REPUBLIC OF THE PHILIPPINES
DEPARTMENT OF PUBLIC WORKS AND HIGHWAYS

STUDY OF AGNO RIVER BASIN FLOOD CONTROL

FINAL REPORT

VOLUME I

SUMMARY REPORT

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

P R E F A C E

In response to a request from the Government of the Republic of the Philippines, the Government of Japan decided to conduct a study on Agno River Basin Flood Control and entrusted the study to the Japan International Cooperation Agency (JICA).

JICA sent to the Philippines a study team headed by Mr. Hideki Sato of Nippon Koei Co., Ltd., from April 1989 to September 1991.

The team held discussions with the officials concerned of the Government of the Philippines, and conducted field surveys at the study area. After the team returned to Japan, further studies were made and the present report was prepared.

I hope that this report will contribute to the promotion of the project and to the enhancement of friendly relations between our two countries.

I wish to express my sincere appreciation to the officials concerned of the Government of the Republic of the Philippines for their close cooperation extended to the team.

December 1991

Kensuke Yanagiya

Kensuke Yanagiya
President
Japan International Cooperation Agency

STUDY OF AGNO RIVER BASIN FLOOD CONTROL

December , 1991

Mr. Kensuke Yanagiya
President
Japan International Cooperation Agency
Tokyo

LETTER OF TRANSMITTAL

Dear Sir,

We are pleased to submit the Final Report on the Study of Agno River Basin Flood Control which was executed on the basis of the Implementation Arrangement of the Technical Cooperation between the Department of Public Works and Highways (DPWH) of the Government of the Philippines and the Japan International Cooperation Agency (JICA) dated December 2, 1988.

The report presents the result of the Master Plan for flood control in the Agno River Basin including the Allied Rivers and the Feasibility Study of the flood control projects in the priority areas. It also proposes the priority projects to be implemented for controlling and/or mitigating frequent flood damages which obstruct the socio-economic development of the region.

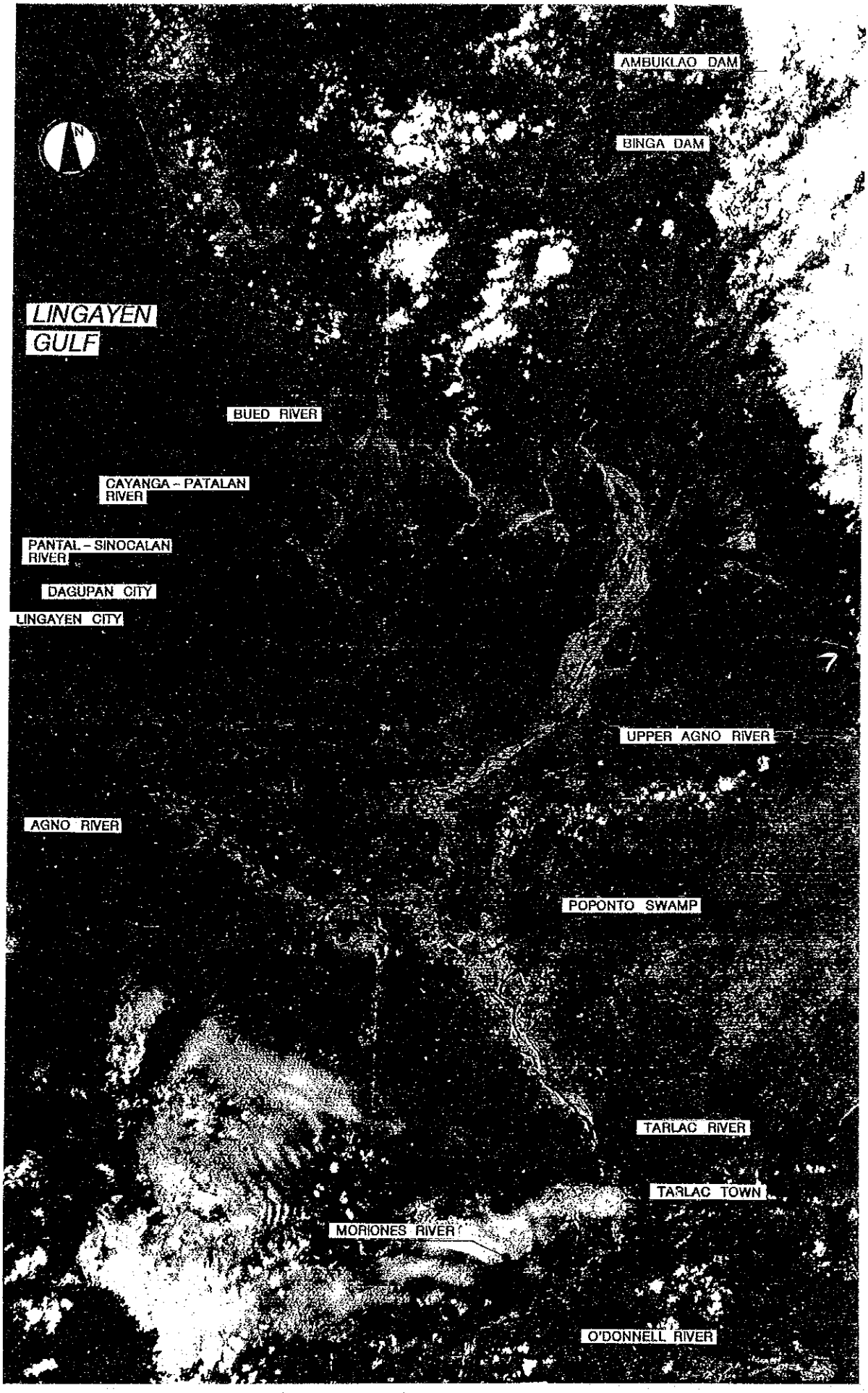
The report consists of a summary report, a main report, a supporting report and a data book. The summary report briefs the principal study results of the Master Plan and the Feasibility Study. The main report presents the flood control plans including their background, conditions and assumptions. The supporting report details the conditions, methodology, and technical planning aspects. The data book contains meteohydrological records, records of the sediment material survey, and geological drill logs.

The main report and supporting report are compiled in two parts each: Part I Master Plan and Part II Feasibility Study.

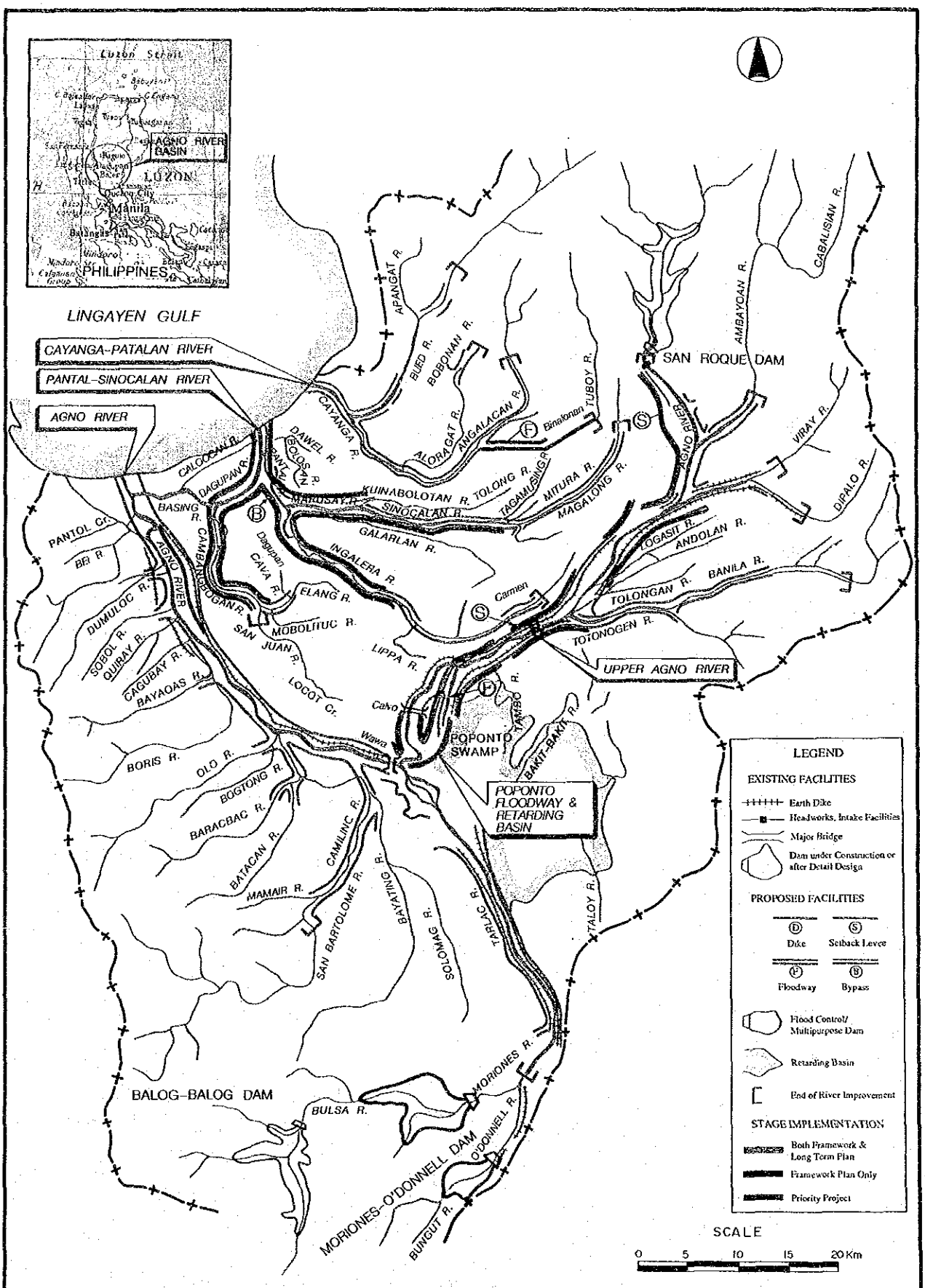
All members of the Study Team wish to express grateful acknowledgment to the personnel of your Agency, the Advisory Committee, the Ministry of Foreign Affairs, the Ministry of Construction, and the Embassy of Japan in the Philippines, as well as to officials and individuals of the Philippines for the valuable assistance extended to the Study Team. The Study Team sincerely hopes that the study results will contribute to the socio-economic development and well-being in the Agno River basin.

Yours sincerely,

Hideki Sato
Team Leader



AGNO RIVER BASIN



GENERAL PLAN OF FRAMEWORK AND LONG TERM PLANS, AND PRIORITY PROJECTS

SUMMARY REPORT

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.

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. MASTER PLAN

3.1 Definition of Master Plan

(1) The Master Plan is composed of two stage plans, the Framework Plan and the Long Term Plan. The Framework Plan is defined as an ideal portrait of flood control plan which is to be achieved in the unspecified future. The Long Term Plan is defined as an stage development plan of the Framework Plan, the completion target year of which is set at the year 2010 (20 year - long term plan).

(2) The flood control target of the Framework Plan is set at a 100-year probable flood for the Main Agno River and the Tarlac River and at a 50-year probable flood for the other tributaries of Agno and the Allied Rivers. The flood control target of the Long Term Plan is set at a feasible scale during a project life of 50 years starting construction from 1995.

(3) Rivers subject to the study are :

Agno River : Main stream, Tarlac, Ambayoan, Viray-Dipalo, Banila, Camiling

Allied Rivers : The main stream of Cayanga-Patalan, Bued, Aloragat, Angalacan, The main stream of Pantal-Sinocalan, Tagamusing, Macalang, Ingalera, Dagupan

(4) The study focuses on the flood control plan but also studies the sediment control at a conceptual level only. The flood forecasting and warning system is studied as a part of the nonstructural measures.

3.2 Framework Plan

(1) The Framework Plan of the Agno River and its tributary the Tarlac River is composed of river improvements (stretch of 146.4 km), the Poponto floodway and natural retarding basin, and the Moriones-O'Donnel dam. Length of channel improvements including short cuts and length of dikes in both banks are 136.9 km and 258.1 km, respectively. The flood control effect of the San Roque dam (design was completed) is taken into account in the plan. The project economic cost is estimated to be 13,682 million pesos at 1989 price level. The principal features of the works are presented at the back of these sheets (refer to the general plan).

