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REPUBLIC OF THE PHILIPPINES
DEPARTMENT OF PUBLIC WORKS AND HIGHWAYS

STUDY OF AGNO RIVER BASIN FLOOD CONTROL

FINAL REPORT

VOLUME II

MAIN REPORT
PART II FEASIBILITY STUDY

DECEMBER, 1991

JAPAN INTERNATIONAL COOPERATION AGENCY

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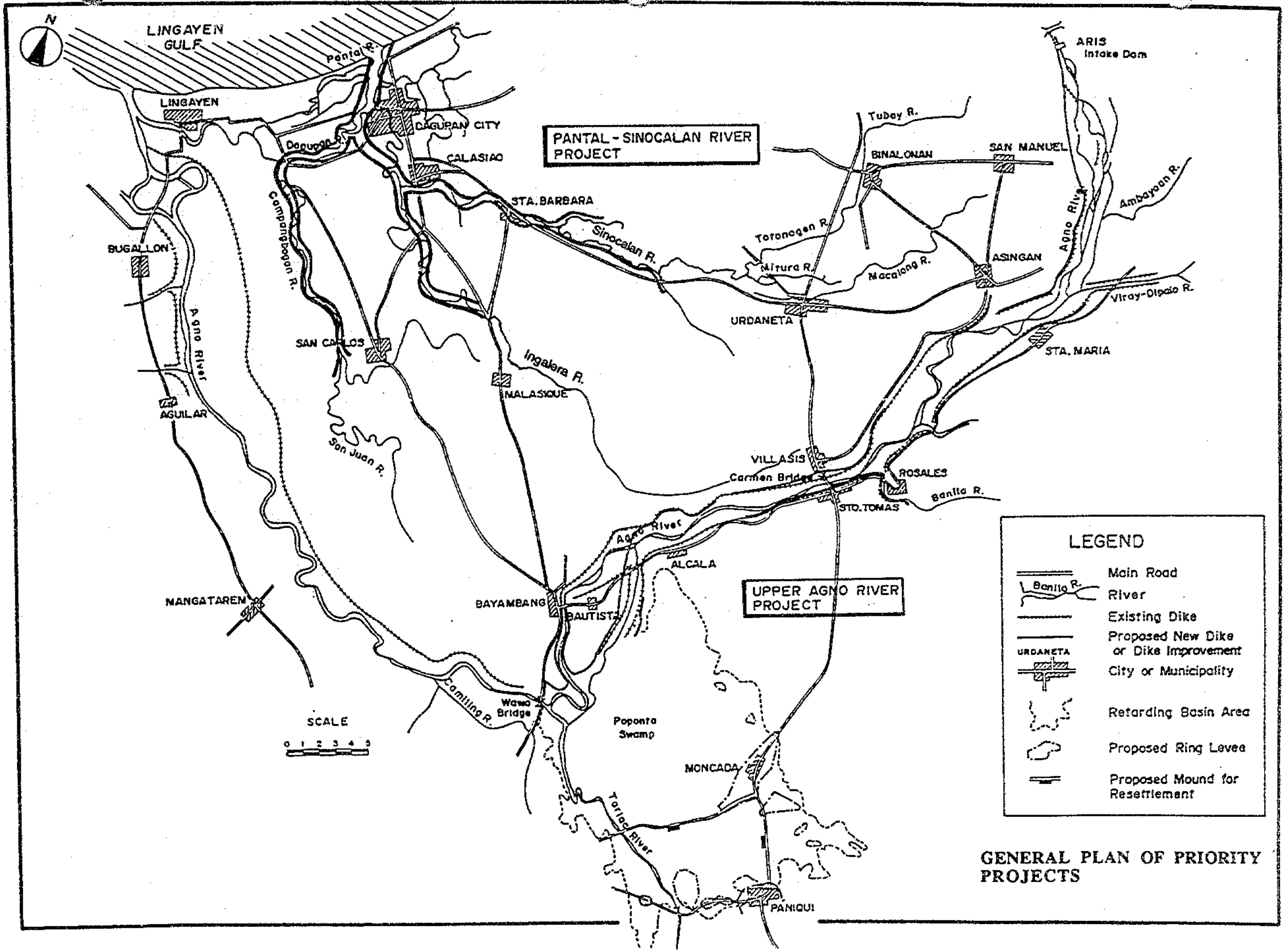
The report is published in six volumes under the following titles :

VOLUME I SUMMARY REPORT
II MAIN REPORT PART I MASTER PLAN
III MAIN REPORT PART II FEASIBILITY STUDY
IV SUPPORTING REPORT PART I MASTER PLAN
V SUPPORTING REPORT PART II FEASIBILITY STUDY
VI DATA BOOK



GENERAL PLAN OF PRIORITY PROJECTS

MAIN REPORT PART II FEASIBILITY STUDY

PRINCIPAL CONCLUSIONS

1. STUDY OBJECTIVES

The objectives of the Study as stipulated in the Implementation Arrangement of the Technical Cooperation between the Japan International Cooperation Agency (JICA) and Department of Public Works and Highways (DPWH) of the Government of the Philippines are :

1) To formulate a Master Plan for flood control in the Agno River Basin and identify the priority areas.

2) To conduct a Feasibility Study on the flood control projects in the identified priority areas.

This Part-2 of Main Report presents all the results of the Feasibility Study.

2. THE STUDY AREA

2.1 Master Plan Study Area

(1) The Master Plan Study Area covers three river systems and the vast alluvial plain called the Pangasinan plain in the western part of Central Luzon. The Study Area's drainage area totaling about 7,640 km^2, broken down into 5,907 km^2 for the Agno River basin, 1,115 km^2 for the Pantal-Sinocalan River, and 618 km^2 for the Cayanga-Patalan River. Aggregates of the Pantal-Sinocalan and Cayanga-Patalan Rivers are called together as the Allied Rivers.

The Master Plan Study Area straddle 9 provinces of the four Regions, Ilocos (Region I), Cordillera Autonomous Region (CAR), Cagayan Valley (Region II), and Central Luzon (Region III). These are Benguet, La Union, Pangasinan, Ifugao, Nueva Vizcaya, Nueva Ecija, Pampanga, Tarlac, and Zambales.

(2) The maximum inundation area in the Master Plan is estimated to be 2,465 km^2, largely covering the cultivated lands in the flood plains of the Agno River and the Allied Rivers in Pangasinan and Tarlac.

2.2 Feasibility Study Area

(1) The Feasibility Study Area, which comprises the identified priority flood control areas in the Upper Agno River and the Pantal-Sinocalan River, includes 32 cities and municipalities.

(2) The Upper Agno project has a beneficial area of 1,264 km^2, covering entirely the lowlands along the Allied Rivers. It spans 32 human settlements in central and northwestern Pangasinan, including the cities of Dagupan and San Carlos, and the towns of Camiling in Tarlac and Rosario in La Union. This overlaps with the beneficial area of the Pantal-Sinocalan project, which covers 879 km^2, including 15 municipalities and 2 cities in Pangasinan.

3. FEASIBILITY STUDY

3.1 Definition of Priority Projects

(1) In the Master Plan the Upper Agno River and Pantal-Sinocalan River are identified as the Priority Project Areas subject to the Feasibility Study taking account of economic efficiency and regional significance of flood control.

A. Upper Agno River ; Bayambang stretch with Poponto retarding basin (AG180) to the San Manuel stretch (AG473); the stretch of 69 km between the Wawa bridge and the San Roque bridge in the Upper Agno River.

B. Pantal-Sinocalan River ; River mouth to the upstream to protect Dagupan city and towns of Calasiao and Santa Barbara; the downstream stretch of 27.5 km of the mainstream, 19.5 km of the Dagupan River and 10.7 km of the Ingalera River.

(2) Priority Projects are a step to the Long Term Plan with the flood protection level of 10-year design flood.

3.2 Flood Control Plan for the Upper Agno River

(1) The Upper Agno River Priority Project is composed of river improvement to the Bayambang-Alcala, Alcala-Asingan, and Asingan-San Manuel stretches, and construction of new Poponto floodway and natural retarding basin. The Poponto natural retarding basin aims to regulate the confined flood discharge in the lower Agno River stretch within an allowable level (refer to the general plan). The principle features of the works are presented at the back of these sheets.

River Improvement Plan

(2) The proposed river improvement plan for the upper Agno River is composed of the following major three works in view of the river regime and channel conditions (refer to Figure 9.1.2):

a) Bayambang - Alcala stretch (AG181-AG321 : 22.55 km)
b) Alcala - Asingan stretch (AG321-AG414 : 30.85 km)
c) Asingan - San Manuel stretch (AG414-AG473 : 15.66 km)

(3) The river improvement works in the Alcala - Bayambang stretch consist of following three components:

- Construction of a new dike downstream of the Calvo bridge to the Wawa bridge
- Demolition of the existing Poponto inlet weir and construction of new 1,200m wide Poponto floodway together with channel improvement thereof
- Construction of a new diversion channel at the bifurcation point of the floodway leading to the Bayambang stretch

(4) The Carmen stretch in the Alcala-Asingan stretch forms a bottleneck near the Carmen bridge with the minimum river width of 650 m in the 30.85 km long Alcala - Asingan stretch. The river improvement works consist of:

- Enlargement of the existing low water channel; the design bed width of 150 m

- Construction of a new setback levee which is 0.3 m higher than the existing dike height on the right bank to enlarge the existing minimum river width to 900 m; stretch length of 2.8 km.
- Heightening of the existing dike; 0.6 m for the existing 3.6 km long concrete dike on the left bank

(5) The river improvement works in the Asingan - San Manuel stretch consist of:

- Construction of a new setback levee on the right bank; stretch length of 7 km
- Heightening of existing dikes
- Improvement of the existing low water channel; downstream from AG416 at the junction of the Viray-Dipalo River

Poponto Retarding Basin

(6) Poponto retarding basin dose not require specific flood control facilities except the construction of dikes on both abutments of the Wawa bridge. However, the works involve protection and evacuation measures for the residents and heightening and renovation of the existing roads and bridges in the affected Poponto swamp area due to raising of flood water level from the existing EL.14.5 m to EL.16.00 m (10-year design flood).

(7) Of the affected population of 67,000, 44,000 residents (65%) are planned to be protected by ring levees. The remaining 23,800 (35%) are planned to be resettled either to planned mounds, to the areas inside the ring levees, or to the areas outside the retarding basin.

(8) Heightening of roads and improvement of bridges are planed. The rail road is kept untouched because of no concrete future operation plan at present.

3.3 Flood Control Plan for the Pantal-Sinocalan Rivers

(1) This river improvement aims primarily to protect Dagupan city, the towns of Calaciao and Santa Barbara, and their neighboring areas (refer to the general plan).

(2) The proposed river improvement plan of the Pantal-Sinocalan River is composed of the following components:

1)	Main Pantal-Sinocalan River	: from river mouth to upstream of the Catablan River junction (27.5 km)
2)	Dagupan River	: from Bypass channel junction to upstream of Elang River junction (19.5 km)
3)	Ingalera River	: from Pantal-River junction to downstream of Bogtong bridge, Sta. I.8 + 0.8 km (10.7 km)

The principle features of the works are presented at the back of these sheets.

(3) The bypass channel plan aims to divert the flood discharge of the Sinocalan River at the junction with the tributary Ingalera toward the Dagupan river and to discharge it finally into the Pantal River downstream of Dagupan City. With this bypass channel the river widening works of the existing urban stretch which involves significant compensation and resettlement issues are avoided. The length, river width, and bedwidth of the low water channel of the proposed bypass is 3.20 km, 220 m, and 40 m respectively.

(4) Two water gates are provided for flood control of the urban stretch (Marusay stretch) of the Pantal River: a 10 m wide lower gate at the junction with the Pantal River and a 10 m wide upper gate at the inlet from the bypass channel. These gates are opened during low flow discharge and closed when a flood at the bypass inlet exceeds the 95 - day discharge (about 30 m^3/s).

(5) The existing community boat transports and small fishing boats can be maintained through the 10 m wide water gate, however, the vertical clearance of the gate is not sufficient for naval ships and dredgers. A loading yard or pier space is required for these ships, and thus the lower water gate is installed about 100 m upstream from the junction of the Pantal River.

3.4 Project Costs and Economic Evaluation

(1) The financial project cost and the economic project cost for the Upper Agno River are estimated at 3,913.2 million pesos and 3,475.9 million pesos,

respectively. The economic internal rate (EIIR) is estimated at 20.6% under the future development condition, and this project is assessed to be economically viable.

(2) The financial project cost and the economic project cost for the Pantal-Sinocalan River are estimated at 3,895.7 million pesos and 3,306.9 million pesos, respectively. The EIIR is estimated at 17.0% under the future development condition, and this project is assessed to be economically viable.

3.5 Implementation Schedule of Priority Projects

(1) Given the first priority on the Upper Agno River and, the second priority on the Pantal-Sinocalan River, each project is planned to be implemented in two stages in each 10 year period. All the projects are planned to be completed in 15 years. The project implementation schedule is prepared with the target construction commencement of the Upper Agno River in 1995 and that of the Pantal-Sinocalan River in 2000 (refer to Figure 9.1.1).

Unit: Million Pesos (price level on May 1991)

Project	First Stage	Second Stage	Total
a. Upper Agno River	1995 - 1999 2,923.4	2000 - 2004 989.8	3,913.2
b. Pantal-Sinocalan River	2000 - 2004 1,977.4	2005 - 2009 1,918.4	3,895.7

(2) The first stage of the Upper Agno River Project aims primarily to restore and reinforce the existing diking system against a 10-year design flood discharge, together with construction of the new Poponto floodway and natural retarding basin. The second stage consists of excavating low water channels, installing revetments and other remaining works (refer to Figure 9.1.2).

(3) The first stage of the Pantal-Sinocalan River Project aims to protect Dagupan city, and the towns of Calasiao and Santa Barbara from a 10-year design flood discharge with provision of the proposed by-pass channel, the

diking system from the river mouth to the upstream of Santa Barbara on the right bank of the Sinocalan River, the diking system for the Santa Barbara stretch on the left bank of the Sinocalan River, and bank protection on both banks of the Pantal River. The second stage consists of the remaining diking systems for the Sinocalan, Dagupan and Ingarela Rivers, low water channel improvement, revetments and other remaining works (refer to Figure 9.1.3).

4. PRELIMINARY ENVIRONMENTAL IMPACT ASSESSMENT

(1) Among the environmental parameter items which were identified as significant, social environments are impacted more than natural environments in both the Upper Agno River and Pantal-Sinocalan River projects.

Environmental Items	Upper Agno River	Pantal-Sinocalan River
Natural Environment		
· Effects on groundwater	no effect	low
· Deterioration of water quality	low	low
· Intrusion of saline water	no effect	low
Social Environment		
· Resettlement	high	high
· Encroachment of lands	high to medium	high to low
· Impair of navigation	no effect	low
· Loss of community	medium to low	low
· Hazards to workers and nearby residents	low	low
· Vector disease hazards	low	no effect
· Public health hazards	low	no effect

Expected positive impacts are an increase in land value, decrease in vector disease hazards, and decrease in public health hazards.

(2) In the Upper Agno River Projects, construction of new dikes and Poponto floodway, and expansion of Poponto retarding basin are expected to have significant impact on the social environment in terms of resettlement and encroachment of agricultural and residential lands. Loss of the community

is also an adverse effect due to the resettlement. The identified areas to be affected are :

a) Poponto floodway and retarding basin.
b) Carmen and Asingan-San Manuel stretches.

(3) In the Pantal-Sinocalan River Projects, construction of new dikes in the areas of Dagupan city and towns of Calasiao and Santa Barbara are expected to impose significant impact on the social environment in terms of resettlement, encroachment of agricultural and residential lands, and loss of community. The identified areas to be affected are :

a) Pantal-Sinocalan River from river mouth to the upstream including the Dagupan and Ingalera Rivers.
b) Dagupan-bypass

(4) The impact due to problems during construction and intrusion of saline water, and the impact on navigation, vector disease and public health are all at a low level of significance and are expected to be mitigated to a satisfactory level. Although the expected impact on water quality in the urban stretch of the Sinocalan River and on fishponds along the Dagupan River is assessed to be low level, further detailed study will be required in order to clarify some unknowns involved due to insufficient information and recorded data.

5. RECOMMENDATIONS

5.1 Recommended Projects

(1) The Priority Projects are highly justifiable economically with their sufficient EIRR. Given the first priority on the Upper Agno River and, the second priority on the Pantal-Sinocalan River, the first and second stages of the Priority Projects are recommended to be implemented as urgent flood protection measures. The project's financial costs are :

Unit : Million Pesos (price level on May 1991)

	Upper Agno River	Pantal-Sinocalan River
First stage	2,923.4	1,977.3
Second stage	989.8	1,918.4
Total	3,913.2	3,895.7

Following the Priority Projects the Long Term Plan is recommended to be implemented with the target commission year 2020.

(2) If the Study Area's flood control succeeds in containing damages with implementation of the proposed Long Term Plan, the basin economy of Pangasinan and Tarlac will become more productive. Flood protection allows the basin economy of Pangasinan and Tarlac to achieve its potential and this, in turn, makes it possible for the province to set a faster growth for the Region. The regional economy will then be able to meet, and perhaps even exceed, the projected GRDP growth.

5.2 Recommendation for Further Study

(1) The Government of the Philippines is recommended to conduct a detailed environmental study to prepare the Environmental Impact Statement because the environmental impact assessment done by the Study is preliminary. The major items to be assessed are :

1) Social impact with respect to land acquisition and resettlement issues in both the Upper Agno and the Pantal-Sinocalan Rivers.
2) Water use, water quality and related issues in the dry and wet seasons in the Bayambang stretch of the Agno River, the urban stretch of the Sinocalan River, and in fishponds along the Dagupan River.

(2) The following laboratory hydraulic model tests are recommended to determine the alignment and detailed dimension of the structures concerned and to confirm the stability of the river channels and beds :

a) Upper Agno River ; Alcala stretch - Poponto floodway, and Carmen - San Manuel stretches

b) Pantal-Sinocalan River ; Dagupan bypass and related distribution facilities

(3) The seismic resistance survey and design done in this Study is preliminary, and thus further detailed survey and design on this subject are recommended to be conducted in the detailed design stage.

PRINCIPAL FEATURES OF PRIORITY PROJECTS

1. PROJECT COST AND EIIR

(price level on May 1991)

Priority Project	Flood Control Scale	Project Financial Cost (million pesos)	EIRR (%)
Upper Agno River	10-year flood	3,913.2	20.6
Pantal-Sinocalan River	10-year flood	3,895.7	17.0

2. DESIGN FLOOD DISTRIBUTION

. Upper Agno River (refer to Figure 2.4.5)

Wawa bridge	6,200 m^3/sec
Confluence with Tarlac River	1,700 m^3/sec
Alcala	4,000 m^3/sec
for Poponto floodway	3,500 m^3/sec
for Bayambang stretch	500 m^3/sec
Ambayoan	2,400 m^3/sec

. Pantal-Sinocalan River (refer to Figure 4.1.3)

River mouth	2,000 m^3/sec
Dagupan River	1,850 m^3/sec
Inlet of bypass	1,250 m^3/sec

3. IMPROVEMENT WORKS, WORK QUANTITIES AND COST BREAKDOWN

3.1 Upper Agno River

River Improvement Works

- New dike construction : 46.00 km earthdike and 7.70 km setback levee
- Heightening of dike : 29.50 km earthdike and 2.50 km concrete dike

- Counterweight earthdike : 42.00 km
- Channel improvement : 48.20 km
- Revetment : 23.20 km for low-water channel
  37.30 km for earthdike
- Groins : 10.55 km
- Drainage facilities : 18 sluiceways
- Diversion structures : Bayambang diversion channel
- Irrigation facilities : 2 box culverts with gates of the LAIS
- Bridges : 3 road bridges (Calvo/Floodway/Plaridel) and 2 railways bridges demolished

Retarding Basin Works

- Ring levee: 11 sites, total length 36.71 km, total embankment volume 940,400 m^3
- Mound for resettlement: 2 sites, total embankment volume 469,000 m^3
- Road heightening: National road length 5.3 km, provincial road length 6.0 km, municipal road length 6.9 km
- Bridge improvement: San Ishidro, Camangahan and Morong

Work Quantities and Cost Breakdown

		1st State		2nd Stage		Total	
		Work Quantity	Cost (mill.P)	Work Quantity	Cost (mill.P)	Work Quantity	Cost (mill.P)
Excavation	$1000m^3$	4,784.0	213.0	3,634.0	243.5	8,418.0	456.5
Dredging	$1000m^3$	0.0	0.0	0.0	0.0	0.0	0.0
Embankment	$1000m^3$	4,852.0	466.0	446.0	34.8	5,298.0	500.8
Revetment	km	32.0	343.0	20.0	175.7	52.0	518.7
Groin	pcs	54	12.2	61	13.8	115	26
Sluiceway	pcs	12	72.7	6	10.2	18	82.9
Water Gate	pcs	0	0	0	0	0	0
Bridge	m^2	8,524.0	126.6	2,046.0	30.4	10,570.0	157.0
Others	Lot	1.0	178.8	1.0	54.2	1.0	233.0
Preparatory Works	Lot	1.0	141.1	1.0	56.2	1.0	197.3
Miscellaneous W.	Lot	1.0	232.9	1.0	92.7	1.0	325.6
Main Construction			1,786.3		711.5		2,497.8
Compensation			398.0		14.0		412.0
Administration			109.2		36.3		145.5
Contingency			344.0		114.3		458.3
Engineering Services			285.8		113.8		399.6
Project Cost			2,923.4		989.8		3,923.2

3.2 Pantal-Sinocalan River

River Improvement Works

Flood Control Works	Pantal-Sinocalan River	Dagupan River	Ingalera River
. New earthdike (km)	48.50	41.90	19.00
. Channel improvement (km)	15.85	7.00	10.70
. Protection works of low-water channel (km)	6.25	0.55	0.80
. Protection works of dike and dike foundation (km)	7.06	2.87	0.93
. Drainage gates (pcs.)	17	11	3
. Bridges (pcs.)	5	5	4
. Water intake (pcs.)	5	16	0

Work Quantities and Cost Breakdown

		1st State		2nd Stage		Total	
		Work Quantity	Cost (mill.P)	Work Quantity	Cost (mill.P)	Work Quantity	Cost (mill.P)
Excavation	1000m3	1,243.0	35.5	2,105.0	82.2	3,348.0	117.7
Dredging	1000m3	160.0	5.6	20.0	0.7	180.0	6.3
Embankment	1000m3	1,806.0	189.6	2,482.0	260.6	4,288.0	450.2
Revetment	km	12.0	171.0	12.0	141.2	24.0	312.2
Groin	pcs	0	0	39	5.2	39	5.2
Sluiceway	pcs	14	32.4	29	87.8	43	120.2
Water Gate	pcs	4	236.5	5	178.5	9	415
Bridge	m2	11,048.0	164.1	8,609.0	127.8	19,657.0	291.9
Others	Lot	1.0	76.0	1.0	80.5	1.0	156.5
Preparatory Works	Lot	1.0	91.1	1.0	96.4	1.0	187.5
Miscellaneous W.	Lot	1.0	150.2	1.0	159.1	1.0	309.4
Main Construction			1,151.9		1,220.0		2,371.9
Compensation			333.0		207.0		540.0
Administration			74.2		71.4		145.6
Contingency			233.9		224.8		458.6
Engineering Services			184.3		195.2		379.5
Project Cost			1,977.3		1,918.4		3,895.7

STUDY OF AGNO RIVER BASIN FLOOD CONTROL

MAIN REPORT

PART 2 FEASIBILITY STUDY

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ABBREVIATIONS

(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)	mth(mths)	month(s)
		yr(yrs)	year(s)

(Volume)		(Others)	
cm^3	cubic centimeter(s)	%	percent(s)
m^3	cubic meter(s)	o	degree(s)
ltr	liter(s)	10^3	thousand
		10^6	million
		10^9	billion

1. INTRODUCTION

1. INTRODUCTION

1.1 The Feasibility Study

The objectives of the Study stipulated in the Implementing Arrangement of the Technical Cooperation between the Japan International Cooperation Agency (JICA) and Department of Public Works and Highways (DPWH) are:

1) To formulate the Master Plan for flood control in the Agno River Basin and identify the priority areas.

2) To conduct the Feasibility Study on the flood control projects in the identified priority areas.

The Master Plan Study was conducted in the period of March 25, 1989 - February 15, 1990 and the study results were presented in the Interim Report. The report, which was issued in February 1990, identified the Upper Agno River and the Pantal-Sinocalan River as the priority project areas to be implemented urgently among the river basins and stretches in the Study Area. Upon approval by JICA and DPWH, the Feasibility Study commenced on these two priority areas on May 1, 1990.

The background of initiation of the Study has been described in the introduction of Part-1 of the Main Report.

1.2 Suspension and Resumption of the Study

The Feasibility Study commenced on May 1, 1990 and was scheduled to be completed by the end of January, 1991. The part of basic investigation consisting of topographic survey and geotechnical investigation progressed on schedule. However, the planning study which was scheduled to start from August 1990 was suspended due to the occurrence of an earthquake on July 16, 1990 which inflicted heavy damages to the study area.

JICA dispatched the Study Team from September 9 to September 27, 1990 and conducted the leveling survey to determine the ground movement in the Study Area after the earthquake in order to:

i) inspect the conditions of the study area after the earthquake.

ii) confirm the possibility of resuming the Study, and

iii) set up the scope of work and work schedule required for its resumption.

After review of the foregoing inspection results, JICA, the Steering Committee (DPWH) and the Study Team confirmed the following basic principles for resumption of the study:

a. The Master Plan of the Agno River Basin Flood Control established in the Interim Report is unchanged.

b. The Feasibility Study areas selected in the Interim Report and accepted in the Joint Meeting on March 1, 1990, are unchanged.

The study was resumed on November 26, 1990, followed by a series of supplemental investigations, and completed at the beginning of September, 1991. The investigation included topographic and river surveys, geological core drills, soil property tests, and liquefaction and seismic resistance surveys.

1.3 Contents of the Report

This Part-2 of Main Report presents all the results of the Feasibility Study. The details of sectoral studies are presented in the Supporting Report. Some supporting data to these reports are compiled in a data book. The study outputs of the Master Plan are presented in Part-1 of Main Report and its Supporting Report. Summary of both the Master Plan and Feasibility Study is presented in the Summary Report. The Supporting Report comprises fourteen sectors; Socio-Economy, Hydrology, Geology, Liquefaction Study, Seismic Resistance Study, Survey, Flood Damage, Sediment Control Plan, River Improvement Plan, Dam and Retarding Basin Plan, Flood Forecasting and Warning System, Design of Structures, Construction Plan and Cost Estimates, Environmental Impact Assessment.

2. THE PROJECT AREA

2. THE PROJECT AREA

2.1 Location and Socio-Economic Conditions

2.1.1 The Project Area

The Master Plan Study Area covers three river systems and a vast alluvial plain called the Pangasinan plain in the western part of Central Luzon. These rivers from the Cordillera and Zambales mountains drain the plain into the Lingayen Gulf. The largest of these rivers is the 275 km long Agno River which flows from its sources 55 km north-east of Baguio City (longitude 16°51'N and latitude 120°52'E) down the southern slopes of the Cordilleras. It flows in a southerly course to Tayag where it veers round southwest through Villasis and Bayambang into Poponto swamp. It then flows northeast, skirting the eastern slopes of the Zambales mountains and empties into the Lingayen Gulf. Its major tributaries are the Tarlac, Camiling, Ambayaoan, Viray-Dipalo, and Banila Rivers. The southern end of the Study Area is bounded by the watershed of the Tarlac River near Mt. Pinatubo (latitude 15°10'N).

In the northwestern part of the Pangasinan plain, there is a group of medium-size river systems known as the Allied Rivers which also discharge into the Lingayen Gulf. They consist of the Pantal-Sinocalan River system and the Cayanga-Patalan River system.

Figure 2.1.1 shows the Master Plan Study Area's drainage area totaling about 7,640 km^2, broken down into 5,907 km^2 in the Agno River basin, 1,115 km^2 in the Pantal-Sinocalan River basin including the Dagupan River, and 618 km^2 in the Cayanga-Patalan River basin including the Bued River.

These river basins provide an economic basis for fairly diversified agricultural production, mainly paddy and fish culture, the full potential of which cannot be exploited owing to recurrent damaging floods. The Master Plan Study Area straddles 9 provinces of Ilocos (Region I), Cordillera Autonomous Region (CAR), Cagayan Valley (Region II), and Central Luzon (Region III). These are Benguet, La Union, Pangasinan, Ifugao, Nueva Vizcaya, Ueva Ecija, Pampanga, Tarlac, and Zambales. It covers 83 municipalities out of 189 municipalities in the 9 provinces.

Figure 2.1.2 delineates the Feasibility Study Area which comprises the identified priority flood control areas in the Upper Agno River and the Pantal-Sinocalan River. Administratively the Feasibility Study Area includes 32 cities and municipalities, with an aggregate area of 2,530 km^2.

2.1.2 Maximum Inundation Area and Project Beneficial Area

Figure 2.1.3 shows the maximum inundation area in the Master Plan or the maximum area that would be flooded as determined by the flood inundation analysis. The maximum inundation area is estimated to be 2,465 km^2, largely covering the cultivated lands in the flood plains of the Agno River and the Allied Rivers in Pangasinan and Tarlac.

The maximum inundation areas, broken down by river basins, serve as the basis for defining the project beneficial areas or the areas which will benefit from the flood control projects. The Priority Project areas exclude the Lower Agno River, the tributaries of the Agno River, the Cayanga-Patalan River and an upstream part of the Pantal-Sinocalan River.

The Feasibility Study's design flood is a 10-year probable flood while the Master Plan's design flood is a 100-year probable flood. In this regard the beneficial area of the Priority Projects is reduced to 1,264 km^2:

Project Beneficial Area	Area (km^2)	Affected Settlements
Upper Agno River Basin	180	12
Pantal-Sinocalan Basin	879	17
Cayanga-Patalan Basin	205	10
Total	1,264	32

The Upper Agno project has a beneficial area of 1,264 km^2, covering entirely the lowlands along the Allied Rivers. It spans 32 human settlements in central and northwestern Pangasinan, including the cities of Dagupan and San Carlos, as well as the towns of Camiling in Tarlac and of Rosario in La Union. This overlaps with the beneficial area of the Pantal-Sinocalan project, which covers 879 km^2, including 15 municipalities and 2 cities in Pangasinan.

2.1.3 Definition of the Impact Area

Seen on the basis of a "growth center" framework, the flood control projects likely have economic and social impacts extending beyond the confines of the directly benefited areas where they are situated. The growth center approach which classifies settlements on the basis of their centrality, accessibility, areas of influence, and development potential views the urban growth center and its rural hinterland as a single spatial system.

Figure 2.1.4 groups together Pangasinan's urban centers and their satellite municipalities as based on the hierarchy of settlements:

Urban Center	Satellite Municipalities
Dagupan City - San Carlos City	Mangaldan, San Fabian, Jacinto, Mapandan, Sta. Barbara, Calasiao, Malasiqui, Bayambang, Binmaley, Bautista.
Urdaneta	Alcala, Sto. Tomas, Villasis, Manaoag, Binalonan, Pozzorubio, Sison, Basista, Laoac.
Tayung	Sta. Maria, Umingan, San Nicolas, San Quintin, Natividad, San Manuel, Asingan, Balungao, Rosales.
Lingayen	Urbiztondo, Sual, Labrador, Bugallon, Aguilar, Mangatarem.
Alaminos	Bolinao, Anda, Agno, Burgos, Mabini, Dasol, Infanta, Bani.

Source: Medium-Term Ilocos Region Development Plan, 1987-1992.

Moreover, the project priority areas span most of Pangasinan's growth centers; Dagupan City, San Carlos City, Longayen, Urdaneta, and Tayug. Dagupan City is the province's center of trade and commerce. San Carlos City is an emerging agro-processing center. Lingayen is the seat of provincial administration, Urdaneta and Tayug are significant trade centers and serve as market towns for smaller municipalities, although Tayug is seen losing in importance to upcoming Rosales. Villasis is also fast coming up as a market town. Protection of these relatively prosperous and populous centers will redound to the benefit of the province's economy.

In this regard, both priority projects will have the greatest bearing on the Dagupan City-San Carlos City group and, to a lesser extent, on the Urdaneta group. Specifically, diking systems will protect settlements along the left and right banks of Upper Agno. With the use of Poponto swamp as a natural retarding basin, flood discharges are controlled, benefiting municipalities down the Lower Agno stretches and along the lowlying Allied Rivers. The proposed bypass cannel in Dagupan City, on the other hand, will protect urban stretches in the city and relieve flood pressures in Calasiao, Sta. Barbara and other nearby municipalities. The levees on the tributaries will safeguard towns in the Pantal-Sinocalan basin.

Only the Upper Agno project will have an impact on the Tayug grouping. Of the Lingayen grouping, only Lingayen and Urbiztondo are within the project beneficial areas. The Alaminos grouping is outside the beneficial areas. But because of the significance of the river basins on Pangasinan's economy, flood protection will have an impact on both groupings. It is therefore appropriate to view Pangasinan as the Impact Area of the Project. Table 2.1.1 shows the demographic profile of cities and municipalities affected by the Project. Table 2.1.2 delineates the areas and settlements in the project beneficial area, broken down by river basin.

In like manner, benefits accruing to Pangasinan will also redound to Ilocos Region, to which it belongs administratively. Since Pangasinan is the pacesetter for Ilocos Region, the Project will have a significant impact on the regional economy. Ilocos Region is therefore the broader Impact Area of the Project.

2.1.4 Social Indicators

(1) Population

The population in the Master Plan Study Area increased from 1.72 million persons in 1970 to 2.05 million persons in 1980 at an average growth rate of 1.75% per year during this 10-year period. The growth rate is similar to that of Region I (1.70%) but significantly lower than those of Region II (2.73%), Region III (2.88%) and the whole country (2.75%). This lower growth rate in the Area may indicate that net out-migration was high in the Area between 1970 and 1980. The 1989 population in the Area is estimated at 2.41 million persons, and is projected to increase to 3.18 million persons in 2010. The population in the maximum inundation area is projected to increase from 1.56 million persons in 1989 to 2.05 million persons in 2010. The population density in the Area was 246 persons/km^2 in 1980 which was higher than the average of 160 persons/km^2 for the whole country. During this period, the average population density in the Area and the inundation area will go up from 290 persons/km^2 and 630 persons/km^2 in 1989 to 383 persons/km^2 and 830 persons/km^2 in 2010 respectively. The most densely populated municipalities with cultivated agricultural land are located in the flood plain of the Agno River and the Allied Rivers in Pangasinan and Tarlac.

