JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)

REPUBLIC OF THE PHILIPPINES
DEPARTMENT OF PUBLIC WORKS AND HIGHWAYS

THE STUDY ON SABO AND FLOOD CONTROL IN THE LAOAG RIVER BASIN

FINAL REPORT

VOLUME I

SUMMARY

DECEMBER 1997

CTI ENGINEERING CO., LTD.
IN ASSOCIATION WITH
SANYU CONSULTANTS INC.
PASCO INTERNATIONAL INC.

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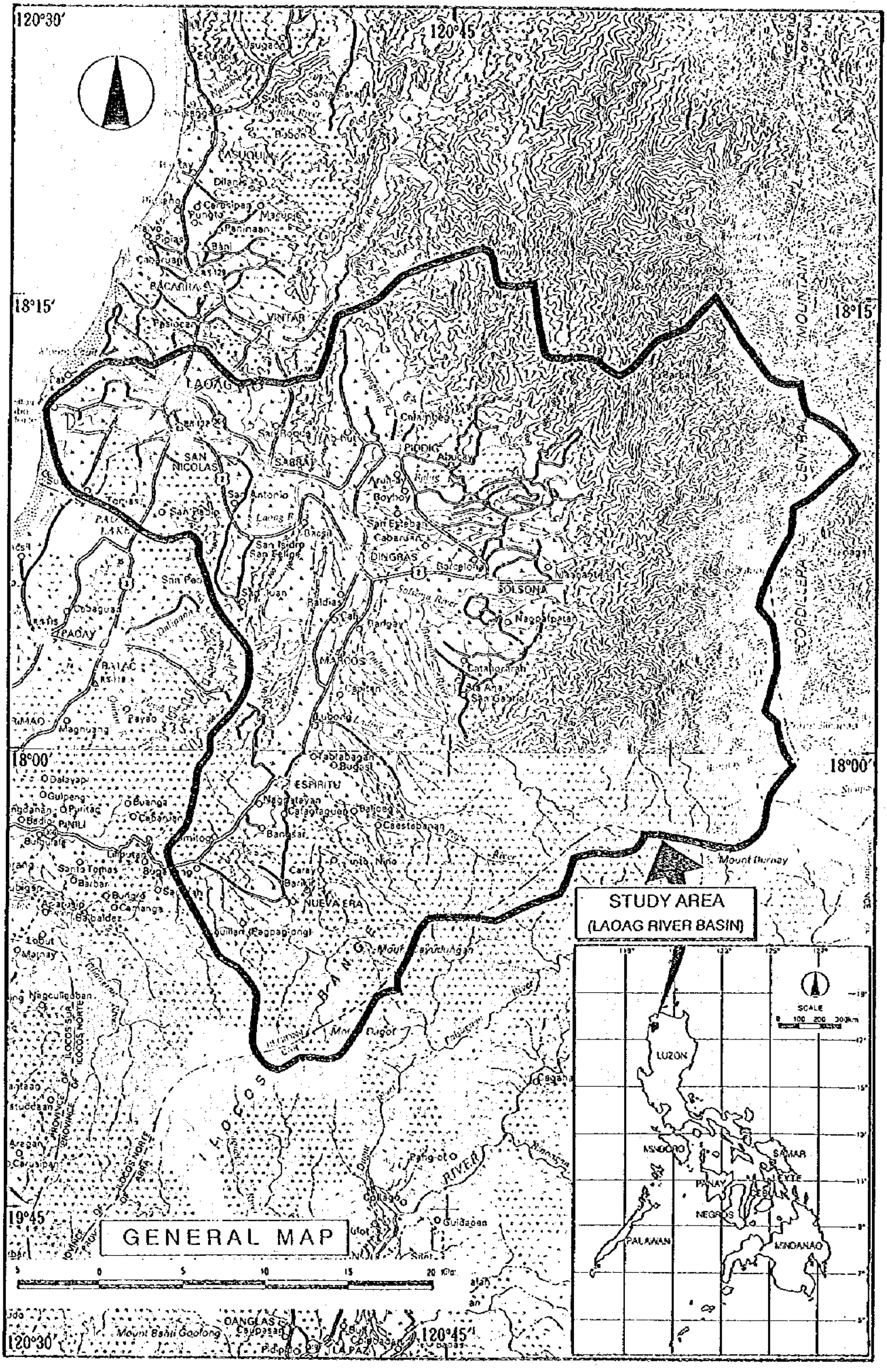
The cost estimates in this Study are based on the price levels indicated below and expressed in Philippine Peso according to the following exchange rates:

Master Plan	:	US$1.00 = Philippine Peso 26.00 = Japanese Yen 105, as of August 1996
Feasibility Study	:	US$1.00 = Philippine Peso 26.00 = Japanese Yen 115, as of June 1997



GENERAL MAP
STUDY AREA
(LAOAG RIVER BASIN)
120°30′
120°45′
18°15′
18°00′
LAOAG
SAN NICOLAS
SARRAT
PIDDIG
DINGRAS
SOLSONA
MARCOS
ESPIRITU
NUEVA ERA
VINTAR
BACARRA
PASUQUIN
PAOAY
BATAC
PINILI
CORDILLERA CENTRAL MOUNTAIN
LUZON
MINDORO
SAMAR
LEYTE
PANAY
CEBU
NEGROS
PALAWAN
MINDANAO
SCALE

PREFACE

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

JICA sent to the Philippines a study team, headed by Mr. Naohito Murata, Senior Chief Engineer, Overseas Department, CTI Engineering Co., Ltd. and composed of members from CTI Engineering Co., Ltd., Sanyu Consultants Inc. and Pasco International Inc., four times between March 1996 and December 1997.

The team held discussions with the officials concerned of the Government of the Republic 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, 1997

KIMIO FUJITA
President
Japan International Cooperation Agency

December 1997

Mr. Kimio Fujita
President
Japan International Cooperation Agency
Tokyo, Japan

Sir:

LETTER OF TRANSMITTAL

We are pleased to submit herewith the Final Report for the Study on Sabo and Flood Control in the Laoag River Basin, Republic of the Philippines. The report contains the advices and suggestions of authorities concerned of the Government of Japan and the Japan International Cooperation Agency (JICA), as well as the formulation of the sabo and river improvement projects for the Laoag River Basin and the urban drainage improvement project for Laoag City. Also included are the comments made by the Department of Public Works and Highways, Government of the Republic of the Philippines, during the technical discussion on the Draft Final Report in the Philippines.

The Final Report presents the Master Plan of Sabo and Flood Control in the Laoag River Basin. It also presents the Feasibility Study on priority sabo and river improvement projects for the Basin, including the urban drainage improvement project for Laoag City.

In view of the urgency and necessity of socio-economic development, we recommend that the Government of the Republic of the Philippines should adopt all means possible to promote the priority sabo and river improvement projects for the Basin and the urban drainage improvement project for Laoag City to the next stage of project implementation at the earliest possible time.

Finally, we wish to take this opportunity to express our sincere gratitude to the Government of Japan, particularly, JICA, the Ministry of Foreign Affairs, the Ministry of Construction and other offices concerned. We also wish to express our deep appreciation to the Department of Public Works and Highways and other authorities concerned of the Government of the Republic of the Philippines for their close cooperation and assistance extended to the JICA Study Team during the Study.

Very truly yours,

村田直人

NAOHITO MURATA
Leader
JICA Study Team

Encl.: a/s

EXECUTIVE SUMMARY

1. INTRODUCTION

The Laoag River is located in Ilocos Norte Province in the northern part of Luzon Island. The river system drains an area of 1,332 km^2 into the South China Sea at Laoag City, the capital of the province. The Basin is damaged due to severe flooding and sediment deposition by typhoon every year (refer to Fig. I). Sediment and flood control works are essentially necessary for the development of the Basin.

Laoag City is affected by not only floods of the Laoag River but also flooding by local storm water. Urban drainage improvement in the City is also urgently necessary.

In response to the request of the Government of the Republic of the Philippines (GOP), the Japan International Cooperation Agency (JICA) conducted the Study on Sabo and Flood Control in the Laoag River Basin from March 1996 to November 1997. The objectives of the Study are:

(1) To formulate a master plan on sabo and flood control for the Laoag River Basin;

(2) To conduct a feasibility study on the urgent and/or priority project(s) identified in the master plan;

(3) To conduct a feasibility study on urban drainage for Laoag City; and

(4) To pursue technology transfer to the counterpart personnel of the GOP in the course of the Study.

2. LAOAG RIVER SABO AND FLOOD CONTROL

2.1 Flooding Problems

The Laoag River system consists of six (6) principal rivers: Laoag, Bongo, Cura/Labugaon, Solsona, Madongan and Papa. The Solsona, Madongan and Papa rivers are confined by temporary dikes, while the other rivers flow within natural banks. The Basin is flooded every year due to the small flood carrying capacity of the rivers.

The eastern watersheds of the Basin are highly weathered and denuded, yielding much sediment. Excessive sediment runoff from the mountains further worsen the flood situation of the rivers, especially in the alluvial fan areas. The probable flood damage by a 25-year flood is estimated as shown below.

Item	25-Year Flood
Inundation Area (ha)	17,290
Affected Population	61,118
Damageable Assets	
Houses/Other Buildings (unit)	12,584
Agricultural Production (ha)	10,988
Probable Damage (million peso)	696.1

Note: Probable damage is estimated at 1996 prices.

2.2 Master Plan

(1) Flood Protection Target

The master plan is arranged to meet the design flood with a return period of 25 years. The plan will protect a total inundation area of 15,300 ha and relieve some 57,600 residents in the potential inundation area of the 25-year flood mentioned above.

(2) Proposed Structural Plan

Eight (8) sabo dams and twelve (12) river improvement projects are proposed to protect the potential inundation area. The main features of the proposed sabo dams and river improvement projects are shown below.

Sabo Dam

Sabo Dam	C.A. (km^2)	Design Sedimentation Capacity (m^3)
Cura No. 1	68.2	391,000
Cura No. 2	63.1	150,000
Labugaon No. 1	100.5	1,043,000
Labugaon No. 2	90.9	511,000
Solsona No. 1	72.2	233,000
Solsona No. 2	68.2	233,000
Madongan	153.8	2,192,000
Papa	51.4	707,000
Total		5,460,000

River Improvement

River	Improv. Length (km)	River Width (m)	Dikes Const. (m)	Bank Protection (m)
Laoag-Bongo River	30.0	300-1,000	30,000	
Tangid Laoag	6.5		6,500	
Suyo Laoag	2.1		2,100	
Pob. Laoag	1.5		1,500	
Camangaan Laoag	4.0		4,000	
Pob. San Nicolas	3.0		3,000	
San Manuel Sarat	3.6		3,600	
Suyo Dingras	3.7		3,700	
Pob. Dingras	5.6		5,600	
Cura/Labugaon River	13.5	200-340	21,900	22,200
Solsona River	11.0	230-330	10,900*	13,700
Madongan River	9.0	300	4,000*	17,500
Papa River	7.0	223	1,000*	12,400
Total	70.5		67,800	65,800

Note: * : strengthening of existing dikes

(3) Project Cost

The total project cost is estimated at 2,177.8 million pesos at August 1996 prices.

(4) Project Benefits

(a) The project will protect a total flood prone area of 15,300 ha with a resident population of 57,600.

(b) The project will prevent land loss. Farmland of 52 ha has been washed out on annual average in the alluvial fan areas.

(c) The project is expected to restore the devastated land of 1,800 ha into land available for grazing and crop cultivation.

(d) The project will contribute to the improvement of public health, social amenity, etc.

(5) Nonstructural Measures

The following nonstructural measures are recommended to supplement the sediment and flood control capacity of the proposed structural measures.

(a) Extension of the ongoing reforestation projects.

(b) Establishment of flood forecasting/warning and flood fighting systems.

(c) Promotion of land use management in the high flood risk areas.

2.3 Priority Project Plan

(1) Objective Projects and Target Flood Protection Areas

Five (5) sabo dams and seven (7) river improvement projects are selected as the priority projects from the eight (8) sabo dams and 12 river improvement projects proposed in the Master Plan.

The priority projects and their target flood protection districts, areas and resident population are tabulated below.

River	Objective Project	Protection District	Area (ha)	Population
Laoag	Pob. Laoag R/I	Pob. Laoag	330	6,203
Laoag	Pob. San Nicolas R/I	Pob. San Nicolas	230	5,835
Laoag-Bongo	Pob. Dingras R/I	Pob. Dingras	550	4,228
Cura/Labugaon	Cura Sabo Dam No. 1 Labugaon Sabo Dam No. 1 Cura/Labugaon R/I	Cura/Labugaon River	3,900	11,115
Solsona	Solsona Sabo Dam No. 1 Solsona R/I	Solsona River	2,280	7,152
Madongan	Madongan Sabo Dam Madongan R/I	Madongan River	4,180	8,764
Papa	Papa Sabo Dam Papa R/I	Papa River	1,950	4,651
Total			13,420	47,948

Note: Pob. : Poblacion, R/I : River improvement

(2) Project Plan

The priority sabo dams and river improvement projects are designed based on more detailed field surveys. Their design flood discharges are the same as proposed in the Master Plan. The main features and works of the proposed sabo dam and river improvement projects are tabulated below. Their locations are shown in Fig. II.

Laoag-Bongo River Improvement

Item	Pob. Laoag	Pob. San Nicolas	Pob. Dingras	Total
Improvement Length (km)	3.49	4.20	5.45	13.14
Earth Dike (m)	2,250	4,200	5,150	11,600
River Wall (m)	1,240	-	300	1,540
Revetment (m)	160	-	300	460
Spur Dike (unit)	-	5	-	5
Sluiceway (unit)	2	2	1	5
Compensation				
Land (ha)	6.1	9.9	13.0	29.0
House (No.)	-	-	3	3

Note: Pob. : poblacion

Sabo Dam

Item	Cura No. 1	Labugaon No. 1	Solsona No. 1	Madongan	Papa	Total
C.A. (km^2)	68.2	100.5	72.2	153.8	51.4	
Sediment Capacity (1,000 m^3)	422	1,197	242	2,207	794	4,862
Dam Type	floating	fixed	fixed	floating	floating	
Dam Height (m)	9.0	17.0	12.0	10.5	9.0	
Dam Length (m)	183	118	118	183	233	
Sub-dam Height (m)	4.0	7.5	4.0	4.5	3.5	
Apron (unit)	1	-	-	1	1	
Concrete Vol. (m^3)	15,100	16,900	5,200	20,800	16,900	74,900
Compensation						
Land (ha)	0.4	-	0.1	-	1.0	1.5
House (No.)	-	-	-	-	-	-

Note: C.A. : catchment area

Alluvial Fan River Improvement

Item	Cura/Labugaon River	Solsona River	Madongan River	Papa River	Total
Improvement Length (km)	12.7	11.0	9.0	7.0	39.7
River Width (m)	200-340	230-330	300	223	
Earth Dike (m)	21,500	16,000*	10,000*	4,500*	52,000
Channel Excavation (m^3)	992,000	-	-	-	992,000
Spur Dike (unit)	349	302	394	283	1,328
Groundsill (unit)	1	1	1	1	4
Sluiceway (unit)	4	3	8	2	17
Bridge Extension (unit)	1	-	-	-	1
Compensation					
Land (ha)	10.0	-	-	-	10.0
House (No.)	-	-	-	-	-

Note: * : Strengthening of existing dikes

(3) Project Cost

The total cost of the proposed priority projects is estimated to be 1,911.3 million pesos at June 1997 prices, and at 2,333.1 million pesos including price contingency.

(4) Project Benefit

The projects will produce the following economic benefits:

(a) The projects will protect land of 13,400 ha with 47,900 resident population and mitigate flood damage on properties and crop production.

(b) In the alluvial fan areas, the projects will prevent annual land loss of 52 ha and restore the devastated area of 1,800 ha into land available for grazing and crop cultivation.

Socially, the projects will improve social amenity and public hygiene, and create temporary jobs of 1.4 million man-days during the construction period.

(2) Economic Evaluation

The economic viability of the projects is evaluated as follows:

Index	Value
Economic Internal Rate of Return (EIRR, %)	20.3
Cost-Benefit Ratio (B/C)	1.43
Net Present Value (NPV, million peso)	442

2.4 Environmental Impact Assessment

The projects have no significant adverse impacts on the environment.

Water pollution during the construction phase is the only negative impact to be managed. Water pollution sources will be the dewatering work for structural foundations, earth work operations adjacent to a stream, and aggregate processing. However, water pollution due to these works is considered not much since the riverbed materials of the project sites are mainly composed of sand, gravel and boulder with very little silt and clay.

3. LAOAG CITY URBAN DRAINAGE

3.1 Flooding Problems

Most parts of the urban area of Laoag City are directly drained into the South China Sea through the Daorao-Tupec Creek system which is hydrologically independent from the Laoag River. Only a small portion is directly drained into the Laoag River.

The urban area of Laoag City is habitually inundated due to the insufficient flood carrying capacity of the Daorao-Tupec Creek system. Flood damage concentrates on the basin of the San Isidro Creek which is a tributary of the Daorao-Tupec Creek.

3.2 Urgent Urban Drainage Improvement

The project is planned to meet the design flood of 5-year return period. It covers channel improvement for San Isidro Creek, part of Daorao-Tupec Creek and related drainage mains. The major construction works are tabulated below. The location of the urgent urban drainage improvement project is shown in Fig. III.

Work Items	Quantity
Channel Improvement Length (m)	2,410
Earth Works (m3)	106,000
Revetment Works (m)	2,300
Bridge and Culvert (unit)	10
Compensation	
Land Acquisition (ha)	2.71
House Resettlement (No.)	none

3.5 Project Evaluation

The project will eradicate flood damage caused by floods below a 5-year return period. The economic viability of the project is evaluated as follows.

Index	Value
Economic Internal Rate of Return (EIRR, %)	31.9
Cost-Benefit Ratio (B/C)	2.45
Net Present Value (NPV, million peso)	105

Socially, the project will improve social amenity and public hygiene, and create temporary jobs during the construction period.

3.6 Environmental Impact Assessment

The project has no significant adverse impacts on the environment.

Water pollution during the construction phase is the only negative impact to be managed. Water pollution sources will be the dewatering work for structural foundations and earth work operations in the channel. However, water pollution due to these works is not heavy because their work volumes are small.

4. RECOMMENDATION

The proposed priority projects of sabo dam and river improvement, and urgent urban drainage improvement project are technically and economically feasible. Environmentally, they will generate no significant adverse impacts. Urgent implementation of the projects is recommended in consideration of the recurrent serious floods in the project areas. The required financial sources should be arranged as soon as possible.

The following items are recommended in connection with the proposed projects:

(1) Necessary hydraulic model tests to check the effects of sandbar formation on riverbanks and to determine the detailed structural dimensions of spur dikes should be conducted in the detailed design phase.