(2) For the four Agno River tributaries, Camiling, Banila, Viray-Dipalo and Ambayoan, the case of sole river improvement is adopted as the Framework Plan. The economic project cost is estimated to be 1,925 million pesos at 1989 price level. The principal features of the works are presented at the back of these sheets.

(3) A combination of river improvement and the Binalonan floodway is adopted as the Framework Plan for the Allied Rivers. The project economic costs of the Pantal-Sinocalan River and the Cayanga-Patalan River are estimated to be 2,553 million pesos and 1,246 million pesos respectively at 1989 price level. The principal features of the works are presented at the back of these sheets.

3.3 Long Term Plan

(1) The flood control scale and the financial project costs of the proposed Long Term Plan are as follows :

River/Region	Flood Control Scale	Financial Project Cost (million pesos)	EIRR (%)
Agno River and Tarlac River	25-year flood	11,048	16.6
Agno River Tributaries	25-year flood	1,640	15.5
Allied Rivers	10-year flood	3,286	33.8
Whole Study Area		15,974	20.5

(2) Although the Moriones - O'Donnell dam is included in the proposed Framework Plan, it is excluded from the Long Term Plan because of the expected issues of the land acquisition and resettlement in the reservoir areas. The reservoir areas are occupied by about 1,600 families, an agricultural land of about 40 km^2 (refer to the general plan in Figure 3.3.5).

(3) The proposed Long Term Plan (10-year flood) for the Allied Rivers is designed without the Binalonan floodway but takes into account the design flood distribution of the Framework Plan with the Binalonan floodway (50-year flood).

3.4 Implementation Schedule of Long Term Plan

The total project cost of the Long Term Plan is estimated to be 15,974 million pesos at 1989 constant price level. Since the amount of public funds required for the flood control works is very high if it is compared with the present level (some 0.5% of GRDP), a longer implementation schedule is formulated as an alternative. In this program the Long Term Plan can be achieved by the end of year 2020 with the public fund allocation of about 1.0% of Gross Regional Domestic Product (GRDP) of the Study Area.

3.5 Flood Forecasting and Warning System (FFWS)

(1) The FFWS Framework Plan aims to up-grade the existing ABC (Agno, Bicoland Cagayan Rivers) system and to achieve an integrated nation wide flood forecasting and warning system which fulfills the following objectives:

i) FFWS for resident's protection from flood incident

ii) FFWS for flood operation

iii) FFWS for basinwide flood management

(2) The proposed FFWS Framework Plan is composed of the system components listed below :

i) Hydrological observation network system

ii) Telemetering network system

iii) Flood forecasting system

iv) Flood warning network system

v) Monitoring system for flood operation

The total cost of the integrated FFWS in the Agno River basin is estimated at 796 million pesos at 1989 price level.

(3) The FFWS Long Term Plan is formulated as a part of a stagewise development plan which finally aims to set up the FFWS integrated system planning as the Framework Plan. Its objective is :

i) To improve the flood forecasting accuracy of the forecasting points in the existing Agno River FFWS.

ii) To carry out the effective flood warning activity in the Study Area.

The total project cost of the FFWS Long Term Plan is estimated at 281 million pesos at 1989 price level. The economic internal rate of return is expected to be 28.9%.

3.6 Sabo Works

(1) The average natural sediment yield of the mountainous areas is estimated to be about 7,800 $m^3/km^2/year$. Neither Sabo works, afforestation nor legal sediment control alone can control this large amount of sediment yield. Sabo Framework Plan is formulated as a part of sediment control, assuming that the sediment control plan will be proceeded in the future as described below :

a) Afforestation
Fifty percent of the sediment yield in the mountainous areas will be mitigated by afforestation/reforestation.

b) Sediment due to mine tailings, land slide and soil erosion due to road construction will be totally controlled.

(2) The Sabo Framework Plan is formulated for the project life of 20 years assuming that the excess sediment yield will be all stored inside the Sabo dam reservoirs. The required number of Sabo dams are 32 in addition to the San Roque dam and the Moriones - o'Donnell dam. The Total construction cost is estimated at about 2.6 billion pesos at 1989 price level.

(3) If the project life is set at 50 years an additional 72 dams will be required each approximately 25m high. It is recommended to proceed with afforestation/reforestation simultaneously with Sabo dam construction instead of proceeding with Sabo dam construction only.

4. FEASIBILITY STUDY

4.1 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.

4.2 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 in Figure 4.1.2).

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 4.6.2):

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.

4.3 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 in Figure 4.1.2).

(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)

(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.

4.4 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.

4.5 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 4.6.1).

Unit: Million Pesos (price level on May 1991)

Project	First Stage	Second Stage	Total
a. Upper Agno River	1995 - 1999	2000 - 2004	
	2,923.4	989.8	3,913.2
b. Pantal-Sinocalan River	2000 - 2004	2005 - 2009	
	1,977.4	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 4.6.2).

(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 4.6.3).

5. ENVIRONMENTAL IMPACT ASSESSMENT

5.1 Initial Environmental Examination (IEE) of the Master Plan Study Area

(1) Among the proposed schemes of the Framework Plan, the San Roque dam (assumed as existing), the Moriones-O'Donnell dam, provision of new dikes and the extension of Poponto retarding basin may have environmentally significant impacts, such as resettlement problems and encroachment of agricultural lands. Thus, the most careful attention shall be paid to those prospective socio-economic impacts.

(2) As for the other environmental parameters, no significant environmental effects may be expected by both the Framework Plan and Long Term Plan. However, some natural environmental impacts having low or medium level of significance may be expected. Further environmental study shall, therefore, be required to visualize the expected impacts, and to find proper and possible countermeasures.

5.2 Preliminary Environmental Impact Assessment (EIA) on Priority Projects

(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.

6. RECOMMENDATIONS

6.1 Recommended Projects

(1) Both the Long Term Plan and 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.

6.2 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 FLOOD CONTROL WORKS

1. FRAMEWORK PLAN

1.1 Project Economic Cost

Unit : Million Pesos (price level on June 1989)

. Agno River including Tarlac	13,682
. Agno Tributaries	
Camiling River	451
Banila River	1,023
Viray-Dipalo River	278
Ambayoan River	173
. Pantal-Sinocalan River	2,553
. Cayanga-Patalan River	1,246
Total	19,406

1.2 Design Flood Distribution

. Agno River including Tarlac, 100-year flood (refer to Figure 3.3.3)

River mouth	13,800 m^3/sec
Wawa bridge	11,200 m^3/sec
Confluence with Tarlac River	2,600 m^3/sec
Alcala	
for Poponto floodway	8,200 m^3/sec
for Bayambang stretch	1,000 m^3/sec
Ambayoan	6,400 m^3/sec

. Agno Tributaries, 50-year flood (refer to Figure 3.3.3)

Camiling River (confluence with Agno)	1,750 m^3/sec
Banila River (confluence with Agno)	1,400 m^3/sec
Viray-Dipalo River (confluence with Agno)	750 m^3/sec
Ambayoan River (confluence with Agno)	1,750 m^3/sec

. Pantal-Sinocalan River, 50-year flood (refer to Figure 3.3.4)

Main stream (river mouth)	2,900 m^3/sec
Dagupan River (confluence with Pantal)	2,700 m^3/sec
Ingalera River (confluence with Sinocalan)	600 m^3/sec

. Cayanga-Patalan River, 50 year flood (refer to Figure 3.3.4)

Main stream (river mouth)	3,100 m^3/sec
Bued River (confluence with Cayanga)	1,300 m^3/sec
Anglacan River (with Binalonan floodway)	1,250 m^3/sec

1.3 Flood Control Works and Work Quantities

(1) Agno River

River Improvement Works and Flood Control Dam

Flood Control Works	Agno Main Stream	Tarlac River	Agno Tributaries
a) Length of River Improvement (km)	109.4	37.0	79.7
b) Channel Improvement Including Short Cut (km)	99.9	37.0	71.5
c) Diking System Including Back Water Stretch; both banks (km)	201.3	56.8	127.1
. new dikes	(87.0)	(1.3)	(90.1)
. heightening	(98.5)	(45.5)	(12.8)
. existing	(15.8)	(10.0)	(24.2)
d) Drainage Facilities	18	2	26
e) Bridge Reconstruction	5	3	14
f) Flood control dam	-	1 (Moriones-O'Donnell dam)	-

Work Quantities

Items	Unit	Main Agno	Tarlac River	Agno Tributaries
Excavation	1,000m^3	28,875	4,300	2,083
Dredging	1,000m^3	17,075	0	0
Embankment	1,000m^3	20,370	1,355	3,370
Revetment	1,000m^2	588	96	190
Groin	Pc.	958	244	1,070
Drainage facility	Pc.	18	2	26
Bridge	Pc.	5	3	14
Intake facility	Pc.	0	0	4
Flood control dam	Nos.	0	1	0

(2) Allied Rivers

River Improvement Works

Flood Control Works	Pantal-Sinocalan River	Cayanga-Patalan River
a) Length of River Improvement (km)	142.2	77.0
b) Channel Improvement Including Short Cut (km)	131.7	72.3
c) Diking System Including Back Water Stretch (km)	246.3	99.9
d) Drainage Facilities	41	22
e) Bridge Reconstruction	24	9

Work Quantities

Items	Unit	Pantal-Sinocalan River	Cayanga-Patalan River
Excavation	1,000m^3	5,712	2,361
Dredging	1,000m^3	38	440
Embankment	1,000m^3	6,515	1,773
Revetment	1,000m^2	470	194
Groin	Pc.	754	1,095
Drainage facility	Pc.	41	22
Bridge	Pc.	24	9
Intake facility	Pc.	4	0

2. LONG TERM PLAN

2.1 Project Cost and EIRR

(price level on June 1989)

River/Region	Flood Control Scale	Project Financial Cost (million pesos)	EIRR (%)
Agno River and Tarlac River	25-year flood	11,048	16.6
Agno River Tributaries	25-year flood	1,640	15.5
Allied Rivers	10-year flood	3,286	33.8
Whole Study Area		15,974	20.5

2.2 Design Flood Distribution

. Agno River including Tarlac, 25-year flood (refer to Figure 3.3.7)

River mouth	10,100 m^3/sec
Wawa bridge	8,400 m^3/sec
Confluence with Tarlac River	2,600 m^3/sec
Alcala	
for Poponto floodway	5,200 m^3/sec
for Bayambang stretch	600 m^3/sec
Ambayoan	3,800 m^3/sec

. Agno Tributaries, 25-year flood (refer to Figure 3.3.7)

Camiling River (confluence with Agno)	1,650 m^3/sec
Banila River (confluence with Agno)	1,000 m^3/sec
Viray-Dipalo River (confluence with Agno)	550 m^3/sec
Ambayoan River (confluence with Agno)	1,350 m^3/sec

. Pantal-Sinocalan River, 10-year flood (refer to Figure 3.3.7)

Main stream (river mouth)	2,000 m^3/sec
Dagupan River (confluence with Pantal)	1,850 m^3/sec
Ingalera River (confluence with Sinocalan)	360 m^3/sec

. Cayanga-Patalan River, 10-year flood (refer to Figure 3.3.7)

Main stream (river mouth)	1,500 m^3/sec
Bued River (confluence with Cayanga)	750 m^3/sec
Anglacan River (with Binalonan floodway)	400 m^3/sec

2.3 Improvement Works and Work Quantities

(1) Agno River

River Improvement Works

Flood Control Works	Agno Main Stream	Tarlac River	Agno Tributaries
a) Length of River Improvement Including Poponto Floodway and Short Cut (km)	109.4	37.0	79.7
b) Channel Improvement Including Poponto Floodway and Short Cut (km)	99.9	37.0	71.5
c) Diking System Including Back Water Stretch (km)	201.3	56.8	126.7
. new dikes (km)	68.5	1.3	88.7
. heightening (km)	98.6	45.5	13.4
. existing (km)	34.2	10.0	24.6
d) Drainage Facilities	18	2	26
e) Bridge Reconstruction	5	3	14