The average household size and dwelling occupancy in the Area in 1980 is estimated at 5.6 persons/household and 5.7 persons/dwelling unit, respectively. The urban population in the Area, as defined by the National Statistics Office, was 529,000 in 1980 which accounted for 26% of the total population. This was lower than the country's urban population share of 37% indicating a slower urbanization rate in the area.

(2) Employment

The working age population group, 15 years old and over, in the Area was 1.24 million persons or 61%. Labor force in the Area totaled 694,000 persons or 56% of the working age population. This was lower than the country's 60% indicating that on a per capita basis there were fewer economically active persons in this Area than the national average.

The number of employed persons in the Area increased from 670,000 in 1980 to 800,000 in 1987. In 1987, the agriculture sector absorbed 405,000 workers or 51% of total employment compared to 55% in 1980. During the same period, the sector increased its share of total employment from 30% in 1980 to 34% in 1987. This employment share of the industry sector remained at 15%. Although mainly agriculture based, the structure of the Area's economy is shifting gradually towards a service sector orientation. In 1987, the Area accounted for 4.1% of the country's agricultural workers, 4.0% of the country's industrial workers and 3.5% of the country's service sector workers.

(3) GDP and Income

In 1987, the Gross Domestic Product (GDP) of the Area amounted to 17,500 million pesos which was 2.5% of the country's GDP. In real terms, the local economy grew at an average of 2.95% per year during the period of 1980 to 1987 while the national economy grew at a slower rate of 0.44% per year during the same period. Per capita GDP of the Area in 1987 was estimated at 7,539 pesos, the same as the per capita GDP of Region I, which was lower than the average per capita GDP of the whole country of 12,300 pesos.

2.2 Economic Profile and Role of Pangasinan in Ilocos Region

2.2.1 Development Role of Pangasinan

Pangasinan has socio-economic profile of: (a) an economy which is dependent on agriculture and fishing but with strong potentials for agro based industrialization; (b) a populous province which relies mainly on the primary sector to absorb labor but has substantial and growing secondary and tertiary sectors; and (c) a largely rural society dependent on farm incomes but which manages to achieve a satisfactory standard of living.

In line with the regional development framework, the Department of Trade and Industry (DTI) has further outlined the following development vision, namely, for Pangasinan to become:

(i) A primary manufacturing and trading center in Ilocos Region by the year 1992; and
(ii) A major exporting province of the Philippines by the year 2000.

In line with the development vision, DTI has defined the following development thrusts for Pangasinan: (a) enhancement of agricultural productivity; (b) development of livelihood and industry; (c) improvement of health and nutrition; (d) improvement of peace and order; and (e) generation of revenues.

The above development vision fits Pangasinan's resource endowment perfectly. DTI enumerates the province's comparative advantages include:

vast farmlands and substantial water resources; rich marine resources in Lingayen Gulf and extensive areas for fishpond development; availability of mineral resources; skilled craftmanship; and favorable geographic location.

Owing to extensive croplands and abundant water resources, Pangasinan is the leading producer of rice, corn, vegetables and livestock in the region. It also abuts the fishing grounds of Lingayen Gulf. Fish farming abounds in the coastal areas and certain river stretches of the province.

With relative availability of food raw materials and proximity to expanding consumer markets, Pangasinan can easily develop and promote indigenous food manufacturing industries.

Pangasinan is endowed with mineral deposits of commercial quantities, largely chromite ore, copper and silica. It has also abundant red clay deposits for brick manufacturing. Deposits of kaolinite, a primary raw material for manufacture of porcelain and china wares, remain relatively untapped.

Pangasinan boasts of manpower skilled in crafts. Basista is reputed for buri rope making and coco-midrib handicrafts; Pozzorubio for hamper-making; and Sta. Barbara for brickmaking. This can be the basis for promoting an export-oriented crafts industry.

As the gateway of Ilocos Region, Pangasinan assumes the link-up function between North-South routes and, to some extent, the East-West routes. This has given rise to the importance of Urdaneta, Villasis and Rosales (Carmen) as trading centers.

Pangasinan is close to transshipment points like Baguio City and Mariveles, Bataan; and, possibly in the future, Poro Point, La Union; Subic, Zambales; and Angeles City (Clark). Likewise, it is near San Fernando, La Union, which is being groomed as the RIC for Ilocos.

2.2.2 Region Performance

To reiterate, the medium-term regional development plan for 1987-1992 envisions faster growth for Ilocos Region in order to reduce disparities in regional development. The region is seen to remain agricultural-oriented although, under CAIDS, a more balanced agro-industrial development strategy will be pursued.

Under this scenario, agriculture will remain as the lead sector in Pangasinan. The province is also groomed to become a leading manufacturing and trading center as well as a major exporting province. The Agno River and Allied River basins under this development framework play a significant role as a water resource base.

In recent years, however, the faster growth envisioned for Ilocos Region did not materialize. This is evident in the comparison of the region's performance from 1987-1989 vis-à-vis the medium-term targets for 1987-1992. Agriculture, seen as the growth sector for the region, did not live up to its role as pacesetter.

	Ilocos Region	
Average Annual Growth Rate (%)	Medium-Term Targets 1987-1992	Performance 1987-1989
GRDP	7.4	3.1
Agriculture	5.4	0.2
Industry	10.5	7.1
Services	7.9	5.0
Population	1.9	1.9
Per Capita GRDP	5.5	1.2

Source: Medium-Term Philippine Development Plan; Medium-Term Ilocos Region Development Plan for targets. National Statistical Coordination Board for actual figures.

2.2.3 GRDP Projection

(1) GRDP Projection for Ilocos

The trend growth rates of GDP and GRDP of Ilocos are presented for different time periods: (a) modest growth (1975-1982); (b) contraction (1981-1985); (c) recovery; and (d) incipient slowdown (1990-1992).

Trend Growth Rate (%)	Philippines GDP	Ilocos GRDP
<u>Actual Growth for the Period</u>		
Modest Growth (1975-1982)	5.4	5.2
Contraction (1982-1985)	(3.2)	0.1
Recovery (1985-1989)	4.5	4.1
Slowdown (1989-1992)*	2.7	1.1
<u>Trend Growth (Compound Growth Rate)</u>		
1975-1992*	3.3	3.2
1987-1992*	4.1	2.2
<u>High Growth Scenario</u> (Used in Interim Report)		
1992-2000	6.8	5.2
2000-2010	7.6	5.6
<u>Modified Growth Scenario</u>		
1992-2000	5.1	4.3
2000-2010	5.9	4.6

* Incorporates projections for 1991 and 1992

Source: National Income Accounts, National Statistical Coordination Board for actual growth rates.

For 1991 to 1992, an economic slowdown is likely for Ilocos Region and probably for Pangasinan. As the national economy pursues a short-term stabilization program to steer itself back into a sustainable growth path, the region and the province will have to undertake reconstruction of earthquake-ravaged areas. The development objectives set by NEDA are to: (a) bring the economy back to its pre-quake situation; (b) ensure that the capacity of the region to withstand similar disasters is set in place; and (c) stimulate the growth momentum to catch up on lost time.

Figure 2.2.1 shows the trendline based on this long-term growth vis-à-vis the trendline based on the high growth scenario of NEDA. The latter represents robust economic expansion, assuming the economy adjusts fully to structural reforms. The midpoint between the two trends is proposed to be used in the socio-economic projections as being reflective of a more realistic growth scenario.

The "modified growth" scenario shows GDP growth rates of 5.1% for the 1992-2000 period and of 5.9% for the 2000-2010 period. Under this scenario, GRDP for Ilocos Region is projected to grow at 4.3% for the 1992-2000 period and at 4.6% for the 2000-2010 period.

The projections are summarized below:

Growth Projections (Million Pesos)	1990	2000	2010
GDP at constant			
1972 prices	109,890	172,630	305,876
1990 prices	1,129,817	1,774,861	3,144,803
GRDP at constant			
1972 prices	3,349	4,891	7,662
1990 prices	34,419	50,288	78,772
* Growth in Price Deflator (1990/1972) = 10.2813			

(2) GRDP Projection for Pangasinan and Beneficial Area

The above socio-economic projections apply also to Pangasinan as well as the project beneficial areas as these have basically similar socio-economic conditions. It is more likely for Pangasinan to have relatively faster economic growth, more rapid industrialization, greater investment requirements, higher population increases and higher standard of living than other provinces in the Region.

Two "what-if" cases are assumed to estimate gross domestic output of Pangasinan and of the beneficial areas:

(i) the use of per capita GRDP as projected for Ilocos, and
(ii) the use of a per capita GRDP figure higher by 15% to reflect the role of Pangasinan as the "pacesetter" province.

The 15% factor is deemed conservative since this implies a 4.7% growth in Pangasinan's GDP against the projected 4.2% growth in Ilocos GRDP. The estimates must be taken as broad magnitudes, not as precise estimates, reflecting the dynamic interplay between population growth and economic growth.

The area GDP levels of each scenario are summarized below.

a) Base Case

	1990	2000	2010	Implied Growth (%)
Per Capita GDP	943	1,185	1,644	2.8
Population (In Thousand)				
Pangasinan	2,018	2,255	2,506	1.1
Beneficial Areas	991	1,152	1,283	1.3
GRDP at constant 1972 prices (In Million Pesos)				
Pangasinan	1,903	2,672	4,120	3.9
Beneficial Areas	935	1,365	2,109	4.2

The base case assumes: (1) Per capita GDP based on projections for the region; (2) Population projections based on NEDA medium assumption projections.

b) Higher Growth Case

	1990	2000	2010	Implied Growth (%)
Per Capita GDP*	943	1,362	1,891	3.5
Population (In Thousand)				
Pangasinan	2,018	2,255	2,506	1.1
Beneficial Areas	991	1,152	1,283	1.3
GRDP at constant 1972 prices (In Million Pesos)				
Pangasinan	1,903	3,071	4,739	4.7
Beneficial Areas	935	1,569	2,426	4.9

The high growth case assumes: (1) Per capita GDP higher by a factor of 15% than the regional average in line with Pangasinan's "pacesetter" role; (2) Population projections based on NEDA medium assumption projections.

The latter scenario is considered more plausible and more consistent with the defined development role of Pangasinan, and is adopted in this Study.

2.2.4 Regional Investment Flows

Official figures of GRDP levels broken down by expenditure shares are not available. To determine the flows of private and public investments by region, two indicators are used: (a) the cost of Board of Investments (BOI)-registered projects and (b) programmed infrastructure spending by the Department of Public Works and Highways (DPWH).

Table 2.2.1 shows private investments trends using BOI project costs as indicator. The high-investment regions are NCR and Southern Tagalog. Southern Tagalog, on account of the CAvite-LAguna-BAtangas-Rizal-QueZON (CALABARZON) subregion, is shaping out as a favorite investment site in recent months.

Central Luzon and Central Visayas are also attracting considerable investment flows. Ilocos has been lagging in recent years but surged in 1990 with ₱9,293 million in planned investments. The full impact of these investments is not yet apparent in the region's economy.

Table 2.2.2 shows public investments as reflected in the DPWH programmed spending. Here, Ilocos lags behind other regions. In 1990, it ranks second to the last among all regions with just ₱658 million programmed infrastructure spending.

Comparison of the shares of infrastructure spending to GRDP as shown in Table 2.2.3 indicates that NCR and the more developed regions appear to rely less on public investments. From 1986 to 1990, the share of infrastructure spending to GRDP has ranged from 1.5% to 2.5% in Ilocos against the national average of 0.84% to 1.19%. It can be conceded that the Government has attempted to spur development in depressed areas through infrastructure investments but perhaps not in the required magnitudes to lift them to "takeoff" stage.

2.3 Climate

The climate in the Agno River basin is characterized by distinct dry and wet seasons. The dry season lasts usually from November to April and the wet season from May to October.

The annual rainfall varies from about 2,000 mm in the southeastern portion of the basin adjoining the Pampanga River basin to over 4,000 mm in the northern mountains as shown in Figure 2.3.1 - Isohyetal map of the Study Area. This variation is mainly due to the topographic condition of the basin. More than 90% of the annual rainfall occurs in the six months of the wet season. The Agno River basin is often hit by tropical typhoons and storms which bring about heavy rainfall causing harmful flooding.

The mean annual temperature is 28°C in Dagupan City located in the Pangasinan Plain in the Agno River basin and the mean monthly temperature varies from 23°C to 32°C. The relative humidity in Dagupan City is recorded at 77% on annual average. The month of April has the lowest at 70%, while the highest at 85% occurs in August.

2.4 Hydrology

2.4.1 General

Flood runoff analysis, flood inundation analysis and low flow analysis were executed in the Master Plan Study stage. In this stage hydrological study covers the following items which are required for refinement of planning in the Feasibility Study:

- i) Review of flood runoff analysis
- ii) Review of design flood distribution
- iii) Flood analysis of Dagupan city area
- iv) Sea water intrusion analysis

2.4.2 Review of Flood Runoff Analysis

A flood runoff simulation model using the storage function method was made in the Master Plan Study stage for estimating the probable flood runoff distribution. The simulation model for the Agno River was calibrated on the basis of the flood record of typhoon Maring in 1984.

Since no flood record was available for the Allied River basins, the flood simulation model was developed assuming that the empirical formula calibrated in the Agno River was applicable in the determination of model parameters of the Allied River basin runoff model.

Flood analysis was performed to examine the accuracy of the flood simulation model of the Pantal-Sinocalan River in comparison with the simulation results with the newly observed flood records by AFCS. The flood record of typhoon Bising in 1990 was selected for the comparison. The flood hydrographs were simulated well at Tagamusing, Sinocalan and Santa Barbara stations, and it was assessed unnecessary to modify the flood simulation model. Thus, the probable flood peak discharge distribution of the Agno and Allied Rivers under confining dike condition as determined in the Master Plan Study stage is adopted without change as given in Figure 2.4.1 for the Agno River and Figure 2.4.2 for the Allied Rivers.

2.4.3 Review of Design Flood Distribution

The design flood discharge distribution of the Agno River was reviewed by using the new storage capacity curve of the Poponto swamp which was revised based on new maps on a scale of 1/25,000. The peak flood discharge distribution in the downstream reaches of the Wawa station increases due to reduction of natural retarding function of the Poponto swamp. The revised discharge distributions are illustrated in Figure 2.4.3 for the Framework Plan, Figure 2.4.4 for the Long Term Plan and Figure 2.4.5 for the 10-year flood control plan. The previous discharges are shown in parentheses.

The difference between the revised values and previous ones at the river mouth of the Agno River is as follows:

Risk Level	Previous Design Flood (m^3/s)	Revised Design Flood (m^3/s)	Rate of Increase (%)
100-year flood (Framework Plan)	12,300	13,800	12
25-year flood (Long Term Plan)	9,000	10,100	12
10-year flood	6,500	7,400	14

The design flood discharge distribution of the Pantal-Sinocalan River for the 10-year flood control plan was unchanged, as shown in Figure 2.4.6.

2.4.4 Flood Analysis of Dagupan City Area

The proposed Dagupan by-pass with closure of the urban stretch of the Sinocalan River requires an inner drainage plan for Dagupan City with a drainage area of 6.33 km^2.

The probable basin mean rainfall is thus estimated by means of Pearson Type III method as summarized below:

Return Period (Year)	Probable rainfall (mm)			
	1-day	2-day	3-day	4-day
1.05	75	107	131	145
2	158	228	265	291
5	230	351	408	450
10	281	449	522	578
25	346	584	689	768

The probable flood peak discharge in Dagupan City area with a drainage area of 6.33 km^2 is estimated below:

Return period (Year)	Peak discharge (m^3/sec)
5	50
10	58

The relationship between specific probable flood peak discharge and drainage area is examined for drainage sluice/gate design in lowland area along the Pantal-Sinocalan River. The specific runoff curves for 5-year and 10-year probable floods are shown in Figure 2.4.7.

2.4.5 Seawater Intrusion Analysis

Sea water intrusion analysis was performed to assess its influence on the existing water use along the Pantal-Sinocalan River by comparing the extent of sea water intrusion under the existing and proposed by-pass channel conditions. The extent of sea water intrusion was assessed assuming that the boundary face between sea water and fresh water clearly exists in a shape of salt wedge.

The rate of seawater intrusion is influenced by the tide levels at the river mouth, river discharge and shape of channel sections. The following two cases are simulated in order to estimate the upstream front of a salt wedge:

Condition	Case 1	Case 2
(1) Tide level	El. 0.70 m, MSL of average monthly maximum water level	El. 0.70 m, MSL of average monthly maximum water level
(2) River discharge	3.5 m^3/sec, the 95% dependable discharge	3.5 m^3/sec, the 95% dependable discharge
(3) River condition	existing channel	proposed by-pass channel

The simulation results are shown in Figure 2.4.8. The estimated maximum positions of the front of salt wedge are briefly described below:

Case 1 Existing channel	:	about 13 km upstream from the river mouth (about 0.5 km upstream of the junction of the Ingalera River)
Case 2 By-pass channel	:	about 14 km upstream from the river mouth (about 0.5 km upstream of the Calasiao bridge)

In the case of the proposed by-pass channel, the front of salt wedge intrudes about 1 km more stream from the existing condition. Therefore, the Sinocalan irrigation dam of the existing water intake facility which is located about 24 km from the river mouth is assessed to be unaffected by seawater intrusion.

2.5 Geotechnical Conditions

2.5.1 Physiography and Geology

Physiographically, the Study Area is divided into three provinces. One is the South Cordillera Mountains. This province is the northern mountainous area ranging in altitude from about 70 to 2,900 meters, and includes the Agno, Ambayoan, Tuboy and Bued Rivers. The second is the Central Luzon Plain. This province is the central widespread plain area ranging in altitude from 0 to 380 meters, and includes the Agno and Tarlac Rivers and the Poponto swamp. The third is the Zambales Mountains. This province is the southwestern mountainous area ranging in altitude from about 20 to 1,700 meters, and includes the O'Donnell, Moriones (Bulsa) and Camiling Rivers.

The Agno River and Allied River basins are underlain by sedimentary rocks, igneous rocks and metamorphic rocks of Jurassic to Quarternary age as shown in Figure 2.5.1. Sedimentary rocks consist of sandstone, conglomerate and siltstone of Tertiary age. These sedimentary rocks are distributed in the Bued and Tuboy River basins, upper and downstream basin of the Agno River and eastern area of the Zambales Mountains.

The igneous rocks are divided into volcanic and intrusive rocks. The volcanic rocks consist of andesetic to dasitic plugs and basaltic to dacitic lavas and pyroclastics of Quaternary age. These plugs are exposed in Mt. Pulag, Pinatubo and Isolated mountains in the Central Luzon Plain and eastern foot of the Zambales Mountains. The intrusive rocks consist of diorite of Neogene age and ultramafic rocks of Cretaceous to Paleogene age. The former called the Agno batholith is widespread in the South Cordillera Mountains. The latter consists of predominantly periodotite, gabbro, and diabase dykes, composing the majority of the Zambales Mountains.

Metamorphic rocks are the oldest rocks in the basin and consist of metasediments and metavolcanics of probably Jurassic, Neogene age. These rocks are widespread in the South Cordillera Mountains and exposed in a limited area of the Zambales Mountains. The Pangasinan Plain is underlain by alluvium and fluvial and beach deposits.

2.5.2 Geotechnical Investigations

Geological core drillings, test pitting and material laboratory tests were performed for obtaining geotechnical data on the sub-surface soil and foundation conditions in the Feasibility Study Area in the following three stages:

i) May - July, 1990; 29 core drills for the Agno River and 26 core dills for the Pantal-Sinocalan River, 20 test pits for soil material tests and 20 test pits for aggregate tests.

ii) December, 1990 - January, 1991; 20 core drills for the middle Agno River and Dgupan City area for liquefaction analysis and foundation design for the earthquake-prone river facilities, and soil property tests.

iii) May - July, 1991; 6 core drills for the Agno River and Dagupan City area, and soil property tests for liquefaction analysis.

The geological core logs, geological cross-sections, material test results and detailed technical assessment are presented in the Supporting Report, Geology.

2.5.3 Foundation Conditions along River Dikes

The geological conditions of the Study Area are assessed in terms of soil foundations for dikes and other flood control structures by use of the core drill logs and laboratory soil test results, and the results are summarized below.

(1) Upper Agno River

San Manuel - Asingan Area

The area upstream of Agno River from Asingan (Station No. AG408 - AG472) is underlain by mainly gravel and sand mixtures in the lower layer and partly silty soil in the upper layer with 2 to 4 meters thickness. The consistency of silty soil is medium stiff to stiff (N-value is almost more than 8) and the relative density of gravel is medium dense to very dense. Therefore, no major bearing capacity and settlement problems are expected in this area.

Permeation problem is expected to occur at the dike resting on the permeable foundation, such as the old river channel. The dike in this area had repeatedly been breached. The dike failure is considered to be caused partly by seepage and piping through soil foundation, and partly by scouring of the dike slope due to flood flow. Sheet piling is considered to be one of the effective countermeasures against foundation seepage except in the area upstream of AG460 where there exist boulders.

Upper Agno River, Back-Levee Route

This area (Station No. AG421 - AG470) is underlain by mainly gravel and sand mixtures in the lower layer and silty soil in the upper layer which is 2 to 3 meters thick. No major problem of bearing capacity and settlement is expected.

Permeation problem is not expected to occur in the area which is covered by silty soil layer, except in the old river channel area near UA 4. Sheet piling will be required in the strip of old river channel of about 500 m length.

Asingan - Bayambang Area

The stretch from Bayambang to Asingan (Station No. AG281 - AG408) is underlain by sand and clayey soil (silt to clay) alternately by physiographical conditions. Grain size of soil seems to have a tendency to decrease from the upstream to the downstream.

The relative density of the upper sand layer is partly loose and the N-value of this loose sand is expected to be 5. The consistency of clayey soil is expected to be medium stiff to stiff except the drill hole AG22 site. The drill hole AG22 site is underlain by soft clayey soil because of closing area of the river bed, but not soft clayey soil is expected along the dike on the right bank.

Poponto Floodway

The Poponto floodway area (Station No. AG308 - FW310) is mainly underlain by clayey soil and partly sandy soil while some areas are underlain by very loose sandy soil in the upper layer. The N-value of this loose soil is expected to be only 3. The N-value of clayey soil in upper layer is expected to be more than 4. Chance of permeation problem is expected to be low in this area. Some areas are underlain by very soft to soft clayey soil at 3-5 m depth and more than 12 m depth. The N-value of this layer is expected to be 2 to 3, and some settlement is expected to occur.

Diversion Channel Area in Alcala - Bayambang

Loose sand deposits were encountered in the vicinity of the proposed diversion channel leading to the Bayambang stretch, the inlet of the Poponto floodway, in the drill holes AG20 and AG26 made in 1989. The additional drill hole MA-11 shows that a sand layer, of which N-value is more than 29, exists in the area. This area is presumed to be underlain by alluvial deposit and recent river deposit. The recent river deposit of about 20 m thick from the ground surface is composed of loose to dense sand. The alluvial deposit is assumed to exist under about 20m depth, and is composed of dense sand. Pile foundations reaching the alluvial deposit will be required for heavy concrete structures. Permeation prevention measures also will be required.

(2) Pantal - Sinocalan River

Pantal River Mouth

The Pantal-Sinocalan River mouth area (drilled on the left bank) is mainly underlain by thick fine to medium sand in the upper layer and clayey silt in the lower layer. The relative density of sand is medium dense to dense. No major problem is expected except some permeation.

Downstream Reach of Sinocalan River

The stretch from the junction with the Pantal River to about 2 km upstream of Calasiao is mainly underlain by fine to medium sand with silty soil layer in the upper layer. The lower silty soil layer exists under the sand layer in Dagupan City area. The relative density of the upper part of sand layer is very loose to loose. Its N-value is expected to be around 2 to 4 (minimum 1 at point AL14). Permeation and liquefaction problems are expected in this area. Sheet piling is considered to be an effective countermeasure for these problems.

Middle Reach of Soncocalan River

The stretch from upstream of Calasiao to about 3.5 km upstream of Santa Barbara is mainly underlain by clayey soil in the upper layer and sand in the lower layer. The N-value of the upper clayey soil layer is expected to be more than 4. The relative density of the lower sand layer deems partly loose. No major permeation and liquefaction problems are expected in this area.

Proposed Bypass Route

The proposed by-pass route area between the Sinocalan River and the Dagupan River is underlain by clayey soil and fine sand. The upper layer of 0-3m depth is mainly composed of very soft to soft silty clay with some organic materials. The middle layer (3-20m depth) is mainly composed of medium dense fine sand. The lower layer (below 20m depth) is composed of very stiff clayey soil. Replacement or pre-loading is recommended as a foundation treatment measure. Excavation of the by-pass will involve trafficability problem due to the presence of very soft clay with organic materials.

Dagupan River

The downstream area of the Dagupan River is underlain by fine to medium sand, and the upstream area is mainly underlain by fine to medium sand with silty sand layer in the upper layer. The relative density of the silty sand deems very loose to loose, and the N-value of this layer is expected to be only 2. Since very soft silt layer exists at the drill hole AL-6, some settlement problem is expected in this area. Serious potential permeation and liquefaction problems are expected in the downstream area.

Ingalera River

This area is underlain by clayey soil of very soft to soft consistency, and fine to medium sand having very loose to loose relative density. Some problems of bearing capacity and settlement are expected in the case of dike construction.

2.5.4 Construction Material Sources

(1) Test Results

Ten dike material sites and ten concrete aggregate sites were identified in the physiographical map shown in Figure 2.5.2 by site inspection from physiographical and geological viewpoints.

The results of laboratory tests of dike materials are summarized in Tables 2.5.1 (1/3) - (3/3). The results of laboratory tests of concrete aggregates are summarized in Tables 2.5.2 (1/2) - (2/2).

(2) Evaluation of Material Sources

The material sources are evaluated based on these test results and available quantities. The evaluation results are summarized in Table 2.5.3 for dike materials and Table 2.5.4 for concrete aggregates. Grain size distribution of the soil materials deposited along the Agno River and the Allied Rivers mostly falls within the adopted range for dike materials shown in Figure 2.5.3 except sand and gravel areas such as those in San Manuel stretch of the Upper Agno River and in the Bued River. The soils along the Agno River and Allied River are therefore assessed to be mostly suitable as dike materials.

The dike materials and aggregates investigated by test pits are assessed as follows:

Dike materials

- . Excellent soil materials : TS 1, TS 9, TS 10
- . Good soil materials : TS 2, TS 8
- . Acceptable soil materials : TS 4, TS 6, TS 7

Aggregate materials

. Good aggregates : TA 7, TA 10

. Acceptable aggregates : TA 1, TA 2, TA 4, TA 9

The amounts of construction materials are assessed roughly as summarized below:

a) Residual soil of hilly areas and weathered terrus deposits are available as dike construction materials. The potential quantity of these dike materials including those in plain area amounts to 12.4 x $10^6 m^3$.

b) Gravel and sand mixtures of the Agno, Bued and Aloragat Rivers are available for concrete aggregates. The potential quantity of coarse aggregates amounts to about 1.7 x $10^6 m^3$, and that of fine aggregates to about 1.1 x $10^6 m^3$.

2.6 Sediment Analysis

2.6.1 Natural Sediment Yield After Earthquake

In the Master Plan Study the annual average natural sediment yield was estimated to be 7,800 $m^3/km^2/year$ in the whole Study Area; i.e., 8,100 $m^3/km^2/year$ in the Southern Cordillera mountains and 7,400 $m^3/km^2/year$ in the Zambales mountains.

The mountain areas upstream of the Priority Project areas such as the Agno, Ambayoan, Viray-Dipalo, Banila, Tarlac and Tuboy River Basins might have been affected by the earthquake which occurred on July 16, 1990 in Central Luzon, and the sediment yield of the basins might have increased. Field investigations were, therefore, conducted to verify the sediment yield rate. The riverbeds were inspected at the outlets of valleys up to their alluvial fans. According to the disaster survey report on the Kennon Road prepared by DPWH, slope failure, rock and debris fall and landslide significantly increased after the earthquake along the road in the Bued River Basin. The riverbed rose significantly due to the sediment flow from these new sediment sources.

No remarkable effect of the earthquake was observed in the Agno, Ambayoan, Banila, Tarlac and Tuboy Rivers insofar as the riverbed conditions are concerned. The riverbed elevation of these rivers has been almost unchanged after the earthquake. As for the Viray and Dipalo Rivers, their riverbeds rose more than 5 m due to debris flow from landslides of mountain slopes, and the irrigation dams have been completely buried in some 5 m thick of sediment.

The sediment yield rates of the two devastated river basins of Viray and Dipalo are estimated to have increased to a considerable extent by the effect of the earthquake. The mountainous area of the two river basins (111 km^2) however, is less than 4% of that of the whole upper Agno River Basin upstream of Wawa (2,863 km^2 excluding the Tarlac) of which sediment yield is related to the priority project area. As far as the project area of the upper Agno River stretch and the Poponto swamp is concerned, it is evaluated that the devastation of the two river basins does not lead to a significant change of sedimentation condition. Therefore, the design sediment yield rate estimated in the Master Plan Study is adopted without any revision for the Feasibility Study.

2.6.2 Sedimentation in Poponto Swamp

(1) Sediment Record

Field investigation and interview survey were conducted to review the present conditions of sedimentation in the Poponto swamp. The heaviest sedimentation for the last 20 years was experienced during the flood of July 1972, when the maximum water level in the swamp reached to about EL. 16 m. The flood deposited about 1 m layer of sand and silt on some lower areas near the Agno and Tarlac Rivers.

Heavy sedimentation has been taking place in areas such as the lowest portion below EL. 10 m and the areas near the outlets of the Poponto swamp and the confluence with the Tarlac River. In such areas, the accumulative depth since 1972 has reached up to 1 to 2 m. The accumulative depth of sedimentation in the period from 1972 to 1991 for each interview site is shown in Figure 2.6.1.

(2) Design Sediment Volume for Retarding Basin

The Poponto swamp is proposed to be utilized as a natural retarding basin, and most of the floodwater from the Upper Agno River will be led to it together with sediment. The design sedimentation volume in the Poponto swamp was estimated at 5,143,000 m^3/year or 260 million m^3 for 50 years (refer to Figure 2.6.2).

(3) Monitoring of Sedimentation

The design sediment volume was obtained on the basis of some assumptions such as sediment yield rates and trap efficiency, although the value is considered to be the safest value at present. Therefore, in order to get reliable quantitative sediment record monitoring of sedimentation in the swamp is recommended (refer to Section 5.3).

2.6.3 River Mouth Clogging of Pantal-Sinocalan River

(1) Sediment Record in The River Mouth

Excessive sedimentation at a river mouth may block river flow and may be a cause of overbanking. Moreover, it may hinder navigation of fishing boats. As for the Pantal-Sinocalan River, a sand bar is developing from the left side and the water depth at the river mouth is as shallow as only 1 m although a 60 m wide portion with the maximum depth of from 7 to 8 m exists along the left shore. Field investigation and interview survey were additionally conducted to assess the river mouth condition. The results of the investigations are summarized as follows:

a) The width of the river mouth has been naturally maintained at about 200 to 300 m in spite of seasonal fluctuations; it is wider in the rainy season and narrower in the dry season.

b) In the dry season the water depth sometimes becomes shallow due to sedimentation, however, the river mouth has never been closed completely. Motorized fishing boats navigate along the deeper portion of the channel.

c) AFCS introduced the Dredger Visayas I to the downstream stretch of the Pantal-Sinocalan River in 1986. Since then, the Visayas I has been dredging the channel to the downstream of the Quintos bridge. In the stretch of 2 km long which is suffering form sedimentation, some 90,000 m^3 of sediment have been removed yearly. The purpose of the dredging is to maintain the required carrying capacity of the channel to prevent the banks from overtopping of floodwater.

(2) Assessment of Potential River Mouth Clogging

It is assessed that the proposed river improvement plan of the priority project will not aggravate the existing condition of the river mouth based on the following reasons:

a) The river improvement plan of the proposed priority project will keep the existing condition of the river mouth unchanged, although a by-pass channel will be newly constructed from Calasiao to the Dagupan River. The flow regime will never be changed even after the completion of the project because neither dams nor floodways will be provided in the upstream. The project, therefore, will not aggravate the existing condition of the river mouth which has been naturally maintained.

b) Overtopping of floodwater will not take place during a flood less than the design flood insofar as the river mouth is maintained under the existing condition.

2.6.4 Sediment Control under the Project

(1) Upper Agno River

Widening of the Poponto floodway and the Carmen stretch of the upper Agno River is proposed under the Priority Project. The low water channel is also proposed to be widened to 150 m. The sediment balance model is formulated as shown in Figure 2.6.2. The results of sediment balance analysis shown in Figure 2.6.3 and riverbed fluctuation analysis shown in Figure 2.6.4 indicate that the proposed river channel is more stable than the existing one. In particular, scouring at the Carmen stretch (AG-343) will be considerably mitigated from 1.6 m to 0.8 m in case of the Framework Plan as shown in Figure 2.6.4 by widening the stretch. In case of the Priority Project riverbed fluctuation is less significant as shown in Figure 2.6.5.

(2) Pantal-Sinocalan River

The major improvement works for the Pantal-Sinocalan River are the construction of a by-pass channel from Calasiao to the Dagupan River. The existing narrow and meandering channel is also to be widened to 100-200 m with some short cuts. The sediment balance model is formulated as shown in Figure 2.6.6. The results of sediment balance analysis indicate that the existing river channel is originally stable except the upper stretches in the upstream of Binalonan. The proposed river channel is also expected to be as stable as the existing one as shown in Figure 2.6.7 in spite of the major improvement works.

2.7 Seismic Resistance Survey

2.7.1 Seismic Intensity and Design Seismic Coefficient

The Philippine Institute of Volcanology and Seismology (PHIVOLCS), Department of Science and Technology recorded the first main shock of the 16th July 1990 earthquake as follows:

Time	:	4:26:36.07 PM. (Philippine time), July 16, 1990
Duration	:	45 sec.
Magnitude	:	7.7 (USGS)
Epicenter	:	16 km NNE of Cabanatuan
Depth	:	52.45 km (+ 7.74 km)

The seismic intensity in the Study Area (Dagupan-Rosales area) was reported to be VIII on the Richter Scale.