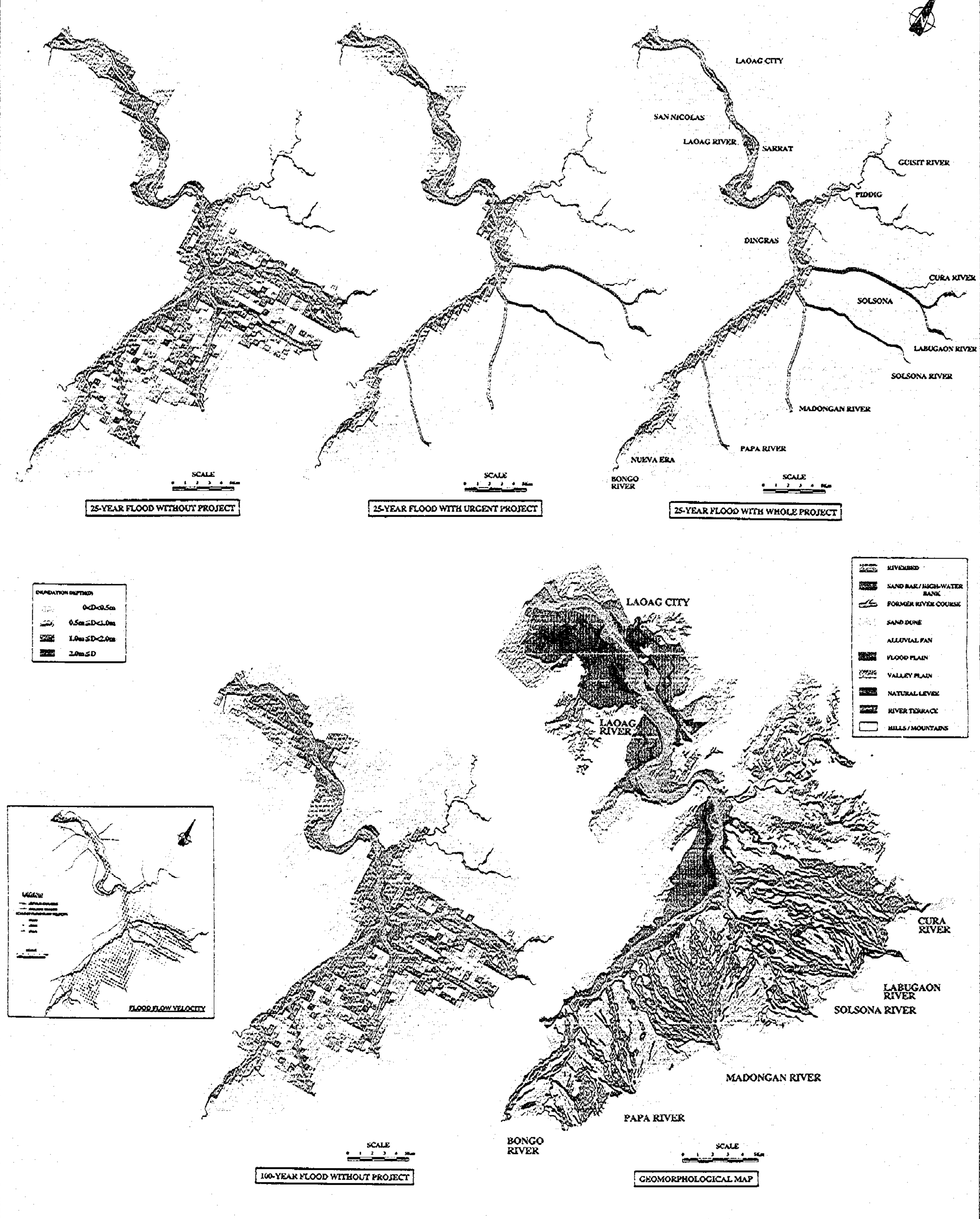
(2) Monitoring of riverbed variation and local scouring around the major structures should be continued, especially in the alluvial fan rivers, to avert flood risk due to unexpected sediment deposition and structural destruction.

(3) The existing temporary dikes built by NIA under INIP-I should now be transferred to DPWH to prevent further deterioration.

(4) Watershed management, including the extension of ongoing reforestation projects in the Madongan and Papa river basins, should be promoted to supplement the sediment control of the proposed structural measures.

(5) Practical flood forecasting/warning and flood fighting systems should be established to supplement the capacity of the proposed flood control structures.

FLOOD HAZARD MAP IN THE LAOAG RIVER BASIN



Note:

Shown is the flood hazard map of the Laoag River Basin, including the geomorphological map. Simulation of inundation areas and depths of floods of 25-year and 100-year return periods was performed using the Two-Dimensional Unsteady Flow Model, by dividing the flood prone areas into mesh blocks of 500m by 500m and putting hydraulic and topographic data into each mesh. Also, simulation of floods of 25-year return period after construction of the proposed master plan project (whole project) and the selected urgent project was carried out.

THE STUDY ON SABO AND FLOOD CONTROL IN THE LAOAG RIVER BASIN

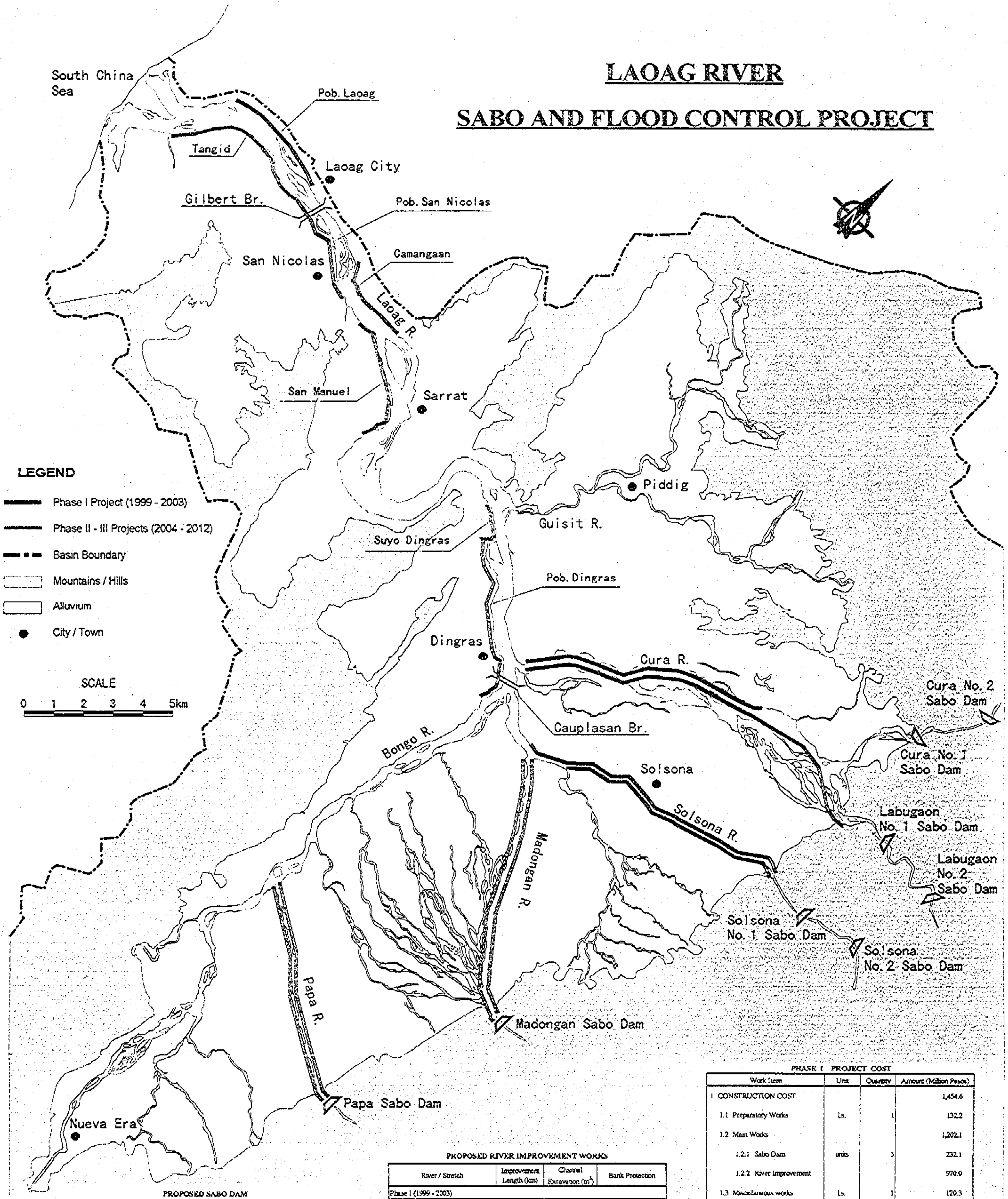
JAPAN INTERNATIONAL COOPERATION AGENCY

DEPARTMENT OF PUBLIC WORKS AND HIGHWAYS, REPUBLIC OF THE PHILIPPINES

Fig. 1

LAOAG RIVER

SABO AND FLOOD CONTROL PROJECT



PROPOSED SABO DAM

Sabo Dam	Catchment Area (km^2)	Dam Height (m)	Dam Length (m)	Sedimentation Volume (m^3)
Phase I (1999 - 2003)				
Cura No.1	68.2	9.0	183	422,000
Labugaon No.1	100.5	17.0	118	1,197,000
Solsona No.1	72.2	12.0	118	242,000
Madongan	153.8	10.5	183	2,207,000
Papa	51.4	9.0	233	794,000
Phase II (2004 - 2009)				
Cura No.2	63.1	4.5	70	150,000
Labugaon No.2	90.9	7.0	160	511,000
Solsona No.2	68.2	10.0	90	233,000

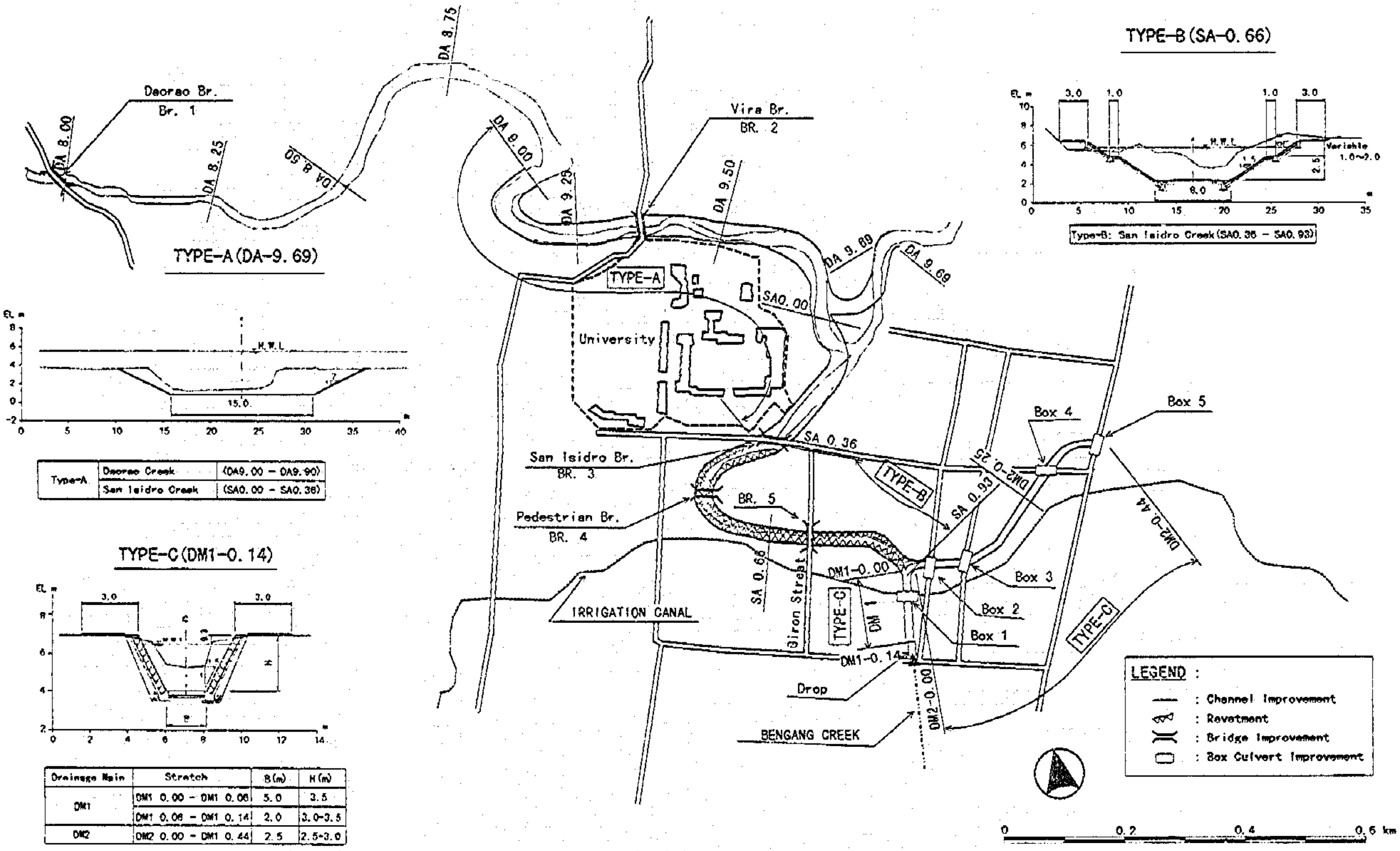
PROPOSED RIVER IMPROVEMENT WORKS

River / Stretch	Improvement Length (km)	Channel Excavation (m^3)	Bank Protection
Phase I (1999 - 2003)			
Laoag R. (Pob. Laoag)	3.49	-	River Wall (1,240m)
Laoag R. (Pob. San Nicolas)	4.20	-	-
Laoag - Bongo R. (Pob. Dingras)	5.45	-	River Wall (300m)
Cura / Labugaon R.	21.50	992,000	Spur Dike (349 Units)
Solsona R.	16.00	-	Spur Dike (302 Units)
Madongan R.	10.00	-	Spur Dike (394 Units)
Papa R.	4.50	-	Spur Dike (283 Units)
Phase II (2004 - 2009)			
Laoag R. (Tangid)	5.25	-	-
Laoag R. (Camangaan)	4.00	-	-
Laoag R. (San Manuel)	3.60	-	-
Laoag R. (Suyo, Dingras)	3.70	-	-

PHASE I PROJECT COST

Work Item	Unit	Quantity	Amount (Million Pesos)
1 CONSTRUCTION COST			1,454.6
1.1 Preparatory Works	l.s.	1	132.2
1.2 Main Works			1,202.1
1.2.1 Sabo Dam	units	5	232.1
1.2.2 River Improvement			970.0
1.3 Miscellaneous works	l.s.	1	120.3
2 COMPENSATION COST			6.4
2.1 Land Acquisition	ha	41	6.0
2.2 House Relocation	houses	3	0.4
3 ADMINISTRATION COST	l.s.	1	43.8
4 ENGINEERING SERVICE COST	l.s.	1	232.7
5 PHYSICAL CONTINGENCY	l.s.	1	173.8
6 PRICE CONTINGENCY	l.s.	1	421.8
Total			2,333.1

Fig. 1



Type-A	Daorao Creek	(DA9.00 - DA9.90)
	San Isidro Creek	(SA0.00 - SA0.36)

Drainage Main	Stretch	B (m)	H (m)
DM1	DM1 0.00 - DM1 0.06	5.0	3.5
	DM1 0.06 - DM1 0.14	2.0	3.0-3.5
DM2	DM2 0.00 - DM1 0.44	2.5	2.5-3.0

LAOAG CITY URBAN DRAINAGE IMPROVEMENT

- URGENT PROJECT -

Fig. III

THE STUDY ON SABO AND FLOOD CONTROL IN THE LAOAG RIVER BASIN

FINAL REPORT

VOLUME I

SUMMARY

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ANNEX

ABBREVIATIONS

AGENCIES/ORGANIZATIONS

BDCC	:	Barangay Disaster Coordinating Council
BOD	:	Bureau Of Design, DPWH
CENRO	:	Community Environment and Natural Resources Office
DENR	:	Department of Environment and National Resources
DPWH	:	Department of Public Works and Highways
EMB	:	Environmental Management Bureau, DENR
GOJ	:	Government of Japan
GOP	:	Government of the Philippines
INIP	:	Ilocos Norte Irrigation Project
JICA	:	Japan International Cooperation Agency
LGU	:	Local Government Unit
MDCC	:	Municipal Disaster Coordinating Council
NAMRIA	:	National Mapping and Resources Information Authority
NDCC	:	National Disaster Coordinating Council
NEDA	:	National Economic and Development Authority
NGO	:	Non-Governmental Organization
NIA	:	National Irrigation Administration
NPC	:	National Power Corporation
NSCB	:	National Statistics Coordination Board
NSO	:	National Statistics Office
OCD	:	Office of Civil Defense, Department of National Defense
OECF	:	Overseas Economic Cooperation Fund, Japan
PAGASA	:	Philippine Atmospheric, Geophysical and Astronomical Services Administration
PDC	:	Provincial Development Council
PDDC	:	Provincial Disaster Coordinating Council
PDOC	:	Provincial Disaster Operation Center
PENRO	:	Provincial Environment and Natural Resources Office
PMO	:	Project Management Office, DPWH
PPDO	:	Provincial Planning and Development Office
PWDEO	:	Public Works District Engineer's Office

ACRONYMS

B/C	:	Benefit-Cost Ratio
BOD	:	Biological Oxygen Demand
ECC	:	Environmental Compliance Certificate
EIA	:	Environmental Impact Assessment
EIRR	:	Economical Internal Rate of Return
FOB	:	Free-on-Board
GDP	:	Gross Domestic Product
GRDP	:	Gross Regional Domestic Product
NIS	:	National Irrigation System
NPV	:	Net Present Value
O&M	:	Operation and Maintenance
RIS	:	River Irrigation System
SS	:	Suspended Solids

MEASUREMENTS/SYMBOLS

mm	:	millimeter
cm	:	centimeter
m	:	meter
km	:	kilometer
g, gr.	:	gram
kg	:	kilogram
t, ton	:	metric ton
m^2	:	square meter
ha, has	:	hectare, hectares
km^2	:	square kilometer
l, lt., ltr	:	liter
m^3	:	cubic meter
s, sec	:	second
min.	:	minute
hr	:	hour
yr	:	year
MW	:	megawatt
mm/hr	:	millimeter per hour
m/s	:	meter per second
km/hr	:	kilometer per hour
mg/l	:	milligram per liter
m^3/s	:	cubic meter per second
$m^3/s/km^2$	:	cubic meter per second per square kilometer
%	:	percent
¥	:	Japanese Yen
₱	:	Philippine Peso
$	:	US Dollar

1. INTRODUCTION

The Laoag River runs in Ilocos Norte Province which is located in the northern part of the Island of Luzon. The river system drains an area of 1,332 km^2 into the South China Sea west of Laoag City, the provincial capital. The Basin suffers damage due to severe flooding and sediment deposition by typhoons every year, and sediment and flood control works are considered absolutely necessary for development.

Laoag City is affected by not only floods of the Laoag River but also flooding by local storm water. Urban drainage improvement of the City is thus also urgent.

In response to the request of the Government of the Republic of the Philippines (GOP), the Japan International Cooperation Agency (JICA) of the Government of Japan conducted the Study on Sabo and Flood Control in the Laoag River Basin from March 1996 to November 1997. The objectives of the Study are:

(1) To formulate a master plan on sabo and flood control for the Laoag River Basin;

(2) To conduct a feasibility study on the urgent and/or priority project(s) identified in the master plan;

(3) To conduct a feasibility study on urban drainage improvement for Laoag City; and,

(4) To pursue technology transfer to the counterpart personnel of the GOP in the course of the Study.

2. LAOAG RIVER SABO AND FLOOD CONTROL

2.1 Study Area

(1) River Basin

As mentioned before, the river system drains an area of 1,332 km^2 into the South China Sea. Originating in the Central Cordillera Mountains which has a peak elevation of more than 2,000 m, the main river course is called Bongo River in the upper and middle reaches, and Laoag River in the lower reaches. The location of the Basin is shown in the General Map.

The main river course flows down along the western fringe of the alluvial fan in the middle reaches. After passing through the narrow flood plain in the lower reaches, it finally empties into the South China Sea west of Laoag City. In the middle reaches, the main river is joined by many tributaries that flow down the alluvial fan. Among the major tributaries are the Papa, Madongan, Solsona, Labugaon and Cura rivers.

(2) Socio-economic Conditions

The Basin extends over eleven (11) administrative units consisting of one city and 10 municipalities; namely, Laoag City, San Nicolas, Sarrat, Dingras, Solsona, Piddig, Marcos, Banna, Nueva Era, Carasi and Vintar. The total population within the basin area was 197,000 in 1995, which is projected to increase to 247,000 in 2020. In the Basin, agriculture is a major industry and per capita GRDP in 1995 is estimated to be ₱14,900 (US$580) at 1995 prices.

