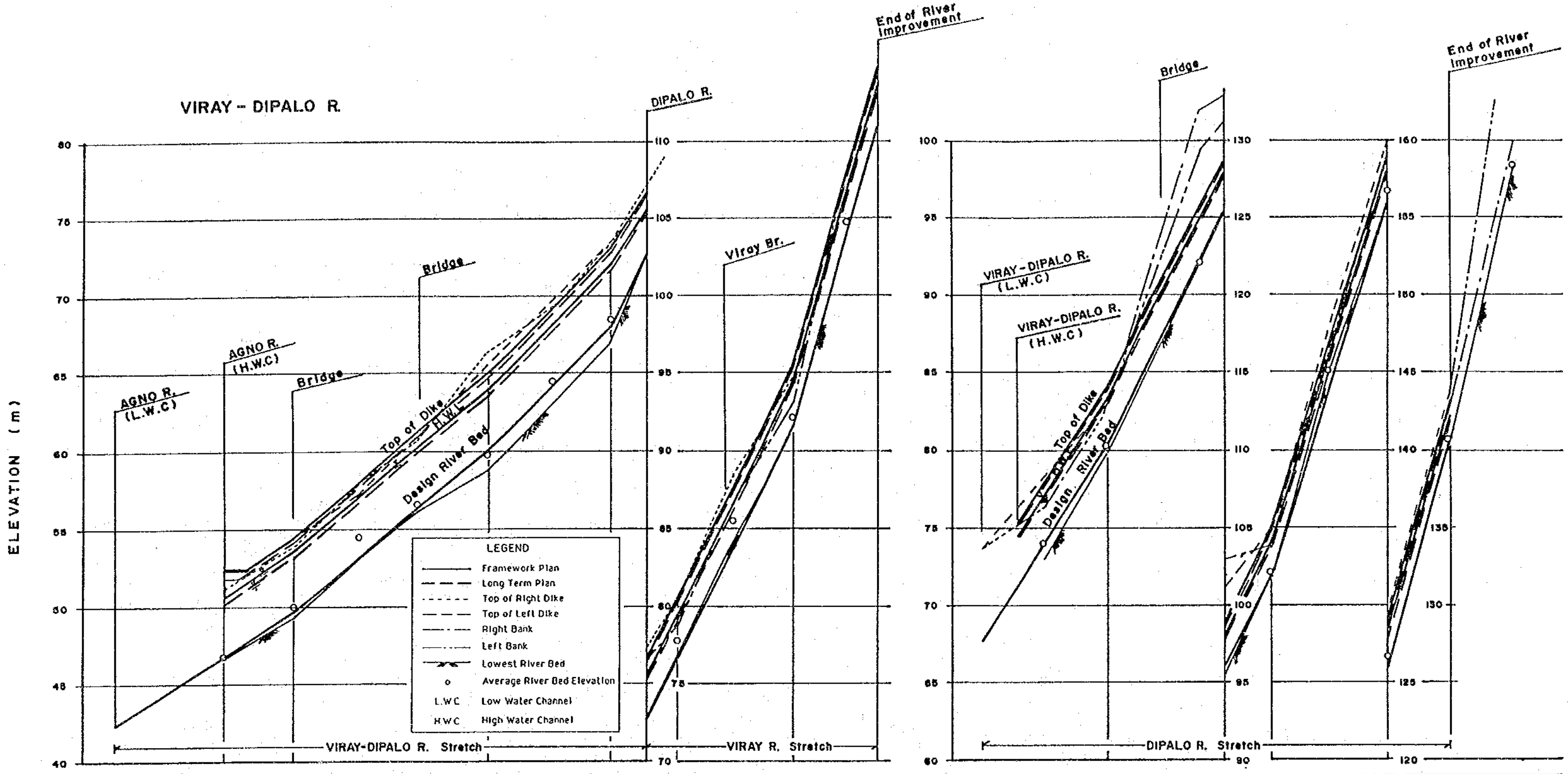
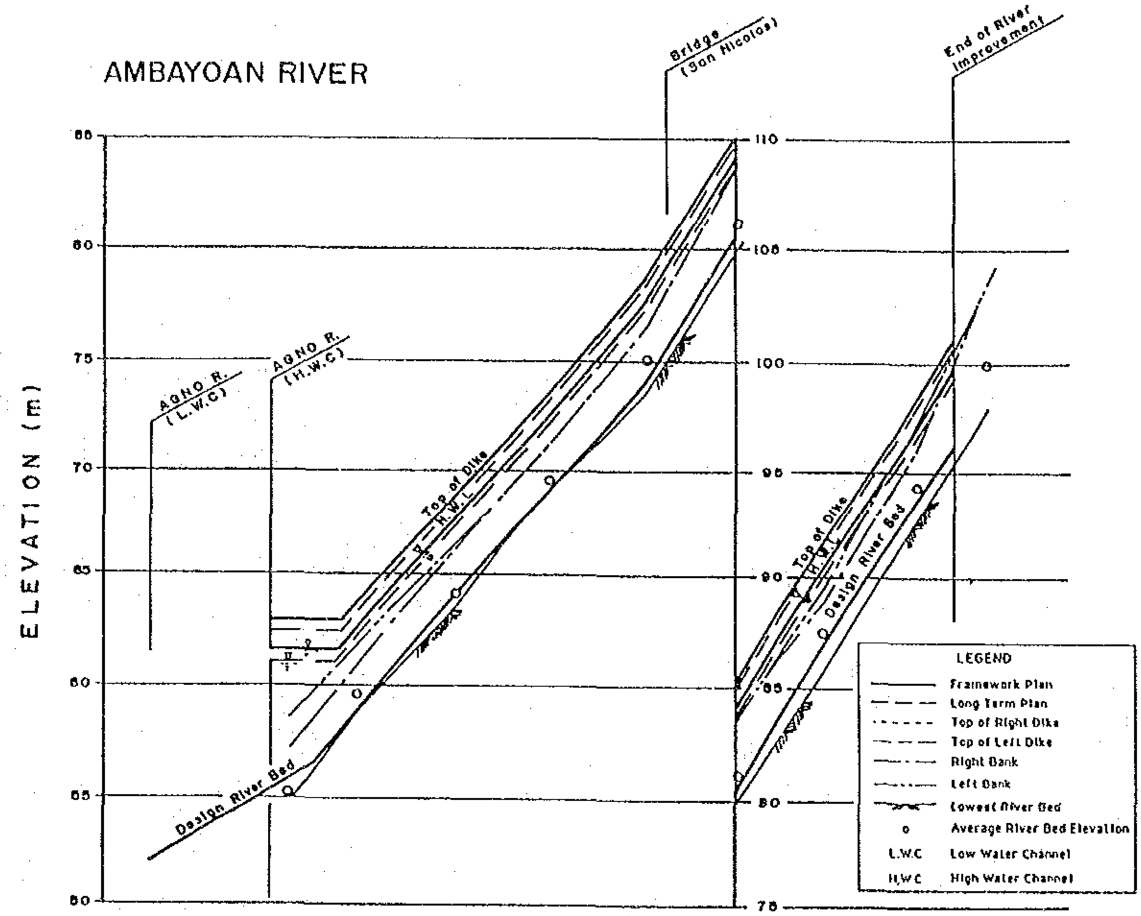


Section No.	AG 414	VD424	VD425	VD426	VD427	VD428	VD429	VD430	VD431	VD432	VD433	VD434	
Design Flood Discharge (m³/s)		750 (550)							370 (270)				
Gradient of H.W.L.		1/387	1/300			1/250		1/241	1/127		1/75		
Gradient of Channel Bed	1/378		1/300			1/250		1/127			1/75		
Top of Dike (El. m)		52.36 (51.86)	54.70 (54.40)	58.20	61.53	65.03 (64.73)	69.23	73.03 (72.73)	80.59 (80.24)	87.48	95.32 (95.17)	106.02	114.65 (114.50)
H.W.L. (El. m)		50.86 (50.36)	53.70 (53.40)	57.20	60.53	64.03 (63.73)	68.23	72.03 (71.73)	79.59 (79.44)	86.68	94.52 (94.37)	107.22	113.85 (113.70)
Channel Bed (El. m)	42.23	46.76	49.70	53.20	56.53	60.03	64.23	68.03	76.69	83.78	91.65	104.32	110.98
Distance (Km)	0	1.70	2.80	3.85	4.85	5.90	6.95	7.90	9.00	9.90	10.90	11.85	12.35

Section No.	VD430		VD435	VD436	VD437	VD438	VD439	VD440	VD441	VD442	VD443
Design Flood Discharge (m³/s)		350 (250)			210 (150)						
Gradient of H.W.L.			1/170		1/125		1/60		1/68		
Gradient of Channel Bed	1/170			1/125			1/60		1/68		
Top of Dike (El. m)		75.32 (75.12)	78.01	84.10	89.70 (89.50)	95.60	104.80 (104.45)	124.30	128.98 (128.63)	143.49 (143.14)	
H.W.L. (El. m)		74.52 (74.32)	77.21	83.30	88.90 (88.70)	94.80	104.00 (103.85)	116.30	128.18 (128.03)	142.69 (142.54)	
Channel Bed (El. m)	68.03		74.21	80.30	85.90	92.30	101.50	114.00	125.88	140.59	
Distance (Km)	0	0.60	1.05	2.10	2.80	3.60	4.75	5.75	6.70	7.70	8.70

Note; ( ):Long Term Plan

Fig. 7.13 LONGITUDINAL PROFILE OF VIRAY-DIPALO RIVER



Design Flood Discharge (m^3/s)		1750 (1330) →											
Gradient of H.W.L		1/208 →							1/180 →				
Gradient of Channel Bed	1/390 →			1/205 →				1/150 →					
Top of Dike (El.m)		62.90 (62.40)	62.90 (62.40)		64.12 (63.82)	68.74	73.62	78.74 (78.44)	85.21	91.54	98.21	100.87 (100.57)	
H.W.L (El.m)		61.40 (60.90)	61.40 (60.90)		62.62 (62.32)	67.74	72.62	77.74 (77.44)	84.21	90.54	97.21	99.87 (99.57)	
Channel Bed (El.m)	52.10		55.95	56.72	58.92	64.04	68.92	74.04	80.71	87.04	93.71	96.37	
Distance (Km)	0	1.30	1.95	1.80	2.25	3.30	4.30	5.35	6.35	7.30	8.30	8.70	9.10
Section No.	AS481		AM444		AM445	AM446	AM447	AM448	AM449	AM450	AM451		AM452

Note; ( ):Long Term Plan

Fig. 7.14 LONGITUDINAL PROFILE OF AMBAYOAN RIVER

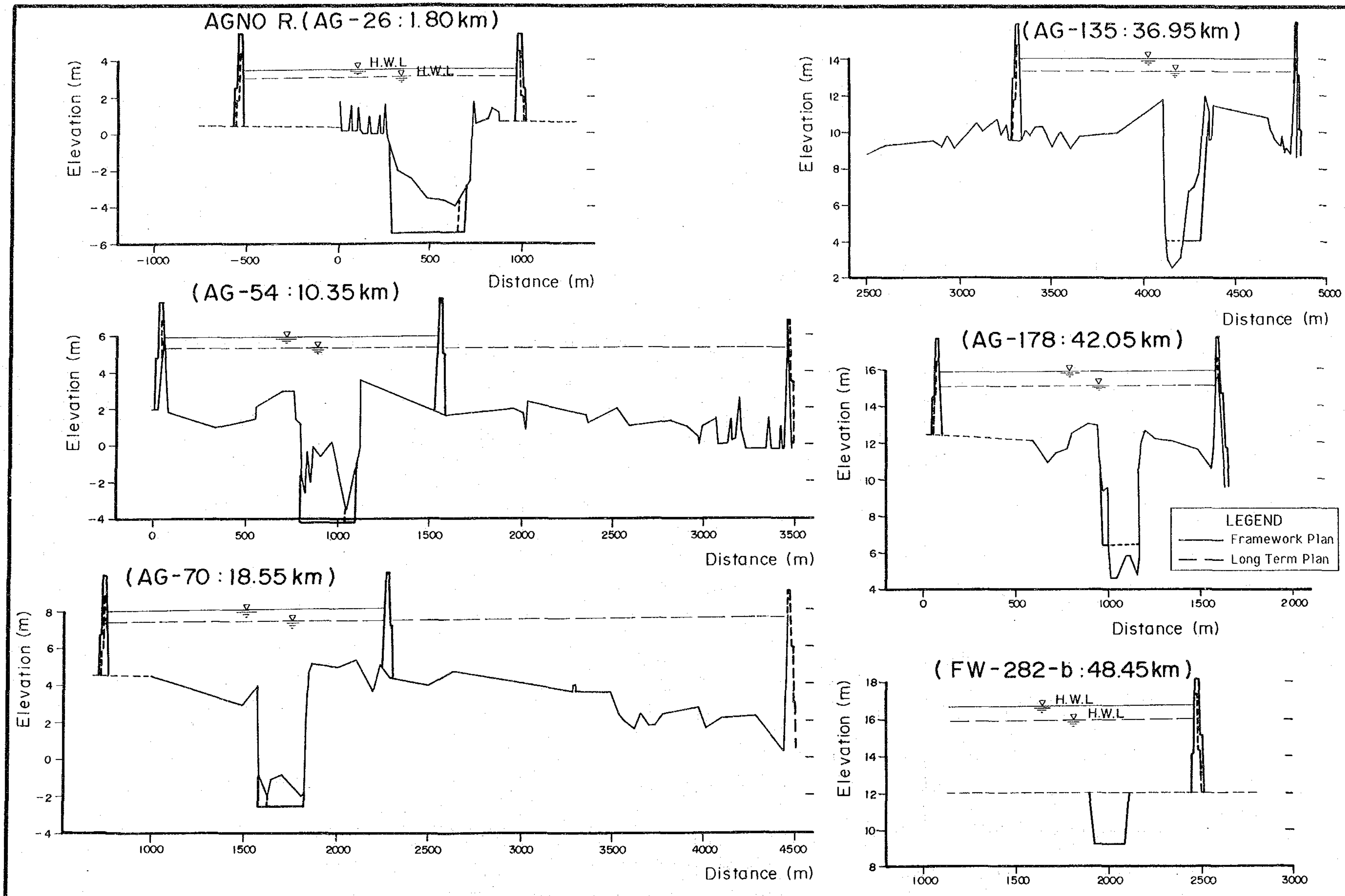


Fig. 7.15 TYPICAL CROSS-SECTION OF AGNO RIVER (1/2)

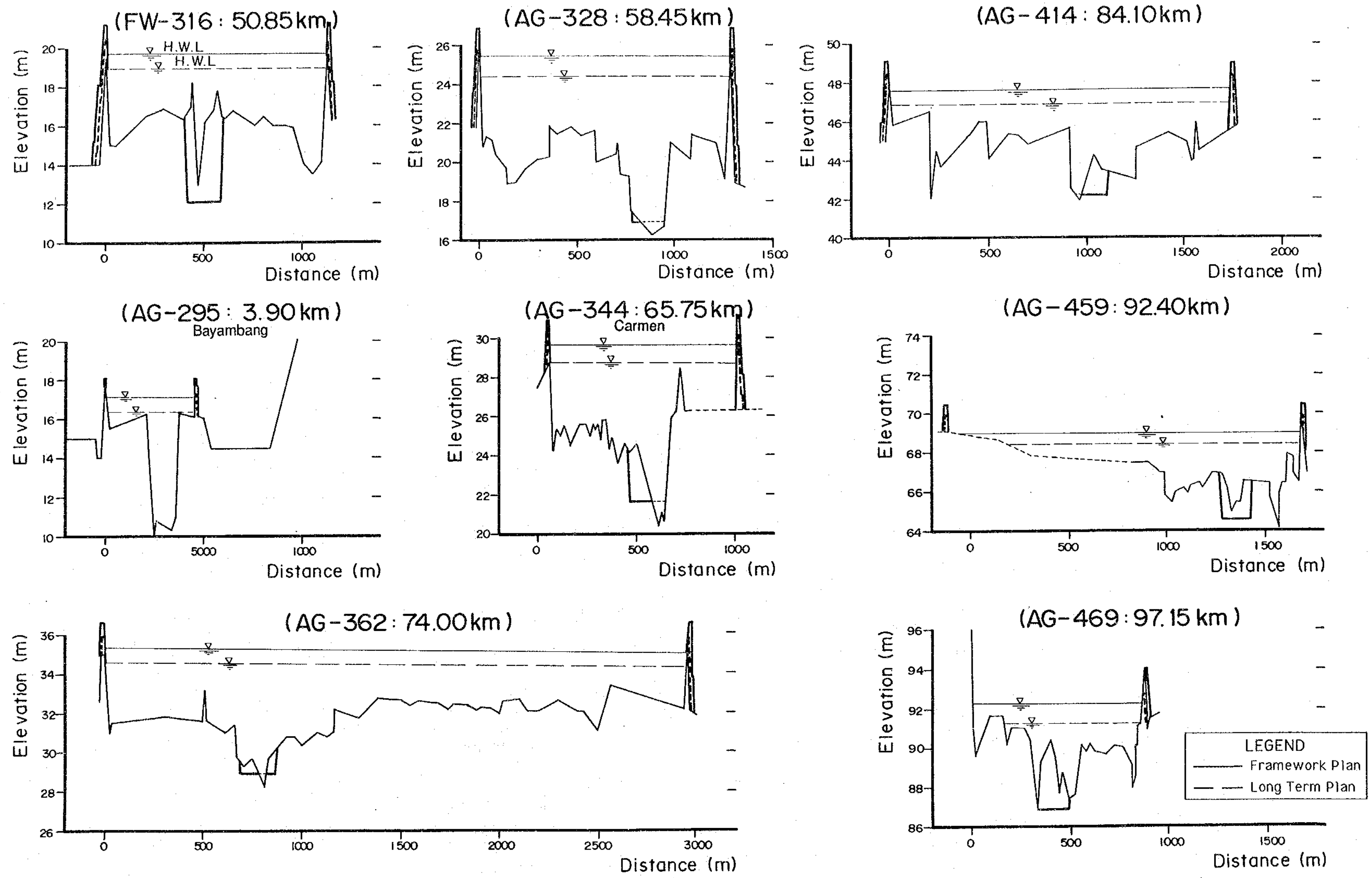


Fig. 7.15 TYPICAL CROSS-SECTION OF AGNO RIVER (2/2)