Frequency analysis of earthquake magnitude is made for the Dagupan city and the upper Agno River areas separately by the use of the earthquake records in 1907 - 1990 (PHIVOLCS). The recurrence interval of magnitude 7.7 is estimated to be about once in every 80 years in the Study Area as shown in Figure 2.7.1. The average distance from the epicenter to Dagupan city and the upper Agno River is assumed to be 100 km and 70 km respectively.

The maximum ground acceleration is estimated by a method proposed by the research institute of Ministry of Construction in Japan. The result of the frequency analysis of the maximum ground acceleration shown in Figure 2.7.2 infers that the maximum ground acceleration of this event was about 160 gal in Dagupan city area and about 220 gal in the upper Agno River area.

The basic seismic coefficient is estimated to be 0.15 for the whole Study Area. The recurrence interval of 0.1 is about 30 years while that of 0.15 is about 80 years. In Japan 0.15 is adopted for an area where the probable ground acceleration is around 200 gal and safety of subject structures is significant.

The design horizontal seismic coefficient is determined to be 0.18 for the mainstream of the Agno River and the downstream urban area of the Pantal-Sinocalan River and 0.10 for the rural areas of the upper Pantal-Sinocalan River and its tributaries, taking into account the regional significance of flood control works and the type of foundation. The adopted coefficient of regional significance is 1.0 for the former areas and 0.6 for the latter areas. The adopted coefficient for foundation types is 1.2 for the former and 1.0 - 1.1 for the latter depending on the actual foundation conditions.

2.7.2 Assessment of Seismic Damage

In Dagupan City the damage was concentrated in the area where ground was once an ancient river channel, the reclaimed ground along the river and the area of past fish ponds as shown in Figure 2.7.3. The primal cause of these damages is assessed to be liquefaction of ground as evidenced by sand boils and based on the result of liquefaction analysis done by the Study Team.

In the middle to upstream reaches of the Agno River the damage was concentrated on the earth dikes. The sink and settlement of the major dikes are in the range of 0.5 m to 3.0 m. The longitudinal cracks are mainly observed on the crest and slope of earthdikes as shown in Figure 2.7.4. It is assessed that heavy dike damages were caused mainly by collapse of dike foundation. The foundation collapse is assessed to be caused mainly by liquefaction of the ground. The damaged shapes of earth dikes were characterized by sink, settlement of crest and slope, and longitudinal cracks on the crest and slope, and sometimes by swell, which are of similar nature as pointed out in the case history in Japan. The locations of the damage sites caused by liquefaction in the middle and upper Agno River areas are shown in Figure 2.7.5. The dike on the right bank in San Manuel is assessed to be damaged by sliding of the dike itself instead of liquefaction.

2.7.3 Liquefaction Potential

Double core tube sampling was executed in 100 mm core drill holes (8 holes in the Dagupan area and 4 holes in the Agno River). Standard penetration test, gradation analysis, Atterberg's limits, natural moisture content, and specific gravity tests were executed in laboratory for liquefaction analysis. The composite features of these sand deposits are mainly fine sands with fine contents (less than 75 microns) of 4% to 33%, mean particle size of 0.10 mm to 0.34 mm, specific gravity of 2.55 to 2.79. The gradation curves are very similar to the sands liquefied by the Niigate Earthquake, 1964.

The particle size distribution of these sampled materials is compared with the practice applied in Japan as shown in Figure 2.7.6. These sands all fall within the envelope of spouted sands as determined in Japan. This implies that liquefaction can possibly happen on these materials.

Although the test data are not sufficient enough, the liquefaction potential of the damaged foundation soils is assessed by the simplified method specified in the Earthquake Resistant Design, Road Bridge Standard in Japan, 1990. It is assessed that the sand deposits in Dagupan City and in the middle Agno reaches where liquefaction occurred are mainly in the shallow depth of 5 m to 8 m from the ground surface.

2.7.4 Earthquake Resistance Measures

Suitable countermeasures against liquefaction for the earth dikes are compaction of shallow foundation with a vibro tamper or a counterweight earthfill. The Study adopts the counterweight earthfill 2-4 m height and 5-10 m in length in both land and river sides depending on the dike height. For concrete revetments and structures pile foundations are adopted.

Slope stability analysis of the dikes in the potential liquefaction areas is made with the seismic coefficient determined in Section 2.7.1. The areas which require counterweight fills are identified as shown in Figure 2.7.7. The standard design cross sections of the counterweight fill are shown in Figure 3.1.16 for the upper Agno River and Figure 4.1.16 for the Pantal-Sinocalan River.

2.8 Profile of Agno River and Existing River Facilities

2.8.1 The River System

(1) Location and Tributaries

The Agno River having a drainage area of 5,910 km^2 and a length of about 275 km is ranked the fifth largest river in the Philippines. Figure 2.8.1 illustrates the river system of the Agno including its tributaries, the Tarlac, Camiling, Ambayoan, Viray-Dipalo and Banila Rivers.

The Priority Project Area covers the river reaches upstream of the Wawa bridge which is located about 44 km from the river mouth. The river drainage area at this site is 4,338 km^2. The concerned tributaries are the Tarlac, Ambayoan, Viray-Dipalo, and Banila Rivers.

The Poponto swamp is located at the junction with the Tarlac River and is functioning as a natural retarding basin with the existing Alcala floodway. Its total drainage area, 4,338 km^2 is broken down into 2,441 km^2 of the Agno River and 1,896 km^2 of the Tarlac River.

(2) Channel Condition

Seen from stream form the Agno River channel condition is classified into meandering and braided types. Straight channels are only found in the artificial channels such as cut-off channels and the Poponto floodway.

Braided channels are observed upstream of the junction with the Viray-Dipalo River where gravel-sand bars are continuously formed.

The river width, low water channel size and bed slope of the Agno main stream are as follows:

Stretch	River Width (m)	Low-water Width(m)	Channel Depth(m)	River Bed Slope
Lower Agno (Mouth-Tarlac)	4,000-1,500	550-100	8.0-4.0	1/7,000-2,000
Upper Agno (Tarlac-ARIS dam)	3,000- 450	350- 75	5.5-3.0	1/1,800- 200

Figure 2.8.2 shows the channel dimensions such as river width, channel width, bed slope, and channel depth-width ratio in the Upper Agno River.

Historic transformation of the river course in the Upper Agno River from 1947 to 1979 is shown in Figure 2.8.3 which was prepared using the existing topographic maps and aerial photographs. It is observed that the present diking system in the stretch between Wawa and Asingan is located out of the sifting area of river course, and it is located within the past shifting area in the upstream reach of Asingan.

(3) Sediment

The estimated annual sediment transport capacity of the main Agno is summarized as follows (refer to details in the Supporting Report, Sediment Control Plan):

- From Tarlac junction to inlet of Floodway ; 240×10^3 - $160 \times 10^3 m3/yr$
- From inlet of Floodway to Carmen ; $140 \times 10^3 m3/yr$
- From Carmen to Banila junction ; 500×10^3 - $240 \times 10^3 m3/yr$
- From Banila junction to Ambayoan junction ; $250 \times 10^3 m3/yr$
- Upstream of Ambayoan junction ; $600 \times 10^3 m3/yr$

The tendency of the longitudinal variation of the channel bed fluctuation show that the channel beds are aggragating in the lower reaches of junction with the Tarlac River and in the upper reaches of the junction with the Banila River. The middle reaches are degradating but their change is not so high. Figure 2.8.3 shows changes of elevation at the deepest channel bed and sediment deposition volume which are estimated by comparing river cross-section data surveyed in 1981 and 1989.

2.8.2 Existing River Facilities and Related Structures

(1) River Facilities for Flood Control

At present, the DPWH manages 34 existing flood control projects. Most of these are earth and concrete dikes, revetments, groins (spur dikes) and the Poponto floodway channel. Locations and quantities of the existing river facilities in the upper Agno River are shown in Figure 2.8.4 and Table 2.8.1 respectively.

Diking system

The diking system is one of the most progressive flood control facilities in the main Agno. In the downstream reaches between the river mouth and the Wawa bridge which has a 44 km long channel, the existing right earth dike and the left earth dike are about 40.5 km long and 16.3 km long respectively. In the upstream reaches of the Wawa bridge, there are a 59 km long channel, a 49.0 km long right dike including the 3.2 km concrete dike in Bayambang and Asingan, and a 40.0 km long left dike including the 10.5 km parallel earth dike of the Poponto floodway and the 3.6 km concrete dike in Carmen.

Revetments and groins

Revetments and spur dikes have been constructed part by part in the past as required. The present condition on those protection works against stream current erosion of dikes and banks in the upper Agno River are shown in Table 2.8.1 and summarized as follows:

- Revetment of low water channel ; 7.5 km
- Revetment of earth dike ; none
- Boulder dike of earth dike ; 0.7 km
- Spur dike of low water channel ; 14.2 km
- Spur dike of high water channel ; 19.3 km

The eroded dikes and banks can be found in the stretches having a braided plan and meandering with developed bars in the Agno River Basin. Figure 2.8.5 shows the location of breaches, gaps and scours caused by past floods in the period from 1984 to 1988.

Poponto floodway facility

The existing Poponto floodway was planned to divert a part of flood water of the main Agno to the Poponto swamp to improve the hydraulic bottle-neck of the existing river channel in the Bayambang stretch. The construction works was commenced in 1975. At present, extension works of the right dike is planned by the AFCS office. The major features of present facilities are as follows:

- Floodway

Length of stretch	:	6,000 m
Width of floodway	:	800 - 1,000 m
Width of low-water channel	:	30 - 50 m
Length of dike stretch (Right)	:	6,000 m (Right), 4,500 m (Left)

- Spillway

Length	:	1,020 m
Crest elevation	:	18.75 m
Crest height	:	3.55 m

(2) Water Use Facilities

Present irrigation water use in the upper Agno River is for the paddy fields of about 14,300 ha in the Pangasinan plain covered by the Agno River Irrigation System (ARIS) on the right bank and about 10,000 ha covered by the Lower Agno River Irrigation System (LARIS) on the left bank. The intake facility of the ARIS is a headworks type, and the LARIS has only a inlet with gates.

(3) Bridges

There are five road bridges and two railway bridges crossing the upper main Agno. The Major features of bridges are as follows:

Name of Bridge	Location	Type of Bridge	Bridge Length(m)	Width(m)	Lowest E.1 of Girder(m)
Wawa	Wawa	Concrete	440	7.3	17.85
Calvo	Bayambang	Concrete	160	7.3	17.20
Railway	Bayambang	Steel	-	-	-
(Road)	Floodway	(pier only)	1,020	-	21.20
Railway	Floodway	-	127	4.0	13.60
Plaridel	Carmen	Concrete	650	-	29.95
San Rouge	San Rouge	Concrete	230	7.3	109.80

2.8.3 River Facility Damages due to the Earthquake in 1990

(1) Damages on Flood Control Facilities

River control facilities structural damage due to the earthquake was considerable. It was reported by DPWH that the damage amounted to more than 260 million pesos in the Agno River Basin including the Allied Rivers in terms of the cost required for rehabilitation works.

The most serious damages to the flood control facilities were seen in the upper Agno and Tarlac Rivers in the Agno River Basin. Those typical damages are categorized below:

- Earth dike : Sinking of dike crest, slope sliding, settlement of embankment due to the earthquake

- Concrete dike (Mortal facing dike) : Cracks of moltar facing and collapse of head walls due to seismic settlement of inside fill materials

- Spur dike : Settlement of cobble stones by the earthquake

The extent of damage to the dikes in the Agno River is summarized as follows based on data inspected and surveyed by the AFCS office and the results of site inspection by JICA Study Team in September, 1990.

River/Stretch (Right/Left Bank)		River Length (km)	Length of Damage Extent(km) Earth dike	Conc. dike/ Revetment
Main Agno River				
River mouth - Wawa	(R)	45.0	2.32	0.11
	(L)		0	0.99
Wawa - ARIS dam	(R)	54.0	16.60	0.20
	(L)		19.56	0.99
Poponto Floodway	(R/L)	6.0	1.31	0
Tarlac River	(R/L)	37.0	44.92	0.50
Camiling River	(R/L)	20.8	0	3.74
Banila River	(R/L)	30.9	2.12	0
Viray-Depalo River	(R/L)	20.5	1.30	0
Ambayoan River	(R/L)	8.7	0	0

Those damages are attributable to not only seismic failure but also foundation failure. Liquefacting of sandy foundation is assessed to be one of the most probable cause of such large damage to the dike. The liquefaction damage was found in the downstream of Asingan in the main Agno. The damage upstream of Asingan was caused by the earthquake inertial force.

At five sites in the upper Agno River, partially damaged dikes were breached by the flood which followed after the earthquake in July.

The damage condition in major stretches of the upper Agno River are shown in Figure 2.7.5.

(2) Rehabilitation works by DPWH

The PMO-AFCS Flood Control Program for Earthquake Damage Rehabilitation/Restoration was formulated. Those works in the Agno River Basin consist of 39 projects with total cost of 165 million pesos as of February 28, 1991. The major works and the required cost by river stretch are summarized below:

River/Stretch	Nos. of Project	Cost (1,000 Pesos)
Main Agno River		
River mouth - Wawa bridge	16	39,512 (24.0%)
Wawa bridge - Carmen	11	42,742 (25.9%)
Carmen - San Manuel	5	13,520 (8.2%)
(Sub Total)	32	95,774 (58.1%)
Tarlac River	5	58,540 (35.5%)
Other Tributaries	7	10,585 (6.4%)
(Total)	44	164,899 (100.0%)

2.8.4 Flow Carrying Capacity

The flow carrying capacity of the existing river channel of the main Agno was estimated by means of non-uniform flow calculations. The carrying capacity is defined as the discharge at the water level having a freeboard below the dike crest of the bank.

The estimated carrying capacity is shown in Figure 2.8.6 and is summarized below:

Stretch	Carrying Capacity Discharge(m3/s)	Return Period(yr)
River mouth - 19km upstream	2,500 - 8,000	2 - 30
19km upstream - Wawa stretch	4,500 - 13,500	5 - 100
Bayambang stretch	1,000 - 2,000	2 - 5
Poponto Floodway stretch	1,000 - 1,500	2 - 8
Alcala - Carmen stretch	1,700 - 10,000	3 - 100
Carmen - Asinga stretch	1,500 - 9,000	3 - 100
Asinga - San Manuel stretch	1,000 - 11,000	3 - 100

2.9 Profile of Pantal-Sinocalan River and Existing River Facilities

2.9.1 The River System

(1) Location and Tributaries

The main stream of the Pantal-Sinocalan River is called from the river mouth to the upstream end as Pantal, Marusay, Sinocalan, Tagamusing and Tuboy. Its major tributaries are the Dagupan, Ingalera, Macalong and Mitra Rivers as shown in Figure 2.8.1. The river originates north of Binalonan in the South Cordillera mountains. The catchment area and river length are 1,115 km^2 and 75.5 km respectively. The majority of the watershed is located in the Pangasinan plain.

Traces of the old Agno River can be seen in the stream form of the Pantal River and the lower and middle reaches of the Dagupan River.

(2) Channel Conditions

The Pantal River stretch, which is a trace of the old Agno River, forms a straight channel, while the Sinocalan and Tagumising River stretches form meandering channels. There are cut-off channels around Calasiao town in the Sinocalan River. The channel width, channel depth and bed slope of the river system are illustrated in Figure 2.9.1 and are summarized as follows:

River/Stretch	Channel Width(m)	Channel Depth(m)	Bed Slope
Pantal-Sinocalan River			
. Pantal R. stretch	350 - 210	7.0 - 3.9	1/400
. Marusay R. stretch	110	5.2 - 3.9	1/3,300
. Sinocalan R. stretch	280 - 50	6.4 - 3.3	1/3,300 - 1,300
. Tagamusing R. stretch	200 - 40	7.2 - 3.8	1/1,100 - 500
Dagupan River			
. Pantal junction - Capangbogan junction	280 - 90	12.0 - 6.0	1/3,000
. Capangbogan junction - Elang junction	30 - 20	7.8 - 2.3	1/10,000
Ingalera River			
. Sinocalan junction - Marasiqui	100 - 60	7.0 - 3.0	1/5,000

(3) Sediment

The annual sediment transport capacity of the main Pantal-Sinocalan River is estimated between 450,000 - 550,000 m^3/yr. The longitudinal channel bed fluctuation has a trend of aggregating in the lower reaches from the junction with the Ingalera River and in the upper reaches from Binalonan, and of degradating in the middle reaches (refer to Figure 2.6.8). There is no evidence of river mouth clogging in the Pantal River.

2.9.2 Existing River Facilities and Related Structures

River Facilities for Flood Control

Existing river facilities for flood control in the Pantal-Sinocalan River are mainly bank protection works such as groins and revetments, and earth-dikes of only 3 km cumulative length along the main stream in Santa Barbara. Spur dikes and boulders are widely used for bank protection works. These locations are shown in Figure 2.8.4. The quantities are listed in Table 2.9.1.

Water Use Facilities

The irrigation intake dam for the Sinocalan River Irrigation System exists at Santa Barbara in the main Sinocalan River. An improvement plan to use a rubber gate type with a 28 m width and a bottom elevation of 3.10 m is proposed by the NIA. Two units of irrigation syphons cross the main river around 21 km and 34 km upstream of the river mouth.

There are many check gates for fish cultures along the downstream stretch of the Pantal-Sinocalan River. Three ferry ports exists in the downstream stretch of the Pantal River.

Bridges

Thirty one bridges cross the rivers in the project area as:

River	Stretch	Number of Bridges
Main Pantal-Sinocalan	River mouth - Sta. S70	13
Dagupan River	Junction - Sta. D27	6
Ingalera River	Junction - Sat. I13	12

2.9.3 River Facility Damages due to the Earthquake in 1990

(1) Damages on flood control facilities

It was reported by the DPWH that the damage amounted to about 86 million pesos in the Allied River Basins in terms of the cost of rehabilitation works required. The Pantal-Sinocalan River accounted for 17.4 million pesos. The majority damaged facilities were revetments and boulder dikes.

(2) Rehabilitation Works by DPWH

The PMO-AFCS/DPWH Flood Control Program for Earthquake-Damage Rehabilitation/Restoration in the Allied Rivers consists of 29 projects with a total cost of 86 million pesos as of February 28, 1991.

2.9.4 Flow Carrying Capacity

The flow carrying capacity of the existing river channels of the main Pantal-Sinocalan, Dagupan and Ingalera Rivers was estimated by means of non-uniform flow calculation based on river cross-sections surveyed after the Master Plan Study. The carrying capacity is defined as a bankfull discharge. The estimated carrying capacity is summarized as follows:

River/Stretch	Carrying Capacity Discharge (m3/s)	Return Period(yr)
- Main Pantal-Sinocalan River		
River mouth - Ingalera junction	100 - 500	1 - 2
Ingalera junction - Mitura junction	100 - 900	1 - 10
Mitura junction - Binalonan	200 - 900	3 - 25
- Dagupan River		
Pantal junction - Capangbogan junc.		
Capangbogan junction - Elang junc.		
- Ingalera River		
Sinocalan junction - Marasiqui	80 - 450	1 - 20

Figure 2.9.2 shows the longitudinal profile of the calculated water levels of some probable floods for the existing main river.

Table 2.1.1 LAND AREA AND POPULATION BY GROWTH CENTER GROUPING, 1980 (1/2)

Growth Center Grouping City/Town	Impact Area		Beneficial Area		
	Land Area (Hectares)	Population 1980	Land Area (Hectares)	Percent to Total Area	Population Benefitted
A. DAGUPAN CITY/SAN CARLOS CITY					
Dagupan City	3,720	98,344	3,720	100.0%	98,344
San Carlos City	16,640	101,243	13,300	79.9%	80,921
Malasiqui	12,700	70,905	9,200	72.4%	51,364
Bayambang	7,520	64,037	5,700	75.8%	49,539
Mangaldan	4,480	50,434	4,480	100.0%	50,434
Calasiao	5,340	48,101	5,340	100.0%	48,101
Binmaley	6,120	47,332	6,120	100.0%	47,332
San Fabian	9,240	42,018	1,100	11.9%	5,002
Santa Barbara	7,740	37,001	6,900	89.1%	32,985
San Jacinto	3,910	20,612	2,800	71.6%	14,761
Mapandan	3,000	20,094	3,000	100.0%	20,094
Bautista	12,630	18,072	600	4.8%	859
Sub-total:	93,040	618,193	62,260	66.9%	498,736
B. URDANETA					
Urdaneta	12,100	71,796	11,100	91.7%	65,862
Villasis	7,580	39,126	6,000	79.2%	30,970
Pozzorubio	13,460	38,257	3,200	23.8%	9,095
Manaoag	2,720	36,742	1,900	69.9%	25,665
Binalonan	7,760	35,574	6,100	78.6%	27,964
Sison	9,770	25,053	1,200	12.3%	3,077
Alcala	3,650	24,993	1,300	35.6%	8,902
Laoac	4,050	19,252	4,050	100.0%	19,252
Basista	1,560	17,191	1,560	100.0%	17,191
Santo Tomas	830	8,946	500	60.2%	5,389
Sub-total:	63,480	316,930	36,910	58.1%	213,369
C. TAYUG					
Tayug	5,130	26,273	1,500	29.2%	7,682
Umingan	26,460	41,364			
Asingan	6,660	37,301	6,660	100.0%	37,301
Rosales	6,840	36,582	800	11.7%	4,279
San Manuel	13,370	29,622	5,200	38.9%	11,521
San Nicolas	21,020	23,243	100	0.5%	111
San Quintin	11,590	20,835			
Santa Maria	6,950	19,018	2,800	40.3%	7,662
Balungao	9,380	17,342			
Natividad	7,680	15,246			
Sub-total:	115,080	266,826	17,060	14.8%	68,555

Table 2.1.1 LAND AREA AND POPULATION BY GROWTH CENTER GROUPING, 1980 (2/2)

Growth Center Grouping City/Town	Impact Area		Beneficial Area		
	Land Area (Hectares)	Population 1980	Land Area (Hectares)	Percent to Total Area	Population Benefitted
D. LINGAYEN					
Lingayen	6,770	65,187	2,900	42.8%	27,924
Mangatarem	31,760	40,582			
Bugallon	16,930	39,072			
Urbiztondo	8,180	27,348	5,800	70.9%	19,391
Aguilar	15,290	22,080			
Sual	15,030	15,796			
Labrador	8,780	12,120			
Sub-total:	102,740	222,185	8,700	8.5%	47,315
E. ALAMINOS					
Alaminos	15,920	47,715			
Bolinao	23,220	39,335			
Bani	15,270	29,102			
Anda	8,200	20,454			
Agno	16,520	17,241			
Dasol	23,090	16,957			
Mabini	23,630	15,979			
Burgos	11,900	12,817			
Infanta	24,740	12,323			
Sub-total:	162,490	211,923	0	0.0%	0
F. OUTSIDE PANGASINAN					
Anao, Tarlac	2,390	6,519			
Camiling, Tarlac	14,050	53,860	100	0.7%	383
Cuyapo, Nueva Ecija	16,750	39,654			
Moncada, Tarlac	8,570	34,451			
San Manuel, Tarlac	4,210	13,491			
Rosario, La Union	7,280	29,331	1,000	13.7%	4,029
Nampicuan, Nueva Ecija	5,260	7,597			
Sub-total:	58,510	184,903	1,100	1.9%	4,412
TOTAL PANGASINAN	536,830	1,636,057			
TOTAL IMPACT AREA	595,340	1,820,960			
TOTAL BENEFICIAL AREA (As defined):			126,030	23.3%	832,386

Source of Data: National Statistics Office

Table 2.1.2 FEASIBILITY STUDY AND PROJECT BENEFICIAL AREA BY RIVER BASIN AND GROWTH CENTER GROUPING (1/2)

(Hectares)

Growth Center Grouping City/Town	Feasibility Study Land Area	Project Beneficial Area: Total Area	Upper Agno	Pantal-Sinocalana	Cayanga-Patalan
A. DAGUPAN CITY/SAN CARLOS CITY					
Dagupan City	3,720	3,720		3,720	
San Carlos City	16,640	13,300		13,300	
Malasiqui	12,700	9,200	400	8,800	
Bayambang	7,520	5,700	1,700	4,000	
Mangaldan	4,480	4,480		2,980	1,500
Calasiao	5,340	5,340		5,340	
Binmaley	6,120	6,120		6,120	
San Fabian	9,240	1,100			1,100
Santa Barbara	7,740	6,900		6,900	
San Jacinto	3,910	2,800			2,800
Mapandan	3,000	3,000		1,900	1,100
Bautista	12,630	600	600		
Sub-total:	93,040	62,260	2,700	53,060	6,500
B. URDANETA					
Urdaneta	12,100	11,100		10,500	600
Villasis	7,580	6,000	1,600	4,400	
Pozzorubio	13,460	3,200			3,200
Manaoag	2,720	1,900			1,900
Binalonan	7,760	6,100		4,100	2,000
Sison	9,770	1,200			1,200
Alcala	3,650	1,300	1,300		
Laoac	4,050	4,050			4,050
Basista	1,560	1,560		1,560	
Santo Tomas	830	500	500		
Sub-total:	63,480	36,910	3,400	20,560	12,950
C. TAYUG					
Tayug	5,130	1,500	1,500		
Umingan	26,460				
Asingan	6,660	6,600	3,000	3,660	
Rosales	6,840	800	800		
San Manuel	13,370	5,200	3,600	1,600	
San Nicolas	21,020	100	100		
San Quintin	11,590				
Santa Maria	6,950	2,800	2,800		
Balungao	9,380				
Natividad	7,680				
Sub-total:	115,080	17,060	11,800	5,260	0

Table 2.1.2 FEASIBILITY STUDY AND PROJECT BENEFICIAL AREA BY RIVER BASIN AND GROWTH CENTER GROUPING (2/2)

(Hectares)

Growth Center Grouping City/Town	Feasibility Study Land Area	Project Beneficial Area: Total Area	Upper Agno	Pantal-Sinocalana	Cayanga-Patalan
D. LINGAYEN					
Lingayen	6,770	2,900		2,900	
Mangatarem	31,760				
Bugallon	16,930				
Urbiztondo	8,180	5,800		5,800	
Aguilar	15,290				
Sual	15,030				
Labrador	8,780				
Sub-total:	102,740	8,700	0	8,700	0
E. ALAMINOS					
Alaminos	15,920				
Bolinao	23,220				
Bani	15,270				
Anda	8,200				
Agno	16,520				
Dasol	23,090				
Mabini	23,630				
Burgos	11,900				
Infanta	24,740				
Sub-total:	162,490	0	0	0	0
F. OUTSIDE PANGASINAN					
Anao, Tarlac	2,390				
Camiling, Tarlac	14,050	100	100		
Cuyapo, Nueva Ecija	16,750				
Moncada, Tarlac	8,570				
San Manuel, Tarlac	4,210				
Rosario, La Union	7,280	1,000			1,000
Nampicuan, Nueva Ecija	5,260				
Sub-total:	58,510	1,100	100	0	1,000
TOTAL PANGASINAN	536,830				
TOTAL IMPACT AREA	595,340				
TOTAL BENEFICIAL AREA (As defined):		126,030	18,000	87,580	20,450

Source of Data: National Statistics Office; Flood Damage Analysis Report, 1991

Table 2.2.1 INVESTMENT FLOWS BY REGION, 1986-1990

(In Thousand Pesos)

Region	1986	1987	1988	1989	1990
Philippines	2,191,961	9,844,141	28,720,161	62,303,895	99,895,449
NCR	1,121,321	4,519,640	13,122,913	20,676,587	24,454,625
CAR	0	0	0	655,346	6,780,000
Ilocos	0	21,598	86,276	1,143,198	9,293,321
Cagayan Valley	0	0	0	39,273	127,661
Central Luzon	99,732	1,376,808	6,580,109	4,972,642	5,959,213
Southern Tagalog	429,399	2,740,778	4,577,464	24,837,674	39,035,816
Bicol	5,500	164,095	77,992	168,489	67,026
Western Visayas	285,115	358,006	640,560	1,333,637	571,086
Central Visayas	106,450	182,270	1,171,313	3,212,079	4,063,117
Eastern Visayas	0	0	31,858	1,092,533	33,705
Western Mindanao	17,502	184,552	362,195	184,579	235,764
Northern Mindanao	63,491	48,846	1,283,287	795,073	2,995,834
Southern Mindanao	26,609	112,938	745,261	581,998	722,950
Central Mindanao	36,000	29,528	0	743,681	171,005
No Site Yet	842	102,082	40,933	1,867,106	5,384,326

Source of Data: Planning and Research Division, Board of Investments

Table 2.2.2 INFRASTRUCTURE SPENDING PROGRAM, 1986-1990

(In Thousand Pesos)

Region	1986	1987	1988	1989	1990
Philippines	6,448,173	8,051,216	8,596,470	12,720,288	16,734,551
NCR	1,054,267	1,094,285	1,001,873	1,869,496	2,295,843
Ilocos	525,924	700,846	387,303	583,149	658,379
CAR	-	-	282,392	393,924	539,694
Cagayan Valley	290,245	448,672	368,505	521,042	713,145
Central Luzon	466,924	486,050	530,140	740,470	1,067,172
Southern Tagalog	852,540	1,086,531	1,002,554	1,367,714	2,033,923
Bicol	486,246	568,501	648,198	924,256	1,129,371
Western Visayas	450,866	479,842	613,393	915,589	1,217,235
Central Cisayas	257,523	379,458	535,827	820,297	954,563
Eastern Visayas	557,646	652,380	662,843	732,134	983,799
Western Mindanao	314,152	473,217	459,400	582,429	1,101,344
Northern Mindanao	309,191	439,890	540,603	821,878	921,385
Southern Mindanao	429,028	527,854	606,632	815,452	994,137
Central Mindanao	291,405	446,330	567,395	682,344	950,563
Nationwide/Inter-Regional	162,216	267,360	389,412	950,215	1,173,991

Table 2.2.3 SHARE OF INFRASTRUCTURE SPENDING TO GRDP AT CONSTANT 1972 PRICES, 1986-1990 (1/2)

(In Thousand Pesos)

Region		1986	1987	1988	1989	1990
First Tier						
NCR	GRDP	26,619,055	28,424,717	31,058,474	33,256,409	34,489,000
	Infra Spending	125,538	122,116	1,011,312	175,046	179,855
	Share	0.47%	0.43%	3.26%	0.53%	0.52%
Second Tier						
Southern Tagalog	GRDP	13,610,324	13,170,897	13,773,667	14,383,703	14,780,500
	Infra Spending	101,517	121,251	101,381	128,063	159,336
	Share	0.75%	0.92%	0.74%	0.89%	1.08%
Central Luzon	GRDP	7,378,268	7,668,896	8,163,608	8,791,424	9,091,000
	Infra Spending	55,599	54,241	53,609	69,332	83,601
	Share	0.75%	0.71%	0.66%	0.79%	0.92%
Central Visayas	GRDP	6,476,978	6,988,714	7,514,039	8,085,819	8,411,000
	Infra Spending	30,665	42,345	54,184	76,807	74,780
	Share	0.47%	0.61%	0.72%	0.95%	0.89%
Western Visayas	GRDP	6,345,818	6,607,940	6,913,268	7,153,836	7,368,500
	Infra Spending	53,687	53,548	62,028	85,729	95,357
	Share	0.85%	0.81%	0.90%	1.20%	1.29%
Third Tier						
Northern Mindanao	GRDP	5,004,118	5,266,857	5,620,172	5,936,841	6,182,500
	Infra Spending	36,817	49,089	54,667	76,955	72,181
	Share	0.74%	0.93%	0.97%	1.30%	1.17%
Central Mindanao	GRDP	3,775,018	3,791,626	3,969,510	4,190,085	4,307,000
	Infra Spending	34,699	49,088	57,376	63,890	74,466
	Share	0.92%	1.31%	1.45%	1.52%	1.73%
Western Mindanao	GRDP	3,367,939	3,630,660	3,788,677	3,976,784	4,113,000
	Infra Spending	37,408	52,809	46,457	54,535	86,278
	Share	1.11%	1.45%	1.23%	1.37%	2.10%

Source: National Statistical Coordination Board for GRDP Levels; Department of Public Works and Highways for programmed infrastructure spending, deflated to 1972 prices using the prices index for government construction.

Table 2.2.3 SHARE OF INFRASTRUCTURE SPENDING TO GRDP AT CONSTANT 1972 PRICES, 1986-1990 (2/2)

(In Thousand Pesos)

Fourth Tier Bicol	GRDP	3,057,901	3,146,819	3,332,379	3,463,705	3,515,000
	Infra Spending	57,900	63,442	65,547	86,541	88,474
	Share	1.89%	2.02%	1.97%	2.50%	2.52%
Ilocos	GRDP	4,253,974	3,182,666	3,327,278	3,387,896	3,348,000
	Infra Spending	62,625	78,211	39,165	54,602	51,577
	Share	1.47%	2.47%	1.18%	1.61%	1.54%
Eastern Visayas	GRDP	2,297,152	2,957,899	3,068,923	3,120,977	3,210,000
	Infra Spending	66,402	72,802	67,028	68,552	77,070
	Share	2.89%	2.46%	2.18%	2.20%	2.40%
Cagayan Valley	GRDP	2,291,183	1,948,413	2,047,626	2,104,369	2,063,500
	Infra Spending	34,561	50,069	37,264	48,787	55,867
	Share	1.51%	2.57%	1.82%	2.32%	2.71%
CAR	GRDP	-	1,466,048	1,547,451	1,664,697	1,581,000
	Infra Spending	-	-	28,556	36,884	42,279
	Share			1.85%	2.22%	2.67%
Total Philippines	GRDP	91,165,600	95,372,760	449,730	107,144,209	109,890,000
	Infra Spending	767,822	89,847	869,296	1,191,038	1,310,971
	Share	0.84%	0.94%	0.86%	1.11%	1.19%

Source: National Statistical Coordination Board for GRDP levels; Department of Public Works and Highways for programmed infrastructure spending, deflated to 1972 prices using the price index for government construction.

