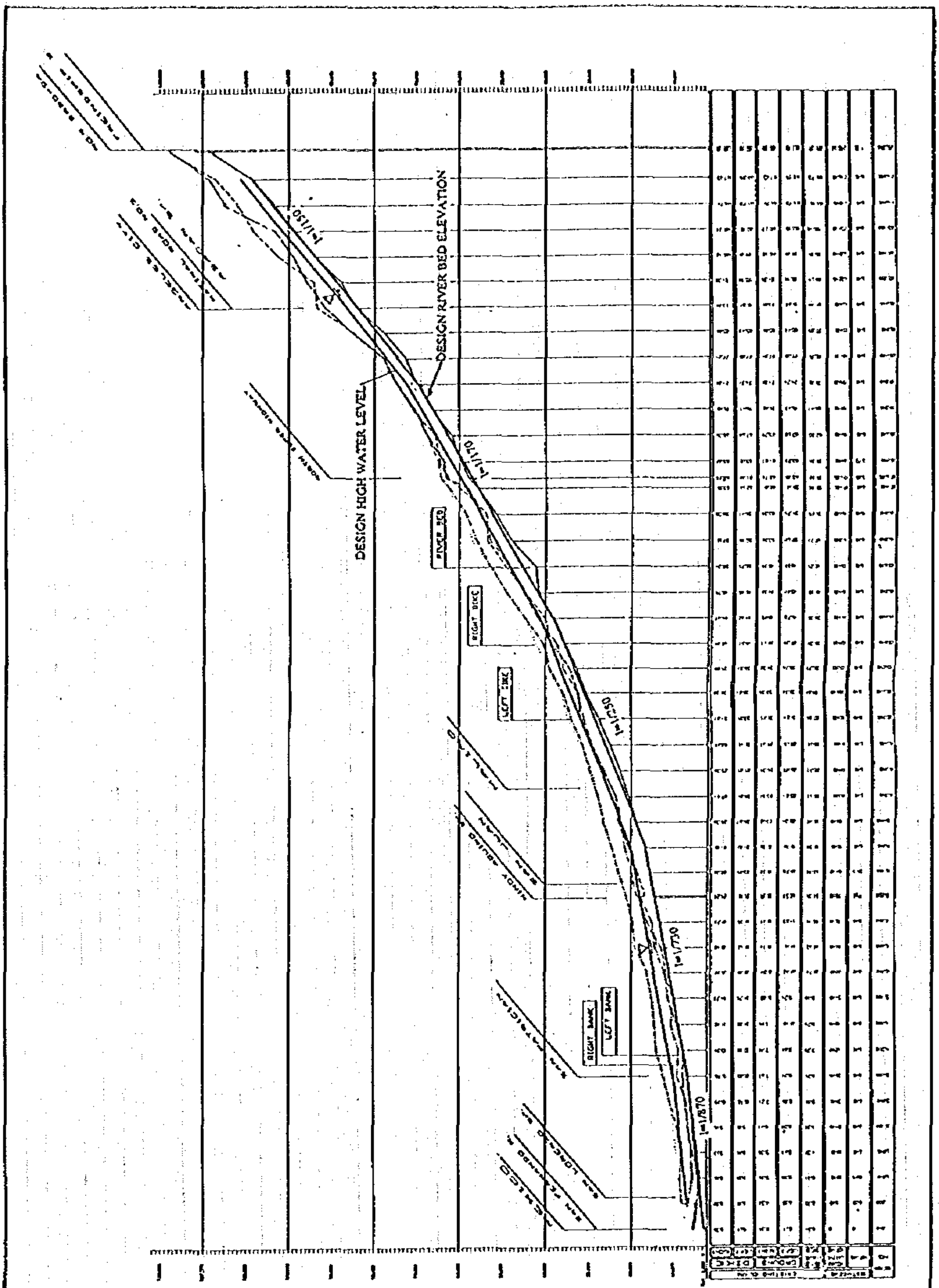


Figure 9.3 Proposed Longitudinal Profile of Lower Abacan River

THE GOVERNMENT OF THE PHILIPPINES
THE DEPARTMENT OF PUBLIC WORKS AND HIGHWAYS
THE STUDY ON FLOOD AND MUDFLOW CONTROL FOR SACOBIA-BAMBAN/ABACAN RIVER DRAINING FROM MT.PINATUBO
JAPAN INTERNATIONAL COOPERATION AGENCY

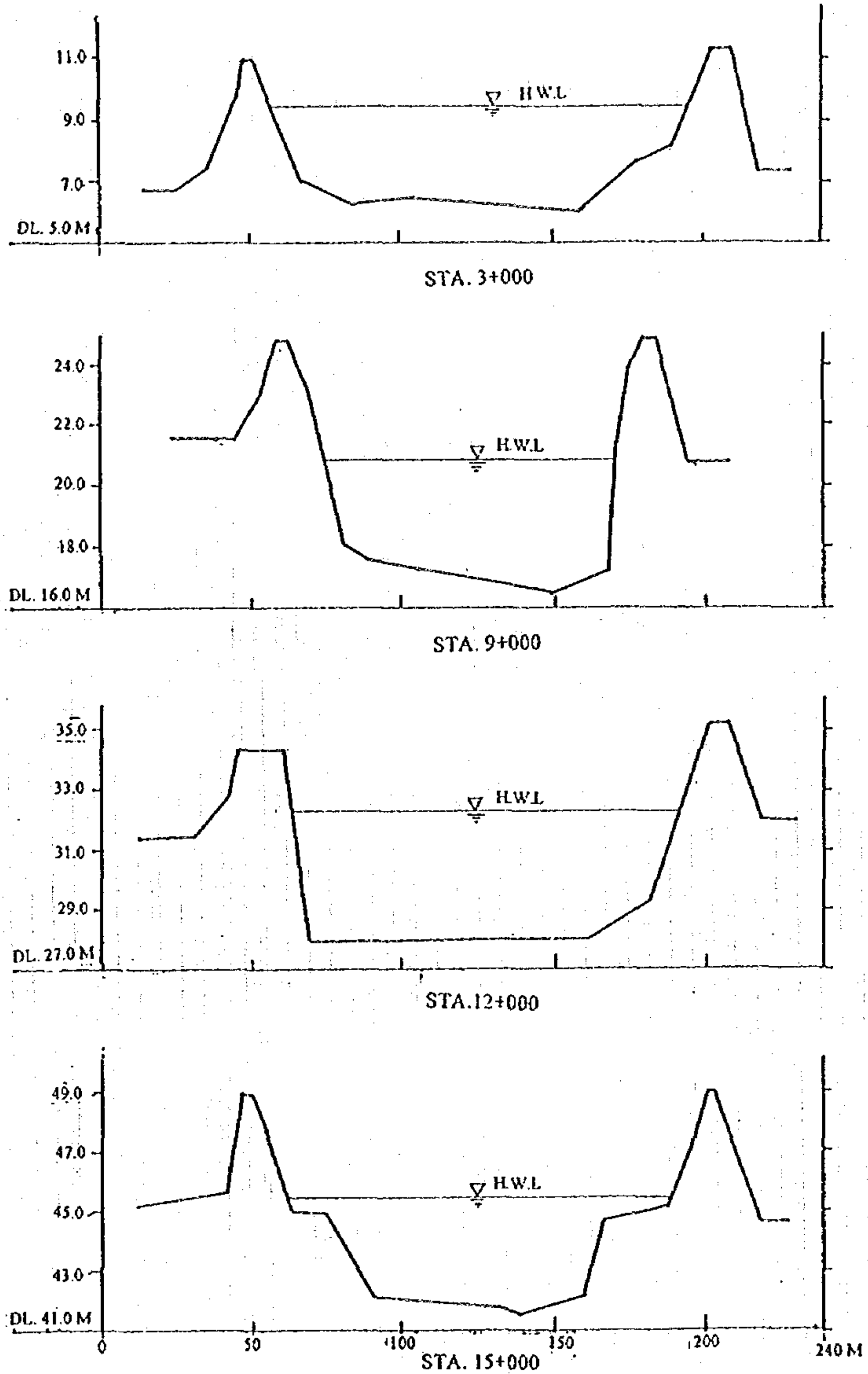


Figure 9.4 Typical Cross Section of Abacan River

THE GOVERNMENT OF THE PHILIPPINES THE DEPARTMENT OF PUBLIC WORKS AND HIGHWAYS
THE STUDY ON FLOOD AND MUDFLOW CONTROL FOR SACOBIA-BAMBAN/ABACAN RIVER DRAINING FROM MT.PINATUBO
JAPAN INTERNATIONAL COOPERATION AGENCY

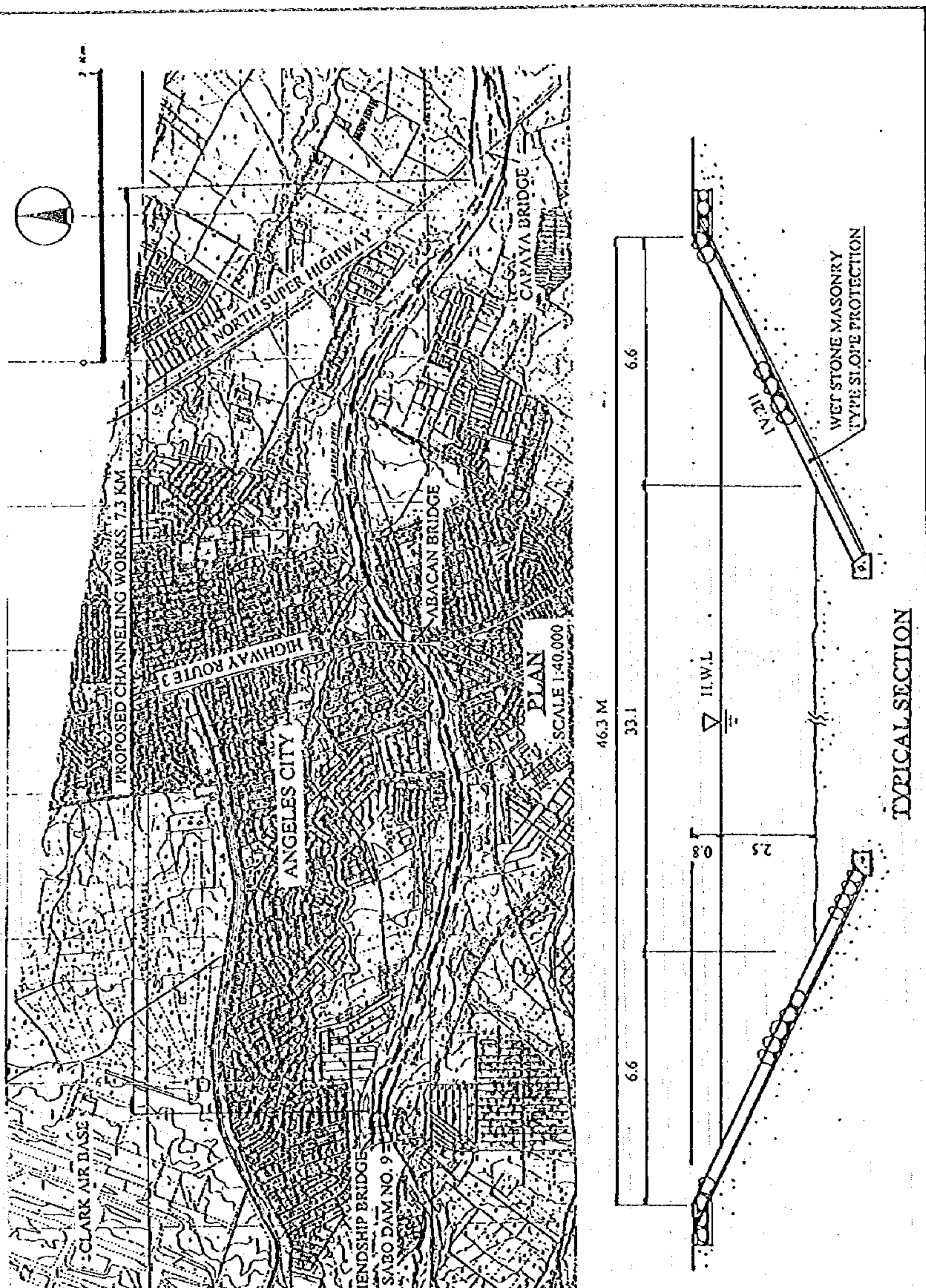


Figure 9.5 Proposed Channeling in Angeles City Urban Reach

THE GOVERNMENT OF THE PHILIPPINES
THE DEPARTMENT OF PUBLIC WORKS AND HIGHWAYS

THE STUDY ON FLOOD AND MUDFLOW CONTROL FOR SACOBIA-BAMBAN/ABACAN RIVER DRAINING FROM MT.PINATUBO

JAPAN INTERNATIONAL COOPERATION AGENCY

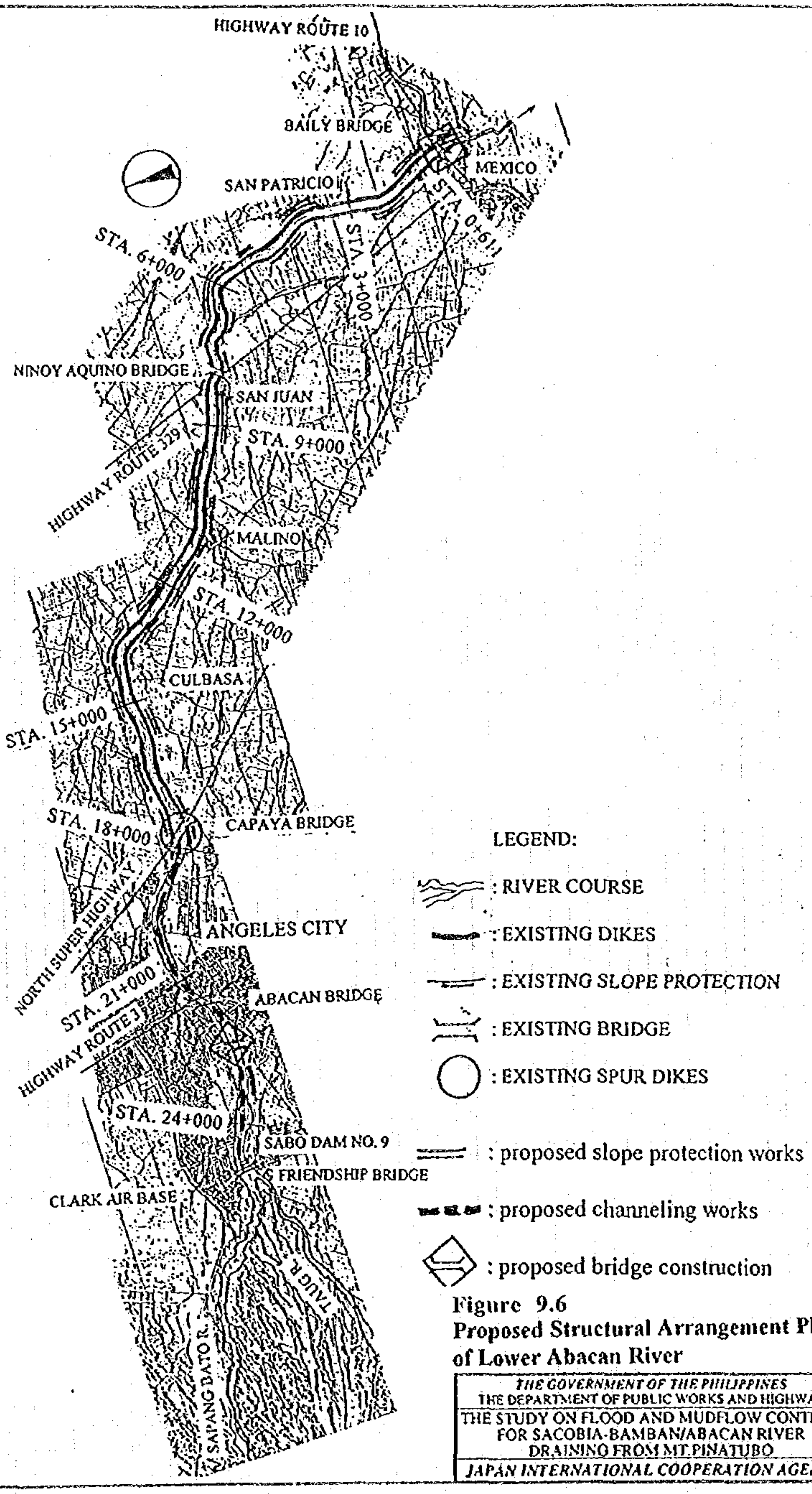


Figure 9.6
Proposed Structural Arrangement Plan of Lower Abacan River

THE GOVERNMENT OF THE PHILIPPINES
THE DEPARTMENT OF PUBLIC WORKS AND HIGHWAYS
THE STUDY ON FLOOD AND MUDFLOW CONTROL FOR SACOBIA-BAMBAN/ABACAN RIVER DRAINING FROM MT.PINATUBO
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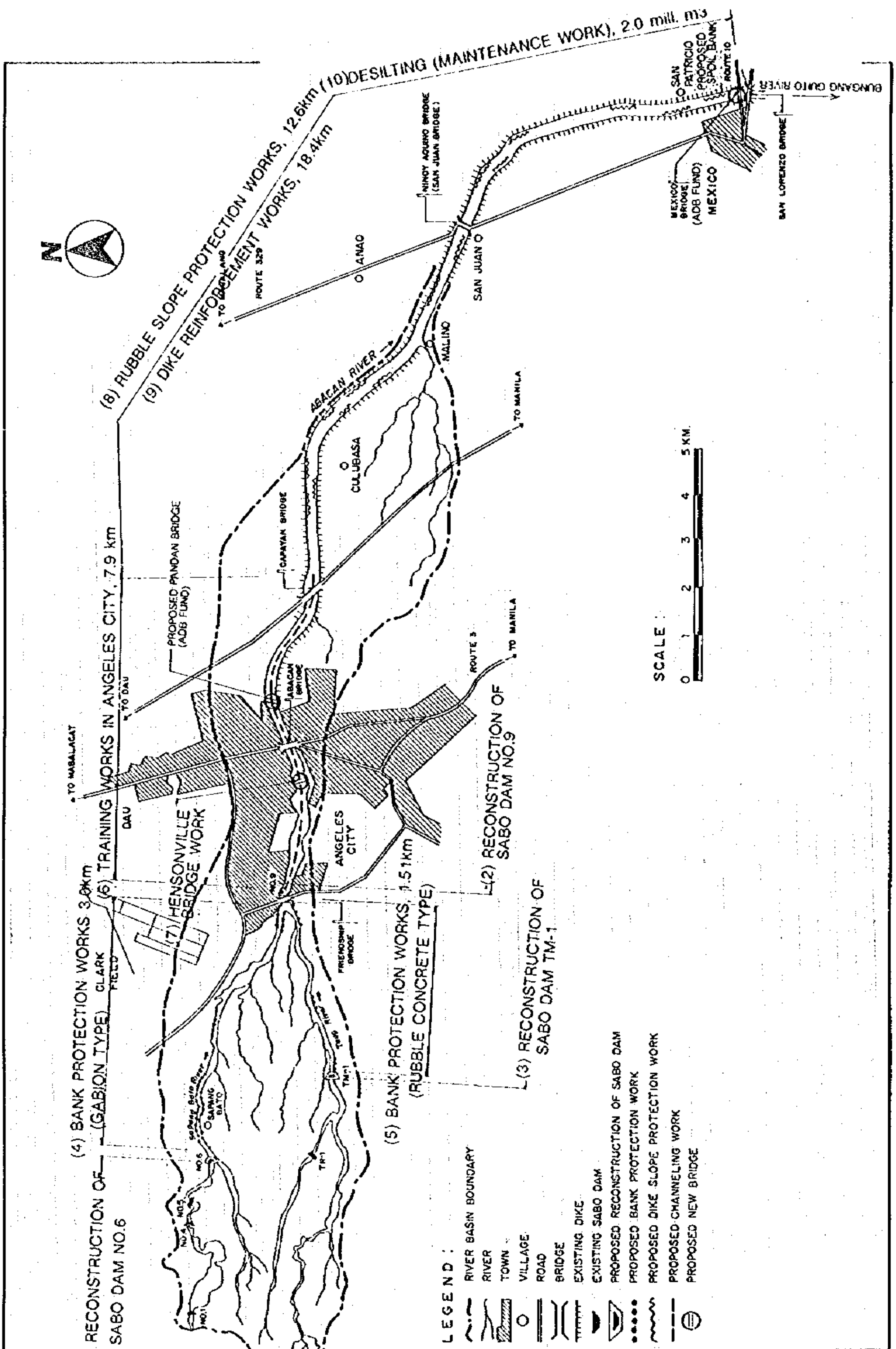


Figure 9.7
Priority Scheme for the Abacan River

THE GOVERNMENT OF THE PHILIPPINES
THE DEPARTMENT OF PUBLIC WORKS AND HIGHWAYS
THE STUDY ON FLOOD AND MUDFLOW CONTROL FOR SACOBIA-BAMBAN/ABACAN RIVER DRAINING FROM MT.PINATUBO
JAPAN INTERNATIONAL COOPERATION AGENCY