As shown in Fig. 1, the existing land use of the Basin consists of mountain area (70.2%), riverbed area (4.3%), cultivated land (18.5%), residential area (1.5%), lowland tree area (1.7%), bush/grass land (1.0%), riverwash area (1.8%) and road/canal/creek area (1.0%). The bush/grass land and riverwash covering a total area of more than 3,600 ha have been devastated due to flooding and sediment deposition in the past. In fact, a cultivated land of 1,130 ha has been washed out during the recent 20 years.

(3) Climate and Hydrology

The climate in the Basin is characterized by two (2) distinct seasons: wet season (May to October) and dry season (November to April). Average annual rainfall at Laoag City is estimated to be 2,135 mm, of which 97% concentrates in the wet season.

The Basin is affected by typhoons every year. Approximately 250 typhoons hit or came close to Northern Luzon, bringing heavy rainfalls on the Basin during the past 48 years.

2.2 Flood Damage

(1) Historical Floods

The flood water level of the Laoag River has been observed at Gilbert Bridge in Laoag City for the recent 37 years. The largest flood was caused by Typhoon Gening in 1967, followed by those of Wanda in 1962, Miding in 1986, Gloring in 1996, Maring in 1992 and Goring in 1977. Their peak water levels, discharges and corresponding return periods at Laoag City (Gilbert Bridge) are as follows:

Typhoon	Water Level (m)	Discharge (m^3/s)	Return Period (year)
Gening, 1967	9.9	10,900	25
Wanda, 1962	9.8	10,800	24
Miding, 1986	9.4	9,700	15
Gloring, 1996	9.3	9,500	15
Maring, 1992	9.0	8,700	10
Goring, 1977	8.9	8,500	9

(2) Flood Damage Potential

The inundation area, affected population, damageable assets and probable flood damage under the existing socio-economic situation corresponding to 25-year flood and 100-year flood are estimated as shown below. The probable inundation area of a 100-year flood is shown in Fig. 2.

Item	25-Year Flood	100-Year Flood
Inundation Area (ha)	17,290	20,220
Affected Population	61,118	78,858
Damageable Assets		
Houses (unit)	12,113	15,630
Agricultural Production (ha)	10,988	13,222
Industrial Establishments (unit)	365	511
Educational Facilities (unit)	85	107
Health Facilities (unit)	21	29
Roads (km)	559.9	675.6
Irrigation Facilities (ha)	10,789	12,934
Probable Damage (million pesos)	696.1	913.8

Note: Probable damage is estimated at 1996 prices.

2.3 Watershed and River Conditions

(1) Watershed

The eastern watershed of the Basin is mainly covered by Neocene Intrusive and Cretaceous-Paleocene Volcanic. The former is highly weathered in many places, disintegrated into thick loose granular materials. The weathered portions are highly porous and permeable. The latter is highly faulted and jointed with fracture zones in some places.

The watershed has been denuded or devastated due to logging and slash-and-burn agriculture since early 17th century. The Department of Environment and Natural Resources (DENR) has eight (8) reforestation projects having an aggregate area of 47,000 ha.

(2) River Morphology

The Laoag River system consists of six (6) principal rivers: Laoag, Bongo, Cura/Labugaon, Solsona, Madongan and Papa. The Laoag and Lower Bongo rivers running through the alluvial plain are comparatively mild in slope. However, the slope of the other rivers flowing down the alluvial fan is very steep. The Solsona, Madongan and Papa rivers are confined by the temporary dikes, while the other rivers flow within natural banks. The Cura/Labugaon River consists of a number of distributaries with braided river streams. The Upper Bongo is also much braided in some sections.

The alignment, slope, width and other features of the rivers are summarized below.

River	Length (km)	Slope (%)	Width (m)	Alignment	Remarks
Laoag	31.6	0.021-0.090	400-1,000	two large bends	no dikes
Lower Bongo	11.0	0.151-0.200	300-600	straight	no dikes
Upper Bongo	12.0	0.311-0.943	300-400	much braided	no dikes
Cura/Labugaon	17.0	0.331-1.08	100-1,000	many distributaries	no dikes
Solsona	11.5	0.137-1.54	230-330	five small bends	with dikes*
Madongan	9.5	0.452-1.35	300	almost straight	with dikes*
Papa	7.5	0.54-1.85	223	almost straight	with dikes*

* Temporary dikes

Sandbars are formed in the beds of all the rivers and, as a result, floodwater convergence and divergence points appear alternately in the longitudinal direction of rivers. Bank erosion occurs at the convergence points.

The river courses of the Laoag and Bongo rivers have been comparatively stable. However, the course of other rivers have changed much. Their main streams at the fan apex have shifted in a wide range.

(3) Flood Carrying Capacity

The flood carrying capacities of the rivers are estimated as follows.

River	Discharge (m^3/s)	Probability (year)
Laoag	2,000-5,000	2-4
Bongo	500-2,000	5
Guisit	500-1,000	2-10
Cura/Labugaon	500-2,000	1-10
Solsona	1,000-1,300*	25
Madongan	2,000*	25
Papa	1,000-1,500*	100

* Discharge capacity of temporary dikes.

The Basin is frequently flooded due to the small flood carrying capacity of river channels. Even the land along the Solsona, Madongan and Papa rivers are exposed to a high flood risk because the existing dikes are temporary ones. However, the central part of Laoag City is protected by a high riverbank which can carry 11,000 to 12,500 m^3/s with a return period of 25 to 50 years.

(4) Existing River Structures

The existing river structures are: (1) river control structures such as dikes, spur dikes and revetment; (2) irrigation facilities such as diversion dam, pumping station and intake sluice; and, (3) other related structures including bridges, roadway crossings and drainage openings/culverts. Locations of existing river structures are shown in Fig. 3.

The dikes along the Solsona, Madongan and Papa rivers are the largest river control structures in the Basin, although they are regarded as temporary ones from the structural viewpoint. They were constructed from 1991 to 1993 under the Urgent Disaster Prevention Works, as a part of Ilocos Norte Irrigation Project I (INIP I). The urgent works are summarized below.

Item	Solsona	Madongan	Papa
Channel Length (km)	11.1	8.5	7.4
Channel Width (m)	230-330	300	223
Dike Length (km)	19.6	13.0	12.2

2.4 Sediment Runoff

(1) Sediment Yield in Watersheds

The watersheds of the Cura, Labugaon, Solsona, Madongan, Papa and Bongo rivers are the major sources of sediment runoff to the Laoag River. Sediment yield is mainly caused by slope failure and surface erosion. The specific sediment yield of the river watersheds ranges from 1,440 $m^3/yr./km^2$ to 2,540 $m^3/yr./km^2$, averaging 2010 $m^3/yr./km^2$.

The sediments run off to the alluvial fan rivers after being naturally controlled in the mountain valleys. The existing sediment deposits in the mountain valleys are the sources of secondary sediment yield. The total volume is estimated at 26,442,000 m^3, which is equivalent to 51,700 m^3/km^2.

(2) Annual Sediment Runoff

Fluvial sediment in transit consists of wash load, bed load and suspended load. The wash load is entirely flushed into the sea. The riverbed is formed by both bed load and suspended load. The specific runoff of wash load from the Basin is estimated at 350 $m^3/yr./km^2$.

The total average annual sediment runoff of bed load and suspended load to the alluvial fan rivers is estimated as follows.

River	Catchment Area (km^2)	Annual Sediment Runoff (m^3/yr.)	Specific Sediment Runoff (m^3/km^2/yr.)
Cura	69.5	54,600	790
Labugaon	100.5	154,700	1,540
Solsona	79.0	114,500	1,450
Madongan	153.8	223,100	1,450
Papa	51.4	99,600	1,940
Bongo	57.0	78,300	1,370
Total/Average	511.2	724,800	1,420

(3) Sediment Balance in Alluvial Fan Rivers

Of the total annual sediment runoff of 724,800 m^3/year mentioned above, 531,900 m^3/year or 73% is expected to be deposited in the bed of the alluvial fan rivers as given below.

Alluvial Fan River	Annual Deposition (m^3/yr.)	Annual Riverbed Aggradation (cm/yr.)
Cura/Labugaon	144,200	3.0
Solsona/Madongan	270,100	5.1
Papa	72,700	4.8
Upper Bongo	44,900	1.6
Total	531,900	

The accumulation of annual deposits will raise the riverbed and exceed the allowable limit in the future. Hence, sediment control in the watersheds and mountain valleys is absolutely necessary.

On the other hand, a large volume of sediment is discharged from the mountain valleys to the alluvial fan rivers at a big flood in a short period. When the sediment transport capacity of river channels is small, excessive sediment is deposited at the fan apex (uppermost reaches) of the alluvial fan rivers, resulting in much riverbed aggradation at the fan apex.

A total sediment volume of 1,123,000 m^3 will run off to the six (6) alluvial fan rivers at a 25-year flood. Among this, 399,000 m^3 or 36% will be deposited at the fan apexes with the breakdown below. Sediment runoff control during a big flood is thus essentially necessary to prevent catastrophic disasters.

Alluvial Fan River	Runoff to Alluvial Fan (m^3)	Deposition at Fan Apex (m^3)
Cura	71,300	28,700
Labugaon	185,200	72,400
Solsona	166,900	58,000
Madongan	454,500	151,700
Papa	147,300	54,300
Upper Bongo	97,500	34,100
Total	1,122,700	399,200

2.5 River Environment

The existing environmental situations in the Basin, especially those related to the sabo and flood control works are described below.

(1) Water Quality: The water in the River is clean at any point from upstream to downstream. All the parameters are within the standard for Class A of the DENR Water Quality Criteria, except suspended solids (SS).

(2) Vegetation: Vegetation of the Basin is in poor condition. DENR is now undertaking various reforestation projects to rehabilitate and manage the watersheds.

(3) Sand Dune: Sand dunes covering 3,350 ha extend along the coastal line from Currimao in the south to Bacarra in the north. The Laoag River passes through the center of this sand dune coastal line. The National Committee on Geological Science intends to establish these sand dunes as one of the National Geological Monuments.

(4) Fishery: People living in the riverside catch freshwater fish in the dry season. Major catches are gubis and freshwater shrimps. In the brackish water zone and its tributary creeks, fishing is more active. Another fishing activity is the gathering of milkfish fry at the estuary of the River.

(5) River Water Use: The river water is mainly used for irrigation purposes. No drinking water is taken from the river and it is all supplied from springs and deep wells.

(6) Ethnic Minorities: The ethnic minorities of the Basin dwell in the mountain areas. They are Tingguians, Itnegs and Isnegs. They form eleven (11) barangays with a total households of 370. Most of them work in the cultivation of ancestral crops and the reforestation projects of the Government.

2.6 Master Plan

2.6.1 Master Plan of Structural Measures

(1) Target Year

The target year of the master plan is set at the year 2020.

(2) Design Flood Discharge

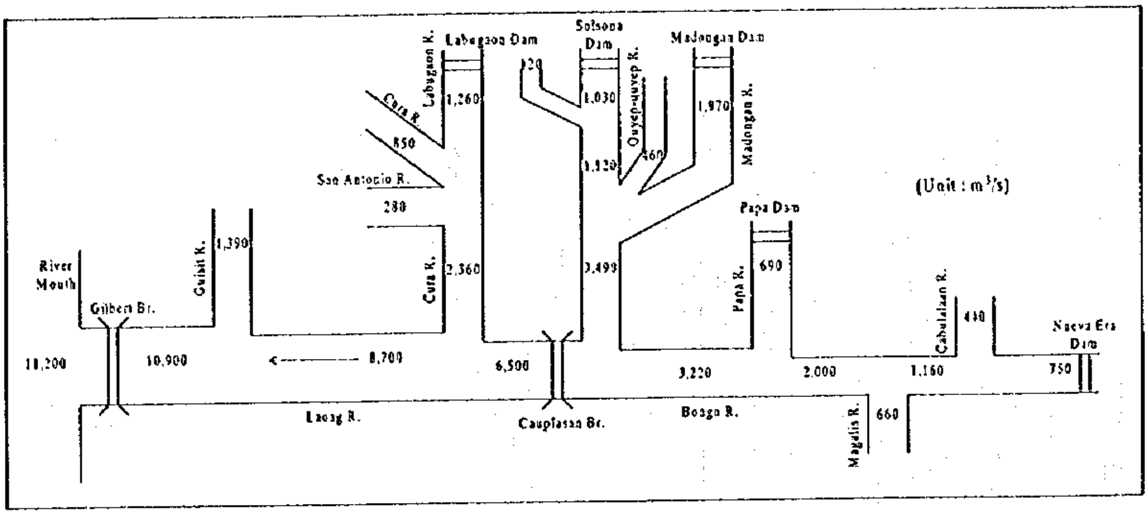
Return period of the design flood discharge of the Laoag River is proposed to be 25 years, based on the following considerations:

(a) The 25-year return period is considered reasonable, compared to the design return periods of the other major rivers in the Philippines;

(b) The largest flood in the Laoag River during the 1967 Typhoon Gening had a recorded peak discharge of 25-year return period; and,

(c) Approximately 90% of the average annual flood damage in the Basin is caused by floods below 25-year return period.

The design flood discharge distribution of the River is shown below.



(3) Flood Protection Target Area

The master plan is proposed to protect a total inundation area of 15,300 ha and relieve some 57,600 residents in consideration of the protected population, economic efficiency, technical problems and environmental aspects. The target flood protection districts, protected area and existing protected population are shown below. Locations of the target flood protection districts are shown in Fig. 4.

Protection District	Protection Area (ha)	Protected Population (existing)
1. Tangit, Laoag	600	3,945
2. Suyo, Laoag	200	1,054
3. Poblacion, Laoag	130	5,149
4. Camangaan, Laoag	480	2,039
5. Poblacion, San Nicolas	230	5,835
6. San Manuel, Sarrat	550	1,339
7. Suyo, Dingras	200	2,317
8. Poblacion, Dingras	550	4,228
Sub-Total (Laoag-Bongo River)	2,940	25,906
9. Cura/Labugaon River	3,900	11,115
10. Solsona River	2,280	7,152
11. Madongan River	4,180	8,764
12. Papa River	1,950	4,651
Total	15,250	57,588

(4) Selection of Possible Structural Measures

(a) Sediment Control Measures

The alluvial fan rivers are affected by two (2) kinds of sediment problems. One is gradual riverbed aggradation over the entire riverbed due to the excessive annual sediment runoff from the mountains. Reforestation and sabo dams are considered effective for the mitigation of riverbed aggradation. However, reforestation is dealt as non-structural measure to supplement the sediment control by sabo dams in this Study.

The other problem is the large sediment deposition at the fan apexes during floods. This problem does not occur every year; however, when it happens, it may bring about catastophic disaster on the alluvial fan area. Only the construction of sabo dam is considered practicable to prevent such a disaster.

(b) Flood Control Measures

Only dikes and river dredging are considered technically practicable for flood control of the River. Dams and retarding basins are obviously inapplicable due to topographic constraints. The necessity of cutoff channel and floodway has not been identified to mitigate the existing flooding problems.

However, river dredging is not economically feasible. Hence, dikes are applied as the principal measures for flood control (river improvement) of the River.

(5) Proposed Structural Plan

Eight (8) sabo dams and twelve (12) river improvement projects are proposed to protect the 12 inundation districts mentioned above as discussed below. Locations of the proposed sabo dams and river improvement projects are shown in Fig. 5.

(a) Sabo Dam

The sabo dam is designed to maintain the riverbed aggradation in the alluvial fan below an allowalbe level and to reduce sediment runoff to the alluvial fan river during the design flood below the transport capacity at the fax apex. For this purpose, the design sedimentation slope of the sabo dam is set at three-fourths (3/4) of the original riverbed at dam site. Further, the design sedimentation capacity of the sabo dam is determined to have enough storage volume to maintain the average annual riverbed aggradation in the alluvial fan below 2.5 cm for at least 20 years.

The main features of the proposed sabo dams are shown below. The required land acquisition is negligible, and no house resettlement is necessary for their construction.

Sabo Dam	C.A. (km^2)	Sediment Capacity (m^3)	Dam Height (m)	Dam Length (m)	Concrete Vol. (m^3)
Cura No. 1	68.2	391,000	6.5	170	14,500
Cura No. 2	63.1	150,000	4.5	70	6,300
Labugaon No. 1	100.5	1,043,000	10.0	100	19,200
Labugaon No. 2	90.9	511,000	7.0	160	16,400
Solsona No. 1	72.2	233,000	10.0	30	9,600
Solsona No. 2	68.2	233,000	10.0	90	11,900
Madongan	153.8	2,192,000	7.0	120	17,300
Papa	51.4	707,000	7.0	210	18,000
Total		5,460,000			113,200

(b) River Improvement

The river channel is designed to safely carry the proposed design flood discharge. The river width and longitudinal profile are designed in due consideration of the stability of riverbed conditions.

The alignment of the Laoag-Bongo River is set at the existing one and dikes, where necessary, will be constructed along this alignment.

The existing alignment and width of the Solsona, Madongan and Papa rivers are smooth and wide enough. Hence, the existing river channels with temporary dikes will be improved.

The existing braided streams of the Cura/Labugaon are united. A new river course is designed to join the Labugaon River to the Cura River at the fan apex and to run along the existing main stream of the Cura River. This new river channel will be totally improved.

The main features and works of the river improvement are shown below. Land acquisition of 50 ha and resettlement of 21 houses are required.

River	Improv't. Length (km)	River Width (m)	Dike Const. (m)	Channel Excavation (m^3)	Bank Protection (m)
Laoag-Bongo River	30.0	300-1,000	30,000		
Tangid, Laoag	6.5		6,500		
Suyo, Laoag	2.1		2,100		
Pob. Laoag	1.5		1,500		
Camangaan, Laoag	4.0		4,000		
Pob. San Nicolas	3.0		3,000		
San Manuel, Sarrat	3.6		3,600		
Suyo, Dingras	3.7		3,700		
Pob. Dingras	5.6		5,600		
Cura/Labugaon River	13.5	200-340	21,900	1,532,000	22,200
Solsona River	11.0	230-330	10,900*		13,700
Madongan River	9.0	300	4,000*		17,500
Papa River	7.0	223	1,000*	1,532,000	12,400
Total	70.5		67,800		65,800

* Strengthening of existing dikes

(6) Project Cost

The total project cost is estimated to be 2,177.8 million pesos at August 1996 prices, as follows:

Work Item	Amount (million pesos)
1. Construction Cost	1,714.3
1.1 Preparatory Works	157.7
1.2 Main Works	1,401.4
(1) Sabo Dam	301.5
(2) River Improvement	1,099.9
1.3 Miscellaneous Works	155.2
2. Compensation Cost	8.0
3. Administration Cost	86.1
4. Engineering Services Cost	171.4
5. Physical Contingency	198.0
Total	2,177.8

Note: Exchange rates are US$1.00 = 26 Pesos = 106 Yen

(7) Project Evaluation

(a) Project Benefits

The project will produce the following flood mitigation and land use enhancement benefits:

(i) The project will protect a total flood prone area of 15,300 ha with a resident population of 57,600. As a result, direct damage on house/household effects, industrial establishments, social/physical infrastructures and crop production, as well as indirect damages, will be reduced.

(ii) Farmland of 52 ha has been washed out on annual average in the alluvial fan areas. The project will prevent this land loss.

(iii) The project is expected to restore the existing devastated land of 1,800 ha to land available for grazing and crop cultivation.