Table 2.5.1 RESULT OF SOIL TESTS (1/3)

LOCATION	(TEST PIT NO.)	SAMPLE NO.	DEPTH m.	SOIL DESCRIPTION	UNIFIED SOIL CLASSIFICATION	SIEVE ANALYSIS % PASSING 3/4"	1/2"	3/8"	#4	#10	#40	#200	SPECIFIC GRAVITY	NATURAL MOISTURE CONTENT %	ATTERBERG LIMIT LL	PL	PI	MOISTURE-DENSITY RELATION OF SOIL OMC %	MDD g/cc	COEFFICIENT OF PERMEABILITY cm/sec.	UNCONFINED COMPRESSION qu kg/cm2	CONSOLIDATION Cc	Pc	eo	REMARKS
TS 1	TS1-1	1	1.00-1.05	Silty clay	CL			100	92	83	70	54	2.61	18.3	44	18	26	23.1	1.53	2.6 x 10	0.68	0.21	1.1	0.74	e- log P
								100	92	81	68	58	2.62	18.5	43	17	26								curves
		2	4.90-5.00	Silty clay	CL			100	91	88	81	72	2.79	24.5	50	14	36	23.0	1.67	3.0 x 10					&
																									Cv, r Log P
	TS1-2	1	0.90-1.20	Sandy silt w/ clay	ML		100	91	86	76	61	55	2.78	26.9	42	30	12	19.6	1.76	1.3 x 10	1.09	0.24	1.0	0.90	Curves are shown in
							100	96	86	77	63	57	2.72	26.0	39	30	9								Appendix.
		2	5.00-5.10	Silty clay	CL		100	94	85	79	66	52	2.54	24.7	48	27	21	19.2	1.64	4.0 x 10					
TS 2	TS2-1	1	1.00-1.20	Clayey silt	ML				100	93	83	69	2.45	19.3	48	27	21	18.3	1.60	2.8 x 10	2.25	0.26	2.5	0.86	
									100	97	89	63	2.51	19.1	45	22	23								
		2	4.50-5.00	Sandy silt w/ clay	ML				100	95	84	59	2.49	29.8	47	28	19	17.3	1.68	------					
	TS2-2	1	1.90-2.05	Silty clay	CH			100	98	97	87	61	2.69	24.6	53	24	29	23.6	1.58	2.4 x 10	3.88	0.25	2.5	0.75	
								100	97	95	82	61	2.68	24.0	49	17	32								
		2	5.00-5.10	Clayey silt	ML			100	94	88	78	63	2.64	20.6	43	29	14	18.7	1.70	1.3 x 10					
TS 3	TS3-1	1	0.90-1.40	Clayey silt	ML			100	98	90	89	77	2.74	12.9	39	28	11	19.0	1.72	1.0 x 10	0.62	0.21	2.3	0.94	
								100	96	92	88	72	2.74	11.8											
		2	2.80-3.80	Clayey silt	MH						100	95	2.50	55.5	52	29	23	31.5	1.32	1.3 x 10					
															54	29	25								
	TS3-2	1	0.90-1.10	Silt	ML						100	92	2.70	27.4	33	26	7	24.1	1.52	----					
											100	92	2.69	26.8											
		2	2.60-3.60	Clayey silt	ML						100	94	2.68	28.5	32	26	6	21.6	1.60	1.3 x 10	3.13	0.19	2.6	0.66	
															33	28	5								
TS 4	TS4-1	1	1.90-2.00	Silty sand	SM						100	27	2.74	4.5	32	27	5	12.6	1.94	----					
											100	30	2.74	4.7											
		2	4.50-5.00	Silt	ML					100	99	78	2.74	30.1	---	NP	---	20.6	1.70	----					
	TS4-2	1	0.95-1.10	Silty sand	SM			100	98	98	90	29	2.62	5.1	---	NP	---	13.0	1.91	----					
								100	96	95	88	26	2.61	5.0											
		2	3.69-4.69	Silty clay	CL					100	98	63	2.64	20.6	41	22	19	17.1	1.76	2.6 x 10	2.98	0.10	3.0	0.75	
															40	20	20								

Note: Sieve sizes converted to millimeter, 3/4"-19.05 mm, 1/2 " - 12.7 mm, 3/8" - 9.595 mm, #4-4.75 mm, #10 -2.0 mm, #40 - 0.0425, #200 - 0.075

Table 2.5.1 RESULT OF SOIL TESTS (2/3)

LOCATION	TEST PIT NO.	SAMPLE NO.	DEPTH m.	SOIL DESCRIPTION	UNIFIED SOIL CLASSIFICATION	SIEVE ANALYSIS % PASSING 3/4"	1/2"	3/8"	#4	#10	#40	#200	SPECIFIC GRAVITY	NATURAL MOISTURE CONTENT %	ATTERBERG LIMIT LL	PL	PI	MOISTURE-DENSITY RELATION OF SOIL: OMC %	MDD g/cc	COEFFICIENT OF PERMEABILITY cm/sec.	UNCONFINED COMPRESSION: qu kg/cm2	CONSOLIDATION Cc	Pc	eo	REMARKS
TS 5	TS5-1	1	0.95-1.05	Silty sand	SM				100	99	96	49	2.68	31.1	---	NP	---	14.6	1.84	----					e- Log P
									100	96	94	37	2.65	31.7											curves
		2	1.20-2.20	Silty clay	CL					100	99	97	2.56	41.1	45	24	21	19.4	1.69	3.0 x 10	1.14	0.35	2.2	0.94	&
															46	25	21								Cv, r log P
	TS5-2	1	0.90-1.10	Silty clay	CL					100	99	96	2.67	45.9	40	22	18	24.3	1.54	2.8 x 10	0.88				Curves are
										100	95	89	2.64	44.3	39	21	18								shown in
		2	4.00-5.00	Clayey silt	MH						100	92	2.67	46.6	56	34	22	21.6	1.62	3.6 x 10		0.22	4.0	0.82	Appendix.
TS 6	TS6-1	1	0.90-1.00	Silty clay	CH			100	97	94	85	79	2.52	42.3	59	27	32	24.5	1.44	3.5 x 10	0.82	0.25	1.2	0.89	
								100	96	93	36	80	2.52	41.9	61	29	32								
		2	1.16-2.16	Silty fine sand	SM				100	97	88	46	2.60	45.7	---	NP	---	14.4	1.85						
	TS6-2	1	0.90-1.00	Silty clay	CH					100	88	71	2.64	42.4	65	27	38	27.0	1.50	3.8 x 10	2.12	0.31	1.8	0.85	
										100	90	70	2.64	41.2	64	26	38								
		2	1.60-2.60	Silty sand	SM				100	98	73	42	2.60	36.7	---	NP	---	16.4	1.77	----					
TS 7	TS7-1	1	0.80-1.10	Clayey silt	ML				100	99	97	73	2.68	27.9	36	32	4	21.3	1.66	6.0 x10	1.19	0.20	1.9	0.71	
									100	98	95	71	2.66	26.8	35	31	4								
		2	1.90-2.90	Silty sand	SM				100	90	83	42	2.66	36.3	---	NP	---	14.8	1.83	----					
	TS7-2	1	1.00-1.05	Silt	ML						100	86	2.78	24.1	---	NP	---	19.6	1.69	----					
											100	88	2.81	23.8											
		2	2.60-3.60	Clayey silt	MH					100	99	89	2.55	35.9	64	42	22	26.4	1.48	1.1 x 10	3.09	0.17	1.0	0.76	
															62	40	22								
TS 8	TS8-1	1	0.90-1.05	Sandy silt w/ clay	ML				100	99	98	57	2.69	22.0	38	20	18	14.0	1.84	2.9 x 10	3.10	0.24	3.6	0.75	
									100	98	96	57	2.71	20.6	40	22	18								
		2	2.84-3.84	Silty sand	SM		100	94	90	73	65	21	2.71	29.4	---	NP	---	12.5	1.95	----					
	TS8-2	1	0.90-1.10	Silty clay	CL				100	99	99	64	2.76	21.4	34	13	21	19.5	1.74	2.6 x 10	2.24	0.20	1.3	0.79	
									100	97	97	62	2.61	20.1	36	15	21								
		2	2.30-3.30	Clayey silt	MH					100	99	83	2.62	21.6	54	42	12	26.6	1.48	1.1 x 10					

Note: Sieve sizes converted to milliter, 3/4"=19.05 mm, 1/2 mm, =12.7 mm, 3/8" = 9.595 mm, #4 = 4.75 um, #10 = 2.0 mm, # 40 = 0.0425, # 200 = 0.075

Table 2.5.1 RESULT OF SOIL TESTS (3/3)

LOCATION (TEST PIT NO.)		SAMPLE NO.	DEPTH M.	SOIL DESCRIPTION	UNIFIED SOIL CLASSIFICATION	SIEVE ANALYSIS % PASSING 3/4"	1/2"	3/8"	#4	#10	#40	#200	SPECIFIC GRAVITY	NATURAL MOISTURE CONTENT %	ATTERBERG LIMIT LL	PL	PI	MOISTURE-DENSITY RELATION OF SOIL: OMC %	MDD g/cc	COEFFICIENT OF PERMEABILITY cm/sec.	UNCONFINED COMPRESSION: qu kg/cm2	CONSOLIDATION Cc	Pc	eo	REMARKS
TS 9	TS9-1	1	0.95-1.10	Silty clay	CH				100	98	81	63	2.67	23.8	60	29	31	25.2	1.52	3.8 x 10	1.17	0.24	2.5	0.84	e- log P curves & Cv, r log P: Curves are shown in Appendix.
									100	96	80	64	2.60	22.9	59	29	30								
		2	4.90-5.00	Sandy silt	ML				100	85	74	55	2.67	20.5	---	NP	---	16.3	1.76	----					
	TS9-2	1	1.50-2.50	Clayey sand	SC					100	83	33	2.58	26.4	37	21	16	18.5	1.69	2.3 x 10	2.01				
										100	88	77	2.64	25.9	37	22	15								
		2	3.50-5.00	Silty clay	CL					100	89	78	2.63	16.5	40	23	17	20.3	1.65	2.9 x 10		0.23	1.4	0.84	
TS 10	TS10-1	1	0.90-1.00	Silty clay	CL						100	96	2.54	21.7	45	26	19	23.8	1.46	6.0 x 10	2.33	0.22	0.5	1.01	
								100	88	85	73	65	2.52	21.6	43	24	19								
		2	1.65-2.80	Clayey silt	MH			100	87	85	75	65	2.67	30.6	64	37	27	21.7	1.64	1.1 x 10					
	TS10-2	1	0.90-1.10	Clayey sand	SC			100	97	94	60	45	2.59	25.4	60	28	32	17.1	1.77	2.3 x 10	2.79	0.22	2.4	0.97	
								100	96	94	61	45	2.59	24.9	59	28	31								
		2	1.68-2.03	Siltstone		(Retrieved sample can not be tested as soil material)																			
TA 1	TA1-2	1	1.00	Silty sand	SM				100	94	87	36	2.64	23.1	----	NP	----	11.2	1.93	----	----	----	----	----	
													2.64												
TA 3	TA3-2	1	1.00-1.10	Sandy silt	ML					100	99	67	2.53	38.7	42	31	11	21.6	1.54	----	1.98	----	----	----	
													2.53												
TA 5	TA5-2	1	0.90-1.10	Sandy silt	ML						100	91	2.73	32.4	58	39	19	29.9	1.44	----	2.39	----	----	----	
													2.73												
TA 6	TA6-1	1	2.00-5.00	Silty sand	SM					100	88	19	2.80	10.2	----	NP	----	12.4	1.99	----	----	----	----	----	
													2.80												
TA 7	TA7-1	1	0.00-0.84	Silty sand	SM					100	98	41	2.72	31.8	----	NP	----	22.3	1.63	----	----	----	----	----	
													2.71												

Note: Sieve sizes converted to millimeter, 3/4" - 19.05 mm, 1/2 " - 12.7 mm, 3/8" - 9.595 mm, #4 = 4.75 mm, #10 - 2.0 mm, #40 - 0.0425, #200 - 0.075

Table 2.5.2 RESULT OF AGGREGATE TESTS (1/2)

LOCATION	(TEST PIT NO.)	DEPTH m.	SOIL DESCRIPTION	UNIFIED SOIL CLASSIFICATION	SAMPLE TYPE	SIEVE ANALYSIS % PASSING – COARSE AGGREGATES 2-1/2"	2"	1-1/2"	1"	3/4"	1/2"	3/8"	FINE AGGREGATES #4	#8	#16	#30	#50	#100	#200	BULK SPECIFIC GRAVITY (DRY)	BULK SPECIFIC GRAVITY (SSD)	APPARENT SPECIFIC GRAVITY	ABSORPTI %	SOUNDNESS	ORGANIC IMPURITIES
TA 1	TA1-1	0.00-2.10	Sandy gravel (Brown to grayish brown)	GP	FINE								5	4	2	2	1	0	0	2.56	2.67	2.88	4.3	5.0	Nil
					COARSE	100	96	83	83	60	32	17								2.75	2.79	2.86	1.4	4.7	
	TA1-2	5.00	Poorly graded sand (Brownish gray)	SP	FINE								5	4	2	1	1	0	0	2.60	2.69	2.87	3.7	6.1	Substantial
					COARSE	100	93	61	61	43	22	13								2.69	2.75	2.86	2.2	2.4	
TA 2	TA2-1	0.30-1.30	Poorly graded sand with silt (Brown to grayish brown)	SP-SM	FINE								4	4	3	2	0	0	0	2.47	2.58	2.78	4.4	7.7	Nil
					COARSE		100	88	78	73	44	30								2.75	2.78	2.84	1.2	8.5	
	TA2-2	0.33-1.00	Poorly graded sand (Gray)	SP	FINE								4	4	3	3	1	0	0	2.61	2.68	2.81	2.7	7.3	Substantial
					COARSE		100	88	77	66	54	35								2.70	2.75	2.84	1.9	7.8	
TA 3	TA3-1	1.00-1.50	Poorly graded sand with silt (Brown to grayish brown)	SP-SM	FINE								7	5	4	3	2	0	0	2.43	2.52	2.67	3.7	6.8	Substantial
					COARSE			100	92	83	72	44								2.69	2.73	2.81	1.6	9.7	
	TA3-2		Tested as soil samples																						
TA 4	TA4-1	2.00-3.00	Silty sand (Grayish brown)	SM	FINE											100	88	63	12				3.1	2.4	Substantial
					COARSE															2.57	2.65	2.79			
	TA4-2	1.70-3.68	Poorly graded sand (Gray to light gray)	SP	FINE										100	98	84	52	13	2.60	2.69	2.86	3.5	3.9	Nil
					COARSE																				
TA 5	TA5-1	1.00-2.00	Poorly graded sand (Light gray)	SP	FINE									100	89	76	28	10	4	2.40	2.48	2.61	3.3	7.7	Nil
					COARSE																				
	TA5-2		Tested as soil samples																						

Note: Sieve sizes converted to millimeter, 3/4"= 19.05 mm, 1/2"=12.7 mm, 3/8" = 9.595 mm, #4= 4.75 mm, #10=2.0 mm, #40= 0.0425, #200= 0.075

Table 2.5.2 RESULT OF AGGREGATE TESTS (2/2)

LOCATION	(TEST PIT NO.)	DEPTH M.	SOIL DESCRIPTION	UNIFIED SOIL CLASSIFICATION	SAMPLE TYPE	SIEVE ANALYSIS % PASSING: COARSE AGGREGATES 2-1/2"	2"	1-1/2"	1"	3/4"	1/2"	3/8"	FINE AGGREGATES #4	#8	#16	#30	#50	#100	#200	BULK SPECIFIC GRAVITY (DRY)	BULK SPECIFIC GRAVITY (SSD)	APPARENT SPECIFIC GRAVITY	ABSORPTI. %	SOUNDNESS	ORGANIC IMPURITIES
TA 6	TA6-1		Tested as soil samples																						
	TA6-2	1.50-3.00	Silty sand (Light gray)	SM	FINE									100	99	95	80	25	10	2.60	2.66	2.75	2.1	4.0	
					COARSE																				
TA 7	TA7-1		Tested as soil samples																						
	TA7-2	0.80-1.80	Sandy gravel (Dark gray)	GP	FINE								4	4	3	2	1	1	0	2.45	2.58	2.84	5.2	6.1	
					COARSE		100	93	89	85	76	62								2.61	2.68	2.81	2.8	8.0	
TA 8	TA8-1	0.70-3.60	Poorly graded sand with silt (Gray)	SP-SM	FINE								98	97	95	91	87	22	9	2.39	2.52	2.74	5.3	6.8	
					COARSE							100													
	TA8-2	0.00-1.50	Silty sand (Light gray)	SM	FINE								8	7	5	2	2	1	0	2.53	2.62	2.78	3.6	5.2	
					COARSE				100	89	64	41								2.73	2.79	2.89	2.0	4.9	
TA 9	TA9-1	0.00-2.00	Poorly graded sand (Gray)	SP	FINE											100	92	87	10	2.43	2.54	2.72	4.3	0.7	Substantial
					COARSE																				
	TA9-2	0.00-1.00	Poorly graded sand with silt (Brown to gray)	SP	FINE								99	87	80	64	55	42	10	2.67	2.79	2.87	4.7	3.3	Substantial
					COARSE							100													
TA 10	TA10-1	1.00-1.50	Poorly graded sand with silt (Brown)	SP-SM	FINE								24	23	20	18	17	7	2	2.33	2.38	2.47	2.5	5.3	Nil
					COARSE						100	80								2.65	2.71	2.83	2.5	4.1	
	TA10-2	1.00-1.20	Poorly graded sand (Gray)	SP	FINE								18	15	14	12	11	4	3	2.59	2.67	2.81	3.1	4.6	Substantial
					COARSE					100	90	75								2.77	2.81	2.88	1.3	5.5	

Note: Sieve sizes converted to millimeter, 3/4" = 19.05 mm, 1/2" = 12.7 mm, 3/8" = 9.595 mm, #4 = 4.75 mm, #10=2.0 mm, #40= 0.0425, #200 = 0.075

Table 2.5.3 CHARACTERISTICS OF SELECTED DIKE MATERIAL

Selected Site No.	Soil Mechanical Assessment(1)	Proposed Area (km^2)	Excavate Depth (m)	Potential Quantity (x10^{6}m^3)	Remarks
TS 1	A	0.55	2.0	1.1	. Residual soil of Terrus . More available area . Problem of land use (cultivate land & - residence)
TS 2	B	1.5	2.0	3.0	. Residual soil of hilly area . Problem of land use
TS 4	C	0.50	2.0	1.0	. Alluvial deposit of swamp . Along Flood way channel
TS 8	B	2.50	1.0	2.5	. Alluvial deposit of plain . Land use (Rice field)
TS 9	A	1.20	2.5	3.0	. Residual soil of undulating to hilly area . Problem of land use (cultivate land)
TS10	A	1.50	1.2	1.8	. Thin residual soil of hilly area . Problem of land use
(Total)	-	-	-	12.4 (x10^{6}m^3)	-

(1) A: Excellent B: Good C: Acceptable

Table 2.5.4 CHARACTERISTICS OF SELECTED CONCRETE AGGREGATE

Selected Site No.	Soil Mechanical Assessment (1)	Proposed Area (km^2)	Excavate Depth (m)	Source	Potential Quantity		Remarks
					% of Volume	Volume (m3) ($x10^6m^3$)	
TA 1	C	0.40	2.0	Fine Coarse	5% 70%	0.04 0.5	. River bank of Upper Agno River . Land use (Rice Field)
TA 2	C	0.50	1.0	Fine Coarse	5% 70%	0.02 0.3	. River bed of Upper Agno River
TA 4	C	0.70	2.0	Fine	50%	0.7	. River bank of Middle Agno R. (Carmen Br.)
TA 7	B	1.10	1.5	Fine Coarse	5% 50%	0.08 0.8	. River bed of Bued R. . More available area
TA 9	C	0.15	2.0	Fine	80%	0.24	. River bed of Aloragat River
TA10	B	0.25	1.0	Fine Coarse	15% 60%	0.03 0.1	. River bed of Aloragat River
(Total)				Fine Coarse		11.8 1.7	($x10^6m^3$) ($x10^6m3$)

(1) A: Excellent B: Good C: Acceptable

Table 2.8.1 EXISTING FLOOD CONTROL FACILITIES IN UPPER AGNO RIVER

STRETCH OF DIKING SYSTEM	EARTH-DIKE (km)	GRAVITY WALL/REVET. (km)	L.W.C REVETMEN (km)	SPUR DIKE (km)	BOULDER (km)
Bayambang Baby Dike Section	0.98 (R)	0	0	0	0
Bayambang-Villasis Dike Section	18.37 (R)	1.89 (R)	0	11.20 (R)	0
Villasis-Asingan Dike Section	12.00 (R)	0.40 (R)	0	3.00 (R)	0
Asingan-Sn.Manuel Dike Section	17.40 (R)	2.20 (R)	0	7.00 (R)	1.10 (R)
Anulid-Bautista Dike Section	5.80 (L)	0	0	0	0
Anulid-Poponto Dike/Floodway	4.67 (L)	0	0	3.80 (L)	0
	6.03 (R)	0	0	9.50 (R)	0
Alcala-Sto.Tomas Dike Section	7.20 (L)	4.73 (L)	7.50 (L)	0	0.70 (L)
Rosales-Lagasit Dike Section	4.00 (L)	1.20 (L)	0	0	0
Lagasit-Sta.Maria Dike Section	12.06 (L)	0	0	0	0
Sta.Maria-Tayug Section	0 (L)	0	0	0	0

NOTE: (R):RIGHT BANK, (L):Left bank
L.W.C ; Low-water channel

Table 2.9.1 EXISTING FLOOD CONTROL FACILITIES IN PANTAL-SINOCALAN RIVER

RIVER/STRETCH	EARTH-DIKE (km)	GRVITY WALL & RIVET. (km)	CUT-OFF CHANNEL (km)	OTHERS
Mam Pantal-Sinocalan R.				
Pantal River	0	0	0	Rivetment of Fish pond Embankment
Marusay River	0	1.5	0	
Sinocalan River	3.0	0	1.6	Spur dike partially constructed
Tagumising River	0	0.8	0	- ditto -
Toributaries				
Mitura River	0	0.2	0	