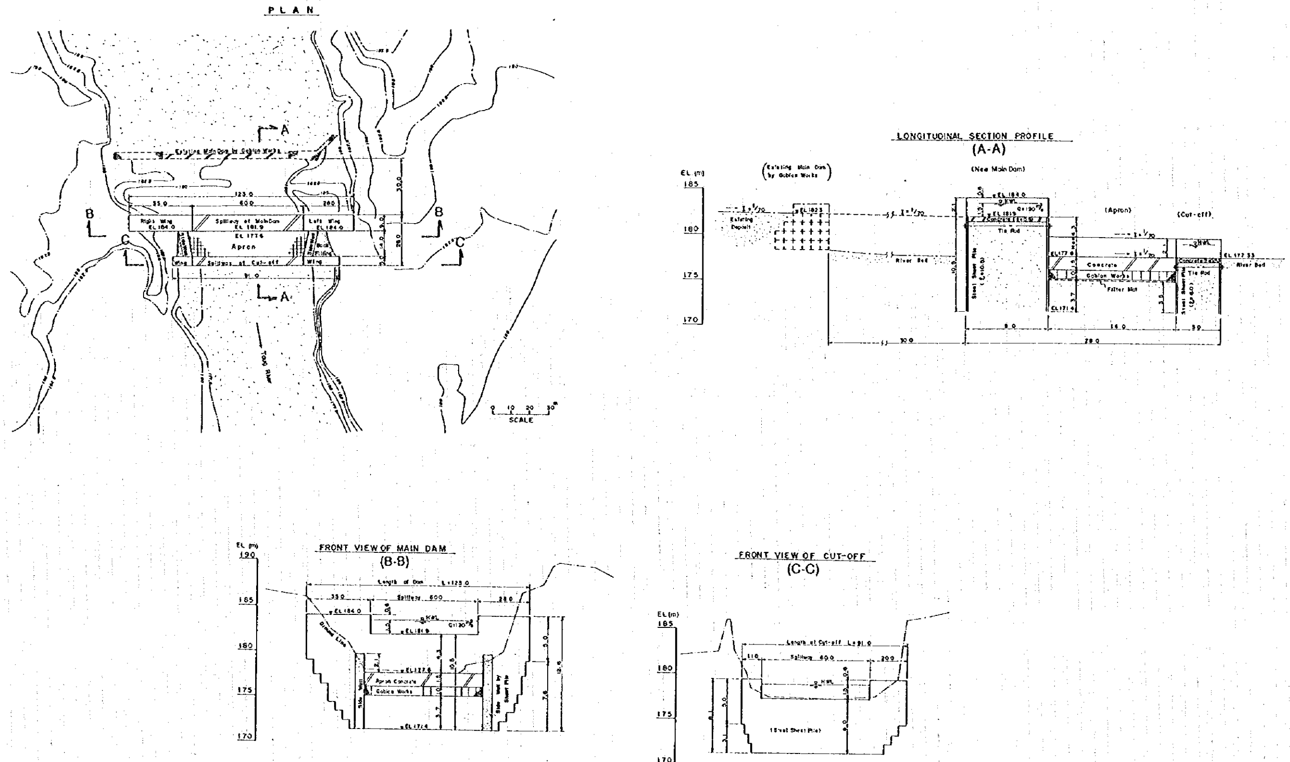
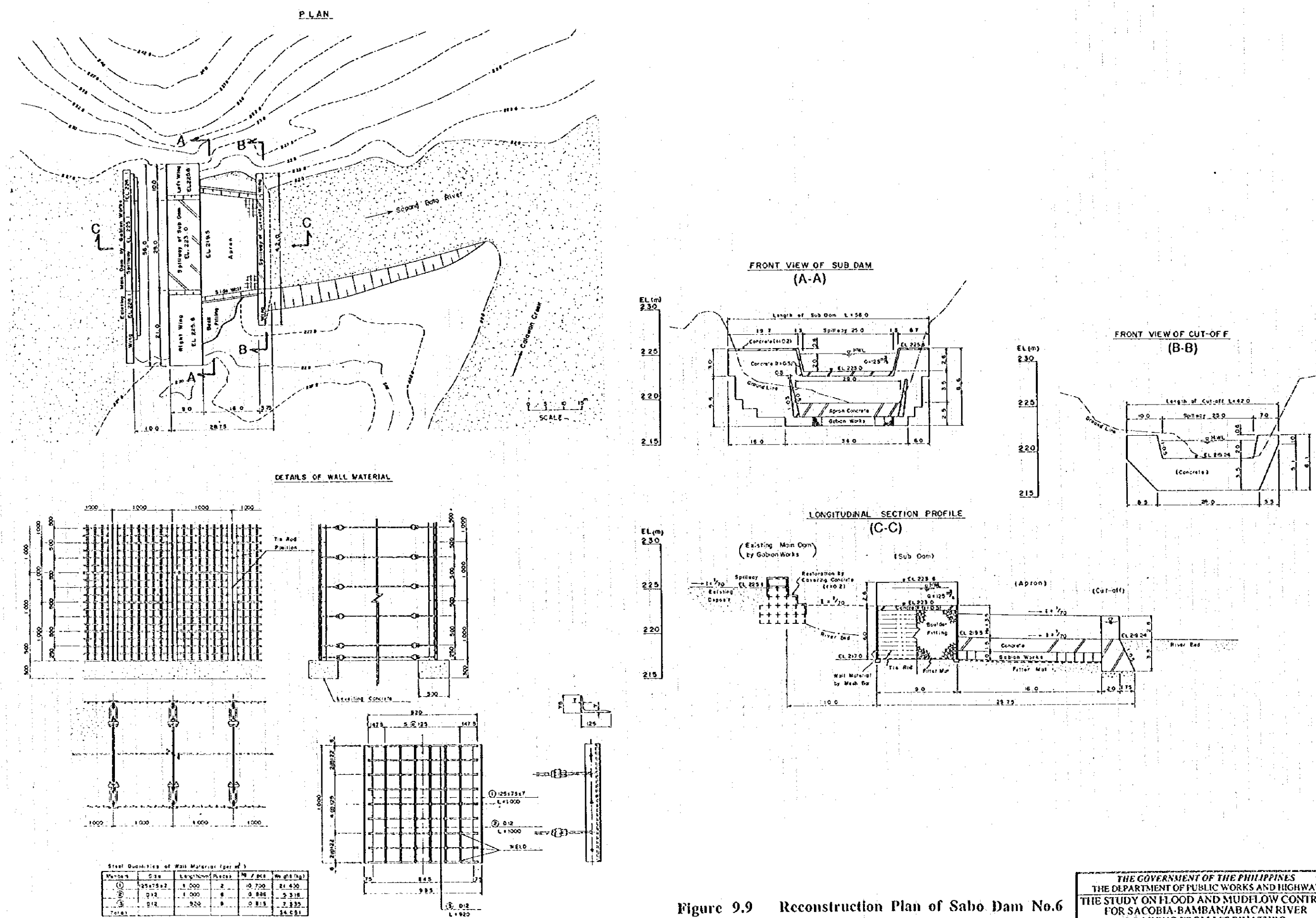


Figure 9.8 Reconstruction Plan of Sabo Dam TM-1

THE GOVERNMENT OF THE PHILIPPINES THE DEPARTMENT OF PUBLIC WORKS AND HIGHWAYS
THE STUDY ON FLOOD AND MUDFLOW CONTROL FOR SACOBIA-BAMBAN/ABACAN RIVER DRAINING FROM MT.PINATUBO
JAPAN INTERNATIONAL COOPERATION AGENCY

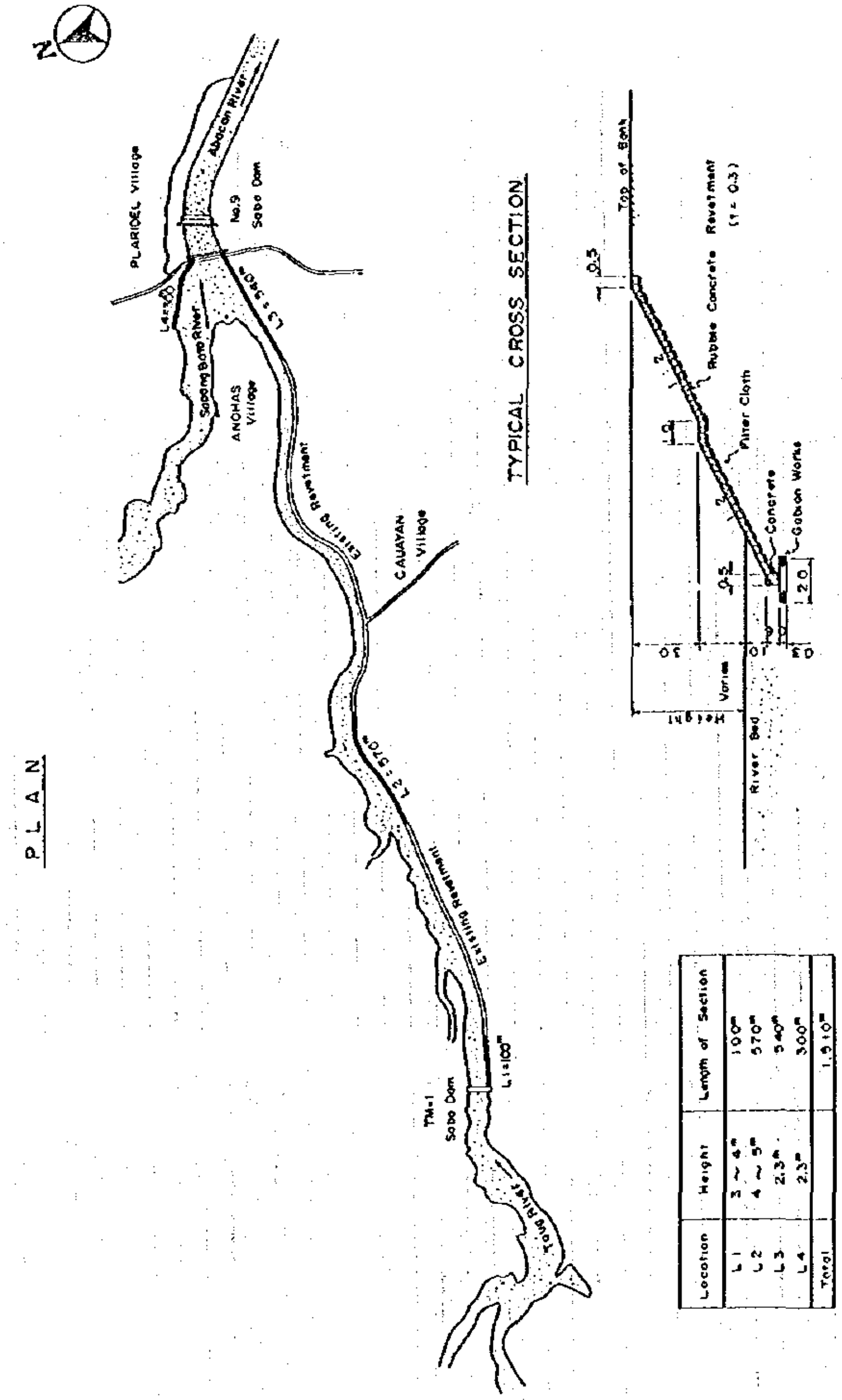


Steel Quantities of Wall Material (per m²)

Member	Size	Length(mm)	Pieces	kg / pce	Weight (kg)
①	125x75x7	1,000	2	10.730	21.460
②	∅12	1,000	6	0.886	5.316
③	∅12	920	9	0.815	7.335
Total					34.051

Figure 9.9 Reconstruction Plan of Sabo Dam No.6

THE GOVERNMENT OF THE PHILIPPINES
THE DEPARTMENT OF PUBLIC WORKS AND HIGHWAYS
THE STUDY ON FLOOD AND MUDFLOW CONTROL FOR SACOBIA-BAMBAN/ABACAN RIVER DRAINING FROM MT.PINATUBO
JAPAN INTERNATIONAL COOPERATION AGENCY



Location	Height	Length of Section
L1	3 ~ 4m	100m
L2	4 ~ 5m	570m
L3	2.3m	540m
L4	2.3m	300m
Total		1,510m

Figure 9.10 Riverbank Protection for Taug River

THE GOVERNMENT OF THE PHILIPPINES
THE DEPARTMENT OF PUBLIC WORKS AND HIGHWAYS

THE STUDY ON FLOOD AND MUDFLOW CONTROL FOR SACOBIA-BAMBAN/ABACAN RIVER DRAINING FROM MT.PINATUBO

JAPAN INTERNATIONAL COOPERATION AGENCY

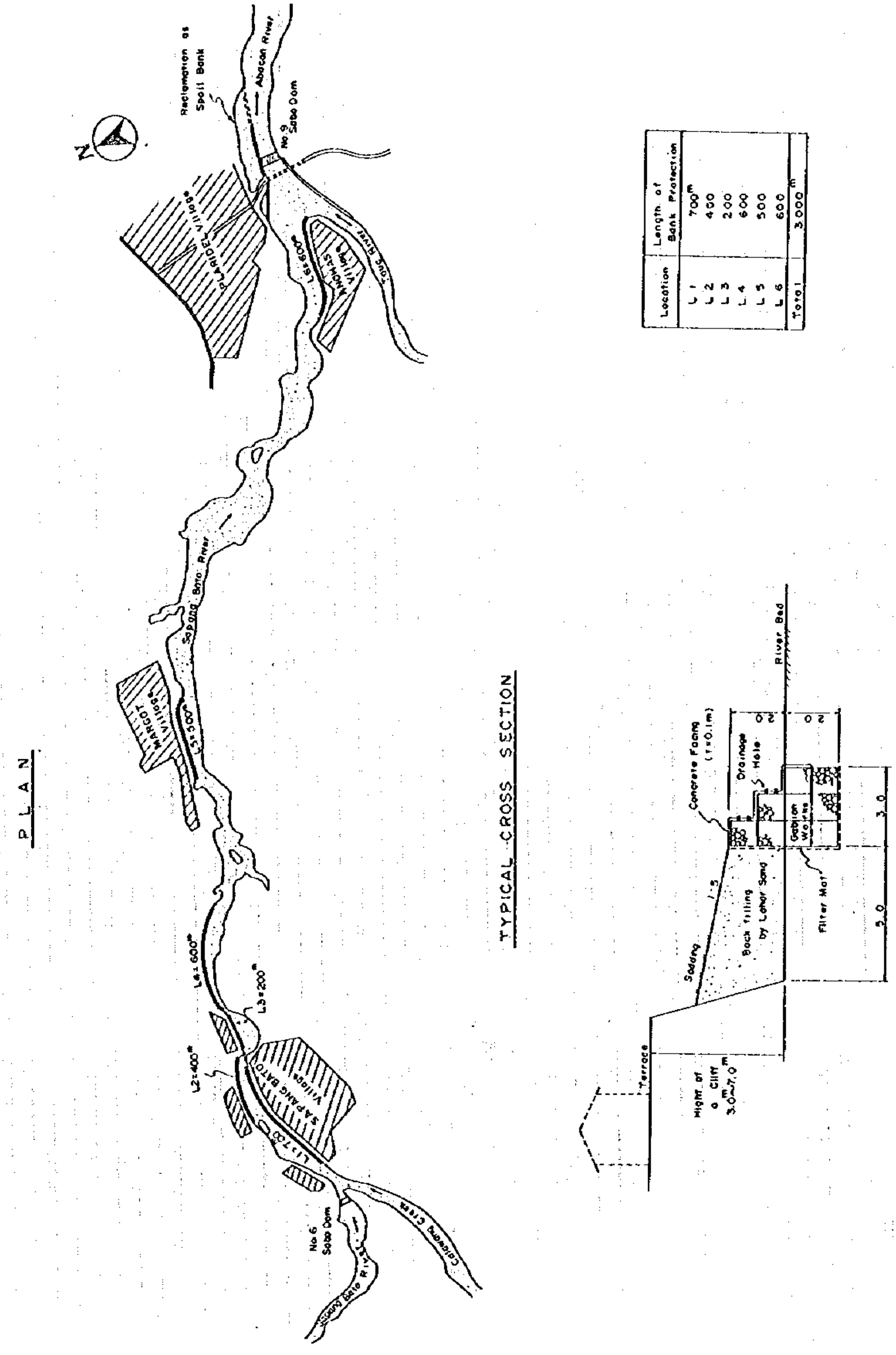


Figure 9.11 Riverbank Protection for Sapangbato River

THE GOVERNMENT OF THE PHILIPPINES
THE DEPARTMENT OF PUBLIC WORKS AND HIGHWAYS
THE STUDY ON FLOOD AND MUDFLOW CONTROL FOR SACOBIA-BAMBAN/ABACAN RIVER DRAINING FROM MT.PINATUBO
JAPAN INTERNATIONAL COOPERATION AGENCY

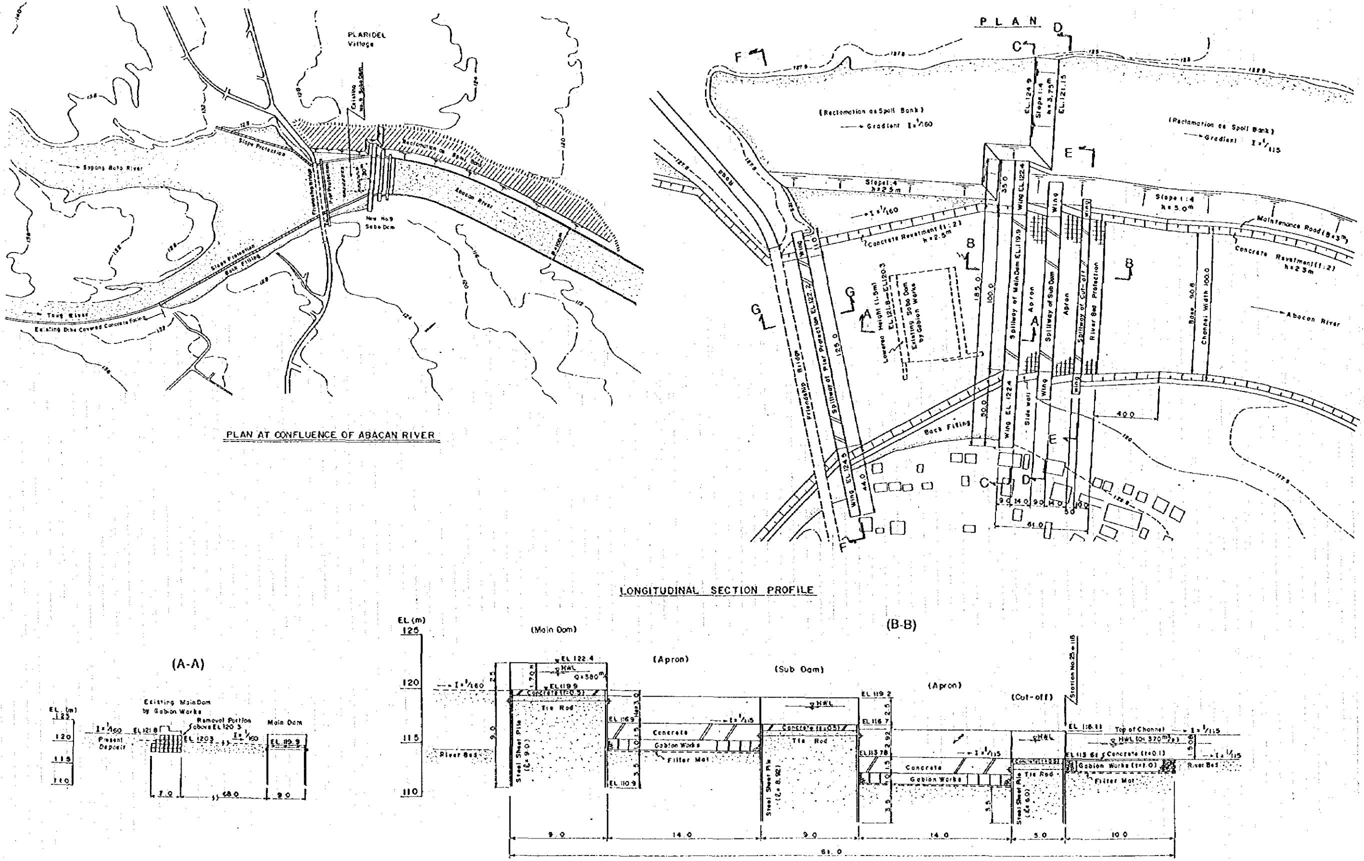
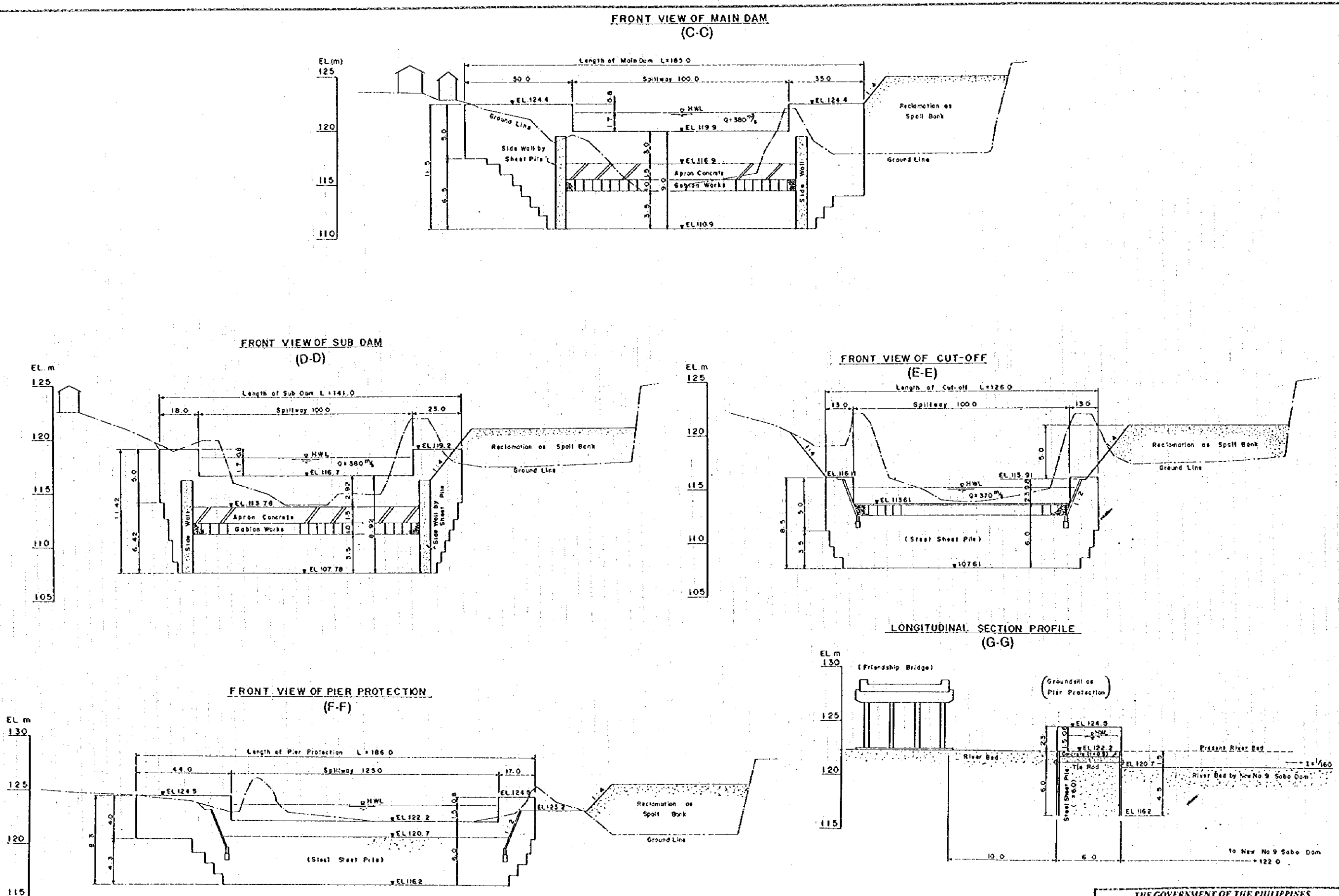