(b) Economic Evaluation

The economic efficiency of the project is evaluated as follows:

Index	Value
Economic Internal Rate of Return (EIRR, %)	20.6
Cost-Benefit Ratio (B/C)	1.50
Net Present Value (NPV, million pesos)	493

(c) Social Evaluation

The project will produce the following social benefits:

(i) Improvement of social amenity and public hygiene
(ii) Mitigation of economic disparity
(iii) Creation of job opportunities

(8) Environmental Impact Assessment

The environmental impacts of the project are assessed from physico-chemical aspects, biological and geological aspects, and socio-economic aspects. The assessed environmental elements are shown below. No major adverse impact by the project is predicted.

(a) Physico-chemical Aspects

Surface water, groundwater, topography, air/noise/offensive odor

(b) Biological and Geological Aspects

Terrestrial species, aquatic species, scientific interest, aesthetic potential

(c) Socio-economic Activities

Economic activities, land use, transportation/traffic, historical/archaeological interests, health/social services, lifestyle/community, cultural community

2.6.2 Recommendation for Non-structural Measures

(1) Reforestation in the eastern watersheds of the Basin, along with the proposed sabo dams, is necessary to reduce the annual sediment runoff to the alluvial fan rivers. The ongoing reforestation project in the watersheds of the Madongan and Papa rivers should be expanded because it covers only a part of both watershed.

(2) At present, no flood forecasting and warning system is available in the Basin. A simple but speedy flood forecasting and warning system should be established. For this purpose, the installation of some hydrological observation and data transmission systems is necessary.

(3) The existing temporary dikes in the alluvial fan rivers are susceptible to breaching at many locations. Necessary flood fighting systems should be established to minimize flood damage.

(4) Even after completion of the Master Plan, 2,000 ha of land with a resident population of 3,500 will remain unprotected. Moreover, some protected lands in the fan apex areas will still be exposed to a high flood risk due to unexpected flood and sediment runoff. Proper land use management for these areas should be promoted.

2.7 Priority Project Plan

2.7.1 Objective Projects and Target Flood Protection Areas

Among the eight (8) sabo dams and twelve (12) river improvement projects in the Master Plan, five (5) sabo dams and seven (7) river improvement projects are selected as the priority projects based on the following considerations.

(1) The sabo dams are prerequisite to the flood control of the Cura/Labugaon, Solsona, Madongan and Papa rivers. Therefore, the sabo dam and river improvement works need to be dealt as a package project in the said four (4) rivers.

(2) The sabo dams of Cura, Labugaon and Solsona rivers can be constructed in stages. The necessary sediment control of the three (3) rivers can be maintained only by Cura No. 1, Labugaon No. 1 and Solsona No. 1 for at least 10 years.

(3) The river improvement works of the Cura/Labugaon, Solsona, Madongan and Papa rivers are expected to produce far larger beneficial effects compared to the other river improvement sub-projects.

(4) The river improvement works for the urban areas of Laoag, San Nicolas and Dingras are also given priority in view of their high economic efficiency.

The priority projects, target flood protection districts, areas and resident population are shown below.

River	Objective Project	Protection District	Area (ha)	Population
Laoag	Pob. Laoag R/I	Pob. Laoag	330*	6,203*
Laoag	Pob. San Nicolas R/I	Pob. San Nicolas	230	5,835
Laoag-Bongo	Pob. Dingras R/I	Pob. Dingras	550	4,228
Cura/ Labugaon	Cura Sabo Dam No. 1 Labugaon Sabo Dam No. 1 Cura/Labugaon R/I	Cura/Labugaon River	3,900	11,115
Solsona	Solsona Sabo Dam No. 1 Solsona R/I	Solsona River	2,280	7,152
Madongan	Madongan Sabo Dam Madongan R/I	Madongan River	4,180	8,764
Papa	Papa Sabo Dam, Papa R/I	Papa River	1,950	4,651
Total			13,420	47,948

Note: 1) * Includes the area and population of Suyo, Laoag proposed in the Master Plan since this protection district is dealt as a package with Pob. Laoag.

2) Pob.: Poblacion; R/I: River improvement

2.7.2 Project Plan

The priority sabo dams and river improvement projects are designed based on the more detailed field surveys. Their design flood discharges and sediment control criteria are as proposed in the Master Plan.

(1) Laoag-Bongo River Improvement Plan

For the flood protection of target areas, the construction of earth dike is proposed in principle; however, construction of river wall is applied for the limited urban areas of Poblacion Laoag and Dingras to minimize house resettlement.

The main features and works of the proposed river improvement project are shown below. The proposed river improvement profile is shown in Fig. 6.

Item	Pob. Laoag	Pob. San Nicolas	Pob. Dingras	Total
Improvement Length (km)	3.4	4.2	5.7	13.3
Earth Dike (m)	2,250	4,200	5,150	11,600
River Wall (m)	1,240	-	300	1,540
Revetment (m)	160	-	300	460
Spur Dike (unit)	-	5	-	5
Sluiceway (unit)	2	2	1	5
Compensation				
Land (ha)	6.1	9.9	13.0	29.0
House (No.)	-	-	3	3

Note: Pob. : poblacion

(2) Sabo Dam Plan

The sedimentation capacity, dam crest elevation and dam structures are designed based on the more detailed topographic and geological data. Either of the two dam foundation types, namely, fixed type on rock foundation or floating type on river deposits is applied depending on the geological conditions of the dam site.

The main features and works of the proposed sabo dams are shown below. The proposed sabo dam profiles are shown in Fig. 7.

Item	Cura No. 1	Labugaon No. 1	Solsona No. 1	Madongan	Papa	Total
C.A. (km^2)	68.2	100.5	72.2	153.8	51.4	
Sediment Capacity (1,000 m^3)	422	1,197	242	2,207	794	4,862
Dam Type	floating	fixed	fixed	floating	floating	
Dam Height (m)	9.0	17.0	12.0	10.5	9.0	
Dam Length (m)	183	118	118	183	233	
Sub-dam Height (m)	4.0	7.5	4.0	4.5	3.5	
Apron (unit)	1	-	-	1	1	
Concrete Vol. (m^3)	15,100	16,900	5,200	20,800	16,900	74,900
Compensation						
Land (ha)	0.4	-	0.1	-	1.0	1.5
House (No.)	-	-	-	-	-	-

Note: C.A. : catchment area

(3) Alluvial Fan River Improvement

The river alignment and river width are proposed to be the same as the Master Plan. The longitudinal profile is designed based on the prediction of riverbed variation in the future.

The riverbed aggradation or degradation in the future is predicted to be comparatively small as described below. Hence, as the principal river channel improvement works, dike construction is proposed for the Cura/Labugaon River and heightening of the existing dikes is proposed for the Solsona, Madongan and Papa rivers. Further, the proposed and existing dikes will be provided with sufficient bank protection works in view of the experiences of dike breaching in the recent floods.

(a) The riverbed aggradation of the alluvial fan rivers in the future will be controlled by the proposed sabo dams. The average riverbed aggradation or degradation of each alluvial fan river after 20 years is predicted as follows.

River	Average Riverbed Aggradation/ Degradation (m)	Average Riverbed Elevation Difference (m)
Cura	0.09	-0.88
Labugaon	-0.35	-1.26
Solsona	0.62	-1.18
Madongan	0.06	-1.58
Papa	0.28	-1.40

Note: Cura No. 2, Labugaon No. 2 and Solsona No. 2 are assumed to be constructed in the future after 10 years.

(b) As a result, the riverbed elevation of the alluvial fan rivers will still be lower than the inland elevation after 20 years. The difference of the average riverbed elevation of each river from the inland elevation is estimated as shown in the above table.

(c) On the other hand, the alluvial fan rivers are usually susceptible to considerable sediment deposition in some critical river sections at a large flood. However, the maximum deposition at the critical river section of each river at the design flood is predicted to be not large, in the range of 0.01 m in Papa River and 0.08 m in Cura/Labugaon River.

The main features and works of the proposed river improvement are shown below. The proposed river improvement profiles are shown in Fig. 8.

Item	Cura/Labugaon River	Solsona River	Madongan River	Papa River	Total
Improvement Length (km)	12.7	11.0	9.0	7.0	39.7
River Width (m)	200-340	230-330	300	223	
Earth Dike (m)	21,500	16,000*	10,000*	4,500*	52,000
Channel Excavation (m^3)	992,000	0	0	0	992,000
Spur Dike (unit)	349	302	394	283	1,328
Groundsill (unit)	1	1	1	1	4
Sluiceway (unit)	4	3	8	2	17
Bridge Extension (unit)	1	0	0	0	1
Compensation					
Land (ha)	10.0	0.0	0.0	0.0	10.0
House (No.)	0	0	0	0	0

Note: * Strengthening of existing dikes

The above priority sabo dams and river improvement projects are summarized in Fig. 9.

(4) Project Cost

The total cost of the proposed priority project is estimated to be 1,911.3 million pesos at June 1997 prices and 2,333.1 million pesos including price contingency. These are broken down by work item and currency portion as follows.

(unit : million pesos)

Item	Foreign Currency	Local Currency	Total
1. Construction Cost	654.1	800.5	1,454.6
1.1 Preparatory Works	59.4	72.8	132.2
1.2 Main Works	540.6	661.6	1,202.2
(1) Sabo Dam	105.4	126.7	232.1
(2) Alluvial Fan River Imp.	358.6	478.1	836.7
(3) Laoag-Bongo River Imp.	76.6	56.8	133.4
1.3 Miscellaneous Works	54.1	66.1	120.2
2. Compensation Cost	0.0	6.4	6.4
2.1 Land Acquisition	0.0	6.0	6.0
2.2 House Resettlement	0.0	0.4	0.4
3. Administration Cost	0.0	43.8	43.8
4. Engineering Services Cost	209.4	23.3	232.7
5. Physical Contingency	86.4	87.4	173.8
Sub-total	949.9	961.4	1,911.3
6. Price Contingency	83.2	338.6	421.8
Total	1,033.1	1,300.0	2,333.1

Note: 1) Exchange rate : US$1.00 = 26 Pesos = 115 Yen at June 1997 prices
2) Price escalation: 2% per annum for foreign currency, 7% per annum for local currency
3) River Imp. : River Improvement

2.7.3 Project Evaluation

(1) Project Benefit

The project will produce flood mitigation and land use enhancement benefits including land loss prevention and land restoration benefits, as follows:

(a) The project will protect land of 13,400 ha with 47,900 resident population, and mitigate flood damage on the properties and crop production tabulated below. Further, it will mitigate the indirect damages such as opportunity loss of business/production activity, emergency activities, medical care/cure for flood victims and preventive activities against crimes.

Property/Crop	Quantity
Housing Units (No.)	9,515
Shopping Store (No.)	187
Factory (No.)	44
School (No.)	71
Hospital (No.)	16
Agricultural Production (ha)	8,600
Road/Irrigation Facilities, etc.	1 l.s.

(b) In the alluvial fan areas, the project will prevent annual land loss of 52 ha and restore the existing devastated area of 1,800 ha to land available for grazing and crop cultivation.

The average annual benefits of flood mitigation and land use enhancement under the present socio-economic conditions are estimated below. These benefits will increase according to the economic growth and population expansion of the Basin in the future.

	Annual benefit (million pesos)
Flood Mitigation	244.4
Land Loss Prevention	3.7
Land Restoration	8.5
Total	256.6

(2) Economic Evaluation

The economic viability of the project is evaluated as follows.

Index	Value
Economic Internal Rate of Return (EIRR, %)	20.3
Cost-Benefit Ratio (B/C)	1.43
Net Present Value (NPV, million pesos)	442

(3) Social Evaluation

The project will create the temporary jobs shown below during the 4-year construction period. Besides the temporary labor, some support services for the construction will be required. These support services will create another job opportunity and activate the regional economy. Further, the project will mitigate the existing economic disparity in the Basin and improve social amenity and public hygiene.

Labor	Labor Force (man-day)
Skilled	520,000
Unskilled	900,000
Total	1,420,000

2.7.4 Environmental Impact Assessment

The potential impacts of the proposed project to the environment during both construction and operation phases are predicted and assessed as shown in Table 1.

Water pollution during the construction phase is considered the only negative impact to be managed. Water pollution sources would be dewatering work for structural foundations, earth work operations adjacent to a stream and aggregate processing. However, water pollution due to these works is considered not much since the riverbed materials of the project sites are mainly composed of sand, gravel and boulder with very little silt and clay.

The method of riverbed excavation, excavation of structural foundations, dewatering and aggregate processing will be planned to minimize the generation of turbid water. For this purpose, a settling basin will be provided immediately downstream of the construction sites, if necessary.

2.7.5 Project Implementation and Operation/Maintenance

(1) Implementation Schedule

The project will be implemented from 1997 to 2003 based on the schedule mentioned below. The detailed construction schedule is shown in Fig. 10.

(a) Loan application and agreement to/between foreign financing organization, and other preparations from 1997 to 1998

(b) Detailed design in 1999

(c) Construction from 2000 to 2003

(2) Project Implementation Organization

For the implementation of the project, a new project management field office will be organized to function under the direct supervision of the Project Management Office for Major Flood Control and Drainage in the DPWH.

(3) Operation and Maintenance

The operation and maintenance of the Laoag River will further become important after completion of the project. The major operation and maintenance activities to be conducted by DPWH will include the following:

(a) Flood forecasting and warning in cooperation with the Provincial Disaster Operation Center

(b) Maintenance of the existing and proposed river structures as shown below.

River Structures	Unit	Quantity		
		Existing	Proposed	Total
Earth Dike	km	49.8	33.1	77.9
River Wall/Revetment	km	4.1	0.5	4.6
Spur Dike	unit	80	1,328	1,408
Groundsill	unit	0	4	4
Drainage Sluiceway	unit	0	5	5
Sabo Dam	unit	0	5	5

(c) Hydrological and river morphological observation

DPWH, District Engineering Office will be responsible for the above works. The Maintenance Section of the District Engineering Office should be strengthened to carry its assigned task.

3. LAOAG CITY URBAN DRAINAGE

3.1 Study Area

(1) Drainage Basin

The urban area of Laoag City is located on the right bank of the Laoag River 8 km upstream from the river mouth. Most of the urban area is drained by the Daorao-Tupec Creek which is hydrologically independent from the Laoag River. Only a small portion, where the drainage problem is not significant, is directly drained into the Laoag River. Hence, the study area for the Laoag City Urban Drainage Improvement covers the Daorao-Tupec Creek Basin with a total drainage area of 38.79 km^2. Salient topographic features of the Basin are shown in Fig. 11.

The main river course is called Tupec in the upper reaches and Daorao in the middle and lower reaches. The Daorao-Tupec Creek joins two major tributaries, the San Isidro and Pandan creeks, in the middle reaches.

The Daorao Creek runs through the northern outskirts of the urban area from east to west. Thereafter, it turns toward the north and, after passing through the sand dune, finally empties into the South China Sea.

(2) Socio-economic Conditions

Laoag City covers a total administrative area of 107.51 km^2. The Daorao-Tupec Creek Basin with an area of 38.79 km^2 is entirely located within the territory of Laoag City.

The total population of Laoag City was 88,336 in 1995 among which 57,883 resided within the Basin. The population of Laoag City is projected to increase to 111,400 in 2020.

The existing land use of the Basin consists of residential area (11.1%), tree area (29.6%), orchard (0.5%), grassland (1.0%), paddy field (49.6%), upland crop area (6.0%), riverbed (0.8%) and sand dune (1.4%).

3.2 Existing Urban Drainage System

(1) Conditions of Creeks

Most of the urban storm water of Laoag City is finally drained by the San Isidro and Daorao-Tupec creeks. The river course of the Daorao and San Isidro creeks are shown in Figs. 11 and 12.

The Daorao-Tupec Creek is very gentle in slope (Level - 1/2,300) and very narrow in width (10 - 40 m). The creek meanders at many locations. No dike is provided along the creek. Hence, the flood carrying capacity is small.

The mouth of Daorao-Tupec Creek is clogged all year round except during big floods. The downstream of Daorao Creek is subject to the backwater effect of the small mouth at flood time.

The San Isidro Creek running through the low-lying built-up areas drains an area of 1.99 km^2 at the confluence with the Daorao Creek. Storm and wastewater from the urban residential area is mainly drained by the San Isidro Creek. The San Isidro Creek is much affected by the backwater of the Daorao Creek. No dike is provided along the creek. The flood carrying capacity is very small due to the backwater effects of the Daorao Creek and the narrow width (2 - 4 m).

(2) Urban Drainage System

The existing urban drainage system covers a total land area of 501.4 ha consisting of 333.7 ha of built-up area and 167.7 ha of farmland. The drainage system is divided into 11 sub-drainage systems as shown in Fig. 12. The area of each sub-drainage system is shown below.

Drainage Area (ha)			
DA-1	53.0	DA-7	80.0
DA-2	94.1	DA-8	42.0
DA-3	23.9	DA-9	36.2
DA-4	11.0	DA-10	23.1
DA-5	17.0	DA-11	38.1
DA-6	83.0	Total = 501.4 ha	

3.3 Flood Damage

(1) Flood Damage of 1996 Typhoon Gloring

The Basin was ravaged by Typhoon Gloring in July 1996. The total inundation area reached 1,035 ha. During Typhoon Gloring, the Laoag River overflowed its right bank at the western fringe of the urban area into the Daorao-Tupec Creek Basin. This further worsened the flooding situation in the downstream areas of Daorao-Tupec Creek.

The higher land in the urban area suffered from scattered local floods. However, the low-lying areas along the San Isidro Creek were seriously inundated.

The flood damages of the Basin are estimated below. The flooding by 1996 Typhoon Gloring is shown in Fig. 13.

Item	Affected
People	11,259
Inundated Area (ha)	1,035
Housing Units (No.)	2,048
Industrial Establishment (No.)	299
Educational Facility (No.)	39
Health Facility (No.)	8
Road (km)	126

(2) Flood Damage Analysis

Severe floods of the Basin are usually caused by heavy rainfall brought by typhoons. The flooded area is divided into four (4) districts by flooding cause as shown below.

Districts	Main Causes of Flood Damage
1. City Proper I (DA 7 to DA 11 Drainage Area)	- Overflow from Laoag River
2. City Proper II (San Isidro Creek Basin, DA-1 to DA-5 Drainage Area)	- Poor flow capacity of San Isidro Creek - Backwater of Daorao Creek
3. City Proper III (DA 6 Drainage Area)	- Poor flow capacity of Daorao-Tupec Creek - Backwater of Daorao Creek
4. Rural Area	- Overflow from Laoag River - Mouth clogging of Daorao Creek - Poor flow capacity of Daorao Creek

The overflow from the Laoag River will be prevented by the flood protection dikes proposed in the Laoag Sabo and Flood Control Project. The river mouth of the Daorao Creek may be easily opened prior to the coming of flood by some small maintenance works.

After the above mentioned works, more than 90% of the flood damage in the Basin will concentrate on the City Proper II Area.

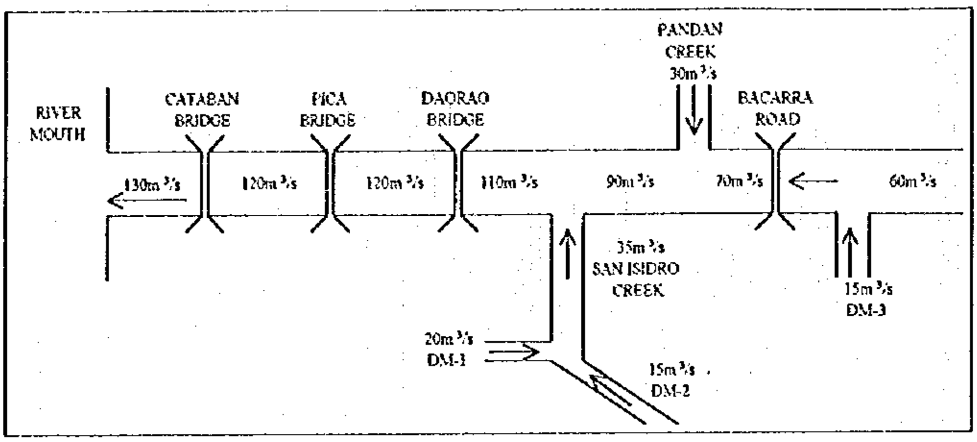
3.4 Urgent Urban Drainage Improvement

(1) Target Area

The flood damages in Laog City will concentrate on the San Isidro Creek Basin after completion of the Laoag River flood protection dikes and establishment of the proper mouth maintenance system of the Daorao Creek. Hence, the San Isidro Basin is selected as the target area for the urgent urban drainage improvement of Laoag City.