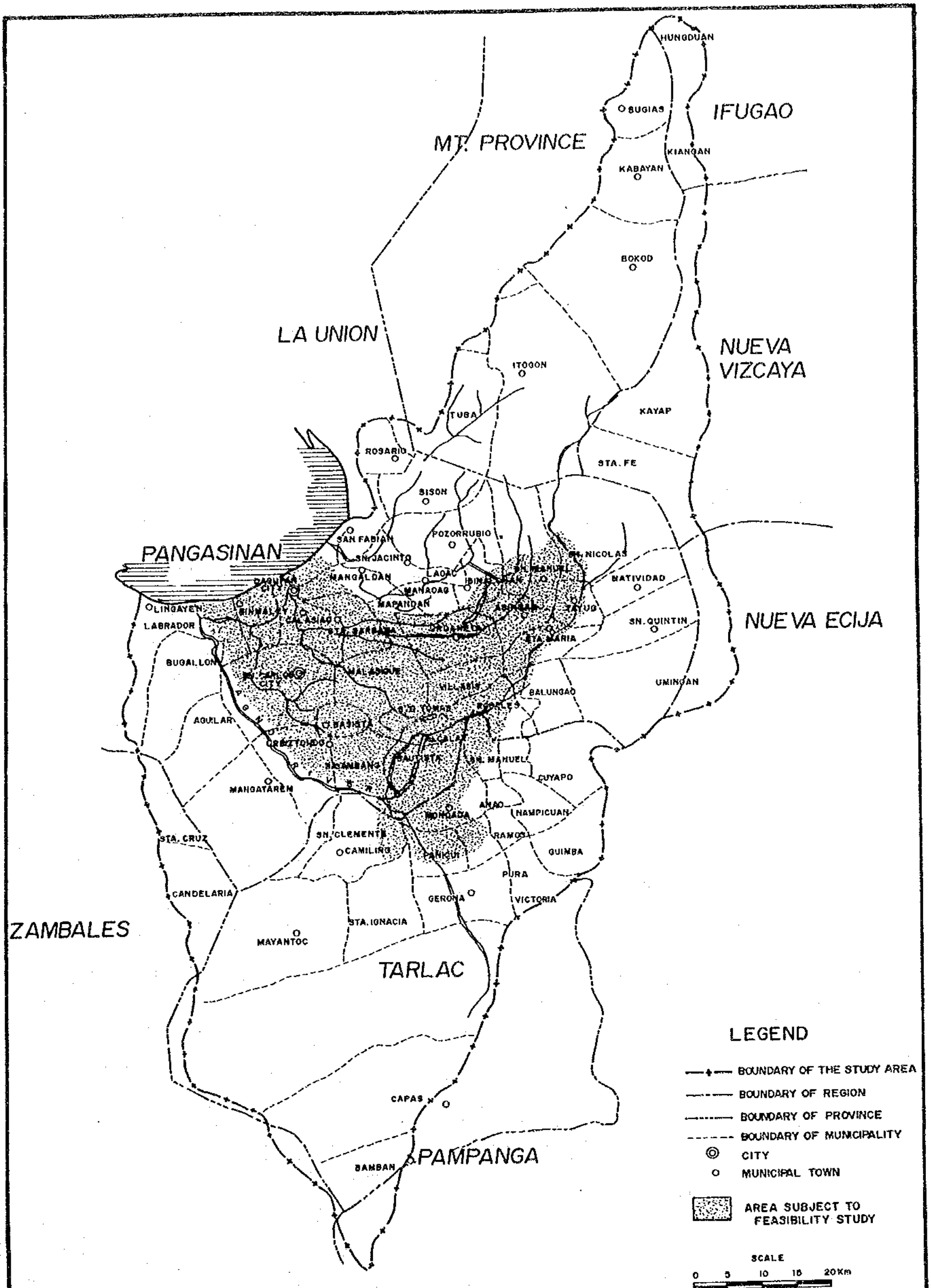


Fig. 2.1.1 DEFINITION OF STUDY AREA AND FEASIBILITY AREAS

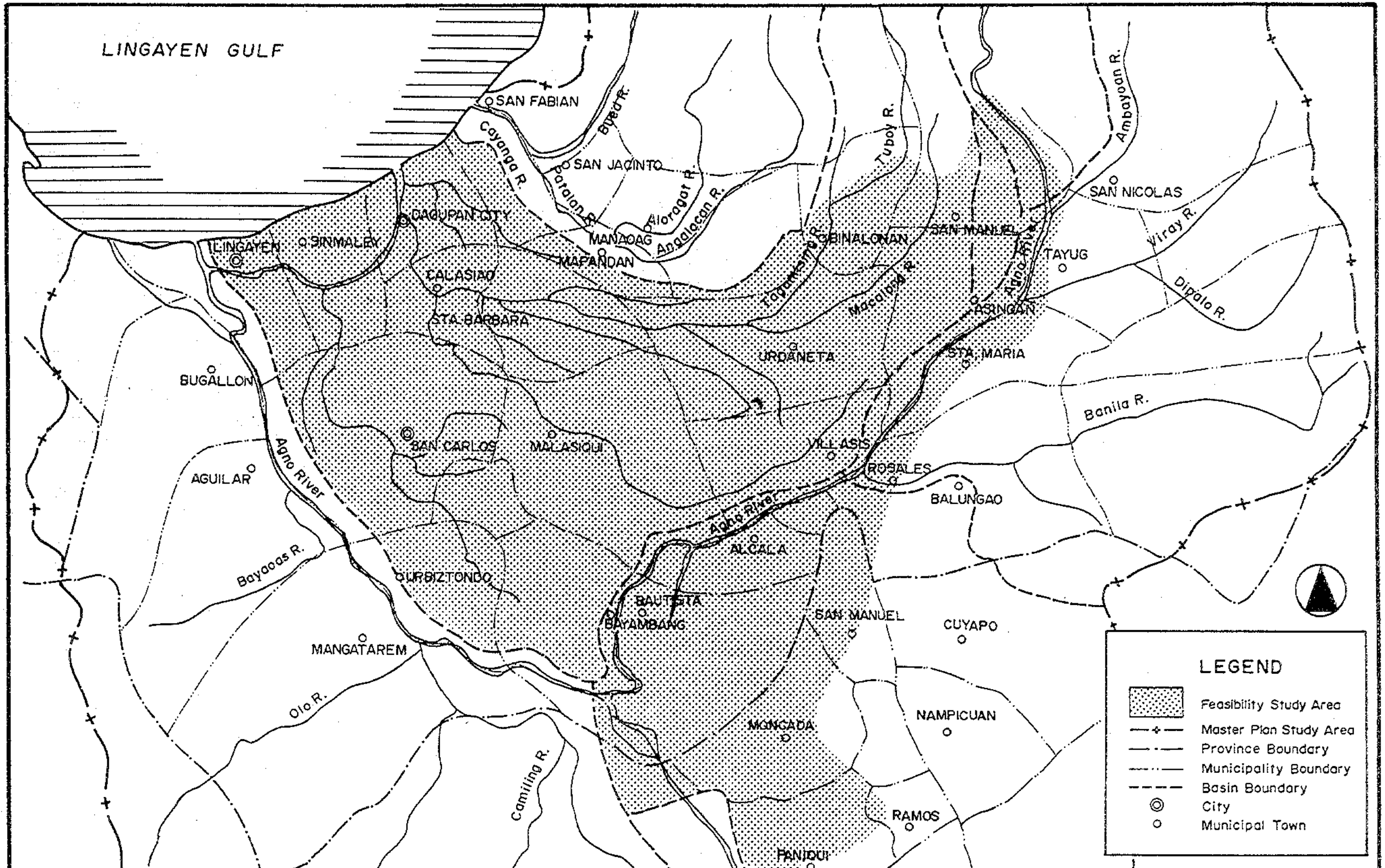


Fig. 2.1.2 CITY AND MUNICIPALITIES IN THE STUDY AREA

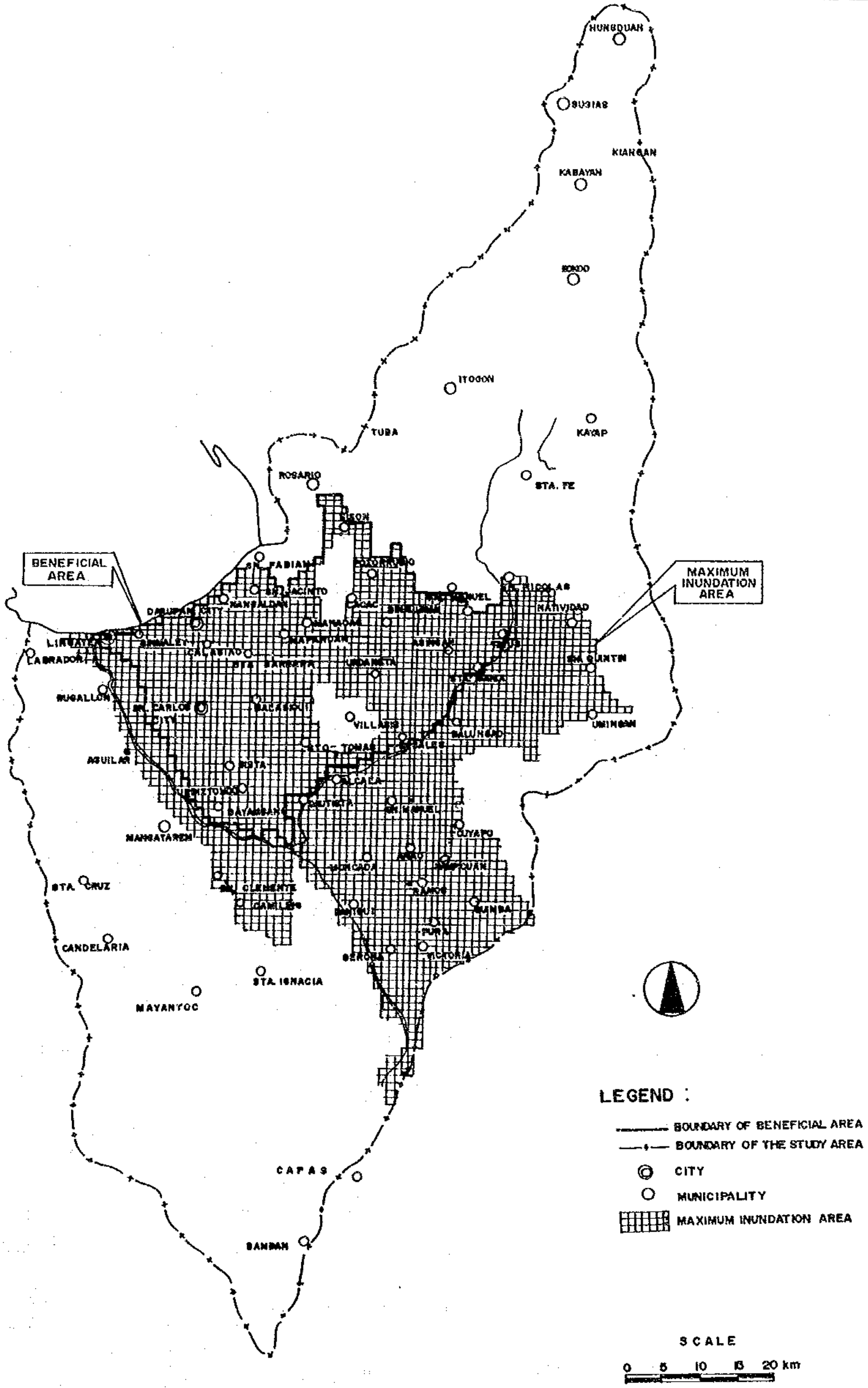


Fig. 2.1.3 DEFINITION OF BENEFICIAL AREA AND MAXIMUM INUNDATION AREA

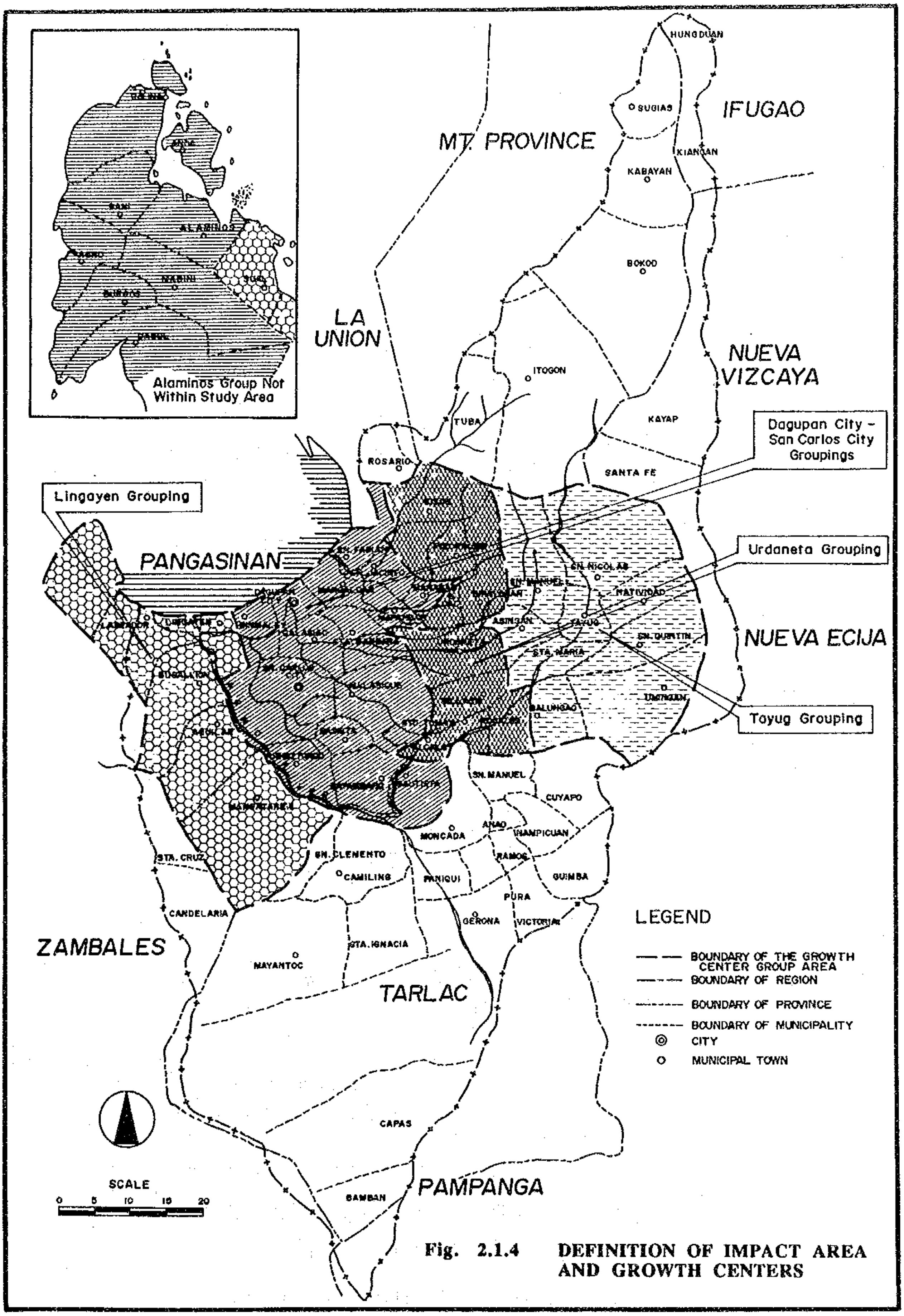
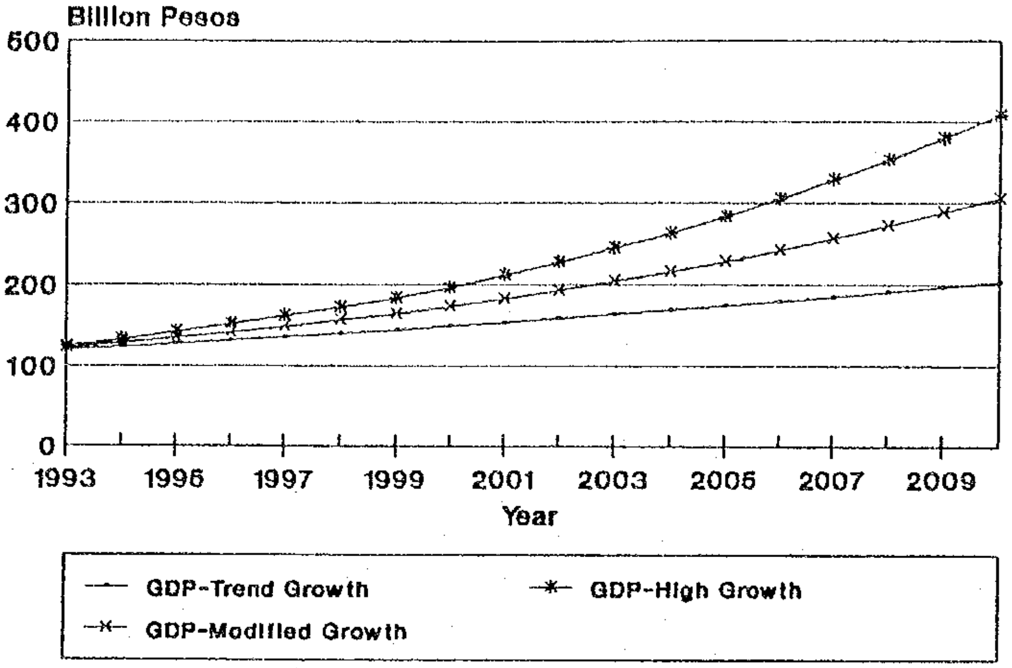
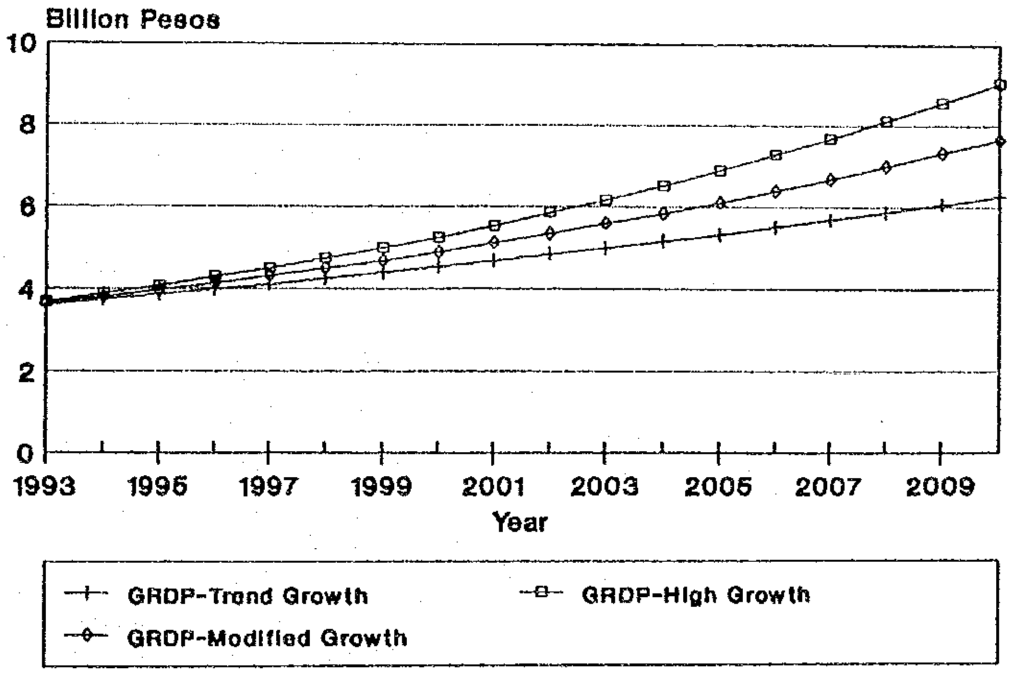


Fig. 2.1.4 DEFINITION OF IMPACT AREA AND GROWTH CENTERS



PROJECTED GDP - 1993 TO 2010
(In Constant 1972 Prices)



* Ilocos Region excluding CAR Provinces

PROJECTED GRDP* - 1993 TO 2010
(In Constant 1972 Prices)

Fig. 2.2.1 MODIFIED GROWTH SCENARIO

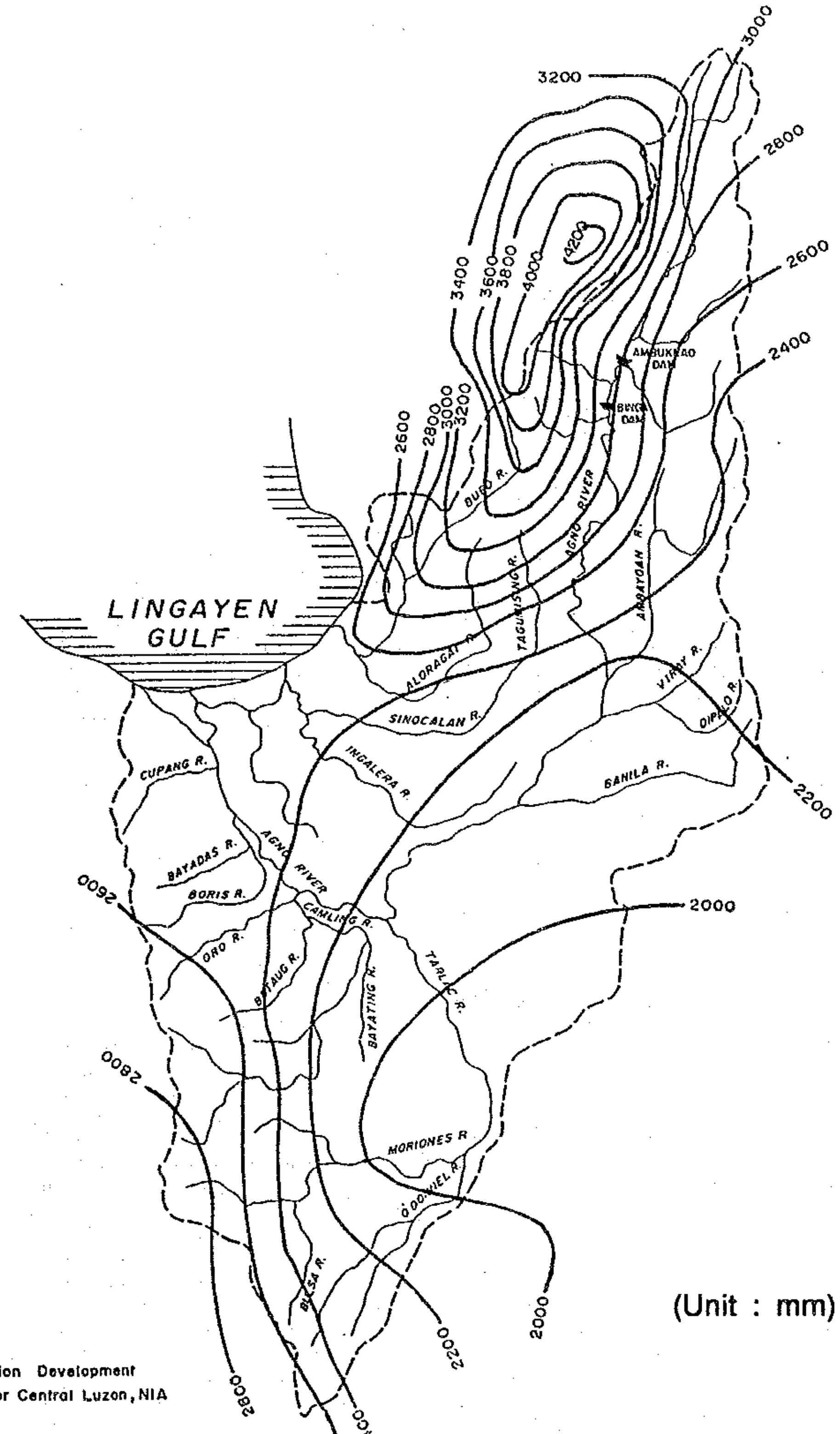
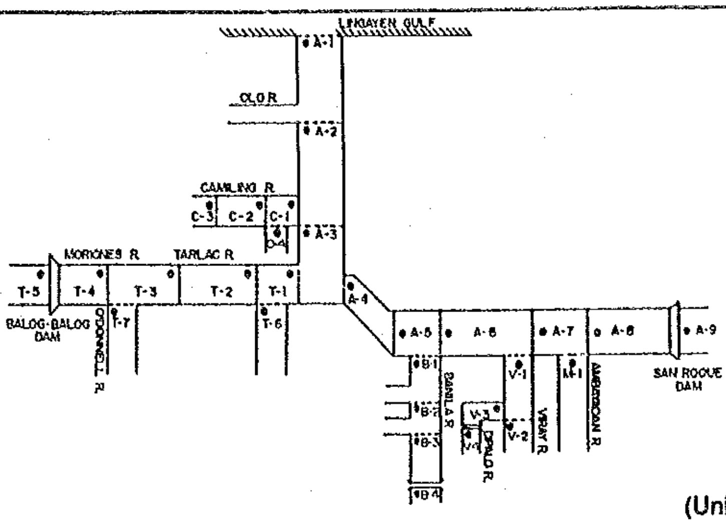


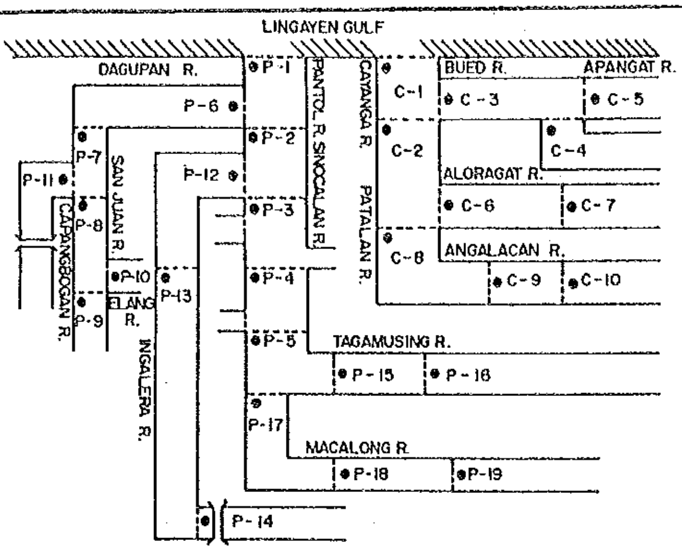
Fig. 2.3.1 ISOHYETAL MAP OF AGNO RIVER BASIN



(Unit : m³/sec)

River/Stretch	Location No.	1.05	2	5	10	25	50	100
		Return Period (year)						
1. Main Agno River								
Rivermouth	A-1	1160	2510	5100	7610	11220	14170	17310
Before Junction with Olo R.	A-2	990	2250	4700	6910	10140	12730	15680
Before Junction with Camiling R.	A-3	880	2100	4350	6410	9330	11960	14820
Before Junction with Tarlac R.	A-4	500	1330	2690	3980	5760	7460	9210
Upstream of Poponto Floodway	A-5	490	1320	2680	3960	5730	7430	9190
Before Junction with Banila R.	A-6	410	1140	2330	3470	5020	6570	8140
Before Junction with Viray-Dipalo R.	A-7	360	970	2050	3010	4380	5930	7280
Before Junction with Ambayoan R.	A-8	260	700	1530	2340	3780	5120	6370
San Roque Dam	A-9	320	830	1710	2600	3950	5060	6260
2. Tarlac River								
Junction with Agno R.	T-1	460	960	2000	2930	4350	5510	6720
Before Junction of Baka R.	T-2	240	550	1140	1690	2540	3230	3940
Tarlac	T-3	180	430	870	1340	2020	2580	3180
Baka R. + Sub Basin	T-6	260	530	1000	1490	2150	2640	3150
Moriones R.	T-4	110	280	570	860	1270	1610	1950
O'Donnell R.	T-7	70	170	310	490	760	1000	1230
Balog-Balog	T-5	80	160	300	430	610	760	900
3. Camiling River								
Junction with Agno R.	C-1	200	360	660	1020	1630	2170	2660
Before Junction with Bayating R.	C-2	130	240	450	700	1140	1520	1850
Before Junction with Hamair R.	C-3	90	170	310	480	850	1130	1380
Bayating R.	C-4	70	120	210	320	500	660	800
4. Banila River								
Junction with Agno R.	B-1	110	250	510	740	990	1380	1610
Before Junction with Matablong R.	B-2	60	160	320	470	650	950	1100
Before Junction with Karayoga R.	B-3	30	70	150	220	300	440	510
Bridge	B-4	20	60	110	160	230	330	390
5. Viray-Dipalo River								
Junction with Agno R.	V-1	50	120	240	380	530	730	840
Viray R.	V-2	20	60	130	190	270	370	420
Dipalo R. (Down stream of San Pedro)	V-3	20	60	110	170	250	350	400
(Upstream of San Pedro)	V-4	10	30	70	100	150	210	240
6. Ambayoan River								
Junction with Agno R.	M-1	110	300	590	880	1310	1730	2090

Fig. 2.4.1 PROBABLE FLOOD PEAK DISCHARGE DISTRIBUTION OF AGNO RIVER UNDER CONFINING DIKE CONDITION (WITH SAN ROQUE DAM)



(Unit : m^3/sec)

River/Stretch	Location No.	1.05	2	5	10	25	50	100
1.1 Cayanga/Patalan Rivers								
Rivermouth	C-1	270	580	1070	1490	2080	2560	3030
Before Junction with Bued R.	C-2	140	300	550	770	1060	1310	1550
1.2 Bued River								
Junction with Cayanga R.	C-3	130	290	520	730	1040	1290	1550
Before Junction with Apangat R.	C-4	90	200	340	500	750	950	1170
Apangat R.	C-5	30	60	120	160	220	260	300
1.3 Aloragat River								
Junction with Patalan R.	C-6	50	110	210	280	380	470	550
Amagbagan	C-7	30	60	100	140	200	240	290
1.4 Angalacan River								
Junction with Patalan R.	C-8	70	150	280	400	570	710	840
Maraboc	C-9	50	110	190	270	400	510	620
Kilo	C-10	30	80	130	190	290	370	460
2.1 Panto/Sinocalan River								
Rivermouth	P-1	450	850	1390	2000	2820	3510	4130
Before Junction with Dagupan R.	P-2	270	540	850	1220	1740	2220	2670
Before Junction with Ingalera R.	P-3	190	380	600	860	1260	1640	2000
Before Junction with Quinabolotan R.	P-4	140	280	430	620	950	1250	1530
Catablan	P-5	120	250	370	540	850	1120	1380
2.2 Dagupan River								
Junction with Panto R.	P-6	170	300	480	690	950	1110	1260
Before Junction with Basing R.	P-7	130	240	380	540	740	870	990
Lower San Juan R.	P-8	100	170	270	390	540	630	720
Upper San Juan R.	P-9	50	90	150	200	280	330	380
Elang R.	P-10	50	80	120	190	260	310	350
Campangbogan R.	P-11	30	50	80	120	170	190	220
2.3 Ingalera River								
Junction with Sinocalan R.	P-12	80	150	250	360	500	600	700
Talospatang	P-13	60	120	180	260	370	450	540
San Nicolas	P-14	20	40	50	80	120	150	180
2.4 Tagumising/Tuboy River								
Junction with Sinocalan R.	P-15	80	170	250	350	580	790	990
Yatyat	P-16	70	150	230	330	540	730	910
2.5 Macalong River								
Junction with Sinocalan R.	P-17	40	90	130	190	270	330	390
Urdaneta	P-18	30	60	80	120	190	240	280
San Manuel	P-19	10	30	50	70	100	140	160

Fig. 2.4.2 PROBABLE FLOOD PEAK DISCHARGE DISTRIBUTION OF ALLIED RIVERS UNDER CONFINING DIKE CONDITION

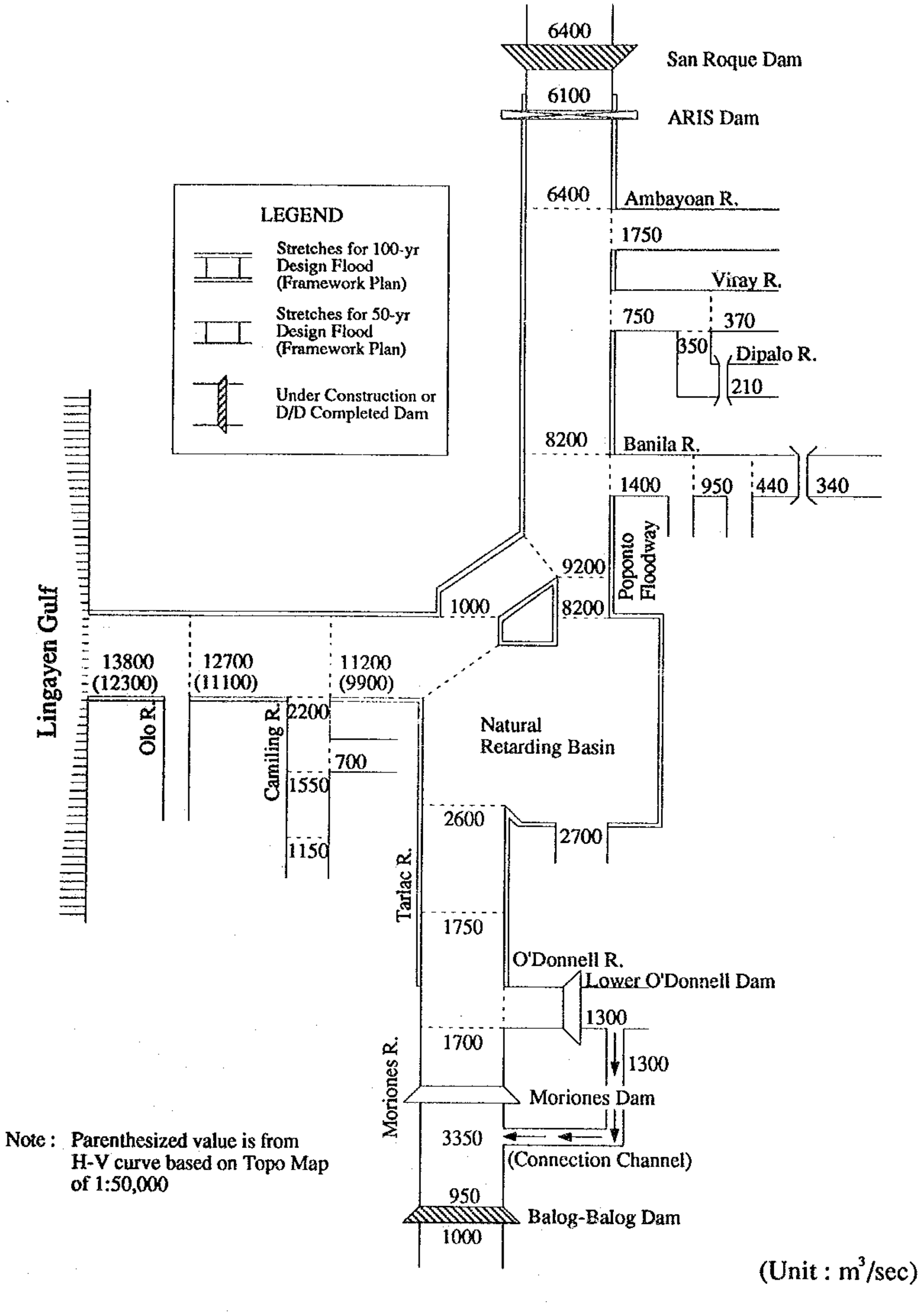
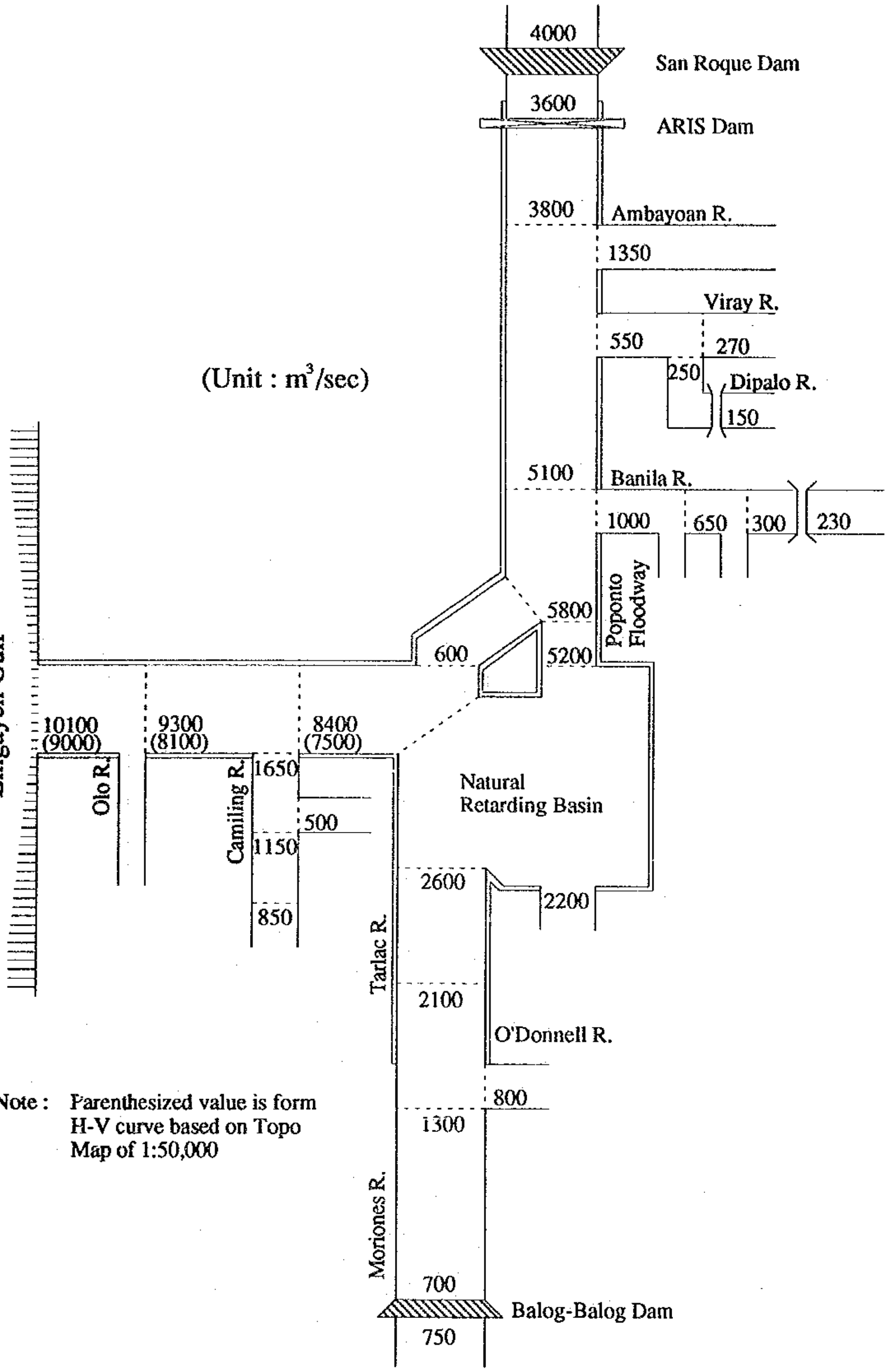


Fig. 2.4.3 REVISED DESIGN FLOOD DISTRIBUTION OF FRAMEWORK PLAN OF AGNO RIVER



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

Fig. 2.4.4 REVISED DESIGN FLOOD DISTRIBUTION OF LONG TERM PLAN OF AGNO RIVER (25-YEAR FLOOD)

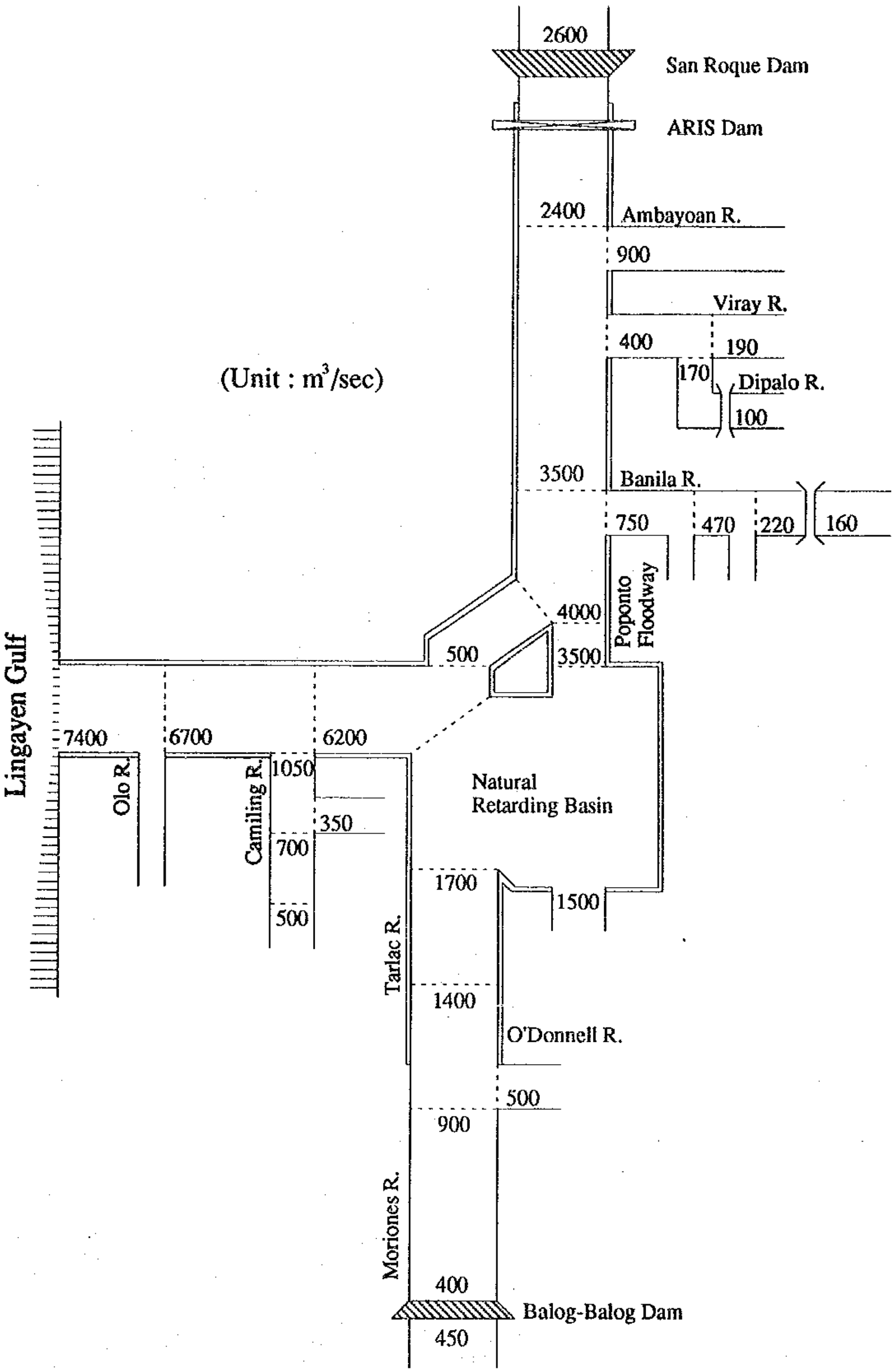


Fig. 2.4.5 REVISED DESIGN FLOOD DISTRIBUTION OF PRIORITY PROJECT OF AGNO RIVER (10-YEAR FLOOD)

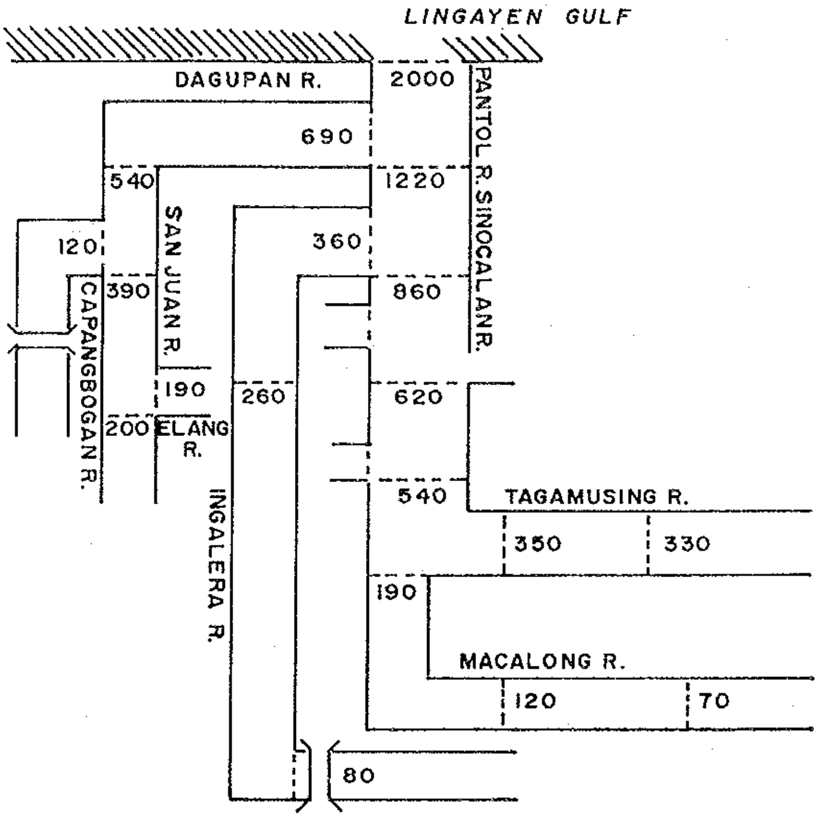


Fig. 2.4.6 PROBABLE FLOOD DISCHARGE DISTRIBUTION OF PANTAL-SINOCALAN RIVER (10-YEAR FLOOD)