Work Quantities

Items	Unit	Main Agno	Tarlac River	Agno Tributaries
Excavation	1,000m^3	24,673	4,300	1,200
Dredging	1,000m^3	13,027	0	0
Embankment	1,000m^3	15,269	1,355	2,581
Revetment	1,000m^2	514	96	190
Groin	Pc.	958	244	1,070
Drainage facility	Pc.	18	2	26
Bridge	Pc.	5	3	14
Fixed weir	Pc.	1	0	0
Intake facility	Pc.	0	0	4

(2) Allied Rivers

River Improvement Works

Flood Control Works	Pantal-Sinocalan River	Cayanga-Patalan River
a) Length of River Improvement (km)	129.6	77.0
c) Channel Improvement Including Short Cut (km)	119.1	72.3
d) Diking System Including Back Water Stretch (km)	210.2	99.7
. new dikes (km)	206.4	99.7
. heightening (km)	3.8	-
. existing (km)	-	-
e) Drainage Facilities	39	22
g) Bridge Reconstruction	22	9

Work Quantities

Items	Unit	Pantal-Sinocalan River	Cayanga-Patalan River
Excavation	1,000m^3	4,216	1,842
Dredging	1,000m^3	38	260
Embankment	1,000m^3	4,012	718
Revetment	1,000m^2	373	193
Groin	Pc.	952	1,095
Drainage facility	Pc.	39	22
Bridge	Pc.	22	9
Intake facility	Pc.	4	0

3. PRIORITY PROJECTS

3.1 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

3.2 Design Flood Distribution

. Upper Agno River (refer to Figure 4.1.1)

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 4.2.1)

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

3.3 Improvement Works, Work Quantities and Cost Breakdown

(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

(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

SUMMARY REPORT

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ABBREVIATIONS

ADB	:	Asian Development Bank
AFCS	:	Agno Flood Control System
ARIS	:	Agno River Irrigation System
ARFFO	:	Agno River Flood Forecasting Office
ARFC	:	Agno River Flood Control
BP	:	Base Point
BUTEL	:	Bureau of Telecommunications
DAF	:	Department of Agriculture and Food
DENR	:	Department of Environment and Natural Resources
DOTC	:	Department of Transportation and Communication
DPWH	:	Department of Public Works and Highways
EIA	:	Environmental Impact Assessment
FFWS	:	Flood Forecasting and Warning System
FFWSDO	:	Flood Forecasting and Warning System for Dam Operation
GDP	:	Gross Domestic Product
GF	:	Growth Factor
GOJ	:	Government of Japan
GOP	:	Government of Philippines
GRDP	:	Gross Regional Domestic Product
IEE	:	Initial Environmental Examination
JICA	:	Japan International Cooperation Agency
MOC	:	Ministry of Construction, Japan
LARIS		Lower Agno River Irrigation System
LATRIS	:	Lower Agno and Totonogen River Irrigation System
NAPOCOR	:	National Power Cooperation
NEDA	:	National Economic Development Authority
NFFO	:	National Flood Forecasting Office
NIA	:	National Irrigation Administration
NWRB	:	National Water Resources Board
OCD	:	Office of Civil Defense
OECF	:	Overseas Economic Cooperation Fund, Japan
PAGASA	:	Philippine Atmospheric Geophysical and Astronomical Services Administration
PM	:	Project Manager
PMO	:	Project Management Office
PNR	:	Philippine National Railways
SMORIS	:	San Miguel-O'Donnell River Irrigation System
UN	:	United Nations

ABBREVIATIONS OF MEASUREMENT

(Length)	
mm	millimeter(s)
cm	centimeter(s)
m	meter(s)
km	kilometer(s)

(Area)	
mm^2	square millimeter(s)
cm^2	square centimeter(s)
m^2	square meter(s)
km^2	square kilometer(s)
ha(has)	hectare(s)

(Volume)	
cm^3	cubic centimeter(s)
m^3	cubic meter(s)
ltr	liter(s)

(Weight)	
gr(grs)	gramme(s)
kg(kgs)	kilogramme(s)
ton(s)	ton(s), eq'vt to 1,000 kg

(Time)	
sec	second(s)
min	minute(s)
hr(hrs)	hour(s)
dy(dys)	day(s)
mth(mths)	month(s)
yr(yrs)	year(s)

(Otheres)	
%	percent(s)
o	degree(s)
10^3	thousand
10^6	million
10^9	billion

1. INTRODUCTION

1.1 Objective of the Study

The Government of the Republic of the Philippines (GOP) has been making efforts for providing various kinds of flood control measures which are prerequisite to the economic development of the country. Among the major rivers of the country, GOP places high priority to the implementation of the rehabilitation and improvement works for flood control facilities in the Agro River and the Allied River basins on account of their urgency. In response to GOP's request the Government of Japan (GOJ) decided to conduct the study of the Agno River Basin Flood Control (the Study) and entrusted the Study to the Japan International Cooperation Agency (JICA).

The objectives of the Study as stipulated in the Implementing Arrangement on the Technical Cooperation between the JICA (JICA) and the Department of Public Works and Highways (DPWH) 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.

1.2 Background of the Study

Frequent recurrence of floods, which are caused by typhoons or tropical storms, has been inflicting serious damages to crops, properties, and lives of inhabitants in the Pangasinan Plain almost every year. In line with the national and regional development goals, it has been recognized quite important to accelerate various protective measures for relieving the inhabitants from damages to crops, properties and public facilities, and risk to their lives.

The Agno River basin and the Allied River basins are located in the western part of Central Luzon. The Agno River has a catchment area of 5,910 km^2 while the Allied River basins have a total catchment area of 1,730 km^2. These basins and the adjacent Pampanga River basin cover a large part of the

country's granary areas. This is one of the reasons why this area is regarded as one of the most important areas where flood control should be given priority attention.

It is estimated that a total area of 150,000 ha to 250,000 ha (depending on the flood scale) is susceptible to inundation in the provinces of Pangasinan, Tarlac and Nueva Ecija in consequence of floods from the said river system. The population in this flood-prone area is estimated to be about 1.5 million. The Agno River basin experienced large floods in 1935, 1936, 1937, 1938, 1943, 1950, 1960, 1968, 1972, 1980, 1984, 1985, and 1986. The 1935 flood recorded the largest inundation area but had no damage record. The flood of 1972, the second largest record, inundated more than 80% of the flood-prone area mentioned above. The damages incurred by this flood amounted to ₱ 2 billion in Central Luzon. This frequent recurrence of floods and insufficient protective measures thus seriously hinders the economic development of the project area.

At present, the Agno River basin and the Allied River basins are extensively utilized for irrigation and human settlement, making it now more susceptible to flood damages in economic terms. Urgent rehabilitation and improvement of the existing flood control facilities, including reconstruction and improvement of damaged dikes and augmentation of channel capacity and retarding basin, are of primary necessity.

1.3 Suspension and Resumption of the Study

The Study was commenced on March 25, 1989 and the Master Plan was presented as the Interim Report in February 1990, while the Feasibility Study was commenced on May 1, 1990 and was scheduled to be completed by the end of January 1991. The Feasibility Study, however, was suspended in August, 1990 after occurrence of the earthquake on July 16, 1990. At the end of November 1990 it was resumed and the Draft Final Report was issued at the middle of September 1991. On the other hand Mount Pinatubo first erupted on June 9, 1991 after 600 years of lying dormant and its mudflow and lahar cascaded down the slopes and poured into the Tarlac River, a tributary of the Agno River.

Under the circumstances the Study notes two matters:

a) The price level used for the Master Plan Study was June 1989 while it was May 1991 for the Feasibility Study. Price adjustments of these two periods have not been made due to different escalation rates of materials (average 50%), equipment (average 30%) and labours (average 80%) between the two periods and differences in the accuracy of cost estimates and work quantities between the two studies.

b) The effects of the earthquake of July 1990 have been taken into account in the design of the Feasibility Study based on the supplemental liquefaction and seismic resistance studies. The effects of the eruption of Mount Pinatubo, however, have not been reflected in the study because they were not included in the scope of work of the study and the eruptive activity of Mount Pinatubo still continues and involves some uncertainties and unknowns.

1.4 Contents of the Report

This summary report briefs the principal study results of the two part report, the Master Plan and the Feasibility Study. Each part is comprised of a main report and a supporting report. The main report presents all the study results while the supporting report describes the details of the respective sectoral studies. A data book compiles the supporting data to these reports. The composition of the supporting report is as follows:

Sector		Part 1 Master Plan	Part 2 Feasibility Study
SE	Socio-Economy	*	*
HY	Hydrology	*	*
GL	Geology	*	*
LF	Liquefaction Study	out of scope	*
SR	Seismic Resistance Study	out of scope	*
SV	Survey	*	*
FD	Flood Damage	*	*
SD	Sediment Control Plan	*	*
RV	River Improvement Plan	*	*
DM	Dam and Retarding Basin Plan	*	*
FF	Flood Forecasting and Warning System	*	*
DS	Design of Structures	*	*
CP	Construction Plan and Cost Estimates	*	*
EI	Environmental Impact Assessment	*	*

*: Subject to Study

The contents of the Main Reports for Part 1 and Part 2 are compiled in Appendix-A.

1.5 Acknowledgment

Grateful acknowledgment is made of the willing assistance given by the personnel of the many Government Departments of the Philippines, without whose co-operation the Master Plan and the Feasibility Study of Agno River Basin Flood Control could not have been satisfactorily completed.

2. THE STUDY AREA

2.1 Location and River Basins

2.1.1 Master Plan Study Area

The Master Plan Study Area covers three river systems and the vast alluvial plain called the Pangasinan plain in the western part of the Central Luzon. These rivers from the Cordillera and Zambales mountains drains the plain into the Lingayen Gulf. The largest of these rivers is the 275 km long Agno River which flow from its sources 55 km north-east of Baguio City (the longitude 16°51'N and the latitude 120°52'E) down the southern slopes of the Cordilleras. It flows in a southerly course to Tayug 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. It's major tributaries are the Tarlac, Camiling, Ambayoan, Viray-Dipalo, and Banila Rivers. The southern end of the Study Area is bounded by the water-shed of the Tarlac River near Mt. Pinatubo (the 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. The Allied Rivers are broadly divided into 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 for the Agno River basin, 1,115 km^2 for the Pantal-Sinocalan River including the Dagupan River, and 618 km^2 for the Cayanga-Patalan River 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 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, Ueva Ecija, Pampanga, Tarlac, and Zambales. It covers 83 municipalities out of 189 municipalities in the 9 provinces.

2.1.2 Feasibility Study Area

Figure 2.1.1 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.

2.2 Socio-Economic Conditions

2.2.1 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 that of the whole country (2.75%). The 1989 population in the Area was 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.

The average household size and dwelling occupancy in the Area in 1980 was estimated at 5.6 persons/household and 5.7 persons/dwelling unit, respectively. The urban population in the Area 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%.

2.2.2 Employment

Labor force in the Area totaled to 694,000 persons or 56% of the working age population of 1.24 million persons. This was lower than the country's 60%.

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. 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 oriented one.

2.2.3 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 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. (refer to Table 2.2.1)

2.3 Beneficial and Impact Areas

2.3.1 Maximum Inundation Area

Figure 2.3.1 shows the maximum inundation area subject to the Master Plan 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.

2.3.2 Beneficial Areas of Priority Projects

The Priority Project areas subject to the Feasibility Study excludes the Lower Agno River, the tributaries of the Agno River, the Cayanga-Patalan River and an upstream part of the Pantal-Sinocalan River from the Master Plan Study Area.

The feasibility study's design flood is a 10-year probable flood while the Master Plan's design flood is a 100-year or 50-year probable flood. In this regard the beneficial area of the Priority Projects is reduced to 1,264 km^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, 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.

2.3.3 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. Pangasinan's urban centers and their satellite municipalities are grouped into five, Dagupan City - San Carlos City, Urdaneta, Tayung, Lingayen and Alaminos based on the hierarchy of settlements.