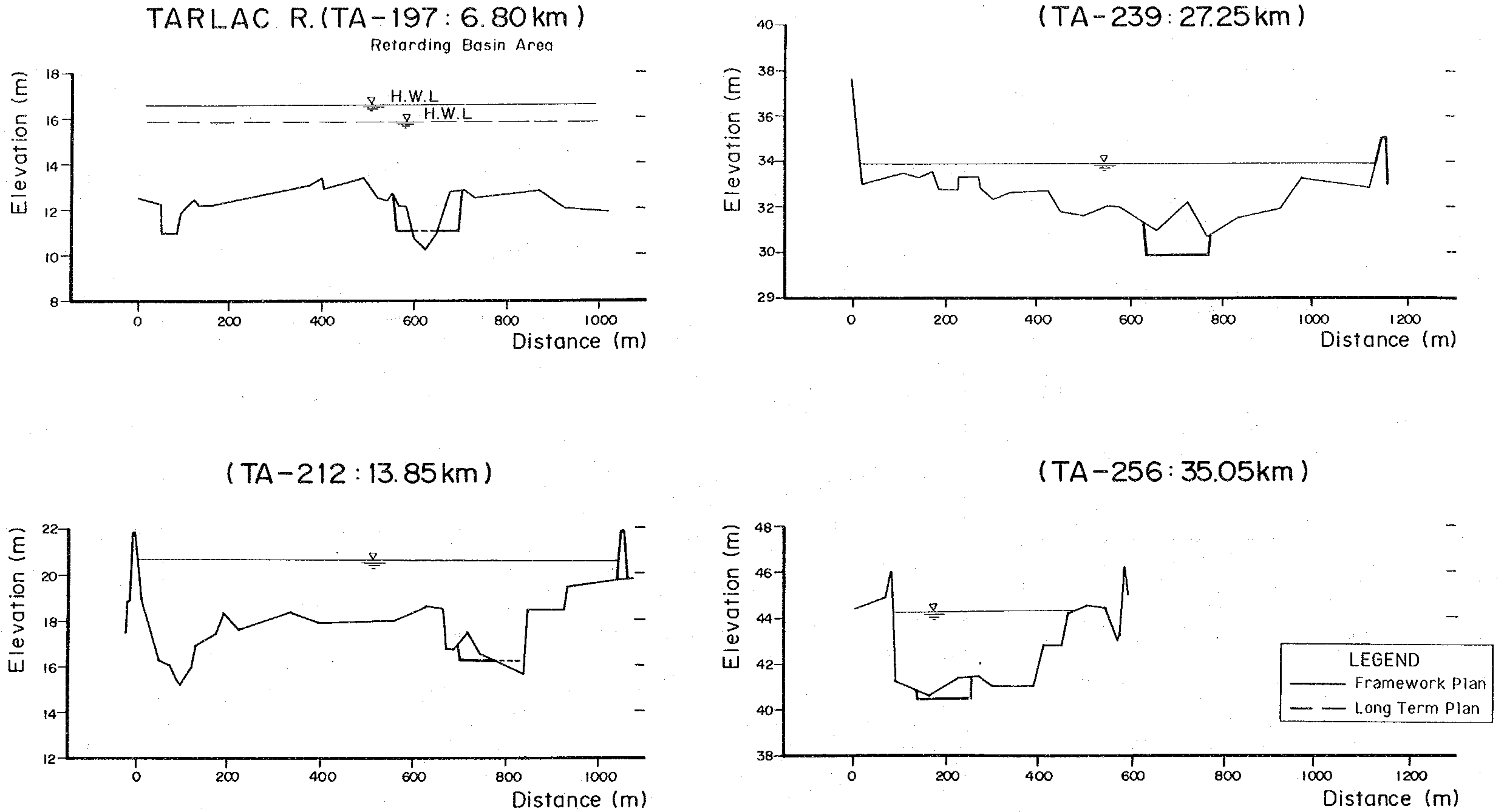


Fig. 7.16 TYPICAL CROSS-SECTION OF TARLAC RIVER

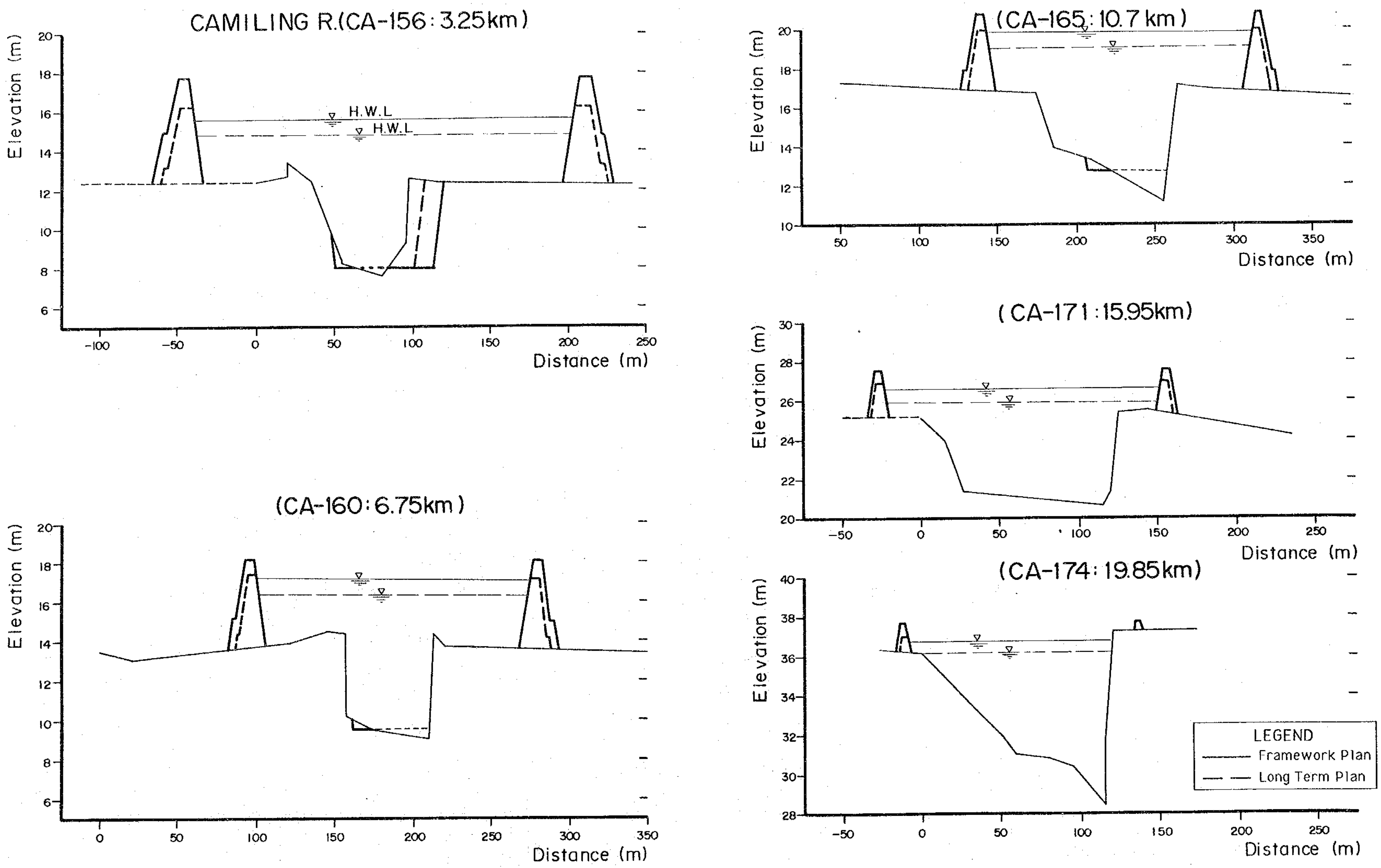


Fig. 7.17 TYPICAL CROSS-SECTION OF CAMILING RIVER

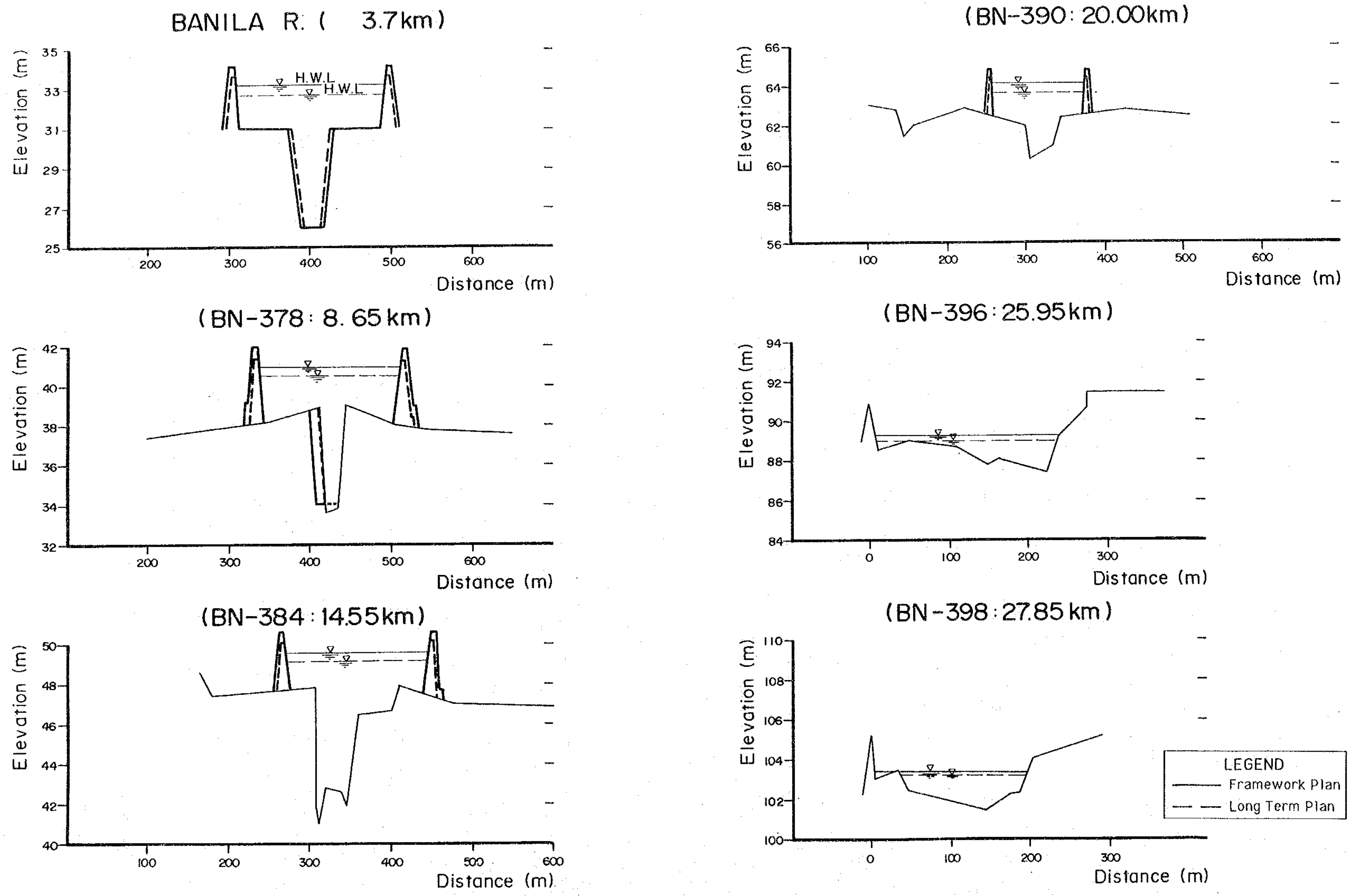


Fig. 7.18 TYPICAL CROSS – SECTION OF BANILA RIVER

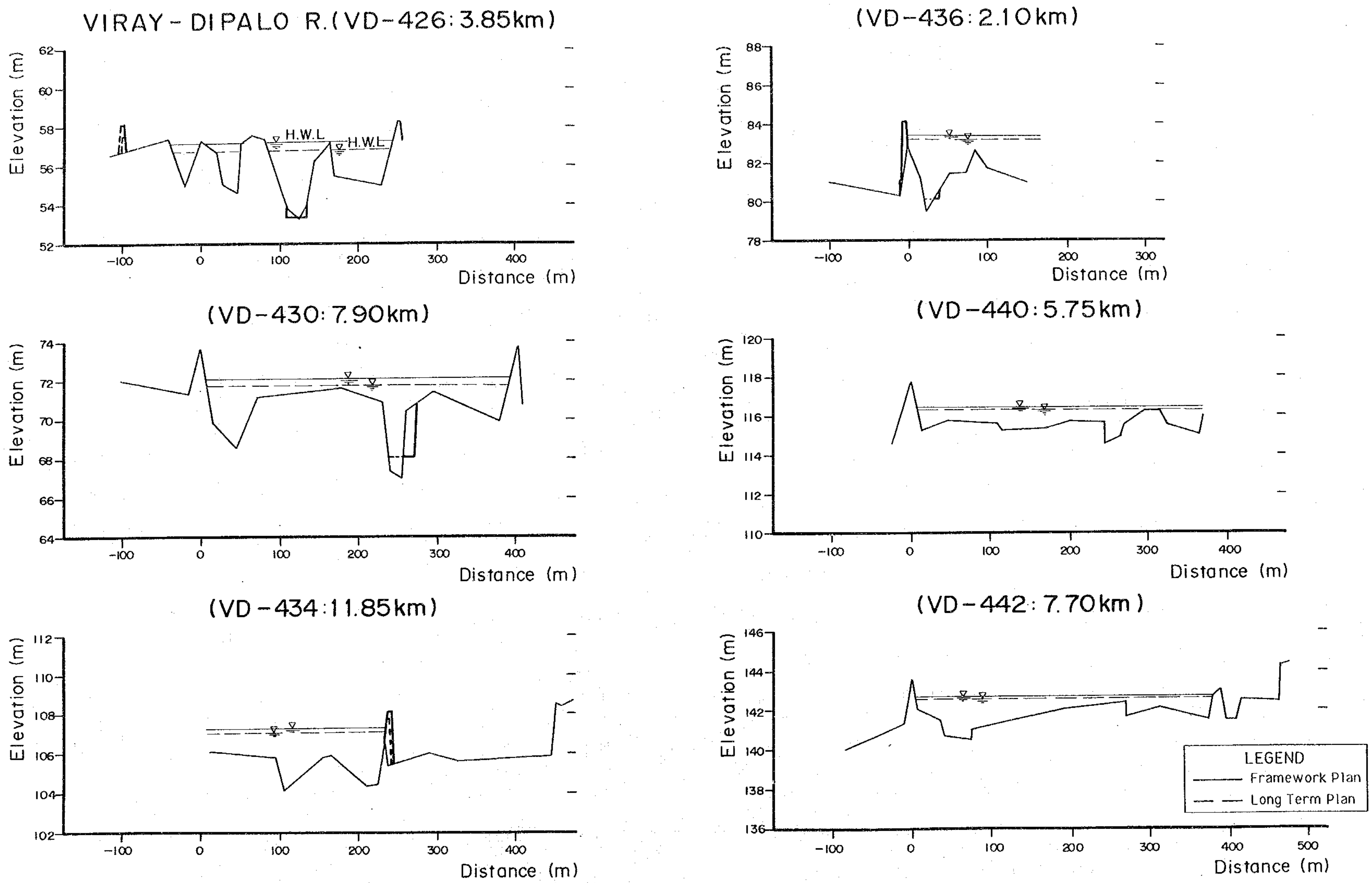


Fig. 7.19 TYPICAL CROSS - SECTION OF VIRAY - DIPALO RIVER

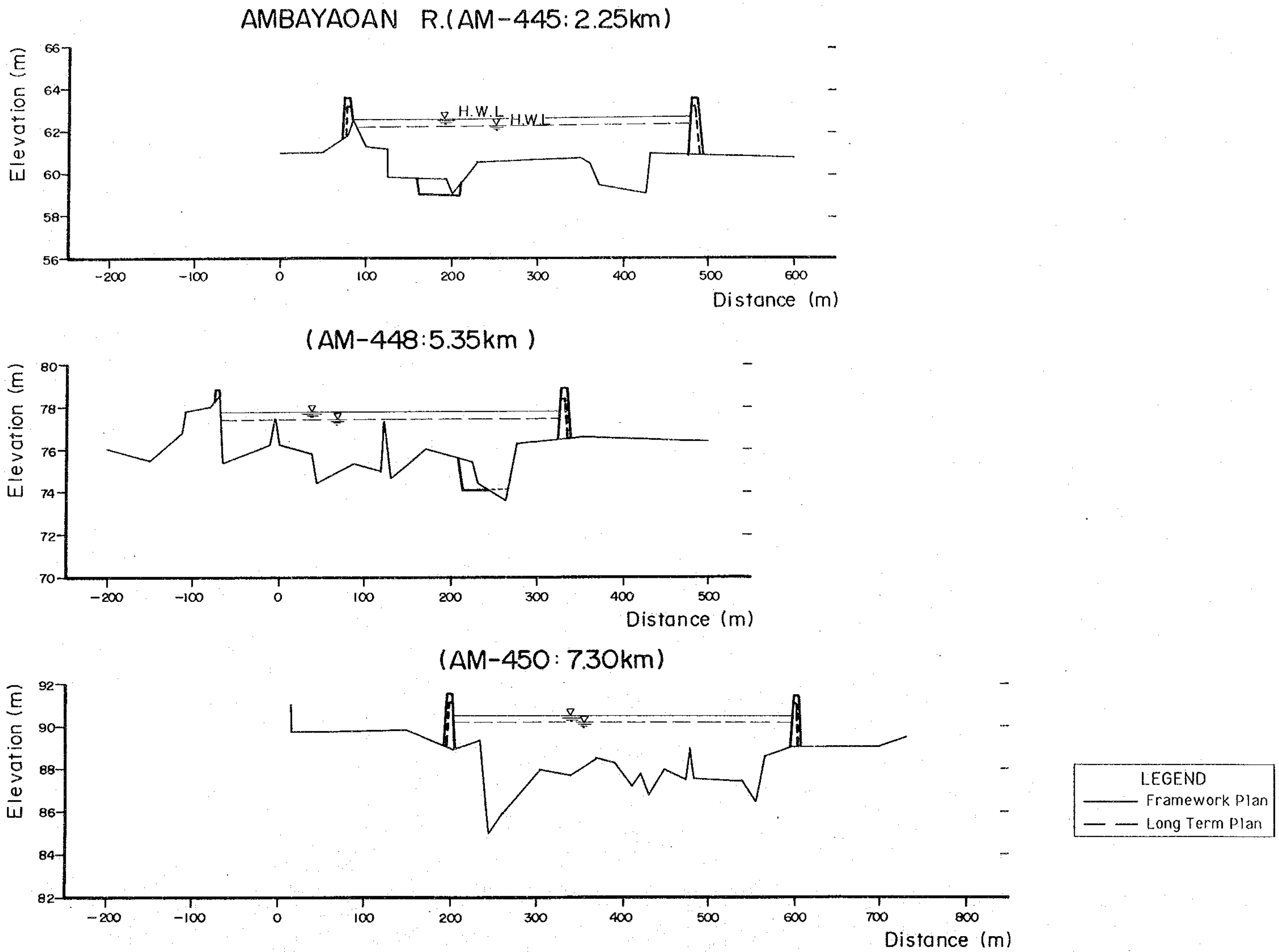


Fig. 7.20 TYPICAL CROSS-SECTION OF AMBAYAOAN RIVER

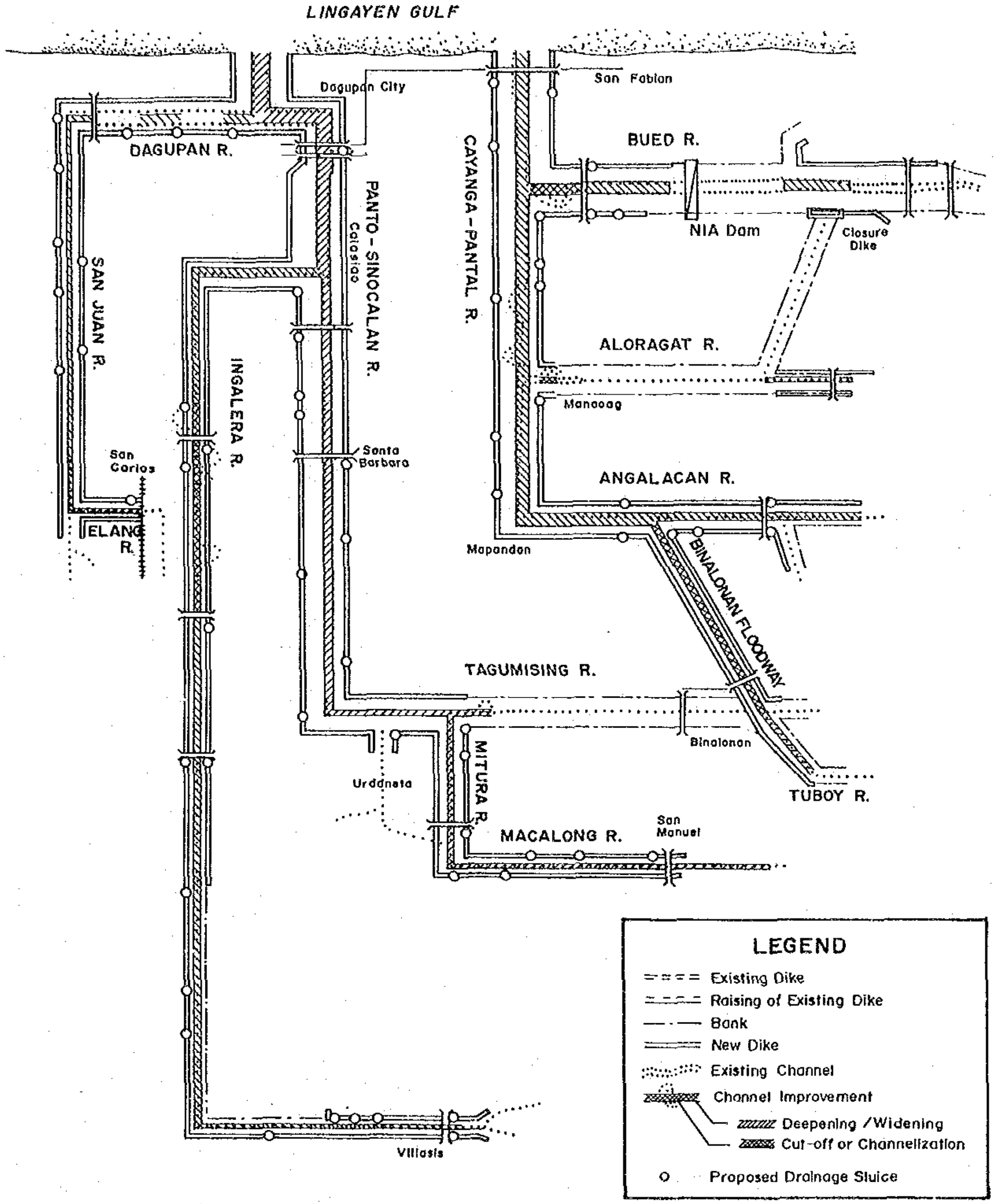


Fig. 7.21 GENERAL LAYOUT OF ALLIED RIVER IMPROVEMENT PLAN FOR FRAMEWORK PLAN

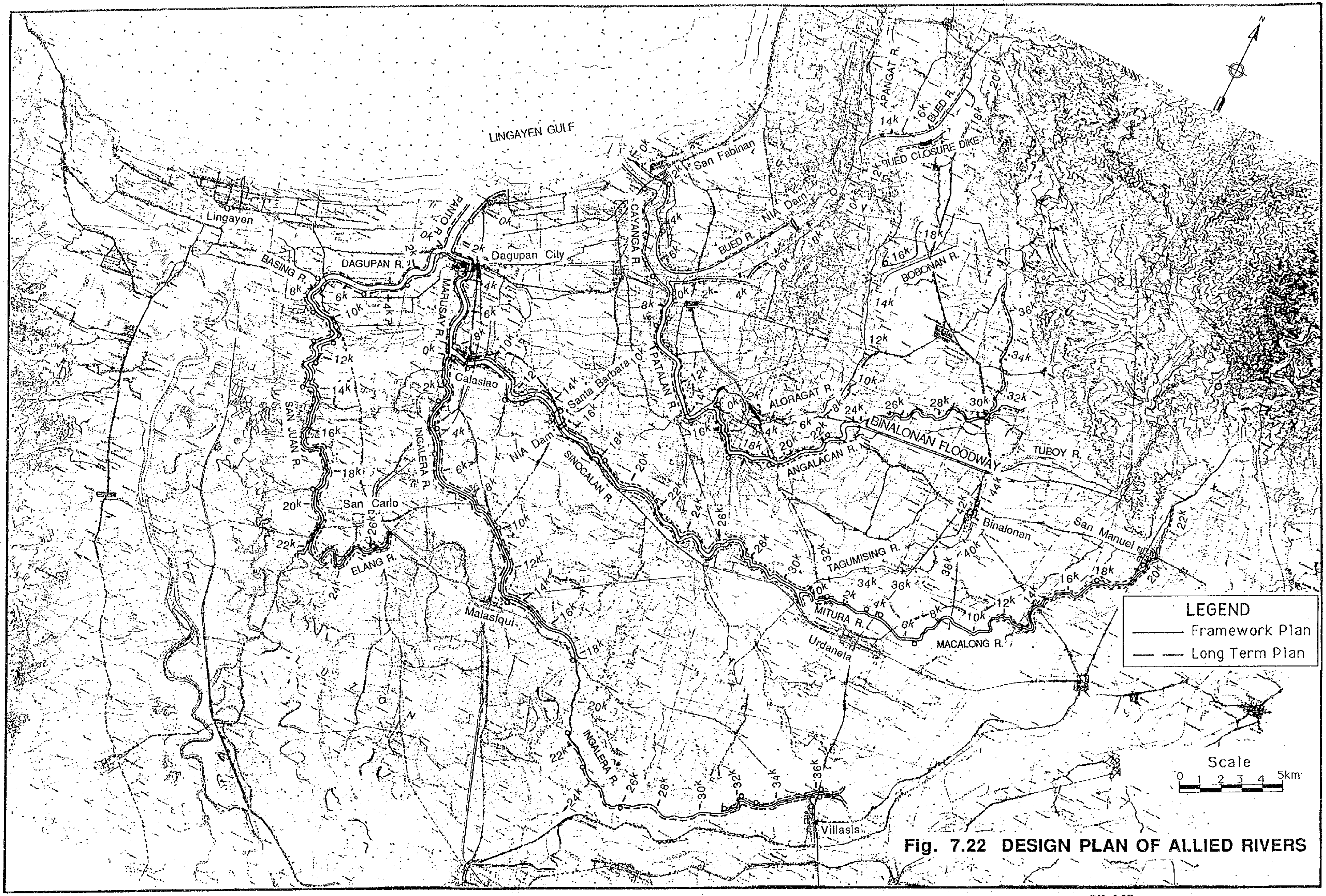
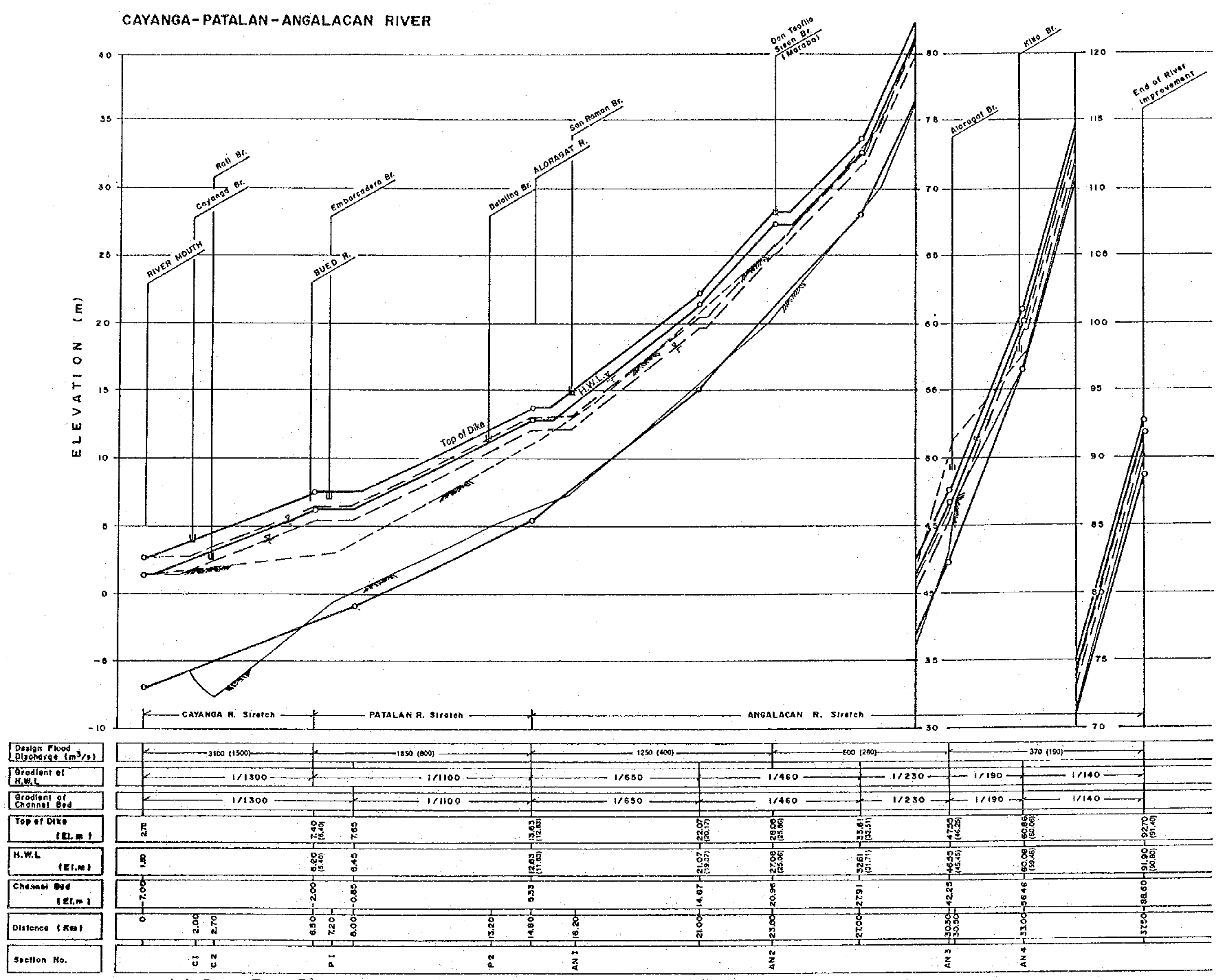
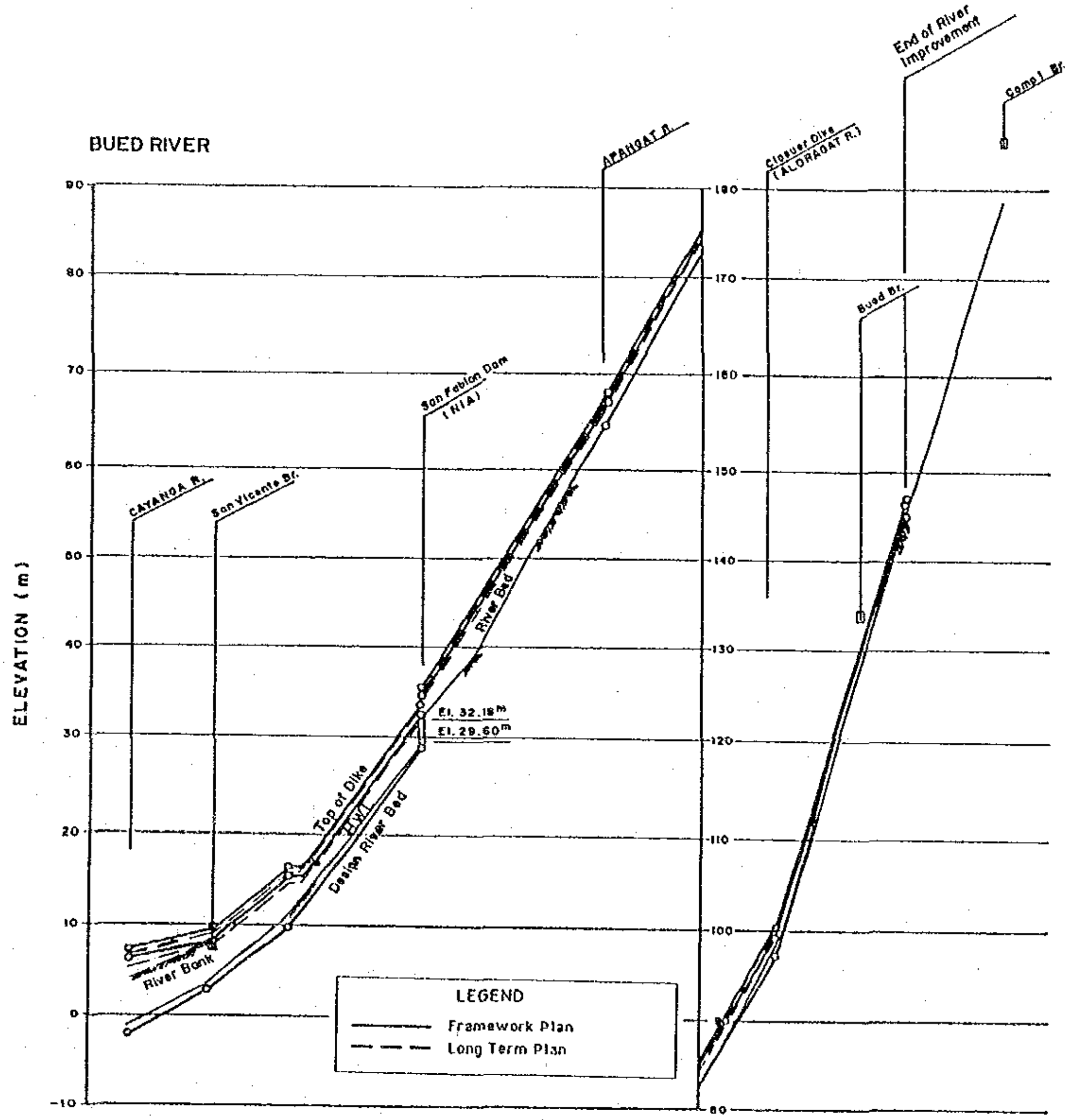


Fig. 7.22 DESIGN PLAN OF ALLIED RIVERS



Note; ( ):Long Term Plan

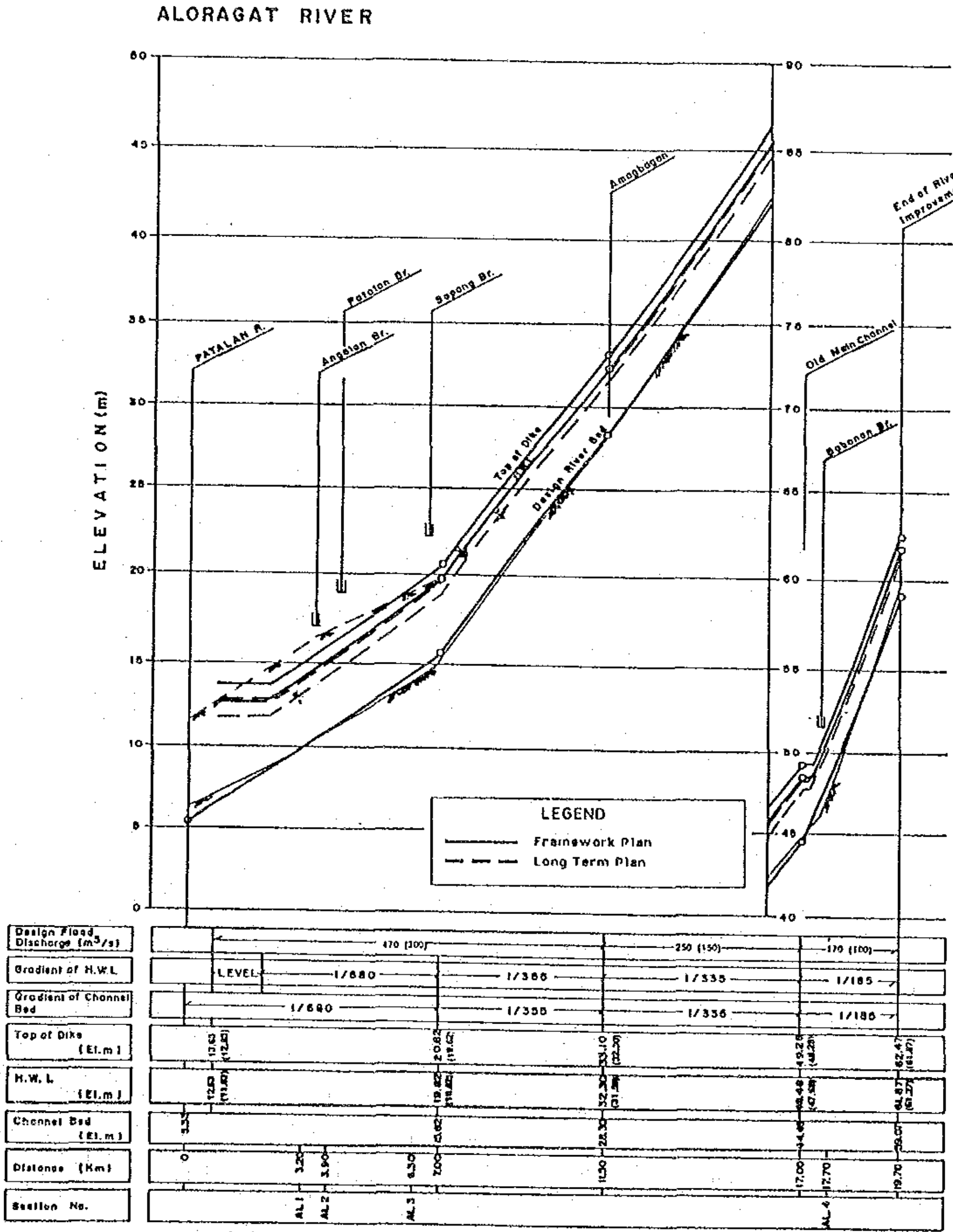
Fig. 7.23 LONGITUDINAL PROFILE OF CAYANGA-PATALAN RIVER



Design Flood Discharge (m^3/s)	1300 (750)				1000 (500)			