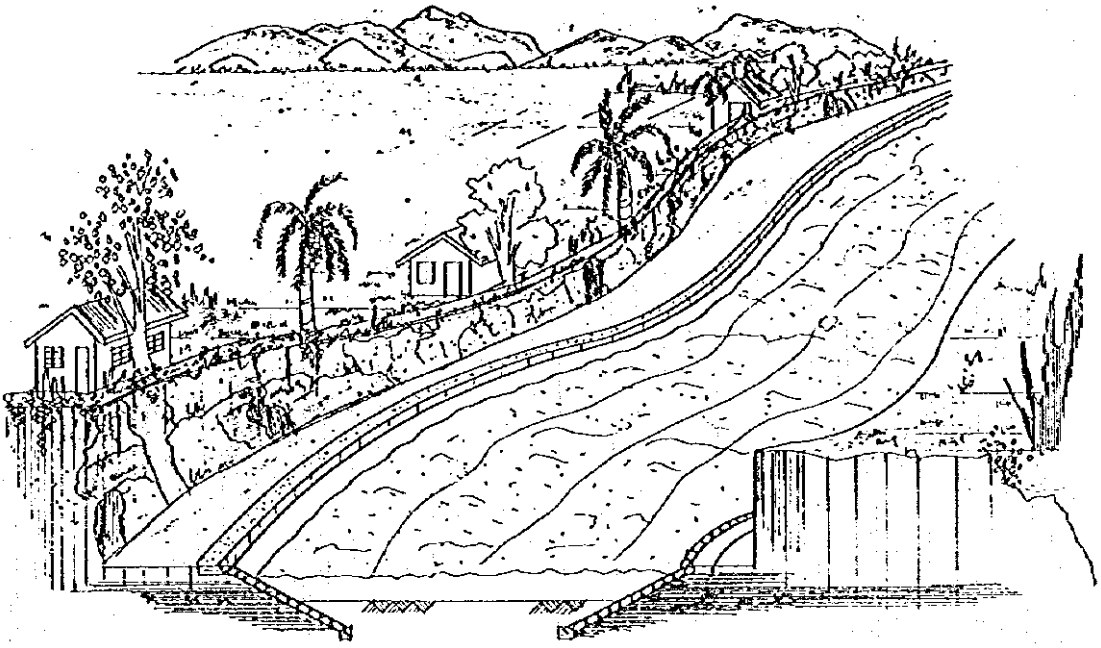
Figure 9.12 Reconstruction Plan of Sabo Dam No.9 (1/2)

THE GOVERNMENT OF THE PHILIPPINES
THE DEPARTMENT OF PUBLIC WORKS AND HIGHWAYS
THE STUDY ON FLOOD AND MUDFLOW CONTROL FOR SACOBIA-BAMBAN/ABACAN RIVER DRAINING FROM MT.PINATUBO
JAPAN INTERNATIONAL COOPERATION AGENCY

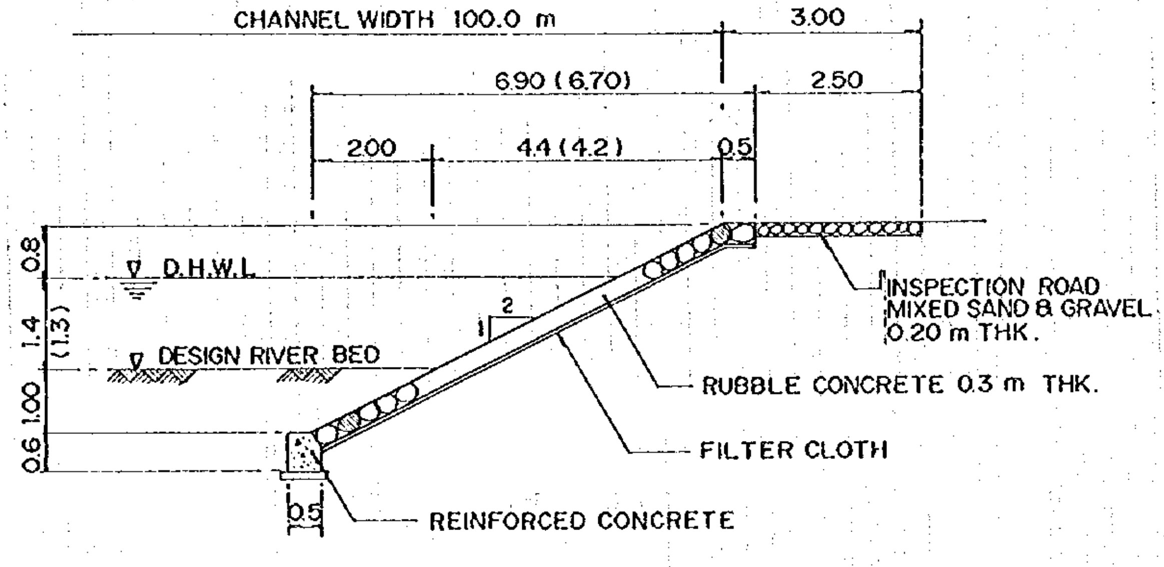


THE GOVERNMENT OF THE PHILIPPINES
THE DEPARTMENT OF PUBLIC WORKS AND HIGHWAYS
THE STUDY ON FLOOD AND MUDFLOW CONTROL FOR SACOBIA-BAMBAN/ABACAN RIVER DRAINING FROM MT.PINATUBO
JAPAN INTERNATIONAL COOPERATION AGENCY

Figure 9.12 Reconstruction Plan of Sabo Dam No.9 (2/2)



AERIAL VIEW



DETAIL OF SLOPE PROTECTION

NOTE :
WITHOUT ( ) CAPAYA BR. TO ABACAN BR.
WITH ( ) ABACAN BR. TO NO.9 DAM

Figure 9.13 Standard Section of Proposed Training Works along Angeles City

THE GOVERNMENT OF THE PHILIPPINES   THE DEPARTMENT OF PUBLIC WORKS AND HIGHWAYS
THE STUDY ON FLOOD AND MUDFLOW CONTROL FOR SACOBIA-BAMBAN/ABACAN RIVER DRAINING FROM MT.PINATUBO
JAPAN INTERNATIONAL COOPERATION AGENCY

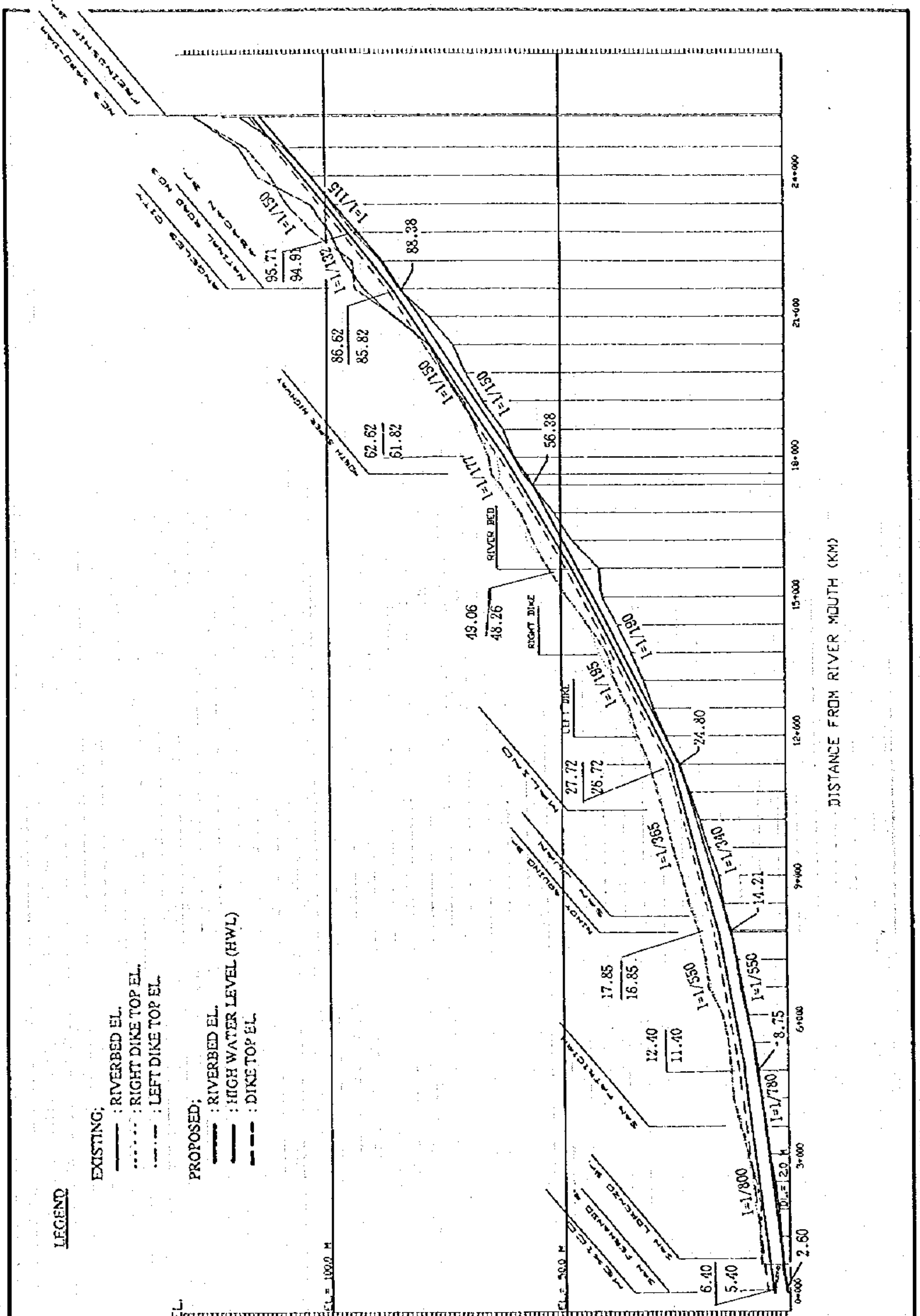
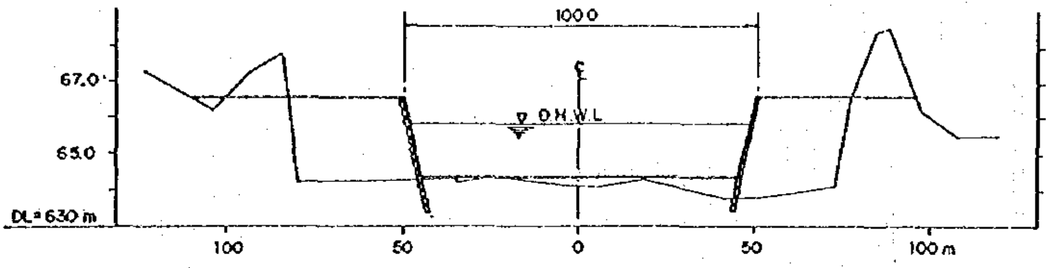
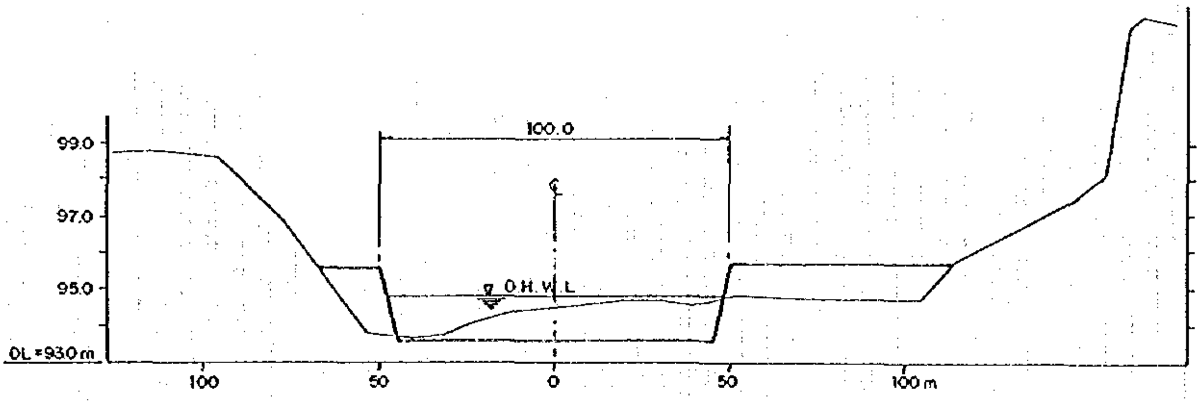


Figure 9.14 Design Longitudinal Profiles of Abacan River

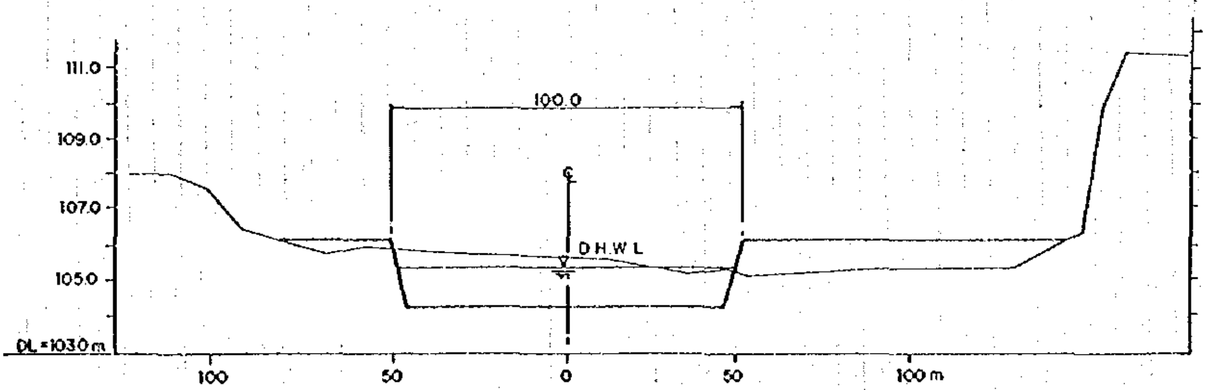
THE GOVERNMENT OF THE PHILIPPINES
THE DEPARTMENT OF PUBLIC WORKS AND HIGHWAYS
THE STUDY ON FLOOD AND MUDFLOW CONTROL FOR SACOBIA-BAMBAN/ABACAN RIVER DRAINING FROM MT.PINATUBO
JAPAN INTERNATIONAL COOPERATION AGENCY



STA. 18 + 600



STA. 22 + 800



STA. 24 + 000

Figure 9.15 Proposed Cross Sections of Upper Abacan River

THE GOVERNMENT OF THE PHILIPPINES THE DEPARTMENT OF PUBLIC WORKS AND HIGHWAYS
THE STUDY ON FLOOD AND MUDFLOW CONTROL FOR SACOBIA-BAMBAN/ABACAN RIVER DRAINING FROM MT.PINATUBO
JAPAN INTERNATIONAL COOPERATION AGENCY

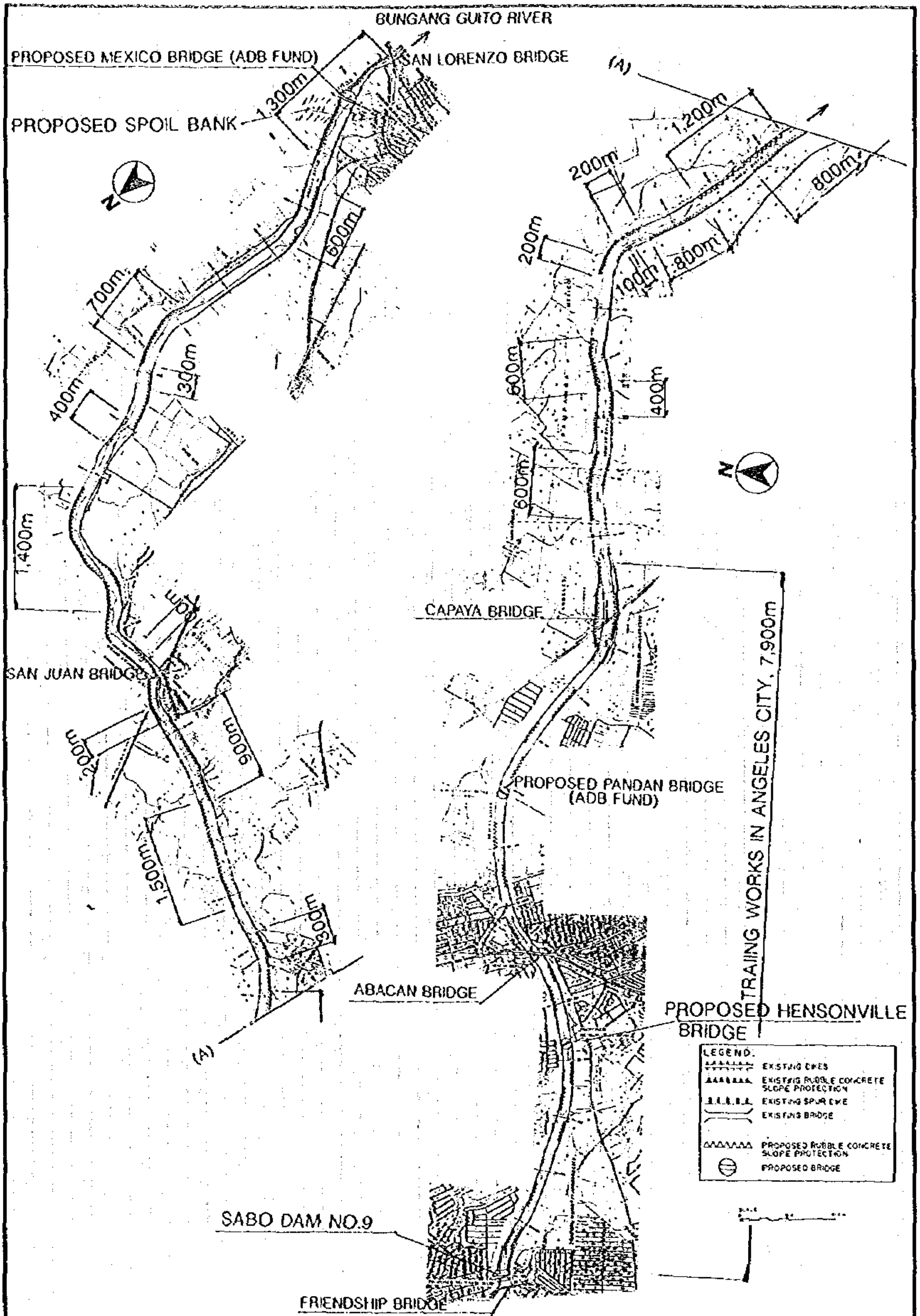


Figure 9.16 General Plan of Lower/Middle Abacan River Improvement

THE GOVERNMENT OF THE PHILIPPINES
THE DEPARTMENT OF PUBLIC WORKS AND HIGHWAYS
THE STUDY ON FLOOD AND MUDFLOW CONTROL FOR SACOBIA-BAMBAN/ABACAN RIVER DRAINING FROM MT.PINATUBO
JAPAN INTERNATIONAL COOPERATION AGENCY