The project priority areas span most of Pangasinan's growth centers, Dagupan City, San Carlos City, Lingayen, 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. In this regard, both priority projects will have greatest bearing on the Dagupan City-San Carlos City group and, to a lesser extent, on the Urdaneta group.

It is appropriate to view Pangasinan as the Impact Area of the Project. In like manner, benefits accruing to Pangasinan will also redound to the 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.

2.3.4 Economic Profile and Role of Pangasinan in Ilocos Region

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.

Under this 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 including: 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.

2.3.5 GRDP Projection

(1) GRDP Projection for Master Plan

The trend growth rates of GDP of the Philippines and GRDP of Ilocos are assessed to be: (a) modest growth (1975-1982); (b) contraction (1981-1985); (c) recovery; and (d) incipient slowdown (1990-1992).

The midpoint between the two trends, high growth scenario and low growth scenario was used in the socio-economic projections for the Master Plan 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.

(2) GRDP Projection for Feasibility Study

In recent years, the faster growth envisioned for Ilocos Region did not materialize. For 1991 to 1992, an economic slowdown is likely for Ilocos Region and probably for Pangasinan.

The above socio-economic projections applies also to the Pangasinan as well as the project beneficial areas as these have basically similar socio-economic conditions. It is, however, 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. The area GDP levels of the Pangacinan's higher growth scenario is provided and adopted for the Feasibility Study:

Higher Growth Case	1990	2000	2010	Implied Growth (%)
Per Capita GDP*	943	1,362	1,891	3.5
Population (In Thousand):	NEDA medium assumption projections			
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

2.4 Existing Conditions of Agno River and Allied Rivers

2.4.1 Present River Conditions

(1) River Systems

The Study Area is divided into three river systems: Agno River System (C.A.=5,907 km^2), Pantal-Sinocalan River System (C.A.=1,115 km^2), and Cayanga-Patalan River System (C.A.=618 km^2). The location map is shown in Figure 2.4.1. Their river system diagrams are shown in Figure 2.4.2, together with their drainage area and river length.

(2) Channel Conditions

The general features of the river channels of the Agno River main stream, its major tributaries, and the Allied Rivers are described as follows:

River	Stretch	River width (m)	Low Water width (m)	Channel depth (m)	River Bed Slope
Agno	(Mouth-Tarlac)	4,000-1,500	550-100	8.0-4.0	1/7,000-1,650
	(Tarlac-ARIS dam)	2,400-450	350- 75	5.5-3.0	1/1,650- 200
Tarlac	(8km Us.-Tarlac city)	1,500-600	550- 60	3.5-2.5	1/1,200- 750
Ambayoan	(Ds.end-9km Us.)	450-150	75- 60	2.5-1.5	1/200- 150
Viray-Dipalo	(Ds.end-8km Us.)	450-250	120- 60	4.0-3.0	1/400- 250
Banila	(Ds.end-30km Us.)	120- 30	120- 25	4.0-1.5	1/850- 100
Camiling	(Camiling-Mayantoc)	120- 50	120- 50	6.0-5.0	1/2,000- 250
Pantal-Sinocalan-Tagamusing		300- 35	160- 10	7.0-1.5	1/1,750- 70
Cayanga-Patalan-Angalacan		300- 35	170- 20	6.0-2.0	1/1,300- 140

Note Ds. : Downstream, Us. : Upstream

(3) Carrying Capacity

There is no dike in the 40 km section on the left bank from the mouth of the Agno River. The bankfull capacity of the stretch is estimated to be about equivalent to the peak flood discharge with a 1 to 2 year return period, while the carrying capacity of the river stretch near the river mouth is in the order of the peak flood discharge with a 2-3 year return period.

The average discharge carrying capacity of the dike stretch is estimated equal to the peak flood discharge with a 10 year return period. However the carrying capacity fluctuates along the river length. The river stretch in Bayambang near the confluence of the Tarlac River and the stretch at Carmen bridge form hydraulic bottle-necks, where the carrying capacity are estimated at the peak discharge of a 5 year probable flood.

For the Allied Rivers, no significant river improvement works had been undertaken to increase the flow capacity of the channels. Therefore, the discharge carrying capacity depends on the ground level on both banks of the river. The area along the Sinocalan River from Santa Barbara to Calasiao is habitually inundated by overflow of flood due to the shortage of flow capacity. Inundation due to local drainage problems annually occurred in the area.

2.4.2 Existing River Control Facilities and Structures

As early as the 1930's the Government of the Philippines started a flood control study on the Pampanga and Agno River basins. Due to habitual flooding in the Agno River basin in the 1930's, construction of an earthdike was commenced on the downstream reaches of the Agno River in 1938. By 1960, construction of an earthdike 100 km in length, improvement works of 65 km of river channels and 10 km of revetment were completed.

In 1989 the existing river facilities for flood control in the Agno and Allied Rivers were earth and concrete dikes, groins, revetments and diversion channels. The locations of the major river control facilities and structures are shown in Figure 2.4.3.

Diking systems are one of the most progressive flood control facilities in the Agno River. The lengths of existing dikes of the major rivers are summarized below:

River	Stretch	Length of diking system (km) Right bank	Left bank
Agno River			
Main Agno	River mouth-Bayambang (50 km Upstream)	40.50	16.30
	Bayambang-ARIS Dam (99 km Upstream)	47.80	28.80
Ambayoan	Confluence-8.7 km Upstream	0.00	3.50
Viray-Dipalo	Confluence-8.5 km Upstream	5.70	7.40
	Viray River stretch (L=3.9 km)	3.30	7.00
	Dipalo River stretch (L=8.1 km)	0.00	0.00
Banila	Confluence-30.9 km Upstream	0.00	9.30
Tarlac	Confluence-TARIS Dam (37.0 km Upstream)	29.60	25.50
Camiling	Confluence-Mayantoc (20.8 km Upstream)	0.00	0.00
	Subtotal	126.90	97.80
Allied Rivers			
Cayanga-Patalan	River mouth-37.5 km Upstream	0.00	0.00
	Tributaries	0.00	0.00
Panto-Sinocalan	River mouth-49.4 km Upstream	2.50	1.30
	Tributary	0.00	0.00
	Total	129.40	99.10

2.5 Flood Damage

2.5.1 Flood Damage Records

(1) Flood Records

The Philippine Atmospheric Geophysical and Astronomical Services Administration (PAGASA) and the Office of Civil Defense (OCD) have carried out surveys on each large typhoon and flood in the basin since 1962. The results shows that the largest flood in the last two decades occurred in 1972 and its recurrence interval was 10 years. Most recent floods occurred in August, 1984 and July, 1986 with recurrence intervals of some 4 and 7 years, respectively.

Flood years and flood inundation areas measured from the recorded flood maps are described as follows:

Flood Year	Inundation Area(km^2)	Recurrence Interval (year)
1935	2,100	no hydrological record
1972	2,040	10-year
1973	900	-
1980	1,550	-
1984	1,670	4-year

(2) Flood Damage Records

According to the damage records in Pangasinan Province, during the 1972 flood, 530,000 inhabitants (about 43% of the estimated population of 1,250,000 in 1972) suffered from flooding including 460,000 evacuated persons. On the other hand, in the recent large floods of 1984 (typhoon Maring) and 1986 (typhoon Gading), the number of affected people was reported to be 300,000 and 160,000 respectively. The corresponding share is about 20% and 10% of the estimated population of 1,500,000 in 1984 and 1,550,000 in 1986, respectively. The damages from the 1984 flood and the 1986 flood were estimated at about 99 and 134 million pesos at the price level in the corresponding year, respectively.

2.5.2 Estimation of Maximum Inundation Areas

A flood mark survey for confirming the extent of inundation area as well as water depth and duration of the floods of 1972, 1984, and 1986 was carried out at 240 sites in the flood prone area. Figure 2.3.1 shows the maximum envelope of the flood inundation area which confines the maximum extent of recorded flood inundation area in the Study Area; that is, the maximum extent of inundation area is defined as the probable maximum inundation area for the flood damage analysis. The maximum inundation area amounts to 2,465 km^2.

2.5.3 Probable Flood Damage

The flood damage for the condition without the project is estimated by the use of the inundation water depth and duration of the flood with frequencies of 1.05 years to 100 years. The ratio of the indirect damage to the direct damage is estimated to be 10% to 35%. The Study Area's probable damages are summarized below:

unit : million pesos

Return Period (Year)	2	5	10	50	100
Inundation Area (km2)	1,448	1,665	2,038	2,183	2,465
Affected Inhabitants (million persons)	1.05	1.17	1.37	1.44	1.56
Direct Damage	956	1,512	1,970	3,001	3,493
- Agricultural	315	486	586	762	877
- Non-agricultural	516	739	908	1,382	1,558
- Infrastructures	125	287	476	857	1,058
Indirect Damage	114	299	489	966	1,208
(% ratio)	(11.9)	(19.8)	(24.8)	(32.2)	(34.6)
Total Damage	1,070	1,811	2,458	3,968	4,700

The cumulative annual average probable flood damage up to the 100-year flood is about 1,262 million pesos at the 1989 price level for the whole Study Area.

Return Period (Year)	Probable Annual Average Flood Damage (Million Pesos)
1.05	0
2.0	361.8
5.0	765.0
10.0	973.0
25.0	1,145.8
50.0	1,218.4
100.0	1,261.8

3. MASTER PLAN

3.1 Master Plan Formulation Criteria

3.1.1 Basic Concept

(1) Definition of Flood Control and Sediment Control Plans

The comprehensive flood control master plan is composed of flood control and sediment control plans. The Study focuses on the flood control plan but also studies the sediment control at a conceptual level only. The flood forecasting and warning system is studied as a part of nonstructural measures.

(2) Flood Control Measures Subject to Master Plan

The flood control structural and non-structural measures which are to be studied in the Master Plan are listed below.

Flood Control Plans

a. Flood Control Dams
b. Flood Retarding Basins
c. River Improvements
d. Floodway

Sediment Control

a. Sediment Control in Watershed
   - Sabo dams and other facilities
   - Afforestation
   - Legal and structural measures for preventing mine tailing discharge
   - Legal and structural measures for preventing landslide and soil erosion due to road construction

Afforestation and legal measures for tailing discharge and road construction are not covered by the Master Plan and are limited to recommendation for further study only.

b. River Improvements
   - Channel improvement for flushing sediment
   - Riverbed excavation and/or dredging

Non-structural Measure

a. Flood Forecasting and Warning System

3.1.2 Definition of Framework Plan and Long Term Plan

(1) The Master Plan is composed of two stage plans, the Framework Plan and the Long Term Plan. The Framework Plan is defined as an ideal portrait of a flood control plan which is to be achieved in the unspecified future. The Long Term Plan is defined as a stage development plan of the Framework Plan which is to be achieved at the target year of 2020 (30-year long term plan).

(2) Flood control target of the Framework Plan is set at a 100-year probable flood for the Main Agno River and the Tarlac River and at a 50-year probable flood for the other tributaries of Agno and the Allied Rivers. Flood control target of the Long Term Plan is set at a feasible scale during a project life of 50 years starting construction from 1995.

(3) Rivers subject to the study are:

Agno River	:	Main stream, Tarlac, Ambayoan, Viray-Dipalo, Banila, Camiling
Allied Rivers	:	The main stream of Cayanga-Patalan, Bued, Aloragat, Angalacan, The main stream of Pantal-Sinocalan, Tagamusing, Macaloang, Ingalera, Dagupan

3.2 Flood Control Alternatives

3.2.1 River Improvement and Floodway

The subject river systems are divided into three groups: the Agno River main stream, the Agno River tributaries and the Allied Rivers. River

improvement alternative plans are formulated for each group. Floodway and closing dike plans are also independently formulated for the Agno River main stream and the Allied Rivers as an alternative to the respective river improvement plans. The results of the alternative studies are summarized hereunder.

