APPENDICES

APPENDIX A

DEVELOPMENT DETAILS

USE OF SABO DAMS FOR SEDIMENT CONTROL

Sabo dams have been used successfully in Japan to control the sediment desposition in rivers. It can provide a reliable sediment retention over a long period if provided with the proper sedimentation capacity. A sabo dam is basically a very small dam designed to capture the sediment inflows of a stream. The effective height of such a dam is very low compared to a water reservoir. Its available water impoundment volume is therefore very small. In this project, the effective heights are between four to ten meters.

Sediment control effects of a sabo dam are: (1) prevention of excessive sediment deposition at the fan apexes at flood time, (2) reduction of the annual sediment desposition on the riverbeds, and (2) runoff reduction of large size sediments to the downstream.

Control of Sediment Runoff

Initially, sediment inflow to the sabo dam are trapped by the empty sedimentation basin of the dam which will prevented any sediment discharge to the downstream. Eventually, when the design volume of the basin is fully filled up, the dam will begin to discharge some sediments. The gradient of the filled up basin will also become steeper and will eventually approach the orignal slope of the riverbed. There will be no sediment control effects in this final situation since the sediment outflow of the sabo dam will become equal to its inflow. In this project, the sediment outflow of the sabo dams are within the design sediment discharge capacity at the respective fan apexes until the sedimentation slope of the dams rises up to nearly 3/4 of the original slope.

The sediment control effect is both effective in the prevention of excessive sediment at fan apexes during flood time and the reduction of the annual sediment deposition. Sabo dams are therefore effective in mitigating riverbed aggradation.

Reduction of Large Size Sediments

Without a sabo dam, the ratio of cobbles and boulders to total sediments at fan apexes is between 5 to 10%. With a sabo dam, the ratio could decrease to a very small percentage up to 6% when the sedimentation slope is 1/2 of the original. This is called the "sieving effect" of sediments since it will prevent the deposition of large size sediments at the fan apex which is one of the major causes of channel shifting. This effect will increase the sediment transport capacity in the downstream rivers resulting to the reduction in riverbed aggradation.

Design Considerations

Dam height and sedimentation volume of the proposed sabo dams are determine based on the following issues:

(a) Design sedimentation slope of a dam should correspond to the slope requirement for a discharge sediment outflow equivalent to the sediment discharge capacity at the fan apex of the downstream river during the design flood time. The design sedimentation slope was determined to be 3/4.

(b) Design dam height should correspond to the sedimentation volume and slope which will not exceed the 20 year design life of the dam.

(c) Design dam height or sedimentation volume will be determine so that the effect of sediment control on the average annual riverbed aggradation in the downstream rivers will be below 2.5 cm/yr during the 20 years period.

(d) In rivers where two sabo dams are proposed, the lower dam (referred as No.1) will be constructed first with a design life of 10 years. The upper dam (No.2) will not be constructed until the sedimentation slope of the lower dam reaches the design one.

Table A.1

DAM HEIGHT AND CAPACITY

SABO DAM	HEIGHT (m)	SEDIMENTATION CAPACITY (m^3)
Cura No.1	8.0	422,000
Labugaon No.1	10.0	1,197,000
Solsona No.1	10.0	242,000
Madongan	7.0	2,207,000
Papa	5.5	794,000

Table A.2

RIVER IMPROVEMENT WORKS FOR POBLACION LAOAG CITY

ITEMS	FEATURES	REMARKS
Dike	3,490 m long	
- earth dike	2,250 m long	- embankment 102,800 m^3 - ave. 3.7 m dike height - 4.0 m crown width - 2.5 m wide gravel maintenance road
- heightening of river wall only	620 m long	- reinforced concrete wall
- river wall with revetment and maintenance road	160 m long	- grouted stone pitching - 1.0 high reinforced concrete wall - 4.0 wide crown
Sluiceway	2 units	Reinforced concrete box culvert (1.5 m x 1.5 m) with steel sluice gate
Land Acquisition	5.4 ha	0.8 ha urban area and 4.6 ha farm land; land acquisition is necessary for the construction of the earth dike
House Resettlement	None	

Table A.3

RIVER IMPROVEMENT WORKS FOR POBLACION SAN NICOLAS

ITEMS	FEATURES	REMARKS
Dike	10,900 m long	
- earth dike	4,200 m long	- embankment 188,400 m^3 using of the nearby riverbed materials - ave. 3.5 m dike height - 4.0 m crown width - 2.5 m wide gravel maintenance road
Spur Dike	5 units	- hand laid boulder - 30 m long x 60 m space
Sluiceway	2 units	- drainage purpose - reinforced concrete box culvert (1.5 m x 1.5 m) with steel sluice gate
Land Acquisition	8.6 ha	- farm land; land acquisition is necessary for the construction of the earth dike
House Resettlement	None	

Table A.4

RIVER IMPROVEMENT WORKS FOR POBLACION DINGRAS

ITEMS	FEATURES	REMARKS
Dike	5,450 m long	
- earth dike	5,150 m long	- embankment 279,500 m^3 using the nearby riverbed materials - ave. 4.1 m dike height - 4.0 m crown width - 2.5 m wide gravel maintenance road
- river wall with revetment	300 m long	- crown width 4.0 m for maintenance road - grouted stone pitching revetment - 1.0 m high reinforced concrete wall
Sluiceway	1 unit	- drainage purpose - reinforced concrete box culvert (1.5 m x 1.5 m) with steel sluice gate
Land Acquisition	12.0 ha	- farm land; land acquisition is necessary for the construction of the earth dike
House Resettlement	3	- residential houses

Table A.5

RIVER IMPROVEMENT WORKS FOR CURA/LABUGAON RIVER

ITEMS	FEATURES	REMARKS
Excavation	992,000 m^3	- entire reaches
Dikes	21.5 km	- earth dike (992,000 m^3) - use riverbed material
Spur Dikes	330 units	- entire reaches - 153 pieces at left dike and 109 pieces at right bank of Cura River and 68 pieces at left dike of Labugaon River
Groundsill	1 unit	- stone concrete material - immediate downstream of Labugaon Diversion Dam
Sluiceways	4 units	- intake purpose - reinforced concrete box culvert with sluice gate
Extension of Bridge	1 unit	- Bagbag II Bridge - 90 m long x 9.0 wide

Table A.6

RIVER IMPROVEMENT WORKS FOR SOLSONA RIVER

ITEMS	FEATURES	REMARKS
Heightening of Existing Dikes	202,000 m^3	- total of 16 km - use of riverbed materials
Existing Dikes Repair	5,000 m^3	- use of riverbed materials
Spur Dikes	302 units	- entire reaches - 154 pieces at left dike and 148 pieces at right dike
Groundsill	1 unit	- stone concrete material - immediate downstream of Solsona Diversion Dam
Sluiceways	3 units	- intake purpose - reinforced concrete box culvert with sluice gate

Table A.7

RIVER IMPROVEMENT WORKS FOR MADONGAN RIVER

ITEMS	FEATURES	REMARKS
Heightening of Existing Dikes	110,000 m^3	- total of 10 km - use of riverbed materials
Existing Dikes Repair	18,000 m^3	- use of riverbed materials
Spur Dikes	394 units	- entire reaches - 222 pieces at left dike and 172 pieces at right dike - stone concrete materials
Groundsill	1 unit	- stone concrete material - immediate downstream of Madongan Diversion Dam
Sluiceways	8 units	- intake purpose - reinforced concrete box culvert with sluice gate

Table A.8

RIVER IMPROVEMENT WORKS FOR PAPA RIVER

ITEMS	FEATURES	REMARKS
Heightening of Existing Dikes	20,000 m^3	- total of 4.5 km - use of riverbed materials
Existing Dikes Repair	6,800 m^3	- use of riverbed materials
Spur Dikes	283 units	- entire reaches - 143 pieces at left dike and 140 pieces at right dike - stone concrete materials
Groundsill	1 unit	- stone concrete material - immediate downstream of Papa Diversion Dam
Sluiceways	2 units	- intake purpose - reinforced concrete box culvert with sluice gate

Table A.9

COMPONENTS OF DRAINAGE IMPROVEMENT WORKS

ITEM	QUANTITY	DESCRIPTION
Daorao Creek		
Channel Improvement	1,000 m	excavation
Bridge Work	2 pcs	improvement of Daorao Br. and reconstruction of Vira Br.
Mouth Opening		
San Isidro Creek		
Channel Improvement	200 m	excavation
Channel Improvement	570 m	excavation and filling
Revetment	1,140 m	bank slope lining
Bridge Work	3 pcs	reconstruction of San Isidro Br., Giron St. Br., and a pedestrian Br.
Drainage Main DM1		
Channel Improvement	140 m	excavation and filling
Revetment	280 m	bank slope lining
Box Culvert Work	1 pc	culvert reconstruction
Drop Work	1 pc	approach to Bengang Cr.
Drainage Main DM2		
Channel Improvement	440 m	excavation and filling
Revetment	880 m	bank slope lining
Box Culvert Work	4 pcs	culvert reconstruction
Interceptor Pipe	2,550 m	pipe installation along the improved channel

Bank Slope Protection Works

The bank slope of the channel will be covered with revetment to prevent bank erosion.

Bridges

The existing Daorao Bridge and Vira Bridge in the Daorao Creek and the three bridges (San Isidro Bridge, Giron Bridge, and a pedestrian bridge) in the San Isidro Creek need to be improved or reconstructed to safely carry the design flood of the channels.

The carrying capacity at the Daorao Bridge site will be increased by reconstructing the abutments and deepening the foundation of the piers. The other bridges will be reconstructed to widen their bridge length. Bridge dimensions are presented in Table A.2.

Table A.10

DIMENSION OF BRIDGES

BRIDGE NO.	BRIDGE NAME	WIDTH (meters)	LENGTH (meters)	
			EXISTING	PROPOSED
1	Daorao	5.0	39.5	39.5
2	Vira	5.0	15.0	38.2
3	San Isidro	8.5	12.5	29.7
4	Pedestrian	2.0	14.5	24.5
5	Giron	7.5	2.5	23.3
Note: Daorao Bridge has three spans, while the other bridges have single spans.				