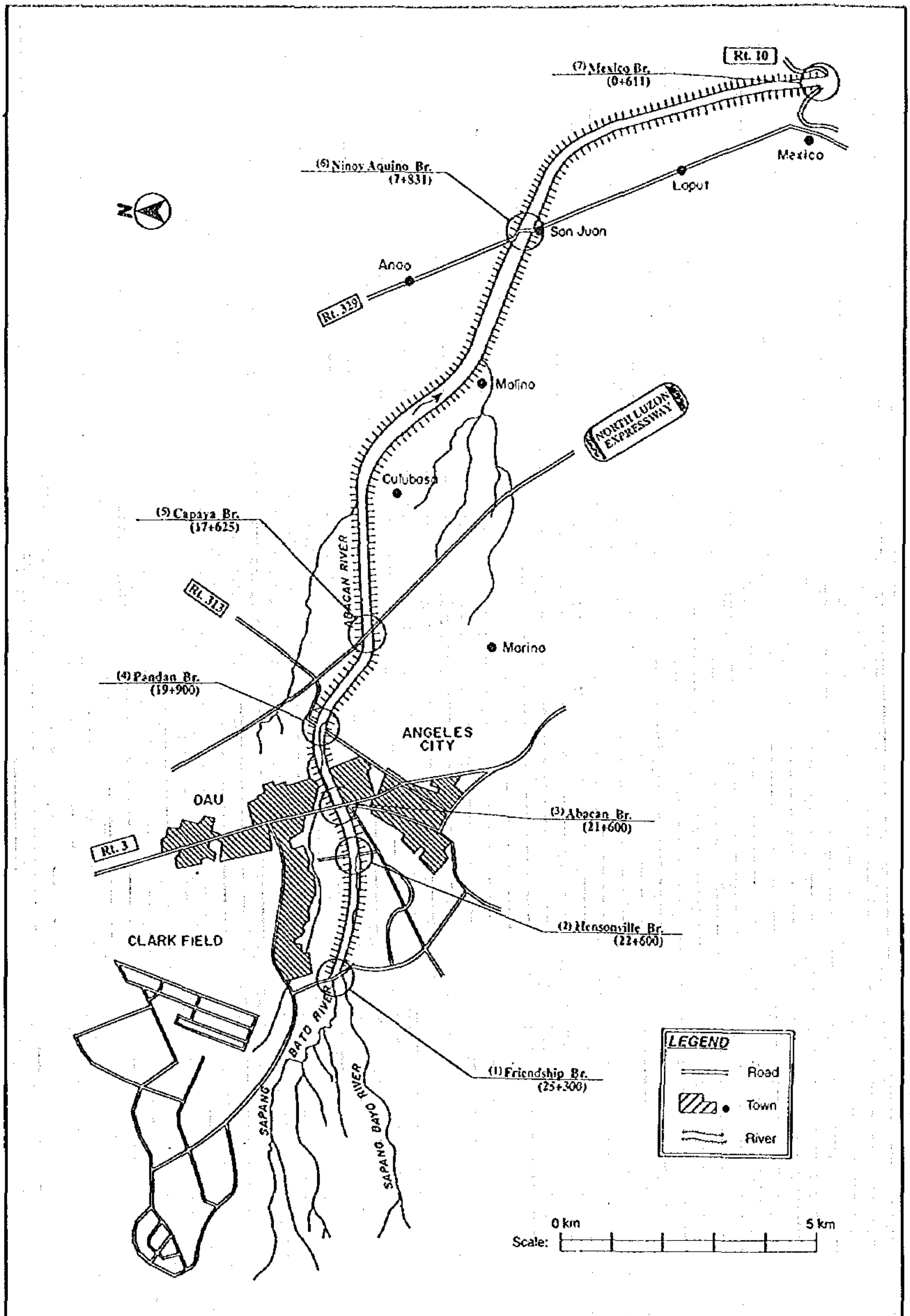


Figure 9.17 Bridge Location across Abacan River

THE GOVERNMENT OF THE PHILIPPINES
THE DEPARTMENT OF PUBLIC WORKS AND HIGHWAYS
THE STUDY ON FLOOD AND MUDFLOW CONTROL FOR SACOBIA-BAMBAN/ABACAN RIVER DRAINING FROM MT.PINATUBO
JAPAN INTERNATIONAL COOPERATION AGENCY

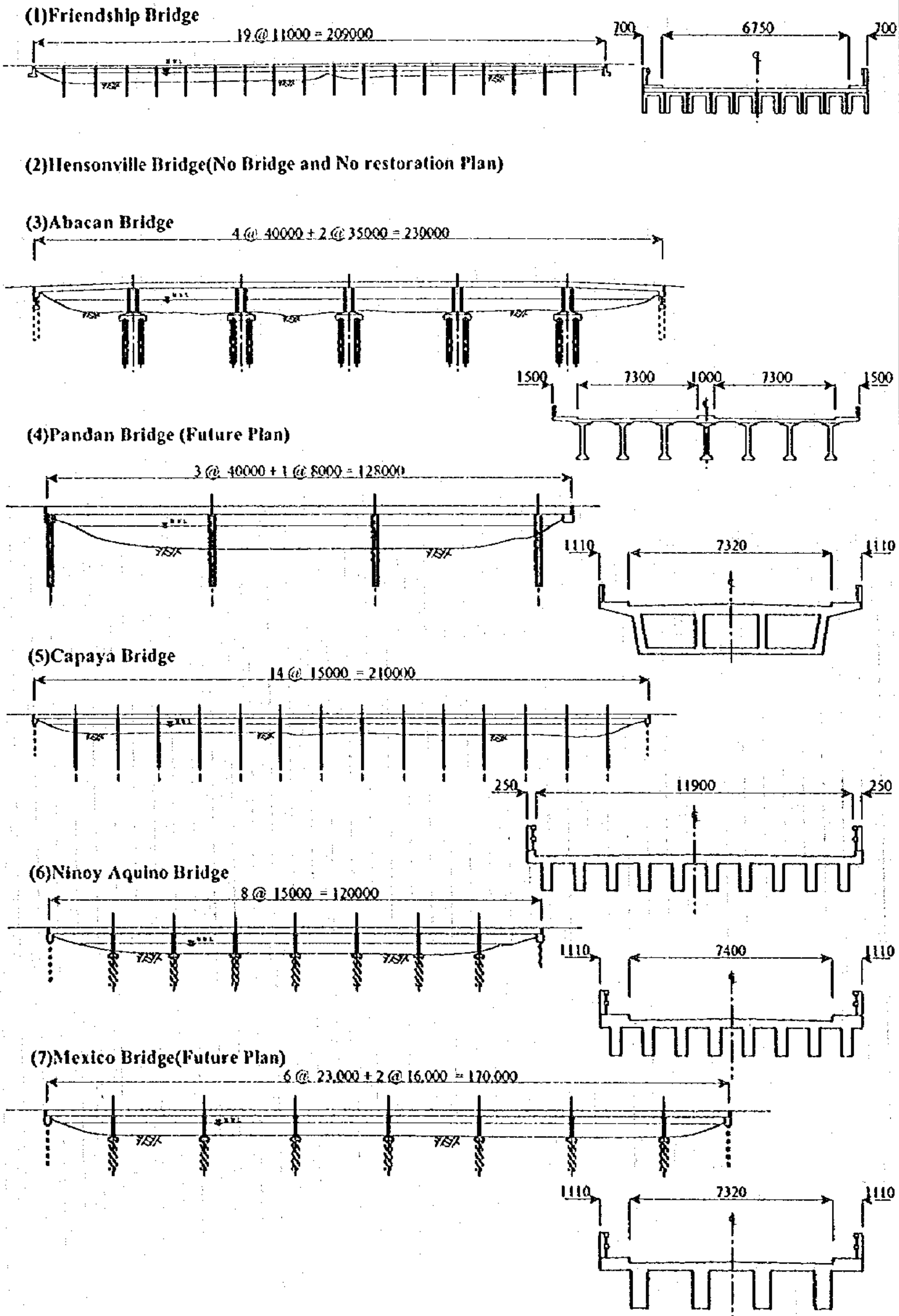


Figure 9.18
Present Condition and Future Plan of Bridges in the Abacan River Basin

THE GOVERMENT OF THE PHILIPPINES
THE DEPARTMENT OF PUBLIC WORKS AND HIGHWAYS
THE STUDY ON FLOOD AND MUDFLOW CONTROL FOR SACOBIA-BAMBAN ABACAN RIVER DRAINING FROM MT.PINATUBO
JAPAN INTERNATIONAL COOPERATION AGENCY

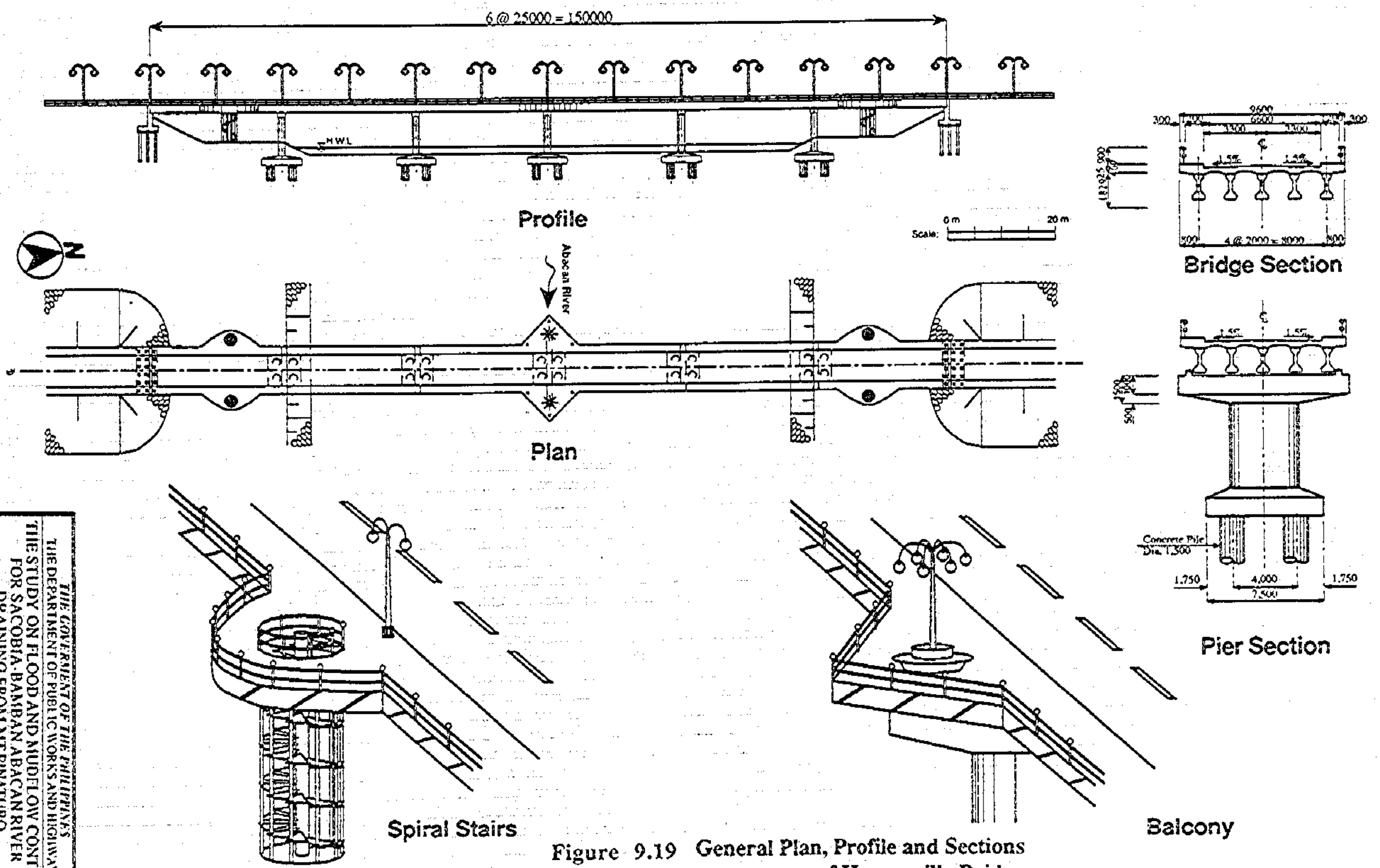


Figure 9.19 General Plan, Profile and Sections of Hensonville Bridge

THE GOVERMENT OF THE PHILIPPINES
THE DEPARTMENT OF PUBLIC WORKS AND HIGHWAYS
THE STUDY ON FLOOD AND MUDFLOW CONTROL FOR SACOBIA-BAMBAN-ABACAN RIVER DRAINING FROM MT.PINATUBO
JAPAN INTERNATIONAL COOPERATION AGENCY

Work Item	Quantity
I. JICA M/P & F/S	
2. Financial Arrangement	
3. Selection of Consultant	
4. Detailed Design	
5. Selection of Contractors	
6. Construction	
I. Mobilization & Preparatory	l. s.
II. Upper Reaches Sediment Control Works	
II. 1 Reconstruction of Sabo Dams	
(1) Sabo Dam No. 6	
a) Assembling of Steel Sheet Wall	61 t
b) Excavation	7.630 m3
c) Gabion Work	440 m3
d) Concreting	1.570 m3
e) Boulder Filling	3.290 m3
(2) Sabo Dam No. 9	
a) Driving Sheet Piles	28.020 m
b) Excavation	20.690 m3
c) Gabion Work	3.890 m3
d) Concreting	6.330 m3
e) Earth Filling	14.500 m3
(3) Sabo Dam TM-1	
a) Driving Sheet Piles	11.220 m
b) Excavation	5.360 m3
c) Gabion Work	2.150 m3
d) Concreting	3.810 m3
e) Earth Filling	3.870 m3
II. 2 Bank Erosion Protection Works	4.510 m
III. Lower/Middle Reaches Flood Control Works	
(1) Slope Protection of Dikes	12.600 m
(2) Training Works in Angeles City	7.900 m
(3) Dike Reinforcement Works	18.400 m
IV. Bridge Works	
(1) Mexico Bridge	
(2) Hensonville Bridge	
(3) Pandan Bridge	
V. Maintenance Works (Desilting)	2 mill. m3

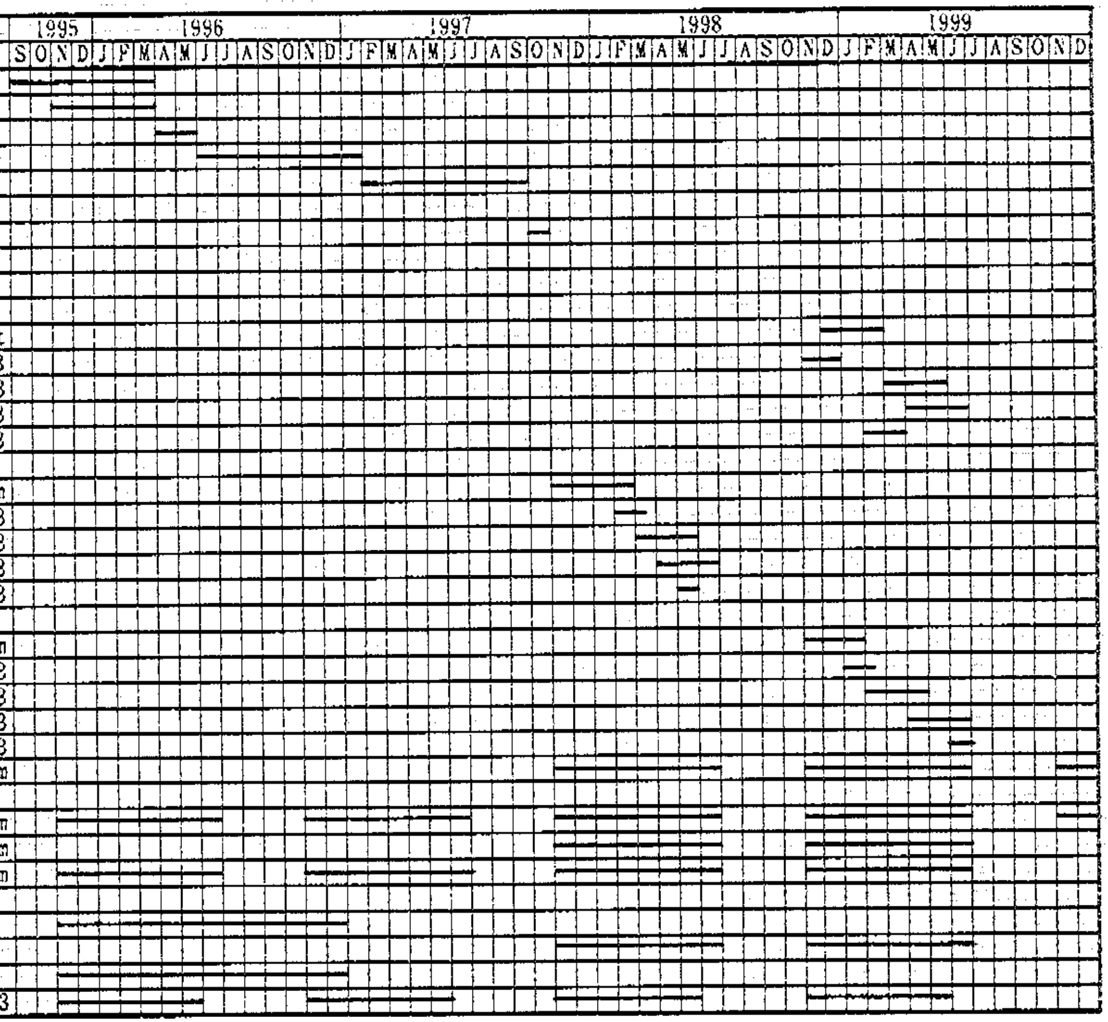


Figure 9.20 Project Implementation Schedule for Abacan River Basin

THE GOVERNMENT OF THE PHILIPPINES
THE DEPARTMENT OF PUBLIC WORKS AND HIGHWAYS
THE STUDY ON FLOOD AND MUDFLOW CONTROL FOR SACOBIA-BAMBAN/ABACAN RIVER DRAINING FROM MT.PINATUBO
JAPAN INTERNATIONAL COOPERATION AGENCY

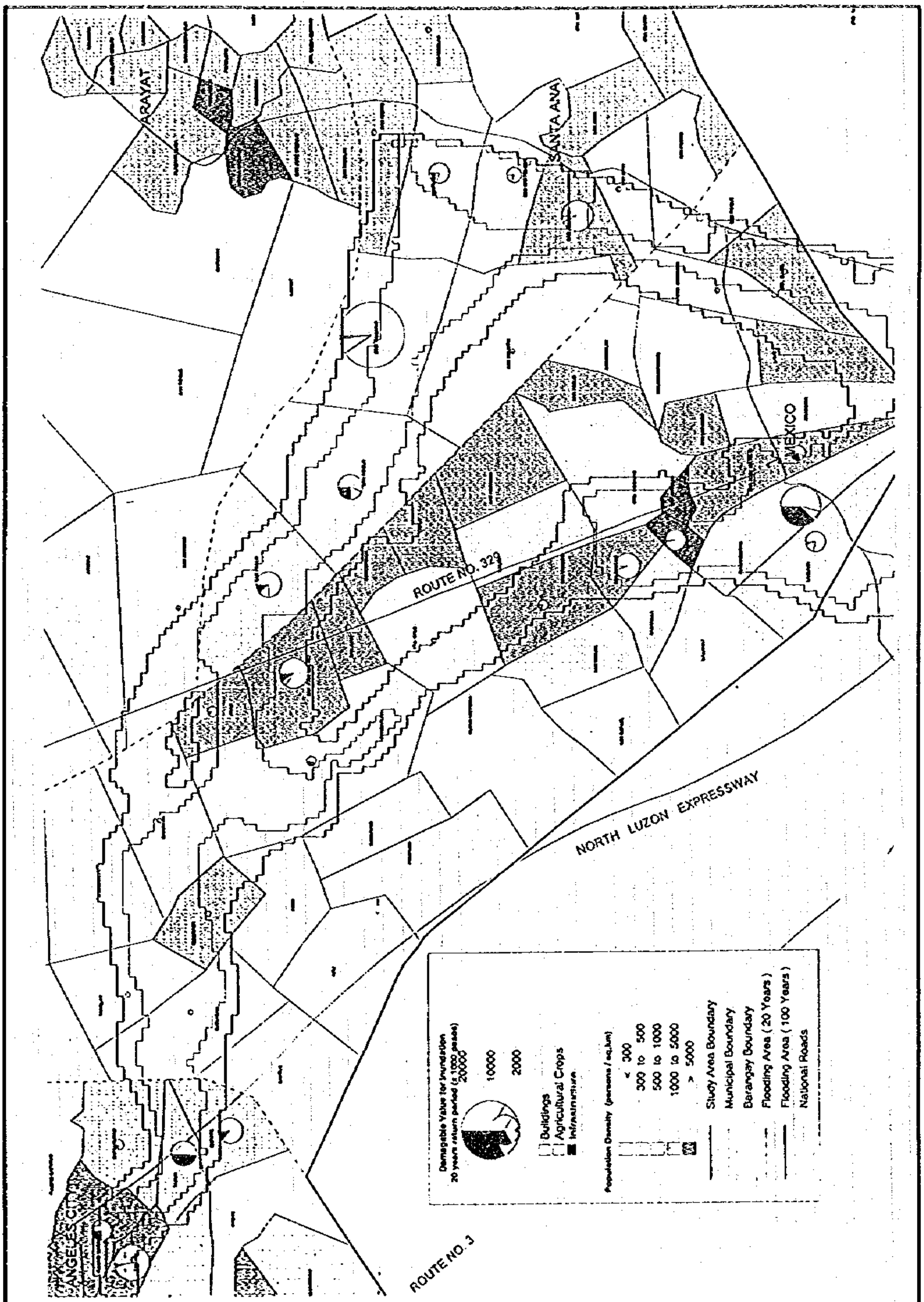


Figure 9.21 Probable Inundation Area in Abacan River Basin

THE GOVERNMENT OF THE PHILIPPINES
THE DEPARTMENT OF PUBLIC WORKS AND HIGHWAYS
THE STUDY ON FLOOD AND MUDFLOW CONTROL FOR SACOBIA-BAMBAN/ABACAN RIVER DRAINING FROM MT.PINATUBO
JAPAN INTERNATIONAL COOPERATION AGENCY

CHAPTER 10

NON-STRUCTURAL MEASURES

CHAPTER 10 NON-STRUCTURAL MEASURE

10.1 WARNING SYSTEM

10.1.1 PRESENT CONDITION

In 1994, the RDCC-III is the inter-agency organization for flood/mudflow warning in the Mt. Pinatubo affected area. The office of RDCC-III was established at the Camp Olivas in San Fernando, Pampanga. Flood/Lahar monitoring system of RDCC-III is organized into four (4) systems;

1) AFP/PNP lahar watchpoint,
2) PHIVOLCS/USGS lahar monitoring system,
3) PAGASA weather information, and
4) OCD/JICA lahar monitoring system

After receipt of the monitored information on lahar and heavy rainfall, the RDCC-III disseminates the lahar/flood warning information to government agencies in Region III, PDCC, MDCC and BDCC. The warning message is also transmitted by hot-line telephone linking the radio stations in Manila. The schematic diagram of flood/mudflow warning system is shown in Figure 10.1. The location map of warning equipment is attached in Figure 3.12 of Chapter 3.