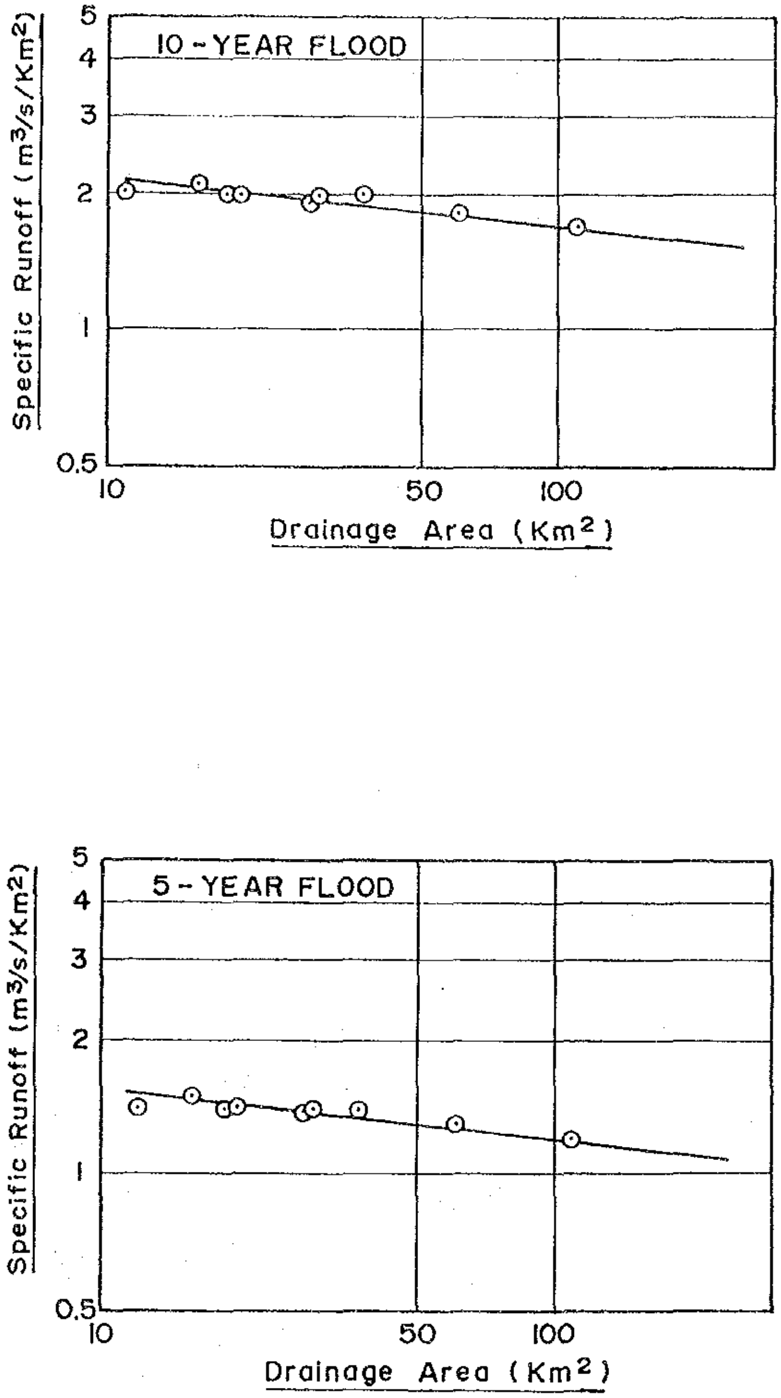
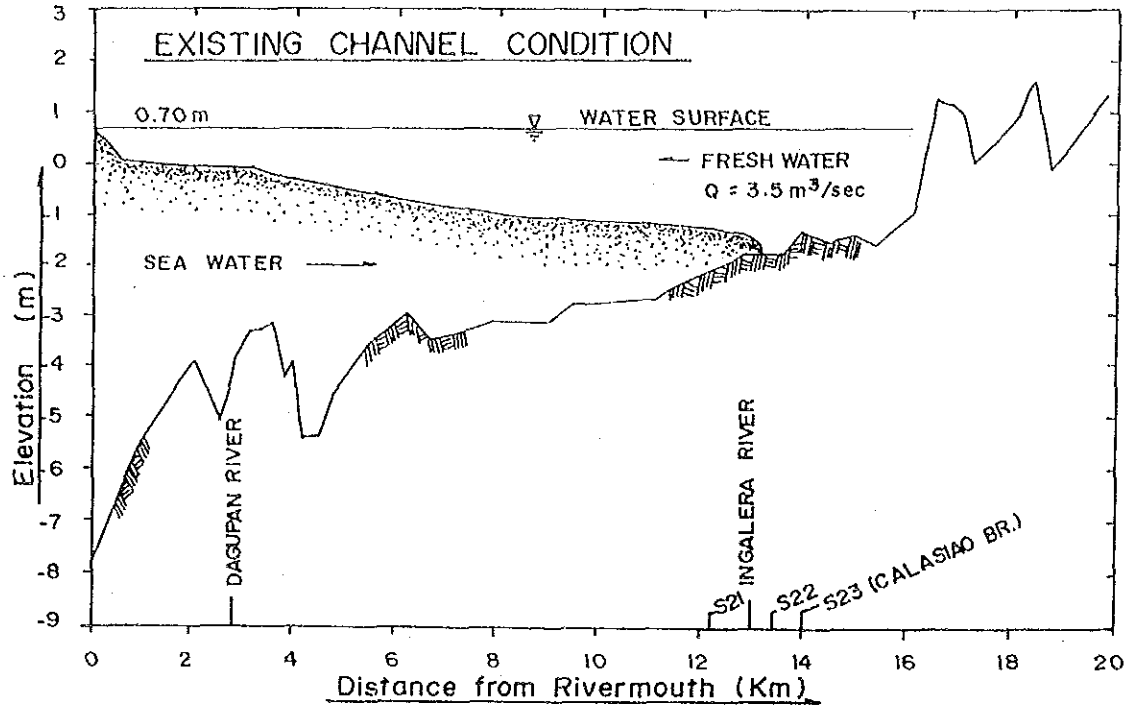


Fig. 2.4.7 RELATIONSHIP BETWEEN SPECIFIC RUNOFF AND DRAINAGE AREA OF LOWLAND AREA IN PANTAL-SINOCALAN RIVER



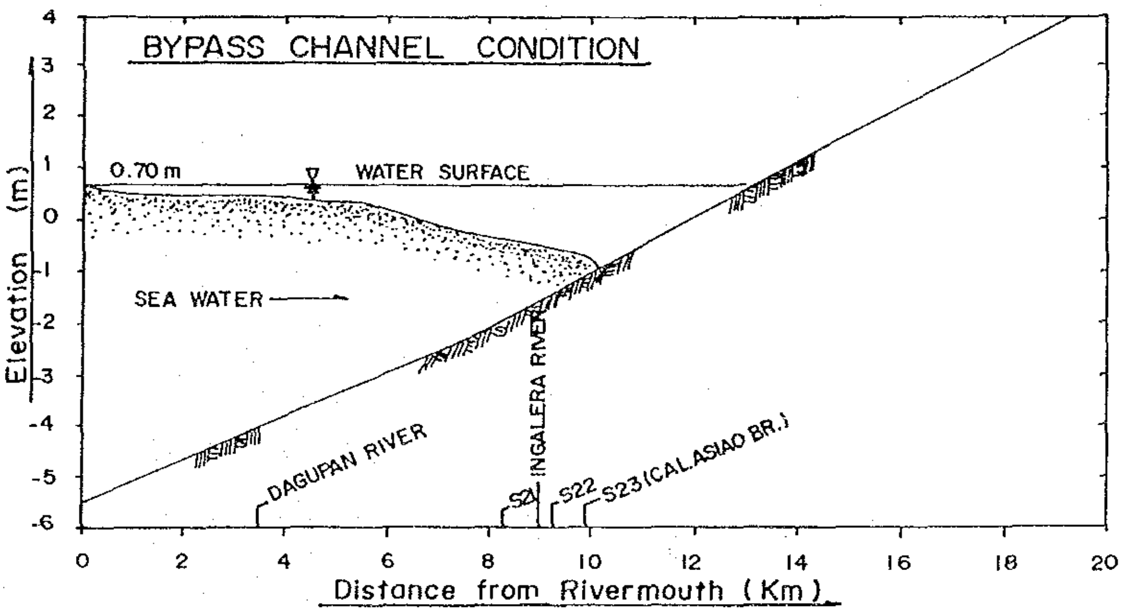
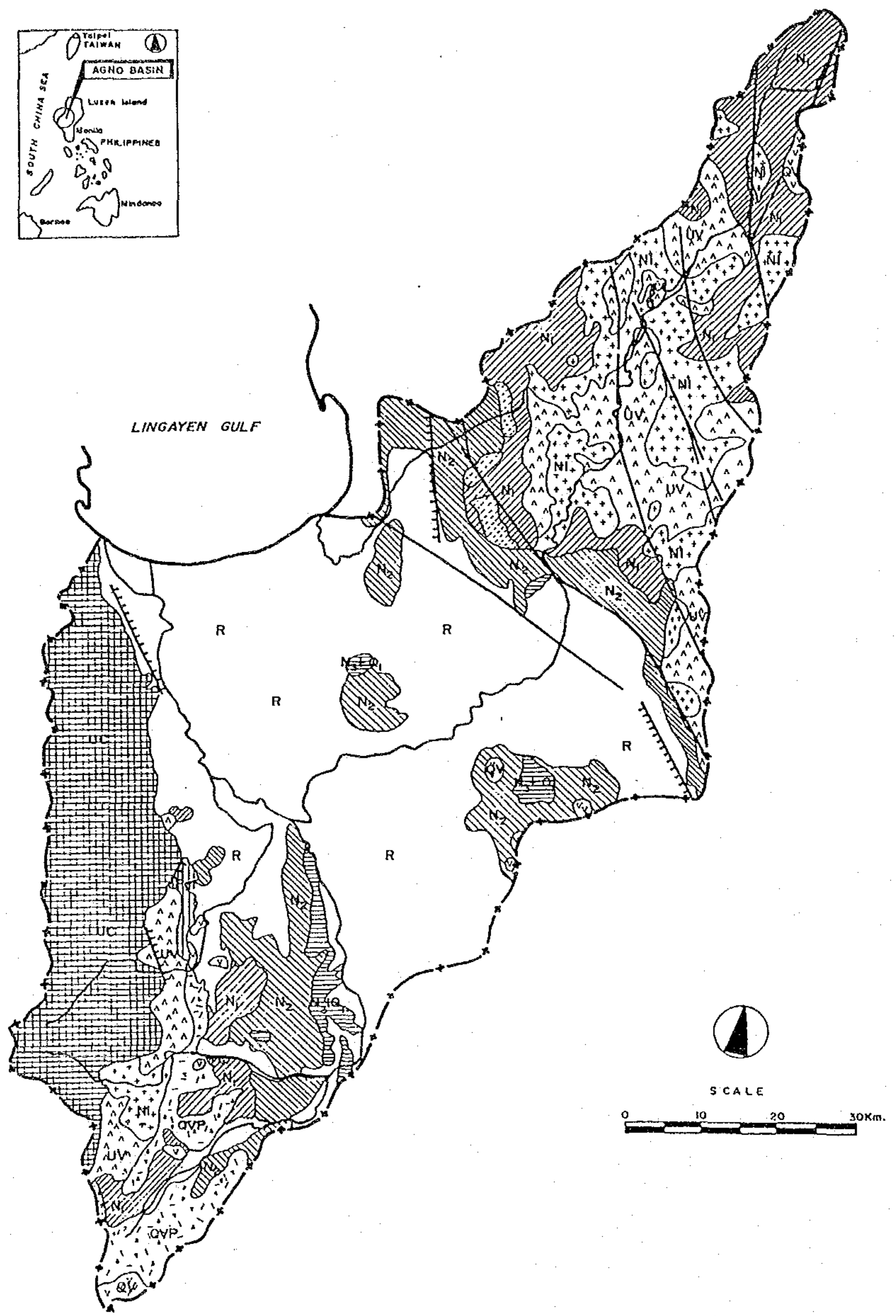


Fig. 2.4.8 ESTIMATED PROFILE OF SEAWATER INTRUSION IN PANTAL-SINOCALAN RIVER UNDER EXISTING AND BYPASS CHANNEL CONDITIONS



SEDIMENTARY ROCKS

R	Recent	Alluvium, fluvial and beach deposits.
Pliocene-Pleistocene	Pliocene-Pleistocene	Marine and terrestrial sediments, associated with reef limestone.
N_2	Upper Miocene-Pliocene	Largely marine clastics overlain by pyroclastics and tuffaceous sedimentary rocks.
N_1	Oligocene-Miocene	Thick, extensive marine deposits, largely wackes, shales and reef limestone, underlain by conglomerate.
Pg_1	Paleocene-Eocene	Thick, extensive marine deposits largely wackes and shales associated with minor conglomerate and reef limestone.

VOLCANIC ROCKS

QVP	Pliocene-Quarternary	Volcanic plain or volcanic piedmont deposits, chiefly pyroclastics and volcanic debris at foot of volcanoes.
QV	Pliocene-Quarternary	Non-active cones (generally andesite), also dacitic and andesitic plugs.
N_1	Oligocene-Miocene	Mostly submarine andesite and basalt flows, intercalated with pyroclastics and clastic sedimentary rocks.
UV	Undifferen-tiated	Metamorphosed submarine flows, largely spilites and basalts. Often designated as "Metavolcanics". Most units probably Cretaceous and Paleogene.

INTRUSIVE ROCKS

NI	Neogene	Largely Miocene quartz diorite. Mostly batholiths and stocks, include granodiorite and diorite porphyry facies.
UC	Cretaceous-Paleogene	Undefferentiated ultramafic and plutonic rocks. Predominantly peridotite associated with gabbro and diabase dikes.

GEOLOGICAL SYMBOLS

- Formational boundary
- High angle fault
- Normal fault

Fig. 2.5.1 GEOLOGICAL MAP OF THE BASIN

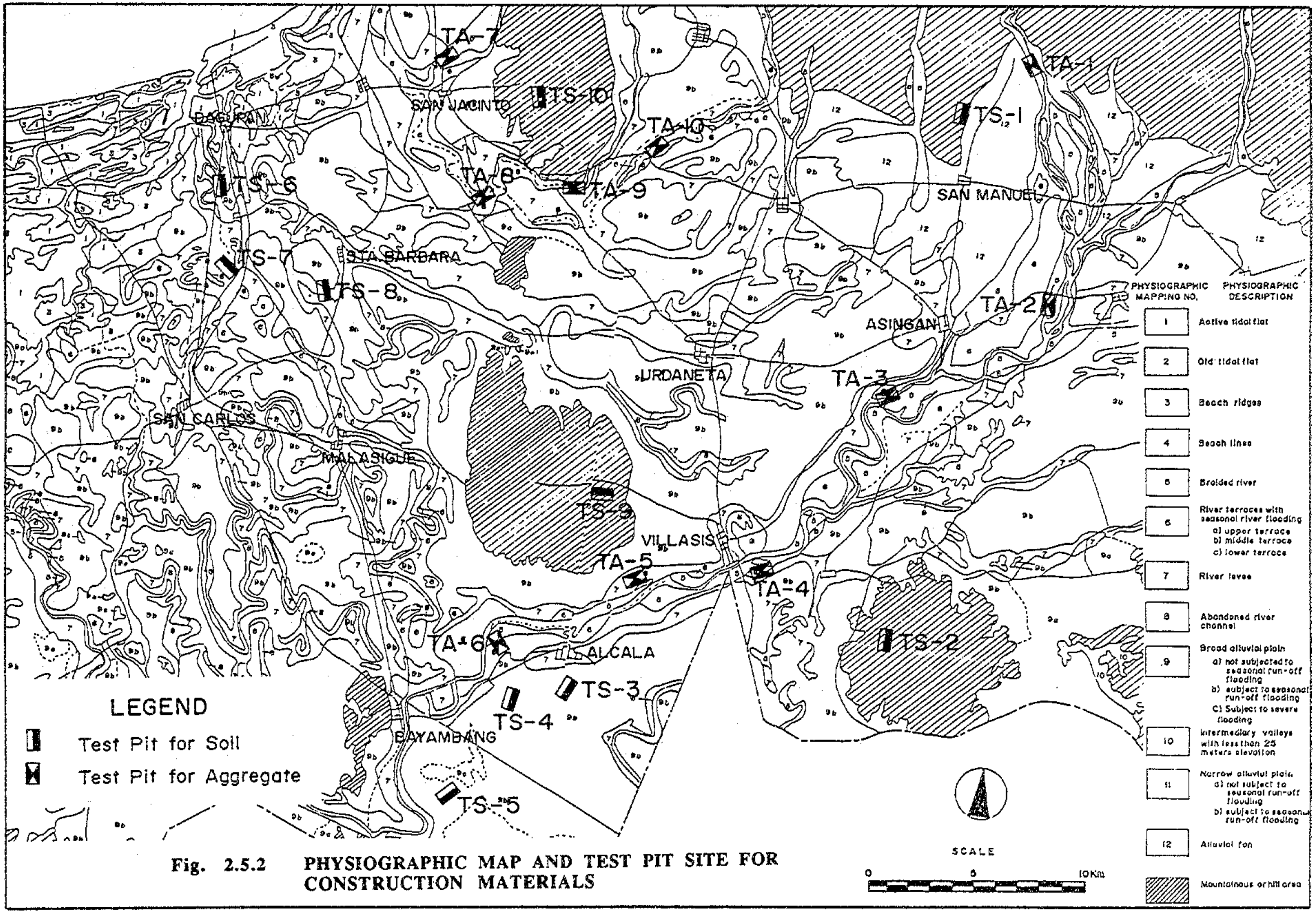
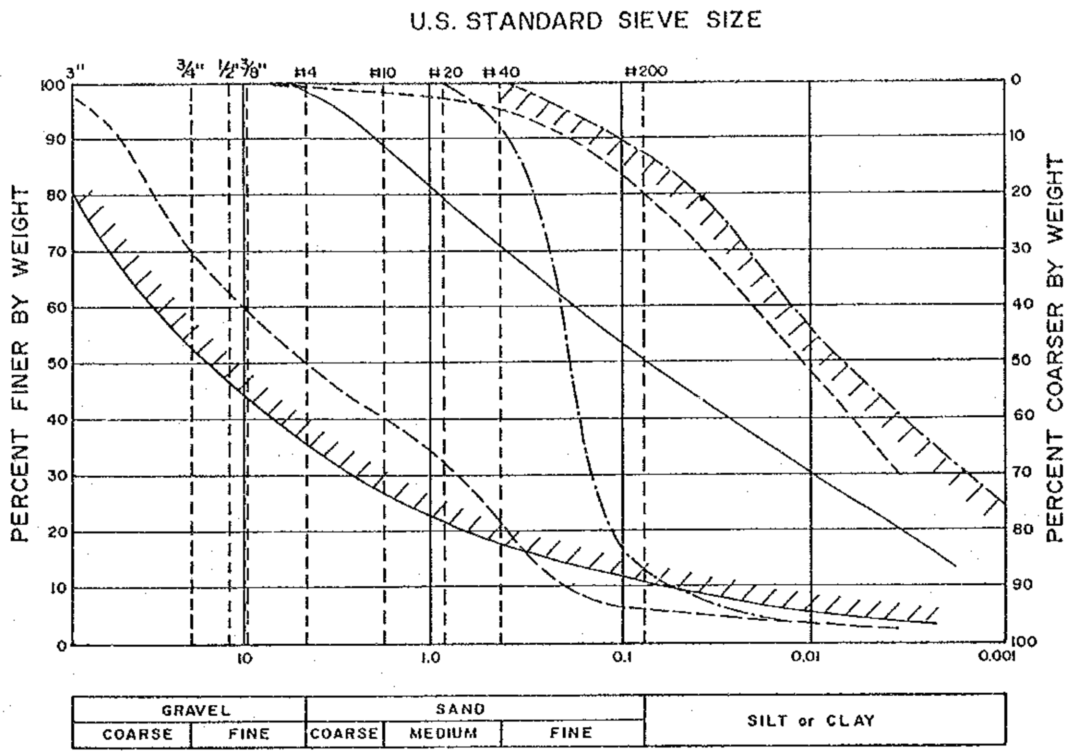


Fig. 2.5.2 PHYSIOGRAPHIC MAP AND TEST PIT SITE FOR CONSTRUCTION MATERIALS



LEGEND

Grain Size Distribution Range

(solid line) : of Impervious Material for Earth Dam

(dashed line) : of Impervious Material for Earth Dam (Bureau of Reclamation, U.S.)

(dash-dot line) : of Existing Dike Material (CL - SM, Japan)

//// : Adopted Range for Dike Material on the Study

Fig. 2.5.3 CRITERION FOR GRAIN SIZE DISTRIBUTION

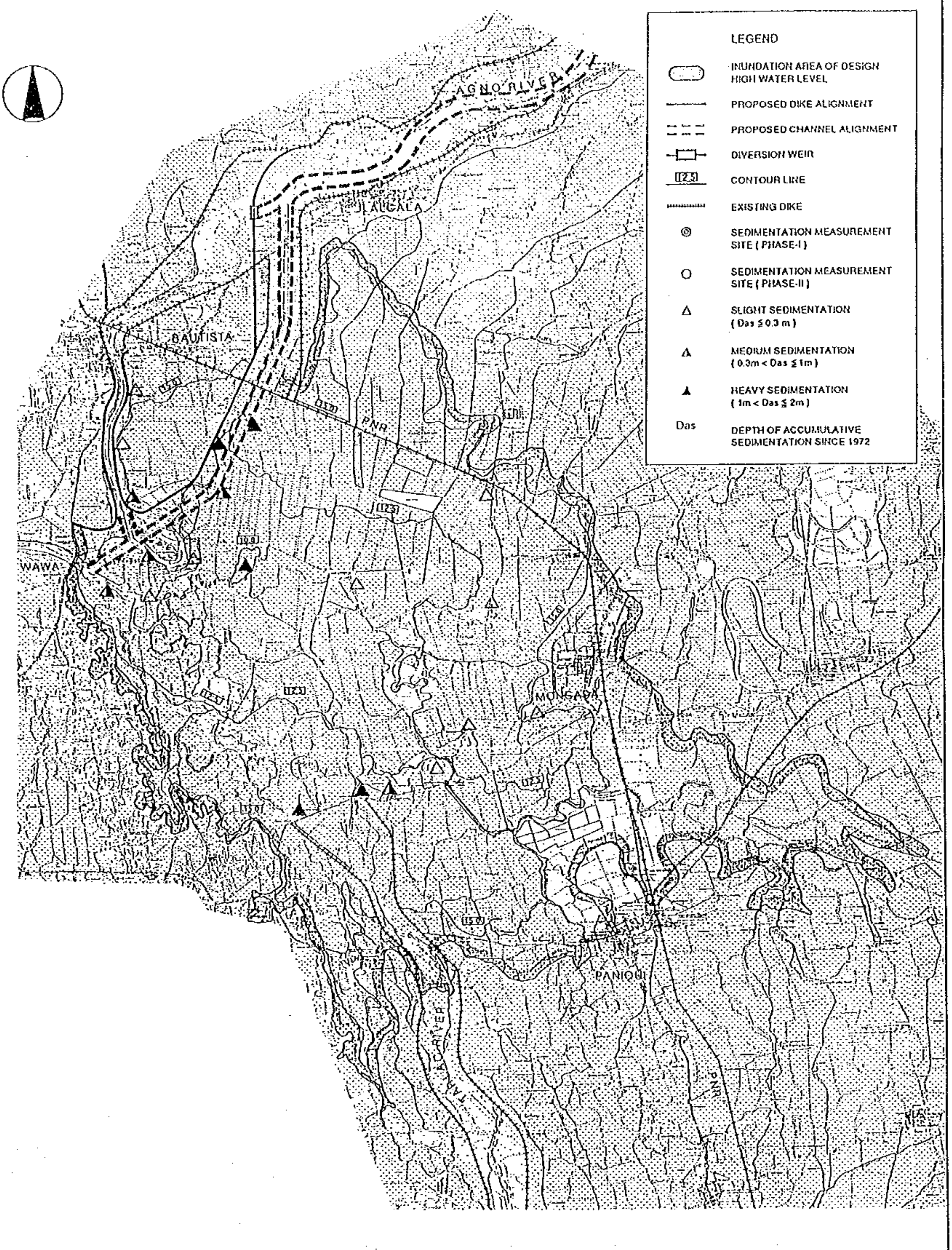


Fig. 2.6.1 RESULT OF INTERVIEW ON SEDIMENTATION IN POPONTO SWAMP AREA

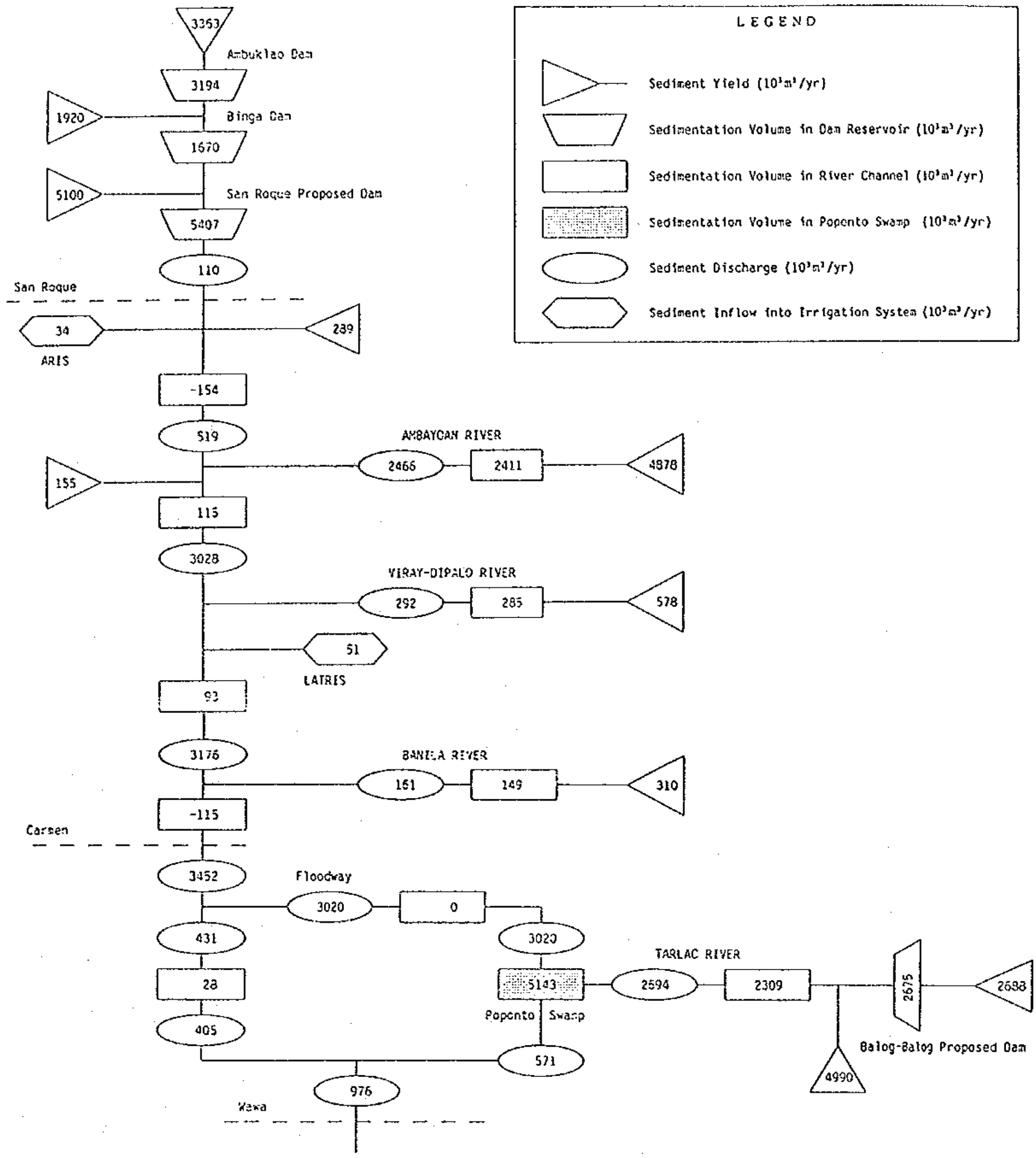


Fig. 2.6.2 SEDIMENT BALANCE DIAGRAM

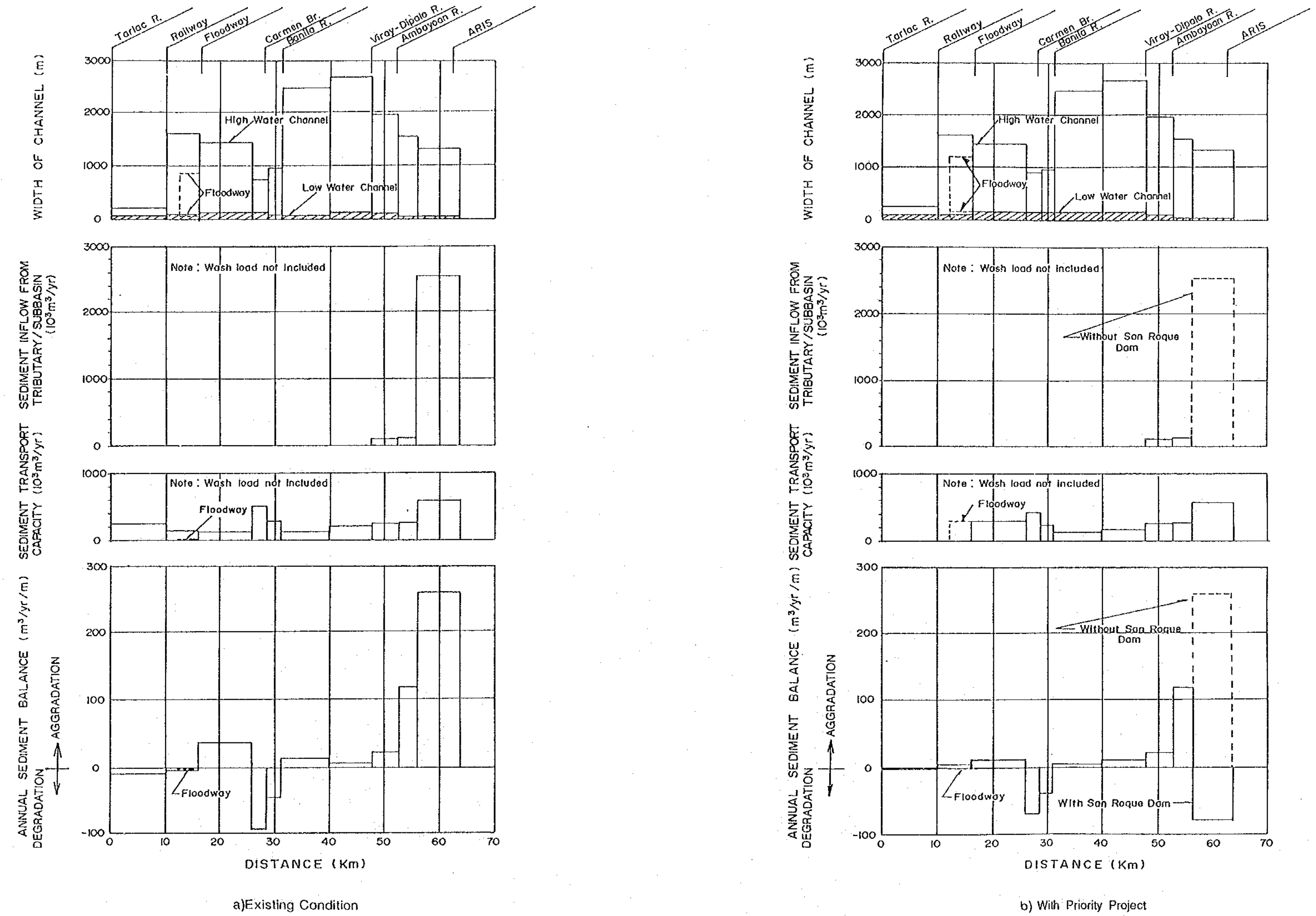


Fig. 2.6.3 UPPER AGNO RIVER SYSTEM SEDIMENT BALANCE

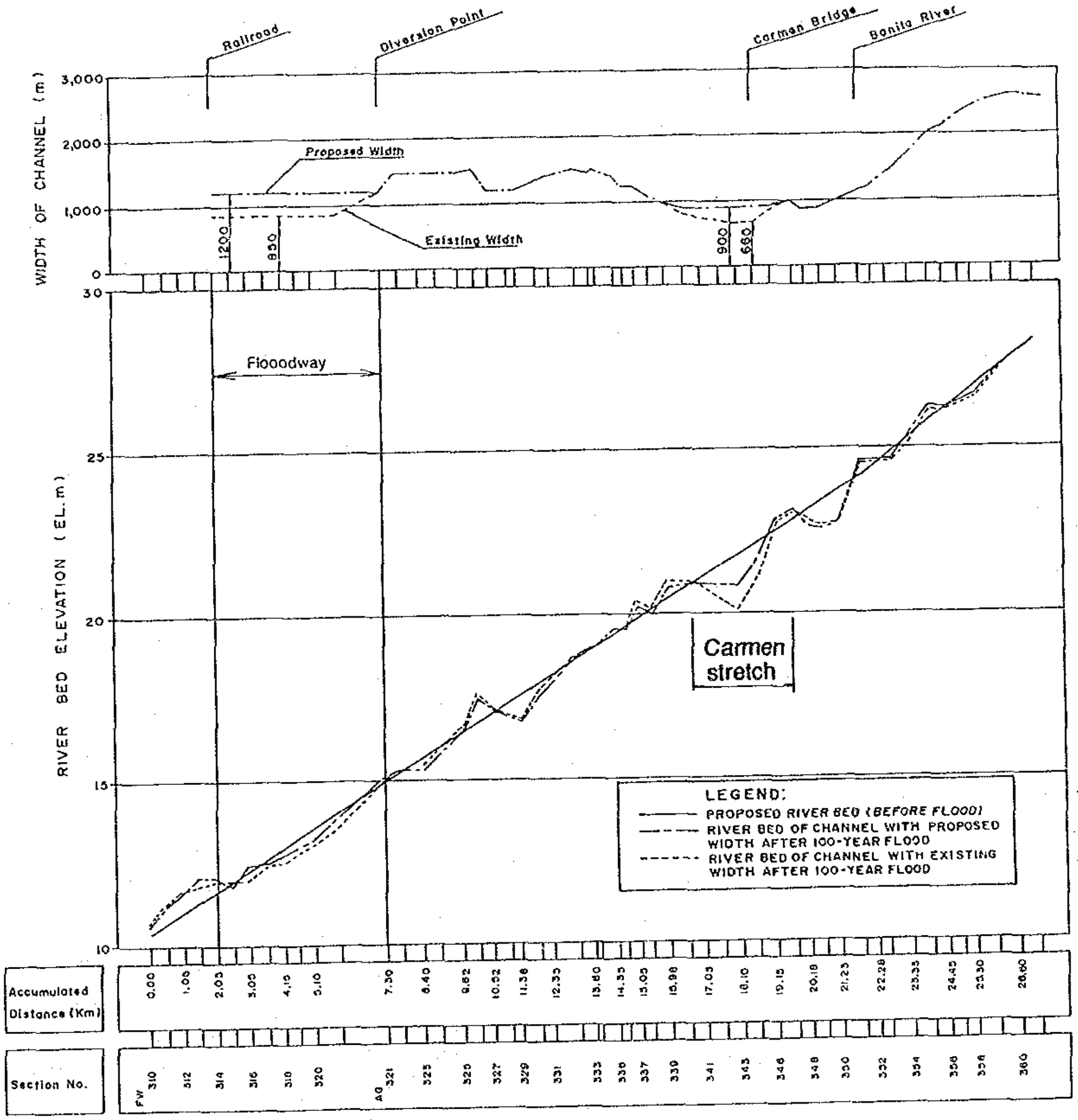


Fig. 2.6.4 RESULT OF RIVER BED FLUCTUATION ANALYSIS (FRAMEWORK PLAN)