Gradient of H.W.L	1/770	1/280	1/170	1/143	1/140	1/70		
Gradient of Channel Bed	1/400	1/280	1/170	Existing (1/143)	1/140	1/70		
Top of Dike (El.m)	7.25 (6.25)	9.66 (8.95)	16.53 (15.53)	[illegible] 33.63 35.58 (35.08)	68.45 (67.95)	100.2[illegible] (99.[illegible])		147.23 (146.90)
H.W.L (El.m)	6.05 (5.25)	8.65 (7.95)	15.53 (14.53)	(32.23) 32.63 34.58 (34.08)	67.45 (66.95)	99.29 (98.[illegible])		146.23 (145.90)
Channel Bed (El.m)	-2.15	2.85	9.93	29.35 32.18	65.00	97.19	131.44	144.35
Distance (Km)	0	2.00 2.10	4.00	7.30	12.00	16.50	18.90	19.80
Section No.		B1		B2			B3	

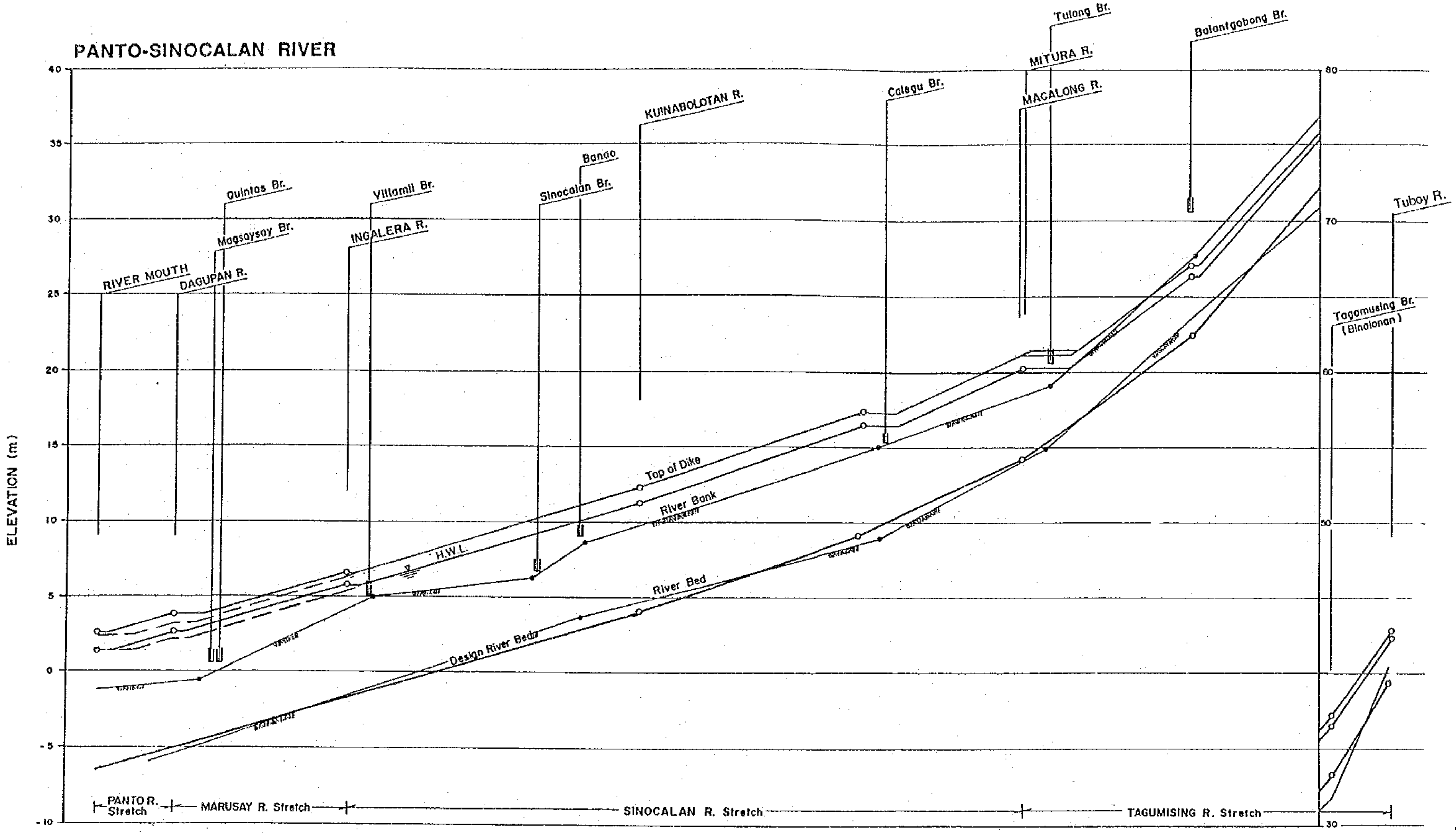
Note; ( ):Long Term Plan

Fig. 7.24 LONGITUDINAL PROFILE OF BUED RIVER



Note; ( ) :Long Term Plan

Fig. 7.25 LONGITUDINAL PROFILE OF ALORAGAT RIVER



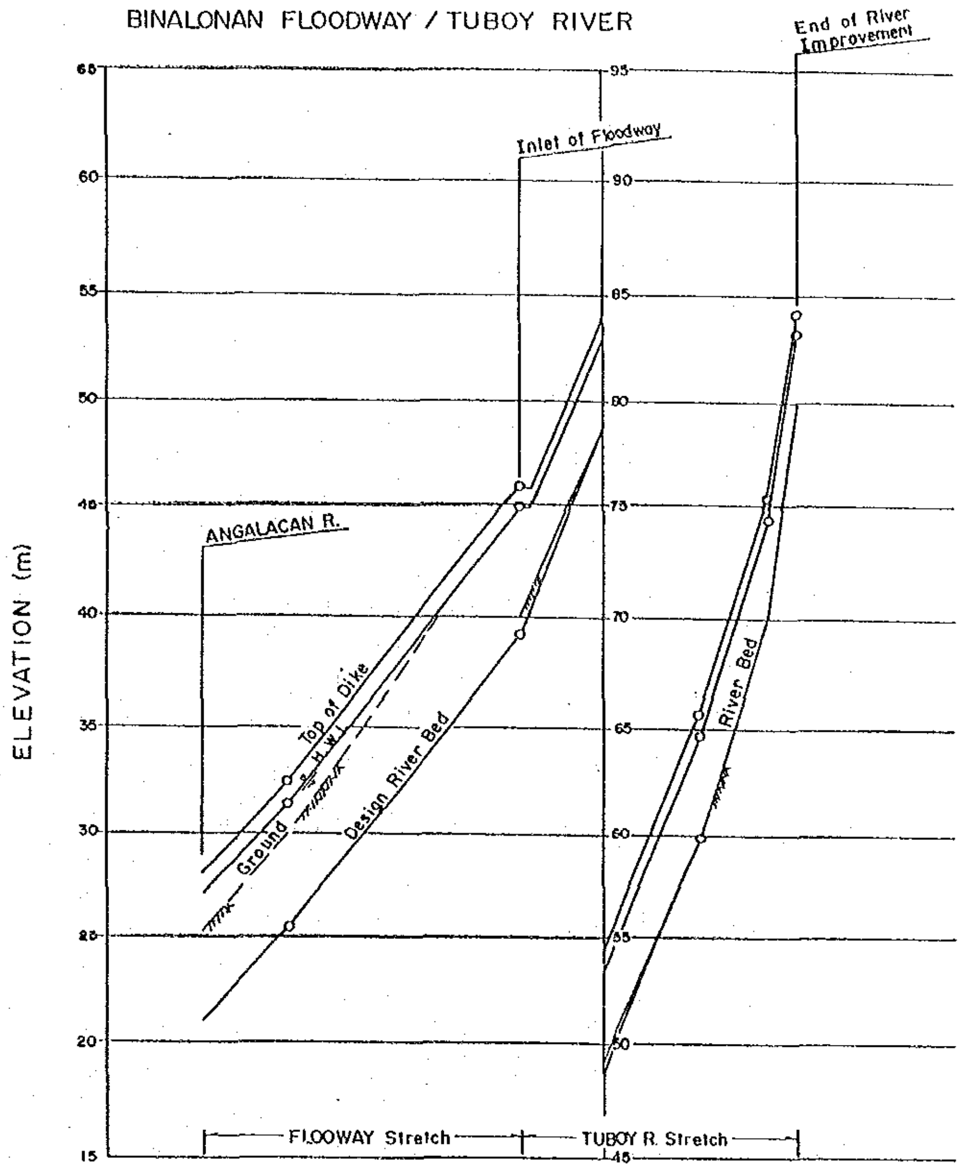
Design Flood Discharge (m^3/s)	2700 (1900)	1650 (1250)	1000 (900)	650 (650)	160 (160)	120 (120)