River Improvement of the Agno River

Sole river improvement and river improvement with floodways are compared by the least cost criteria. The Agno floodway, which is an alternative to the main stream of the Agno River, aims to divert the major flood runoff (about 6,400 m^3/s) from the drainage area upstream of the San Roque dam site toward the Lingayen Gulf, while its runoff is discharged downstream through the existing Agno River channel in the case "without" Agno floodway (sole river improvement). The construction cost of the Agno floodway is very high and, therefore, the scheme "with" Agno floodway is inferior to the scheme of sole river improvement, though flood diversion and drainage effectiveness is extremely high. For the tributaries of Agno River, sole river improvement plans are adopted based on the initial screening study.

River Improvement of Allied Rivers

For the Allied Rivers three floodway alternatives, the Aloragat, San Manuel, and Binalonan, are formulated. The Binalonan floodway, which diverts Tuboy river flood to the Angalacan is adopted as the case which is superior to the case of sole river improvement. A closing dike is planned on the left bank of the Bued River to prevent overflow into the Aloragat River. The Bued closing dike is adopted as a part of the river improvement of the Bued River. For the other part of the Allied Rivers, river improvement plans are adopted.

3.2.2 Flood Control Dams

Existing, on-going, and identified dams are shown in Figure 3.2.1.

Among 14 potential flood control dams excluding the 3 existing dams, San Roque, Lower Ambayoan, Lower O'Donnel, Moriones, and Camiling dams are

selected as sites having high flood control efficiency. It is, however, assessed that none of them is assessed to be viable as a flood control single purpose dam. The combined Moriones - O'Donnel dam connected with an open channel is the only case selected for the integrated flood control plan.

3.2.3 Retarding Basins

Among the three alternatives, a natural retarding basin, a retarding basin with confining dikes, and a retarding basin without confining dikes, the natural retarding basin type is adopted as the Poponto retarding basin based on least cost criteria. As for the Camiling retarding basin, both a natural retarding type and an overflow type are inferior to a river improvement alternative, and are disqualified. The locations of the Poponto swamp and the Camiling swamp are shown in Figure 3.2.1.

3.3 Framework Plan and Long Term Plan

3.3.1 Framework Plan

(1) Alternative Framework Plans

The selected river improvement and floodways, Moriones-O'Donnel dam and Poponto retarding basin are integrated, and alternatives of the framework plans are formulated as set out below.

Agno River Main Stream and Tarlac River

Case 1 : Sole River improvement
Case 2 : Combination of river improvement and Poponto natural retarding basin
Case 3 : Combination of river improvement, Poponto natural retarding basin and Moriones-O'Donnel dam
Case 4 : Combination of river improvement and Moriones-O'Donnel dam

Agno River Tributaries

. Ambayoan River : Sole river improvement

. Viray-Dipalo River : Sole river improvement

. Banila River : Sole river improvement

. Camiling River : Sole river improvement

Allied Rivers

. Pantal-Sinocalan

Case 1 : River improvement and Binalonan floodway

Case 2 : Sole river improvement

. Cayanga-Patalan

Sole river improvement with Bued closing dike

(2) Proposed Framework Plan

Among the four alternatives for the Agno River and the Tarlac River, Case 2 which is a combination of river improvement and Poponto natural retarding basin has the least construction cost. Case 3 which is a combination of river improvement, the Poponto natural retarding basin and the Moriones - O'Donnel dam has the least project cost if the annual sediment dredging cost of river channels is taken into account.

Project Economic Cost (million pesos)

	Case 2; River improvement & Retarding Basin	Case 3; River improvement, Retarding Basin & Dam
Construction Cost Only	12,338	13,682
Construction Cost with reduction in annual dredging cost of sediment	12,338	12,043

Case 3 is proposed as the Framework Plan for the Agno River and the Tarlac River. The Moriones-O'Donnel dam is included in the Framework Plan in spite of the expected land acquisition and resettlement because the project life of small irrigation schemes and small impounding dams are expected to be short and the need for this dam is expected to be very high in the future.

For the Agno River tributaries, the case of sole river improvement is

the least costly and is proposed as the Framework Plan. The economic project cost is summarized below.

Project Economic Cost (million pesos)

Camiling river	451
Banila River	1,023
Viray-Dipalo River	278
Ambayoan River	173
Total	1,925

For the Allied Rivers, Case 1 which is a combination of river improvement and the Binalonan floodway is the least costly and is proposed as the Framework Plan. The Bued closure dike is provided upstream of the Bued River as a part of river improvement works. The location of the Binalonan floodway and the Bued closure dike is illustrated in Figure 3.3.2. The economic project cost of Case 1 and Case 2 is summarized below.

Project Economic Cost (million pesos)

	Case 1; River improvement with Binalonan Floodway	Case 2; Sole River Improvement
Pantal-Sinocalan River	2,553	2,824
Cayanga-Patalan River	1,246	1,158
Total	3,799	3,982

(3) Features of Framework Plan

The general layout of the proposed Framework Plan is illustrated in Figure 3.3.1 for the Agno River and Figure 3.3.2 for the Allied Rivers. The design flood distributions are shown in Figure 3.3.3 for the Agno River and Figure 3.3.4 for the Allied Rivers. The design plan is shown in Figure 3.3.5. The new Poponto retarding basin area is illustrated in Figure 3.3.6.

In the Framework Plan of the Agno River, new dikes with high water channel width of about 1.5 km are planned on the left and right banks from the river mouth to the middle reaches at Bayambang. These new dikes are provided to protect Lingayen town area. At present only the right bank

levee exists from AG-45. Since the existing high water channel in the section between AG-45 and AG-83 varies from 2.5 km to 3.5 km, the new dike on the right bank is to be constructed inside the existing dike. If this new dike is provided the land use between the new dike and the existing dike will be enhanced. However, the existing dike which is planned to be raised in the Long Term Plan, should be kept in the same place as the secondary dike system even after the construction of the new dike. The purpose of the secondary dike is to secure the safety of the primary dike although the newly planned high water channel is wide enough.

The major design features, such as design discharge, river gradient, river width, dike height and water depth are presented in Table 3.3.1 for the Agno River, Table 3.3.2 for the Agno tributaries, and Table 3.3.3 for the Allied Rivers.

3.3.2 Long Term Plan

(1) Optimization of Development Scale

The Long Term Plan is formulated as a stage development plan up to the target year 2020 on the way to the Framework Plan. For optimization of the development scale of the Long Term Plan, the following combinations of the flood control structural measures are adopted:

i) Agno River and Tarlac River; combination of river improvement and Poponto natural retarding basin

ii) Agno River Tributaries; sole river improvement

iii) Allied Rivers; river improvement with Binalonan floodway

Although the Moriones-O'Donnell dam is included in the proposed Framework Plan for the Agno River and the Tarlac River, it is excluded from the Long Term Plan because of the expected short run implementation difficulties involved in the land acquisition and resettlement in its reservoir areas. The reservoir areas are occupied by about 1,600 families (90% in Moriones area and 10% in O'Donnell area), agricultural land of about 40 km^2.

Optimization was made for the range of flood control level between 10-year are 50-year design floods. The corresponding optimum development scale is summarized below.

River/Region	Optimum Development Scale	EIRR (%) Future Development Level
a. Agno River and Tarlac River	25-year flood	16.6
b. Agno River Tributaries	25-year flood	15.5
c. Allied Rivers	10-year flood	33.8
d. Whole Study Area	25-year flood	20.5

(2) Proposed Long Term Plan

The development scale and project cost of the Long Term Plan are proposed as set out below.

Price level on June 1989

	Development Scale	Financial Project Cost (million pesos)
Agno river and Tarlac River	25-year flood	11,048
Agno River Tributaries	25-year flood	1,640
Allied Rivers	10-year	3,286
Total		15,974

The proposed Long Term Plan (10-year flood) for the Allied Rivers is worked out without the Binalonan floodway but takes into account the design flood distribution of the Framework Plan with the Binalonan floodway (50-year flood). The design plan is illustrated in Figure 3.3.5. The design flood distribution of the proposed Long Term Plan is illustrated in Figure 3.3.7 for the Agno River and the Allied Rivers.

The major design features, such as design discharge, river gradient, river width, dike height, and water depth are presented in Table 3.3.4 for the Agno River, Table 3.3.5 for the Agno tributaries, and Table 3.3.6 for the Allied Rivers.

3.3.3 Flood Forecasting and Warning System

(1) Definition and Objective of Flood Forecasting and Warning System

The flood forecasting and warning system (FFWS) is defined as one of the non-structural component of the flood control Master Plan (Framework Plan and Long Term Plan).

The FFWS Framework Plan aims to up-grade the existing system and to achieve an integrated nationwide flood forecasting and warning system which fulfills the following objectives:

i) FFWS for Resident's Protection from Flood Incident

It aims to secure the life of people and to minimize flood damages in the flood prone area by enhancing prompt flood protection activities which necessitate sufficient and accurate information, through agencies and organizations concerned. It necessitates advanced forecast of extreme floods which may exceed the capacity of existing river facilities.

ii) FFWS for Flood Operation

It aims to execute promptly effective operation of the flood control facilities such as dams, floodways and retarding basins by forecasting the magnitude of flood inflow into these facilities in advance. It also aims to avoid artificial flood disasters by disseminating in advance to the people to be affected information concerning flood release from the facilities.

iii) FFWS for Basinwide Flood Management

It aims to execute effective basinwide flood management and administration by integrated real time operation of all the flood control facilities in the basin. It necessitates real time access to the information on river and basin conditions.

The target area of the integrated FFWS is the whole flood prone area in the Study Area.

(2) Existing FFWS

In the Agno River basin there are the ABC (Agno, Bicol and Cagayan Rivers) System installed in 1982 and an on-going system for the Binga-Ambuklao dam basin. However, these systems have operational problems.

(3) FFWS Framework Plan

FFWS Framework plan

The proposed FFWS Framework Plan is composed of the system components listed below.

(a) Hydrological Observation Network System
- Water level stations : 17 stations (existing 7 stations included)
- Raingauge stations : 32 stations (existing 6 stations included)

(b) Telemetering Network System
- System Control Center : Rosales, DPWH
- Repeater Station : 2 stations
  - Mt. Ampucao (extension of the existing station)
  - Mt. Bamban (newly constructed)

(c) Flood Forecasting System
- One computer system in Rosales control center

(d) Flood Warning Network System
- Duplex link between Rosales control center and the related 29 local agencies
- 31 Warning stations along the river

(e) Monitoring System: 4 monitors in Rosales Control Center

a. Flood Operation System
- For Balog-Balog Flood Operation System (New)
- For San Roque Flood Operation System (New after dam construction)
- For Moriones-O'Donnel Flood Operation System (New after dam construction)

b. Monitoring at DPWH central office

The locations of the proposed hydrological observation network system, the telemetering network system, and the control center are illustrated in Figure 3.3.8. The location of the flood warning network system is illustrated in Figure 3.3.9.

The total project cost of the integrated FFWS in the Agno River basin is estimated at 796 million pesos (1989 price level) as shown in Table 3.3.7.

Institutional Arrangement

The following institutional arrangement is recommended for further study to achieve smooth operation of the proposed integrated FFWS:

(a) Local level of FFW activity shall be transferred to the local agency.
(b) The DPWH is responsible for the local flood forecasting in connection with its responsibility for the river administration and the regular maintenance work of the hydrological stations.
(c) Flood warning activity is responsibility of OCD. It is tasked to prepare the program for improvement of Disaster Coordination Council's activities.
(d) A telecommunication training center is to be established in collaboration with PAGASA, NAPOCOR, NIA, DPWH and NTC in Manila. The purpose of the center is to train the staff and to stock and supply the spare parts of the telemetering facilities. Prompt repair work will be expected once the center is established.
(e) The provision of flood operation systems for new dams is the responsibility of the owner agency.

(4) FFWS Long Term Plan

Basic Conditions of The FFWS Long Term Plan

The Long Term Plan is formulated as a stagewise development plan up to the target year 2020 which finally aims to set up the FFWS integrated system planned as the Framework plan.

The following objectives are assessed to formulate the Long Term FFWS development plan in the Study Area.

i) To improve the flood forecasting accuracy of the forecasting points in the existing Agno River FFWS.

ii) To carry out the effective flood warning activity in the Study Area.