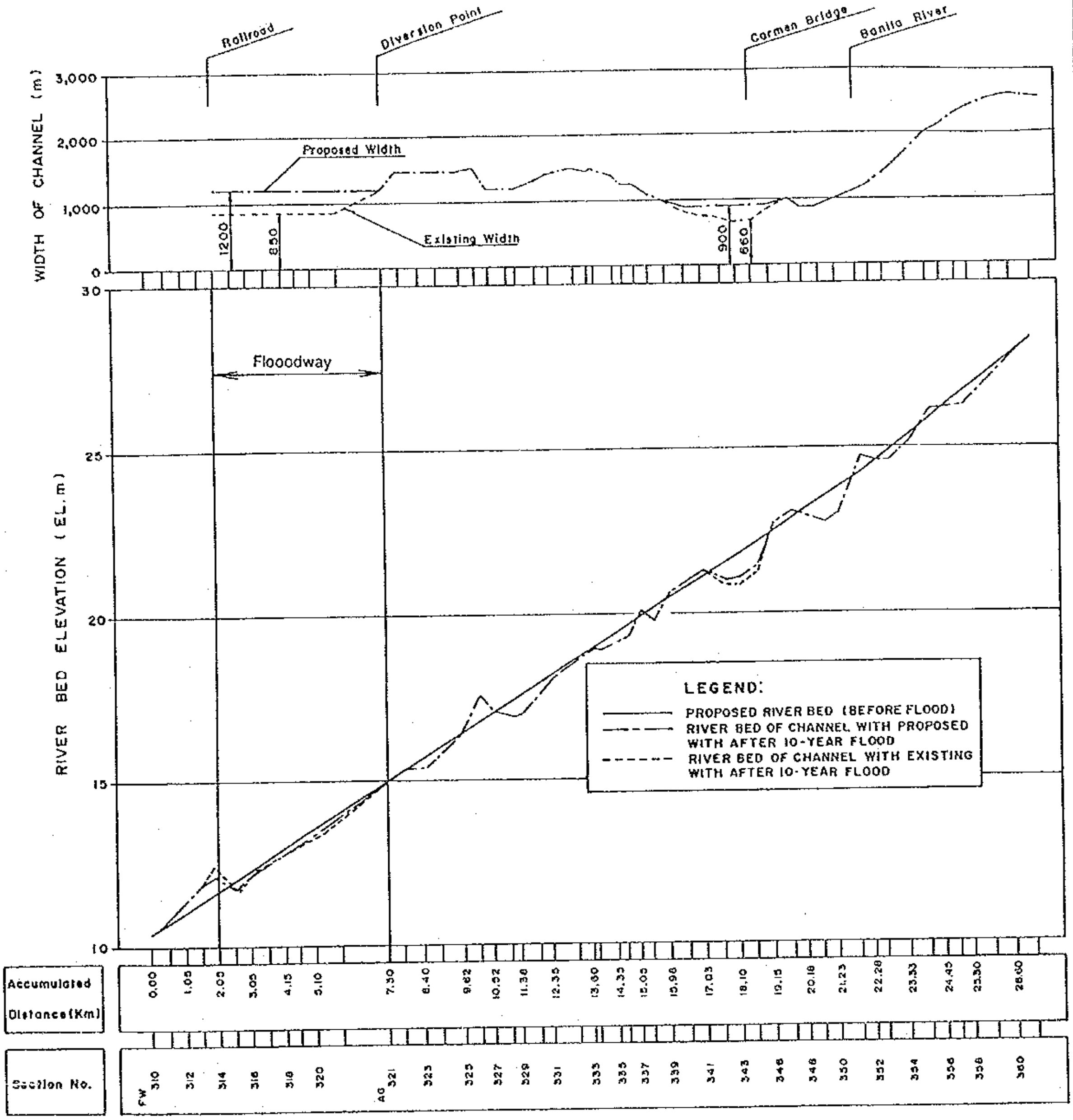
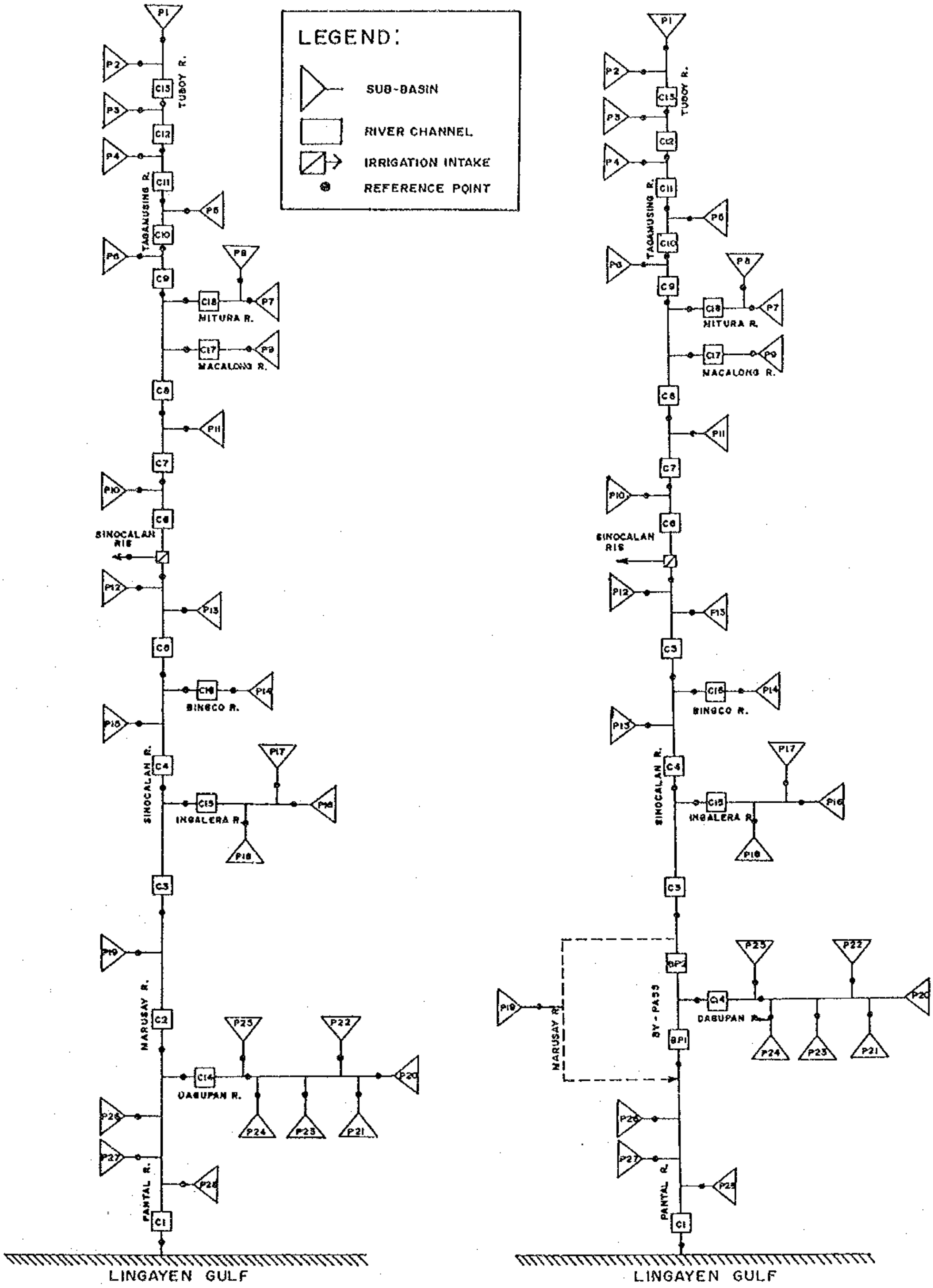


Fig. 2.6.5 RESULT OF RIVER BED FLUCTUATION ANALYSIS (PRIORITY PROJECT)



a) Existing Condition

b) Proposed Priority Project

Fig. 2.6.6 PANTAL-SINOCALAN RIVER SYSTEM SEDIMENT BALANCE MODEL

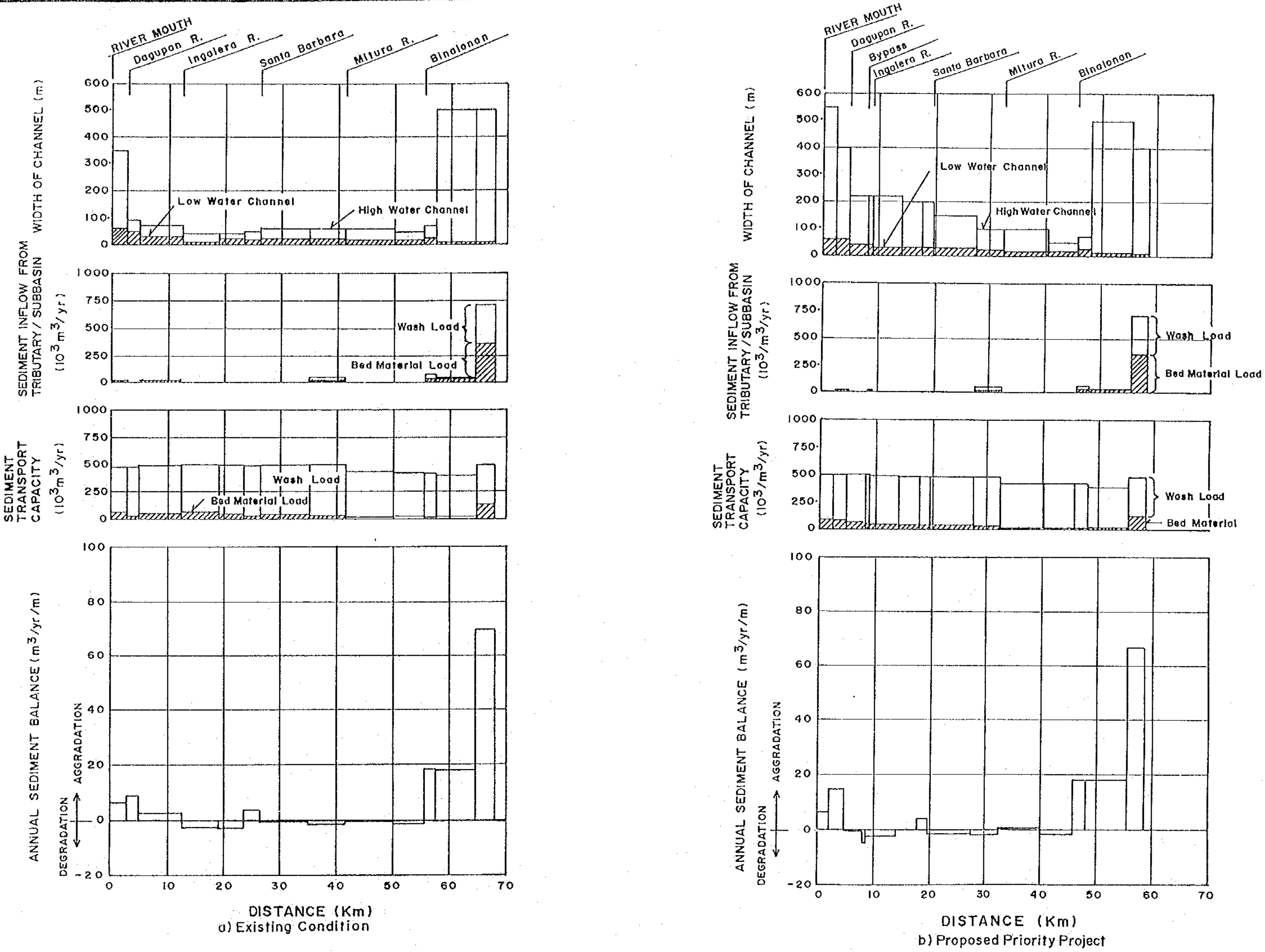


Fig. 2.6.7 PANTAL-SINOCALAN RIVER SYSTEM SEDIMENT BALANCE

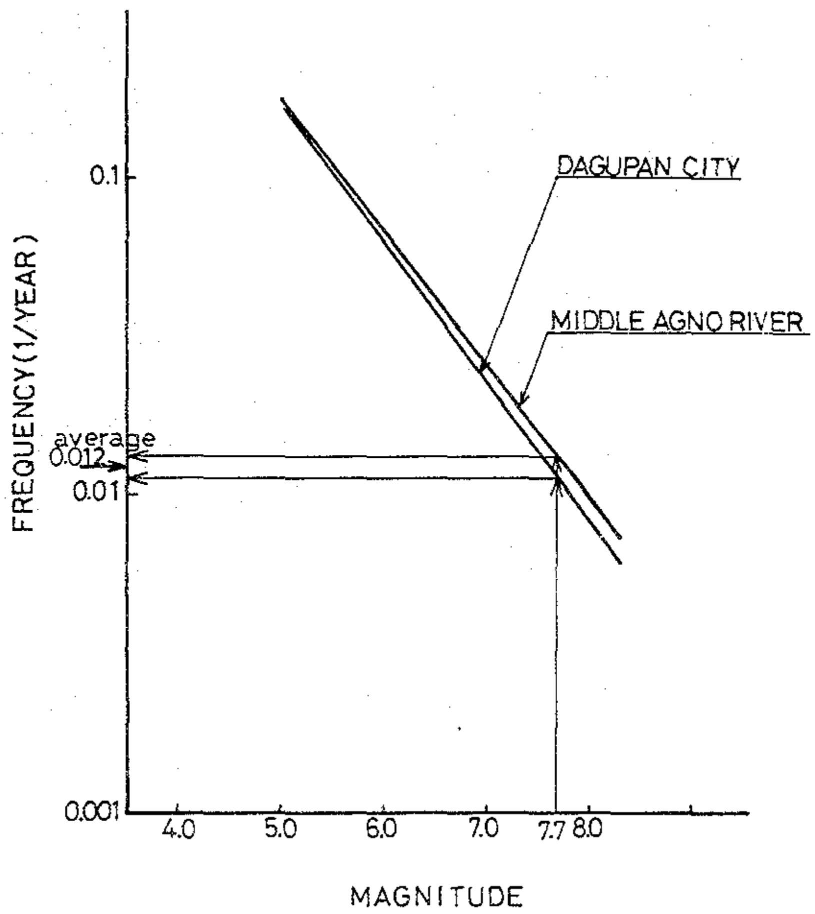


Fig. 2.7.1 FREQUENCY OF MAGNITUDE

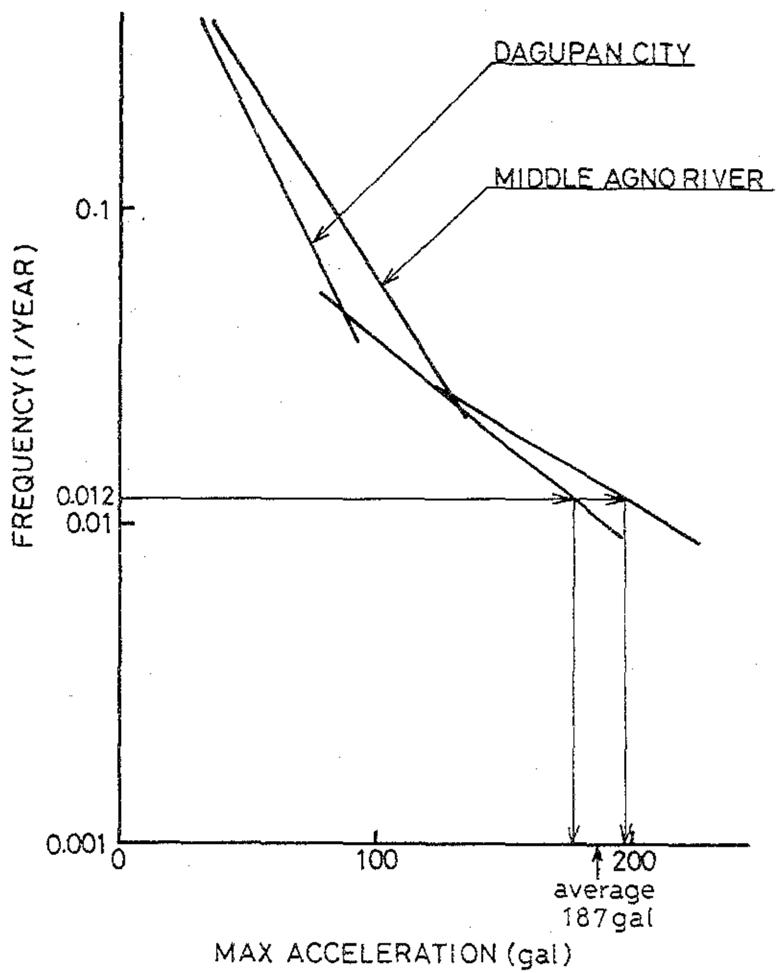
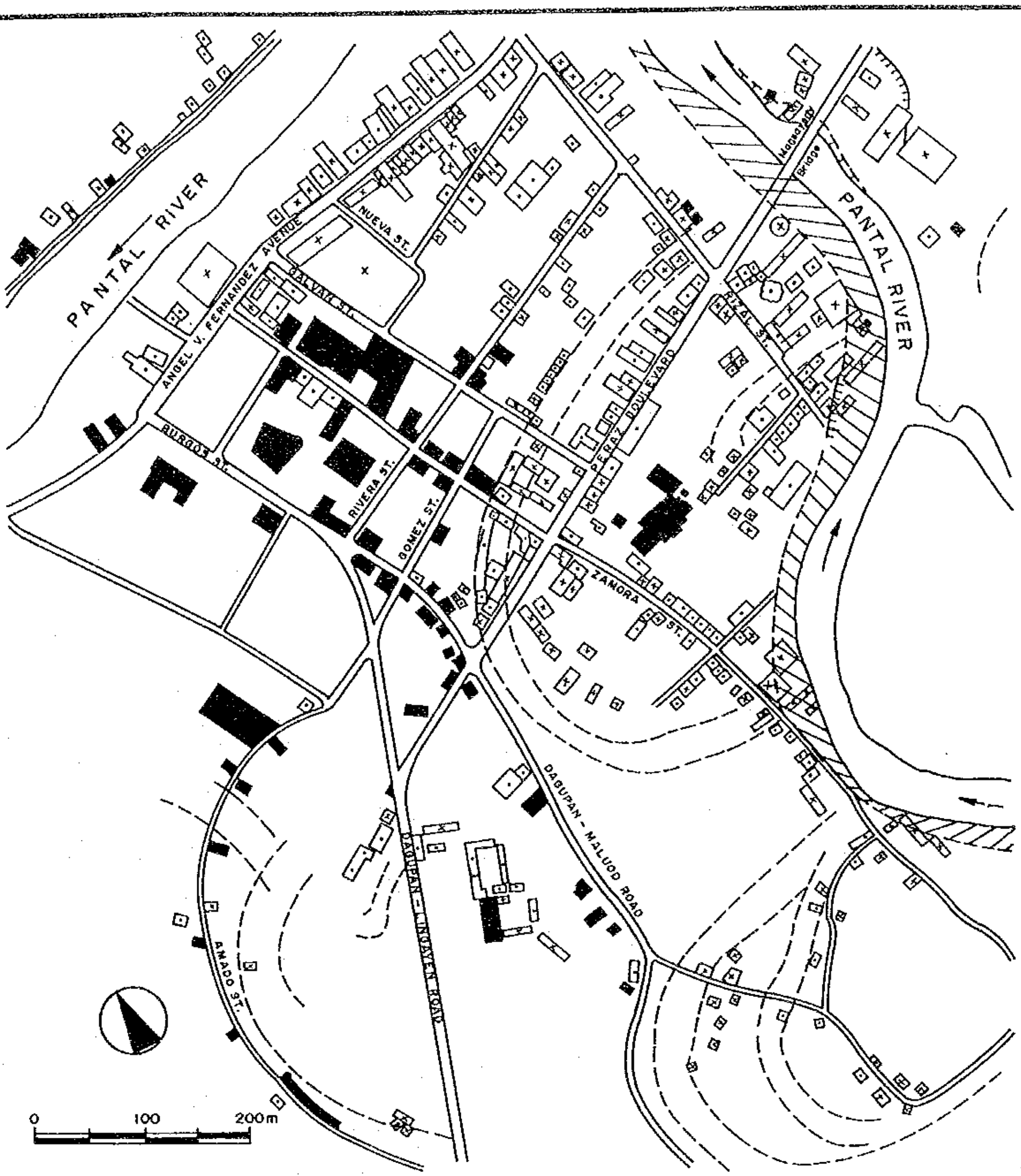


Fig. 2.7.2 FREQUENCY OF MAX ACCELERATION



Source : Philippine Institute of Volcanology and Seismology

LEGEND

TOTALLY DAMAGED BUILDING

PARTIALLY DAMAGED BUILDING

UNDAMAGED BUILDING

ANCIENT RIVER CHANNEL

RECLAIMED RIVERINE AREA

ROAD

Fig. 2.7.3 AFFECTED AND UNAFFECTED BUILDINGS BY LIQUEFACTION IN DAGUPAN CITY DURING THE 16 JULY 1990 NORTHERN LUZON EARTHQUAKES

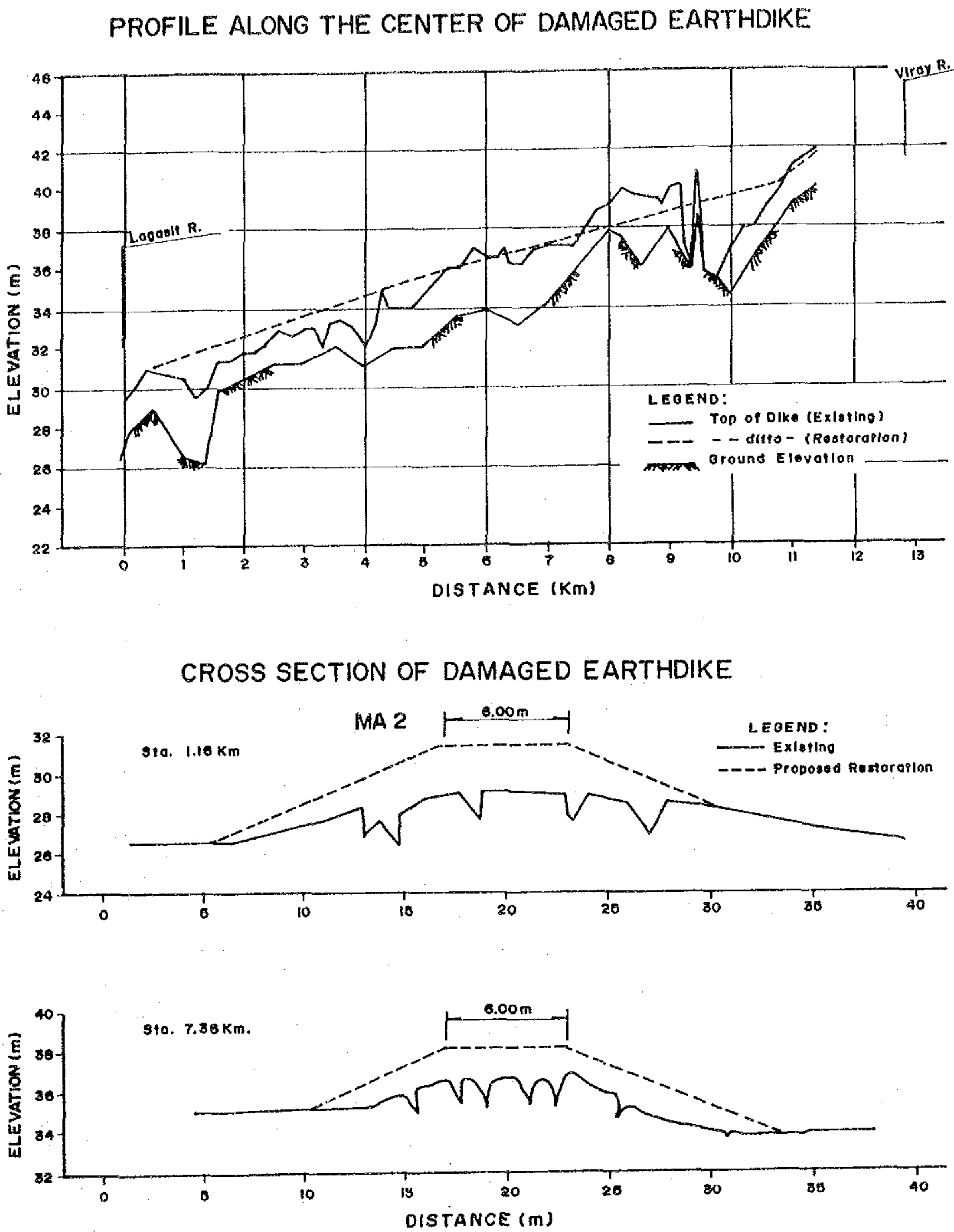


Fig. 2.7.4 EXAMPLE OF DAMAGED LEFT EARTHDIKE OF MAIN AGNO (SANTA MARIA - TAYUG)

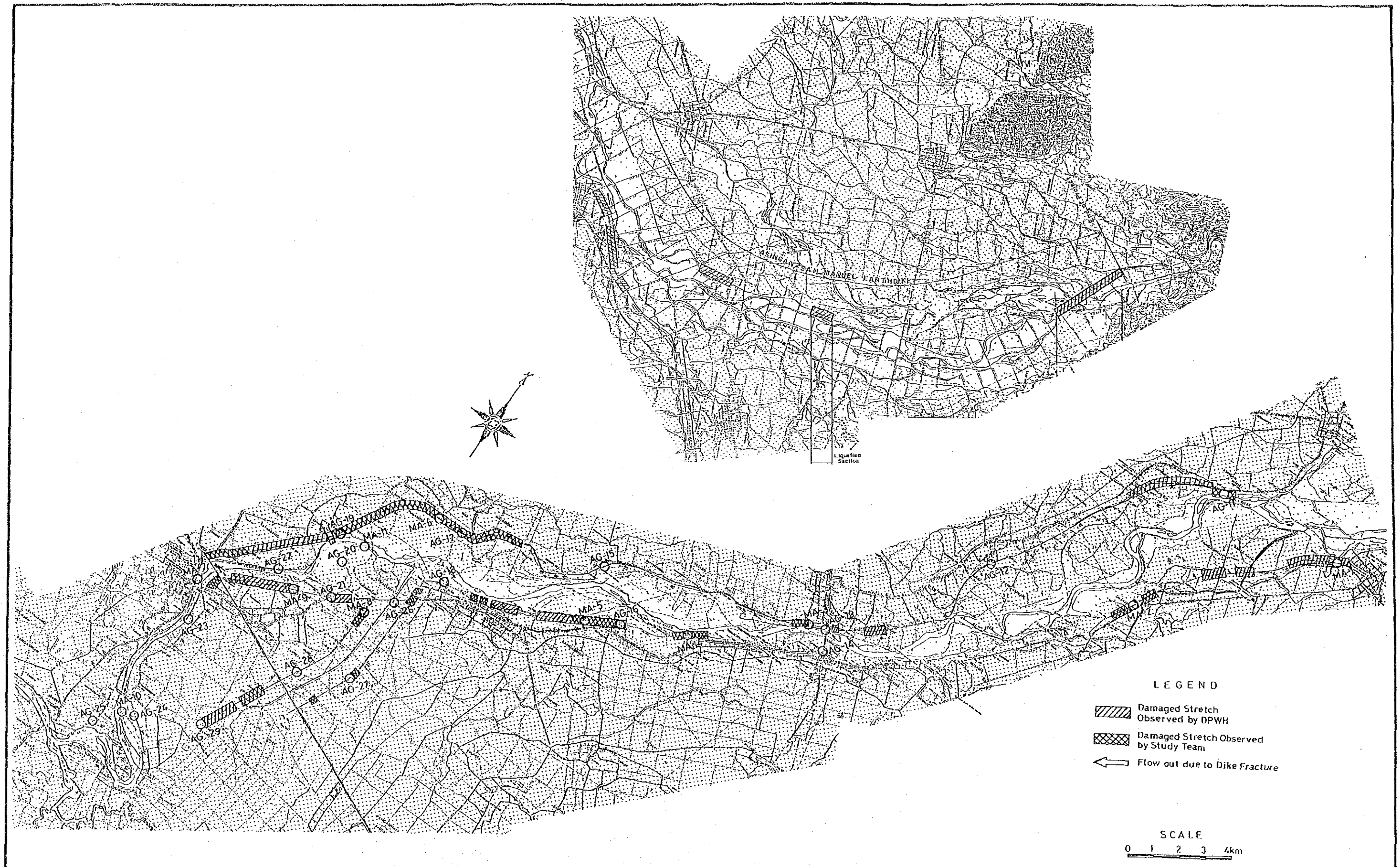
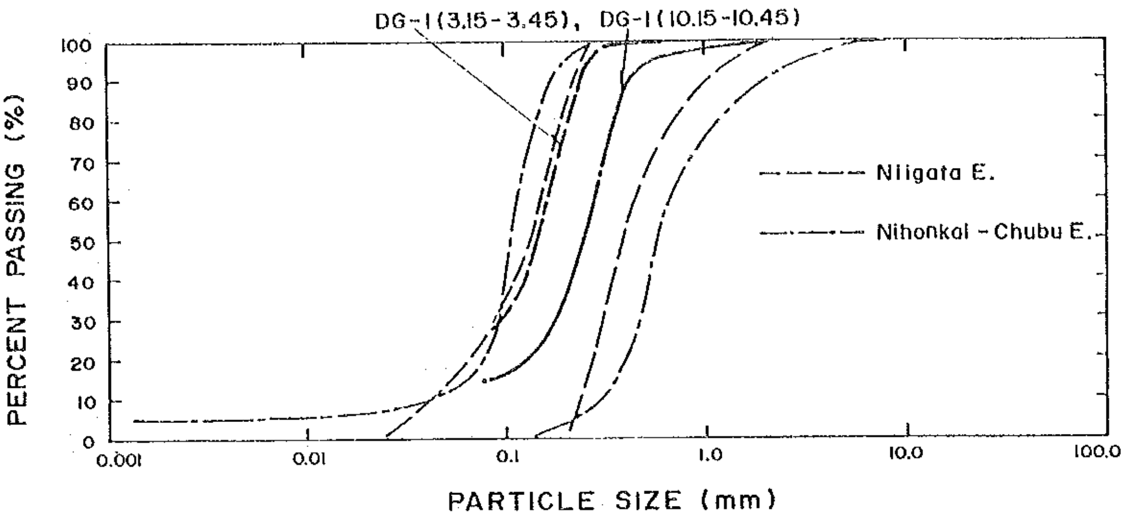
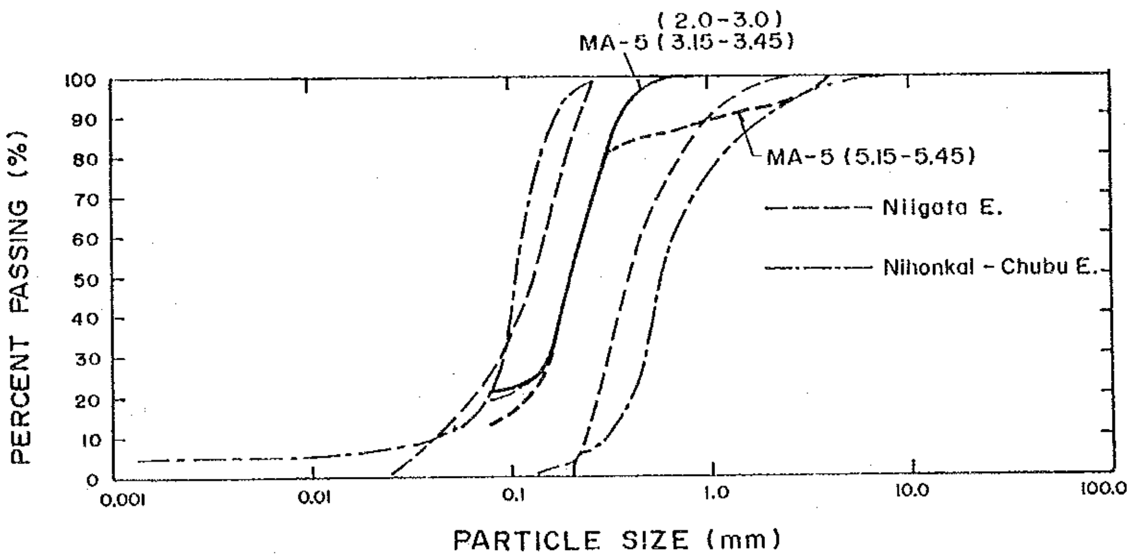