Gradient of H.W.L	1/1750	1/1450	1/1100	1/700	1/430	1/350
Gradient of Channel Bed	1/1760	1/1450	1/1100	1/700	1/430	1/350

Distance (Km)	0	2.50	3.50	3.80	6.30	9.10	14.40	16.20	18.00	25.50	26.20	31.00	31.90	36.70		41.40	43.50
Top of Dike (El. m)	2.70 (2.50)	3.83 (3.13)			6.74 (6.34)				12.10 (12.00)	17.27 (16.27)		21.17 (21.17)		26.91		37.14	42.84
H.W.L. (El. m)	1.50 (1.50)	2.63 (2.13)			5.74 (5.34)				11.10 (11.00)	16.27 (16.27)		20.17 (20.17)		26.31		36.54	42.24
Channel Bed (El. m)	-6.50	-5.07			-1.76			2.78	4.00	9.17		14.17		22.31		33.24	39.24
Section No.			P.1	P.2		S.1	S.2	S.3			S.4		T.1		T.2	T.3	

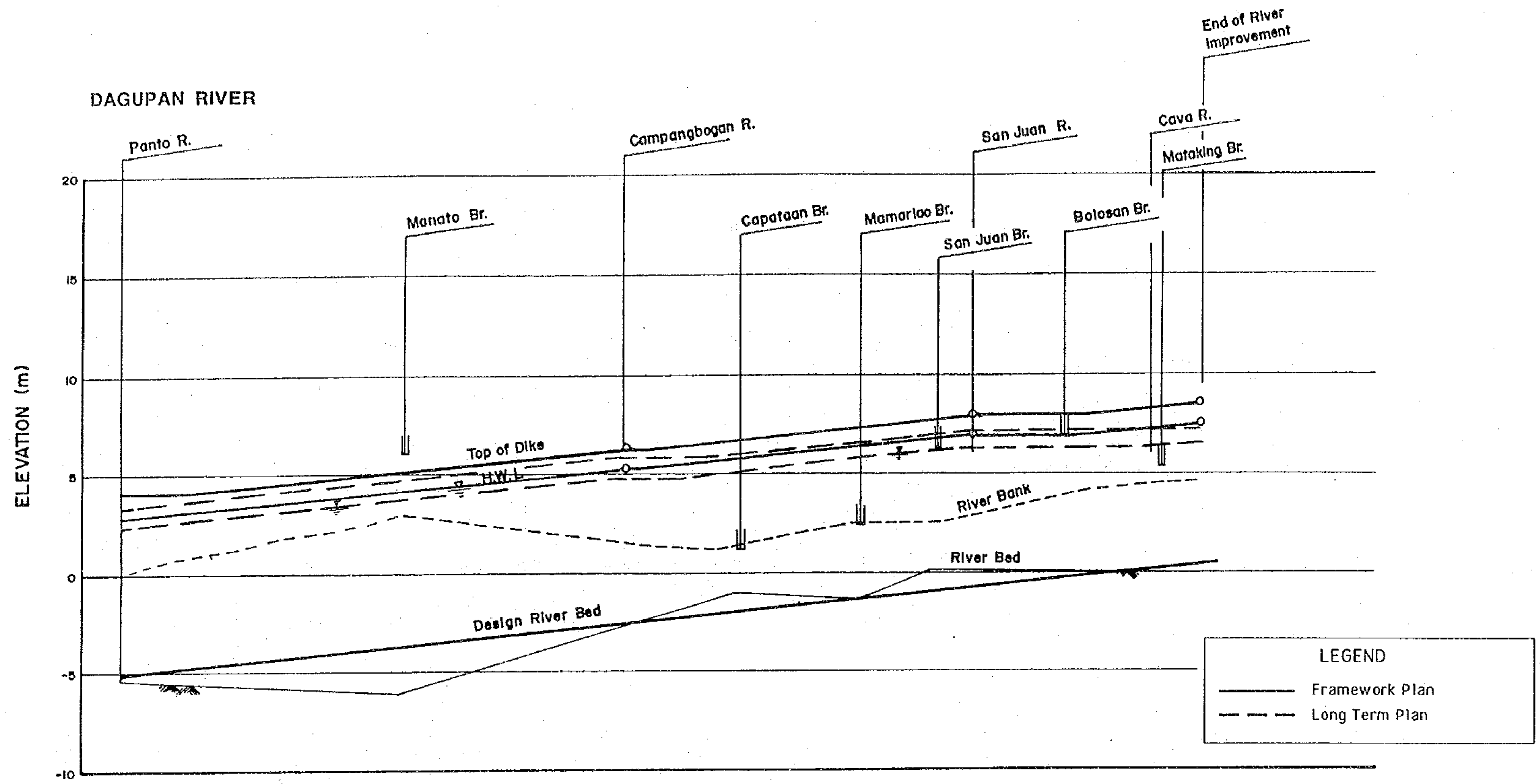
Note; ( ):Long Term Plan

Fig. 7.26 LONGITUDINAL PROFILE OF PANTO-SINOCALAN RIVER



Design Flood Discharge (m³/s)	650			550		
Gradient of H.W.L	1/409	1/355.5	1/190	1/143	1/67	
Gradient of Channel Bed	1/400	1/355.5	1/190	Existing		
Top of Dike (El.m)	28.06	32.46	45.94	65.63	75.40	84.30
H.W.L. (El.m)	27.06	31.46	44.94	64.63	74.40	83.30
Channel Bed (El.m)	20.96	25.46	39.24	59.93	73.00	80.00
Distance (km)	0	1.80	6.70	10.60	12.00	12.60
Section No.	AN 2					

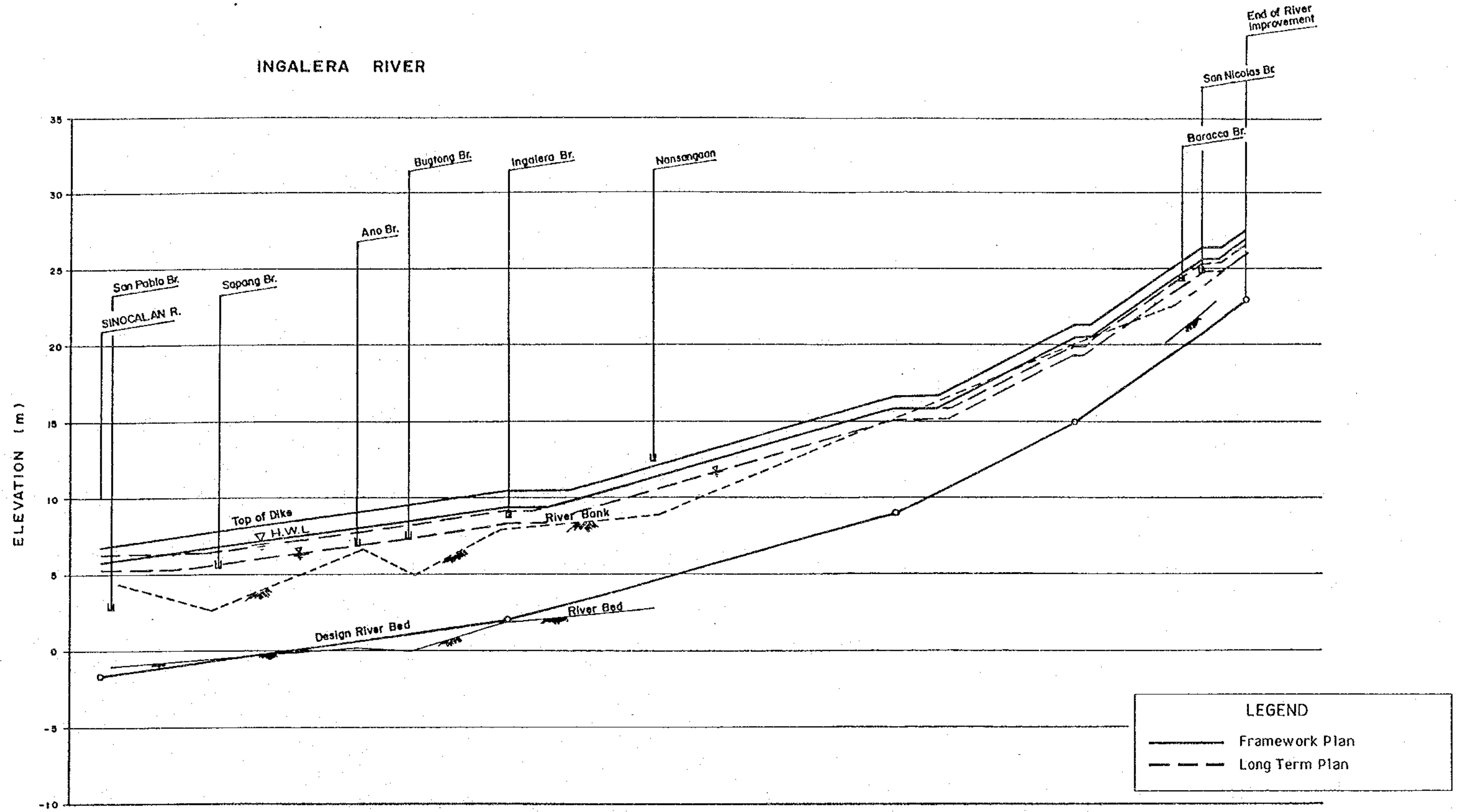
Fig. 7.27 LONGITUDINAL PROFILE OF BINALONAN FLOODWAY



Distance (Km)	0	7.10	7.50	12.70	15.70	18.80	20.80	21.70	24.10	26.60	27.60
Design Flood Discharge (m^3/s)	1100 (700)			900 (550)		650 (390)			310 (190)		
Gradient of H.W.L.	1/5000										
Gradient of Channel Bed	1/5000										
Top of Dike (El.m)	3.83 (3.17)		5.13	6.13 (5.73)				7.87 (7.07)			8.25 (7.05)
H.W.L. (El.m)	2.63 (2.13)		4.13	5.13 (4.73)				6.87 (6.27)			7.45 (6.45)
Channel Bed (El.m)	-5.07	-3.65	-3.57	-2.53	-1.93	-1.31	-0.91	-0.73	-0.25	0.25	0.45
Section No.		D.1			Sa.1	Sa.2	Sa.3		E.1	E.2	

Note; ( ):Long Term Plan

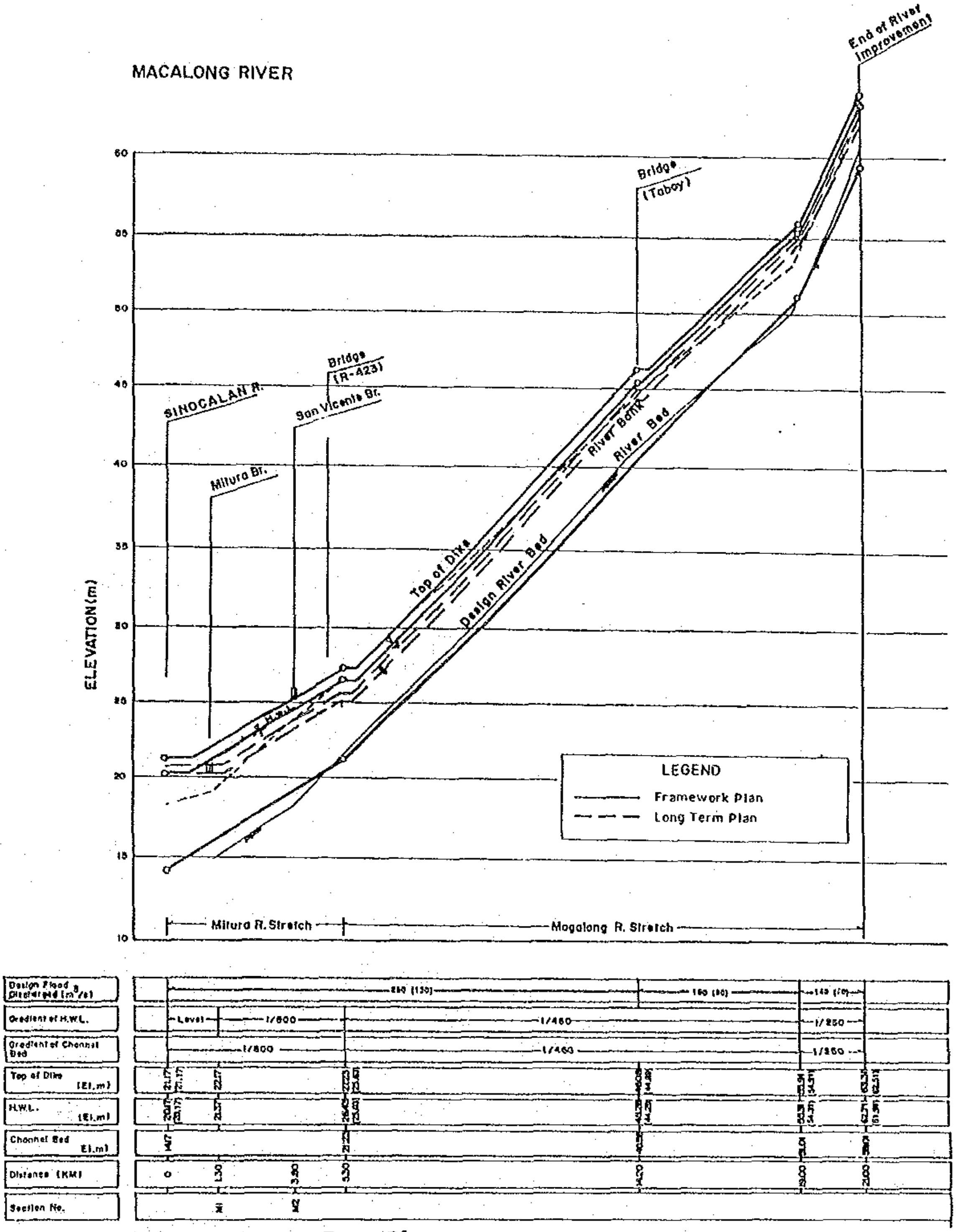
Fig. 7.28 LONGITUDINAL PROFILE OF DAGUPAN RIVER



Design Flood Discharge (m³/s)	600 (360)					460 (260)		260 (150)			150 (80)	
Gradient of H.W.L.	1/3600					1/1800		1/1000	1/700			
Gradient of Channel Bed	1/3600					1/1800		1/1000	1/700			
Top of Dike (El. m)	6.74 (6.34)					10.43 (9.13)		16.89 (15.89)	21.29 (19.89)		26.40 (25.30)	27.65 (26.65)
H.W.L. (El. m)	5.74 (5.34)					9.43 (8.33)		15.89 (15.09)	20.49 (19.29)		25.60 (24.70)	27.05 (26.05)
Channel Bed (El. m)	-1.76					1.93		8.99	14.99		20.70	22.85
Distance (Km)	0.0	0.60	3.60	8.90	10.10	13.30	18.20	26.00	32.00	35.20	36.00	37.50
Section No.		11	12	13	14	15	16			17	18	