(2) Design Flood Discharge

The design flood return period of the project is set at 5-year, referring to similar projects in the Philippines. The design flood discharge at the respective creek sections are shown below.



(3) Improvement Works and Construction Schedule

For the urban drainage improvement of the San Isidro Basin, the following works will be necessary.

(a) Improvement for the San Isidro Creek (Length: 900 m)

(b) Improvement for the upstream of Daorao Creek having backwater effects on the San Isidro Creek (Length: 930 m)

(c) Improvement for the two (2) drainage mains of DM1 and DM2 connected to the San Isidro Creek (Length: 580 m)

Further, the establishment of the proper creek mouth maintenance system is prerequisite for this project. Hence, some necessary equipment will be procured.

The proposed improvement works are shown in Fig. 14. The project will be completed within three (3) years based on the following schedule.

(a) Detailed design in 1999
(b) Construction works from 2000 to 2001

(4) Project Cost

The total project cost is estimated at 118.0 million pesos at June 1997 prices and 134.8 million pesos including price contingency. These are broken down by work item and currency portion as follows.

Work Item	Quantity	Cost (: million pesos)		
		Foreign Currency	Local Currency	Total
1. Construction Cost		44.54	41.48	86.02
1.1 Preparatory Works		4.05	3.77	7.82
1.2 Main Works		36.81	34.28	71.09
(1) Earth Work	106,000 m^3	7.65	4.24	11.89
(2) Revetment Work	2,300 m	3.23	13.24	16.47
(3) Bridge and Culvert	10 units	18.13	14.26	32.39
(4) Other Works		7.80	2.54	10.34
1.3 Miscellaneous Work		3.68	3.43	7.11
2. Compensation Cost		0.00	4.74	4.74
2.1 Land Acquisition	2.71 ha	0.00	4.74	4.74
2.2 House Resettlement	none	0.00	0.00	0.00
3. Administration Cost		0.00	2.72	2.72
4. Engineering Services Cost		12.38	1.38	13.76
5. Physical Contingency		5.30	5.43	10.73
Sub-total		62.22	55.75	117.97
6. Price Contingency		3.98	12.83	16.81
Total		66.20	68.58	134.78

Note: 1) Exchange rate : US$ 1.00 = P 26.00 = Y 115.00
2) Annual price escalation rate : 2.0% for foreign currency and 7.0% for local currency

3.5 Project Evaluation

(1) Project Benefits

The project will produce direct and indirect flood damage mitigation benefits. The direct damages include the damages on houses and household effects, commercial and factory facilities, educational/health facilities and other infrastructures. The indirect damages include opportunity loss of business, emergency activities, medical care/cure and preventive activities against crimes.

The project will remove all the damages caused by floods below a 5-year return period. Hence, the annual flood mitigation benefit of the project is expected to be 21.8 million pesos under the present socio-economic conditions. These benefits will increase according to the economic growth and population expansion of the project area in the future.

(2) Economic Evaluation

The economic viability of the project is evaluated as follows.

Index	Value
Economic Internal Rate of Return (EIRR, %)	31.9
Cost-Benefit Ratio (B/C)	2.45
Net Present Value (NPV, million pesos)	105

(3) Social Evaluation

The project will create a temporary labor force of about 70,000 man-days during the 2 year construction period. Besides these temporary workers, some support services for the construction will be required. These support services will create another job opportunity and activate the regional economy. Further, the project will improve social amenity and public hygiene.

3.6 Environmental Impact Assessment

The potential impacts of the proposed project to the environment during both construction and operation phases have been predicted and assessed.

Water pollution during the construction phase is considered the only negative impact to be managed. Water pollution sources would be dewatering work for structure foundations and earth work operations in the channel. However, water pollution due to these works is considered not heavy since their work volume is comparatively small.

The method of riverbed excavation, excavation of structural foundations and dewatering will be planned to minimize the generation of turbid water. For this purpose, a settling basin will be provided immediately downstream of the construction sites, if necessary.

4. RECOMMENDATION

(1) The proposed sabo dam and river improvement priority projects and the urban drainage improvement project are technically and economically feasible. Environmentally, they will generate no significant adverse effects. Urgent implementation of the projects is recommended in consideration of the recurrent serious floods in the project areas. The required financial sources should be arranged as soon as possible.

(2) Necessary hydraulic model tests to check the effects of sandbar formation on the riverbanks and to determine the detailed structural dimensions of the spur dikes should be conducted in the detailed design phase.

(3) Monitoring of the riverbed variation and local scouring around the major structures should be continued, especially in the alluvial fan rivers, to avert flood risk due to unexpected sediment deposition and structural destruction.

(4) The existing temporary dikes built by NIA under INIP-I should now be transferred to DPWH to prevent further deterioration.

(5) Watershed management, including the extension of the ongoing reforestation projects in the Madongan and Papa river basins, should be promoted to supplement the sediment control of the proposed structural measures.

(6) Practical flood forecasting/warning and flood fighting systems should be established to supplement the capacity of the proposed flood control structures.

TABLES

Table 1 Scaling Checklist for Environmental Impacts

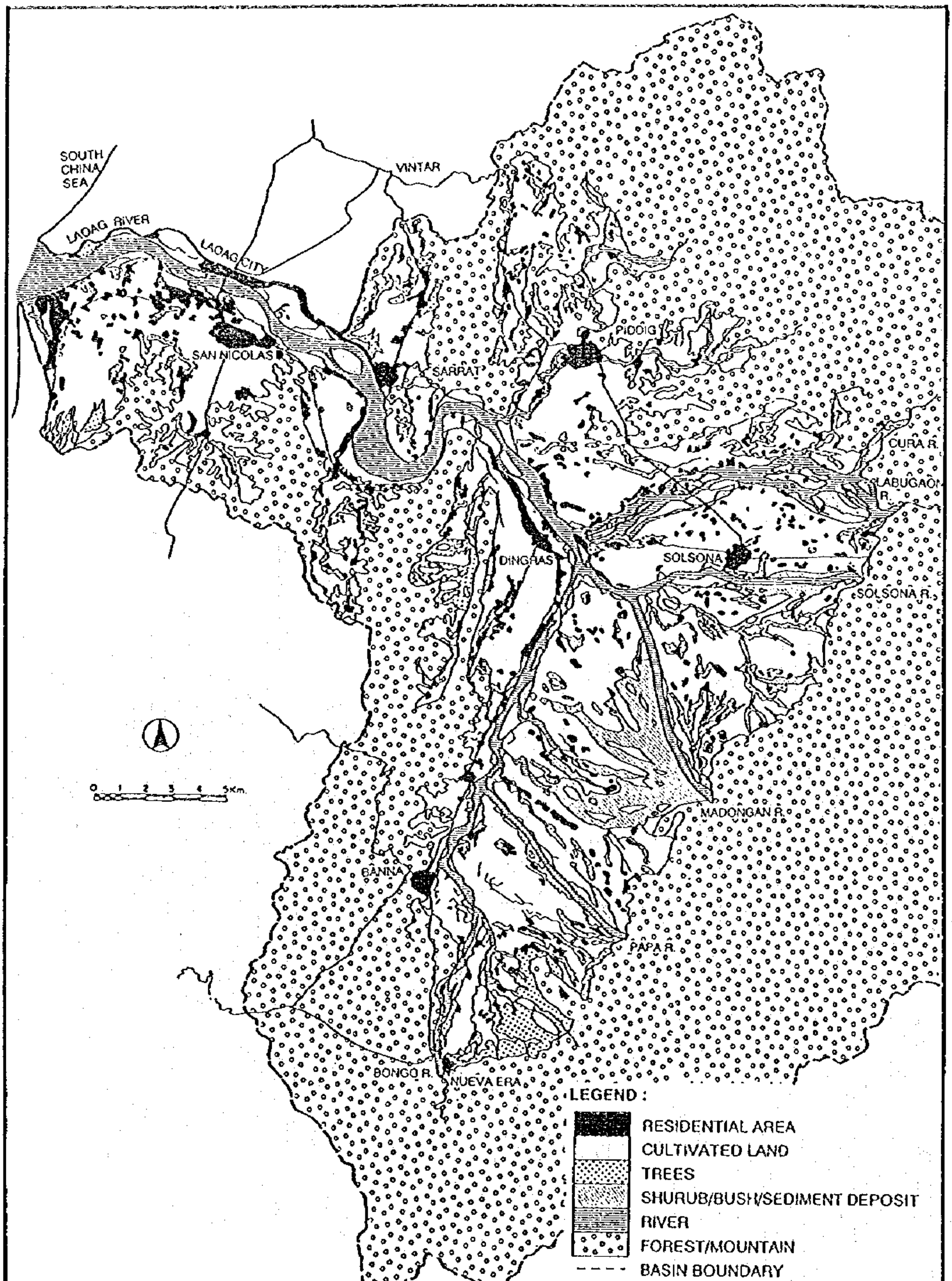
(Construction Phase)

Impact Area	Direct Impact	Nature	Magnitude
Water Quality/Air Quality/ Noise	Water Pollution	Negative	Moderate
	Air Pollution	Negative	Minimal
	Noise Generation	Negative	Minimal
Geology	Soil Erosion	Negative	Minimal
Ecology	Fish/Wildlife Disturbance	Negative	Minimal
	Vegetation Loss	Negative	Minimal
Socio-Economy	Land Aquisition/House Relocation	Negative	Minimal
	Archaeological/Historical Asset Loss	Negative	No Effect
	Traffic Disturbance	Negative	Minimal
	Local Labor Employment	Positive	Significant

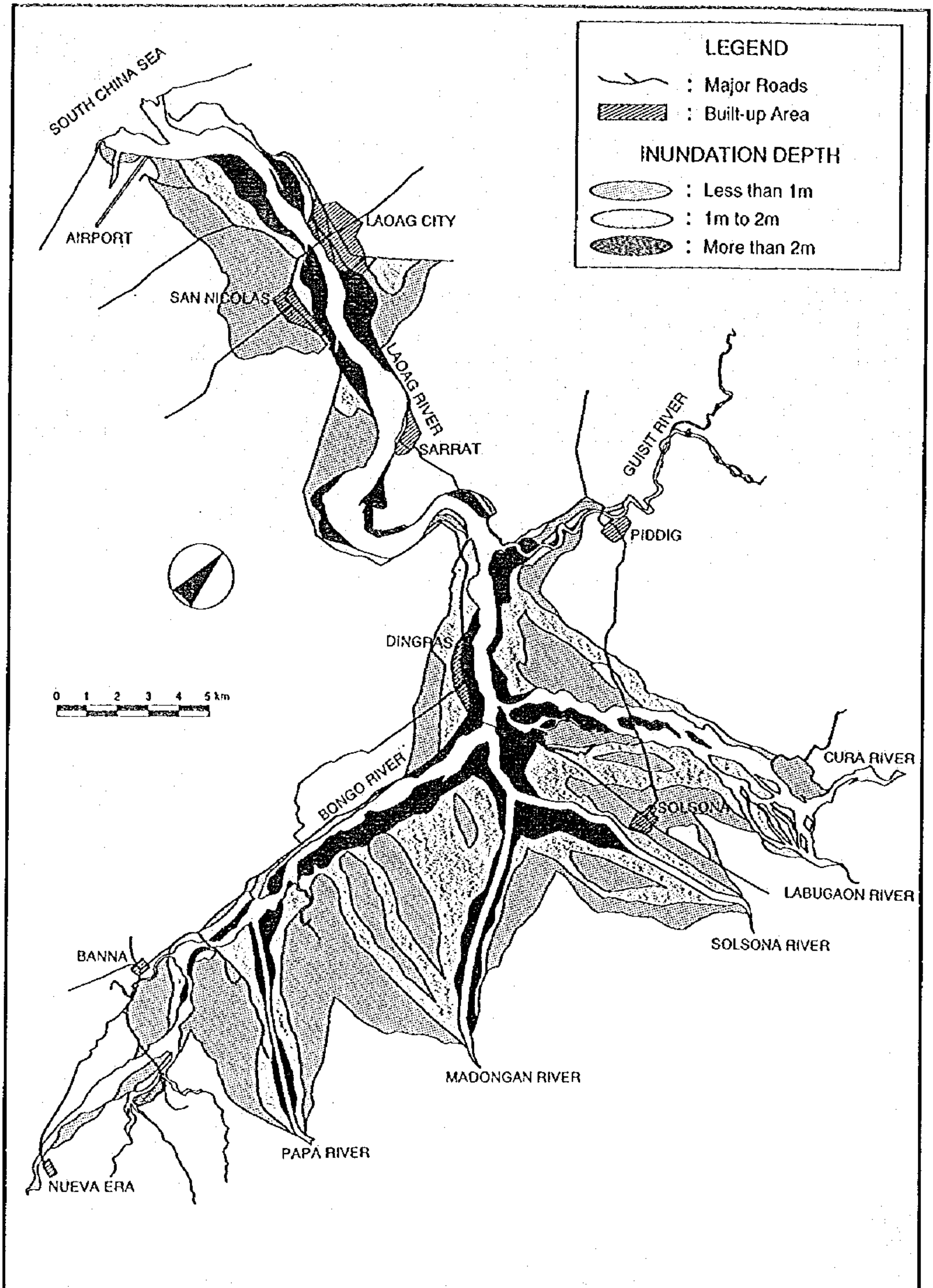
(Operation Phase)

Impact Area	Direct Impact	Nature	Magnitude
Hydrology/River Morphology	Groundwater Recharge Reduction	Negative	Minimal
	Riverbed Aggradation	Negative	Minimal
	Reduction of Channel Shifting	Positive	Significant
	Increase of River Bank Erosion	Negative	Minimal
	Decrease of Sand Supply to Coast	Negative	Minimal
Water Quality/Air Quality/ Noise	Generation of Water Pollutants	Negative	No Effect
	Generation of Air Pollutants	Negative	No Effect
	Generation of Noise	Negative	No Effect
Geology	Geological Destruction	Negative	No Effect
Ecology	Loss of Wildlife Habitat	Negative	No Effect
	Disruption of Fish Spawning Grounds	Negative	Minimal
Aesthetics	Aesthetic Impairment of Landscape	Negative	Minimal
	Visual Impairment of Historical/ Cultural Resources	Negative	No Effect
Natural Resources Use	Loss of Fishing Area	Negative	No Effect
	Impairment of Navigation	Negative	No Effect
	Damage to Economically Valuable Natural Resources	Negative	No Effect
Socio-Economy	Reduction of Economical Loss	Positive	Significant
	Reduction of Health Risk	Positive	Significant
	Increase of Available Farmland	Positive	Significant
	Disruption of Minorities' Life	Negative	No Effect