Box Culverts

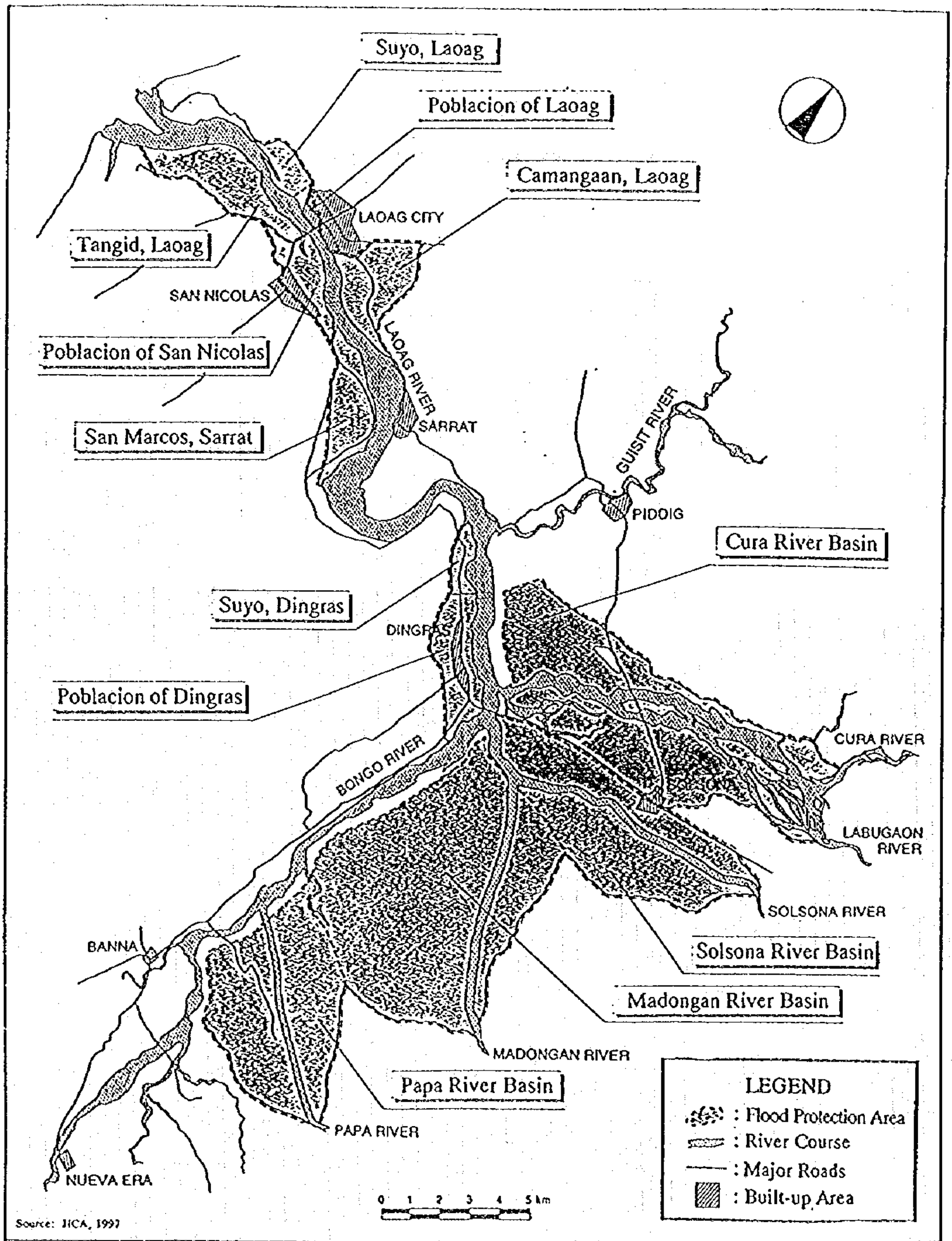
The existing five (5) box culverts of the drainage mains (DM1 and DM2) will be reconstructed to meet the design flood discharge. Culvert dimensions are presented in Table A.3.

Table A.11

DIMENSIONS OF BOX CULVERTS

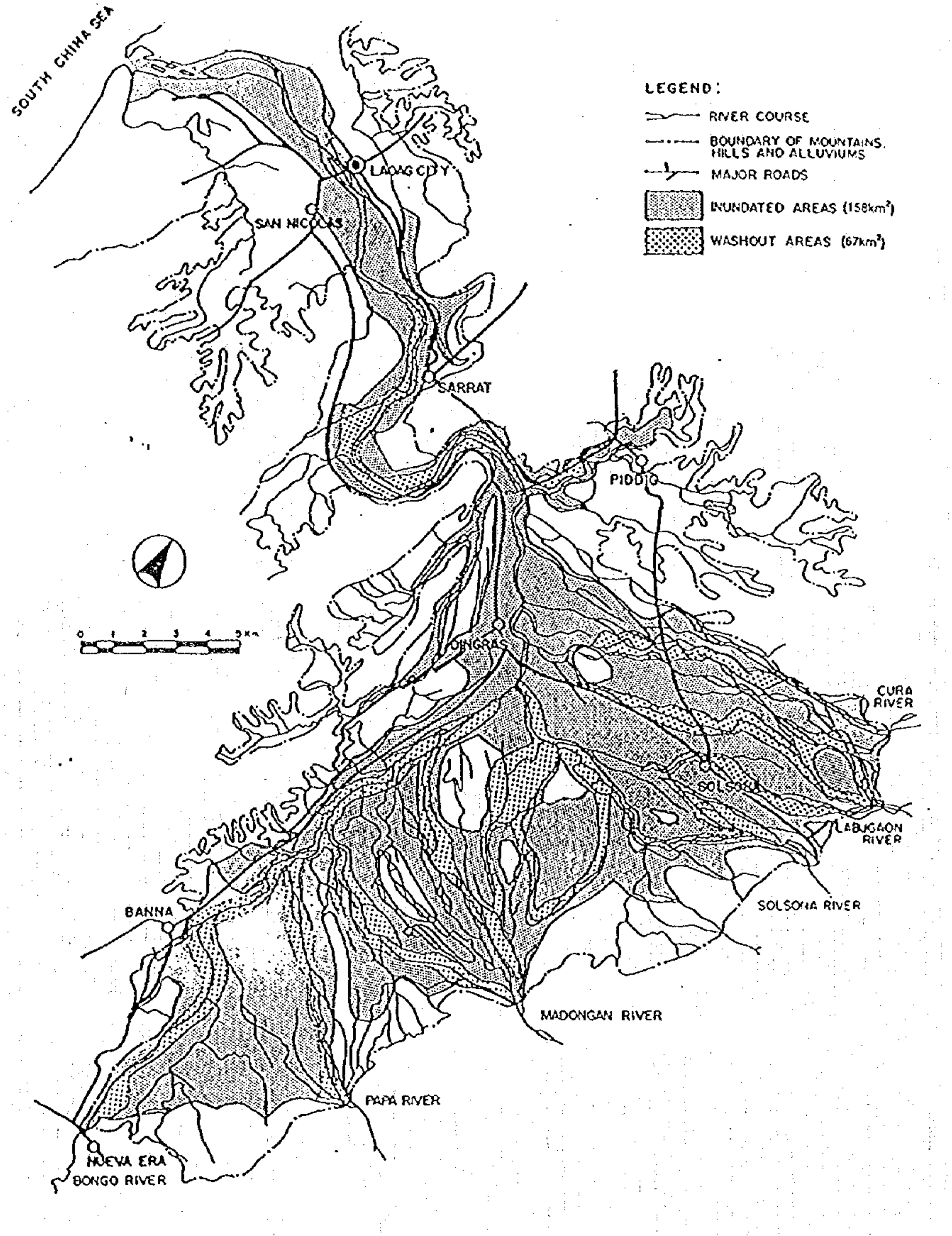
NO.	LOCATION	EXISTING (meters)		PROPOSED (meters)	
		WIDTH	HEIGHT	WIDTH	HEIGHT
1	Irrigation Canal	4.0	1.2	5.0	2.8
2	Mackinley St.	2.5	1.4	5.2	2.7
3	V. Lagasca St.	2.0	1.9	5.1	2.6
4	A. Castro St.	1.5	1.0	5.0	2.5
5	Bacarra Road	3.0	0.5	5.0	2.5

Note: All culverts will have only one box.



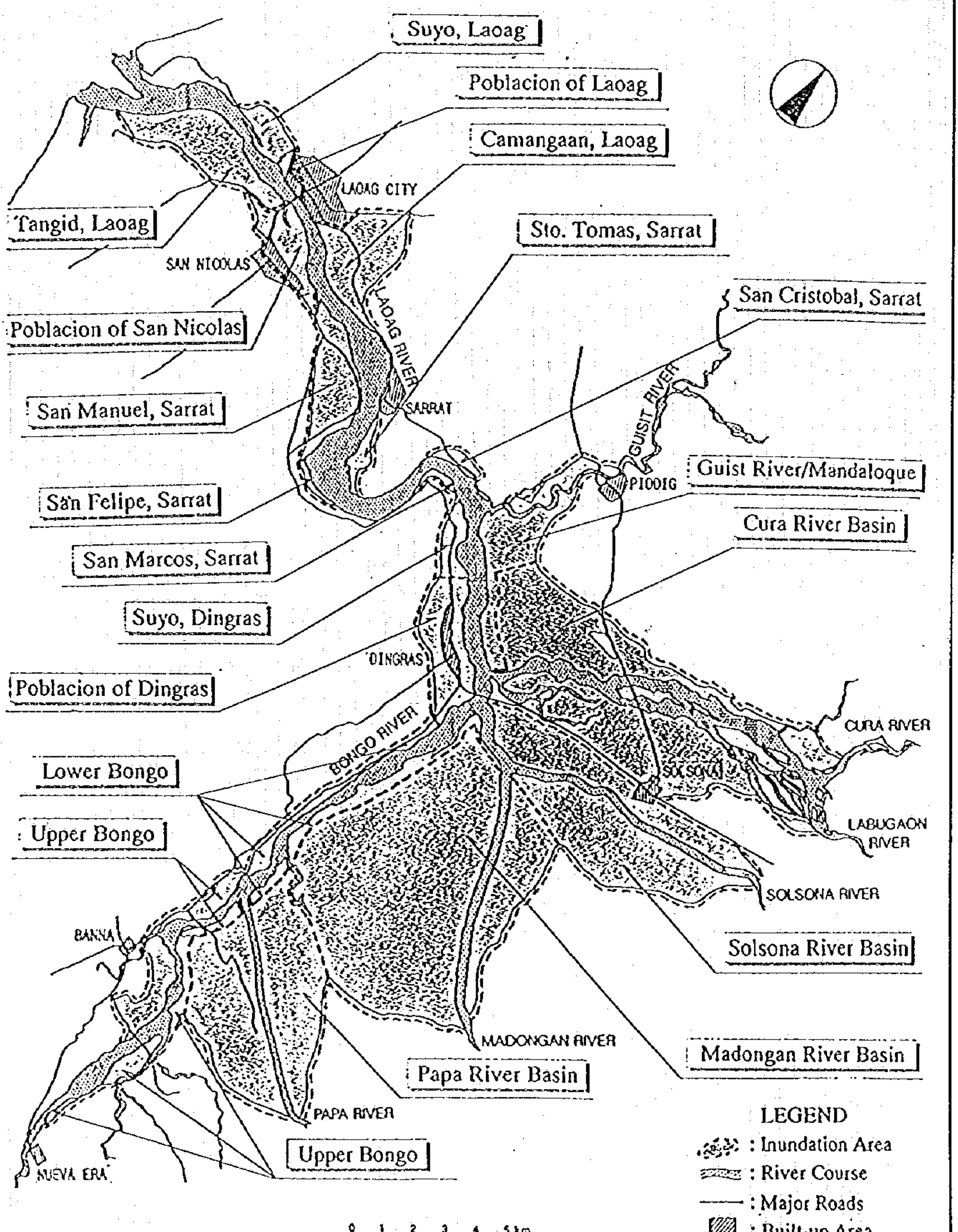
Source: JICA, 1997

ENVIRONMENTAL IMPACT STATEMENT OF THE SABO AND FLOOD CONTROL PROJECT OF THE LAOAG RIVER BASIN	Figure A.1 TARGET FLOOD PROTECTION DISTRICTS