Note; ( ):Long Term Plan

Fig. 7.29 LONGITUDINAL PROFILE OF INGALERA RIVER



Note; ( ):Long Term Plan

Fig. 7.30 LONGITUDINAL PROFILE OF MITURA-MACALONG RIVER

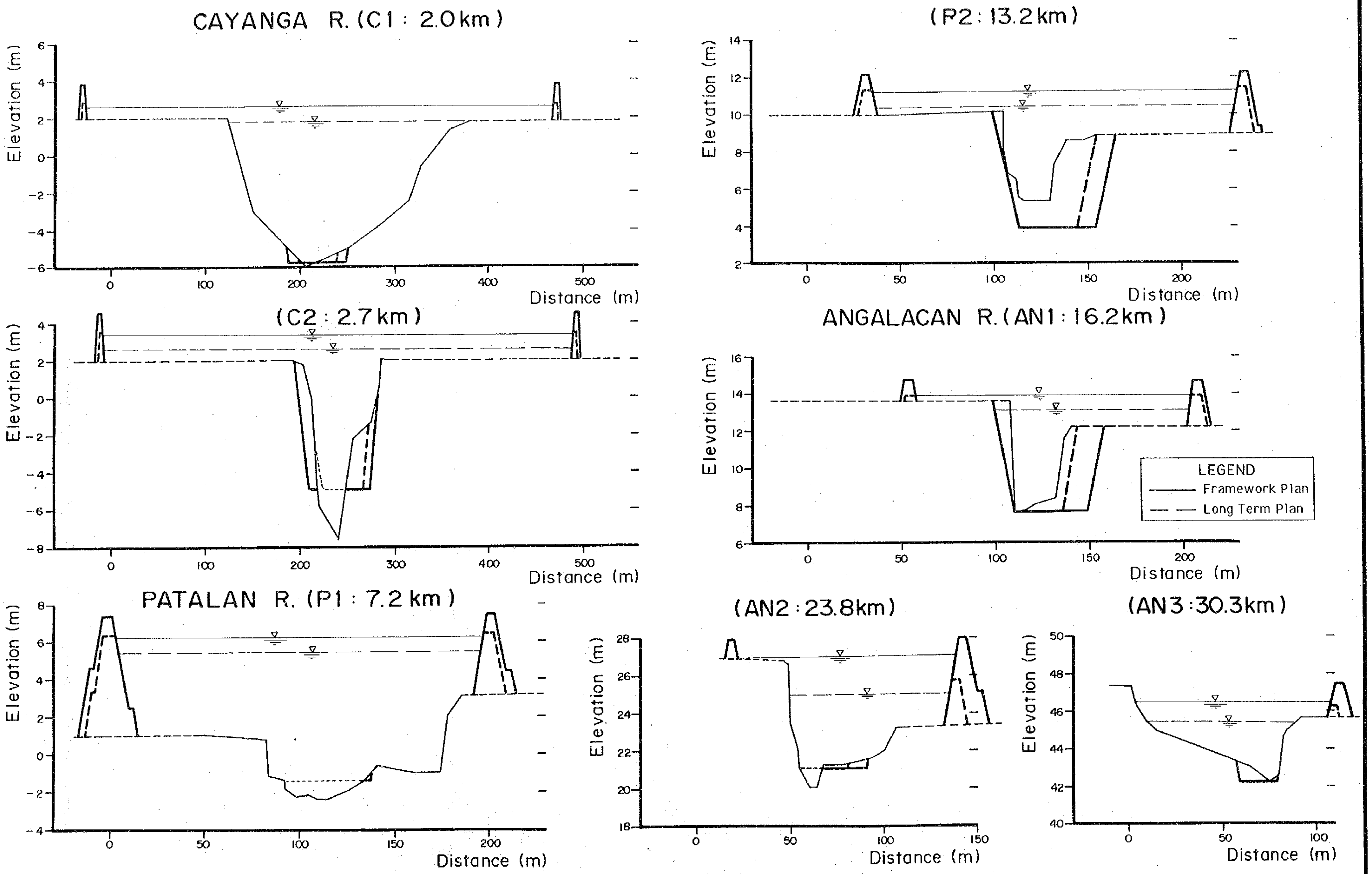


Fig. 7.31 TYPICAL CROSS-SECTION OF CAYANGA-PATALAN RIVER

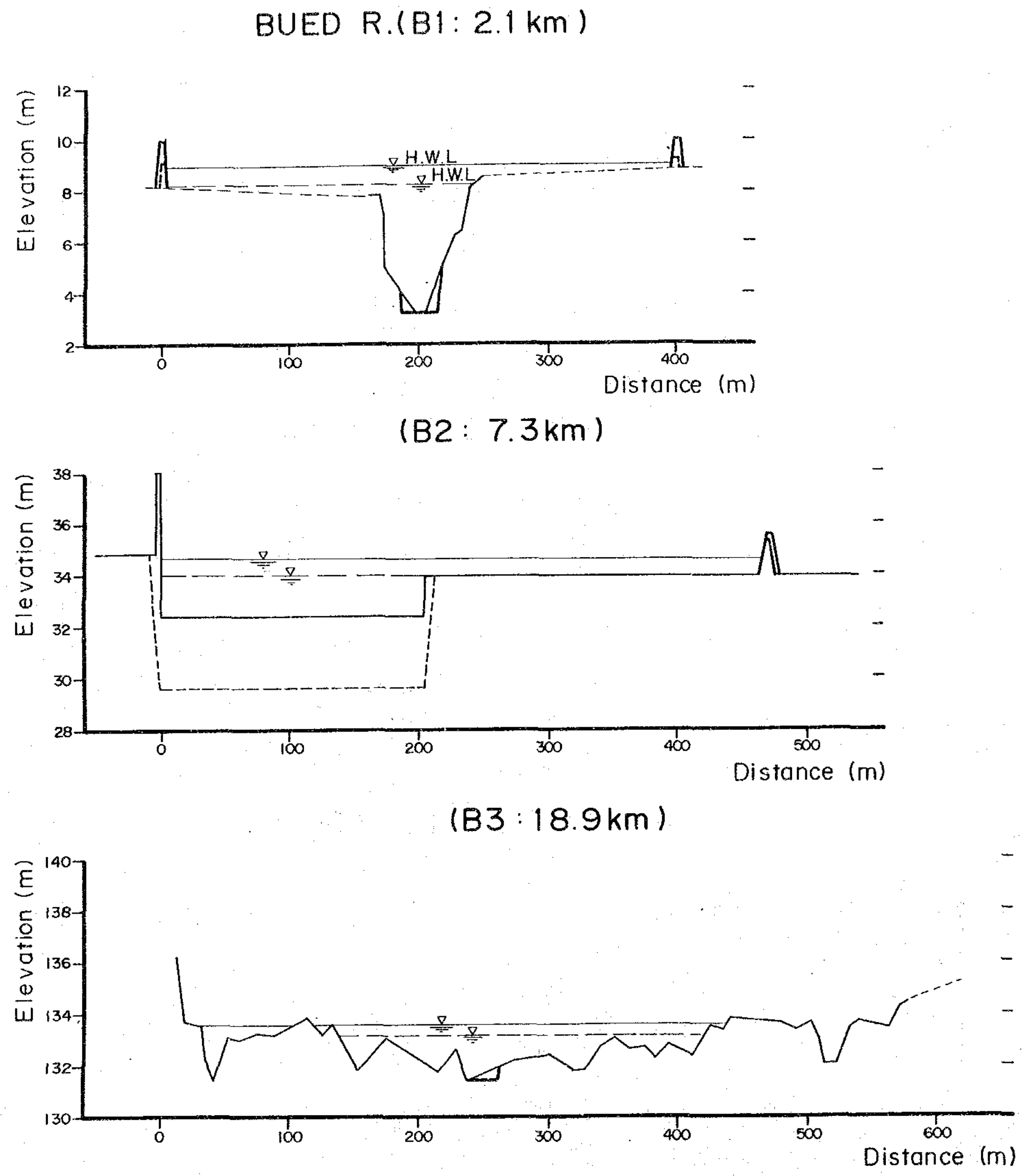


Fig. 7.32 TYPICAL CROSS-SECTION OF BUED RIVER

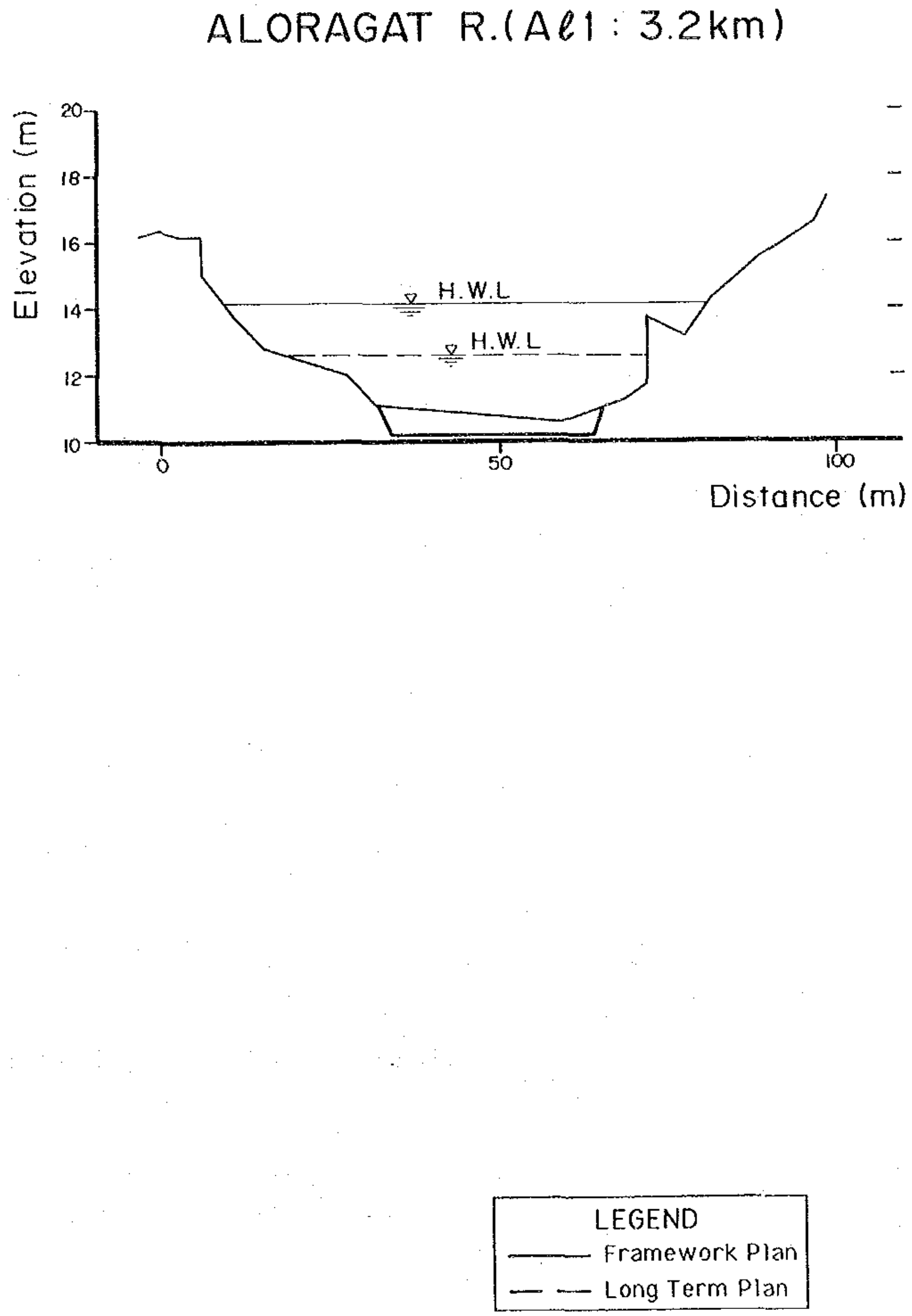


Fig. 7.33 TYPICAL CROSS-SECTION OF ALORAGAT RIVER

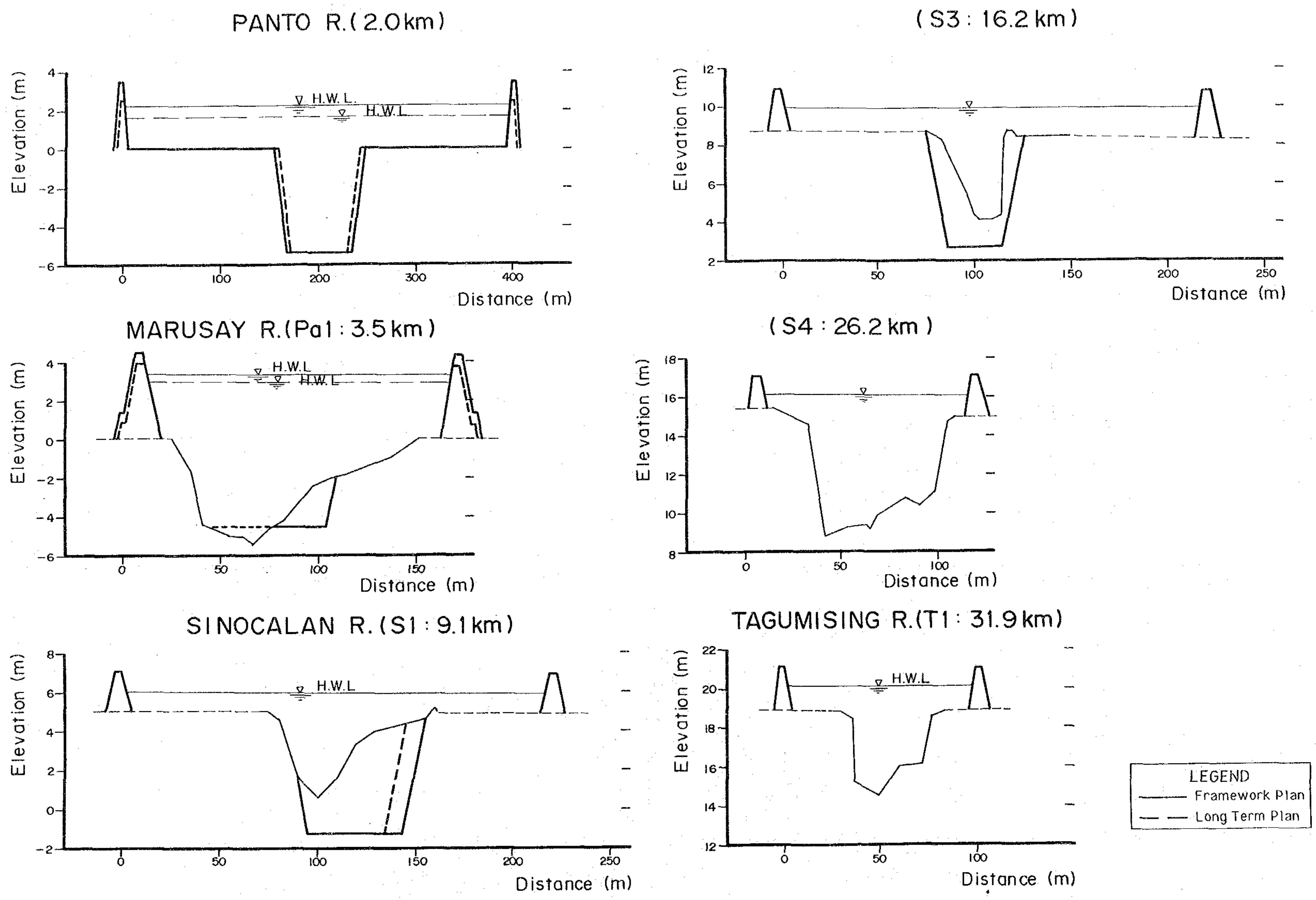


Fig. 7.34 TYPICAL CROSS - SECTION OF PANTO - SINOCALAN RIVER

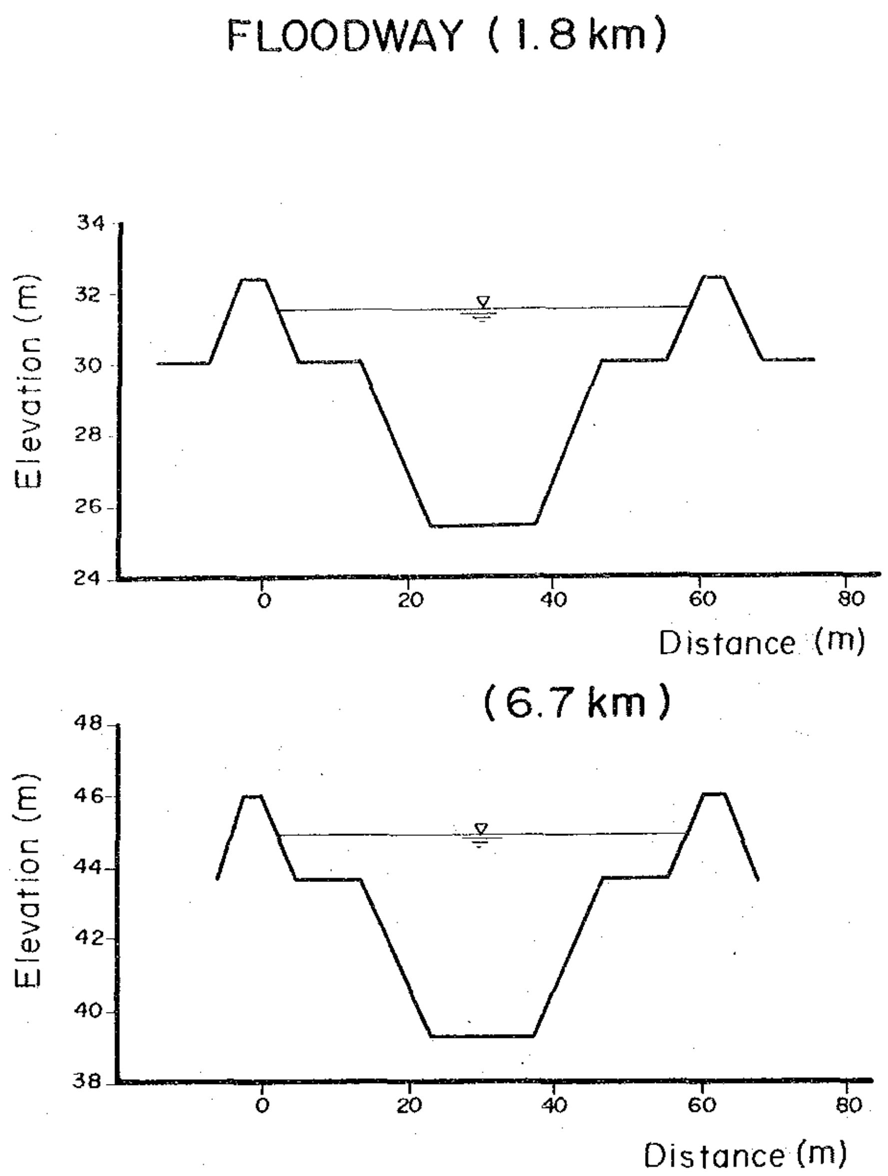