10.1.2 RECOMMENDATION

(1) Needs of Expansion of NDCC

NDCC will have an increasingly important role, since the disaster preparedness and prevention will apparently need more skilled government agency/personnel. However, the OCD, as the center of NDCC, has not at the moment enough capacity of personnel and enough capability in establishing of disaster management plan because of the financial constraint and shortage of the numbers of personnel. The expansion of NDCC will need the additions of equipment, building spaces and numbers of officials as the tutor to the local government units.

(2) Training of the Officials of Local Government Unit

The officials in charge of the disaster preparedness and prevention shall have sound knowledge with regard to the implication of the activities concerning to disaster mitigation. The extent of their capabilities and also the effective procedures lead to a successful evacuation. In this context, training is very important for the officials in local government units. The training program is the form of periodical (not in ad-hoc basis) seminors should be established in the activities of NDCC (OCD).

(3) Integrated Database for Rainfall Observation Network

Pinatubo hazard is characterised by the predominant secondary disaster which is triggered by heavy rainfall due to northeasterly monsoon and typhoon. At present, in and around Mt.Pinatubo hazard area, the rainfall observation stations are managed by PAGASA, DPWH, NIA and OCD. Among the agencies, the representative one should have an integrated database system of rainfall data which retrieve all the rainfall data, and disseminate the warning message for heavy rainfall. Major problem on rainfall observation network in the Philippines is the maintenance of the equipment, especially in case of telemetered equipment. The rainfall radar system which covers Pinatubo hazard area will be one of the solution taking into account an advantage to maintain at specified location and to collect all rainfall data by representative agency.

(4) Coordination with International Organization

Bilateral and multilateral assistance and OCD's staff training by the international organizations related to disaster preparedness and prevention are of great help to the government especially in alleviating the suffering of people.

(5) Coordination with the network of NGO

Remarkable activities in evacuation and resettlement have been carrid out by NGOs in and around Mt.Pinatubo hazard areas. Recently, a NGO's network of disaster prevention is being expanded not only to Pinatubo hazard area but also to countrywide. It is necessary for government agencies, especially for NDCC and OCD, to coordinate with such an network for efficient relief operation and evacuation.

10.2 EVACUATION SYSTEM

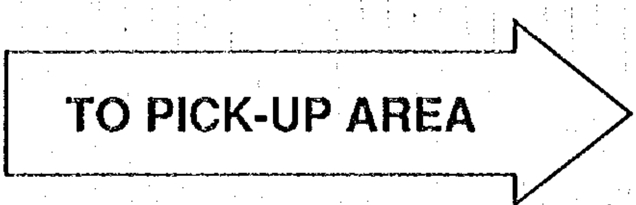
10.2.1 NECESSITY OF DEVELOPMENT PLAN OF EVACUATION SITE

In times of emergency, the usual evacuation sites are the public elementary schools and government offices. Many of these are not equipped for long-term settlement. Some of the designated evacuation sites are also located in lahar and flood-prone areas. In such cases, these elementary schools should only be designated as pick-up points.

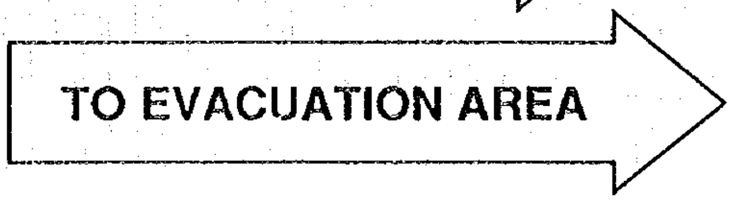
Establishing permanent resettlement sites takes considerable time, Such situation, unfortunately, puts so much stress on the evacuees. There is a need for permanent evacuation sites for the lahar-and flood-prone areas to provide timely and fast services and provisional settlement.

10.2.2 EVACUATION ROUTES

The shortest routes from threatened barangays to the nearest evacuation sites should be elevated in order to prevent isolation in times of floods. However, culverts should be used to serve as passage for flood waters crossing these roads. Road signs like



and



should be placed at intersections to guide evacuees.

10.2.3 PICK UP POINT

Intermediate pick up points where evacuees can be assembled before transporting them to evacuation areas should also be marked.

The pick up points are public areas, such as schools, churches and government office complexes.

10.3 RESETTLEMENT PROGRAM

10.3.1 DISPLACED AND RESETTLED FAMILIES

More than 26,000 families have been displaced as a result of the first two rainy seasons after the eruptions of Mt. Pinatubo in 1991 and 1992 (Lahars I and II). Another 7,400, who are victims of Lahar III (1993 lahar and flooding), have sought temporary shelter in the evacuation areas, and are still to be permanently resettled. In 1994 (Lahar IV), 2,492 families from the Municipalities of Bacolor and Porac and living within the Pasig Potrero river basin were affected and subsequently relocated to the evacuation and resettlement sites of San Fernando and Angeles. The government resettlement program as of 1994, covers the resettlement of 33,096 families including 8,732 proposed in 1994 program by the Mount Pinatubo Commision, of which some 10,000 come from an upland ethnic minority group (the Aetas). The dislocated lowland families, on the other hand, generally come from the river banks of the low-lying plains of Pampanga and Tarlac. The government aims to relocate them as close as possible to their original settlement sites and within the same political jurisdiction if at all possible. The numbers of dislocated and resettled families are enumersted below;

Displaced and Resettled Families in Region III as of 1994

Families	Numbers of Families			Total
	1991 & 1992	1993	1994	
Displaced	26,787	7,400	2,492	36,679
Resettled	21,004	3,360	8,732	33,096
Cumulative Balance	5,733	9,823	3,583	3,583

Note : The above figures shows total numbers in Region III (Tarlac, Pampanga and Zambales).
Source : CABCOM for displaced families and MPC for resettled families.

10.3.2 PLANNING AND IMPLEMENTATION ISSUES

(1) Needs and Aspirations

The major issues are the conflicts arising as a result of differences between the settlers, perceived needs and aspirations and the government solutions and policies on evacuation and resettlement. Resettlements are urban in design and character, while the people to be resettled are mostly agricultural. The urban-type community services and facilities were not perceived to address an immediate need rather than livelihood and shelter.

(2) Resource Limitation

The sheer number of families who have to be evacuated and resettled continue to strain the resources of the government and non-government organizations. Many resettlement areas still have incomplete houses, infrastructures and utilities. A number of houses and productivity centers are not yet occupied for each of electricity.

(3) Sustainability

Private sector-initiated resettlement areas were not recognized by the Mount Pinatubo Commission. Instead of supporting these efforts, these communities were left to fend for themselves. Resettlements within privately-owned lands were similarly left on their own. Infrastructures and utilities have not been installed in these areas pending the transfer of ownership to the settlers. Local governments especially were worried about the continued assistance needed by the resettled families.

(4) Lack of Livelihood Opportunities

In spite of the many livelihood financing programs available, there were few takers. Business planning and employment preparation were lacking, Those who needed capital could not avail of them due to the loan requirements. They have to work for the daily sustenance. Unemployment rate is still very high among the affected and resettled families. First, the closure of the US Military Bases resulted in 42,617 lost jobs. Secondly, the loss of agricultural lands due to lahar, caused many more farmers to lose their traditional source of livelihood. Finally, daily food rations resulted to dependence on external material assistance and less initiative to work.

10.3.3 PROGRAM CONSIDERATIONS

1) Choice of site. The site selected should provide similar opportunities for the livelihood of the settlers. It should be safe from future lahar and flood flows and be accessible even during the rainy season. The site should preferably be in or adjacent to the original habitat.

2) Community and local government participation in planning and implementation of resettlement sites. Both should move toward self-management.

3) Integration of the population into the socio-economic system the barangay and its neighboring barangays instead of designing self-reliant community designs which promote enclaves within the municipality,

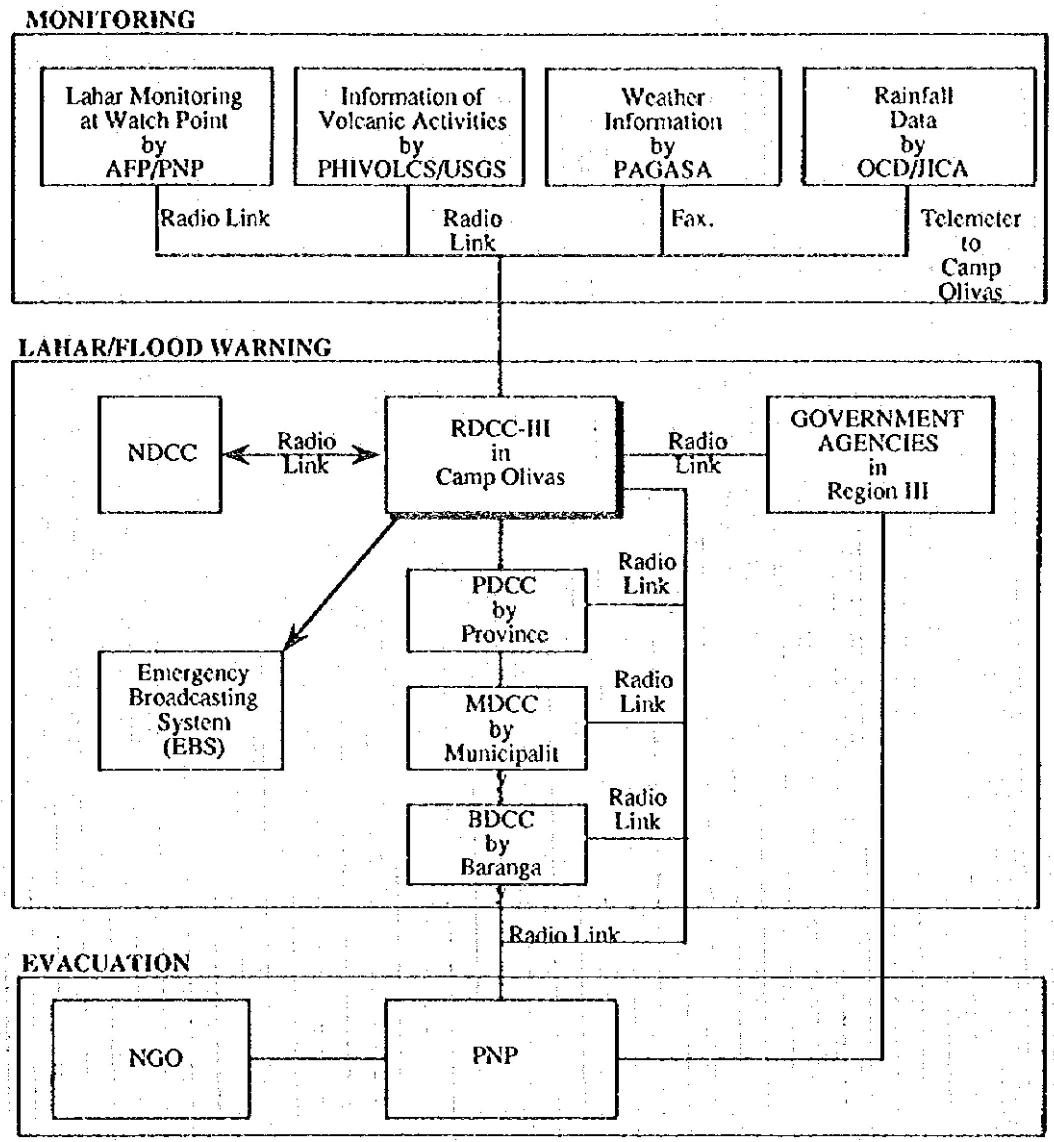
4) Unified program control for better coordination; and

5) Effective site management to ensure smooth transition during turn over of administration.

6) Balance in the provision of housing, livelihood and community services and facilities.

7) Provision of options and flexibility for livelihood and housing appropriate to the skills level and income of the individuals.

8) Integration of self-initiated and privately-initiated evacuation and resettlement areas into the overall government assistance program.



Note

PNP : Philippine National Police
PHIVOLCS : Philippine Institutes of Volcanology and Seismology
PAGASA : Philippine Atmospheric, Geophysical and Astronomical Services Administration
OCD : Office of Civil Defence
NDCC : National Disaster Coordinating Council
RDCC-III : Regional Disaster Coordinating Council
PDCC : Provincial Disaster Coordinating Council
MDCC : Municipal Disaster Coordinating Council
BDCC : Barangay Disaster Coordinating Council
NGO : Non-government Organization

Figure 10.1 Lahar/Flood Warning and Evacuation System in Region III

THE GOVERNMENT OF THE PHILIPPINES
THE DEPARTMENT OF PUBLIC WORKS AND HIGHWAYS
THE STUDY ON FLOOD AND MUDFLOW CONTROL FOR SAÇOBIA-BAMBAN/ABACAN RIVER DRAINING FROM MT.PINATUBO
JAPAN INTERNATIONAL COOPERATION AGENCY

CHAPTER 11

ENVIRONMENTAL STUDY

CHAPTER 11 ENVIRONMENTAL CONDITION

11.1 PROCEDURE OF THE STUDY

In 1994, the initial environmental examination (IEE) was carried out in the Study Area. The major purposes of the study was to enumerated the environmentl changes by the 1991 eruption. There have been two (2) times of workshops held in Pampanga and Tarlac Provinces between September to October 1994.

Following the IEE Study in 1994, the environmental impacts assessment (EIA) study was carried out in 1995 on the basis of the structural arrangement of the selected schemens for the feasibility study. The most notable performance they have made for the EIA Study was of conducting extensive public hearings in order to gather information and opinions on the Project from the local residents who are greatly concerned with the Project. There have been 26 times of public hearings and two (2) times of workshops held between June and October, 1995.

11.2 INITIAL ENVIRONMENTAL EXAMINATION

11.2.1 PHISICO-CHEMICAL ENVIRONMENT

(1) Soil Resources in the Agricultural Areas

Containing mudflow and its deposition into the diked course of river would protect soils of the adjoining prime agricultural lands from further deposition of volcanic materials. Thus the structural measures of the Project should protect present soil fertility from degrading it and that the agricultural activities for planting sugarcane, rice, root crops and vegetabless can resume as soon as, and as safe as, possible.

(2) Geomorphologic Change

(a) Diking

Diked course of river would reduce erosive power of the river. This would mean that the dikes and other structural measures of the Project should hold up essentially all of the natural process of geographical changes associated with the rivers in the Study Area. On the other hand, such limitation to geomorphological changes is considered that it would significantly contribute towards the continuous and sustainable livelihood of the general public in the Study Area. It is also considered that no part of the structural measures of the Project should cause any significant adverse effect on the ambient natural environment.

(b) Spoil Bank

The area of spoil bank planned to create in the area adjacent to the confluence of the Rio Chico River and Bamban River is 432 ha. Dumping operation with heavy construction vehicles and introducing new soil into the natural vegetation area as well as the farming area during the dry season will be affected. Land ownership should also be checked thoroughly as the area appears to be used for rice field.

(3) Water Quality

The Project will not cause any significant changes on the water quality of the surface and ground water. However, construction works of diking and channelization in the Study Area will probably change water quality parameters, especially turbidity, during the construction period, which would normally be conducted in the dry season.

11.2.2 BIOLOGICAL ENVIRONMENT

(1) Fauna

Slopes of the dike could be planted with trees and bamboo that should help stabilize the dikes and these would provide shelters and feeding areas for several species of wildlife such as rodents, birds and amphibians. No other adverse effect to the wildlife in the Study Area is expected to occur.

Sabo dams that shall be constructed at the Sediment Source Zone and Sediment Transition Zone are even beneficial to certain wildlife species as most of the habitats in these areas have been destroyed by the Mt.Pinatubo eruption.

(2) Locust Breeding

Locust infestation is a major problem in the lahar affected areas, especially along the dikes and plowed fields with thick lahar and ashfall deposits. Locust would lay their eggs in water-free, soft sandy substratum and the areas with thick lahar deposition in Concepcion, Mabalacat, Bamban and Angeles City shall be the suitable sites for locust breeding. Since sugarcane is their major food source, preventing them from a large scale reproducing is almost impossible. Locust, however, will attract and enhance the population of insect-eating birds, mammals and lizards.

Sabo dams made either of sandbags, rocks or stones inside wire mesh may provide temporary shelter to small species such as ground skinks, snakes, rodents and shrews. They also provide shelter to other invertebrate species like freshwater crabs and shrimps, and the worms that wildlife species feed on.

(3) Candaba Swamp

The most important environmental impact brought about by this Project is the faster lahar conveyance toward the low-lying areas and natural catch basins such as San Antonio Swamp around the confluence of Rio Chico and Bamban River, Candaba Swamps and many Pampanga River estuaries.

With faster flow of water and lahar during the rainy season along the much improved water channels of Sacobia/Bamban River, Rio Chico river shall be filled up with coarse lahar materials while excessive flood water would carry fine particles of the sand in the river. Slope gradient of the rivers in the Study Area is likely to accumulate much of the deposit in the area adjacent to the Project site. Thereby the water-borne fine particles in the water should settle in the downstream area causing further fine silt material accumulation. As a result, deposition of lahar materials below Rio Chico River is limited i.e. very limited effect is expected to occur to Candaba Swamp.

(4) Flora

(a) Revegetation on the Mt.Pinatubo Slopes

Growing vegetation on the steep slopes accumulated with the pyroclastic material is one of the aims of this study. However, this program is considered not effective, or at least necessary to conduct extensive, thus long term, study.

(b) Revegetation on the Dikes

Slope protection measures for the dikes that have already been constructed for emergency measures is necessary. The dikes made of volcanic materials are left unprotedted and thus vulnerable to heavy rainfalls. Thus extensive slope protection program should be established for the following reasons:

(c) Natural Growth of Grass Species

In general, pioneer grasses like talahib and legumes should dominate thelahar affected areas. These species will be the major species for the next several years to a couple of decades depending on the soil fertility and the level of intensity of man's economic activities conducted in the mudflow deposit area. No part of the structural measures of the Project should adversely affect the natural vegetation in the Study Area.

11.2.3 SOCIAL ENVIRONMENT

(1) Changes in Land Use

(a) Sacobia/Bamban River Basin

It is obvious that the structural measures of the Project should protect agricultural land and residential areas along Sacobia/Bamban River from further mudflow and flood events in most cases. Thus agricultural activities or any other economic activities can resume as soon as the permanent structures for the river improvement measures are completed.

(b) Abacan River Basin

No changes in land use along most part of Abacan River should occur as dikes constructed before Mt.Pinatubo eruption. However, the structural measures for the downstream area of Abacan River should be reviewed as the flood events are getting more frequent comparing to before Mt.Pinatubo eruption. The extent of damage is more wide spread than before.

There is no protection measures in the upstream area of Abacan River. Depending on the way the erosion occurs, part of the settlement in Angeles City, especially southern edge of the Clark Air Force Base, will be severely damaged as well as the settlement of Sapang Bato.

(2) Infrastructure

(a) National Highway

Depending on the intensity of mudflow, San Francisco Bridge on the Route 329 should become endangered, or severely damaged with the present structural measures of the Project as mudflow and flood waters; containing the mudflow into relatively narrow course of the river increases velocity of mudflow. Thus rehabilitation, strengthening, or construction of new San Francisco Bridge should be considered.

(b) Rural Roads

The structural measures of the Project would provide the crest of dikes as rural road. Similarly, the access road to the spoil bank would make the remote area accessible with the local means of transportation.

(3) Agricultural Production System

(a) Resuming Agricultural Activities without Fear

With the sense of security, the local residents should feel that they are away from the damaging effects of lahar. This could only be provided by the structural measures of the Project. Thus farmers should obtain more opportunities to practice farming, including diversifying their agricultural activities if necessary.

(b) Availability of Water for Irrigation

Depending on the locations, availability of irrigation water especially in the main course of Sacobia/Bamban and Abacan River will have to be reorganized as diked river banks would limit the farmers access to water for irrigation. Sapang Balen River Improvement Works would divert original course of water way in places and diking would limit the access to the water in the river. Therefore major reorganization of the way the river is used will have to be considered.

(4) Impacts on Local Communities

(a) Protection of Barangays

The most critical impact given by the structural measures of the Project is protection of the badly devastated areas. Thus psychologically stabilizing the mind of people in the Study Area is achieved. This will make them come back to their original habitat and resume activities such s to invest in their homes, farms and other properties. This positive impact would last for as long as the control structures serve their purpose.

(b) Employment Opportunities During the Construction Works

The constructing works of the river improvement structures would require skilled and unskilled laborers. Recruitment of the local residents from the areas where structures would be built would be relatively easy. This would supplement the deficit of income for those who can not resume agricultural activities in the Study Area.

(c) Strengthening the Organization of the Local Communities

Upon completion of the structural measures of the Project, the adjoining communities would be assigned for the task of maintaining and monitoring the conditions of river improvement structures throughout the year. They would thus be given a concrete opportunity to work together with their neighbors for their common goal. This would function to strengthen their cohesiveness among the communities.

(5) Historical and Cultural Sites

There are various historical buildings and the places where archaeological artifacts may be unearthed. There areas are, however, not directly in the areas of structural measures. Thus no significant loss to historical and cultural sites should occur.