Source: JICA, 1997

ENVIRONMENTAL IMPACT STATEMENT OF THE SABO AND FLOOD CONTROL PROJECT OF THE LAOAG RIVER BASIN	Figure A.2 **POTENTIAL FLOOD AREAS**

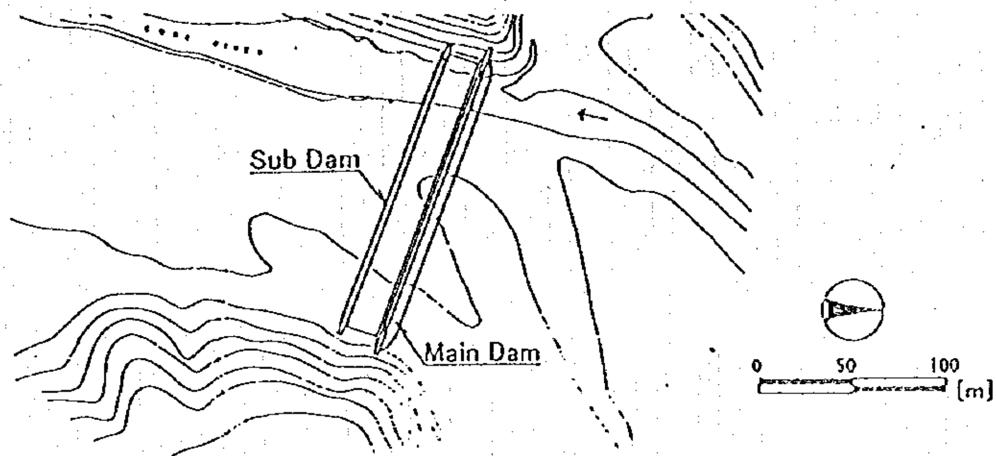


Source: JICA, 1997

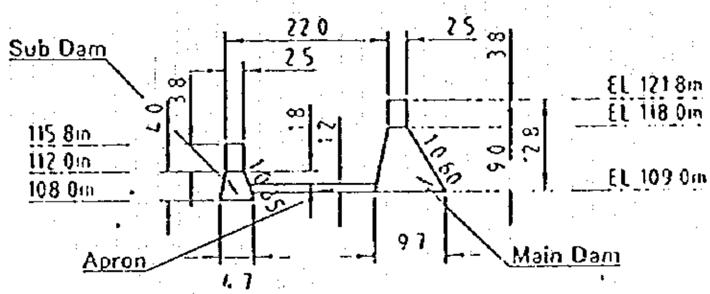
ENVIRONMENTAL IMPACT STATEMENT OF THE SABO AND FLOOD CONTROL PROJECT OF THE LAOAG RIVER BASIN

Figure A.3

INUNDATION AREAS OF 25-YEAR FLOOD



LOCATION



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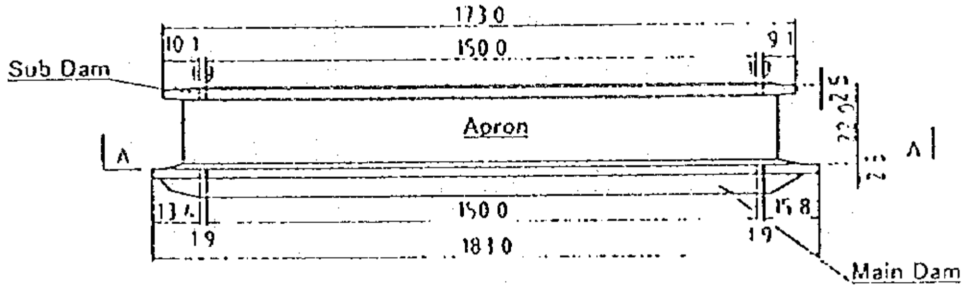
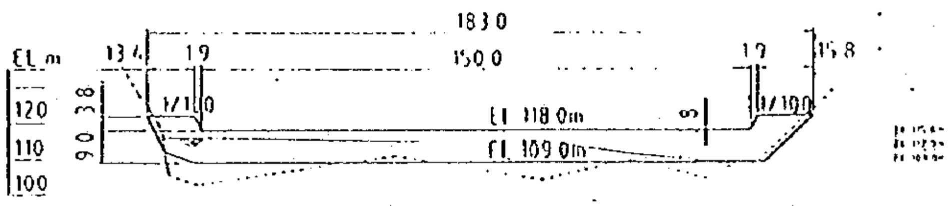


PLAN



ELEVATION A-A

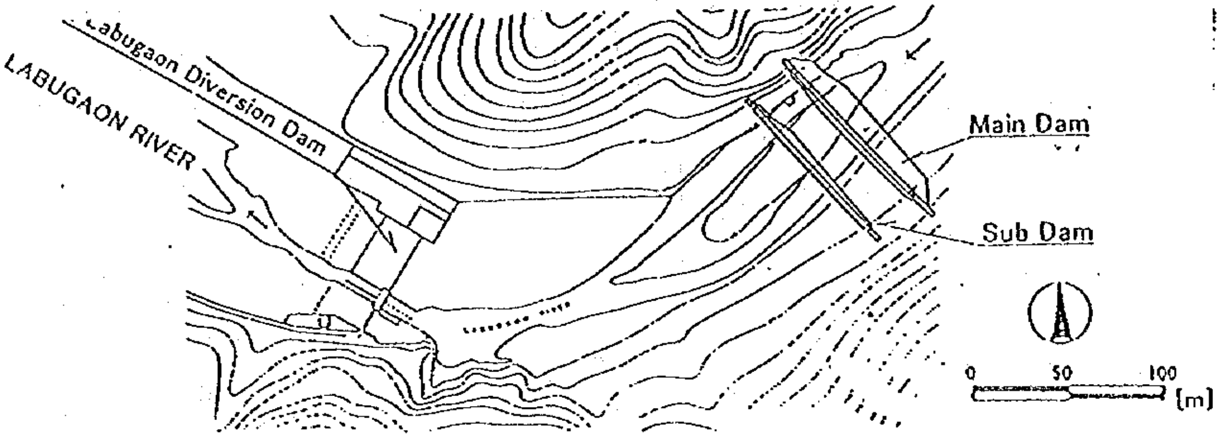
(Unit : in meter)

Source: JICA, 1997

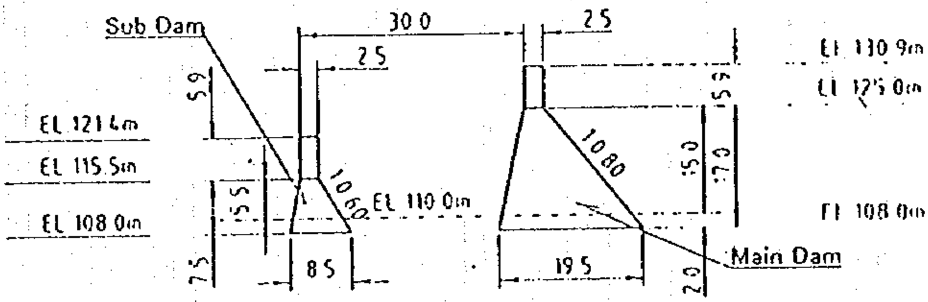
ENVIRONMENTAL IMPACT STATEMENT OF THE SABO AND FLOOD CONTROL PROJECT OF THE LAOAG RIVER BASIN