Fig. 7.35 TYPICAL CROSS-SECTION OF BINALONAN FLOODWAY

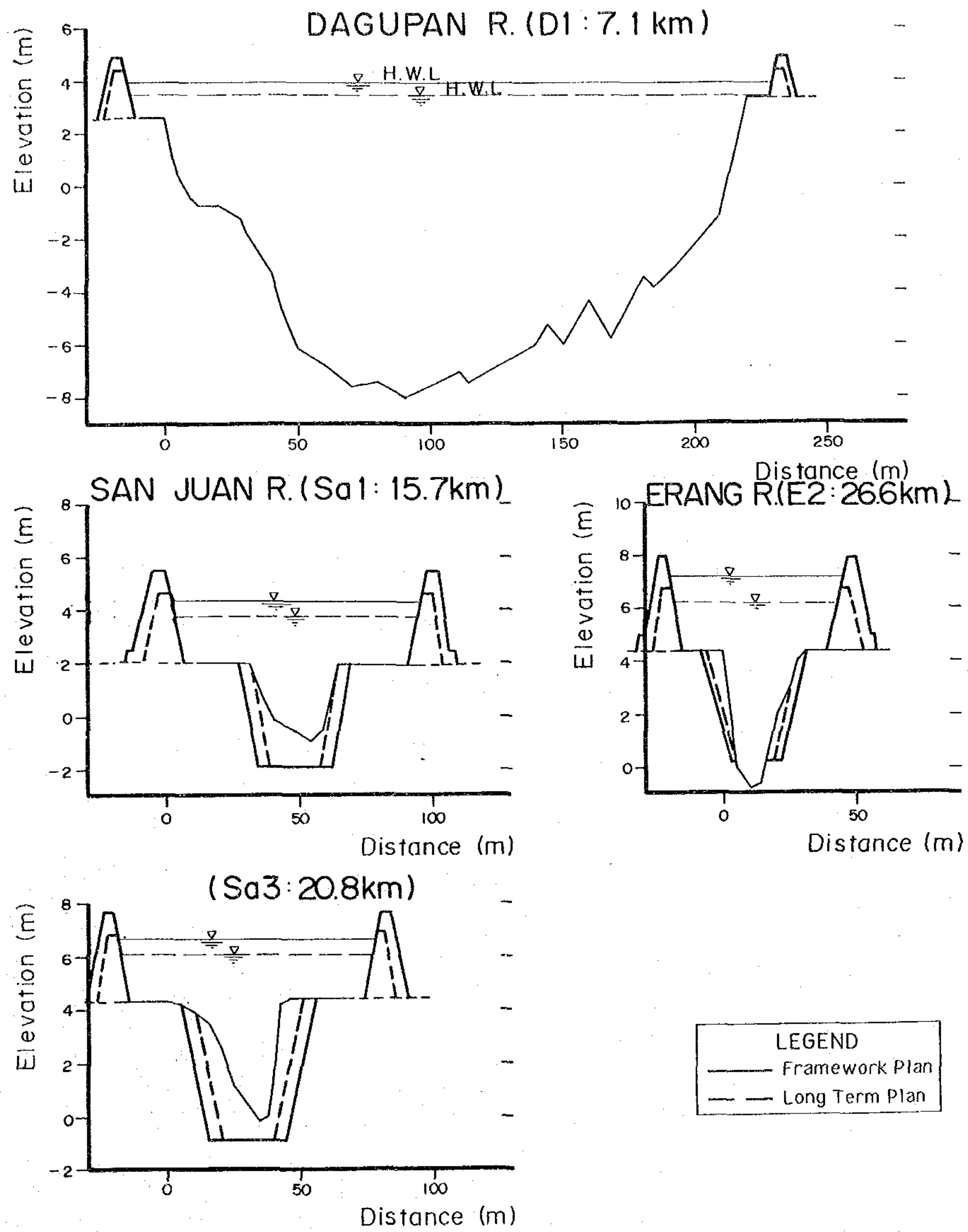


Fig. 7.36 TYPICAL CROSS-SECTION OF DAGUPAN RIVER

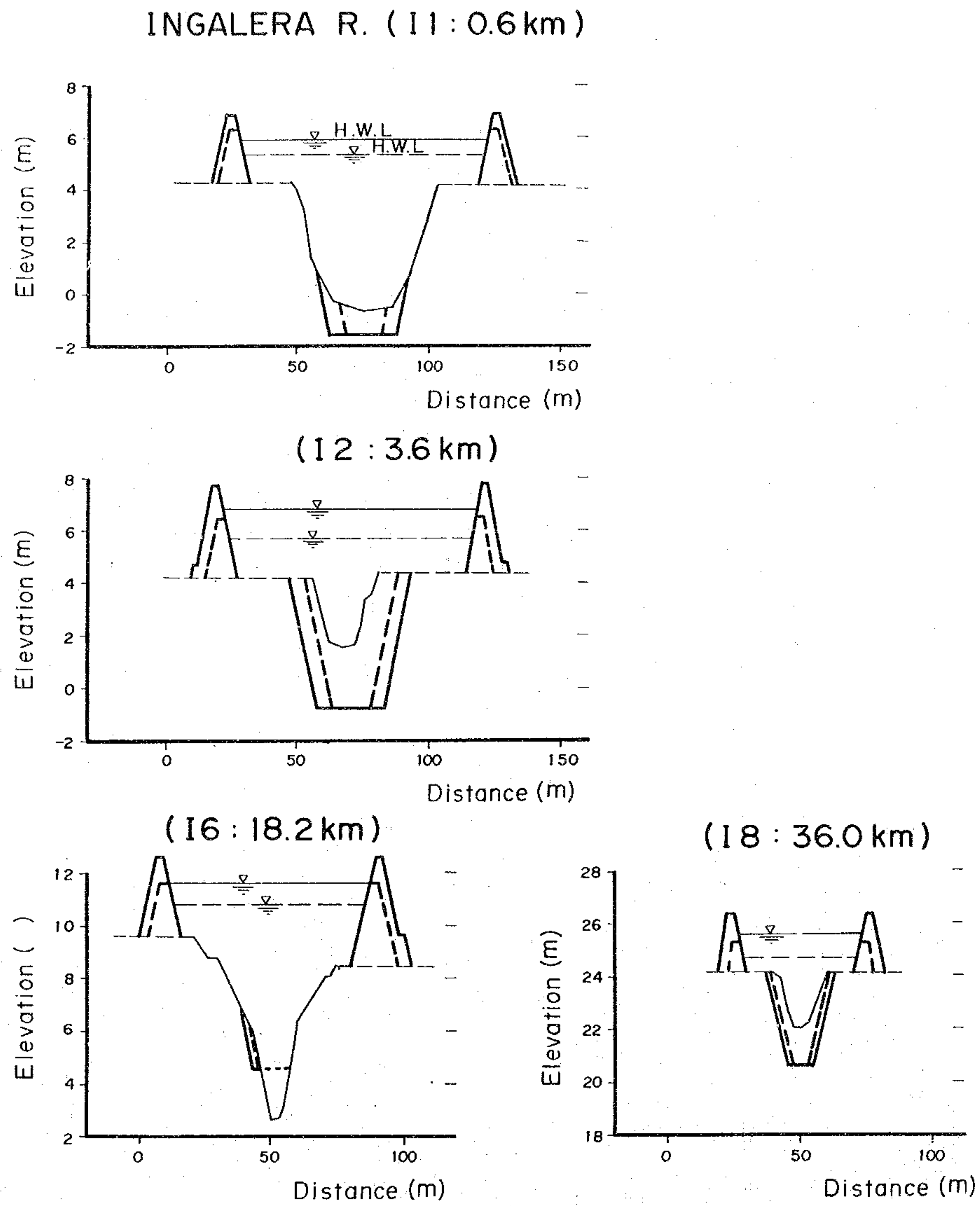


Fig. 7.37 TYPICAL CROSS-SECTION OF INGALERA RIVER

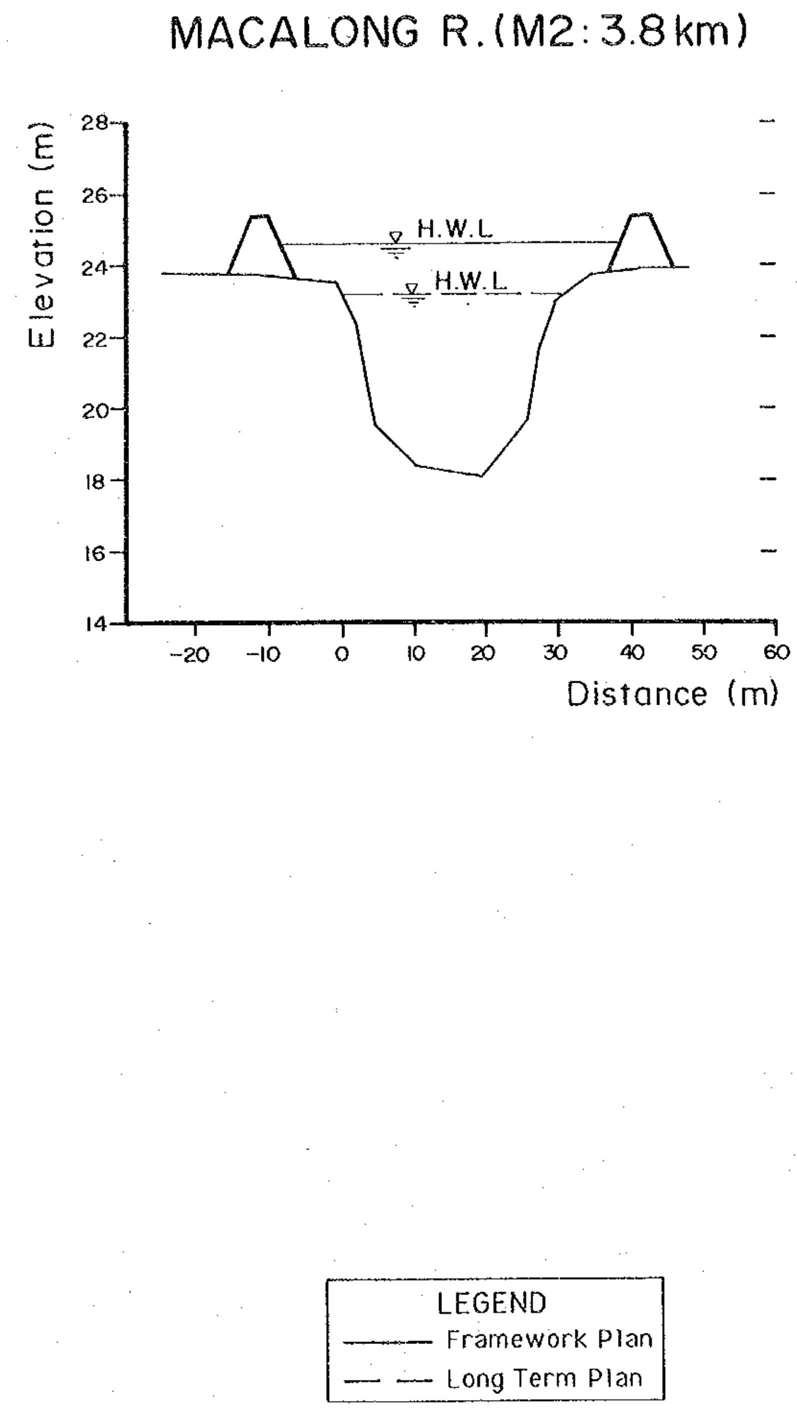


Fig 7.38 TYPICAL CROSS-SECTION OF MACALONG RIVER

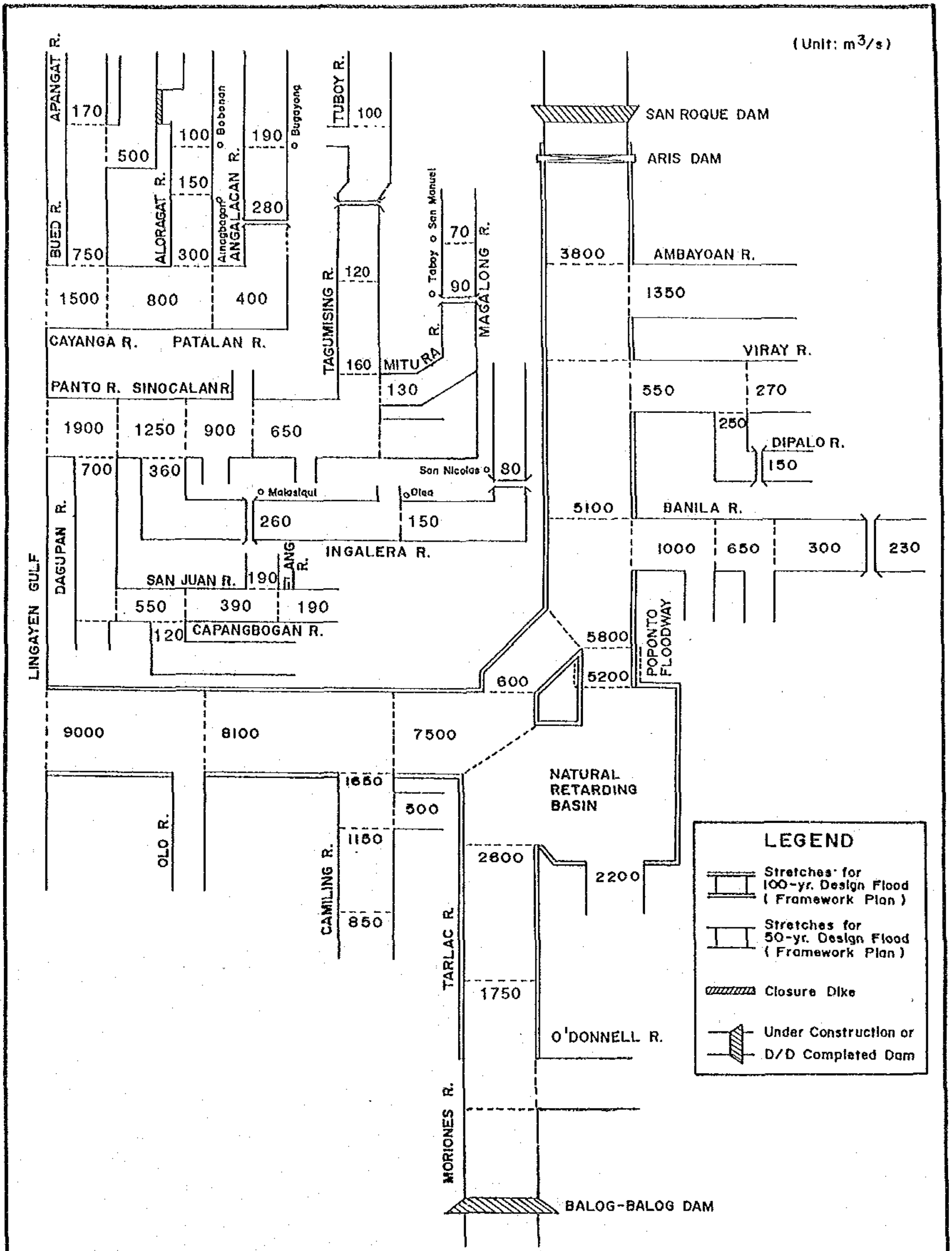
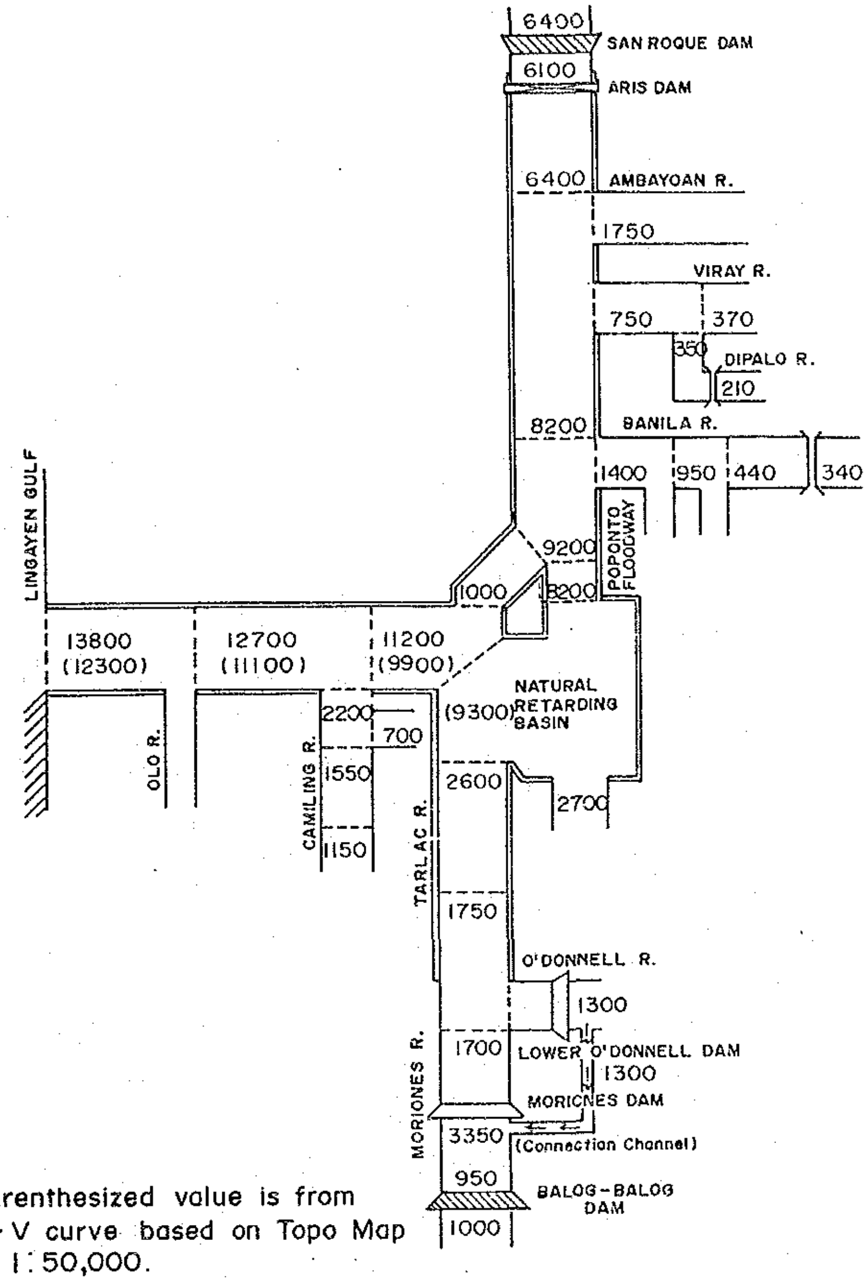
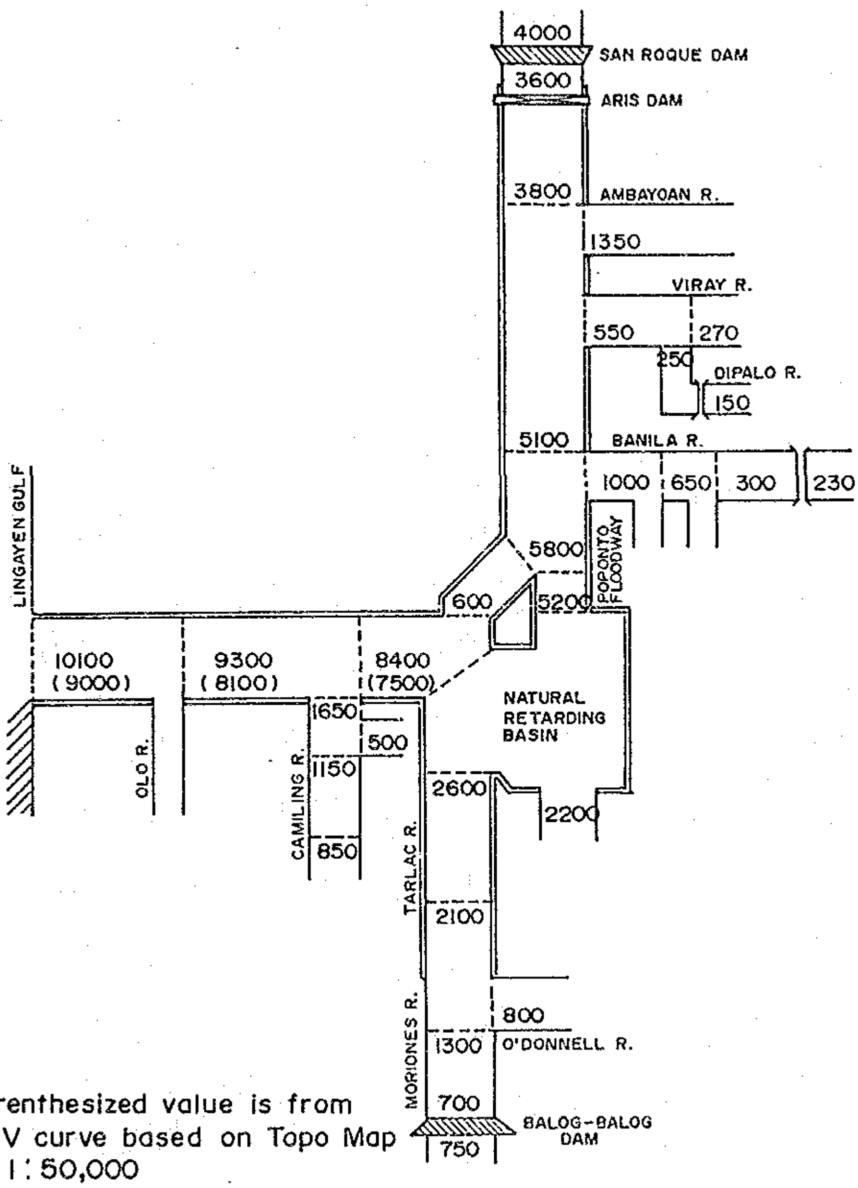


Fig. 8.1 DESIGN FLOOD DISCHARGE DISTRIBUTION OF LOAG TERM PLAN



Note: Parenthesized value is from H-V curve based on Topo Map of 1:50,000.