(6) Aesthetic Value of Landscape

There is no significant deterioration to the aesthetic value of landscape in the Study Area as a result of the implementatioin of the Project.

11.2.4 ENVIRONMENTAL MANAGEMENT PLAN

(1) Livelihood Program

The livelihood program should be based on the extensive rural development studies based on the present physical conditioins of the Study Area. It is also important that it would be incorporated with a number of studies associated with Mt.Pinatubo recovery program.

One of the alternatives, and most realistic and attractive program, would be to incorporate it with the "Central Luzon Development Program" being conducted by the Department of Trade and Industry in association with JICA assistance.

(2) Soil Rehabilitation Program

Soil fertilization is the most important factor for agriculture in the Project Area. Organic matter build up specifically on the top soil is indispensable for sustained productivity. This can be achieved through:

- enhancement of vegetation;
- artificial input of organic matter;
- composting; and/or
- a combination of the above

(3) Pilot Farming

A lot of agricultural crops suitable to grow in the lahar affected areas could be discovered provided that the proper plant nutrition and moisture is maintained. Spontaneous verification trials have been made in the actual lahar fields within the Study Area. However, this should be given priority with large scale research works based on the scientific and commercial basis and that the associated pilot farming can be implemented. A larger scale of government organization, municipality and up, should be responsible for this scheme.

(4) Irrigation Development

The existing irrigation systems must be reorganized in order to increase cropping intensity. It is particularly important as soil fertility in the Study Area has been drastically changed. It is also necessary as potential changes of the waterway in association with the structural measures of the Project should occur.

11.2.5 ENVIRONMENTAL MONITORING PLAN

(1) Water Quality

Monitoring works for water quality should be conducted at least once a year for the next 5 years until such time that there are no further changes on the facility construction works. Monitoring work on the water quality in the study area should be reviewed according to the engineering measures introduced as it changes the present scope of works.

It is also necessary to conduct water quality monitoring during the peak period of construction works, mainly dry season, as turbidity and other parameters related the to water quality of the rivers in the Study Area is disturbed. It is important to note that demand on water goes up toward the end of dry season while dry season is considered best time for construction works.

(2) Living Condition of Resettlement Areas

Monitoring the living conditions in the resentment centers should be divided into two different phases and areas as follows:

(a) Evacuation Centers

Establishing livelihood program for the local residents in the Study Area should solve most of the problems associated with the present evacuation centers. However, as the present evacuation centers are going to be the "permanent residential area" for most of the evacuees, selected locations should be up-graded as village, or town. Facilities for the area of population concentration, such as dispensary, market place, primary schools, etc. should be constructed.

Which evacuation centers are of permanent nature has not been considered. Thus, monitoring various evacuation centers and assessment of them. Information should be gathered on the conditions that they should be up-graded to village or town. Such information and the result of assessment should be provided to the government organizations concerned with community development.

(b) Permanent Resettlement Areas.

The present living conditions of the evacuation centers may not be drastically improved. However, the present effort to monitor and up-grade where there is a sign of deteriorating standard should be maintained to give them further hopes to reestablish their original life style in the future.

The standard of life in the permanent resettlement areas and the level of achievement on the development for their livelihood should be monitored until such time that the life of the resettling families are stabilized and that their traditional life style is taking root in each resettlement area.

(3) Siltation in the River

Heavily silted areas as a result of lahar deposit should be constantly monitored. Criteria of the depth of Siltation in relation to the possible flooding events and adverse effect to the agricultural activity should be established i.e. "preventive measures" should be established in order to minimize damages to the agricultural areas and the livelihood of the general public. This may be incorporated with the "Early Warning System" being considered to establish within the frame work of the Study. The monitoring work should continue until such time that the Sacobia/Bamban and Abacan River basins are declared as safe for economic activity.

(4) Monitoring of Candaba Swamp

(a) Aquatic Life

Lahar deposit and sedimentation in San Antonio Swamp and Candaba Swamps must be monitored after the rainy season and continuous sampling of mud and silt deposits in these areas for invertebrate animals as they indicate availability of food for aquatic birds in these areas.

(b) Locust

Locust population should also be monitored as they are part of the food sources of insectivorous birds and mammals. It will also help in monitoring the spread of locust to other areas, as these insects are pest to sugarcane, corn and rice.

Locust population should be monitored in the lahar affected areas as they are pest to sugarcane, corn and rice.

(c) Migratory Birds

Migratory bird species using Candaba Swamp and San Antonio Swamp as breeding ground or an intermittent point for resting during the migration along the Pacific Flyway should be conducted. The monitoring should be conducted until such time that the lahar flow and siltation to the water channels are considered permanently ceased.

11.3 EIA STUDY FOR SACOBIA-BAMBAN RIVER BASIN

11.3.1 PHYSICO-CHEMICAL ENVIRONMENT

(1) Morphology of Sacobia/Bamban River

Because of the geological activities of shifting volcanic materials accumulated in the upstream area to the downstream area are stabilizing to a large extent, engineering design to improve Sacobia/Bamban River is considered feasible to implement. Thus, the construction works for permanent structures stabilizing the lower section of the river where agricultural activities are anticipated to reopen can be implemented.

As a result, a section of Sacobia/Bamban River between Route 3 and Route 329 goes under a major rehabilitation works during the next five years. This is the work to fix the course of river channel of Sacobia/Bamban River and the confluence of Sapang Cauayan and Marimla River according to the engineering design.

The newly determined course of the river may be slightly different from the original course of the river before the Mt. Pinatubo eruption. It is also different from the present course of river made after the Mt. Pinatubo eruption. The new course of the river has been determined based on the engineering concept of river improving technology. It is also determined according to the changes of topography made by the volcanic materials transported by the river since the eruption.

The natural environment drastically changed since the eruption is going to be changed as a matter of course. This is to secure the lives of general public which has been in jeopardy for the past five years. After the year 2,000, the river bed of the fixed course of river should be deepened to some extent especially at the confluence of Marimla, Sapang Cauayan and Sacobia/Bamban River. However, the scouring action of the river and its subsequent changes on the river morphology would not cause any disadvantages on the surrounding natural and social environment as a whole.

(2) Morphology of Sapang Balen River

A section of Sapang Balen River to the east of Route 329 has been causing a number of flood to the agricultural and residential areas since the Mt. Pinatubo eruption. This is due to the flow of Sacobia/Bamban River became as wide as the width of Sand Pocket area and that the Sand Pocket area has held up the lahar while flood water had to be released to Sapang Balen River in order to minimize the damages on the structures forming the Sand Pocket area. Thereby the damages by lahar to the residential and agricultural areas to the east of Route 329 are minimized.

In order to improve the situation, fixing the course of Sacobia/Bamban River by structural measures is determined. It also confirmed that the security of Sand Pocket area could be confirmed and that the area is released for agricultural development after the completion of the river improvement works on Sacobia/Bamban River.

The creation of exit to Sacobia/Bamban River and straightening up the course of river of Sapang Balen River are the major changes of the meandering river morphology. However, by these measures, the use of the river as irrigation channel would reorganize the agricultural activities of the area and that agricultural yield is stabilized as risks of flood events are reduced.

(3) Flood Water in Candaba Swamp

There was a speculative thinking during the early stage of the studies conducted for Mt. Pinatubo affected areas that the excessive flood water would overflow into Candaba Swamp from Rio Chico River via Candaba Spillway off Pampanga River. However, because of the natural conditions of the flow of water and volcanic materials on Sacobia/Bamban River has been stabilized to some extent during the past couple of years, it would be very unlikely that the food water generated by Sacobia/Bamban River flows out to Candaba Swamp directly from Rio Chico River.

11.3.2 BIOLOGICAL ENVIRONMENT

(1) Excessive Cutting of Trees on Mt.Arayat

The forested area on the lower half of Mt.Arayat slope, in the area west to northwest of the peak, has been heavily denuded during the past couple of years. As is shown in the Figure 11.1, the area below 450 m contour line within the Mt.Arayat National Park is designated as a part of country wide protection area of "National Integrated Protected Area (NIPAS)" of the Philippines. Cutting trees on the slope of Mt.Arayat is taking place within the NIPAS area of Mt.Arayat.

There are a lot of different reasons that the trees on the slope of Mt.Arayat is felled. The demand on fuelwood and charcoal for cooking in the areas affected by lahar is one of the major reasons as trees are the most inexpensive source of fuel. Because of the income level of the local population affected by lahar has been drastically lowered, many would have to depend on the inexpensive fuel. Table 11.1 shows the number of households using various sources of energy for cooking based on the population census before the Mt.Pinatubo eruption.

The increase of demand on fuelwood and charcoal is approximately 12.5% higher than the period before the eruption of Mt.Pinatubo within the Study Area. This is due to the fact that the evacuees are using fuelwood/charcoal. There are a lot of other people demanding fuelwood in other areas affected by lahar since the eruption of Mt. Pinatubo and subsequent lahar and flood events.

Such areas like Zambales and other municipalities in Pampanga outside the Study Area, especially the area along Pasig-Potrero River, also contain a large number of evacuees demanding fuelwood. Further, because of the transportation disruption, shrinking availability of gas and kerosene has made the small industry hitherto depending on gas and kerosene switched its energy over to fuelwood, which is locally available. As its supply is stable, the demand on fuelwood has gone up by about 20-25% comparing to the period before the Mt.Pinatubo eruption.

The resulted excessive cutting of trees in the forested area on Mt. Arayat will further go up as the population in the Study Area as well as the other areas on the east side of Mt. Pinatubo, such as the area along Pasig-Potrero River will continued to live in the evacuation centers, or else where as increasingly affected by flood. Thus the pressure on the demand of trees on Mt. Arayat, the only source of fuelwood in the area east of Mt. Pinatubo, will not be lowered. This will continue until such time that the living conditions of the population affected by flood and lahar in the area east of Mt. Pinatubo are reinstated as before the Mt. Pinatubo eruption.

(2) Planting Trees for Slope Stabilization

As is shown in the Table 11.2, several species have been selected for slope protection. Seedlings of these species are readily available from the nurseries of the Department of Environment and Natural Resources. Planting these trees in the upstream area of Sacobia/Bamban River should become feasible within the next couple of years as the ground temperatures are lowered.

The Sacobia River Basin Development Corporation, an organization for generating livelihood opportunities for the Aetas would be the nominated organization for executing this work. In addition, there has been an Executive Order No. 263, July 19, 1995, for

Community-Based Forest Management (CBFM) declared to generate forest resources for the local communities across the nation. With a combination of the organization and the executive order, a program in combination of the works of planting trees to serve the dual purposes of community-based forest management and protecting the slope of the upstream area of Sacobia/Bamban River could be conducted as soon as practicable.

(3) Use of Talahib Grass

Talahib (*Saccharum spontaneum*) is considered as a good organic fertilizer as it is cut, piled up, fermented and mixed with soil. As agricultural development programs are conducted in the lahar affected areas within the Study Area, a program to generate organic matter to enhance fertility of the lahar affected soil by using the abundantly growing Talahib grass should be formulated. The irrigation system rehabilitation program would recreate agro-ecological environment and that it with provide the ground cover with agricultural plants. With relatively abundant water surface, especially in the Sand Pocket area, the environment that would generate locust population should disappear. In this respect, abundant growth of Talahib grass is essential in two respect:

a. It contributes to prevent the locust population from exploding and subsequently damage agricultural crops in the adjacent area; and

b. Organic material for enhancing soil fertility is readily available.

(4) Planting Tree/Bamboo for Dike Protection

Planting bamboo on the dikes protecting residential and agricultural areas would be effective not only to increase the rigidness of the dike structure but would also enhance the growth of habitat for wildlife. Thereby bird and other insectivorous species would return to the lahar affected areas. This would also contribute to reduce the risk of locust population explosion to some extent.

(5) Wildlife

The study period on wildlife observation in July 1995 was not the season to observe migratory bird species in Pampanga Delta. However, early migratory bird species of White-Headed Stilt (*Himantopus*), Ruff (*Philomachus pugnax*), Cattle Egret (*Bubulcus ibis*) and Litter Egret (*Egretta garsetta*) have been observed. There are other species such as Gray Heron (*Ardea cinerea*), Purple Heron (*Ardea purpurea*), Pheasant-Tailed Jacana (*Hydrophasianus chirurgus*) have been observed although their number are not large. They are insectivorous birds and considered that they are preying mainly on the locust abundantly breeding in the lahar affected areas.

(6) Generation of Locust Population

As was the case in 1994, extensive generation of locust population in the lahar affected area is likely to occur during the dry seasons in the future because of the vegetation in the lahar affected area as well as the local plantation crop of sugar cane would provide best breeding ground for them.

The pioneer grass species that sprout in the lahar affected area of Talahib (*Saccharum spontaneum*) is a good food producer for locust. Sugar cane widely planted in the Study Area is also a family of Talahib grass, which is good food producer for locust. The lack of insectivorous wildlife, such as snake, lizard, amphibians and bird species since the eruption of Mt. Pinatubo further enhances the explosion of locust population for the years to come. The lack of agricultural activities to spray insecticide should also a part contributing to breed locust in the Study Area.

11.3.3 SOCIAL ENVIRONMENT

(1) Land Acquisition

a. Sand Pocket Area

Acquisition of land in the areas where permanent structures are going to occupy has been in progress. In order to help removal of improvement or the belongings of the land owners, 10,000 Pesos/land owner is been paid. However, the Sand Pocket area of 2,300 ha temporarily used for in order to retard lahar is not subject to land acquisition. Retarding volcanic materials transported by Sacobia River to the area on the right bank of Bamban River between Route 3 and the San Francisco bridge on the Route 329 is considered as temporary measure. It was also a countermeasure to stop the lahar from damaging the residential and agricultural land in the downstream area along Sapang Balen River. There was a consent from the land owners of the Sand pocket area that the retarding coarse volcanic materials in the Sand Pocket area is a temporary measure.

As soon as the purpose of the Sand Pocket area is ceased, the Sand Pocket area is converted to an irrigated agricultural area before it is released to the original land owners. Thus no part of the Sand Pocket area is considered subject to land acquisition by DPWH. Method of the acquisition of land within the Sand Pocket area for developing irrigation system is a separate issue involving Department of Agriculture, National Irrigation Administration, Department of Agrarian Reform, municipal government, and the present land owners who own their land in the Sand Pocket Area. There is a possibility that the Land Bank of the Philippines would also be involved in for the financial arrangement as well as the planning of agricultural development in the sand pocket area.

On the other hand, purchasing the land in the Sand Pocket area for the right-of-way to conduct irrigation scheme may lead to an intricate issues, but not limited to, as follows:

1) There are a number of small land owners in heavy debt who cannot sell the land and re-purchase the land for agriculture;

2) There are those who would rather hold it for speculative sale of land as there would be a townships and a new road is constructed;

3) Farmers returning to the Sand Pocket area simply do not want to sell their land if there is a plan to develop irrigation scheme;

4) Tremendous amount of paper works to clear the land ownership is involved and therefore the small land owners do not want to get involved into it;

In the mean time, the land owners in the Sand Pocket area are kept exempt from the payment of land tax. However, there is no income generated from the land they own for a long period of time while some land owners would still have to pay the credit over the land they intend to own.

The period of payment varies from several years to more than twenty years. The land owners involved in the development of Sand Pocket area would have to wait for many years, counting from the time of Mt.Pinatubo eruption to the expected time of the completion of irrigation development, without major income i.e. their planned payment period is stretched by 14-18 years.

b. Spoil Bank

The excavation of 16.5 million m^3 of material from the section of river between the San Francisco bridge and the confluence of Rio Chico for the 9 year period starting in the year 1996 would require a total area of 1,650 ha. In reality, annual excavation operation would produce 1.8 million m^3 of material. This would need to reclaim 180 ha of land near the area of excavation operation.

Although it is agricultural land, the area swamped during the rain season is available for spoil bank in the Municipality of Magalang. The nominated area is on the right bank of Rio Chico River near the Bamban River. Method of disposal is as follows:

i) Remove top soil from the designated spoil bank during the dry season;
ii) Dispose excavated material into the designated spoil bank;
iii) Back-fill the spoil bank with the top soil as soon as the depth of spoil becomes 1 m;
iv) Repeat the process.

In this way, the fertility of the swamp area, most of them are privately owned agricultural area, will be maintained as much as possible. In many cases, reclamation works would raise the ground level of the agriculture area. Thus the area would be made available for year round farming in place of swamped area during the rain season.

Land acquisition is necessary as a matter of course. At 7.5 Pesos/m^2, the total cost of land acquisition would be 6.75 million Pesos per year, or the total cost of 60.75 million Pesos for the 9 year period. Because of the operation would actually improve the swamp land into the productive year-round agricultural area, the cost of land acquisition can be negotiable.

c. Sapang Balen River

Since the petition was sent to DPWH that the meandering water course of Sapang Balen River should be straitened, and the idea of the petition was agreed under the frame work of the Project, there should not be any problem on the land acquisition. The work involves major reorganization of the farmland area and the riverside area. The riverside area would be sold to the farmers while the farmland would be purchased for dike construction area as well as for river side area. These are the permanent acquisition of land and that there is no inequality involved in it.

(2) Effect of the Overall Agricultural Development Program

Since the engineering design to stabilize the river morphology of Sacobia/Bamban River is conducted in the areas where local agriculture was the major economic activity, what is more important for the people in the lahar affected area is to formulate feasible livelihood program based on agriculture or any program that would support agricultural activities.

As is shown in the Table 11.3, 69 % of the farmers in Tarlac would receive benefit from the Agricultural Development Program of the Project. On the other hand, the farmers in Mabalacat and Angeles are not fully benefited from the program, mainly because their agricultural areas are reduced due to the major morphological changes and the shift of river channel caused by the lahar and the permanent structure measures planned to conduct in the lahar affected area.

As a result, only a fraction of the farmers in Mabalacat will return to agriculture under the Agricultural Development Program associated with the Project. Thus it is essential to generate other job opportunities for the farmers who would not receive benefit from it.

(3) Reinstatement of Route 3

As soon as the conditions of the river and the surrounding areas affected by lahar along Sacobia/Bamban River between Mabalacat and Bamban is stabilized, the Route 3 linking Mabalacat and Bamban is planned to reinstate.

Thereby the road traffic between Mabalacat and Bamban is resumed with relatively short haulage and that the flow of population and commodities should become more smooth than as it is now.

11.3.4 ENVIRONMENTAL MANAGEMENT PROGRAM

(1) Land Acquisition

Voluntary effort of the land owners being patients for offering their land to the Sand Pocket area, although much of the area was a result of natural phenomenon, should be rewarded in some ways. The following suggestions, but not limited to, would be sensible to implement in order to conduct smooth implementation of the structural measures of the Project:

a. Promulgate an urgent presidential decree, based on the public hearing yet to be held, that the right-of-way of the designated areas should be vested at rent free for the designated period of time with DPWH for the purpose of implementing the Project. There should be an option that those who would sell their land is not subject to the decree;

b. Exclusively employ small land owners involved in the measures described in the item a. as above for the construction works related to the Project;

c. Obtain guarantee that the irrigation development is conducted upon completion of the structural measures of the Project from the concerned government agencies, including the guarantee that the small land owners involved in the Sand Pocket operation are exclusively employed for the irrigation project;

d. Guarantee that the remaining credit period of the agricultural area of the original landowner is maintained. This should be based on the thought that the area of the measurement of land whose right-of-way is given for a designated period of time to DPWH should be the same area as before the Mt. Pinatubo eruption.

   Conditions of the guarantee should be that the irrigation facilities are the same or compatible to that of the one existed before the Mt. Pinatubo eruption. Any purchase of land exceeding the area the land owner used to own before the Mt. Pinatubo eruption is subject to the general arrangement of the sale of land under the scheme set forth by the development agency or agencies of the irrigation facilities;

e. Any payment not recoverable for the cost incurred by the irrigation facility development after the sales of land should be split among the municipality and provincial government as well as the central government agencies concerned with the irrigation facility development;

f. Establish task force, or appoint an NGO to deal with the land acquisition which would involve tremendous amount of paper works. The appointed task force or NGO should function as middleman agent that assist farmers to obtain certificate related to the land ownership, tax, debt, etc.

   They should also monitor the performance of the arrangement as suggested above until such time that the irrigation facility development project is completed.

(2) Agriculture Development Program as Major Livelihood Program

Major concern over the livelihood program of the Study Area is agriculture rehabilitation works. As irrigation scheme development, soil rehabilitation program and pilot farming are discussed in the Agricultural Development Program in the Master Plan. Most of the environmental management program related to agriculture is included in it.

(3) Tree Cutting on Mt.Arayat

There is no way to reduce the pressure on the fuelwood supply within the Study Area where there are a lot of evacuation centers are filled up with evacuees. Thus there is no way to reduce pressure on cutting trees on Mt.Arayat.

No afforestation measures would catch up the growth of demand on fuelwood immediately. The only way to reduce pressure on the demand of fuelwood is:

a. to reinstate traffic conditions between Manila and Angeles City as soon as possible;

b. increase job opportunities as much as possible; and

c. generate the flow of LPG gas and kerosene for cooking for those affected by flood and lahar.

The overall performance of the resumption of the above conditions should depend much on the maintenance of the road between Manila and Angeles City as well as the road between Olongapo and Angeles City.

11.3.5 ENVIRONMENTAL MONITORING PROGRAM

(1) Tree Cutting on Mt.Arayat

The rate of tree cutting on Mt. Arayat should be closely monitored in relation to the monitoring on the demand of fuelwood within the Study Area as well as the areas affected by lahar.

(2) Locust Breeding

Locust breeding should be monitored until such time that the breeding grounds are eliminated i.e. agro-ecological conditions are reinstated in the Study Area. Any sign of the explosion of locust population should be dealt well in advance with insecticide where appropriate.

(3) Task Force

A task force should be assigned to monitor the arrangement of developing the thought to designate the Sand Pocket area as the area that the right-of-way of the land owners are relaxed for a designated period of time.