Figure A.4

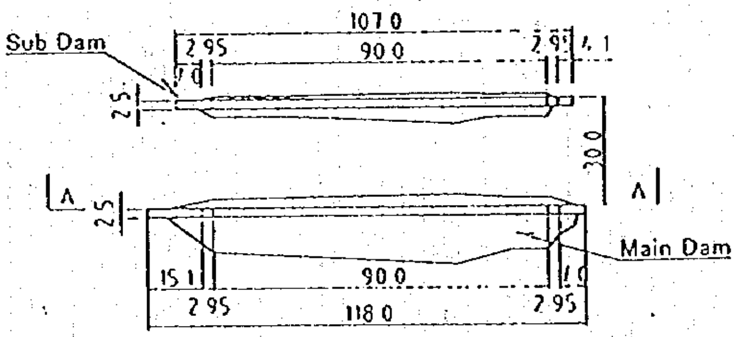
STRUCTURAL DESIGN OF CURA NO.1 SABO DAM



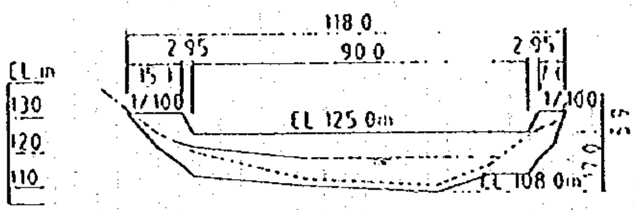
LOCATION



PROFILE



PLAN

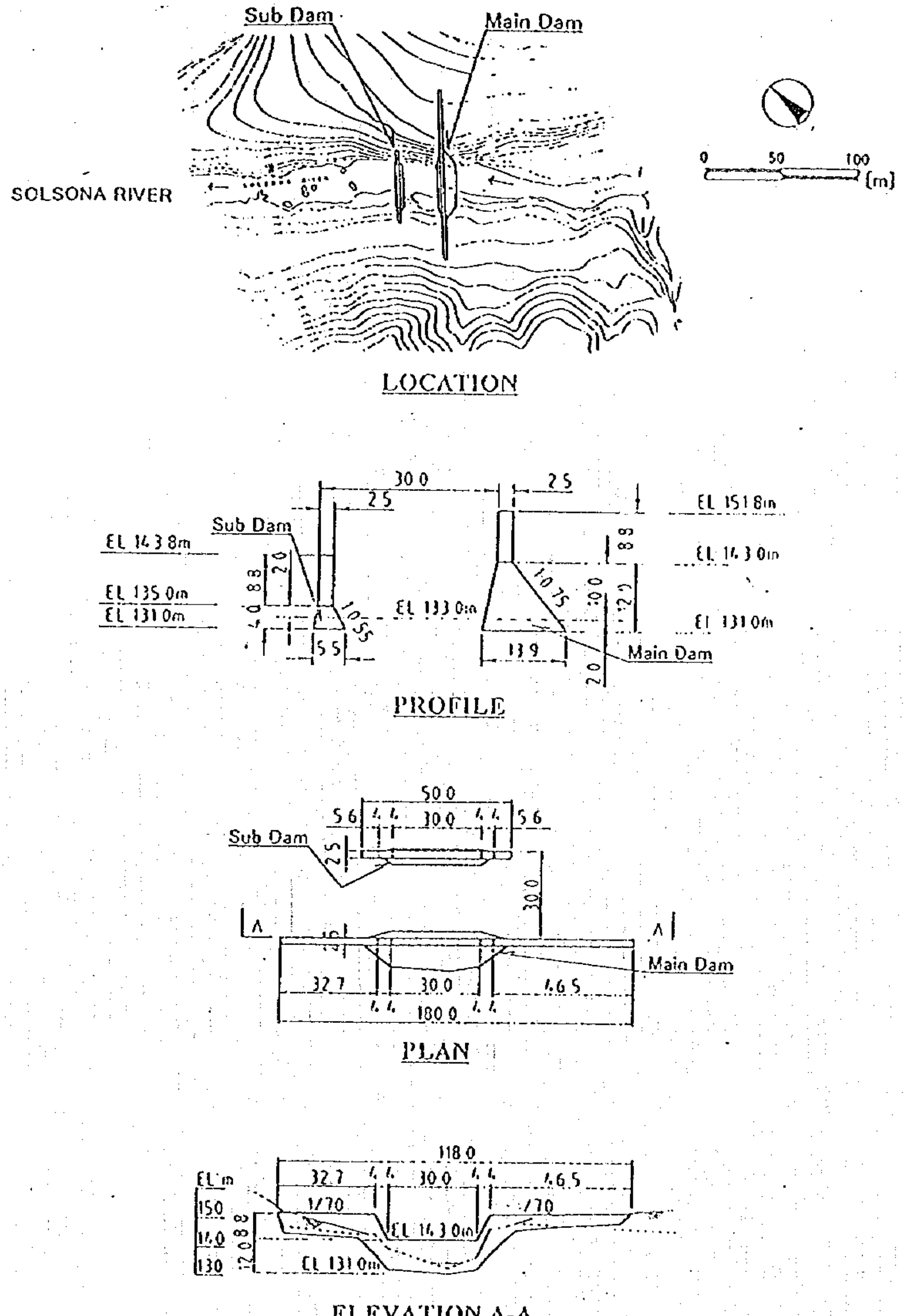


ELEVATION A-A

(Unit : in meter)

Source: JICA, 1997

ENVIRONMENTAL IMPACT STATEMENT OF THE SABO AND FLOOD CONTROL PROJECT OF THE LAOAG RIVER BASIN	Figure A.5 STRUCTURAL DESIGN OF LABUGAON NO.1 SABO DAM

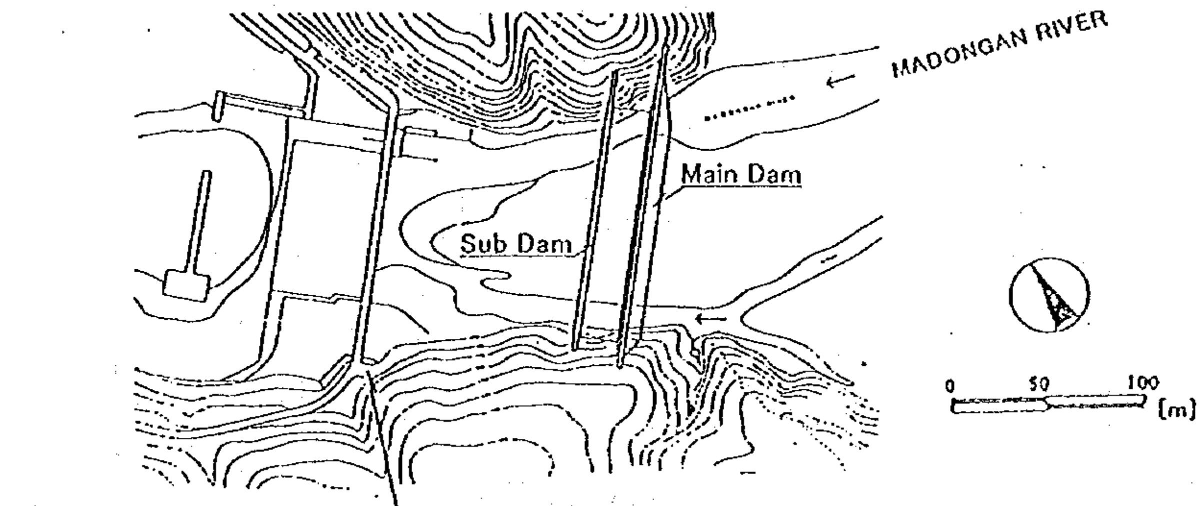


Source: JICA, 1997

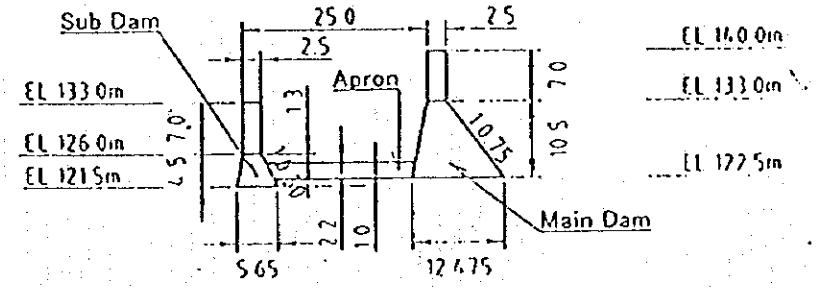
ENVIRONMENTAL IMPACT STATEMENT OF THE SABO AND FLOOD CONTROL PROJECT OF THE LAOAG RIVER BASIN

Figure A.6

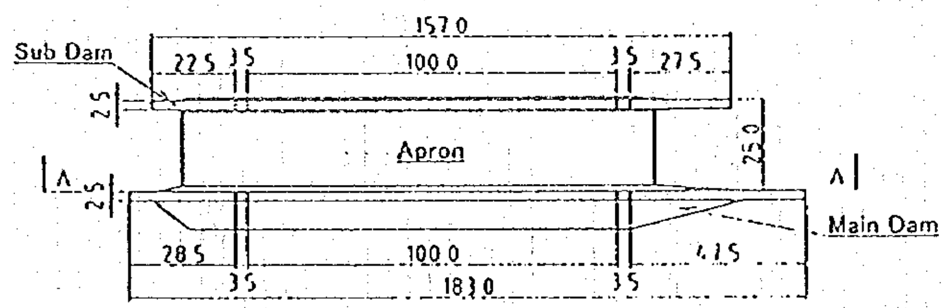
STRUCTURAL DESIGN OF SOLSONA NO.1 SABO DAM



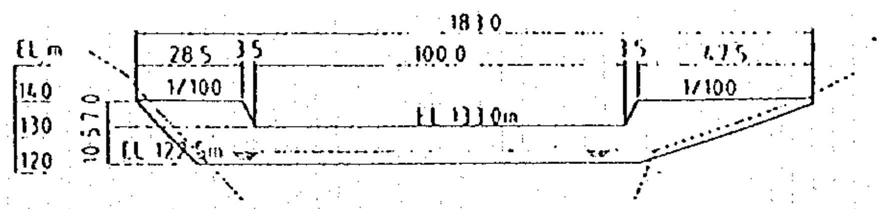
LOCATION



PROFILE



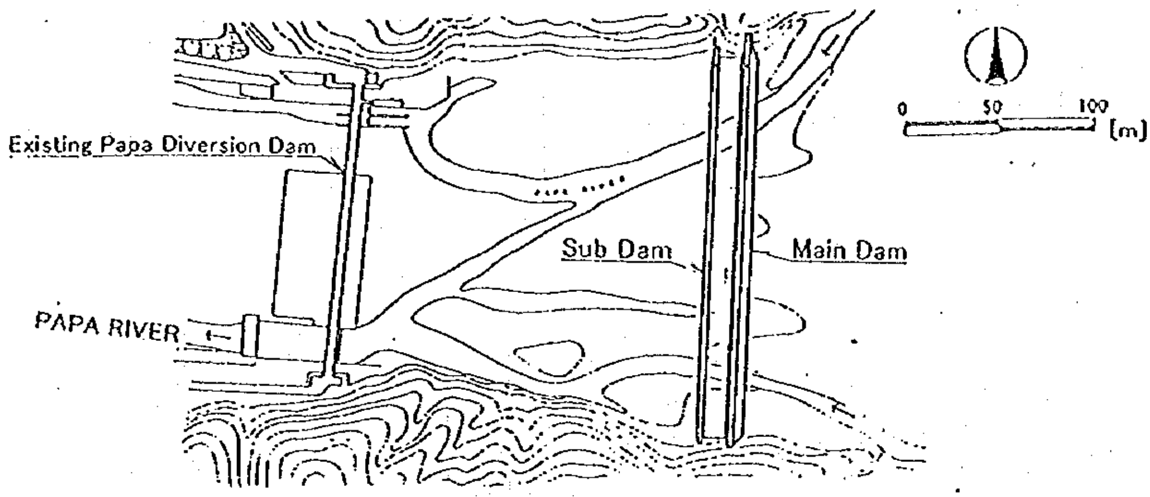
PLAN



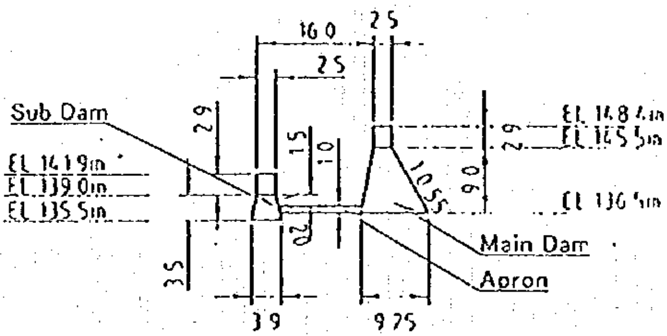
ELEVATION A-A

Source: JICA, 1997

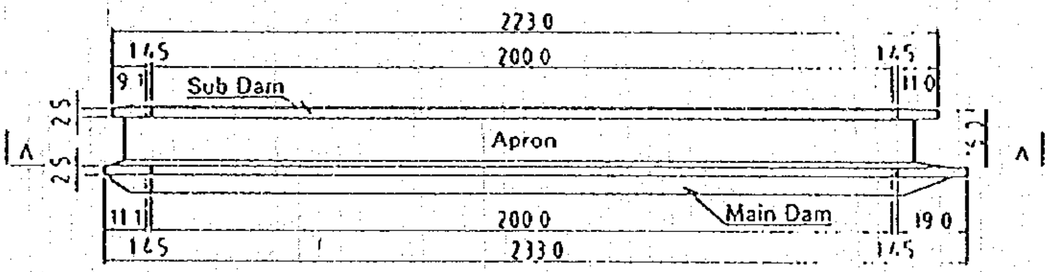
ENVIRONMENTAL IMPACT STATEMENT OF THE SABO AND FLOOD CONTROL PROJECT OF THE LAOAG RIVER BASIN	Figure A.7 STRUCTURAL DESIGN OF MADONGAN SABO DAM