FFWS Long Term Plan

The proposed FFWS Long Term Plan is composed of the system components listed below.

(a) Hydrological Observation Network System
- Water level stations : 7 stations (existing)
- Raingauge stations : 14 stations (existing 6 stations included)

(b) Telemetering Network System
- System Control Center : Rosales, DPWH
- Repeater Station : 2 stations
  - Mt. Ampucao (extension of the existing station)
  - Mt. Bamban (newly constructed)

(c) Flood Forecasting System
- One computer system in Rosales control center

(d) Flood Warning Network System
- Duplex link between Rosales control center and the related 5 local agencies

(e) Monitoring System
- Flood operation system for Binga-Ambuklao FFWSDO sub-system (existing).
- Monitoring at DPWH central office with the existing communication link.

The location of the proposed system is illustrated in Figure 3.3.10.

The total project cost of the FFWS Long Term Plan is estimated at 281 million pesos as shown in Table 3.3.8. The economic internal rate of return is expected to be 28.9%.

3.3.4 Sabo Works

(1) Definition and Objective of Sabo

It is assessed that active yield of sediment in the Study Area is mainly due to poor vegetation in the mountainous area of about 4,200 km^2 which occupies 55% of the study area of 7,460 km^2. Slope erosions caused by road construction and some portion of mine tailings constitute a part of the sediment yield in the watershed.

The average natural sediment yield of the mountainous area is estimated to be about 7,800 $m^3/km^2/year$. Neither sabo works, afforestation nor legal sediment control only can control this large amount of sediment yield.

The Sabo Framework Plan is formulated as a part of sediment control defined, assuming that the sediment control plan will be implemented in the future as described below.

a. Afforestation
   Fifty percent of the sediment yield in the mountain area will be mitigated by afforestation/reforestation. In order to achieve this target all of the partial forest land (800 km^2) and about 60% of the bare land (200 km^2) must be totally afforested; i.e., total afforestation of about 1,000 km^2.

b. Mine and Roads
   Sediment due to mine tailings, landslide and solid erosion due to road construction will be totally controlled.

c. Sabo Works
   The remaining part of the sediment yield which will not be controlled by the foregoing measures (a, b) will be dealt with by sabo works such as sabo dams.

The excess sedimentation in the river channels caused by imbalanced sediment transport capacity is treated by maintenance operation of dredging or excavation.

(2) Sabo Framework Plan

Sabo dam

The Sabo Dam Framework Plan is formulated for the project life of 20 years assuming that the excess sediment yield will be all stored inside the sabo dam reservoir. The required number of sabo dams, total 32, are in addition to the San Roque dam and the Moriones - O'Donnell dam as summarized below.

Location	Volume (10^3m^3/yr)	Required Number of Sabo Dams for 20 years	for 50 years
Ambuklao Dam	1,681	Ambuklao Dam	Ambuklao Dam
Binga Dam	960	Binga Dam	Binga Dam
San Roque Dam	2,550	San Roque Dam	San Roque Dam
Ambayoan	1,126	6	33
Dipalo	13	1	1
Viray	74	4	6
Balog-Balog Dam	1,344	Under const.	Under const.
Moriones Dam	1,042	Moriones-O'Donnell dam	
Lower O'Donnel Dam	1,349	Moriones-O'Donnell dam	
Camiling	373	3	5
Olo	376	4	11
Bayaoas	191	1	3
Tuboy	267	3	9
Angalacan	39	2	3
Bued	346	8	33
Total	11,731	32 plus San Roque, Moriones-O'Donnell dam	104

The locations of the dam sites for the 20-year plan are shown in Figure 3.3.11. The total construction cost is estimated at about 2.6 billion pesos (1989 price level).

If the project life is set at 50 years an additional 72 dams will be required, each with an approximate dam height of 25 m. It is recommended, therefore, to proceed with afforestation/reforestation simultaneously with sabo dam construction instead of proceeding with sabo dam construction alone.

Other facilities

a) Groundsill

The stretches to be provided with groundsill are proposed as follows:

River	Stretch
Agno River	San Roque - San Manuel
Tarlac River	Lower O'Donnell Dam - Confluence of the Tarlac River
- Ditto -	Moriones Dam - Confluence of the Tarlac River

b) Settling Basin

A settling basin shall be provided to trap inflowing sediments in front of the intake of each irrigation system and maintenance dredging in the basin shall also be conducted. The annual sediment inflow to the irrigation systems is estimated based on the results of the sediment balance analysis for the Proposed Framework Plan (River improvement, Moriones - O'Donnell dam and sabo dams):

Irrigation System	Sediment Inflow Volume (m^3/yr)
ARIS	208,000
LATRIS	22,000
Ambayoan RIS	71,000
Dipalo RIS	11,000
SMORIS	4,000
Tarlac RIS	3,000
Camiling RIS	64,000
Total	383,000

(3) Maintenance of River Channel

The total sediment volume in the river channels of the Agno River and the tributaries is estimated at about 1,400,000 m^3/year by the sediment balance simulation analysis under the condition with the proposed Framework Plan as summarized below:

Item	Sediment Volume (10^3m^3/yr)
1) Sediment Yield	15,481
2) Sedimentation in Dam Reservoirs	8,823
3) Sedimentation in Sabo Dams	2,334
4) Sedimentation in Poponto Swamp	244
5) Sediment Inflow to Irrigation Systems	383
6) Sediment Discharge to Lingayen Gulf	2,291
7) Sedimentation in River Channels	1,406
	(15,481 - 14,075)

The amount of excess sedimentation shall be disposed of by annual maintenance dredging operation.

(4) Dam Maintenance

The remaining dead storage of the existing dams, Ambuklao dam and Binga dam is not enough because of the unexpected huge sediment yield. Maintenance dredging of these reservoirs should be conducted for the conservation of the design dead storage. The remaining life of the dead storage is estimated at 18 years for the Binga dam while the dead storage of the Ambuklao dam is almost full.

3.4 Project Cost Estimates

3.4.1 Cost Estimation Criteria

(1) Constitution of Project Cost

Basic Conditions

In estimating the project cost, the following basic conditions are assumed.

i) The construction works are to be procured by bidding.

ii) Unit cost of each construction work item is estimated on a unit price basis, except for some work items to be estimated on a lump sum/percentage basis.

iii) Unit prices are based on the price level of June 1989.

iv) Exchange rates of the foreign and local currencies are US$1.00 = ₱21.30 = ¥132.00.

Constitution of Project Cost

The project cost is composed of main construction cost, compensation cost, administration and engineering services, and contingencies.

(2) Currency Proportion

The financial project cost is estimated with appropriate currency proportion assuming that the majority of it will be financed by international financing agencies.

3.4.2 Cost Estimates

Those project costs and work quantities were estimated for the improvement of river stretches and/or river systems constituted in Figure 3.4.1.

The financial project cost of the Long Term Plan for the flood control

is summarized as follows:

(Unit Mill. Pesos)

River	Foreign Currency Portion	Local Currency Portion	Total
I. Agno River (25-year design flood)			
1. Lower Agno River	4,048	2,248	6,296
2. Poponto Stretch	761	366	1,127
3. Upper Agno River	1,393	811	2,204
Sub-Total	6,203	3,424	9,627
4. Tarlac River	903	518	1,421
5. Tributaries	937	703	1,640
Total of Agno River	8,043	4,645	12,688
II. Allied Rivers (10-year design flood)			
1. Panto-Sinocalan River	1,311	849	2,160
2. Cayanga-Patalan River	615	511	1,126
Total for Allied Rivers	1,926	1,360	3,286
Grand Total	9,969	6,005	15,974

The cost breakdown are listed in Tables 3.5.1 and 3.5.2 by stretches or tributaries.

3.5 Economic Evaluation

3.5.1 Benefit

The cumulative annual average probable flood damages under the 1989 condition without the project are estimated for flood frequencies of 1.05, 2, 5, 10, 25, 50 and 100 years. The amount of these annual average probable flood damages which can be reduced by the flood control structural measures (river improvement, dams, retarding basins, and floodways) is accounted for by the flood control benefit at 1989 constant price level.

The study estimates the following two benefit flows during the project life of 50 years:

a) Current Development Level (Constant benefit flow through project

life)

b) Future Development Level (Future growth of benefit flow)

Since the benefit flow of the current development level, which assumes the damageable assets and indirect damage to be unchanged through the project life, does not reflect the actual condition of the future damages in the Study Area correctly, the benefit flow of the future development level is adopted for assessing viability of the project, while that of current development level is used as supplemental information for sensitivity analysis.

For projecting the future benefit flow, cases of high growth and low growth are reviewed. The high growth case assumes that the region's damageable assets and indirect damages will increase at the same rate as the region's targeted GRDP growth rate (projected by NEDA) while the low growth case assumes that those of the region will increase at the same rate taken from the actual performance of the region's economy during the period 1975-1982. The projected growth rates are as follows:

	1989	1990	1991	2000	2001	2010	2044
High Growth Case							
.GRDP Growth Rate(%/yr)	5.9	5.9	5.2	5.2	5.6	5.6	5.6
Low Growth Case							
.GRDP Growth Rate(%/yr)	5.2	5.2	5.2	5.2	5.2	5.2	5.2

In this study the low GRDP growth case is adopted because it will reflect more realistic future damages in the Study Area.

3.5.2 Project Evaluation

The result of the economic benefit cost analysis justifies that the Long Term Plan is economically viable with the economic internal rate of return of 20.5% in the whole Study Area.

	EIRR(%)
Agno River with Tarlac	16.6 (3.9)
Agno River Tributaries	15.5 (3.1)
Allied Rivers	33.8 (15.2)
Whole Study Area	20.5 (6.5)

The EIRR in the parentheses is the current development level case.

If all the river improvement works of the Long Term Plan are implemented by the end of year 2009, the monetary and non-monetary benefits will be attained as summarized below.

Flood Protection

- Agno River and its tributaries; 25-year flood
- Pantal-Sinocalan River and Cayanga-Patalan River ; 10-year flood

Benefited Area (protected area)

- 1,400 km^2 ; 57% of the potential inundation area

Benefited Resident (protected people)

- 2.1 million at 2010 ; 65% of the residents in the Study Area or 90% in the potential inundation area

Annual Average Economic Benefit

- 1.03 billion pesos/year at 1989
- 3.31 billion pesos/year at 2010 (1989 price level)

Other Non Monetary Benefits

- Reduction in water-borne parasitic diseases which usually break out after large floods
- Reduction in loss of lives
- Enhancement of socio-economic stability in the Study Area
- Creation of job opportunities to the local people both in the Study Area and surrounding impact areas
- Increase in national income both in the Study Area and surrounding impact areas particularly Ilocos Region.

3.6 Implementation Schedule

3.6.1 Priority Project Areas Subject to Feasibility Study

(1) Alternative Priority Flood Control Areas

Among the areas under the Long Term Plan, the priority flood control areas are to be identified for pursuing the Feasibility Study. The priority flood control areas are defined as:

a) The areas where existing and potential flood damages are high, and their flood protection measures are required to be implemented urgently with the highest priority.

b) The areas where flood control performance is high in terms of economic efficiency and social and regional impact.

c) The areas whose discharge carrying capacity is less than the 10-year design flood.

The Long Term Plan areas are assessed for the 10-year design flood in terms of flood control efficiency (EIRR; economic internal rate of return). The main stream of the Agno River is divided into four stretches for assessment: the downstream stretch (river mouth-AG180), Bayambang-Poponto swamp area (AG180-AG309), the upstream stretch (AG309-AG473), and the Tarlac River (AG180-TA265). The four Agno River tributaries (Camiling, Banila, Viray-Dipalo, Ambayoan) are assessed independently. The Pantal-Sinocalan and Cayanga-Patalan Rivers are also assessed independently as a whole.

Since construction of a new diking system in the upstream stretch (AG309-AG473) of the Agno River will confine flood runoff inside the new river area and induce significant increase of flood discharge in the downstream stretches (river mouth to AG309), the improvement of the upstream stretch can only be implemented together with the improvement of the Bayambang stretch including the new Poponto floodway or the whole river improvement. Under this precondition, three alternatives, Cases 1 to 3 are formulated for the Agno River main stream (river mouth to AG473).