Fig. 9.1 REVISED DESIGN FLOOD DISTRIBUTION OF FRAMEWORK PLAN OF AGNO RIVER



Note: Parenthesized value is from H-V curve based on Topo Map of 1:50,000

Fig. 9.2 REVISED DESIGN FLOOD DISTRIBUTION OF LONG TERM PLAN OF AGNO RIVER

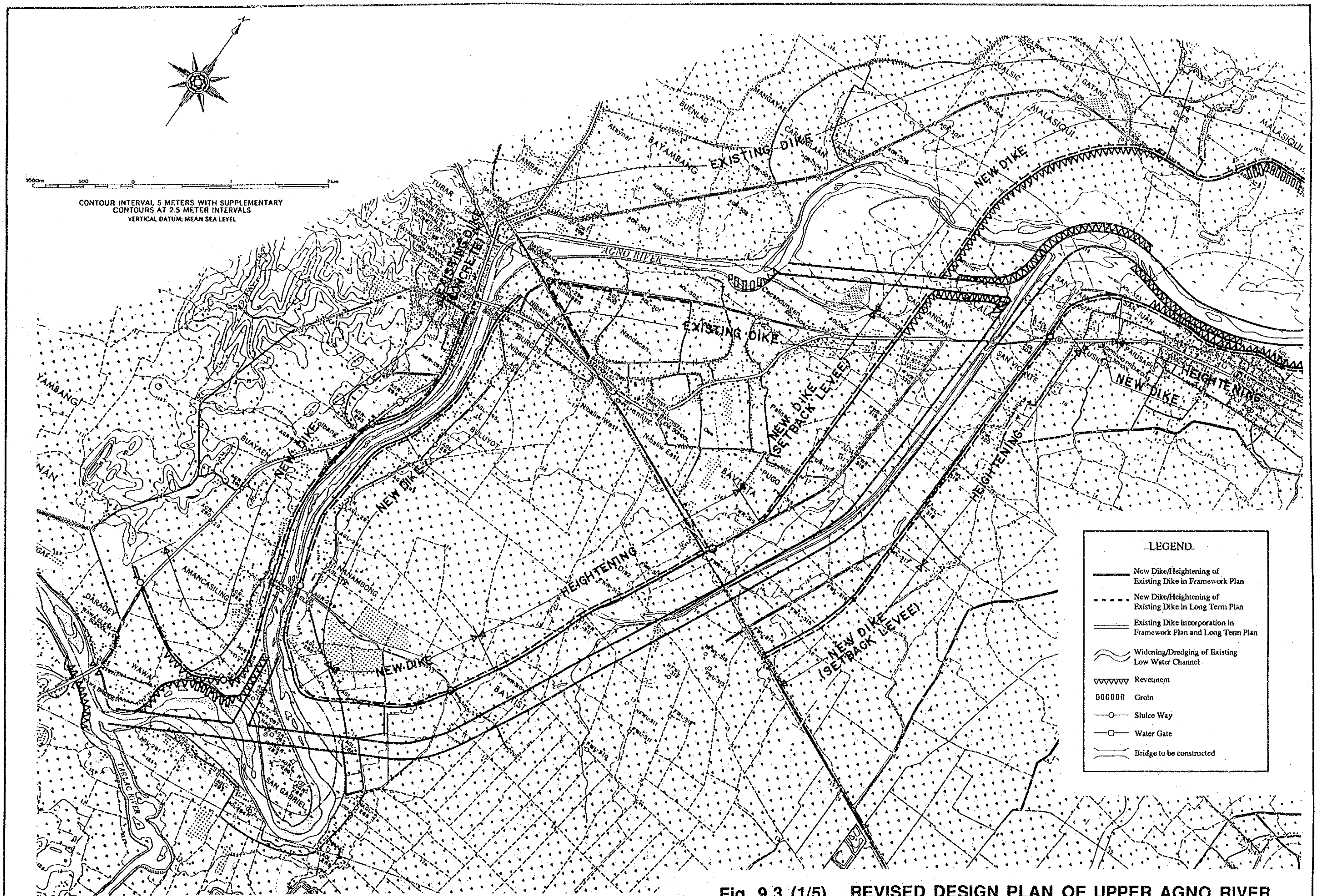


Fig. 9.3 (1/5) REVISED DESIGN PLAN OF UPPER AGNO RIVER

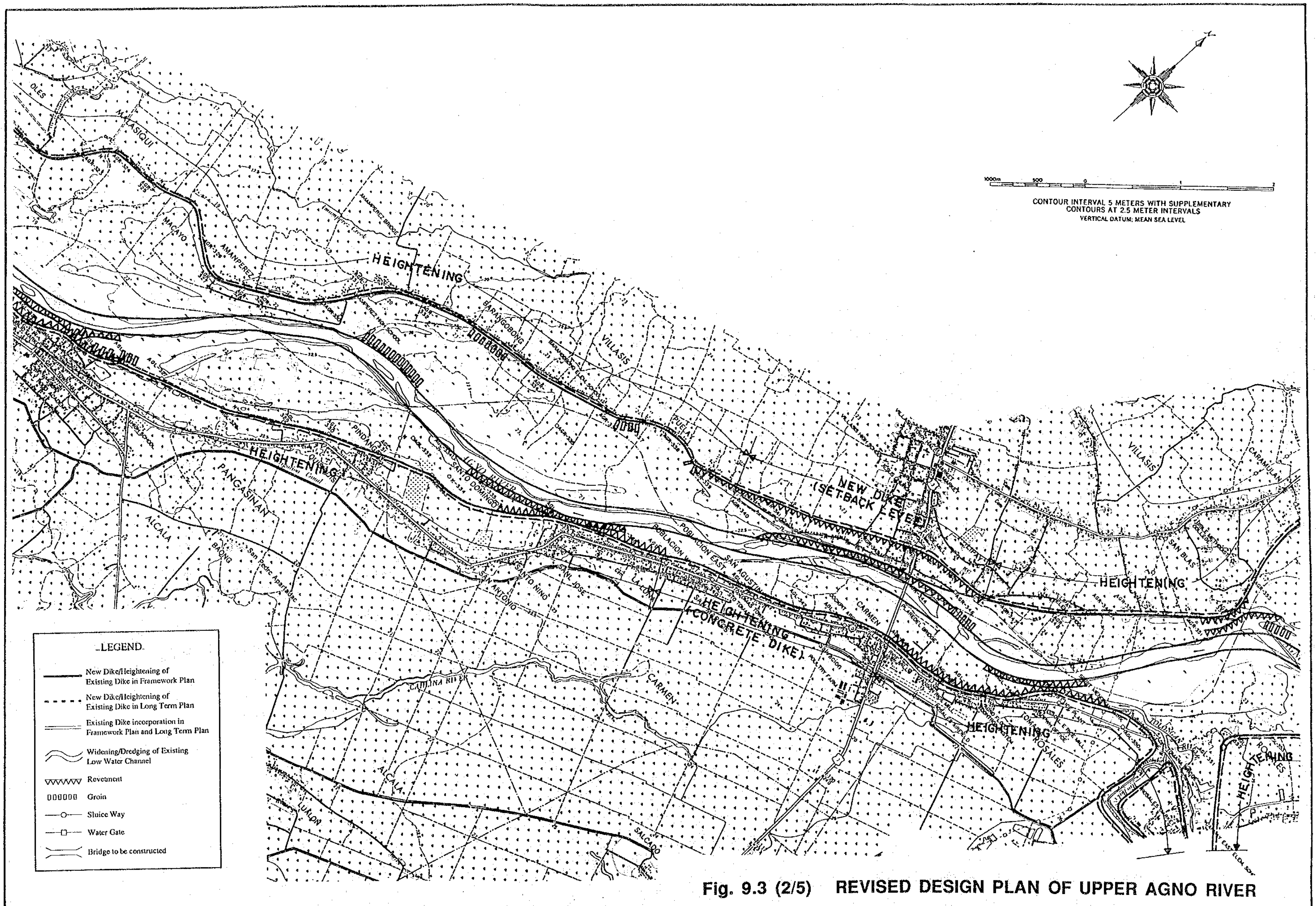


Fig. 9.3 (2/5) REVISED DESIGN PLAN OF UPPER AGNO RIVER

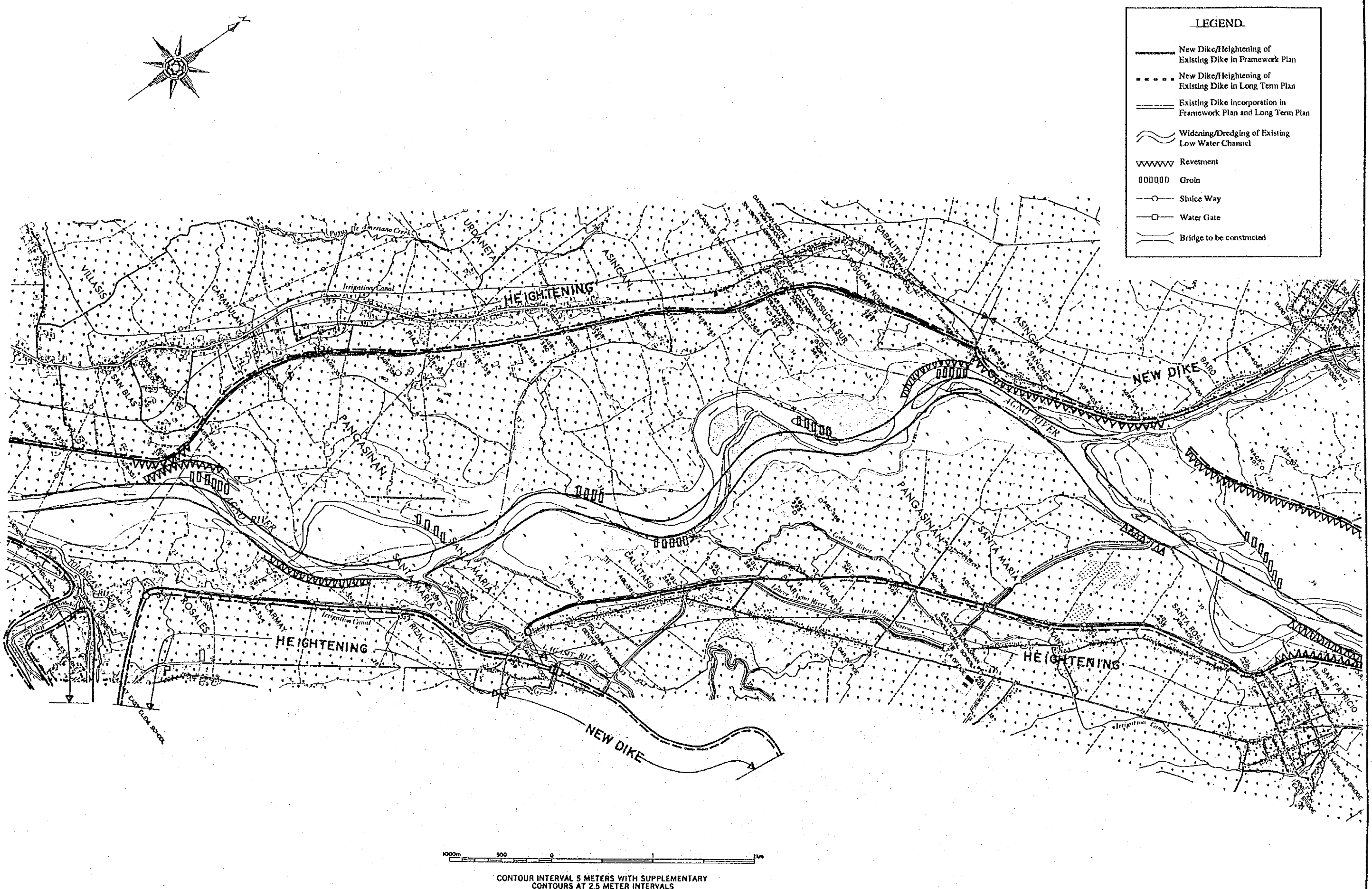


Fig. 9.3 (3/5) REVISED DESIGN PLAN OF UPPER AGNO RIVER

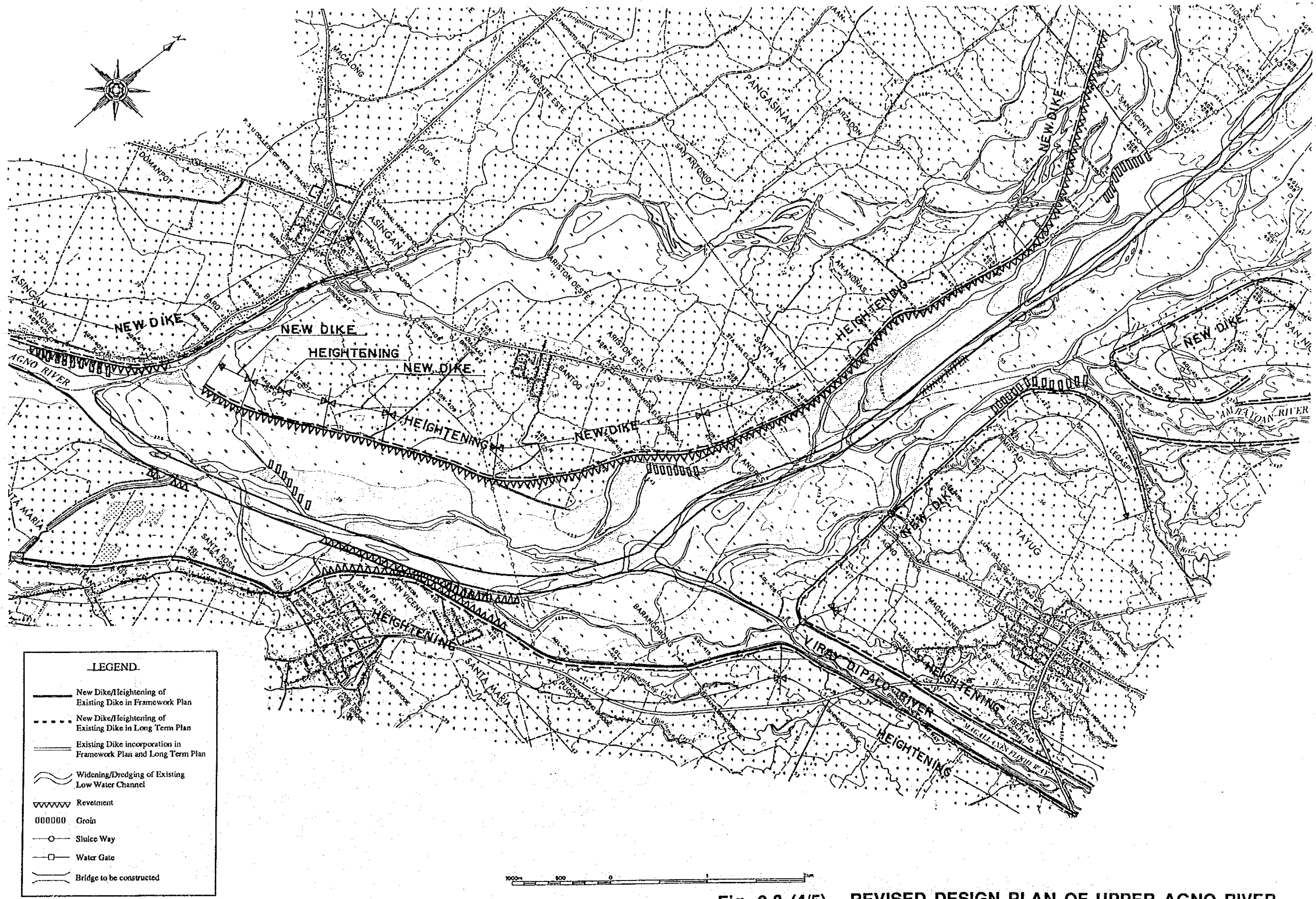


Fig. 9.3 (4/5) REVISED DESIGN PLAN OF UPPER AGNO RIVER

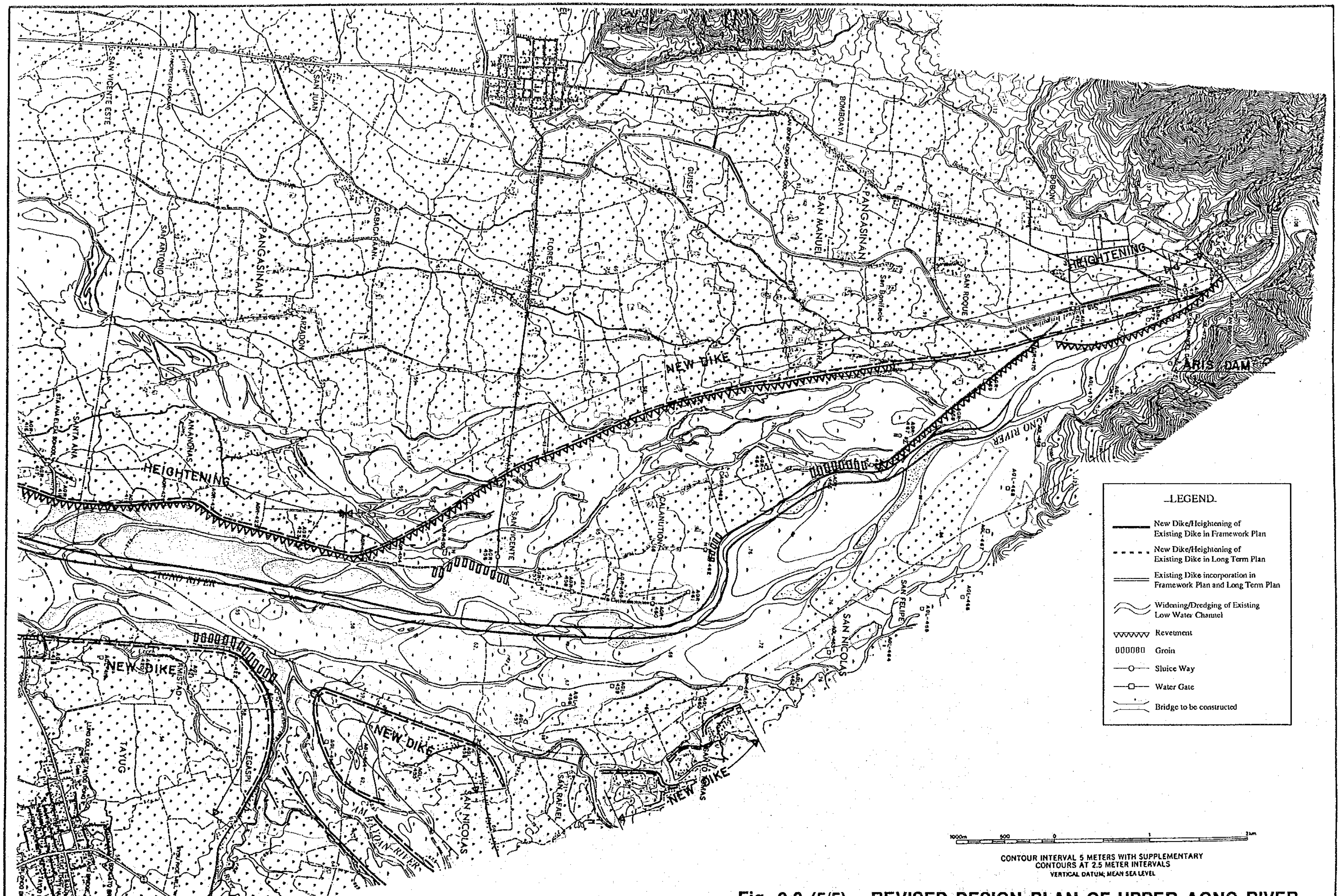


Fig. 9.3 (5/5) REVISED DESIGN PLAN OF UPPER AGNO RIVER

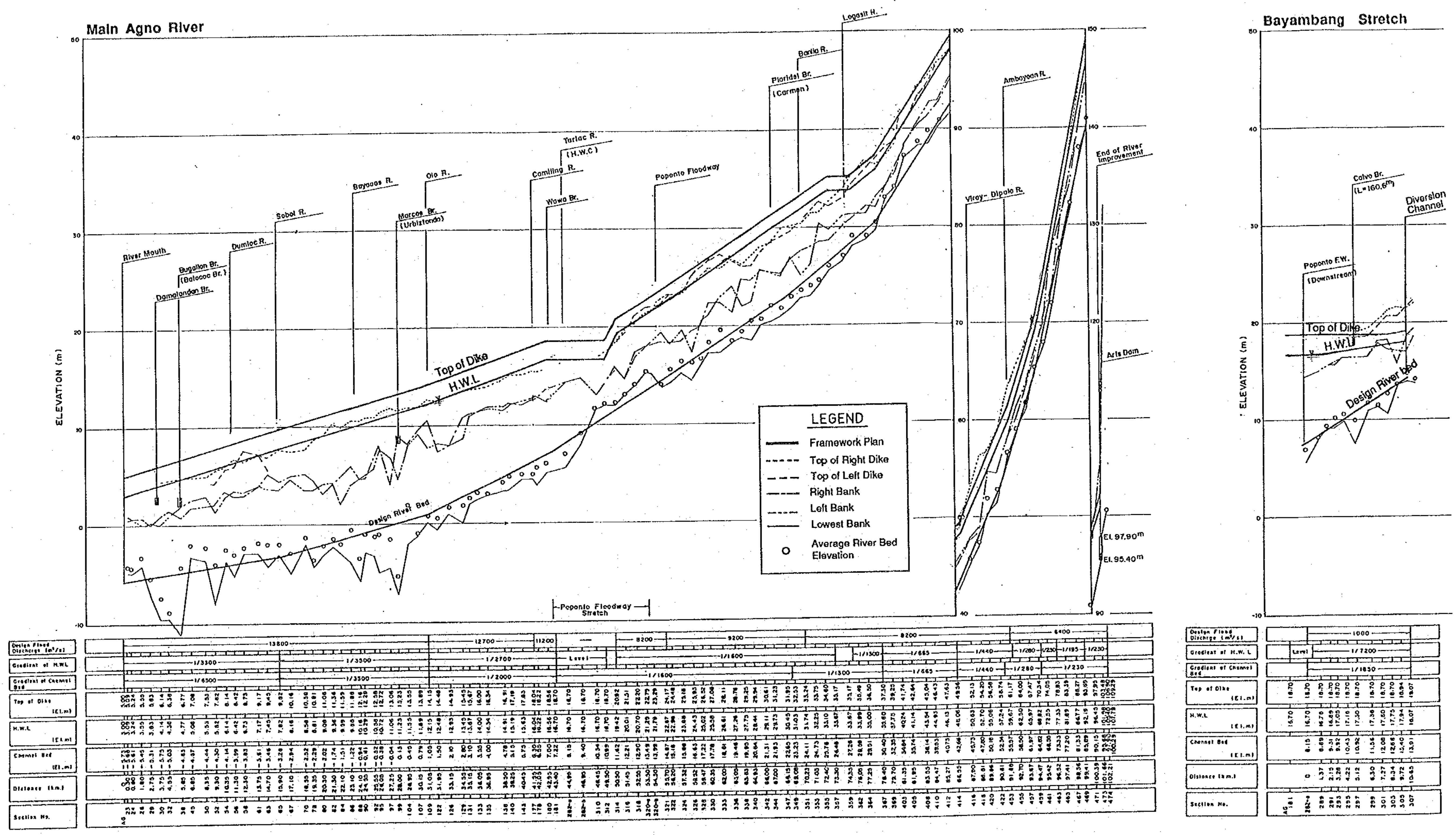


Fig. 9.4 REVISED LONGITUDINAL PROFILE OF FRAMEWORK PLAN

8. DM

8. DM DAM AND RETARDING BASIN PLAN

DM : DAM AND RETARDING BASIN

SUMMARY

(1) The existing dams in the Agno River basin are Ambuklao and Binga dams in the upper reaches of the main Agno. These dams are constructed in 1956 and 1960 respectively for hydropower generation.

The Balog-Balong dam in the upper reaches of the bulsa river is the only on-going dam project in the Study Area. Primary purpose of this dam is the irrigation water supply.

The San Roque dam is planned in the upstream of ARIS intake weir and its detailed design was completed. Primary purpose of this dam is hydropower generation and the irrigation water supply.

(2) Many dam development studies have been done by NAPOCOR, NIA, and DPWH in this basin. In addition to the identified damsites by each agency, the possible damsites on 1/50,000 topographical maps are examined from the viewpoint of topographical condition, land use in reservoir and flood prone area in the downstream reaches and the seventeen (17) damsites are selected by the STUDY. Location of these dams are shown in Fig. 2.1.

In order to find out the prospective flood control damsites, the study on selection of damsites is carried out through two screening steps: the Initial Screening and the Second Screening. Five damsites having the high storage and flood control efficiencies are selected in the First Screening. Selected damsites are San Roque, Lower Ambayoan, Lower O'Donnell, Moriones and Camiling.

(3) Five prospective flood control dams are examined by the Second Screening. In addition to these five dam schemes, the combined dam scheme of Moriones and Lower O'Donnell dams is taken into account.

Moriones and Lower O'Donnell dam reservoirs are bounded by a low and thin ridge. If these two reservoirs are connected by an open channel, more flood control effect is expected at the downstream reaches.

River improvement independent plan is selected as the alternative facilities to a flood control dam. The dam cost is compared with the reduction in river improvement cost gained by flood control effect of a flood control dam.

The study concludes that Lower O'Donnell and Moriones independent dam schemes, and the combined dam scheme of Moriones and Lower O'Donnell dams are the prospective damsites in terms of flood control efficiencies. Among these dam schemes, the combined dam scheme of Moriones and Lower O'Donnell dams is the most advisable one to consider. Accordingly, this combined dam scheme is selected as a part of the integrated flood control plan.

(4) Potential retarding basin areas are Poponto swamp and Camiling swamp from view points of topographical conditions and land use. The Poponto swamp is located in the south of the confluence of the main Agno and Tarlac rivers. This swamp area is functioning naturally as a retarding basin partly for the Tarlac river and partly for the Agno river. The flood flow of the Agno river is diverted into the Poponto swamp through the existing floodway.

A natural retarding basin and three types of retarding basins without confining dikes are studied as illustrated in Fig. 5.2.

The results of alternative cost comparative study with river improvement works are summarized in Table 5.1. The facility costs for retarding basins are all less than the reduction in river improvement cost. The natural retarding basin type, of which additional cost is negligible, is most efficient among these four alternatives, though amount of peak flood reduction is least among these.

(5) The Camiling swamp is located in the downstream reaches of Camiling river. A natural retarding type and an overflow type which has a higher flood control effect than the natural one are introduced as alternative retarding basins taking into account topographic and land use constraints.

Flood retarding effect to the downstream area by the natural retarding type is not so much, since this is located in the lower reaches of the Agno river. Furthermore, retarding capacity of this swamp is very small compare to the Poponto swamp. Accordingly, the natural retarding type is discarded for the integrated flood control plan.

The overflow type is studied changing the amount of flood peak cut. As shown in Table 5.2, the facility cost for this type of retarding basin exceeds the reduction in river improvement cost, therefore, it is assessed that the Camiling retarding basin plan is not predominant to the river improvement plan.

DM: DAM AND RETARDING BASIN

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ABBREVIATIONS

1. NAME OF PHILLIPINE GOVERNMENT AGENCIES AND OTHERS

AFCS	Agno Flood Control System
ARIS	Agno River Irrigation System
DPWH	Department of Public Works and Highways
GOP	Government of the Philippines
NAPOCOR	National Power Corporation
NIA	National Irrigation Administration
SMORIS	San Miguel-O'Donnell River Irrigation System
TARIS	Tarlac River Irrigation System
SWIM	Small-Scale Water Impounding Management Project

2. NAME OF JAPANESE GOVERNMENT AND OTHER OFFICIAL AGENCIES

GOJ	Government of Japan
JICA	Japan International Cooperation Agency
MOC	Ministry of Construction, Japan

3. MEASUREMENTS

(Length)		(Weight)	
mm	millimeter(s)	gr(grs)	gramme(s)
cm	centimeter(s)	kg(kgs)	kilogramme(s)
m	meter(s)	ton(s)	ton(s), eq'vt to 1,000 kg
km	kilometer(s)		
(Area)		(Time)	
mm^2	square millimeter(s)	sec	second(s)
cm^2	square centimeter(s)	min	minute(s)
m^2	square meter(s)	hr(hrs)	hour(s)
km^2	square kilometer(s)	dy(dys)	day(s)
ha(has)	hectare(s)	yr(yrs)	year(s)
(Volume)		(Electrical)	
cm^3	cubic centimeter(s)	MW	megawatt
m^3	cubic meter(s)	GWh	gigawatt hour
(Elevation)		(Elevation)	
HWL	high water level	LWL	low water level
FWL	flood water level	SWL	surcharge water level

1. INTRODUCTION

Agricultural industry dominates in the Agno River basin at present and may continue to remain the same in the future; in principle up to the year 2010, earmarked as the target year for the Master Plan to be formulated under this STUDY. It is observed that fundamental problems in relation to water resources development in the Agno River basin are flood inundation in the agricultural area due to flood during rainy season and water shortage for irrigation during dry season. Water resources development objectives therefore are to be set forth on flood control and irrigation development.