LOCATION



PROFILE



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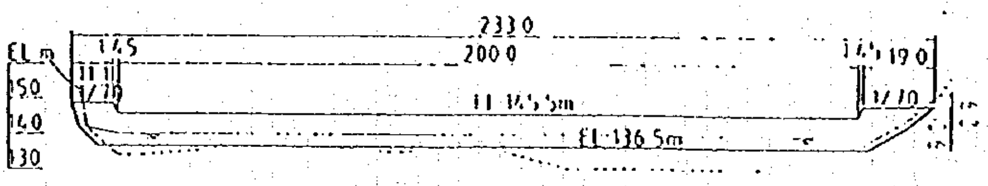
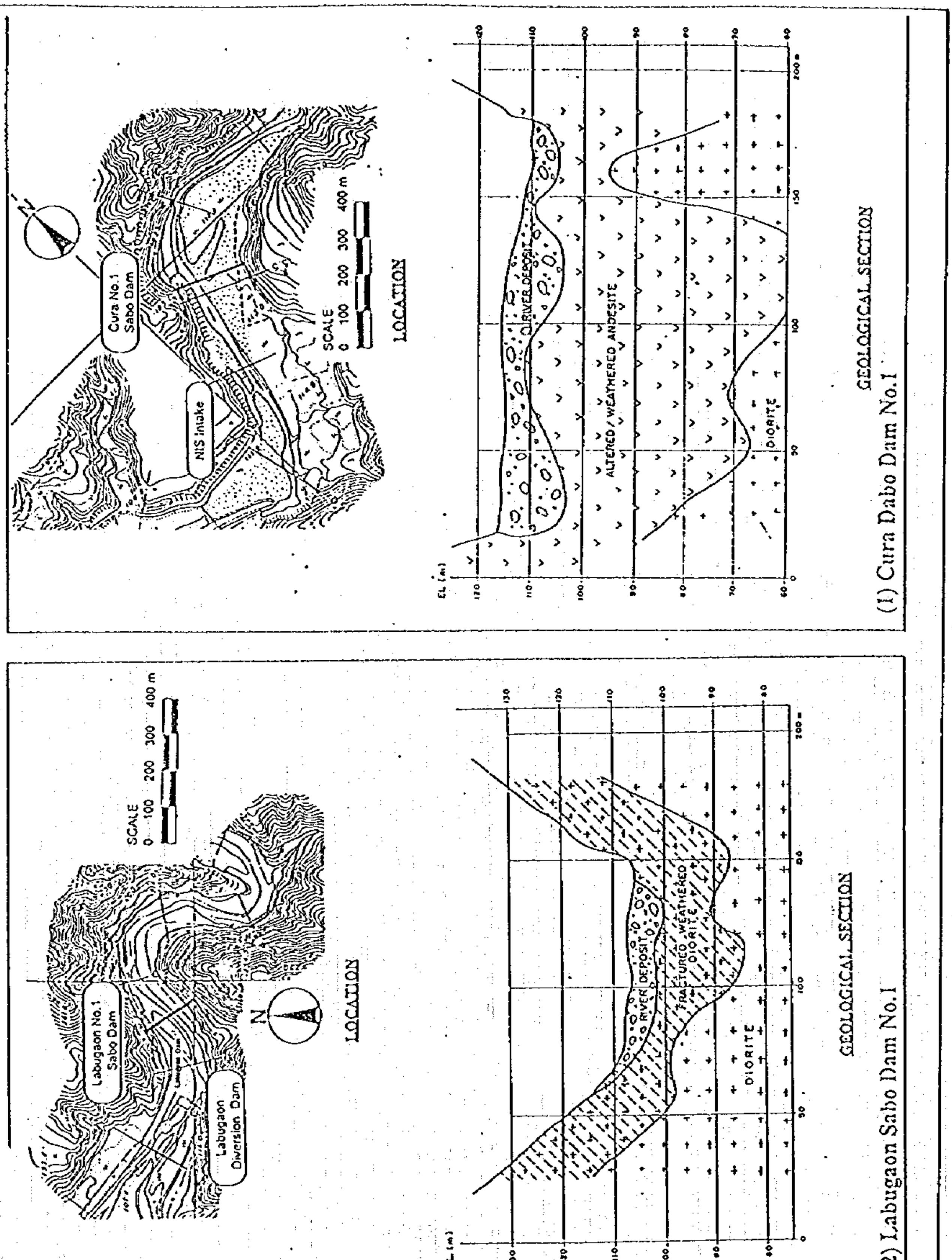


ELEVATION A-A

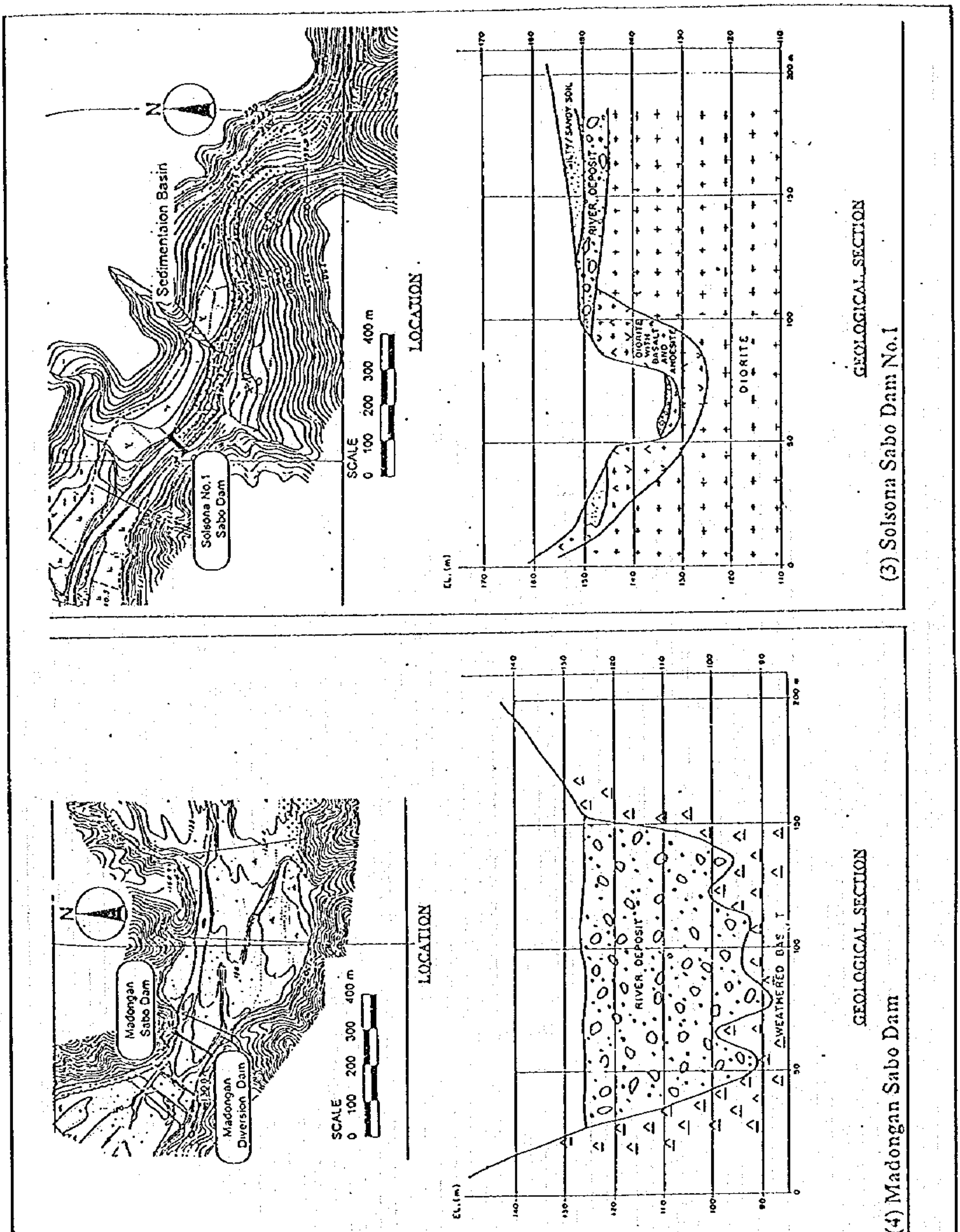
Source: JICA, 1997

ENVIRONMENTAL IMPACT STATEMENT OF THE SABO AND FLOOD CONTROL PROJECT OF THE LAOAG RIVER BASIN	Figure A.8 STRUCTURAL DESIGN OF PAPA SABO DAM



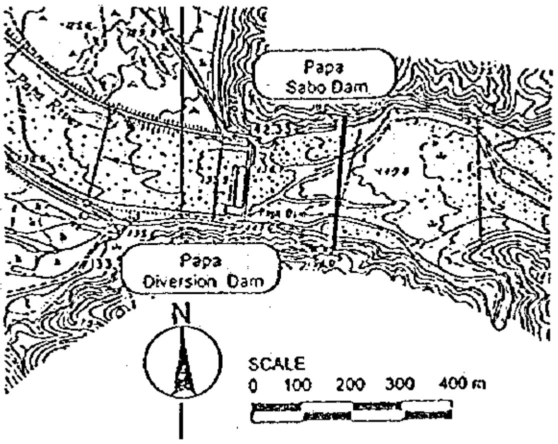
Source: JICA, 1997

ENVIRONMENTAL IMPACT STATEMENT OF THE SABO AND FLOOD CONTROL PROJECT OF THE LAOAG RIVER BASIN	Figure A.9 DAM SITE GEOLOGIC SECTION CURA NO.1 AND LABUGAON NO.1



Source: JICA, 1997

ENVIRONMENTAL IMPACT STATEMENT OF THE SABO AND FLOOD CONTROL PROJECT OF THE LAOAG RIVER BASIN	Figure A.10 DAM SITE GEOLOGIC SECTION SOLSONA NO.1 AND MADONGAN