They also monitor the performance of subsequent irrigation facility development and the transfer of the right-of-way to the original land owners as appropriate. The task force can be any government agency such as Mt. Pinatubo Commission, or a local task force unit including NGO specifically formed and appointed to serve for the purpose.

11.4 EIA STUDY FOR ABACAN RIVER BASIN

11.4.1 PHYSICO-CHEMICAL ENVIRONMENT

(1) Abacan River Extension Channel

Abacan River Extension channel, outside of our Study Area, is under construction by DPWH. Since the area is outside of the frame work of the Project, no research works related to the engineering design has been conducted to date. On the other hand, because of the channelization work is conducted urgently in order to prevent the surrounding residential areas in Mexico from flooding since the Mt. Pinatubo eruption, it has been effective for the purpose originally it intended. However, the concept of engineering works and the way the channelization work has been conducted to date has not been made clear.

It appears that the channelization work is to cut through the swamp area to the south of Mexico in order to drain river water further to the swamp area. This is a significant changes on the morphology of the river and the swamp. Subsequently the biological conditions of the swamp and the agricultural activities taking place in the swamp are all significantly affected. In order to prevent the natural environment and the social environment from flooding by uncontrolled flow of the river, separate engineering scheme for the improvement of this portion of Abacan River should be established as soon as possible.

(2) River Improvement Works

The river improvement works for the section of Abacan River between Friendship Bridge and Capaya Bridge, including sabo dam at the downstream of Friendship Bridge, would fix the river morphology when the work is completed. Permanent embankment on both side of the river is designed to safeguard the residential and business areas as much as possible. There is no negative impacts associated with the river improvement works.

(3) Channelization of Abacan River

A small section of the river, approximately 1.5 km upstream from Bailey Bridge to the exit of the river in Mexico is planned to channelize. Approximately 4 million cu.m. of materials is excavated from the section of the river in order to reinstate the flow condition of the river. Although this is the work that would change the morphology of the river, no adverse effect is expected to associate with the excavation. On the contrary, the work would straighten the river channel to make smooth flow of water. Thereby flooding the surrounding area during the rain season is eliminated.

11.4.2 BIOLOGICAL ENVIRONMENT

(1) Wildlife Habitat

No biological environment in the Abacan River Basin is negatively affected as a result of the project implementation. Rehabilitation of sabo dam is believed to provide habitat for the ground dwelling wildlife. However, sabo dams would provide very small fraction of wildlife habitat comparing to the natural environment. Thus there would not be a very high expectation on nurturing wildlife habitat by this particular work.

(2) Planting Tree/Bamboo for Dike Protection

Planting bamboo on the dikes protecting residential and agricultural areas would be effective not only to increase the rigidness of the dike structure but would also enhance the growth of habitat for wildlife. Thereby bird and other insectivorous species would return to the lahar affected areas. This would also contribute to reduce the risk of locust population explosion to some extent.

11.4.3 SOCIAL ENVIRONMENT

(1) Spoil Bank

An area of 200 ha is required for spoil bank in the area near the exit of Abacan River extenuation channel as 2 million cu.m of volcanic materials are excavated from the river between 1996 and 2000. The nominated spoil bank area can be in the swamp area accessible from Mexico. Method of disposing the spoil is as follows:

a. Remove the top soil of the designated swamp area during the dry season;
b. Dispose excavated materials into the designated area;
c. Back-fill the top soil on the spoil;
d. Move to the other area as soon as the depth of spoil reaches to 1 m;
e. Repeat the process until excavation operation is completed.

In this way the fertility of the spoil bank, most of them are privately owned agricultural area, will be maintained as much as possible. Because of the operation would actually improve the swamp land into the productive year-round agricultural area, the cost of compensation for the improvement can be negotiable.

(2) Increasing Security on the Residential and Commercial Areas

The middle reach of Abacan River is subject to further river improvement works in order to stabilize the river channel. This is the measure designed to safeguard the residential and commercial areas on both side of the river at the section between Friendship Bridge and Capaya Bridge. Excavation of the river channel, construction of the dike on both side of the river, and reconstruction of the sabo dam No.9 in the downstream of Friendship Bridge will all function to safeguard the residential and commercial areas on both side of the river. Thus no significant impact on the social environment is expected to induce by these engineering measures.

11.4.4 ENVIRONMENTAL MANAGEMENT PROGRAM

(1) Agriculture Development Program as Livelihood Program

Major concern over the livelihood program of the Study Area is agriculture rehabilitation works. As irrigation scheme development, soil rehabilitation program and pilot farming are discussed in the Agricultural Development Program in the Master Plan. Most of the environmental management program related to agriculture is included in it.

(2) Fuelwood Supply

There is no way to reduce the pressure on the fuelwood supply within the Study Area where there are a lot of evacuation centers are filled up with evacuees. Thus there is no way to reduce pressure on cutting trees on Mt. Arayat. No afforestation measures would catch up the growth of demand on fuelwood immediately. The only way to reduce pressure on the demand of fuelwood is to reinstate traffic conditions between Manila and Angeles City, increase the job opportunities, and generate the flow of LPG gas and kerosene for cooking.

11.4.5 ENVIRONMENTAL MONITORING PROGRAM

The rate of tree cutting on Mt. Arayat should be closely monitored in relation to the monitoring on the demand of fuelwood within the Study Area as well as the areas affected by lahar.

Table 11.1 Households by Source of Fuel for Cooking

a. Before the Eruption

City/Mun.	Electricity	Kerosene	LPG	Charcoal	Wood	Others	None	Total
Pampanga								
Ageles City	2,992	7,803	24,735	4,701	5,528	87	42	45,888
Arayat	296	1,240	2,820	447	7,266	31	-	12,100
Mabalacat	1,427	3,298	12,299	2,006	3,627	51	42	22,750
Magalang	129	677	2,188	351	3,903	127	14	7,389
Mexico	488	1,231	3,116	65	6,332	-	-	11,232
Santa Ana	149	361	1,330	52	3,323	35	-	5,250
Total	5,481	14,610	46,488	7,622	29,979	331	98	104,609
%	5.2	14.0	44.4	7.3	28.7	0.3	0.1	100
Tarlac								
Bamban	179	624	1,814	253	3,320	19	-	6,209
Capas	199	874	1,850	490	6,810	273	51	10,547
Concepcion	455	2,851	3,581	742	8,853	610	-	17,092
Total	833	4,349	7,245	1,485	18,983	902	51	33,848
%	2.5	12.8	21.4	4.4	56.1	2.7	0.2	100.0

Source: 1990 Census of Population and Housing, Report No.3-83C: Socio-economic and Demographic Characteristics

b. After the Eruption

City/Mun.	Electricity	Kerosene	LPG	Charcoal	Wood	Others	None	Total
Pampanga	4,497	11,986	38,140	10,029	39,606	272	80	104,609
%	4.3	11.5	36.5	9.6	37.9	0.3	0.1	100.0
Tarlac	568	2,964	4,938	2,337	22,391	615	35	33,848
%	1.7	8.8	14.6	6.9	66.2	1.8	0.1	100.0

Table 11.2 Species for Slop Protection

Scientific Name	Local/English Name
Acasia auriculiformis A.Cunn. ex Benth.	Japanese Acasia
Pterocurpus inducus Willd.	Narra
Gliricidia sepium (Jacq.) Kunth. ex Walp.	Kakawati
Casuarina equisetifolia J.R.& G.Foster	Agoho
Sesbania grandiflora (L.) Pers.	Katuray
Samanea saman (Jacq.) Merr.	Rain Tree

Table 11.3 Number of Farmers Expected to Receive Benefit from the Agricultural Development

Area	Farmers*	%	Others*	%	Responded*	Population	Estimated No. of Farmers	1*	2*	Total	%
						(1994)				(1*+2*)	
Tarlac											
Bamban	119	7.2	1,528	92.8	1,647	10,123	731	1,132	60	1,192	163.0
Capas	49	7.9	572	92.1	621	19,987	1,577	-	440	440	27.9
Concepcion	139	6.8	1,914	93.2	2,053	58,004	3,927	1,589	1,252	2,841	72.3
Average/Total	307	7.3	4,014	92.7	4,321	88,114	6,428	2,721	1,752	4,473	69.6
Pampanga											
Magalang	134	18.4	594	81.6	728	44,590	8,208	-	64	64	0.8
Arayat	213	14.1	1,299	85.9	1,512	75,496	10,635	-	336	336	3.2
Sta.Ana	69	5.0	1,310	95.0	1,379	33,664	1,684	-	16	16	0.9
Mexico	303	10.2	2,654	89.8	2,957	70,768	7,252	598	54	652	9.0
Angeles	37	1.5	2,430	98.5	2,467	186,290	2,794	-	16	16	0.6
Mabalacat	73	7.3	925	92.7	998	103,029	7,536	-	237	237	3.1
Others	-	0.0	-	0.0	-	-	-	-	575	575	0.0
Average/Total	829	9.4	9,212	90.6	10,041	513,837	48,437	598	1,298	1,896	3.9

Note: Populatin data is based on the Resettlement/Evacuatioin, Appendix M, Intarim Report (2), March 1995.
Farmers/Others/Responded* - Number of unemployed farmers/others responded during the Resettlement/Evacuation survey

1* - No. of farmers expected to own agricultural area under the scheme of Proposed CIP Project

2* - No. of farmers expected to own agricultural area under the scheme of Urgent Irrigation Scheme Rehabilitation

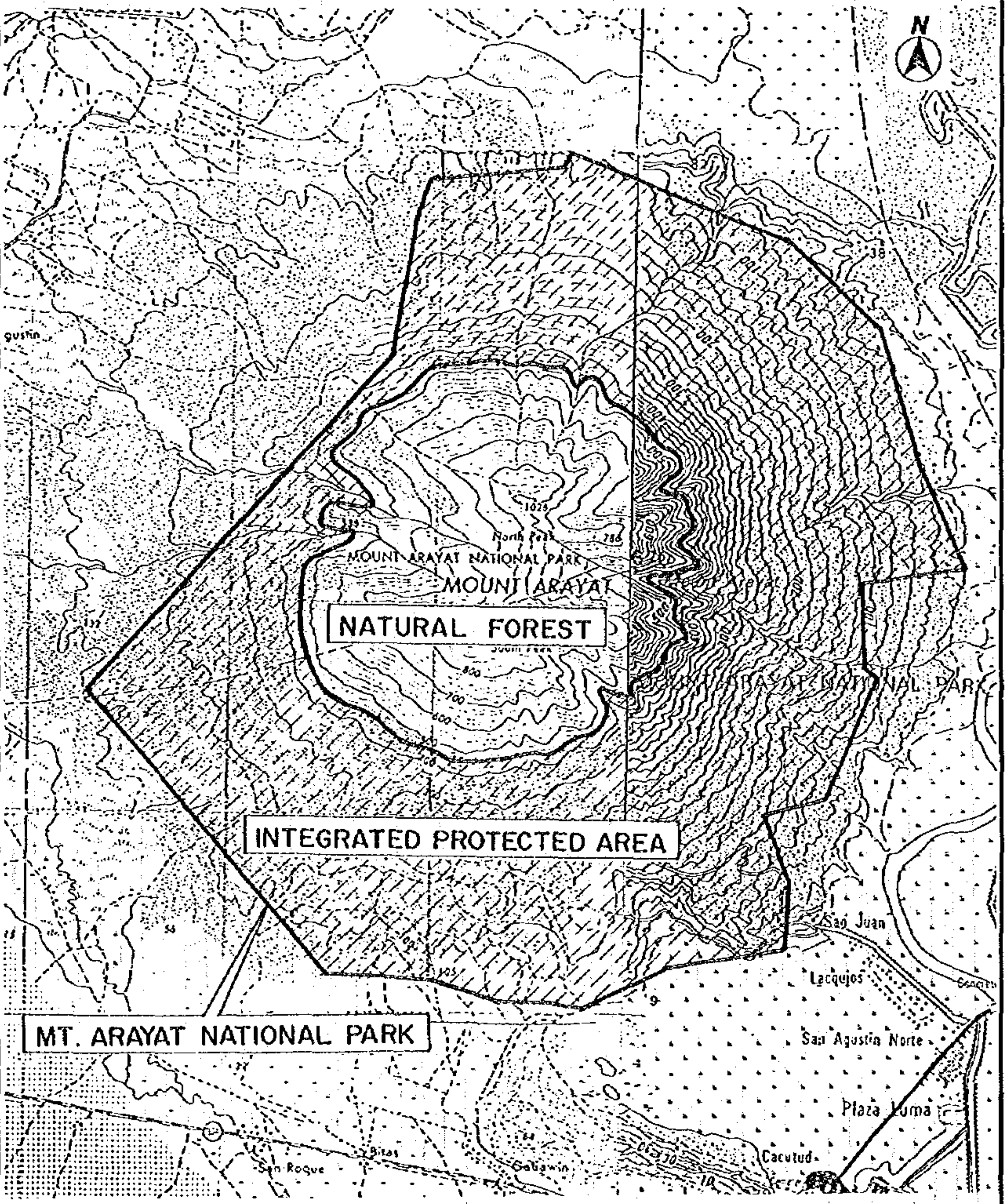


Figure 11.1 National Integrated Protected Area within Mt. Arayat National Park

THE GOVERNMENT OF THE PHILIPPINES
THE DEPARTMENT OF PUBLIC WORKS AND HIGHWAYS
THE STUDY ON FLOOD AND MUDFLOW CONTROL FOR SACOBIA-BAMBAN/ABACAN RIVER DRAINING FROM MT.PINATUBO
JAPAN INTERNATIONAL COOPERATION AGENCY

CHAPTER 12

SEDIMENT MONITORING IN PASIG RIVER

CHAPTER 12 SEDIMENT MONITORING IN PASIG RIVER

12.1 GEOMORPHOLOGIC CHANGES AFTER ERUPTION

(1) Pre-eruption Condition

Before the 1991 eruption, the Pasig headwaters were drained by four streams; Bucbuc, Yangca, Timbu, and Papatac creeks as shown in Figure 12.1. The river channel incised into a gently sloping alluvial fan consisting primarily of pre-1991 lahar and alluvial deposits. The stretch from the Angeles-Porac road to about Highway 7 (San Fernando - Olongapo road) has caused damage to farmlands and barangays. The Pasig River flows into the Pasac-Guagua River, which pours into Pampanga Bay. This delta reach is flat and consists of silts and fine sand.

(2) Immediately after the Eruption

On June 15, 1991, pyroclastic flow cascaded down the eastern slope from the crater of Mt.Pinatubo. Pyroclastic flow material of 430 million m^3 of 180 to 200 m high deposited in the deep valley in the Bucbuc drainage. Outside of the canyon, the pyroclastic deposits were observed at only 10 to 20 m deep.

Lahar occurred immediately after the climactic eruption on June 15. According to the observation by PHIVOLCS, the early flows were reported to be almost certainly more dilute and thus more erosive than those later in the June-September period, reflecting the gradual integration of the drainage system on the vast pyroclastic flow deposits upstream and the consequent increase in sediment conveyance.

(3) 1991 Lahar Events

The riverbed scouring began with flows associated with the eruption, and the Mancatian bridge was destroyed shortly thereafter. The scouring of 15 m was recorded at Mancatian during August 1991.

The most destructive lahar in 1991 occurred on September 7. The Yangca creek choked by the riverbed aggradation of Bucbuc creek with approximately 5 million m^3 of pyroclastic flow material of 400 m wide. It functioned as a dam, and the volume grew to approximate 10 million m^3 before its failure on September 7. The lahar due to the failure of dammed lake caused the erosion of an additional 10 to 15 million m^3 in the downstream reach. Then, the channel of Papatac Creek was scoured to as much as 20 m below its pre-eruption riverbed, while the riverbeds of Timbu Creek and the Pasig River were eroded 5 to 10 m as far downstream as Mancatian. This lahar buried parts of the town of Bacolor with 1 to 3 m deep.

(4) 1992 Lahar Events

A second blockage formed in early August 1992 as the result of a large secondary pyroclastic flow along Papatac Creek. This blockage was larger than the 1991 blockage, and more than 20 million m^3 of material filled the confluence area and Papatac Creek as far downstream as its confluence with Timbu Creek. Storms on August 29 to 30 and on September 3 to 4 transported the sediment of 10 million m^3 to the lower Pasig river basin. Deposition filled the channel around Mancatian. Mudflow deposits in the overbanked areas were 1 to 2 m deep around Mitla, Porac and about 0.5 m near Balas, Bacolor. To ensure the passability of Highway 7 , the road was raised by several meters before the onset of the 1992 rainy season.

(5) 1993 Lahar Events

Typhoon on August 17 caused a mudflow and 3 to 5 million m^3 of deposition around Mancatian. The deposits filled the channel for about 1 km upstream of Mancatian and damaged the northern portion of the barangay. Flooding occurred in Santa Rita, where lahar flowed through an uncompleted portion of the dike.

On October 4, 1993, typhoon Kadiang caused hyperconcentrated flows and mudflows that delivered another 20 to 25 million m^3 of material to the lower alluvial fan. Most of the sediment was deposited in the southern overbank from Mancatian, Porac to San Isidro, Santa Rita. During this event, furthermore, large scale landslide triggered by a secondary explosion in the upstream reach of the Sacobia River, and the Sacobia headwaters of 23 km^2 swerved into the Pasig-Potrero river basin . Figure 12.1 also shows the topographic changes in the uppermost reach.

(6) 1994 Lahar Events

From the beginning of the 1994 rainy season, the lahar activity of the Pasig-Potrero River had intensified because that the increased catchment area of 23 km^2 with annexed pyroclastic flow deposits of 320 million m^3. The secondary pyroclastis flows from annexed pyroclastic flow deposit field resulted not only the dammed lake of the Yangca creek but also swerved into the Timbu creek drainage astride thin ridge. As a result of the massive movement of secondary pyroclastic flows, the valley from Timbu Creek down to Watch Point No.5 had been fully buried with sediment of about 30 to 100 m deep, of which the accumulated sediment volume in the Timbu valley was estimated at about 37 million m^3.

Meanwhile, the dammed lake at the mouth of Yangca Creek grew with impounded water of 3 million m^3 as of August. The failure of dammed lake on September 23 due to the passage of typhoon eroded an enormous volume of clogged sediment involving impounded water. This lahar incised a wide and deep channel along the Pasig River, moved to the east around Manibaug, and breached the left secondary dike about 500 m downstream of the Angeles-Porac road. The lahar deposition in 1994 along the Pasig River was observed mainly in Bacolor.

12.2 STRUCTURAL MEASURES

River improvement works and sediment control measures had been undertaken by DPWH, before the 1991 eruption in the Pasig River. Major structures were dike with dry masonry in a stretch of about 4 km upstream of the Angeles-Porac road to the mouth on the right bank and about 2 km downstream of the road to the mouth on the left bank as shown in Figure 12.2, and three sabo dams, of which two sabo dams were built on Papatac Creek and one was built on Timbu Creek. These dams were effective to store the secondary pyroclastis immediately after the eruption. However, the dams were colapsed due to tremendous volume of lahar beyond the design condition.

DPWH commenced to build the lahar retention dike in 1993, although DPWH concentrated to the rehabilitation works for the damaged primary dike which was 4 m high and desilting its channel in order to confine the lahar into this channel.

After the 1993 rainy season, the secondary dike system of 6 m high was completed partially expanding the inner area of the primary dike system. Since the riverbed from the confluence of Timbu and Papatac creeks to around Mancatian rapidly raised due to the enormous volume of lahar deposition by the middle of the 1994 rainy season, the left secondary dike was extended to Watch Point 5 to prevent lahars from intrusion into the

Angeles City area. In addition, the construction of right tertiary dike was also commenced at the same time.

During the 1994 rainy season the inner area between the secondary dikes were completely filled up near Maliwalu, Bacolor, about 3 km upstream of the Angeles-Porac road. Furthermore, the September 23 lahar caused by lake breakout of Yangca Creek encroached and entered Gugu Creek far beyond the secondary dike.

After the 1994 rainy season DPWH commenced construction of the Gugu tertiary dike, the Maliwalu-Bulu dike and the secondary dike upstream of the Angeles-Porac road up to the hillside on the right bank. Although the tertiary dike system was almost completed before the onset of the 1995 rainy season, the first big-scale lahar on June 1 to 7 in 1995 easily breached the Gugu tertiary dike about 1 km downstream of the Angeles-Porac road because of no slope protection works. In the June to July lahar events, dike breached frequently around the Angeles-Porac road on the left bank, while the right tertiary dike was not damaged in 1995 because the right bank received only a few lahars.

After the dike breach about 300 m upstream of the downstream end of the Gugu tertiary dike on August 21,1995 the situation in the whole stretch of the Pasig-Potrero River has drastically changed. The active channel deeply incised into not only the lahar deposits after the 1991 eruption but also pre-eruption alluvial deposits, and frequently meandered over the deposits. As the result, many portions of the Gugu tertiary dike were completely eroded or damaged in a stretch of about 2 km downstream of the Angeles-Porac road to its downstream end.

12.3 LAHAR MONITORING IN 1995

(1) June 1 to 7 Lahars

During the June 1 lahar event triggered by the hourly rainfall of 32 mm/hr, the left secondary dike was breached at the junction with the Angeles-Porac road, and the Gugu tertiary dike was also washed out near Calzadang Bayu, Porac, while lahar flow overtopped the right secondary dike on June 7 along the old channel. The sediment deposition area is illustrated in Figure 12.3. According to the PHIVOLCS observation, at least 0.5 to 1 m thick of material was deposited after the secondary dike breach, and in the area downstream of the Angeles-Porac road at least 0.75 m thick of deposition was found by spot survey.