(2) Selection of Priority Project Areas

The following three significant flood control areas are identified based on the result of economic assessment tabulated in Table 3.6.1:

Priority No.1 Upper Agno River: Case 2, Bayambang stretch with Poponto retarding basin to upstream end
Priority No.2 Pantal-Sinocalan River
Priority No.3 Cayanga-Patalan River with Bued River

Among the foregoing three projects, Project-A, Upper Agno River and Project-B, Pantal-Sinocalan River are chosen as the Priority Project Areas to the retained for the Feasibility Study taking into account the economic efficiency and regional significance of flood control. The locations of these areas are shown in Figure 3.6.1.

A. Upper Agno River; Bayambang stretch (AG180) with Poponto retarding basin to the San Manuel stretch (AG473)
   . Improvement of Bayambang stretch of the main Agno River
   . Improvement of Poponto floodway
   . Improvement of Upper Agno stretch

B. Pantal-Sinocalan River; River mouth to the upstream to protect Dagupan city, Calasiao and Santa Barbara towns
   . Improvement of the main Pantal-Sinocalan River
   . Improvement of Dagupan River
   . Improvement of Ingalera River

The economic internal rate of return is preliminarily estimated to be about 24% for Project-A and 40% for Project-B under future development level.

3.6.2 Implementation Schedule

The total project cost of the Long Term Plan is estimated to be 15,974 million pesos at 1989 constant price level. The Study proposes the implementation schedule shown in Figure 3.6.2, commissioning the Long Term Plan by the beginning of the year 2020, though the optimization of the Long Term Plan was made for the commission year of 2010. In this case public funds of about 1.0% of GRDP of the Study Area will be required to be allocated to the sector for flood control.

4. THE FEASIBILITY STUDY

4.1 Flood Control Plan for Upper Agno River

4.1.1 River Improvement Plan

(1) Outline of Priority Project

The river improvement for the stretch between the Wawa bridge and the San Roque bridge in the upper Agno River, which has a total river length of about 69 km, was selected as the Priority Flood Control Project to be implemented urgently with the minimum flood protection level of 10-year design flood in conformity with the Master Plan. The design flood distribution is shown in Figure 4.1.1.

This river improvement aims primarily to restore and reinforce the diking system of the Asingan-San Manuel stretch on the right bank where flooding penetrates habitually into the Allied River basin area through the existing breaches. These works, however, confine flood flow inside the river area and induce significant increase of flood run-off in the downstream reaches. In this respect, this improvement should be implemented together with reinforcement of the Alcala-Asingan and Bayambang-Alcala stretches, and construction of the new Poponto floodway and natural retarding basin. The Poponto floodway and natural retarding basin aim to regulate the confined flood discharge in the lower Agno River stretch within an allowable level. The general plan of the project is shown in Figure 4.1.2.

(2) River Improvement Plan

The proposed river improvement plan for the upper Agno River is composed of the following three major works in view of the river regime and channel conditions:

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)

a) Bayambang - Alcala Stretch

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

- Construction of a new dike downstream of the Calvo bridge
- Demolition of the existing Poponto inlet weir and construction of a new Poponto floodway together with channel improvement thereof
- Construction of a new distribution channel at the bifurcation point of the floodway leading to the Bayambang stretch

The layout and typical cross-sections are shown in Figure 4.1.3 (1/5). The design features including river width and dike height are summarized in Table 4.1.1.

Diversion and Distribution Facilities

To prevent the Bayambang stretch from overtopping the design flood discharge for the Bayambang stretch and the floodway are planned to be controlled with the following distribution:

Flood control Plan	Design flood (m^3/sec)	Distributed flood (m^3/sec)	
		Bayambang Stretch	Poponto Floodway
Framework (100-year flood)	9,200	1,000	8,200
Priority project (10-year flood)	4,000	500	3,500

A non-gated distribution channel is adopted in order to ease operation and maintenance.

With these diversion and distribution facilities about 15% (5.0 m^3/s) of the monthly average (33 m^3/s) of the dry season river flow can be distributed to the Bayambang stretch, fulfilling the existing irrigation water use of about 2 m^3/s.

Floodway

The 1,200 m wide floodway is planned by providing a new setback levee on the right bank outside the existing 850 m wide floodway and one in the downstream part on the left bank. Widening of the floodway is required to ease fluctuations of the river bed due to scouring and to mitigate dynamic hydraulic forces acting on the right bank which might loose stability of the guide wall structure of the right bank.

(b) Carmen Stretch in Alcala - Asingan Stretch

This stretch forms a bottleneck near the Carmen bridge with a 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

In the Framework Plan it is a prerequisite to widen the existing river width at least to 900 m because of significant degradation of the river bed (about 2 m in case of the 100-year flood). The new setback levee on the right bank is proposed to be implemented as a part of the Priority Project because the land acquisition and resettlement issues after completion of the project are expected to be much more significant.

The design cross-section of the concrete dike heightening is adopted after comparative study with an earthdike heightening plan which involves land compensation and evacuation of the residents along the left bank. The design features including river width and dike height are summarized in Table 4.1.1.

(c) Asingan - San Manuel Stretch

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

The general layout of the plan and the typical cross-sections are shown in Figure 4.1.3 (4/5)-(5/5). The design features including river width and dike height are summarized in Table 4.1.1.

The new setback levee on the right bank is aligned over the paddy land alongside the old river channel area in the stretch between stretch AG470 in the downstream of the ARIS intake dam and stretch AG453 at the junction of the Ambayoan River in consideration of the following technical aspects:

a) Flow velocity in this stretch is assessed around 3.6 m/sec - 5.5 m/s for the 10-year probable flood.
b) Foundation of the old river areas along the existing breaches (AG421 - AG470) on the right bank is highly permeable due to sand and gravel formation therein.

The existing damaged diking system is planned to be maintained as a guide wall to prevent flood flow from colliding directly against the new setback levee.

Since sandy gravels are heavily deposited in the upstream stretch of the junction with the Viray-Dipalo River located at the tip of the alluvial fan, maintenance works for the low water channel would not overcome the supply of heavy sediment conveyed from the upstream basin. The improvement and training works for the low water channel is recommended to be followed after the completion of the San Roque dam which traps the majority of sediment supply inside its reservoir.

(3) Principal Design Features

Principal features of the design channel are shown in Table 4.1.1 and are summarized below:

Stretches	Bayambang - Alcala	Poponto Floodway	Alcala -Asingan	Asingan -San Manuel
Design discharge(m^3/s)	500	3,500	4,000-3,500	3,500-2,400
River width(m)	1,300-250	1,200	3,000- 900	3,000- 300
Gradient of channel bed	1/1,850	1/1,600	1/1,600-1/665	1/665-1/230
Channel bed width(m)	100	150	150	Existing
Design water depth(m)	7.85-3.79	8.78-5.85	5.85	5.85-3.30

The typical cross-sections are illustrated in the insets of Figure 4.1.3 (1/5)-(5/5).

The items of river improvement works in the Priority Project area are summarized as follows:

- 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 (against liquefaction)
- 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 facilities : Bayambang diversion channel
- Irrigation facilities : 2 box culverts with gates of the LAIS
- Bridges : 3 road bridges (Calvo/Floodway/Plaridel) and 2 railway bridges demolished

The quantities of dikes and channel improvements are listed by river stretch in Table 4.1.2.

(4) Inner-Water Drainage in Alcala Area

With provision of the Poponto floodway right dike and the Bayambang left dike, inner-water in the Alcala area is confined inside a drainage area of about 12 km^2.

The present land use in this area is classified into mostly paddy field and residential land. The former is in the area around the ground elevation

from 13.0 m to 17.0 m, the latter has the ground elevation from 15.5 m to 16.0 m (M.S.L.). On the other hand, the water levels of 5-year and 10-year probable floods in the Poponto natural retarding basin are 14.1 m and 15.6 m respectively. The inner-water drainage system with 4 drainage gates and the mound construction with a 15 m minimum top elevation are proposed to mitigate submergence damages.

4.1.2 Poponto Retarding Basin Plan

(1) Retarding Basin Plan

Outline of Retarding Basin Plan

Poponto retarding basin naturally regulates the flood inflows from the Upper Agno and Tarlac Rivers without specific flood control facilities other than construction of the dikes on both abutments of the Wawa bridge. 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 condition.

The maximum high water level of the existing Poponto swamp is simulated to be around El. 14.50 m in case of a 10-year design flood with breaches in the Upper Agno River. This water level is expected to be raised up to the design high water level of El. 16.00 m in case of the river improvement works of the Upper Agno because all the flood runoff in the upstream is confined inside the new dike system as illustrated in Figure 4.1.4. The inundation area will increase from 124 km^2 to 203 km^2. Affected number of buildings and houses will increase from 4,420 to 11,390 including public facilities while the affected population will increase from 26,000 to 68,000. Agricultural land and swamp area, and residential and commercial area amounts to 97% and 3% of the inundation area respectively.

Of the affected population of 68,000, 44,000 residents (65%) are planned to be protected by ring levees. The remaining 24,000 (35%) are planned to be resettled to either planned mounds, to the areas inside the ring levees, or to the areas outside the retarding basin. The general plan of these measures is presented in Figure 4.1.5.

Design High Water Level and Freeboard of Retarding Basin

The design high water level of H.W.L 16.00 m is adopted for the Poponto retarding basin.

The crest elevation of the ring levee is set at El. 17.20 m with a 1.2 m freeboard over the H.W.L 16.00 m while the top elevation of the mound for resettlement is set at El. 16.60 m with a 0.6 m freeboard against wind waves over the H.W.L 16.00 m.

(2) Land Use, Resettlement Compensation

The affected population, infrastructures, and land in the expected inundation area of the Poponto retarding basin are roughly estimated for the high water level of El. 16.00 m as summarized below:

Affected Residents

Municipality	Inundation Area (km^2)	Number of Houses	Population
Moncada	104.1	5,530	33,180
Bautista	39.3	780	4,680
Paniqui	32.4	4,260	25,740
Camiling	21.7	440	2,640
Bayambang	2.5	370	2,220
Alcala	1.7	10	60
Anao	1.3	0	0
Total	203.0	11,390	68,340

Affected Infrastructures

Road	National	9.0 km
	Provincial	7.5 km
	Municipal	10.5 km
	Barangay	24.5 km
Bridge	San Isidro (length 62.4 m, width 6.9 m)	
	Camangahan (box curvert)	
	Morong (length 30.0 m, width 6.9 m)	
Rail Road	(non-operational)	23.3 km

Affected Land

Agriculture	Irrigated Paddy	8.7 km^2
	Rainfed Paddy	122.0 km^2
	Sugar Cane	7.5 km^2
	Corn	25.8 km^2
	Tobacco, root crops, etc.	32.7 km^2
Fish pond		0.8 km^2
Residential/Commercial		5.5 km^2

(3) Protection Measures and Resettlement

The residents inside the retarding basin are planned to be protected by either ring levees or resettlement as summarized below.

Protection Measures	Number of Houses	Number of Residents	Share (%)
1) Ring levees	7,430	44,580	65
2) Resettlement			
a) Resettlement to the planned mounds	640	3,840	6
b) Resettlement to the areas inside the ring levees	2,120	12,720	19
c) Resettlement to the areas outside the retarding basin	1,200	7,200	10
Total	11,390	68,340	100

Heightening of roads and improvement of bridges are planned. The rail road is kept untouched because of no concrete operation plan at the present.

Ring Levees

Ring levees are provided for Bautista, Moncada and Paniqui municipalities as set out below. The locations and alignment are illustrated in Figure 4.1.5.