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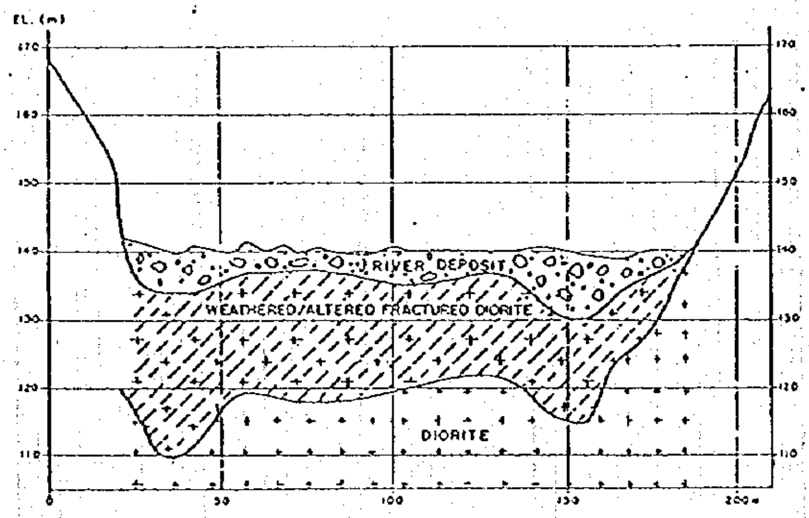
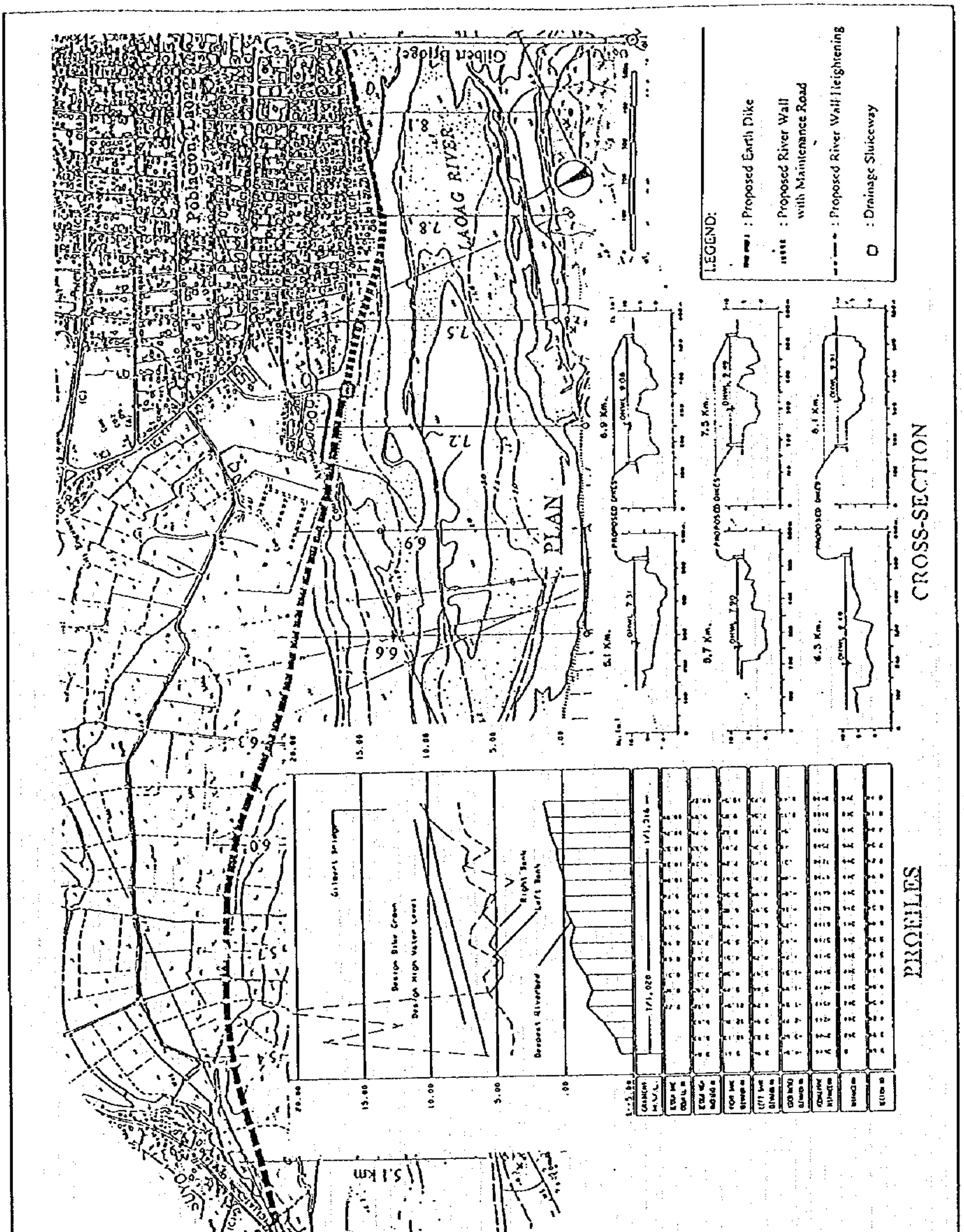


GEOLOGICAL SECTION

(5) Papa Sabo Dam

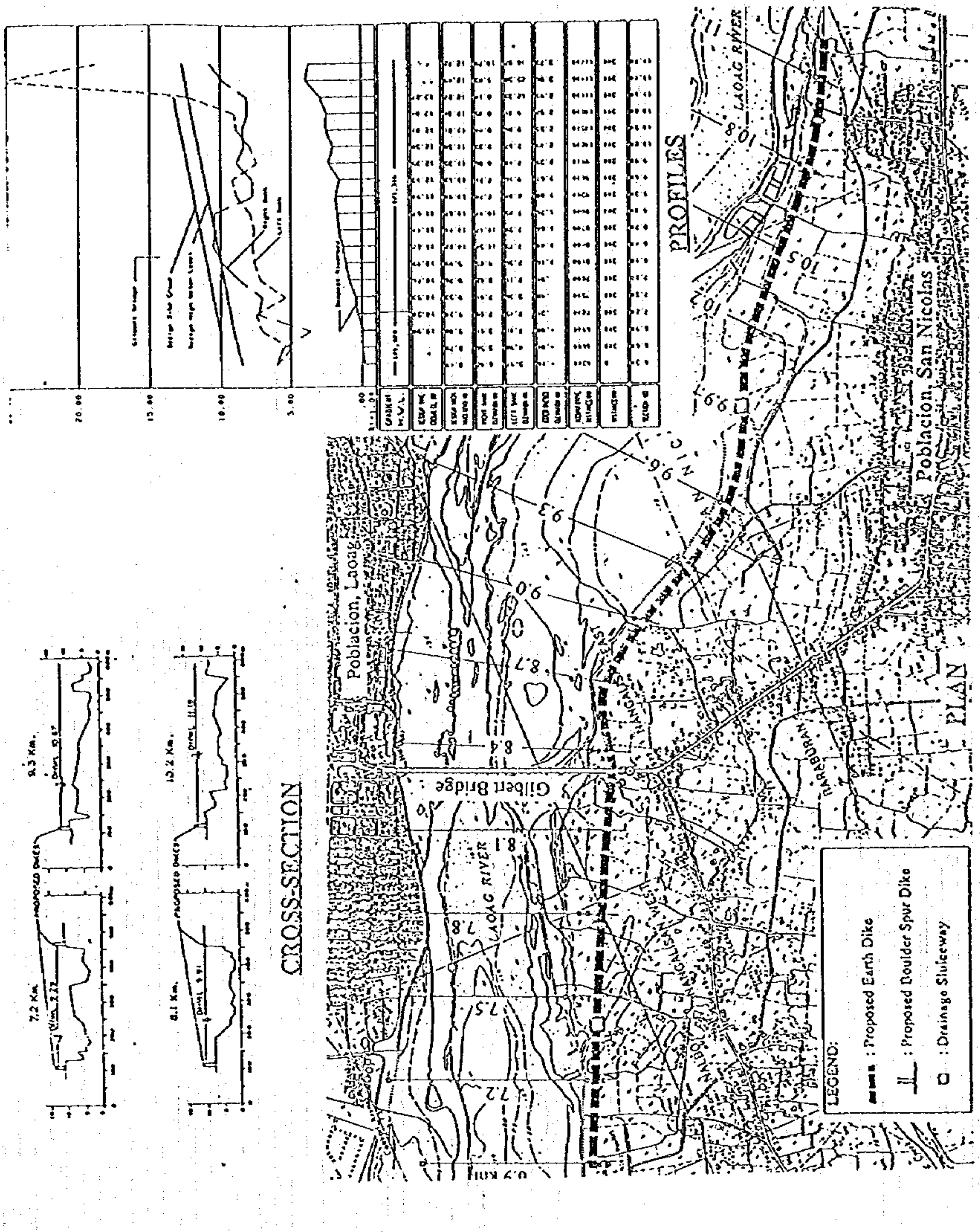
Source: JICA, 1997

ENVIRONMENTAL IMPACT STATEMENT OF THE SABO AND FLOOD CONTROL PROJECT OF THE LAOAG RIVER BASIN	Figure A.11 DAM SITE GEOLOGIC SECTION OF PAPA SABO DAM