(2) July 7 to 11 Lahars

The frequent evening showers from the beginning of July may have saturated the subsurface of the Pasig-Potrero headwaters, and lahar occurred even by small-scale rainfall in the middle of July. A great amount of mudflow or hyperconcentrated flow continued for 0.5 to 1.5 hours with high sediment concentration of more than 50% by volume according to the PHIVOLCS data and the field sampling.

Lahar flow overtopped and washed away the left secondary dike about 2 km upstream of the Angeles-Porac road, and then breached two stretches of the Gugu tertiary dike downstream of the road. Figure 12.4 also illustrates the sediment deposited area in this event. The estimated volume of sediment deposition was some 5 million m^3 on the basis of the interview and spot marking survey.

(3) July 18 Lahar

The lahar was triggered by short-duration rainfall with moderate intensity of 60 mm from 17:30 to 18:30 on July 18. At 18:50, lahar flow of 3.7 m deep was observed at Watch Point 5. Then at 19:40 lahar of 2.4 m deep flowed in the center channel at Mancatian, while another flow 1.2 m deep was observed toward the Gugu tertiary dike, as reported by DPWH. Figure 12.5 presents the sediment deposited area in this event. The estimated volume of sediment deposition was some 2 million m^3 on the inner area along the right tertiary dike, while there was no significant deposit on the upstream area of the Maliwalu-Bulu dike. After this event, the freeboard of Sta. Barbara bridge was reduced to about 0.4 m in the center.

(4) July 27 to 30 Lahars

The destructive lahar on July 30 was triggered by the passage of Typhoon Karing. Figure F.34 shows the typical hyetograph and lahar hydrograph on July 30 observed by the PHIVOLCS telemetry system. The left secondary dike was breached at about 3 km upstream of the Angeles-Porac road. Then the Gugu tertiary dike was also breached over a 1 km stretch around the Angeles-Porac road. The lahar flowed down along the course of Gugu Creek and a part of lahar finally entered Palawe Creek. This lahar, for the first time, encroached the eastern areas beyond Gugu Creek that were previously unaffected. Another flow ran down along the Gugu tertiary dike and the Maliwalu-Bulu dike and deposited much material inside of the dike system. In the downstream reach the lahar overtopped the Santa Barbara bridge and the immediately upstream left dike. The area of sediment deposition in this event is shown in Figure 12.6.

The July 27 to 30 lahar was the last lahar event that breached the tertiary dike around the Angeles-Porac road in 1995. During this event, significant channel incision started from the fan apex, around Delta 5, toward the downstream reaches. Furthermore, based on the ocular investigation, the sediment concentration of lahar may have become lower than the previous mudflows after this event so that the sediment transport mechanisms in the subsequent lahar events may be hyperconcentrated flow. The estimated volume of sediment deposition is about 15 million m^3 based on the interview and spot marking survey.

(5) August 15 to 19 Lahars

The August 15 to 19 lahar event was not large, but it was the only case where lahar material was deposited on the right bank of the Pasig-Potrero River in 1995 as shown Figure 12.7. On August 17, lahar flow buried and overtopped the Santa Barbara bridge of Highway 7 with 0.5 m thick deposits. Lahar material accumulated behind the dammed bridge, and finally a low portion of the right dike 200 m upstream of the bridge was breached. Subsequent lahars had followed through this breached portion and spread out over the low-lying areas. In addition, these lahars accumulated a maximum of 4 m thick inside the lower stretch of the Gugu tertiary dike.

(6) August 28 to September 3 Lahars

After the August 15 to 19 lahar event, the lower part of the catch basin enclosed by the Gugu tertiary dike was filled up with lahar deposits, and serious lateral erosion was observed at some portions along the lower part of the dike. Finally, on August 21, the Gugu tertiary dike 300 m upstream from its downstream end was breached by flood water.

The August 28 to September 3 lahars, which were triggered by Typhoon Gening and Helming, followed through this path to the downstream areas, and then completely buried Bacolor town proper. The lahars also buried or swept out Highway 7 over a stretch between the Santa Barbara bridge and a bridge of Gugu Creek. The field survey could not be conducted until early October because of poor accessibility into the affected area. The area of sediment deposition in this event is presented in Figure 12.8 on the basis of the field survey results on October 3 to 4.

During this event deep channel incision proceeded not only along the Pasig-Potrero River but also along Timbu Creek. The active channel after this event was found to be 100 m wide and 15 to 20 m deep from Delta 5 to the Angeles-Porac road, and 50 to 70 m wide and 6 to 12 m deep downstream of the Angeles-Porac road. On September 9 the Gugu tertiary dike about 1 km upstream of the August 21 breach point was newly breached by progressive bank erosion, and then flood water from the Pasig River spread out through this path so that sediment deposition extended wider to the eastern areas near Gugu Creek. This effect is also reflected in Figure 12.8.

(7) September 30 to October 1 Lahars

The active channel incised deeply on the sediment deposit surface even by 4 to 6 m at the dike breach point. In order to prevent the expansion of flooding area, DPWH had tried to divert surface water back into the center channel about 3 km upstream of the Maliwalu-Bulu dike since the August 21 dike breach event. In late September the diversion was successfully completed to discharge surface water into the center channel.

The September 30 to October 1 lahars occurred due to the passage of Typhoon Mameng. The daily rainfall of 250 mm was recorded at upper Sacobia station on October 1 . The passage of Typhoon Mameng triggered five moderate to big scale lahars that affected the low-lying areas in Bacolor and San Fernando. The most severely affected area was Barangay Cabalantian, Bacolor where deposits are as much as 4 to 5 m thick. The affected areas expanded beyond Palawe Creek and the San Fernando River as shown in Figure 12.9. The estimated volume of sediment deposition is about 22 million m^3 on the basis of the interview survey conducted on October 3 to 4.

During this event flood water heavily re-eroded lahar deposits, which were accumulated in the previous events, in lateral and vertical directions. The Pasig river channel meandered with sharp bends inside of the dike system from Watch Point 5 to the downstream end of the Gugu tertiary dike. The flood runoff breached the Gugu tertiary dike near the September 9 breach point, and then traversed the Gugu creek dike toward San Fernando.

12.4 GEOMORPHOLOGIC CONDITION IN 1995

12.4.1 LAHAR DISASTER AREA

Based on the lahar monitoring survey results, the lahar disaster map was made overlaying the previous lahar deposited areas as shown in Figure 12.10. The affected areas by year are as follows:

Year	Newly Affected Area
1991	37 km^2
1992	6 km^2
1993	5 km^2
1994	30 km^2
1995	19 km^2
Total	97 km^2

The areas affected incrementally by lahars tend to expand mainly southeastern-ward in the 1994 and 1995 rainy seasons after capturing the Sacobia headwaters.

Table 12.1 summarizes the major lahar events in 1995 and 86 million m^3 of sediment deposition in 1995 was estimated. As mentioned in the lahar events in 1995, a remarkable amount of channel erosion occurred in a whole stretch during the 1995 rainy season. In order to estimate this volume, simple cross-sectional survey with an interval of 1 km was conducted in September and in mid-October. Table 12.2 summarizes the survey results and 41 million m^3 of channel erosion volume was estimated. Comparing both figures, 45 million m^3 in volume was computed as a source material transported from the pyroclastic flow deposits.

Regarding sediment transport capacity along the Pasig-Potrero River, sediment sampling and test were conducted at the three sampling points, Delta 5, Mancatian along the Angeles-Porac road, and the Santa Barbara bridge. The results are illustrated in Figure 12.11. Sediment sampling observed two times of high sediment concentration flow with a longitudinal change. The results present a clear contrast of sediment transport mechanism as follows:

(1) The June 3 lahar with sediment concentration of 58% by volume reached the domain of mudflow at Delta 5 (2 to 3% in slope), but sediment concentration reduced to 27% when the flow traveled to Mancatian (about 1% in slope).

(2) Sediment concentration of the August 25 lahar became higher as the flow ran down to Mancatian; sediment concentration of 30% was observed even at the Santa Barbara bridge (0.2 to 0.3% in slope).

These characteristics of lahar may be due to the difference between mudflow and hyperconcentrated flow. The results indicate the following facts as often observed in the field:

(1) Mudflow can reach up to the Angeles-Porac road, then reduce its concentration with some deposition or overtop the dike and form a natural levee as a deposition if the lahar is big-scale.

(2) Hyperconcentrated flow can increase sediment concentration through entrainment of sediment supply by bank erosion on the riverbed of even 1% in slope.

(3) Hyperconcentrated flow can travel to the lower reaches of 0.2 to 0.3% in slope, if it flows down in the confined channel without shallow overbanking outflow.

Figure 12.11 also shows the typical results of sediment material test in scale. The bulk density was estimated at 1.8 to 1.9 ton/m^3 of the June 3 lahar at Delta 5 and of the August 25 lahar at Mancatian, while it was estimated at 1.6 ton/m^3 of the August 25 lahar at the Santa Barbara bridge. The contents of transported material are summarized below.

Type of Material (Particle Size Range)	Delta 5 on June 3	Lahar Material Mancatian on Aug. 25	Sta. Barbara Br. on Aug. 25
Gravel (2 to 32 mm)	19 %	14 %	15 %
Sand (1/16 to 2 mm)	69 %	65 %	51 %
Silt (<1/16 mm)	12 %	21 %	34 %

12.4.2 SITUATION OF SEDIMENT SOURCE AREA

In the early 1994 rainy season, the river course of Bucbuc Creek was diverted from the clogged Papatac Creek into Timbu Creek, then secondary pyroclastic flow deposits of about 37 million m^3 accumulated in the Timbu valley. Timbu Creek has no natural narrow path along its valley except for its constricted outlet, while Papatac Creek has a long narrow path downstream of the confluence with Yangca Creek. In addition to increase of surface water by capture of the Sacobia headwaters, the diversion of Bucbuc Creek into Timbu Creek has intensified the lahar activity.

After this massive movement of secondary pyroclastic flows into Timbu Creek, lahars generated in the headwaters have been increasing in size by involving deposits along the

Timbu valley. A field investigation was made on Timbu Creek on September 28 to clarify the situation of erosion, and an aerial survey was conducted on October 6, 1995 to verify the change caused by Typhoon Mameng. At the Timbu creek channel, it was observed that deep incision and wide lateral erosion had developed on the secondary pyroclastic flow deposits by 30 m deep and 200 m wide immediately upstream of the downmost constriction, and by 40 m deep and 100 m wide about 2.5 km upstream. Surface water of Timbu Creek flows down braiding on such wide and flat beds.

From the results of those surveys, it is estimated that about 20 million m^3 of secondary pyroclastic material was eroded and transported downstream during the 1995 rainy season. Based on this estimation, almost half of the 45 million m^3 source material was transported from the Bucbuc Creek drainage and the former Sacobia headwaters, while the remaining half was re-mobilized from the secondary pyroclastic deposit on Timbu Creek. As a result of heavy erosion during the 1995 rainy season, the secondary pyroclastic flow deposits on Timbu Creek were reduced by half.

Regarding the possibility of re-capture of the headwaters by the Sacobia River, it was found by the aerial survey that the difference of elevation between both river courses around the piracy point became bigger, extending more than 100 m. This indicates that there is only a little likelihood of re-capture for the time being.

12.4.3 RIVERBED FLUCTUATION

After the 1991 eruption, the Pasig River channel frequently and rapidly fluctuated under the influence of the big-scale lahar events that occurred in the headwaters such as secondary pyroclastic flow, blockage and lake failure, and river piracy.

Figure 12.12 presents changes of the Pasig-Potrero riverbed from pre-eruption as a longitudinal profile. The riverbed around Watch Point 5 aggraded 20 m higher in 5 months from March to August 1994, while the riverbed around the Angeles-Porac road was raised by only 2 to 4 m for the same period. The figure indicates that there are clear hinge points, at which channel slope increases, about 2 km upstream of the Santa Barbara bridge, near Dolores in Bacolor, and near the Angeles-Porac road. Around those points there is a tendency of frequent occurrence of overtopping and dike breach because decrease of sediment transport capacity causes sediment deposition and channel aggradation around the hinge point due to change of riverbed gradient.

After the July 28 to 30 lahar event, the river channel development process around Watch Point 5 apparently changed to erosion of deepening and widening. This process has rapidly influenced the whole stretch of the Pasig-Potrero River since the downstream end of the Gugu tertiary was breached on August 21.

During the passage of Typhoon Mameng on October 1, the river course heavily meandered with many sharp bends, and incised pre-eruption deposits, and was widened by headward and lateral erosion as shown in Figure 12.13. The Pasig-Potrero river channel was incised by 15 to 30 m in the stretch of Watch Point 5 up to the Angeles-Porac road for the period from July to October 1995 as shown in Figure 12.12. Those river-morphologic changes may be a sign of rapid decrease of sediment supply from the source areas of EPPFF.

12.4.4 RIVER MEANDERING

As diminishing the sediment supply from the upstream reach, the Pasig-Potrero river channel also meanders frequently in the stretch between Watch Point 5 and Gugu tertiary dike. According to the field observation in 1995, the following phenomena may predominate to the occurrence of meandering.

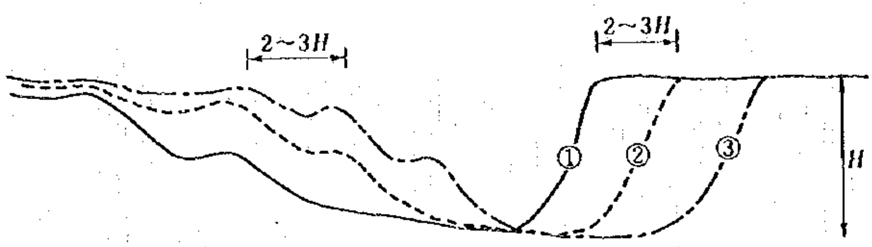
(1) Blockage by old pyroclastic flow deposit

In the meandering portion where the river channel changes sharply its flow direction, the yellowish old pyroclastic flow deposits with rather hardened materials were frequently identified at the bottom of river bank. The difference of cohesion/hardness between pyroclastic flow deposits of 2,000 years ago and those in 1991 may result in sharp meandering of river channel.

(2) Collapse of River Bank

The collapse of river bank was identified immediately after medium-scale flooding along the river channel. These collapsed river banks may trigger the sudden change of river channel with sharp bend.

Also, the following figure shows the schematic diagram of formation of river terrace and linear erosion (K.Yamamoto,"Alluvial River Morphology",1994):



The figure shows the linear concentration of river flow including groundwater erodes the opposite bank and the river channel swerves into the vicinity of opposite bank. Then, further deepening of river channel occurs. According to the field observation in the Beatton River in Canada and the Teshio River in Japan, the horizontal distance between linear erosions is identified at two to three times height of river bank. The volume of bank collapse is almost equivalent to the erosion rate by predominant flood of once in 20-years, and the time interval of development of linear erosion is estimated at 27 years in the Beatton River and 20 years in the Teshio River..

12.4.5 DEEPENING OF RIVER CHANNEL

As shown in Figure 12.12, the riverbed gradient is kept at 1/55 to 1/60 (about 1 degree) in the upstream reach from Watch Point No.5 down to Angeles-Porac road. In this stretch, the riverbed slope is rather smooth without any change of riverbed slope where sediment deposition occurs. The deepening of this stretch is depend on the change of relative height when the river channel swerved along the Gugu tertiary dike in September 1995. The deepening progressed down to Gugu tertiary dike (8 km in the Figure 12.12) with a slope of 1/130 to 1/140 (about 4 degree).

In case that the reinforcement/reconstruction of dike is carried out around the downstream reach, the downstream area will function as catch basin for sedimentation. As far as the sediment deposition surface is kept by the catch basin, the riverbed slope may be kept in the upstream stretch from Angeles-Porac road and the deepening of river channel in the downstream from Angeles-Porac road may be terminated.

As for deepening of river channel in the uppermost reach, many lateral holes were observed at the lower part of river bank above water surface when the riverbed incised suddenly. The riverbed may be deepened in accordance with the lowering of groundwater level at both banks.

12.5 FUTURE PROSPECT OF SEDIMENT DELIVERY

12.5.1 ANNUAL SEDIMENT DELIVERY FROM SOURCE MATERIAL

Regression analysis was made using the actual sediment deposition data combining each deposit among the Sacobia, Abacan and Pasig basins as shown in Figure 12.14. Sediment delivery in 1996 was statistically estimated at 34 million m^3 from EPPFF. As for sediment delivery to the Sacobia River, its volume in 1996 may be negligible taking into account the actual lahar deposit of about 4 million m^3 in 1995 by comparison. Thus, 34 million m^3 of lahar material is expected to be delivered mainly along the Pasig River system in the 1996 rainy season.

Before the onset of the 1995 rainy season, the remaining pyroclastic flow deposits were estimated at 475 million m^3. Out of this amount of material, 37 million m^3 of material was already re-mobilized onto Timbu Creek by secondary pyroclastic flows in the early 1994 rainy season. During the 1995 rainy season, 25 million m^3 of lahar material was transported from the former Bucbuc and Upper Sacobia drainage, while 20 million m^3 of lahar material was eroded from the deposits accumulated on Timbu Creek. Thus, the remaining potential sources to be delivered in the future are 413 million m^3 in the upper drainage and 17 million m^3 on Timbu Creek. If the attenuation rate of 0.46, which was figured out dividing 17 million m^3 by 37 million m^3, could be adopted only to the deposited material on Timbu Creek, 9 million m^3 of secondary pyroclastic material may be eroded in 1996.

Mudflows are generally formed by the collapse of high, hot pyroclastic banks into rapidly moving storm runoff in confined channels. The secondary explosions also contribute to the formation of mudflows by the sudden supply of enormous loosened material into the storm runoff. Based on the aerial survey of the headwaters, the predominant processes of channel development had been deepening and widening, and the previously confined deep channels had become wider so that chances of mudflow formation might have rapidly reduced. Table 12.3 and Figure 12.15 summarize the events of lahar and secondary explosion observed by PHIVOLCS.

This figure indicates the occurrence of big-scale lahar in 1995 has rapidly diminished in comparison to the 1994 situation. Furthermore, a number of big-scale secondary explosions has also reduced by one fourth in 1995 compared with the 1994 events as shown in Table 12.3, and massive movement of secondary pyroclastic flows was not found through the aerial surveys during the 1995 rainy season.

These facts indicate that the source material has become gradually stable and chances of mudflow formation also may have been drastically reduced. Thus, the predominant sediment transport processes could be forecasted as hyperconcentrated flow and muddy water in the 1996 rainy season.

In accordance with the change of predominant sediment transport processes, material transported from the upper drainage areas may decrease by half based on the difference of sediment transport concentrations between mudflow and hyperconcentrated flow. Thus, 13 million m^3 of pyroclastic material is predicted to be delivered from the upper drainage areas.

Based on the field investigation and the comparative consideration of the actual sediment delivery in 1995, 22 million m^3 of source material is estimated to be delivered in 1996. On the other hand, sediment delivery in 1996 is statistically estimated at about 34 million m^3. Combining both results, 22 to 34 million m^3 of source material will be transported from the headwaters in 1995.

12.5.2 SEDIMENT DELIVERY IN 1996

As shown in Figure 12.13, once big-scale hyperconcentrated flow or storm runoff occurs, frequent and sharp meandering will develop through heavy lateral and headward erosion along the river course. According to the field survey results, almost half of the sediment deposits in 1995 has been supplied from these processes. Since chances of mudflow formation has been drastically reduced in the headwaters, the existing deep and wide channels on the alluvial fan are unlikely to be filled up again by massive mudflow in the 1996 rainy season. Therefore, widening and down-cutting channel development may continue in 1996. Although the magnitude of channel erosion will gradually subside and become stable in the future, heavy erosion and meandering is expected to continue for the time being.

The volume of channel erosion apparently depends on the frequency of new river course development and intensity of meandering. Up to the present, the actual sediment transport capacity in the Pasig-Potrero River shows a big difference from the hydraulic estimate using bed load and suspended load transport equations. Assuming that the maximum volume is produced by the same processes as 1995, newly forming incised channel and meandering, 41 million m^3 of channel erosion is estimated, the same amount as in 1995. Assuming that a minimum volume is produced by a half wavelength progress of meandering and burying old channel by half which is a natural tendency of progressive meandering based on the field observation, 21 million m^3 of channel erosion is estimated, half of the 1995 erosion rate.

As summarized above, sediment delivery of 22 to 34 million m^3 from the source material and 21 to 41 million m^3 by channel erosion are predicted for the 1996 rainy season. In total, 43 to 75 million m^3 of sediment will be transported to the downstream reaches and bury the low-lying areas if proper countermeasures are not taken. These predictions are based on average conditions, so that weather disturbances may cause some deviations from the predictions.

12.5.3 LAHARS UNDER 1995 TOPOGRAPHIC CONDITION IN PASIG RIVER

The flow and sediment transport in 1995 was simulated based on the topographic condition simulated in the previous section under the following condition.

Topographic data	:	DTM produced in the 1994 simulation study	
	:	Area of analysis	27 km x 10 km
	:	Mesh size	100 m x 100 m
Hydrograph	:	Combination of three hydrographs	
		Peak discharges	1000 m^3/s, 500 m^3/s and 100 m^3/s
	:	Triangular shape of 5 hours duration for each hydrograph	
	:	One year simulation equivalent to 5 cycles	
	:	Sediment concentration	= 30 % for 1000 m^3/s, 10 % for 500 m^3/s and 5 % for 100 m^3/s

On the basis of the field observation in 1995, it was assumed that the sediment concentrations of lahars were lower in 1995 than those in 1994. The total flow amount in this study was equivalent to 14.4 million m^3 including 32 million m^3 of sediment and 112 million m^3 of water in volume. Figure 12.16 shows the distribution of the maximum water depth on the topographic map. The results can also be compared with the chronological changes of Pasig river basin in 1995. The lahar flows were shifting towards the left hand direction downstream of the Angeles Porac road in 1995 and the situation was well expressed in the simulation study. The break of GSO highway,