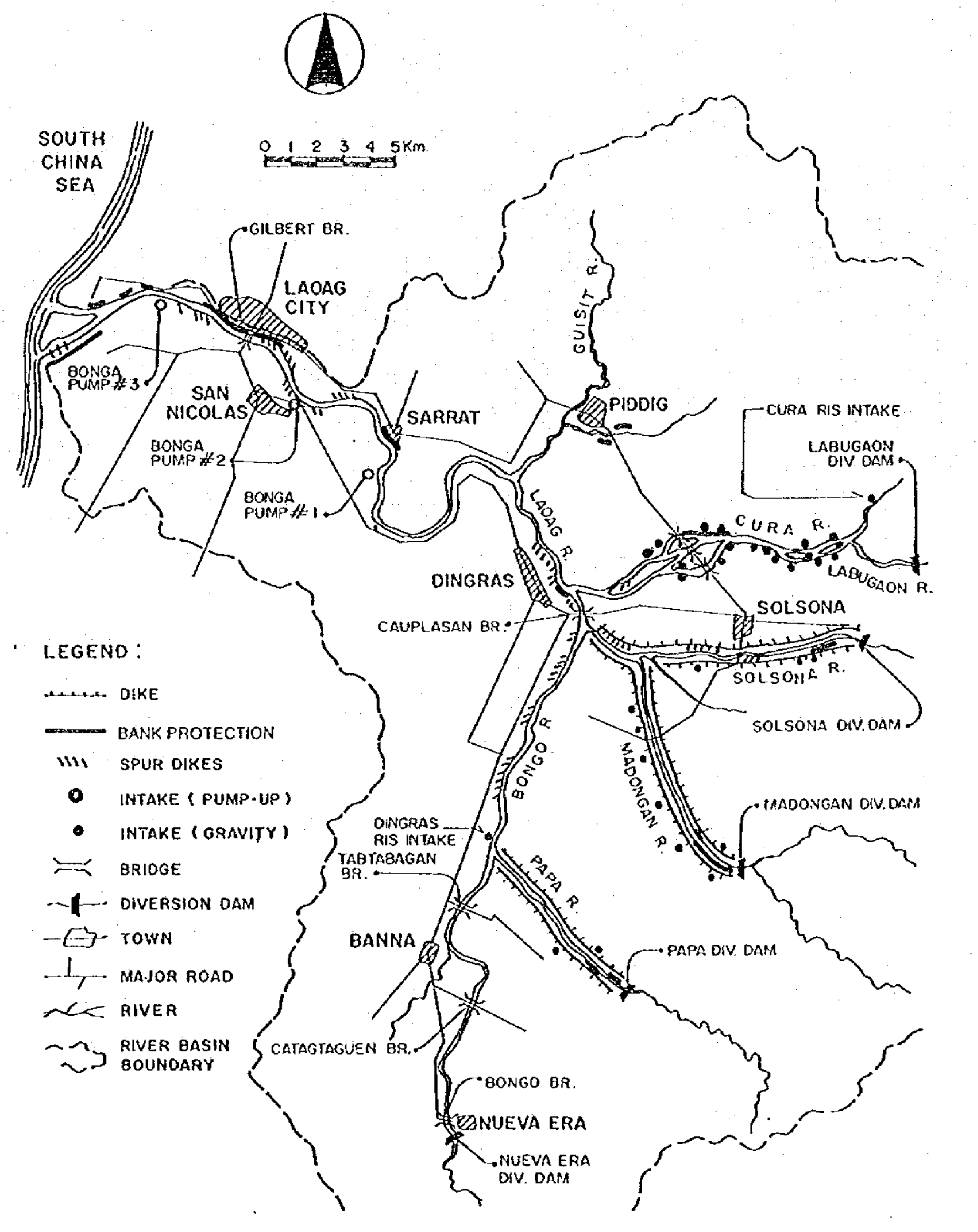
FIGURES



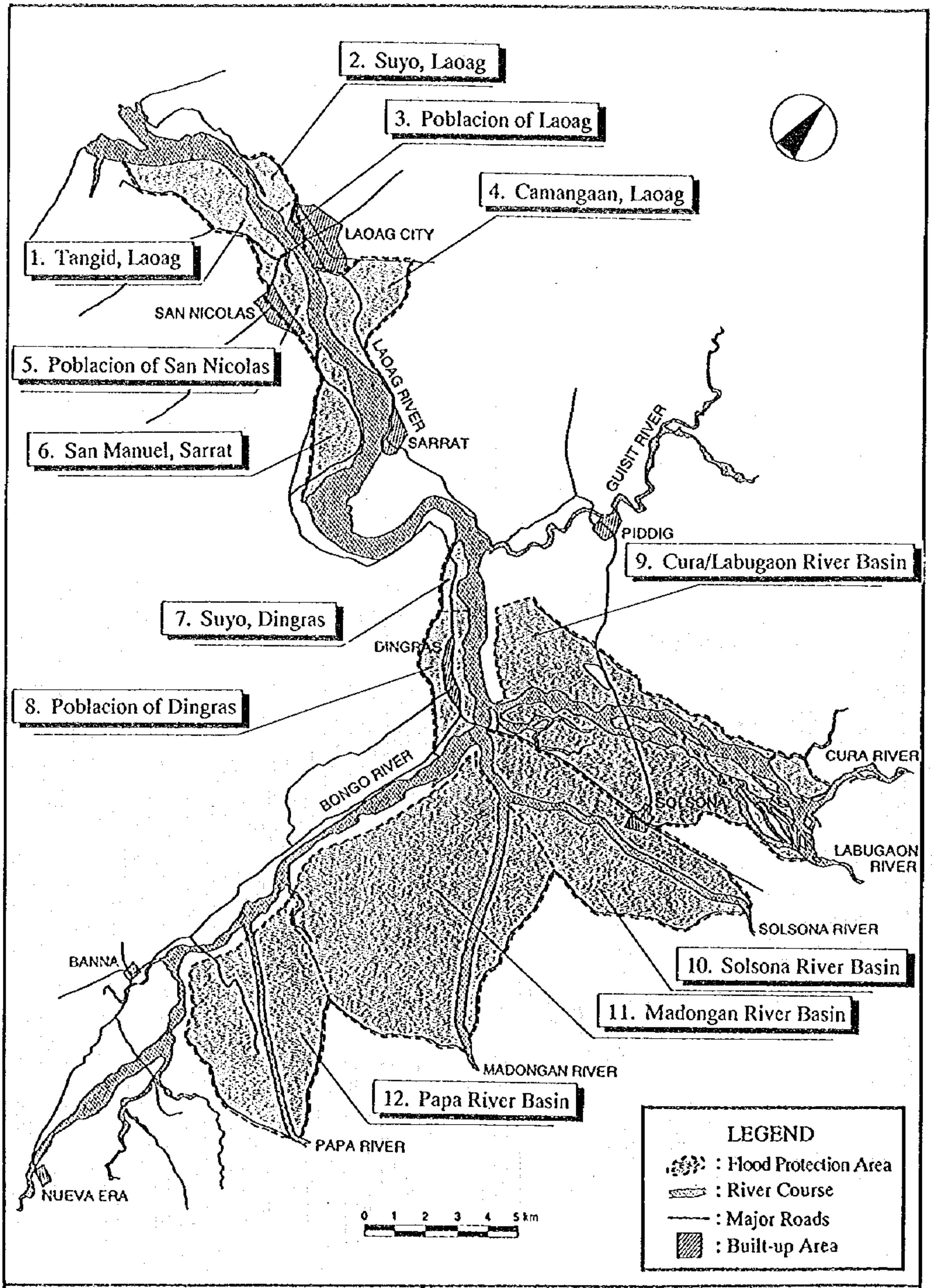
THE STUDY ON SABO AND FLOOD CONTROL IN THE LAOAG RIVER BASIN	Fig. 1 Existing Land Use
JAPAN INTERNATIONAL COOPERATION AGENCY	



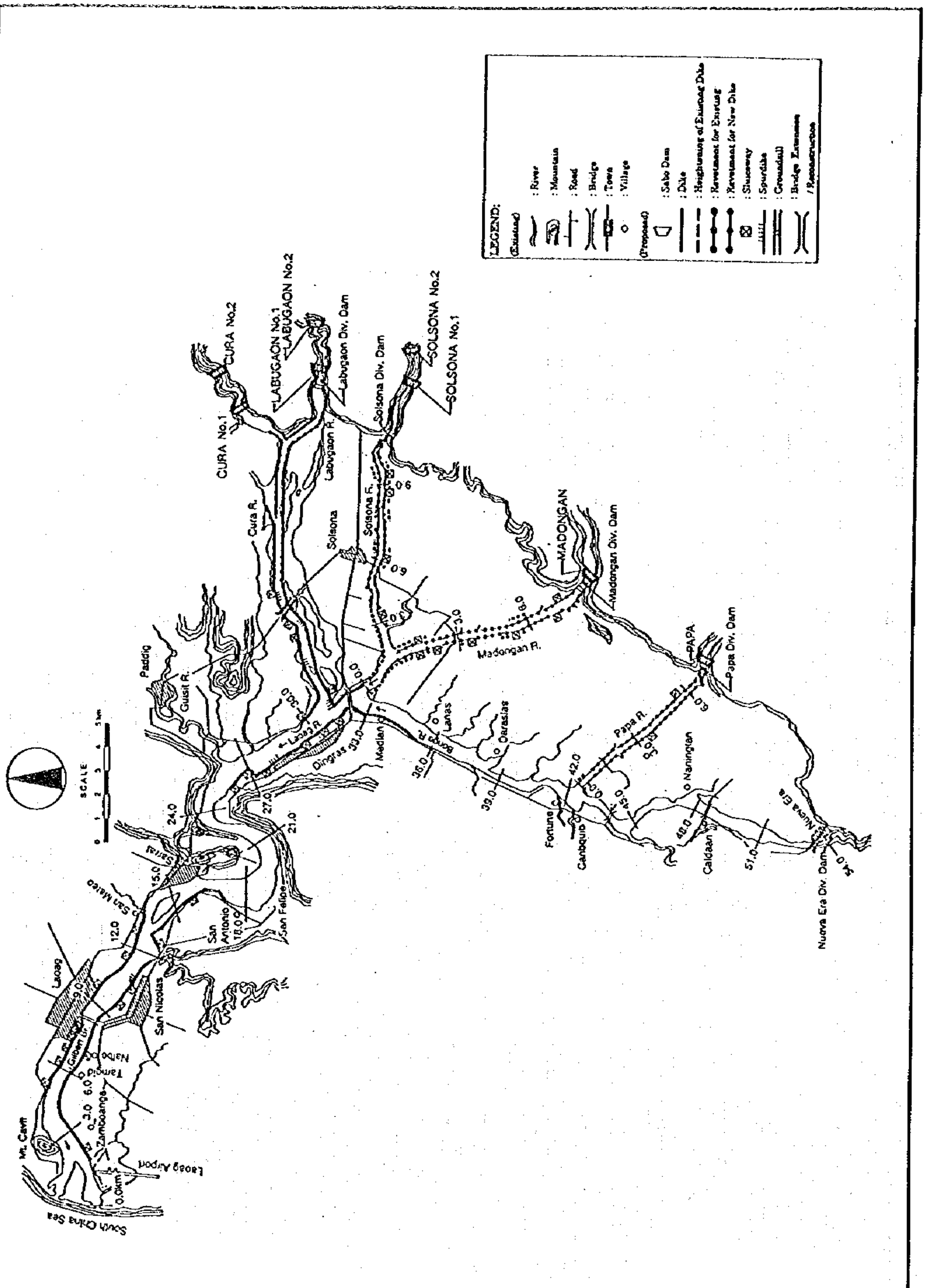
THE STUDY ON SABO AND FLOOD CONTROL IN THE LAOAG RIVER BASIN JAPAN INTERNATIONAL COOPERATION AGENCY	Fig. 2 Inundation Area and Depth by 100-year Flood



THE STUDY ON SABO AND FLOOD CONTROL IN THE LAOAG RIVER BASIN	Fig. 3
JAPAN INTERNATIONAL COOPERATION AGENCY	Existing River Structures



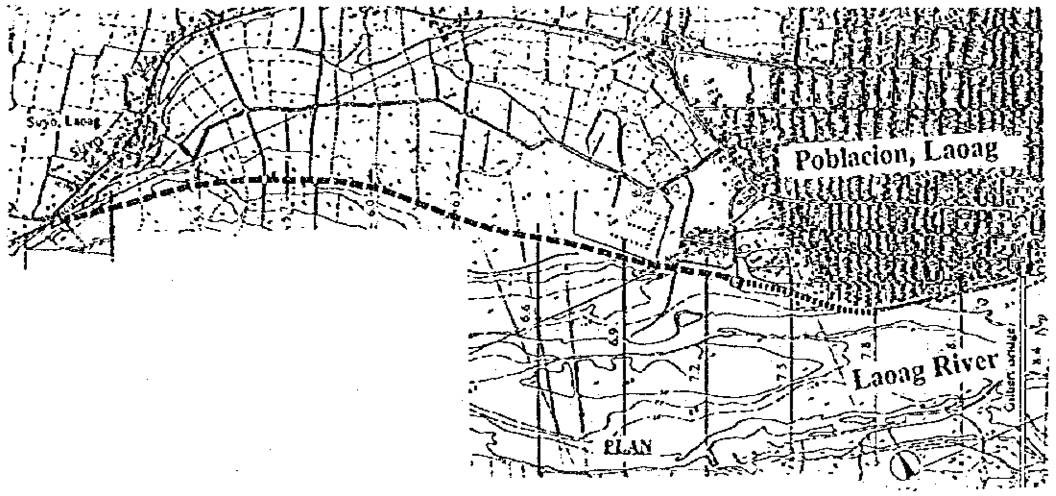
THE STUDY ON SABO AND FLOOD CONTROL IN THE LAOAG RIVER BASIN JAPAN INTERNATIONAL COOPERATION AGENCY	Fig. 4 Target Flood Protection Districts



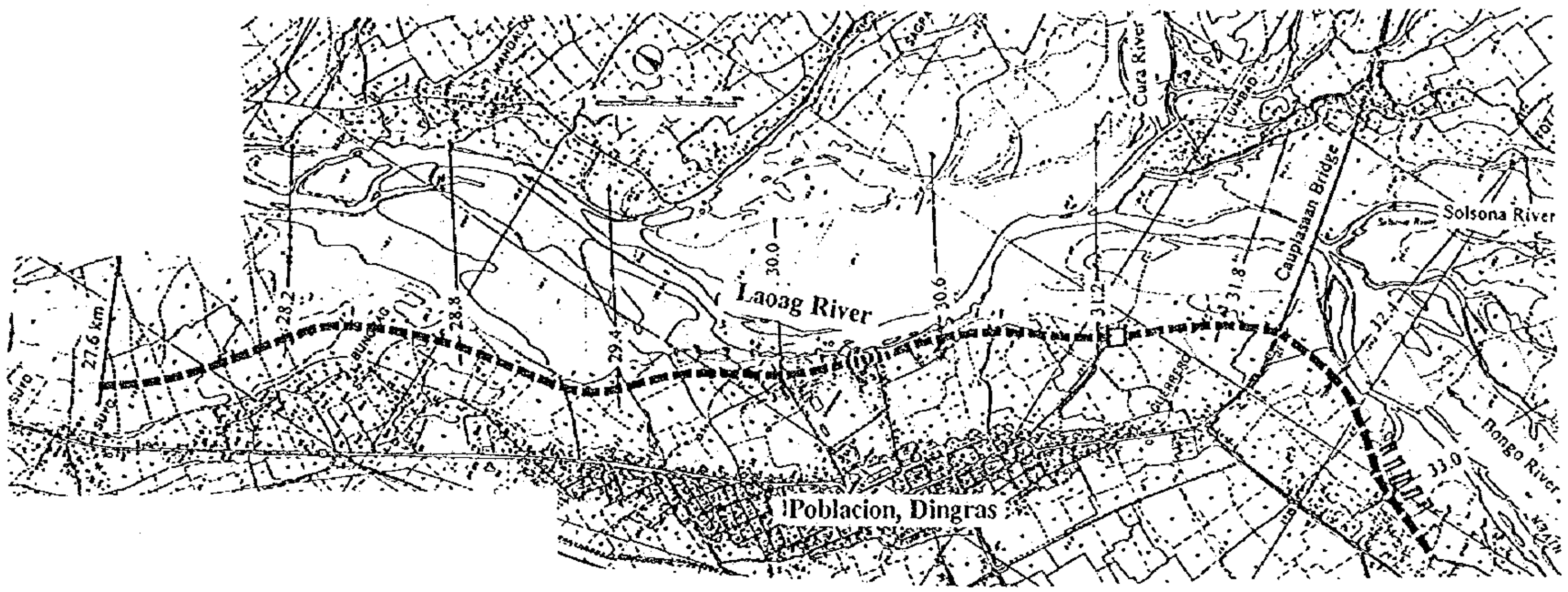
THE STUDY ON SABO AND FLOOD CONTROL IN THE LAOAG RIVER BASIN

JAPAN INTERNATIONAL COOPERATION AGENCY

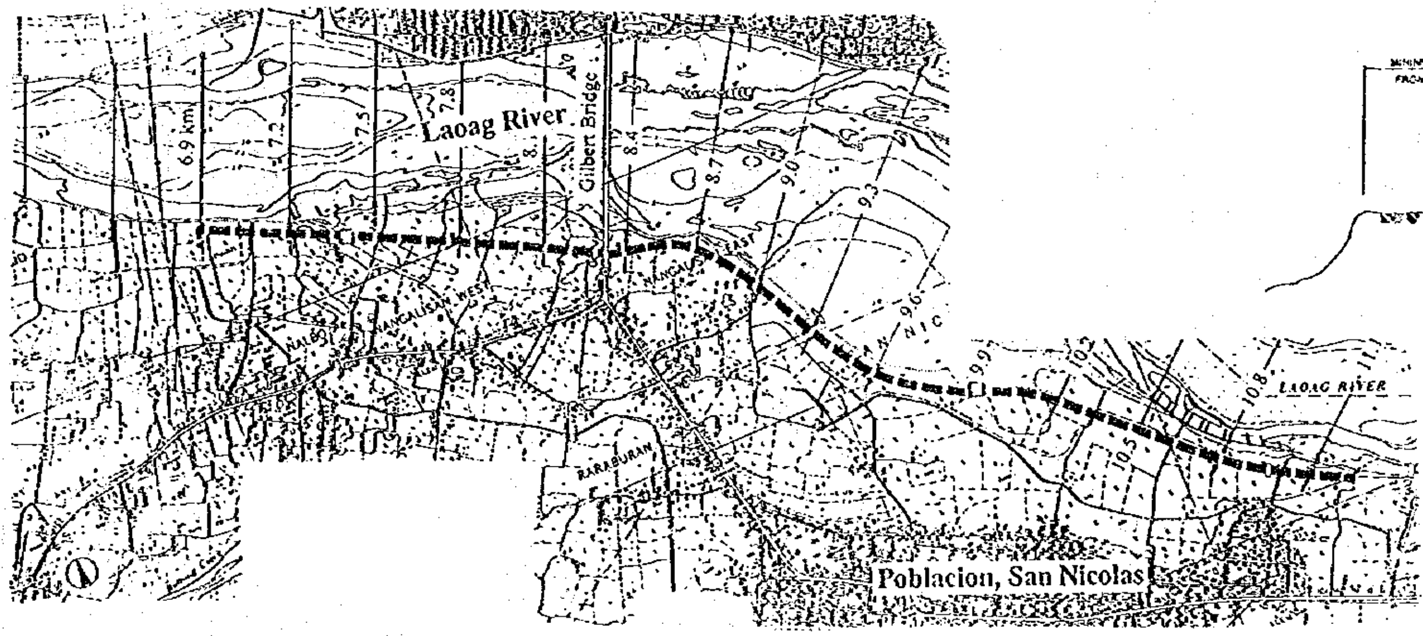
Fig. 5
Sabo and River Improvement Works of Master Plan



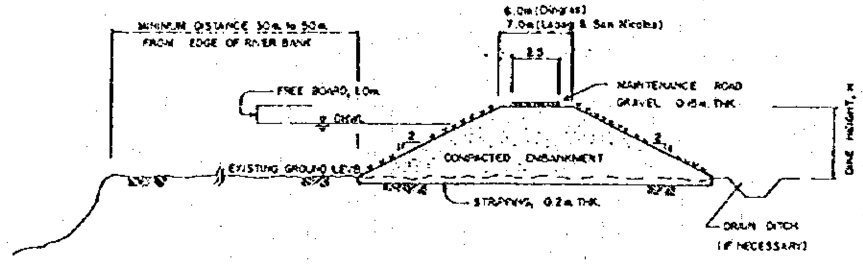
Poblacion Laoag



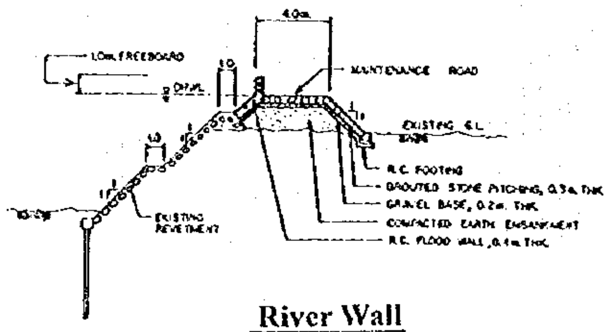
Poblacion Dingras



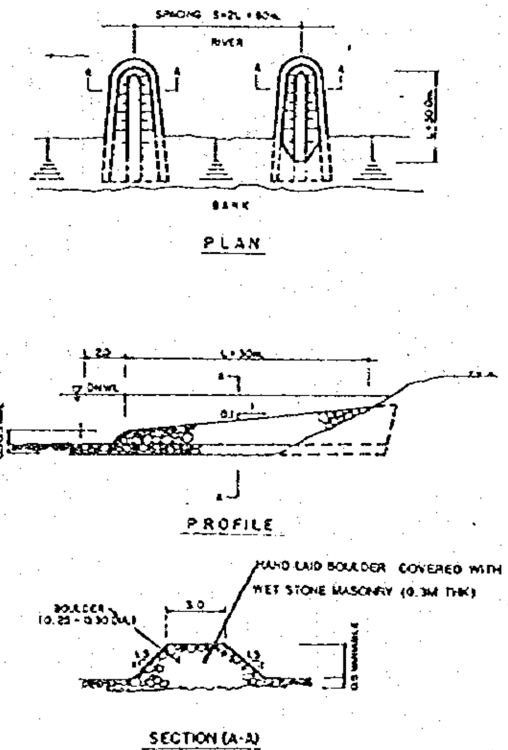
Poblacion San Nicolas



Earth Dike



River Wall



Boulder Spur Dike

LEGEND:

- : Proposed Earth Dike
- : Proposed River Wall with Maintenance Road
- : Proposed River Wall Heightening
- ▫ : Drainage Sluiceway