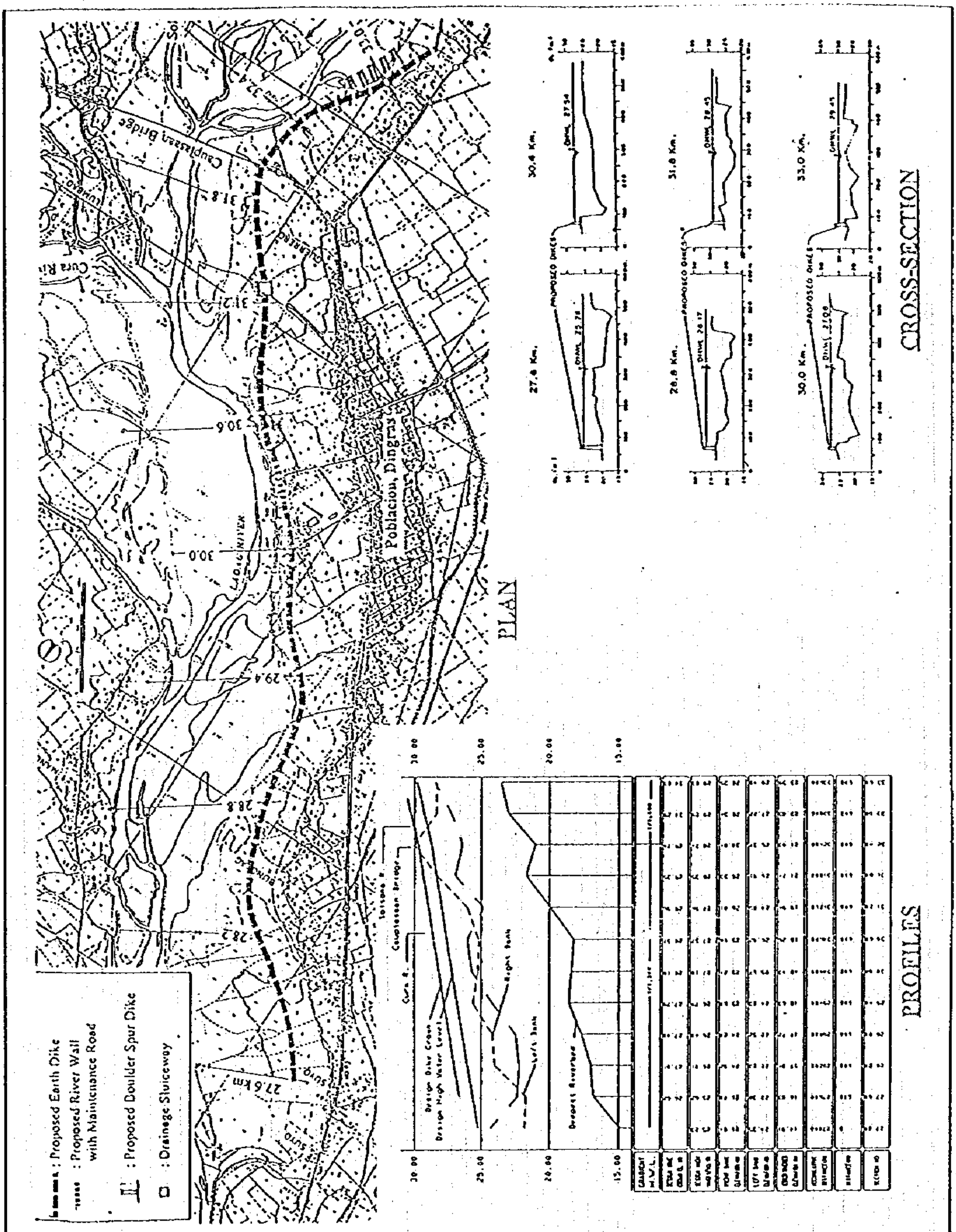
Source: JICA, 1997

ENVIRONMENTAL IMPACT STATEMENT OF THE SABO AND FLOOD CONTROL PROJECT OF THE LAOAG RIVER BASIN	Figure A.12 RIVER IMPROVEMENT ALIGNMENT FOR POBLACION LAOAG



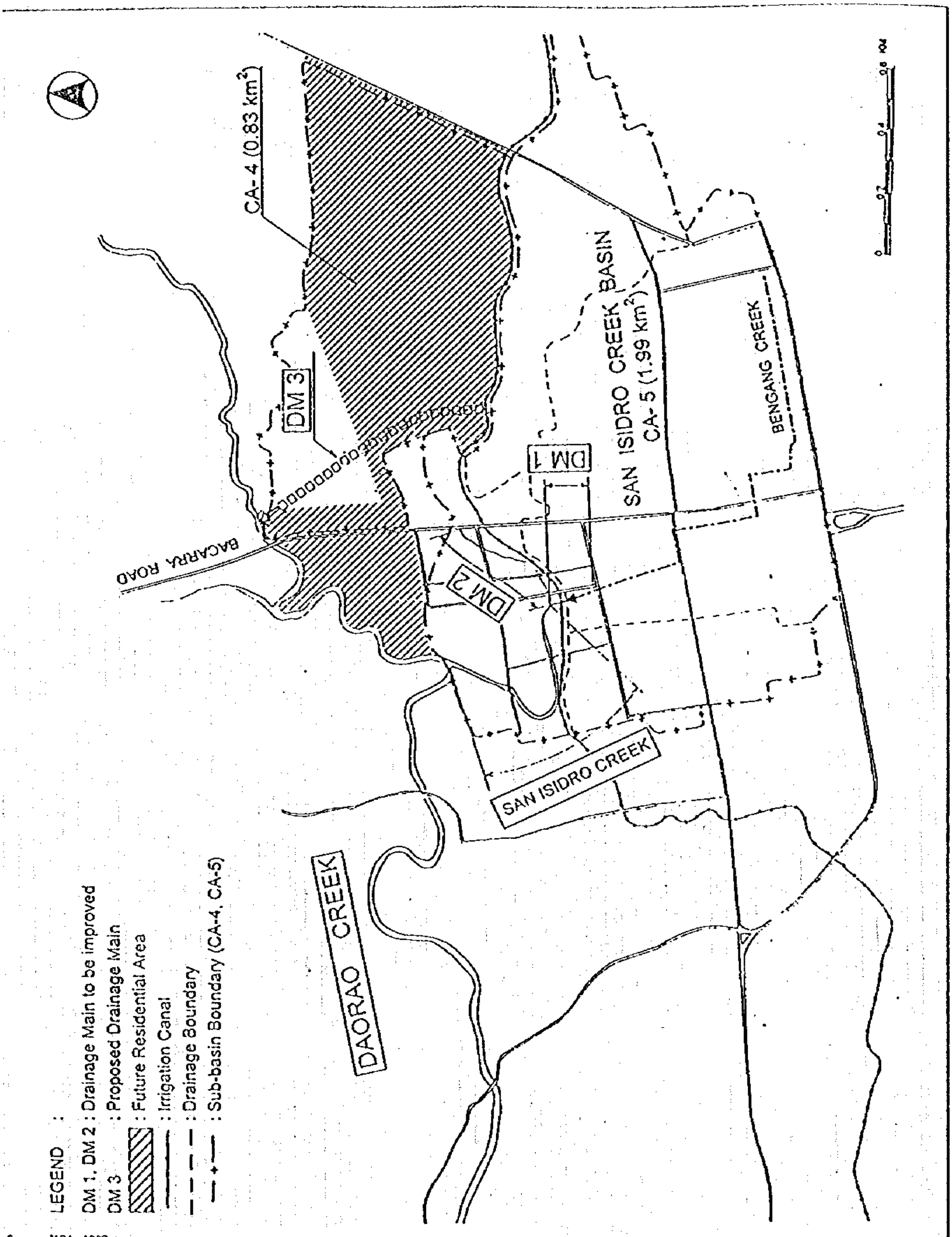
Source: JICA, 1997

ENVIRONMENTAL IMPACT STATEMENT OF THE SABO AND FLOOD CONTROL PROJECT OF THE LAOAG RIVER BASIN	Figure A.13 RIVER IMPROVEMENT ALIGNMENT FOR POBLACION SAN NICOLAS



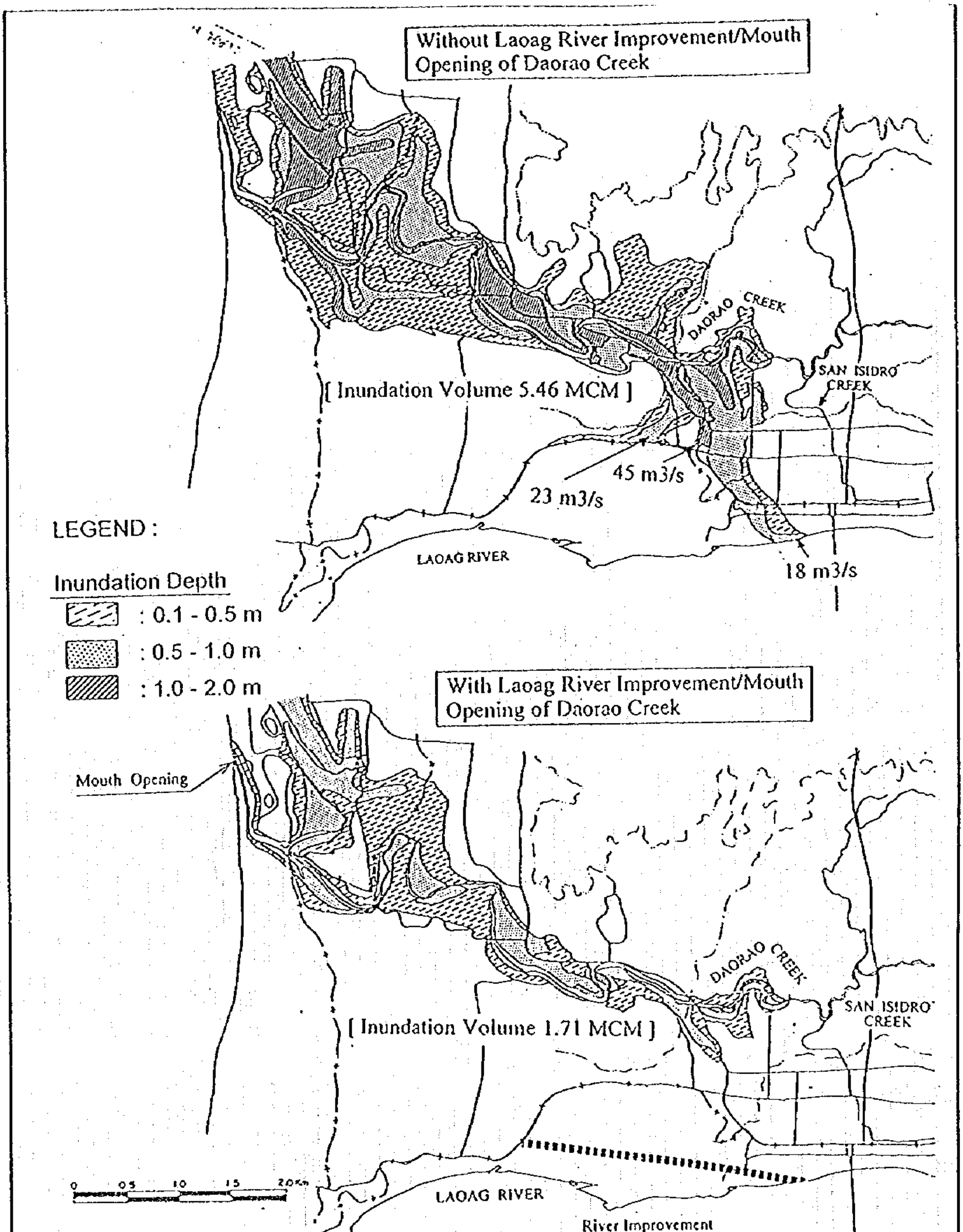
Source: JICA, 1997

ENVIRONMENTAL IMPACT STATEMENT OF THE SABO AND FLOOD CONTROL PROJECT OF THE LAOAG RIVER BASIN	Figure A.14 RIVER IMPROVEMENT ALIGNMENT FOR POBLACION DINGRAS