For irrigation development, two large scale projects such as the San Roque Multipurpose Dam Project and the Balog-Balog Multipurpose Dam Project are being planned and under construction respectively in this basin. On the other hand, the overall flood control plan in the Agno River basin has not yet been formulated and therefore it is required to formulate the Master Plan on flood control in this basin.

Dam and reservoir development and retarding basin development are considered the most effective means of achieving such objective. There are many potential damsites either of single purpose or multipurpose dam development in the basin. National Irrigation Administration (NIA), National Power Corporation (NAPOCOR), and the Department of Public Works and Highways (DPWH) have undertaken studies on various possible dam development schemes. However, purposes of these dams are mainly for irrigation water supply or hydropower generation. Flood control purpose is not included or considered incidentally.

2. EXISTING AND PLANNED DAM SCHEMES AND RETARDING BASIN SCHEMES

2.1 Existing Dams and Retarding Basins

2.1.1 Dams

Ambuklao dam and Binga dam are the only existing dams in the Agno River basin. They are located at the upstream of the Agno River, east of Baguio City as shown in Fig.2.1. These dams were constructed in 1956 and 1960 respectively for the purpose of hydropower generation and are now under operation of NAPOCOR.

These dams were planned as single-purpose for hydropower. Incidental flood control effect by each dam was studied in STUDY OF AMBUKLAO DAM REHABILITATION PROJECT and STUDY OF BINGA DAM REHABILITATION PROJECT by JICA against the flood corresponding to the 120% of 200-year probable flood. The analyzed results of these studies are quoted as follows:

		Ambuklao Dam	Binga Dam
-Peak inflow discharge	(m^3/s)	9,840	11,080
-Peak outflow discharge	(m^3/s)	9,486	11,049
-Peak cut discharge	(m^3/s)	354	31
-Peak cut ratio	(%)	3.6	0.3

As shown above, the flood control effect by each dam is negligibly small.

Principal features of these dams are summarized below:

	Ambuklao Dam	Binga Dam
-Catchment area (km^2)	617	860
-Reservoir area at HWL (km^2)	11.0(1956)	2.9
	7.5(1986)	
-Storage volume (x $10^6 m^3$)		
Gross	327(1956)	87(1960)
	217(1986)	61(1986)
Effective	258(1956)	48(1960)
	209(1986)	39(1986)

-High water level	(El.m)	752	575
-Low water level	(El.m)	694	555
-Dam Type		Rockfill	Rockfill
-Dam height	(m)	129	107
-Dam volume	($x10^6m^3$)	5.8	1.9
-Installed capacity	(MW)	75	100
-Annual energy output	(GWh)	400	516

2.1.2 Retarding Basins

Poponto swamp is the only existing retarding basin which has more or less artificial control structures in the Agno River basin. This swamp is located at southeast of the confluence of the main Agno and Tarlac Rivers as shown in Fig.2.1. The land of Poponto swamp is mainly used for vegetable field, and some areas are used for paddy field and fish pond.

This swamp is habitually inundated due to the flood coming from Agno and Tarlac Rivers during the rainy season. As the result of this inundation, the flood peak discharge coming from both rivers is reduced naturally. Therefore, Poponto swamp provides the important function in reducing a flood peak to the downstream reaches of the Agno River.

In order to divert a part of the flood flow from the Agno River to the swamp, the floodway with a spillway was constructed from 1975 to 1988 by DPWH. Dimensions of the floodway are as follows:

-Width of spillway	(m)	1,020
-Crest elevation of spillway	(El.m)	18.75
-Width of floodway	(m)	800-1,000
-Length of right dike	(m)	5,000
-Length of left dike	(m)	4,500
-Width of low water channel	(m)	30-50

There is no such effective retarding area other than Poponto swamp in this basin. The only conceivable area is the habitually inundated area in the left bank along the lower reaches of the main Agno.

At the lowermost reaches of the Agno River, there are three existing ring dikes to protect paddy field. Excluding these areas, the area of about 70 km^2 which is located in the downstream reaches of Camiling River known as Camiling swamp is conceivable for flood retarding basin.

The lands of Camiling swamp are used mainly for vegetable production and some are used for paddy field. Location of this swamp is shown in Fig.2.1.

2.2 Dams Under Construction, Design and Planning

2.2.1 Dams Under Construction

In the upstream reaches of the Bulsa River which is a tributary of the Tarlac River, the Balog-Balog multipurpose dam is under construction by NIA. Its location is shown in Fig.2.1. This project envisions to provide water supply for year-round irrigation of a net area of about 39,150 ha and generate about 100 GWh of electric power. The irrigation service area of this dam includes the 13,460 ha of already supplied by Tarlac River Irrigation System (TARIS) and San Miguel O'donnell River Irrigation System (SMORIS).

The main features of the Balog-Balog multipurpose dam are as follows:

	Unit	Quantity
-Catchment Area	(km^2)	283
-Reservoir area at HWL	(km^2)	17.5
-Storage volume		
Gross	($x10^6m^3$)	625
Effective	($x10^6m^3$)	575
-High water level	(El.m)	238
-Low water level	(El.m)	180
-Dam type		Gravel fill
-Dam height	(m)	113.5
-Dam volume	($x10^6m^3$)	11.85
-Installed capacity	(MW)	33
-Annual energy output	(GWh)	100

In addition to this large scale dam development, the Small-scale Water Impounding Management Project (SWIM) is on-going in the downstream reaches of the Moriones River. This project is named as Western Barrios Impounding Irrigation Project which is a grant-in-aid by the Government of Japan.

This project is comprised of construction works of 4 small dams and reservoirs, irrigation and drainage facilities, operation and maintenance roads including bridges in the Western Barrios rainfed farming area to contribute in increasing agricultural productivity and income. The main features and locations of 4 dams under this project are shown in Table 2.1 and Fig. 2.2.

2.2.2 Dams Under Design and Planning

Many dam development plans have been studied so far by agencies such as NIA, NAPOCOR and DPWH. Among these dam plans, San Roque Multipurpose Dam Project is planned in the Agno River and the proposed dam site is located at 2 km upstream of Agno River Irrigation System (ARIS) intake dam as shown in Fig. 2.1. Its detailed design was completed by NAPOCOR and NIA.

The main purpose of this project is to provide irrigation water supply for a maximum net area of about 87,000 ha and to generate about 1,200 GWh of electric power annually.

The main features of the San Roque multipurpose dam are as follows:

	Unit	Quantity
-Catchment area	(km^2)	1,250
-Reservoir area at HWL	(km^2)	14
-Storage Volume		
Gross (incl. flood space)	($x10^6m^3$)	1,150
Effective	($x10^6m^3$)	670
-High water level	(El.m)	290
-Low water level	(El.m)	225
-Dam type		Gravel Fill
-Dam height	(m)	210
-Dam volume	($x\ 10^6m^3$)	43.15
-Installed capacity	(MW)	390
-Annual energy output	(GWh)	1,214

In addition, 18 SWIM projects in total are qualified in the Agno River basin through the SWIM Study conducted by JICA. The main features and locations of the said evaluated SWIM projects are shown in Table 2.1 and Fig. 2.2

3. PLAN FORMULATION METHODOLOGY AND CRITERIA FOR INDIVIDUAL PLAN

3.1 Methodology of Alternative Formulation

3.1.1 Flood Control Dams

There are many prospective damsites for flood control purpose in the Agno River basin. However, it would be practically impossible and unrecommendable to implement those dams simultaneously within a limited period of time from the viewpoint of budgetary constraints.

The study of individual flood control plan in terms of identified flood control dam schemes is carried out in order to select possible schemes which may be incorporated as a major component of the integrated flood control plan. This study is conducted in due consideration of flood control efficiencies through two screening steps; the Initial Screening and the Second Screening.

The Initial Screening is carried out through the following procedures and simple criteria in terms of storage efficiency and flood control efficiency. The screening procedures are as follows:

(1) To identify the possible damsites from 1/50,000 topographical map and available project reports in due consideration of the need of development for flood control.

(2) To estimate basic figures of damsite, such as catchment area, reservoir surface area and storage curve, topographically possible dam elevation and make profile of dam axis.

(3) To estimate sediment inflow volume and elevation of dead storage.

(4) To estimate flood peak discharge and hydrograph at damsite.

(5) To estimate required maximum flood control storage.

(6) To decide dam scale and estimate dam volume.

(7) To estimate storage efficiency and flood control efficiency.

(8) To select prospective damsites for flood control.

The Second Screening is further carried out to make a detailed evaluation of the damsites selected in the Initial Screening. In this study, river improvement is considered as the alternative facilities to a flood control dam. Comparison of construction cost between a dam and a river improvement is made by least construction cost criteria.

General procedures are as follows;

(1) To estimate sediment amount and its elevation.

(2) To estimate flood peak discharge and hydrograph at damsite and base points in downstream reaches under without dam condition.

(3) To estimate flood control storage and its surcharge water level (2-4 cases).

(4) To design spillway and estimate flood water level.

(5) To decide dam scale and preliminary design of dam and appurtenant structures.

(6) To estimate work quantities and dam cost.

(7) To estimate flood peak discharge at base points in downstream reaches under with dam condition.

(8) To estimate reduction in river improvement cost due to flood control effect by dam.

(9) To compare dam cost and reduction in river improvement cost.

(10) To select prospective damsites and its scale for flood control.

3.1.2 Retarding Basins

Poponto swamp and Camiling swamp are the existing natural retarding basins. Poponto swamp has been equipped with the floodway with dikes as described in Chapter 2, while Camiling swamp has no any artificial control structures.

In order to formulate an effective and economical retarding basin plan, several conceivable alternative plans are studied for two swamps.

In this study, a river improvement work is considered as the alternative facilities to a retarding basin. Comparison of a retarding basin and a river improvement work is then made by least construction cost criteria.

General procedures are as follows;

(1) To draw up alternative cases.

(2) To estimate basic figures of retarding basin, such as retarding basin surface area and storage curve, and maximum water level.

(3) To estimate flood peak discharge at base points in downstream reaches under without retarding basin condition.

(4) To estimate sediment inflow volume.

(5) To estimate peak inflow discharge to retarding basin and its hydrograph.

(6) To estimate flood control storage, inundated area and its flood water level.

(7) To assess retarding basin scale and to make preliminary design of related structures.

(8) To estimate work quantity and its construction cost.

(9) To estimate flood peak discharge at base points in downstream reaches under with retarding basin condition.

(10) To estimate reduction in river improvement cost due to flood control effect by retarding basin.

(11) To compare retarding basin cost and reduction in river improvement cost.

(12) To select the optimum retarding basin plan.

3.2 Criteria for Alternative Plans

3.2.1 Flood Control Dams

The study on selection of prospective flood control schemes is conducted based on the following basic study criteria.

Basic Study Criteria

(1) The existing Ambuklao dam and Binga dam are studied in terms of flood control effect under existing condition, i.e., modification and/or reconstruction of these dams are not considered.

(2) The Balog-Balog multipurpose dam under construction is also studied in terms of flood control effect without modification of its present design.

(3) The San Roque multipurpose dam which detailed design was completed is studied in terms of flood control effect under its original design. Since this damsite is located at a superior site from flood control point of view, the dam is also studied as a single purpose scheme for flood control.

(4) All the other dams are studied as single purpose schemes for flood control.

The basic conditions and assumptions applied to two screening are as follows:

<u>For Initial Screening</u>

(1) In case there are more damsites with high efficiencies in one tributary, one dam is basically selected in one tributary basin.

(2) Concrete gravity type is applied for flood control dam. Dam slopes are assumed as follows;

- Upstream dam slope 1:0.1
- Downstream dam slope 1:0.7

(3) The lowest dam height is adopted among the following for deciding the dam scale;

- Topographically possible maximum height
- Hydrologically required height
- Technically possible height (Maximum height is assumed at 200 m)

(4) Dam volume is calculated by the following empirical formula based on the profile of dam axis;

- Dam volume = $1/2\ BH\ (L1 + L2) + 1/6\ (m + n)\ H^2\ (L1 + 2L2)$

Where; B = Dam crest width (= 8 m)
H = Dam Height
L1 = Dam length at the crest
L2 = Dam length at the bottom
m = Upstream dam slope (= 0.1)
n = Downstream dam slope (=0.7)

(5) Free-board is assumed at 5 m from surcharge water level.

(6) Annual sediment yield of 5,500 m^3/km^2/year and 4,000 m^3/km^2/year are assumed at damsites in northern and southern mountainous areas respectively. The dead storage is determined by the total sediment

inflow for the period of 50 years.

(7) Flood peak discharge at damsites are estimated by applying the specific discharge diagram which was studied by NATIONWIDE FLOOD CONTROL PLAN AND RIVER DREDGING PROGRAM. Triangular flood hydrograph is assumed in this study.

(8) The horizontal flood peak cut method is applied.

(9) The storage efficiency and flood control efficiency defined by the following equations are taken into account for screening;

- Storage Efficiency (SE) = Flood control storage/Dam volume
- Flood Control Efficiency (FCE)
  = SE x Catchment area x Flood peak cut ratio/1,000

A larger value of SE gives a more efficient dam scheme for comparison. FCE implies that a larger catchment area is more effective for flood control.

<u>For Second Screening</u>

(1) 100-yr probable flood is applied for a flood control dam.

(2) Annual sediment yield estimated in the STUDY (SD: Sediment Analysis)is applied to each damsite and 50 years sediment inflow volume is assumed for dead storage.

(3) Concrete gravity type is applied for main dam, while homogeneous earthfill dam is applied for saddle dam if required. Dam slopes are assumed as follows;

	Main dam	Saddle dam
- Upstream dam slope	1:0.1	1:4.0
- Downstream dam slope	1:0.7	1:3.0

(4) Freeboard is assumed at 2 m from flood water level.

(5) The constant-ratio/constant-amount outflow method is assumed as reservoir operation method.

(6) Design surcharge water level is set at 1.2 times the calculated control storage.

(7) Flood water level is set at estimated level to discharge the peak inflow of a 200-yr probable flood through spillway.

(8) Free overflow crest with gated conduit type is applied for control section of spillway.

(9) Stilling basin type with a dissipate capacity for 100-yr flood is applied for energy dissipater.

(10) Tunnel type is adopted for diversion system during dam construction and 2-yr probable flood is applied for this diversion system.

(11) Hydrological data such as flood discharge at damsite and flood discharge distribution in the downstream reaches are estimated by applying the flood run-off model developed in the STUDY.

(12) River improvement work is selected as the alternative facilities to flood control dams. Reduction in river improvement cost due to flood control effect by dam are compared with dam construction cost.

3.2.2 Retarding Basins

The selection of prospective retarding basin plan is proceeded by applying the following criteria, conditions and assumptions;

(1) Existing 1/50,000 topographical maps are used for estimating the retarding basin capacity.

(2) 100-yr probable flood is applied for evaluation of a retarding basin plan.

(3) Annual sediment yield amount which was obtained in the STUDY is applied at retarding basin and 50 years sediment inflow volume is adopted for dead storage.

(4) The horizontal flood peak cut method is applied for flood control operation at retarding basin in case artificial flood control structures are equipped.

(5) Freeboard is assumed at 1.5 m from flood water level.

(6) Maximum flood water level of Poponto retarding basin is set at EL.18.5 m from the topographical point of view.

(7) Maximum flood water level of the Camiling retarding basin is set at EL.15.0 m so as not to inundate Camiling town.

(8) Discharge capacity of the Agno River at Bayambang is estimated at about 1,000 m^3/s. Since it is considered difficult or almost impossible to increase its discharge capacity by river improvement because of the narrow bridge just completed and the dense population in the area, the flood discharge of 1,000 m^3/s from the upstream of Agno River is planned to be discharged to the existing river channel and all excess flood water to be diverted to the Poponto swamp through the floodway. A non-gated weir is provided at just downstream of the bifurcation of the floodway in the Agno River to control flood inflow to the downstream reaches at Bayambang.

(9) Concrete weir with sluice gates is adopted for gated control weir. Its dimensions are required in different control method.

(10) Concrete facing on the dike structure is adopted for side overflow weir.

(11) Hydrological data such as flood discharge at retarding basin and flood discharge distribution in the downstream reaches are estimated by applying the flood run-off model developed in the STUDY.

(12) River improvement is selected as the alternative facilities to retarding basin. Reduction in river improvement cost gained by flood retarding effect by retarding basin are compared with retarding basin cost.

4. ALTERNATIVE FLOOD CONTROL DAM PLANS

4.1 Identified Dams

Existing dams in the Agno River basin are Ambuklao dam and Binga dam, both of which are located in the upper reaches of the main Agno and the primary purpose is hydropower generation. These two dams are operated and managed by NAPOCOR.

The only on-going dam project is Balog-Balog dam in the upper reaches of Bulsa River, a tributary of Tarlac River. The primary purpose of Balog-Balog dam is irrigation water supply. This dam is under the jurisdiction of NIA.

Many dam development studies have been done by NAPOCOR, NIA, and DPWH in this basin. In addition to the identified damsites by each agency, the possible damsites on 1/50,000 topographical maps are examined from the viewpoint of topographical condition, land use in reservoir and flood prone area in the downstream reaches.

The seventeen (17) prospective damsites selected by the STUDY are all the same as those already identified in the previous studies. Those existing, on-going and identified dams are listed in Table 4.1 and shown in Fig. 2.1.

4.2 Results of Initial Screening

Among the selected seventeen damsites, three are existing and on-going. The remaining fourteen (14) damsites, therefore, are studied by applying the Initial Screening criteria defined in Section 3.2.

The probable flood with 100-year and 50-year return period are applied in the Initial Screening. Flood peak discharge at each damsite is estimated by applying the specific discharge diagram which was studied and prepared by NATIONWIDE FLOOD CONTROL PLAN AND RIVER DREDGING PROGRAM. Relationship between basin area and specific discharge is illustrated in Fig. 4.1.

The Probable 100-year and 50-year basin mean rainfall is also obtained from the same report. The probable flood at each damsite is estimated assuming

0.7 of the runoff coefficient and summarized in Table 4.2.

Simplified triangular flood hydrograph at each damsite is then developed by adopting the flood peak discharge and run-off volume. Estimated flood hydrographs are shown in Fig. 4.2.

Storage Efficiency and Flood Control Efficiency are estimated at each damsite. Screening results are shown in Tables 4.3 and 4.4 for 100-year and 50-year probable floods respectively and summarized in Table 4.5.

Five (5) damsites having high storage and flood control efficiencies are selected for the Second Screening. Selected damsites are as follows:

Selected Damsite	River Basin
-San Roque	Agno
-Lower Ambayoan	Ambayoan
-Lower O'Donnell	Tarlac
-Moriones	Tarlac
-Camiling	Camiling

4.3 Results of Second Screening

Five prospective flood control dams are examined by the Second Screening. In addition to these five dam schemes, the combined dam scheme of Moriones and Lower O'Donnell dams is taken into account.

Moriones and Lower O'Donnell dam reservoirs are bounded by a low and thin ridge. If these two reservoirs are connected by an open channel, more flood control effect is expected at the downstream reaches.

River improvement independent plan is selected as the alternative facilities to a flood control dam. The dam cost is compared with the reduction in river improvement cost gained by flood control effect of a flood control dam.

Alternative cost of the river improvement works is assumed to consist of dike embankment, channel excavation, revetment, groin, and etc., and dredging costs. In this study, the sediment deposit in a dam is counted as the dredging costs because it is necessary to dredge that equivalent sediment amount in the downstream reaches without dam condition.

The study results including dam features, dam construction costs, peak discharge at base points and decreased river improvement costs due to flood control effects by each dam are shown in Tables 4.6 to 4.12. Probable flood discharge distribution controlled by each dam are illustrated in Figs. 4.3 to 4.8.

The results of the Second Screening is summarized below:

Item	Unit	Dam Scheme					
		San Roque	Lower Ambayoan	Lower O'Donnell	Moriones	Moriones & L.O'Donnell	Camiling
Peak cut ratio	%	30	30	30	50	50	30
Surcharge WL	El.m	240.0	230.0	107.2	94.0	98.7	231.5
Dam Crest	El.m	244.1	233.2	109.9	97.9	103.0	235.4
Dam height	m	149.1	118.2	44.9	47.9	53.0	85.4
Dam volume	Mill.m^3	3.87	2.24	0.13	0.22	0.37	0.55
Const. cost	Mill.P	11,001	6,236	1,257	1,182	2,244	1,858
Reduction in river improvement cost	Mill.P	2,714	2,123	1,492	1,490	3,107	831
Difference	Mill.P	8,287	4,113	-235	-308	-863	1,027

The study concludes that Lower O'Donnell and Moriones independent dam schemes, and the combined dam scheme of Moriones and Lower O'Donnell dams are the prospective damsites in terms of flood control efficiencies. Among these dam schemes, the combined dam scheme of Moriones and Lower O'Donnell dams is the most advisable one to consider. Accordingly, this combined dam scheme is considered as a part of the integrated flood control plan.