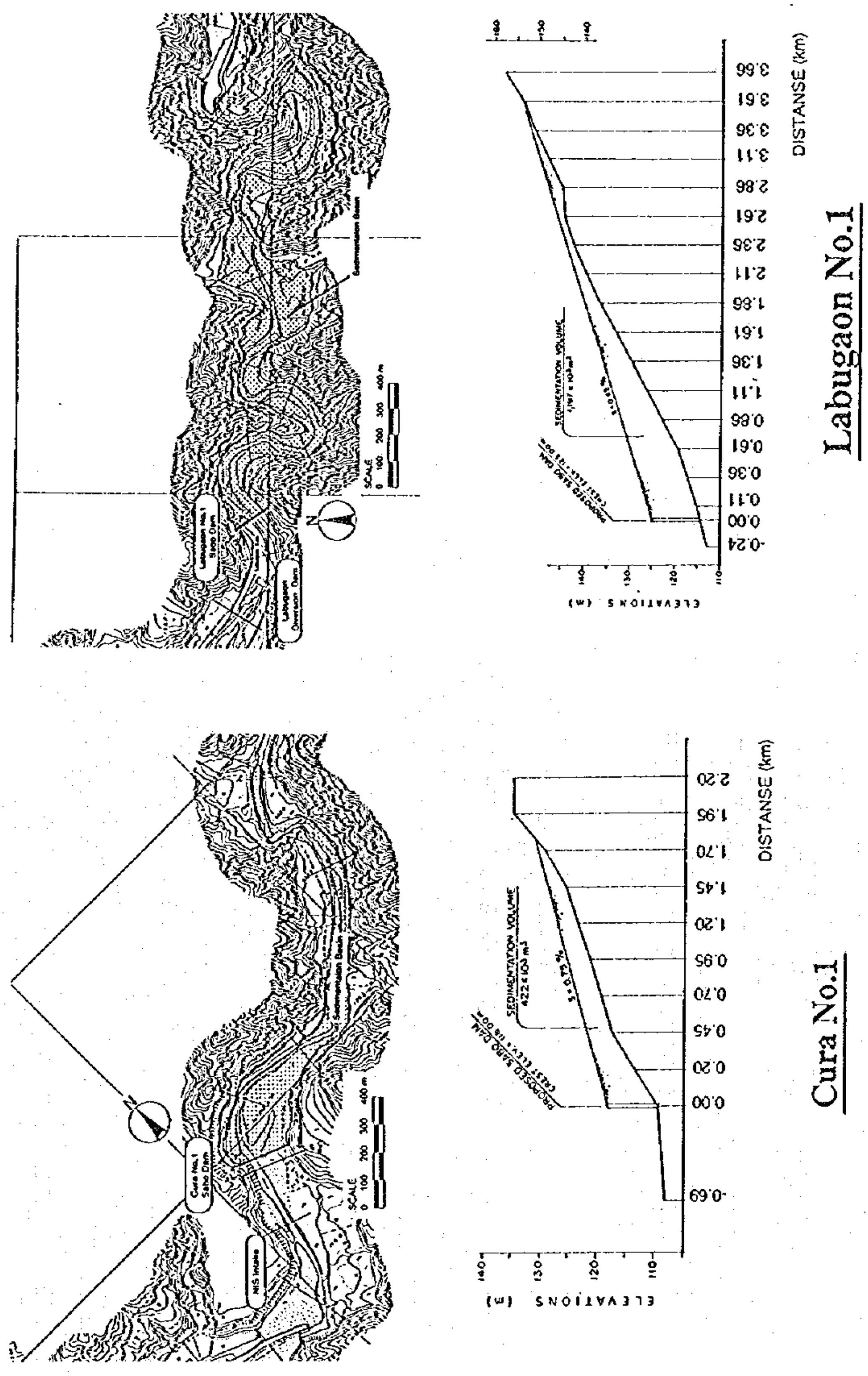
SCALE

0 400 800m

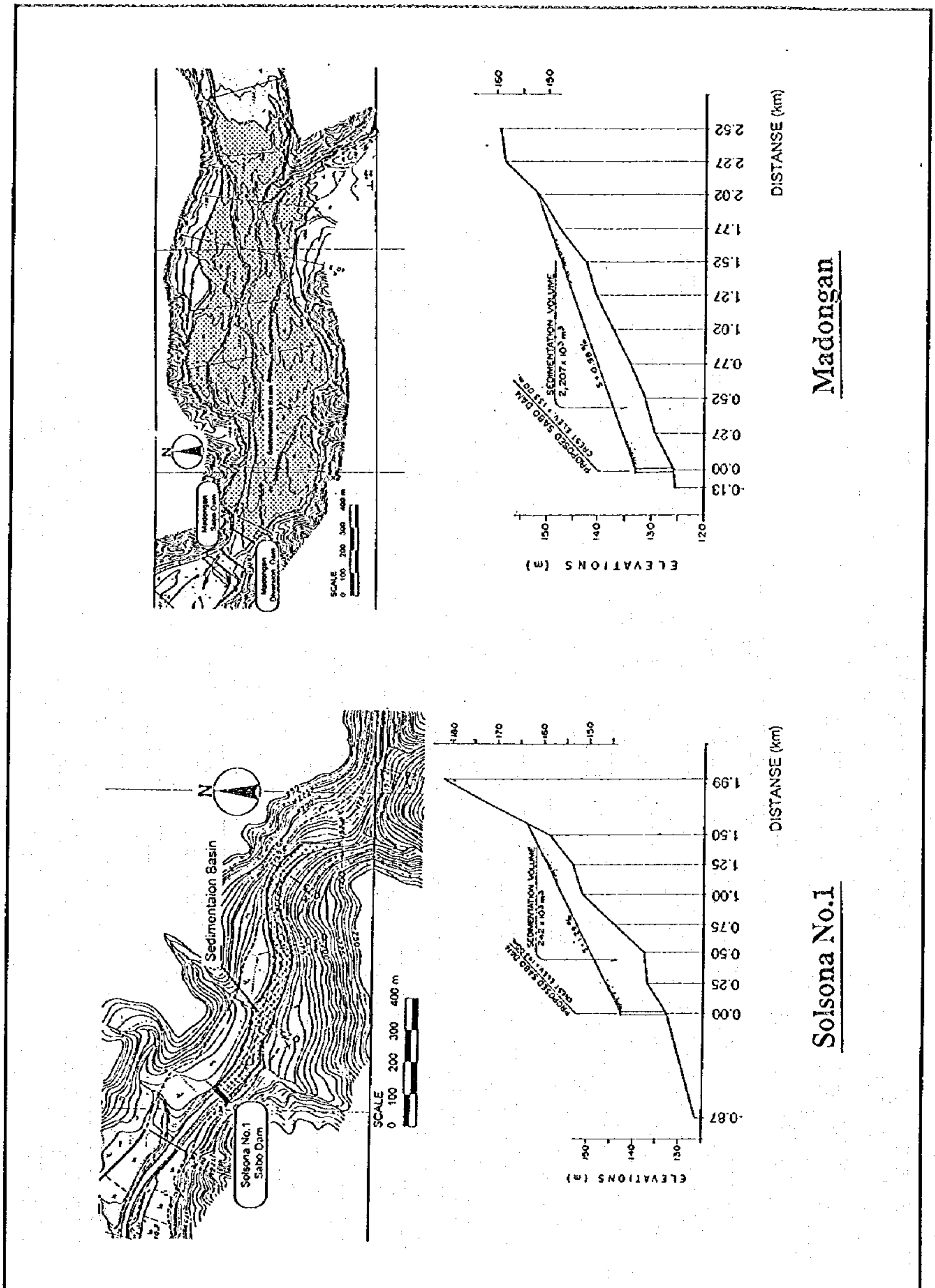
THE STUDY ON SABO AND FLOOD CONTROL IN THE LAOAG RIVER BASIN

JAPAN INTERNATIONAL COOPERATION AGENCY

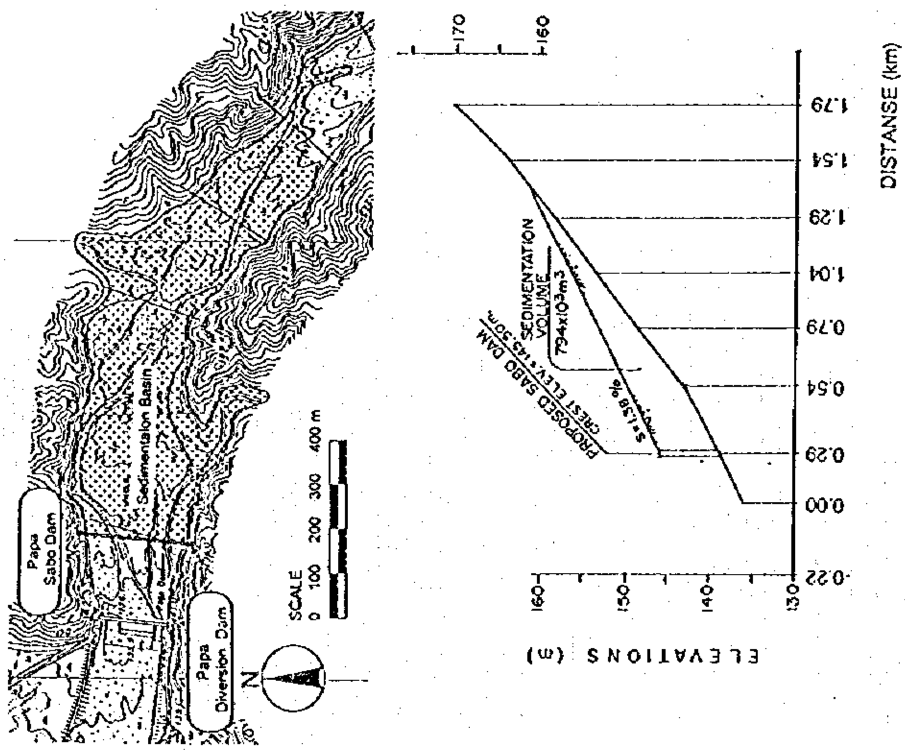
Fig. 6
Proposed River Improvement Profile in the Laoag-Bongo River



THE STUDY ON SABO AND FLOOD CONTROL IN THE LAOAG RIVER BASIN JAPAN INTERNATIONAL COOPERATION AGENCY	Fig. 7 (1) Proposed Sabo Dam Plan

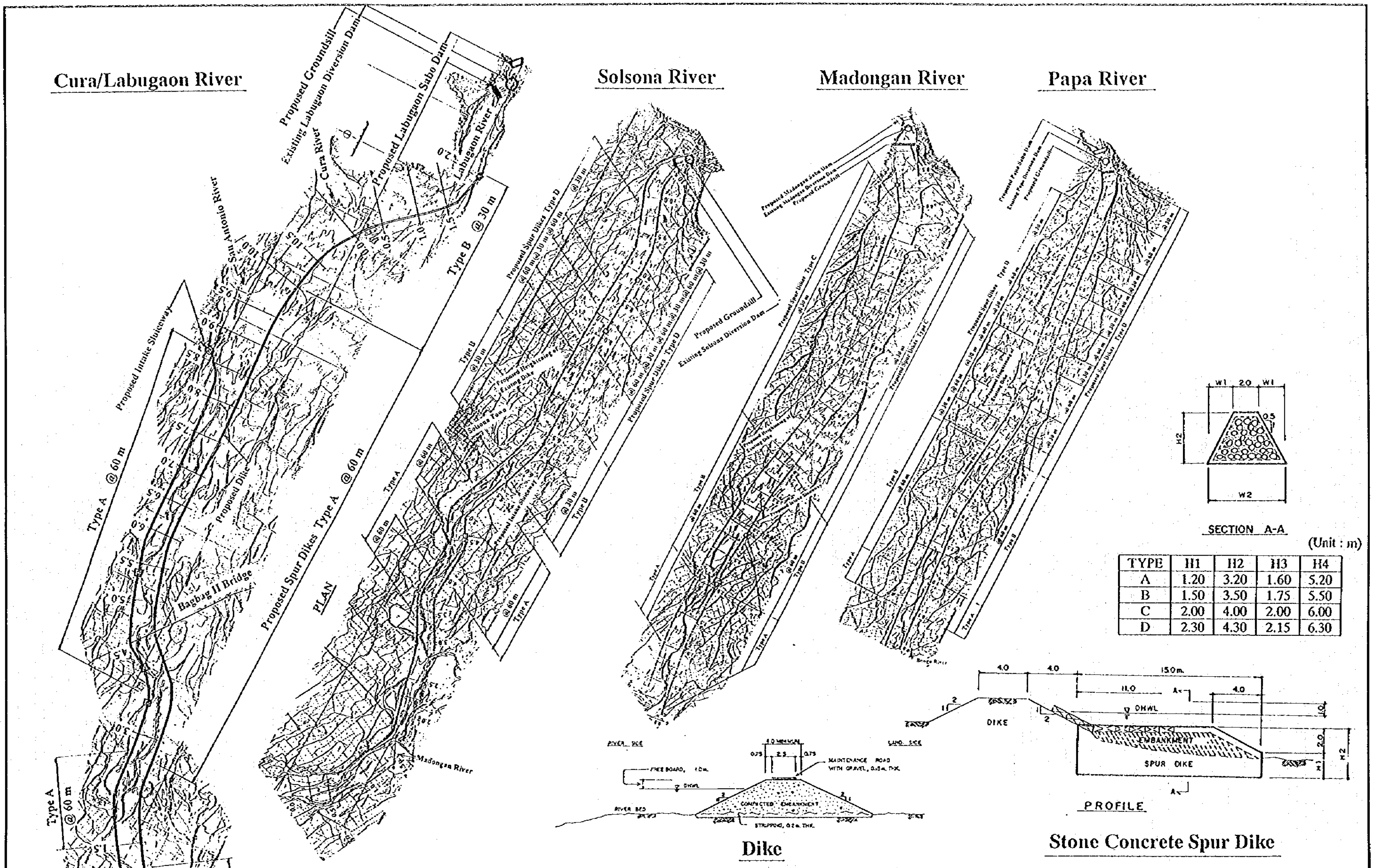


THE STUDY ON SABO AND FLOOD CONTROL IN THE LAOAG RIVER BASIN JAPAN INTERNATIONAL COOPERATION AGENCY	Fig. 7 (2) Proposed Sabo Dam Plan



Papa

THE STUDY ON SABO AND FLOOD CONTROL IN THE LAOAG RIVER BASIN	Fig. 7 (3)
JAPAN INTERNATIONAL COOPERATION AGENCY	Proposed Sabo Dam Plan



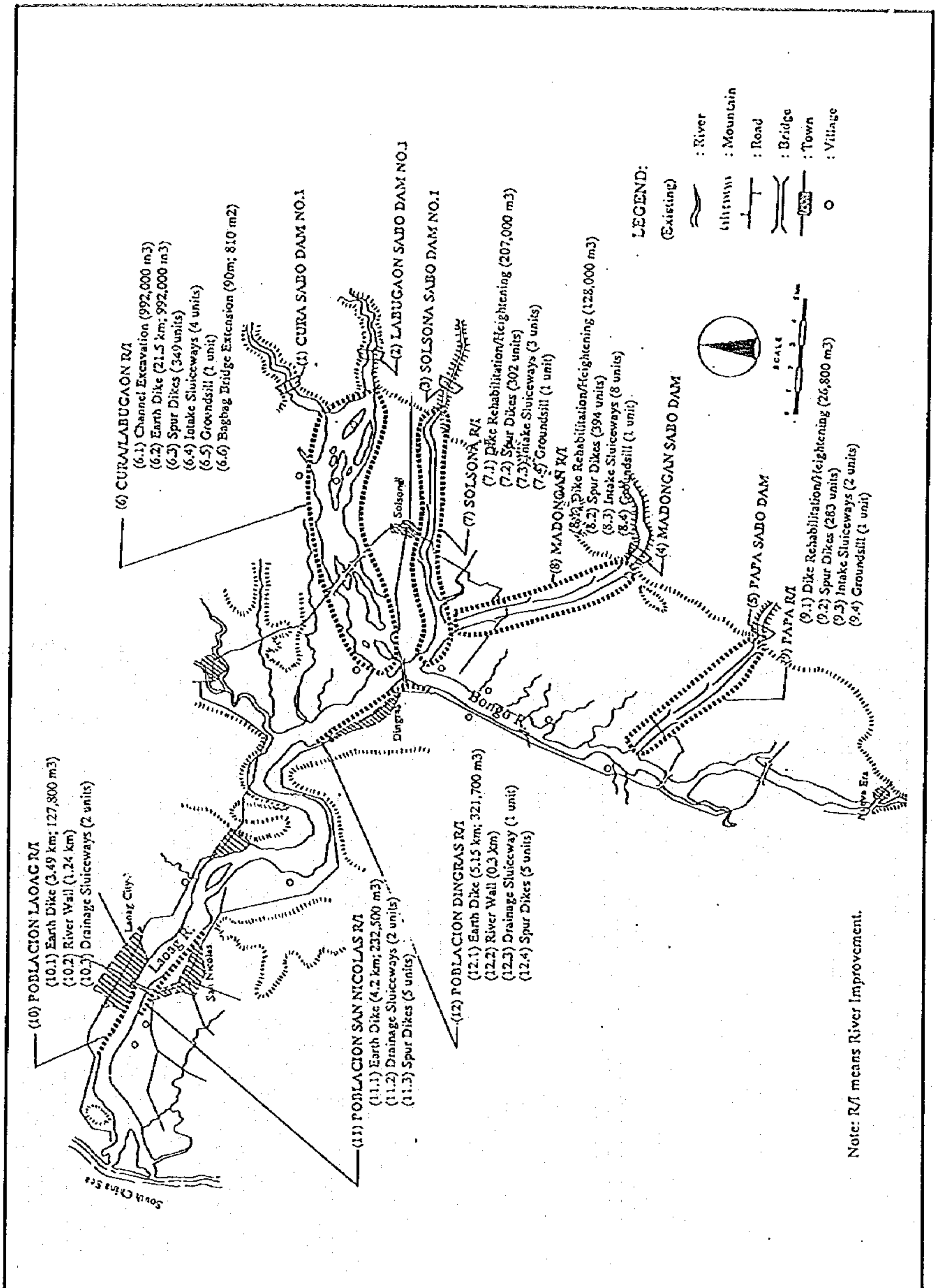
(Unit : m)

TYPE	H1	H2	H3	H4
A	1.20	3.20	1.60	5.20
B	1.50	3.50	1.75	5.50
C	2.00	4.00	2.00	6.00
D	2.30	4.30	2.15	6.30

THE STUDY ON SABO AND FLOOD CONTROL IN THE LAOAG RIVER BASIN

JAPAN INTERNATIONAL COOPERATION AGENCY

Fig. 8
Proposed River Improvement Profile in the Alluvial Fan Area



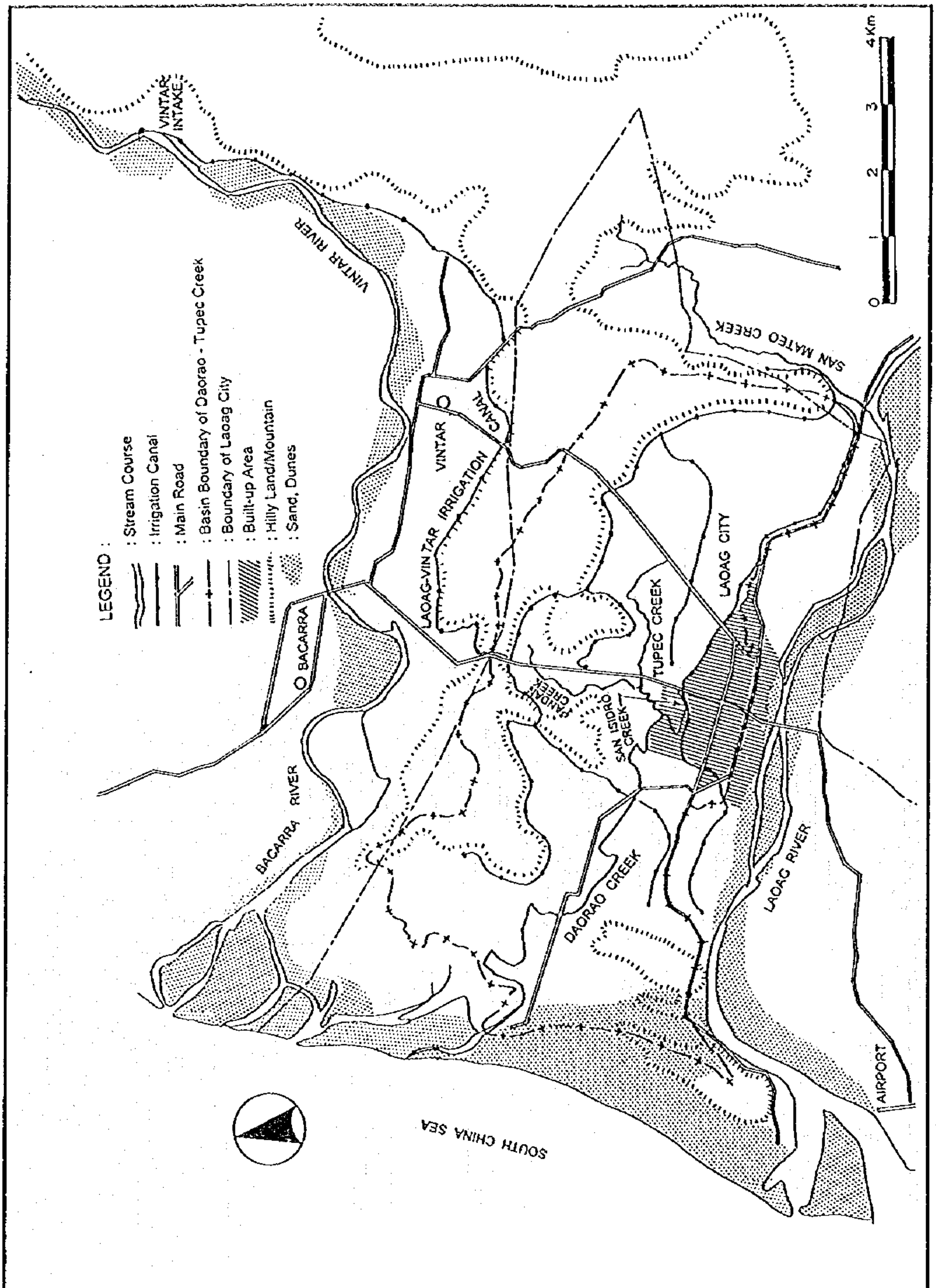
THE STUDY ON SABO AND FLOOD CONTROL IN THE LAOAG RIVER BASIN	Fig. 9
JAPAN INTERNATIONAL COOPERATION AGENCY	Sabo and River Improvement Works of Priority Projects