Municipality	Municipality, Barangay	Protected Area (Km^2)	Levee Length (Km)	Protected Houses (Nos.)
Bautista	Poponto	0.11	1.49	240
Moncada	Moncada	5.07	9.76	3,530
	Tubectubang	0.12	1.40	240
	San Julian	0.69	4.20	430
Paniqui	Paniqui	2.09	3.78	360
	Ines	0.14	1.92	250
	Pance	0.10	1.98	550
	Salomague	0.39	3.70	500
	Baladang	0.20	1.70	450
	Ventemilla	3.17	6.78	880
Total		12.08	36.71	7,430

Resettlement Program

Resettlement program is prepared for the residents who can not be protected by ring levees. The inundation area, other than those protected by the ring levee plan, is divided into 14 blocks (from A to N). An appropriate resettlement program is formulated for each block. The mobilization flow of the resettlement is illustrated in Figure 4.1.6.

Mounds for Resettlement

Mound construction is planned for the residents of Barangay Spang and San Isidro as set out below.

The locations and alignment are illustrated in Figure 4.1.5.

Municipality	Barangay	Area of Mound (m^2)	Resettled Houses (Nos.)
Moncada	Spang	111,000	480
Paniqui	San Isidro	40,000	160
Total		151,000	640

Road Heightening

Heightening is planned for the selected major road systems as setout below. The subject parts are illustrated in Figure 4.1.5.

Road Class	Route	Length (km)	Width (m)	Type of Pavement	Maximum Heightening (m)
National	Moncada-Paniqui	5.3	7.3	Asphalt	1.40
Provincial	Babilang-Paniqui	4.4	6.1	Concrete	1.45
	Aman Casiling -San Vicente	1.6	7.3	Asphalt	3.60
Municipal	Sapang-Moncada	6.9	5.5	Gravel	2.60

Bridge Improvement

Extension of San Isidro bridge, and replacement of Camangahan bridge and Morong bridge are planned. These bridge locations are illustrated in Figure 4.1.5. Replacement of the Wawa bridge will not be required unless the Framework Plan is implemented.

4.2 Flood Control Plan for Pantal-Sinocalan River

4.2.1 Outline of the Priority Project Plan

As a stage development plan of the Framework Plan, the Long Term Plan was formulated with the optimum development scale of a 10-year probable flood. As a step to the Long Term Plan, the river improvements for the downstream stretch of the Pantal-Sinocalan River (27.5 km), the Dagupan River (19.5 km) and the Ingalera River (10.7 km) were selected as the priority flood control project to be urgently implemented.

The downstream reaches of the Pantal-Sinocalan river subject to river improvement lies in the urban area of Dagupan City. After comparative study of alternative river improvement plans, the bypass channel plan which serves to minimize technical and socio-economic issues expected to be induced by river improvement thereof is adopted for the Feasibility Study.

Along this line, the design flood discharge distribution for the Priority Project is updated as shown in Figure 4.2.1.

4.2.2 Priority Project Plan

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

i) Main Pantal-Sinocalan River: from river mouth to upstream of the Catablan River junction (27.5 km)
   . River improvement in the upstream and downstream reaches
ii) Dagupan River: from Bypass channel junction to upstream of Elang River junction (19.5 km)
iii) Ingalera River: from Pantal-River junction to downstream of Bogtong bridge, Sta. I.8 + 0.8 km (10.7 km)

a) Main Pantal-Sinocalan River

River Improvement in the Downstream Reach

The river improvement works of the downstream reach of the Pantal-Sinocalan River consist of the following two components:

- the Pantal river stretch from the river mouth to the junction with the Sinocalan River
- the bypass channel for the urban stretch of the Sinocalan River (the Marusay River)

Pantal river

The minimum design river width of the Pantal River is set at 400 m with a rectangular cross section. A closure dike having a watergate is provided across the Caloocan River on the left bank. A water gate is provided across the Bolosan River on the right bank. The plan is shown in Figure 4.2.2 (1/4).

It is assessed that the project will not aggrade the existing condition of the Pantal River mouth in terms of sediments.

Bypass channel

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 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. The plan and the cross section are shown in Figure 4.2.2 (1/4).

Water gates for Marusay stretch

Two water gates are provided for flood control of the urban stretch (Marusay stretch) of the Sinocalan River: a lower gate at the junction with the Pantal River and an upper gate at the inlet from the bypass channel. These gates are opened during low flow discharge and closed when the flood at the inlet exceeds the 95 - day discharge (about 30 m^3/s). The existing carrying capacity of the Marusay stretch is about 300 m^3/s during high tide.

The design width of the intake channel and the upper closure gate at the inlet is planned at 10 m while the low water channel bed width of the bypass is 40 m. The 10 m wide water gates are provided as the lower water gate.

In the Marusay stretch, the water quality during the dry season is assessed to be well controlled by tidal seawater intrusion and partly by the fresh water (i.e., low flow of about 3.0 m^3/s).

Water Use in Marusay stretch

The existing water use in the Marusay stretch is navigation only. There is no water use for irrigation and domestic water supply because the river water in this stretch is affected by seawater intrusion.

Navigation in this stretch is mostly by community traffic small boats (about 5,000 person trip/day), and fishing boats except a few naval ships and dredgers. The community boat transports and small fishing boats can be maintained through the 10 m wide water gate while the vertical clearance of the gate is not sufficient for the 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.

River Improvement in the Upstream Reaches

The river improvement works of the upstream reach of the Sinocalan River consist of the following works:

- 27.5 km long diking system having design river widths of 200 m to 100 m and low water channel widths of 30 m to 25 m.
- Improvement or replacement of 9 road bridges and connection roads.
- Elimination of a railway bridge.
- Provision of a culvert structure for the rubber irrigation intake gate at Santa Barbara planned by NIA.

b) Dagupan River

The river improvement works of the Dagupan River consist of the following works:

- 19.5 km long diking system (from the outlet with the proposed bypass channel to the stretch D.27 + 0.5 km near San Carlos) having design river widths of 100 m to 400 m
- Enlargement of the existing low water channel having a design width of 25 m including short-cuts

The required stretch for river improvement with a 10-year design flood is extended to the upstream end of the section affected by the back water due to the design flood of the main Pantal-Sinocalan River. The design plan is shown in Figure 4.2.3 (1/2)-(2/2).

c) Ingalera River

The river improvement works of the Ingalera River consist of the following works:

- 10.7 km long diking system (from the junction with the Sinocalan River to the stretch I.18 + 0.8 km, upstream of Malasiqui downstream of Bogtong bridge) having design river widths of 100 m to 120 m
- Enlargement of the existing low water channel having design widths of 15 m to 20 m including shot-cuts

The river stretch for improvement works is also determined based on the same design concept of the Dagupan River. The design plan is shown in Figure 4.2.4 (1/2)-(2/2).

(3) Principal Design Features

a) Design Channel Features of the River Improvement Plan

Principal design features of the proposed river improvement plan are shown in Table 4.2.1 and are summarized below:

Main Pantal-Sinocalan River

River/Stretch	Pantal-Sinocalan		
	River mouth - Ingalera R.	Ingalera R. - Catablan R.(P59)	P 59 - P 70
Design discharge (m^3/s)	2,000-1,250	1,250-650	650-350
River width (m)	600-220	200-150	100
Gradient of channel bed	1/2,350	1/1,850	1/1,150
Channel bed width (m)	60-40	30	25
Design water depth (m)	6.6	6.6-5.95	5.95-5.14

Dagupan and Ingalera Rivers

River/Stretch	Dagupan R.		Ingalera R.	
	By-pass - Capangbogan R.	Capangbogan R. - Elang R.	Sinocalan R. - Marasiqui	Marasiqui - I.
Design discharge (m^3/s)	700-550	400	360	260
River width (m)	450-150	100	120	100
Gradient of channel bed	1/10,000	1/5,800	1/5,000-2,500	1/1,800
Channel bed width (m)	Existing	25	20	15
Design water depth (m)	6.6-6.0	6.0-6.6	6.6-6.3	6.1

b) Work Items

The items of the river improvement works are summarized below:

Major Work Items	Pantal-Sinocalan R.	Dagupan R.	Ingalera R.
. New earth dike (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.)	16	11	3
. Bridges (pcs.)	5	5	4
. Water intake (pcs.)	4	17	0

4.3 Non-Structural Measures

4.3.1 Flood Control Operation and Maintenance System

The flood forecasting and warning system (FFWS) is defined as one of the non-structural components of the Flood Control Plan.

FFWS for the Priority Project Plan considers mainly the functions for Flood Operation: flood control operation and maintenance of the prospective flood control facilities constructed in the Priority Project Plan.

The flood control operation and maintenance system is planned as an extension of the existing FFWS in order to minimize facility costs.

This system requires the following institutional arrangement:

a) PAGASA allows AFCS-DPWH to install new data communication and monitoring equipment in the AFCS office which is to be connected with the existing telemetry equipment in Rosales FFWS sub-center.

b) AFCS-DPWH takes the responsibility of the operation and maintenance of the prospective new communication and operation systems and safety of the flood control facilities.

The unit components of the extension to the existing system are described below.

AFCS Control Office

The AFCS control office will be located at Rosales and all the activities for flood operation and maintenance of facilities will be managed by this office. The equipment to be installed is:

- Data communication and monitoring equipment connected with the existing telemetering equipment in Rosales FFWS sub-center
- Multiplex telecommunication equipment
- Telecommunication equipment for O & M
- Power supply equipment

Dagupan Branch Office

This office will be newly established to operate and maintain the systems in Dagupan city area. The equipment to be installed is:

- Data communication and monitoring equipment
- Multiplex communication equipment
- Telecommunication equipment for O & M
- Power supply equipment

Flood Control Facilities

An operation room is provided to the major flood control facilities. The equipment to be installed is:

- Radio telephone equipment
- Antenna equipment
- Water level gauge station and monitoring equipment

The telecommunication network between the AFCS and flood control facilities aims to exchange information such as flood condition, rainfall, water level, and operating condition of flood control facilities.

The total equipment and facility costs of the proposed system are roughly estimated at about 38 million pesos (1991 price level).

4.3.2 Monitoring of Sedimentation

Poponto Retarding Basin

The design sediment volume of the Poponto retarding basin is estimated based on some assumptions because no sediment records are available for this area. Monitoring of sedimentation in the Poponto swamp area is recommended in order to get reliable quantitative sediment data which will be required for implementing future flood control plans.

River Mouth Clogging of Pantal-Sinocalan River

In order to monitor the transition of the river mouth of the Pantal River, a cross section survey is recommended to be executed once a year, by at least the end of the dry season.

4.4 Project Cost Estimates

4.4.1 Cost Estimation Criteria

Basic Conditions

The same cost estimation criteria applied to the Master Plan in Section 3.4 is also applied to the Feasibility Study except:

a) The price level is as of May, 1991.
b) Foreign currency conversion rates are US$1.00 = ₱27.80 = ¥139.00

Price Escalation

The unit costs used in the Master Plan Stage (June 1989) and the unit costs adopted in this Feasibility Study (May 1991) are compared. The average escalation rates of materials, equipment, labors are 50%, 30%, and 80% respectively in the period 1989 - 1991. The average escalation rate of the financial unit costs is about 40%.

4.4.2 Project Costs

The work quantities of the proposed Priority Projects, the Upper Agno River and the Pantal-Sinocalan River, are summarized:

Work Item	Unit	Upper Agno			Pantal-Sinocalan		
		Stage-1	Stage-2	Total	Stage-1	Stage-2	Total
Excavation	1000m^3	4,784	3,634	8,418	1,243	2,105	3,348
Dredging	1000m^3	0	0	0	160	20	180
Embankment	1000m^3	4,852	446	5,298	1,806	2,482	4,288
Revetment	km	32	20	52	12	12	24
Groyne	pc.	54	61	115	0	39	39
Sluiceway	pc.	32	6	38	14	30	44
Water Gate	pc.	0	0	0	4	5	9
Bridge	m^2	8,524	2,046	10,570	11,048	8,609	19,657
Compensation							
House	unit	4,692	188	4,880	1,442	1,084	2,526
Land	ha	1,179	28	1,207	273	299	572

Upper Agno River Project

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, as shown in Table 4.4.1 and Table 4.4.2.

Unit: Million Pesos

Item	First Stage	Second Stage	Total
Financial Cost	2,923.4	989.8	3,913.2
Economic Cost	2,522.6	923.3	3,475.9

Pantal-Sinocalan River Project

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, as shown in Table 4.4.3 and Table 4.4.4.