Fig. 2.7.5 LOCATION OF DAMAGE SITE AND LIQUEFIED AREA OF MAIN AGNO RIVER



MIDDLE - UPPER AGNO RIVER



DAGUPAN AREA

Fig. 2.7.6 COMPARISON OF PARTICLE SIZE DISTRIBUTION OF SPOUTED SAND DURING AND AFTER EARTHQUAKE

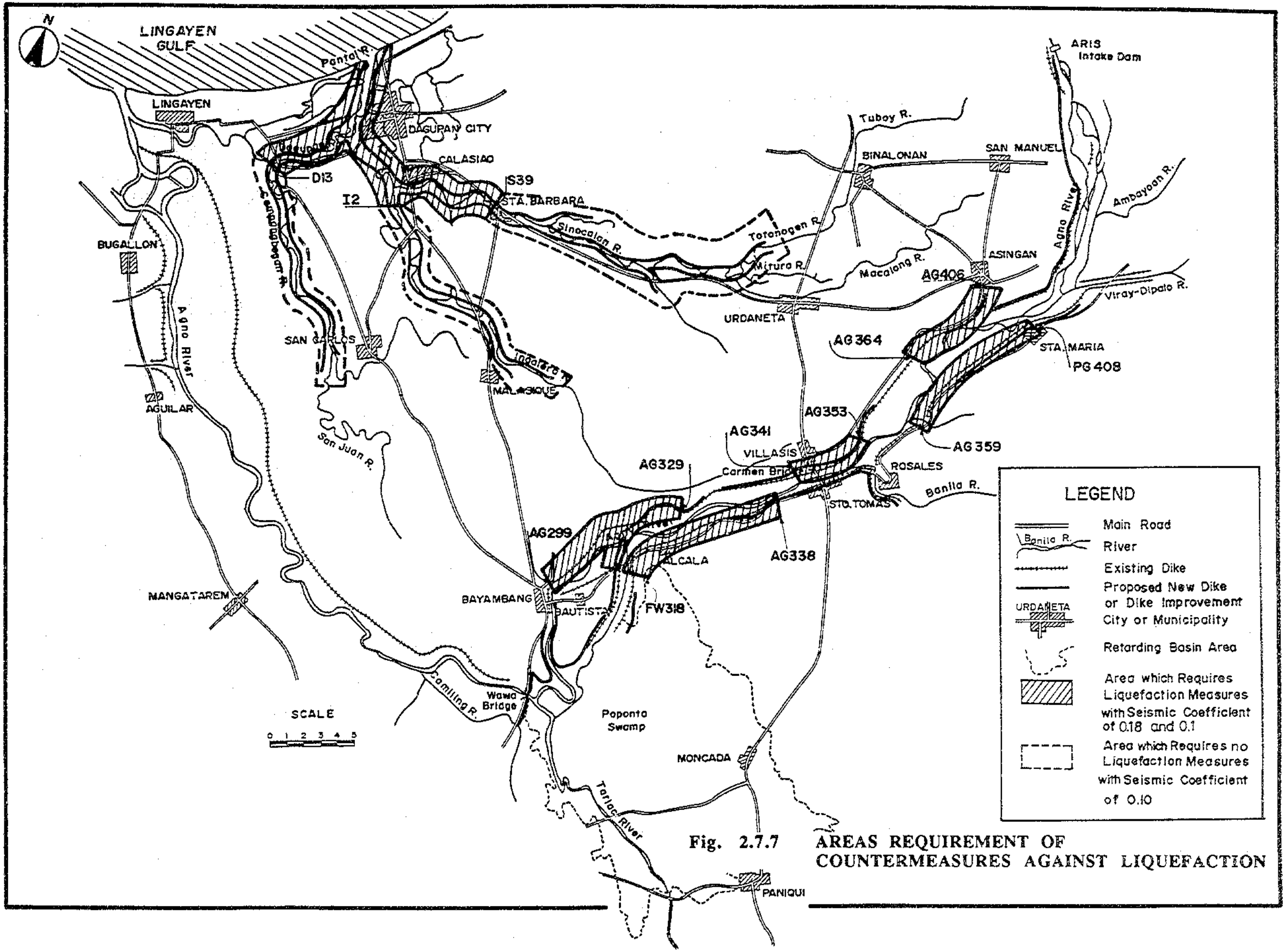
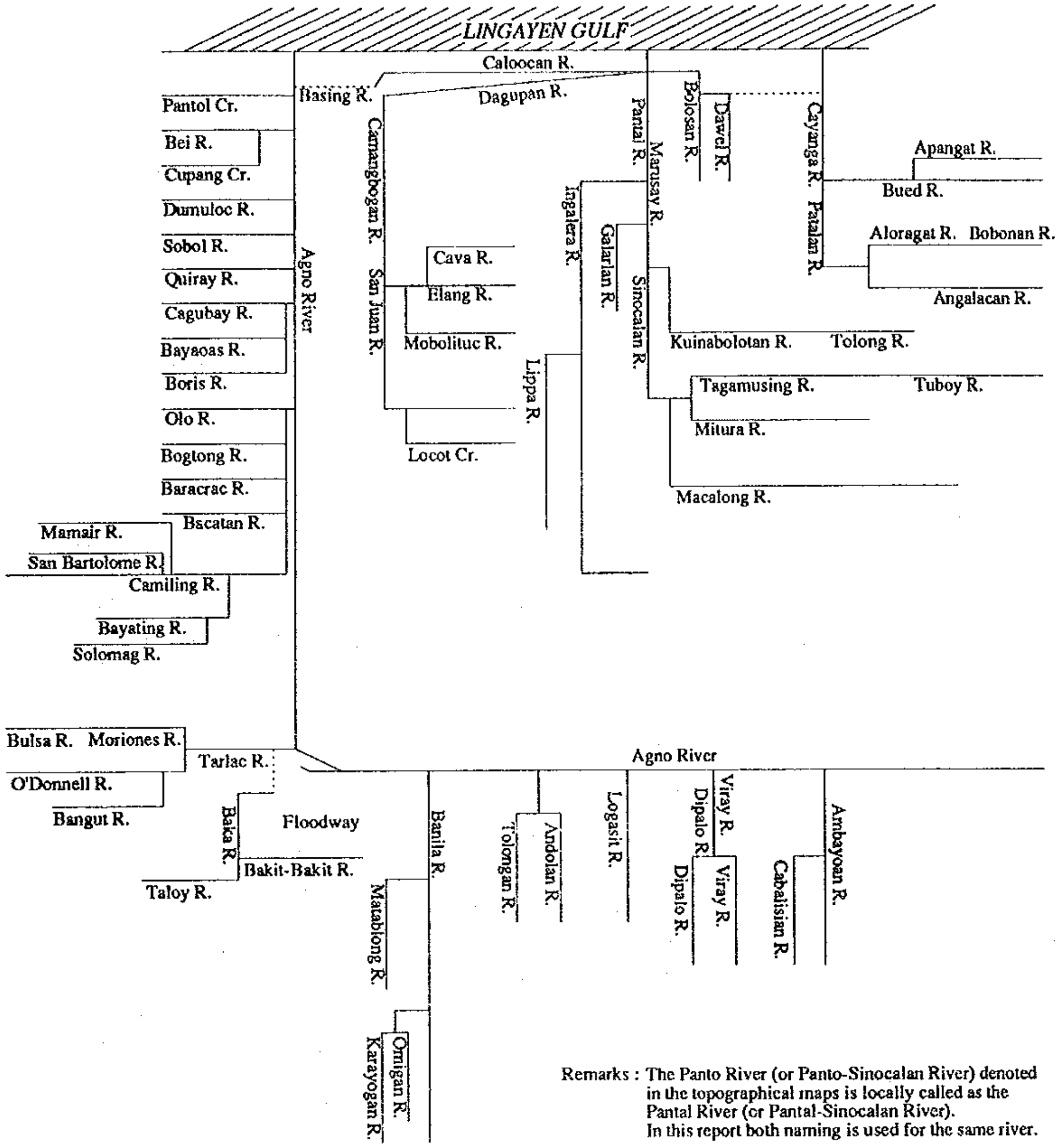


Fig. 2.7.7 AREAS REQUIREMENT OF COUNTERMEASURES AGAINST LIQUEFACTION



Remarks : The Panto River (or Panto-Sinocalan River) denoted in the topographical maps is locally called as the Pantal River (or Pantal-Sinocalan River).
In this report both naming is used for the same river.

AGNO RIVER BASIN

River	Basin Area (km^2)	River Length (km)
Agno River		
Rivermouth	5,907	221.00
Floodway Site	2,477	165.00
Ambayoan River	367	62.20
Viray-Dipalo River	135	21.20
Banila River	309	39.00
Tarlac River	1,896	93.00
Camiling River	604	64.00

ALLIED RIVER BASIN

River	Basin Area (km^2)	River Length (km)
Cayanga-Patalan R.		
(whole)	618	61.00
Angalacan R.	144	25.50
Aloragat R.	116	31.00
Bued R.	286	54.00
Panto-Sinocalan R.		
(whole)	1,115	75.50
Tagumising R.	182	44.50
Mitura-Macalong R.	141	31.00
Ingalera R.	197	32.50
Dagupan R.	273	32.00

Fig. 2.8.1 RIVER SYSTEM DIAGRAM

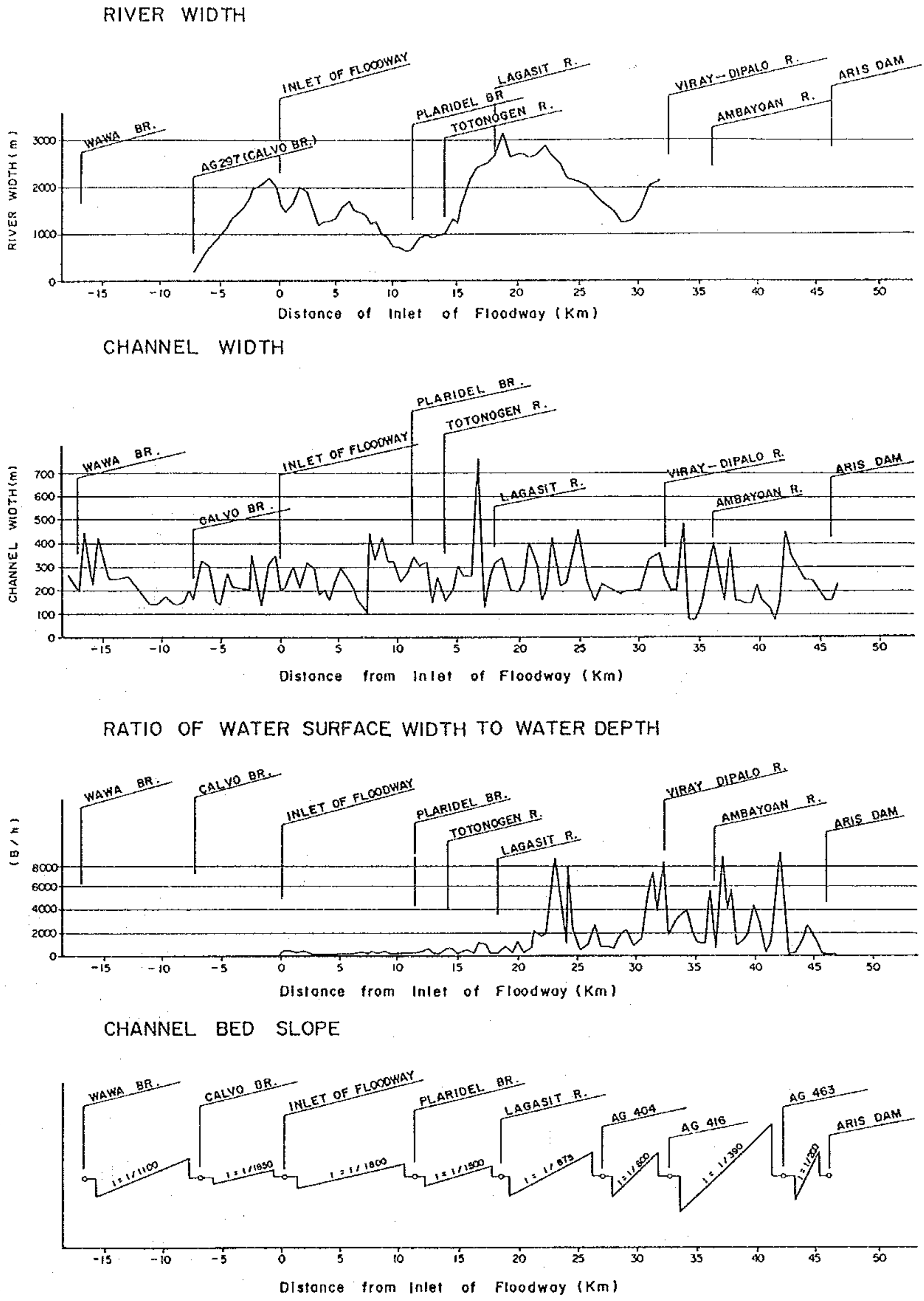


Fig. 2.8.2 EXISTING CHANNEL FEATURES OF UPPER AGNO RIVER

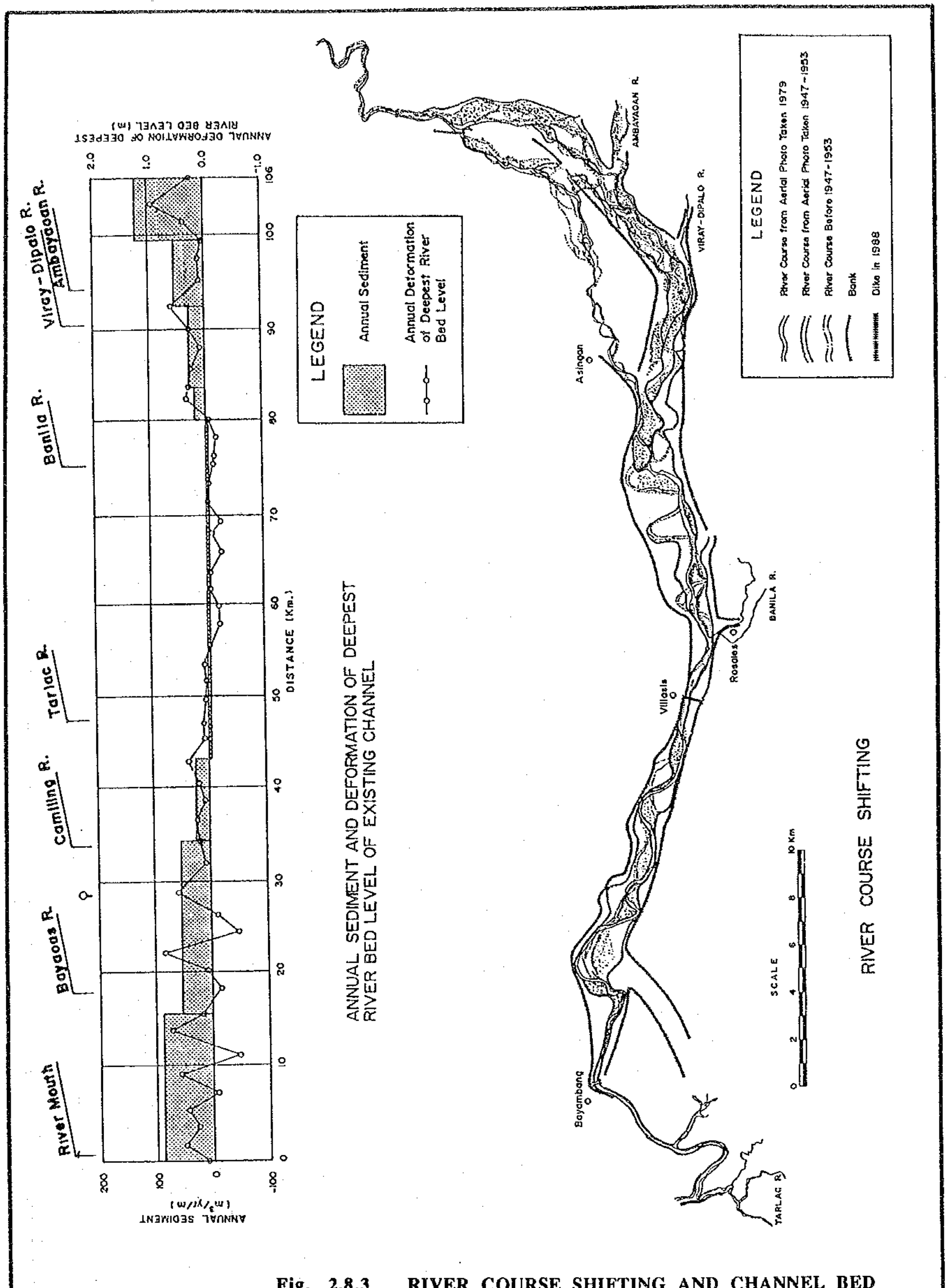


Fig. 2.8.3 RIVER COURSE SHIFTING AND CHANNEL BED FLUCTUATION OF UPPER AGNO RIVER

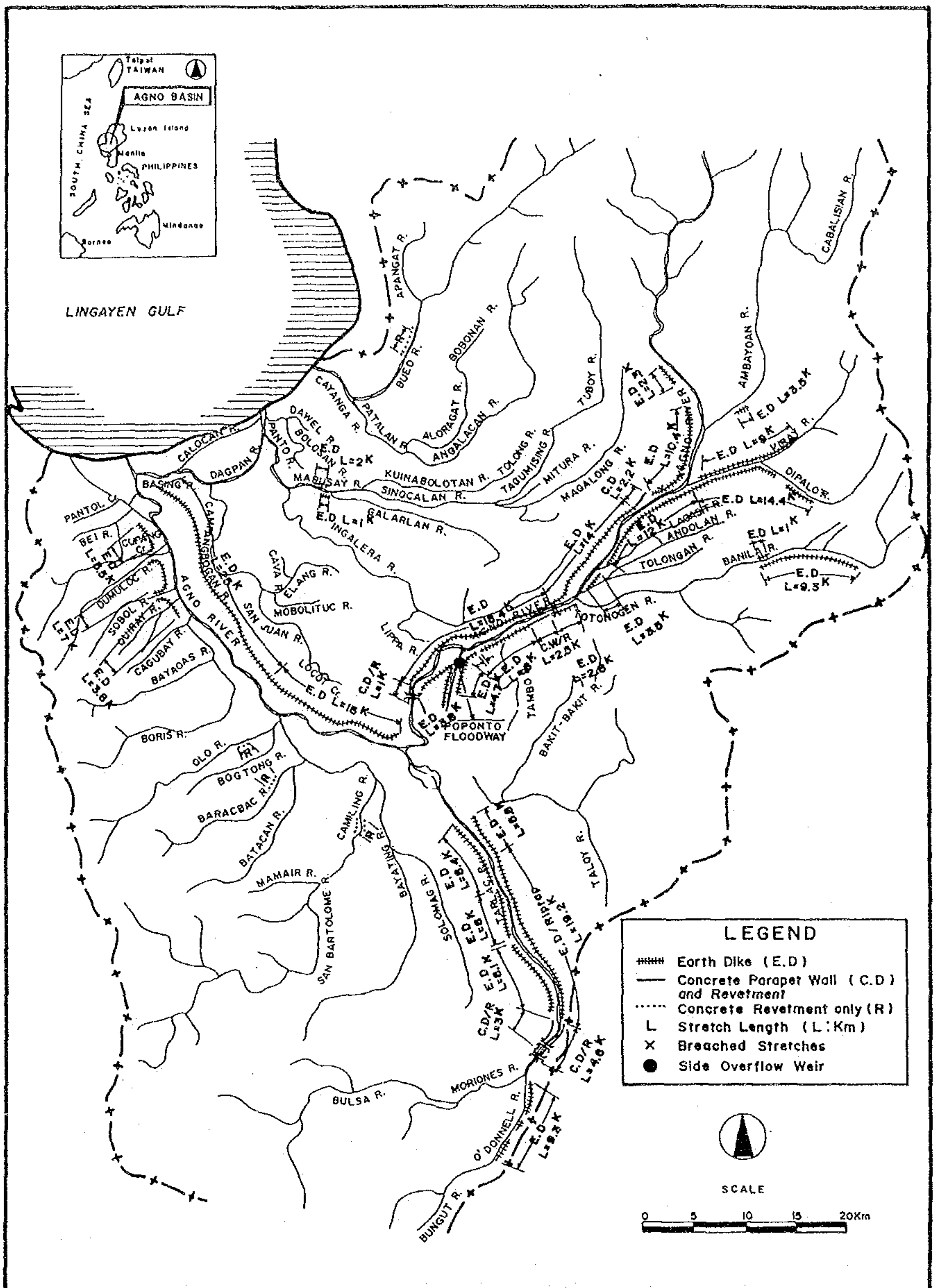


Fig. 2.8.4 LOCATION OF EXISTING FLOOD CONTROL FACILITIES

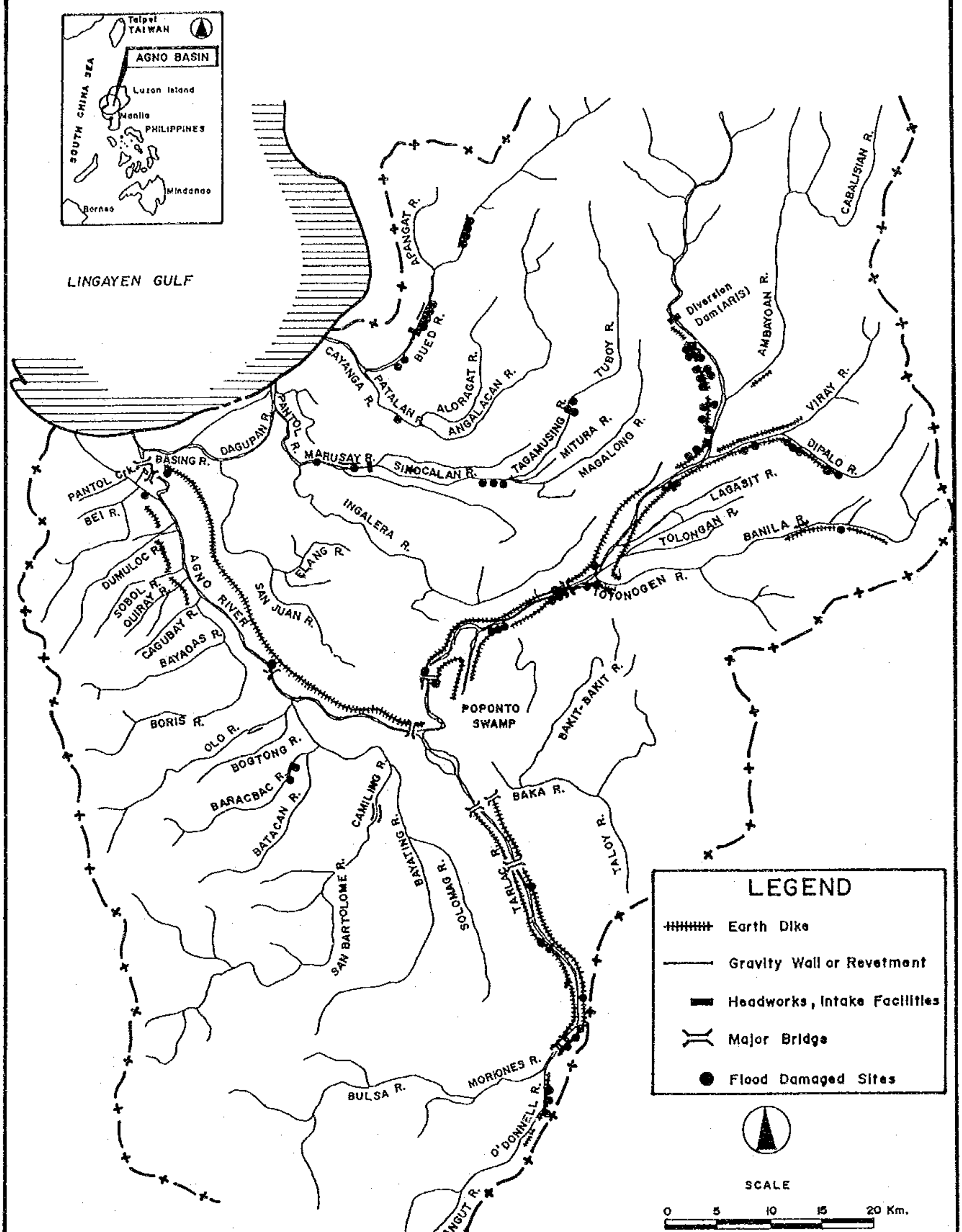


Fig. 2.8.5 LOCATION OF BEACHES/GAPS AND SCOURS CAUSED BY FLOOD (1984-1988)

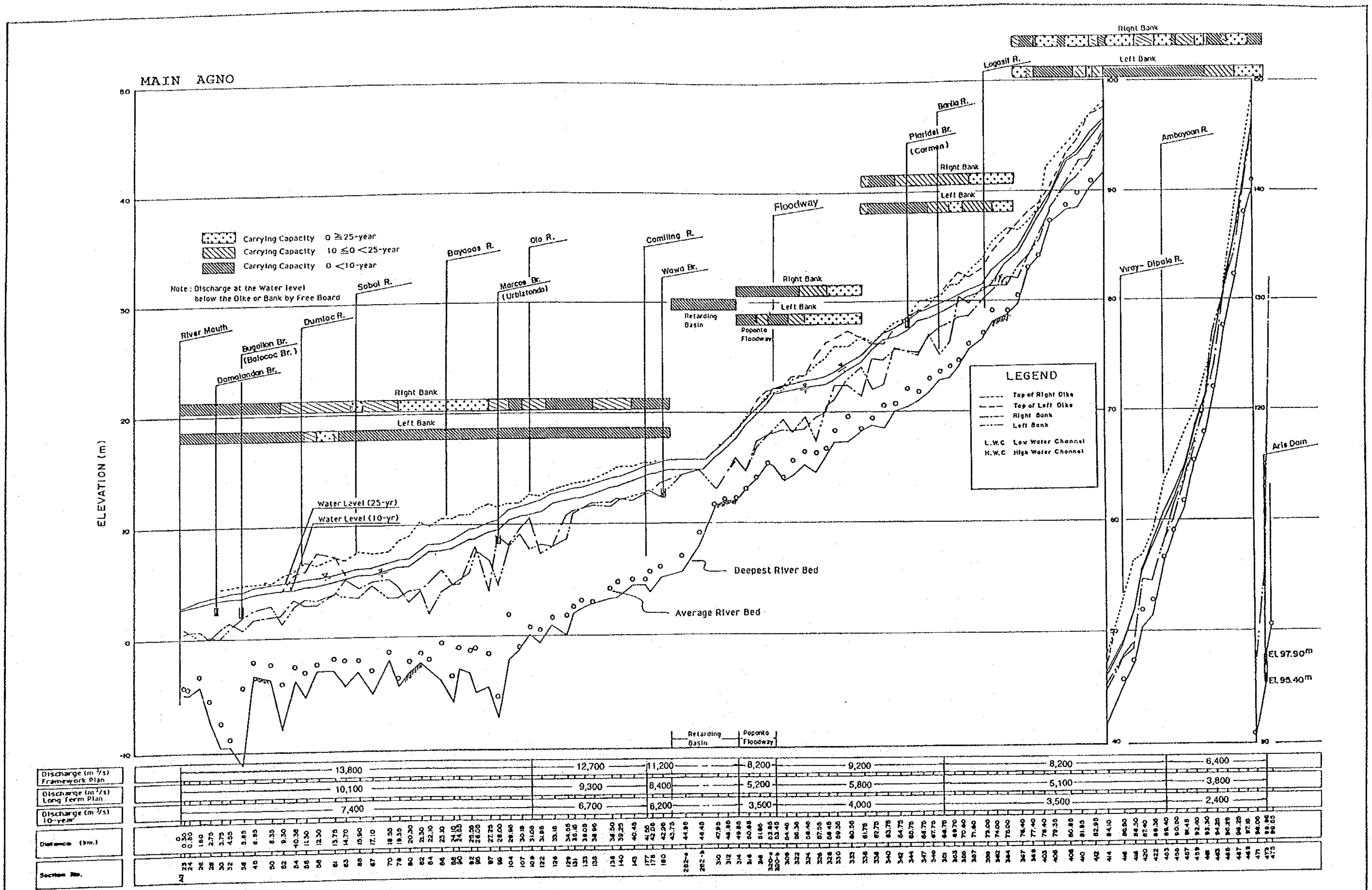


Fig. 2.8.6 PRESENT CARRY CAPACITY OF THE AGNO RIVER

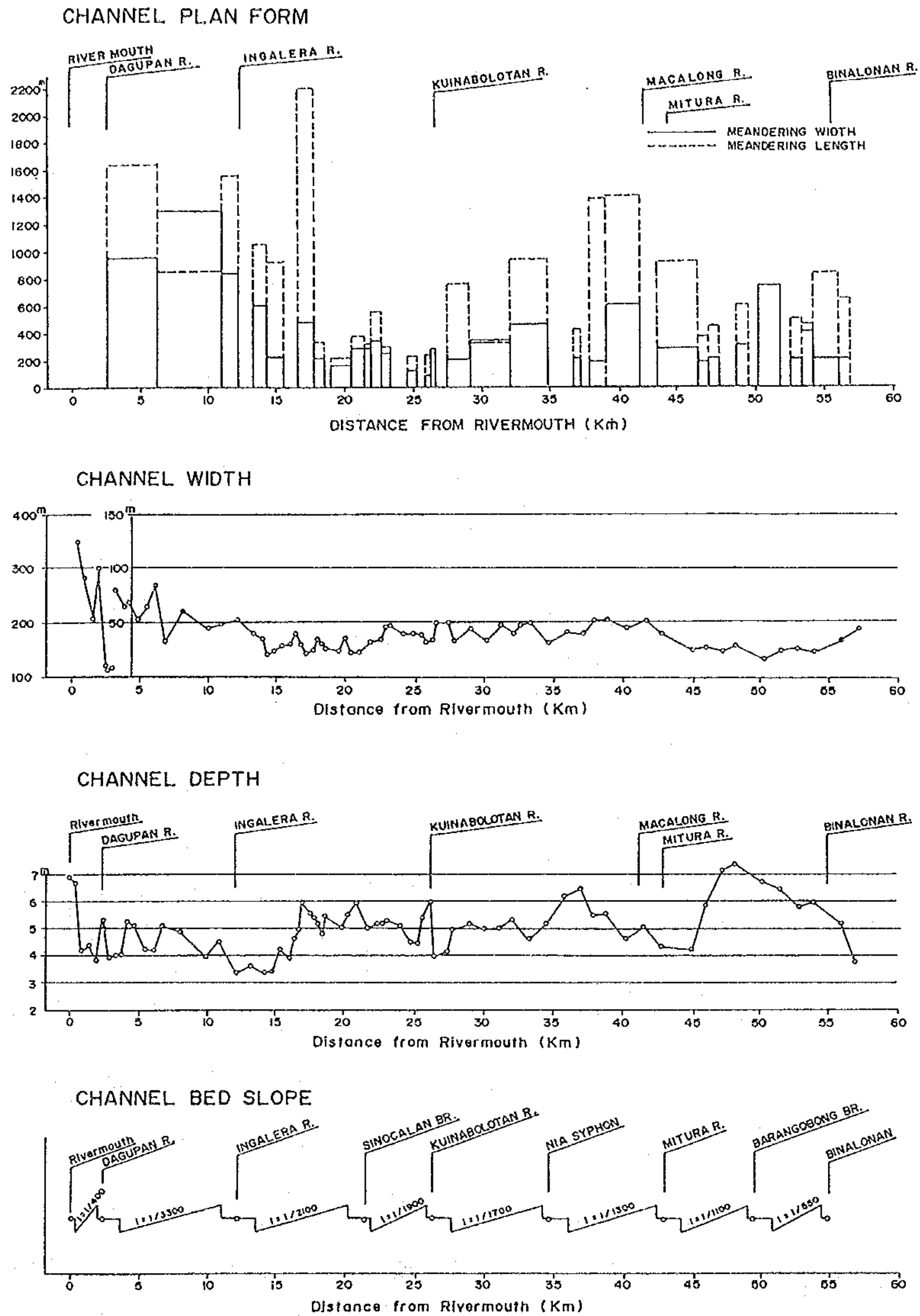


Fig. 2.9.1 EXISTING CHANNEL FEATURES OF PANTAL-SINOCALAN RIVER

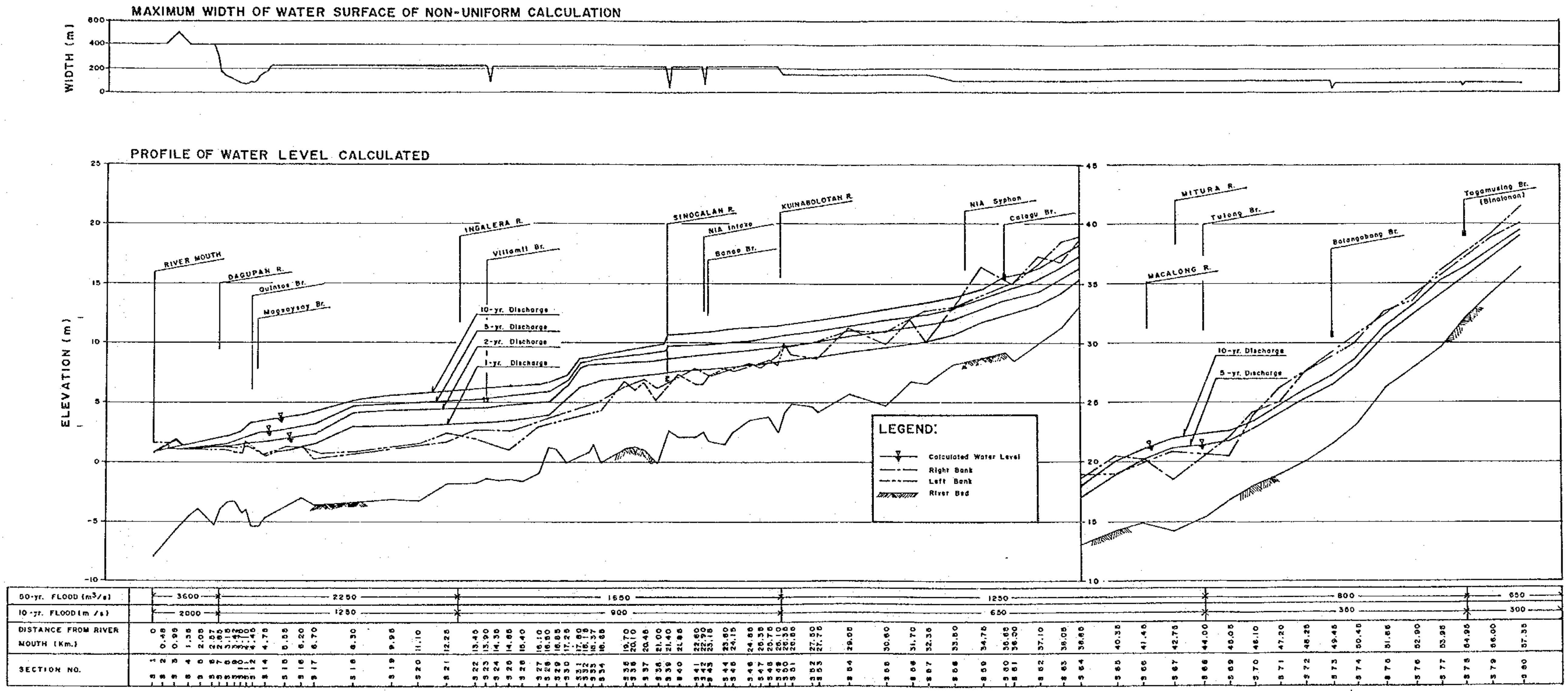


Fig. 2.9.2 ESTIMATED FLOOD WATER LEVEL OF MAIN PANTAL-SINOCALAN RIVER