Items	Quantity	1997	1998	1999	2000	2001	2002	2003
1. Feasibility Study								
2. Loan Application & Other Preparations								
3. Detailed Design								
4. Construction								
4.1 Sabo Dams and Alluvial Fan River Improvement								
(1) Cura/Labugaon River								
a) Cura Sabo Dam No.1	15,100 m3							
b) Labugaon Sabo Dam No.1	16,900 m3							
c) River Improvement	12.7 km							
(2) Solsona River								
a) Solsona Sabo Dam No.1	5,200 m3							
b) River Improvement	11.0 km							
(3) Madongan River								
a) Madongan Sabo Dam	20,800 m3							
b) River Improvement	9.0 km							
(4) Papa River								
a) Papa Sabo Dam	16,900 m3							
b) River Improvement	7.0 km							
4.2 Laoag-Bongo River Improvement	13.14 km							
a) Poblacion Laoag River Improvement	3.49 km							
d) Poblacion San Nicolas River Improvement	4.20 km							
c) Poblacion Dingras River Improvement	5.45 km							
5. Land Acquisition	40.5 ha							

THE STUDY ON SABO AND FLOOD CONTROL IN THE LAOAG RIVER BASIN

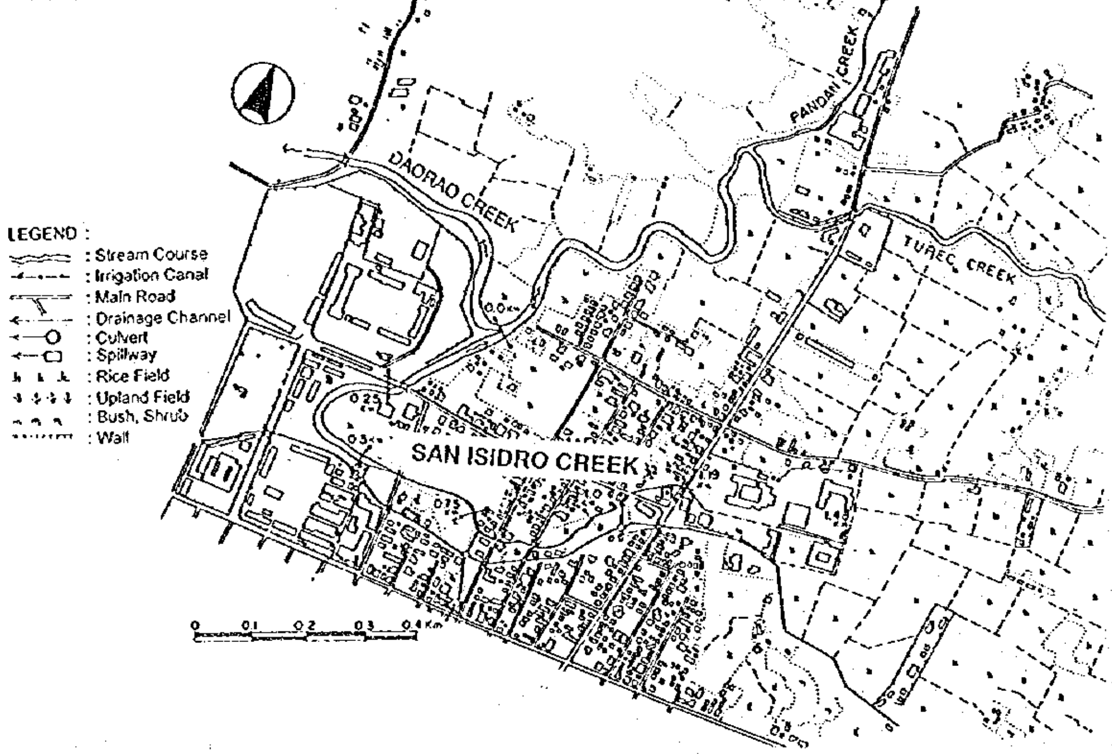
JAPAN INTERNATIONAL COOPERATION AGENCY

Fig. 10
Implementation Schedule of Priority Project

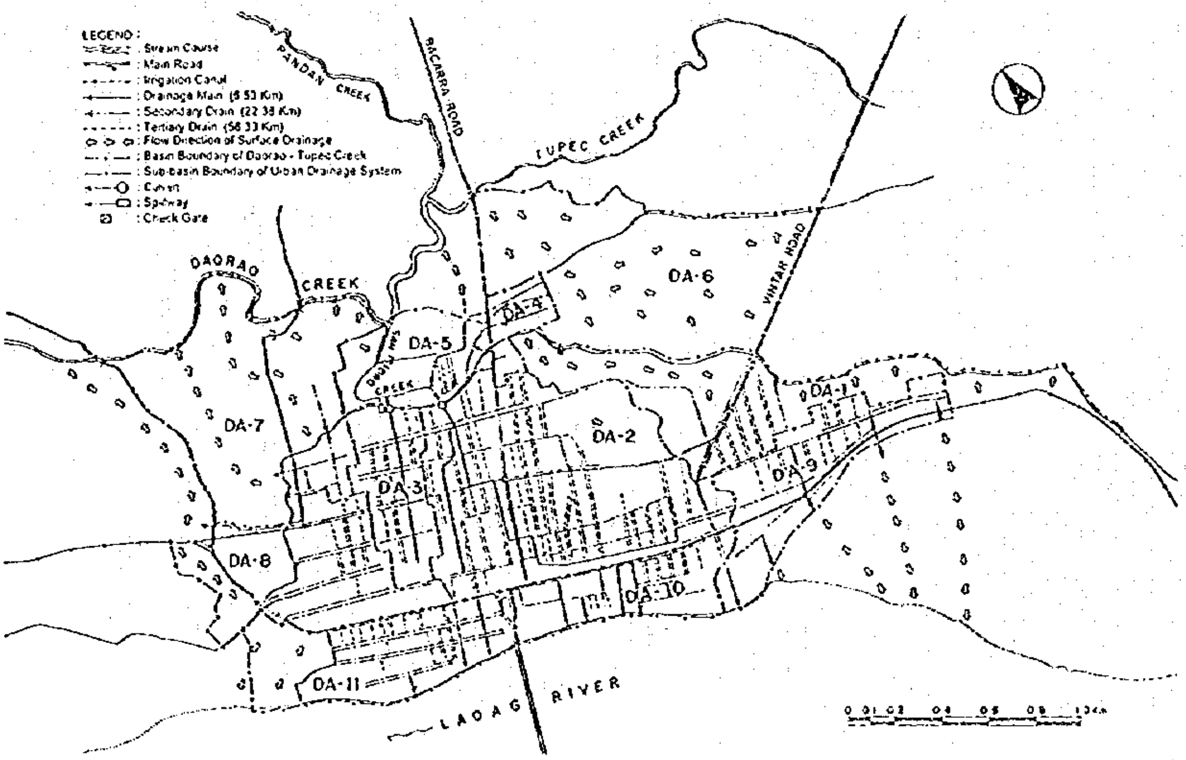


THE STUDY ON SABO AND FLOOD CONTROL IN THE LAOAG RIVER BASIN JAPAN INTERNATIONAL COOPERATION AGENCY	Fig. 11 Salient Topographic Features of the Daorao-Tupec Creek Basin

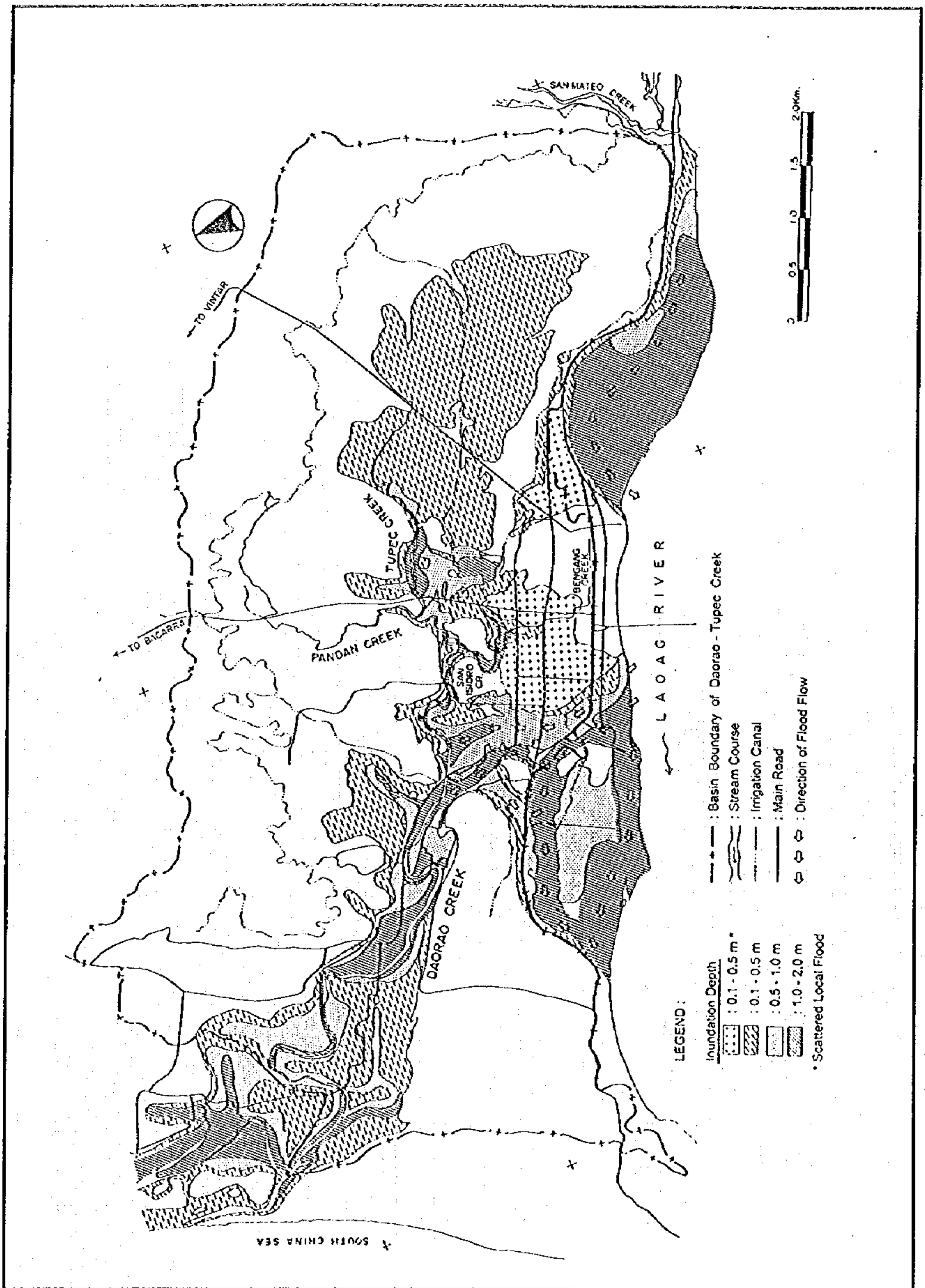
San Isidro Creek



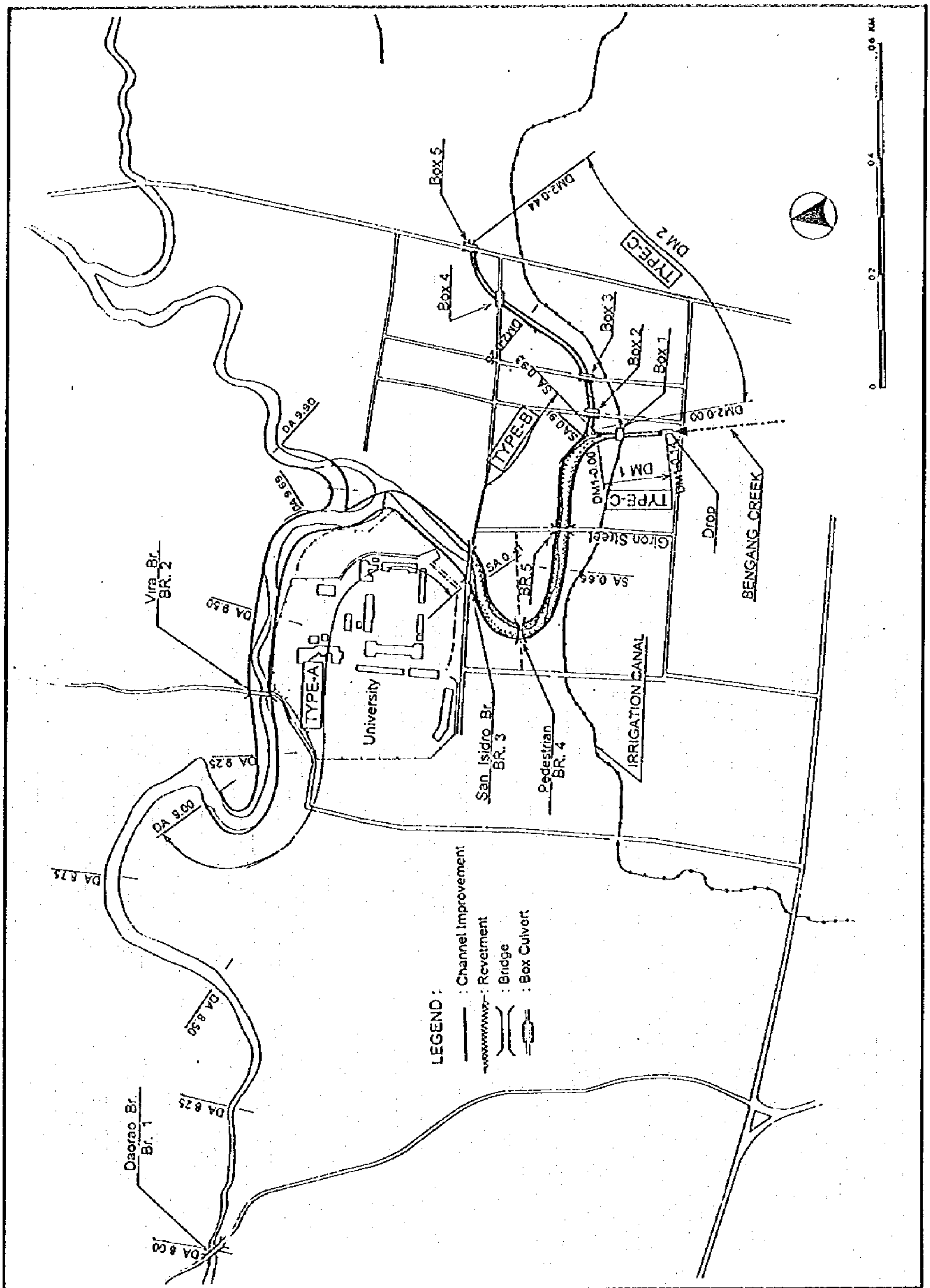
Division of Urban Drainage Area



THE STUDY ON SABO AND FLOOD CONTROL IN THE LAOAG RIVER BASIN JAPAN INTERNATIONAL COOPERATION AGENCY	Fig. 12 San Isidro Creek and Division of Urban Drainage Area



THE STUDY ON SABO AND FLOOD CONTROL IN THE LAOAG RIVER BASIN	Fig. 13
JAPAN INTERNATIONAL COOPERATION AGENCY	Flood Inundation Map of Laoag City by 1996 Typhoon Gloring



THE STUDY ON SABO AND FLOOD CONTROL IN THE LAOAG RIVER BASIN	Fig. 14 Proposed Improvement Works of Urban Drainage
JAPAN INTERNATIONAL COOPERATION AGENCY	

ANNEX

MEMBERS FOR THE STUDY

Members of Steering Committee

	Name	Designation
1.	Teodoro T. Encarnacion	Undersecretary, DPWH (Chairman)
2.	Manuel M. Bonoan	Assistant Secretary for Planning (Vice Chairman)
3.	Bienvenido C. Leuterio	Director, Bureau of Design
4.	Ernesto M. Hernandez	Former Regional Director, DPWH Region I
	Josefino N. Rigor	Incumbent Regional Director, DPWH Region I
5.	Nonito F. Fano	OIC-Project Director, PMO-Major Flood Control Projects

Members of Technical Working Group

	Name	Designation
1.	Resito V. David	Project Manager I, PMO-Major Flood Control Projects
2.	Rolando H. Tamayo	District Engineer, 1st Ilocos Norte Engineering District
3.	Rizal V. Ruiz	Project Manager II, 2nd Ilocos Norte Engineering District
4.	Sofia T. Santiago	Engineer V, Bureau of Design
5.	Manuel S. Alconis	Engineer V, Planning Service

Local Counterpart Personnel

	Name	Office (DPWH)
1.	Ernie U. Fano	PMO-Major Flood Control Projects
2.	Carlos P. Zamora	Planning Service
3.	Napoleon S. Famadico	Planning Service
4.	Johnny Montano	Planning Service
5.	Lalain Malassab	Planning Service
6.	Soledad Q. Balisi	Planning Service
7.	Romy Lescano	PMO-Feasibility Study
8.	Glenn V. Reyes	1st Ilocos Norte Engineering District
9.	Wilson Quiamas	2nd Ilocos Norte Engineering District

Members of JICA Advisory Committee

	Name	Designation
1.	Masayuki WATANABE	Sabo Planner (Chairman)
2.	Fumihiko NAKAMURA	Flood Control Planner

Members of JICA Study Team

	Name	Designation
1.	Naohito MURATA	Team Leader/Flood Control Planner
2.	Kanehiro MORISHITA	Co-Team Leader/Sabo Planner
3.	Yuzo MIZOTA	Hydrologist/Drainage Planner
4.	Kazuto SUZUKI	Flood Damage Analyst
5.	Kazuo IKEDA	Geomorphologist/Geologist
6.	Akio SHICHIJUGARI	Structural Engineer/Construction Planner
7.	Tatsuo TASHINO	Socio-Economist
8.	Masahiro ISOMURA	Land Use Planner/Environmentalist
9.	Nobuyuki TAKANASHI	Drainage Structural Engineer
10.	Antonio A. ALPASAN	Institutional Expert
11.	Hidehiko SUGIYAMA / Shun TAKAGI	Topo. Surveyor
12.	Daikichi NAKAJIMA	Aerophoto. Surveyor
13.	Kazumi AKUZAWA / Tsuyoshi MATSUSHITA	Logistician

JKA