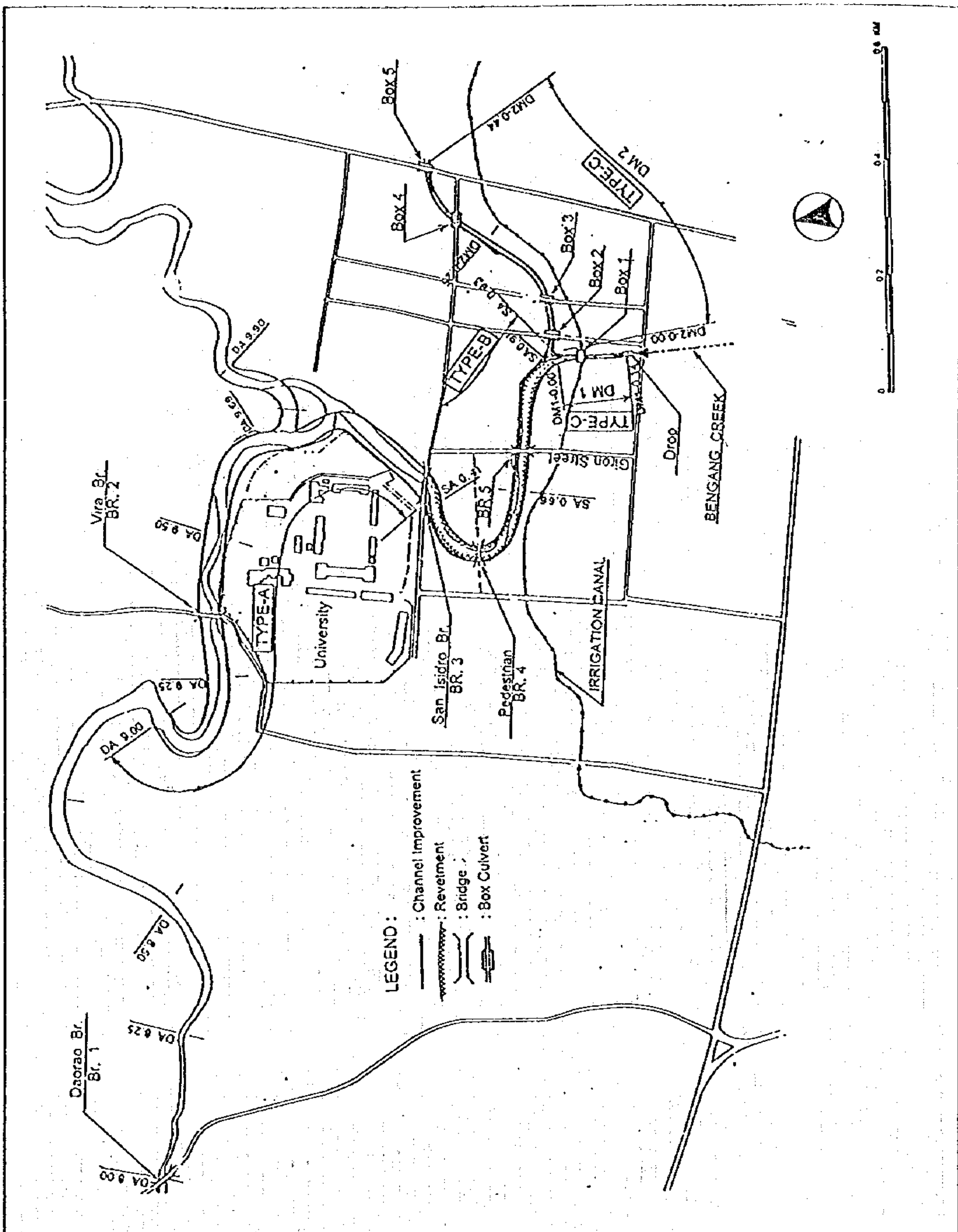
Source: JICA, 1997

ENVIRONMENTAL IMPACT STATEMENT OF THE SABO AND FLOOD CONTROL PROJECT OF THE LAOAG RIVER BASIN	Figure A.15 TARGET AREA FOR LAOAG CITY DRAINAGE IMPROVEMENT



Source: JICA, 1997

ENVIRONMENTAL IMPACT STATEMENT OF THE SABO AND FLOOD CONTROL PROJECT OF THE LAOAG RIVER BASIN	Figure A.16 INUNDATION COMPARISON FOR THE LAOAG CITY DRAINAGE IMPROVEMENT PLAN



Source: JICA, 1997

ENVIRONMENTAL IMPACT STATEMENT OF THE SABO AND FLOOD CONTROL PROJECT OF THE LAOAG RIVER BASIN	Figure A.17 CREEK AND DRAINAGE ALIGNMENT OF THE URGENT DRAINAGE IMPROVEMENT PLAN

APPENDIX B

BASELINE DATA

Table B.1

RECORDED RAINFALL OF TYPHOON GLORING

STATION	5-DAY RAINFALL (23-27 July)	3-DAY RAINFALL (24-26 July)	MAXIMUM HOURLY RAINFALL (25 July)
Laoag	705 mm	643 mm	51 mm (15:00-16:00)
Piddig	786 mm	741 mm	69 mm (16:00-17:00)
Solsona	689 mm	594 mm	30 mm (12:00-13:00)
Nueva Era	829 mm	795 mm	52 mm (12:00-13:00)

Table B.2

SAND BARS DESCRIPTION

RIVER	TYPE	WAVE LENGTH (km)	MOVEMENT/ RESTRICTION
Laoag	single	3.5	by bends
Lower Bongo	single /double	2.0	by tributary joining
Upper Bongo	lower part: single upperpart: scalelike	1.2 small	easy
Cura/Labugaon	single	1.2	easy
Solsona	single	1.2	by tributary joining and bends
Madongan	double	1.0	easy
Papa	single	1.2	not easy, a little restricted

Table B.3

TYPICAL DISTRIBUTION OF RIVERBED MATERIALS

SEDIMENT SIZE	FAN APEX/ MIDDLE FAN REACH	FAN END	LAOAG RIVER
Large Cobble/ Small Boulder (128 - 512 mm)	8 %	-	-
Very Coarse Pebble/ Small Cobble (32 - 128 mm)	21 %	16 %	10 %
Medium/ Coarse Pebble (8 - 32 mm)	29 %	32 %	22 %
Very Fine/ Fine Pebble (2 - 8 mm)	23 %	25 %	35 %
Sand (0.125 - 2 mm)	19 %	27 %	33 %

Table B.4

DIKES OF URGENT DISASTER PREVENTION WORKS (INIP I)

ITEM	SOLSONA	MADONG AN	PAPA
Design Flood Frequency (yr)	20	20	20
Design Flood Discharge (m^3/s)	940 - 2,670	1,620	780
Channel Length (km)	11.1	8.5	7.4
Channel Width (m)	230 -330	300	223
Bed Slope	1/76 - 1/714	1/114 - 1/190	1/60 - 1/200
Levee Length (km)	19.6	13.0	12.2
Channel Excavation (1,000 m^3)	1,361	1,227	712
Levee Embankment (1,000 m^3)	647	436	299

Table B.5

HISTORICAL RECORDED PEAK WATER LEVELS OF LAOAG RIVER

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

Note:

The discharge values are peak discharges estimated from the water levels (peak) using the rating curve developed from the data of Typhoon Gloring (1996).

Table B.6

TIDAL WATER LEVELS OF LAOAG RIVER MOUTH

WATER LEVEL	ELEVATION (m)
Mean Spring Higher High Water	+ 0.134
Mean Higher High Water	- 0.018
Mean Sea Level	- 0.302
Mean Low Water	- 0.586

Table B.7

EXPECTED AIR QUALITY LEVELS

PARAMETER	GROUND LEVEL CONCENTRATIONS RANGE µg/NCM
SO_2	6 to 12
NO_2	3 to 15
TSP	25 to 135

Table B.8

RESULTS OF VEGETATION SURVEY

A. Primary Impact Zone (where sabo dams will be constructed)

Scientific Name	*Common Name*	*Economic Importance*
A. Non-Dipterocarps		
Leucaena Leucocephala	Ipil-ipil	Wood is good for firewood and charcoal; bark produces a brown dye; leaves can be used as animal feeds; seeds used as substitute for coffee
Bauhinia purpurea	Alibangbang	Leaves are edible and can be used as condiment; bark and leaves have medicinal properties; wood can be used for temporary construction, firewood and charcoal
Psidium guajava Linn. (Myrtaceae)	Bayabas	Decoction of leaves is good for stomach ache and as vermifuge. Tea can be made from leaves. Fruit is used for manufacture of jellies. Wood for light construction
Eucalyptus camaldulensis	Eucalyptus	Source of aromatic oils for medicinal use
Acacia mangium	Yellow acacia	Wood used for light construction
Tamarindus indica	Sampalok	Young leaves, flowers and pods are used for seasoning foods; fruit used in the manufacture of jams, sweets and drinks;

		bark is source of ink; seed is source of oil/varnish; street ornamental plant
Gmelina arborea	Gmelina	Reforestation tree species
Acacia auriculiformis		
'Musa sapientum	Banana	Fruit is used as food; the inner core, trunk and flowers are used as vegetables
Colocasia esculentum	Gabi	Fruit/root is used as food
Manihot esculenta	Kamoteng kahoy	Fruit/root is edible
B. Bamboo		
Schizostachyum lumampao	Buho/Kawayan	Young shoots are edible, wood for light construction
Bambusa spinosa	Kawayan	Wood for light construction
Bambusa arundinacea	Kawayan	Young shoots are edible
Bambusa blumeana	Kawayan	Young shoots are edible
C. Grasses		
Imperata cylindrica	Kogon	Pseudostachym polymorphum
Brachiaria reptans	Marakauayan	Good fodder for stock animals

B. Vicinity of Proposed Project Site

Scientific Name	*Common Name*	*Economic Importance*
A. Non-Dipterocarps		
Mangifera indica L.	Mangga	The fruit is highly priced and edible. A decoction of the root is diuretic. Bark and seeds used as astringent. Leaves prepares as tea.
Psidium guajava Linn. (Myrtaceae)	Bayabas	Decoction of leaves is good for stomach ache and as vermifuge. Tea can be made from leaves. Fruit is used for manufacture of jellies. Wood for light construction
Averrhoa carambola	Balimbing	Fruits are edible and has medicinal value; also used as stain remover
Bougainvellia spectabilis	Boganvilla	Ornamental plant
Bixa orellana	Achuete	Seeds are used for coloring food and fabrics; can be used for landscaping
Acacia mangium	Yellow acacia	Wood used for light construction
Maize spp.	Corn	Source of carbohydrates
Eucalyptus robusta	Eucalyptus	Wood used for house shingles, shipbuilding, general construction

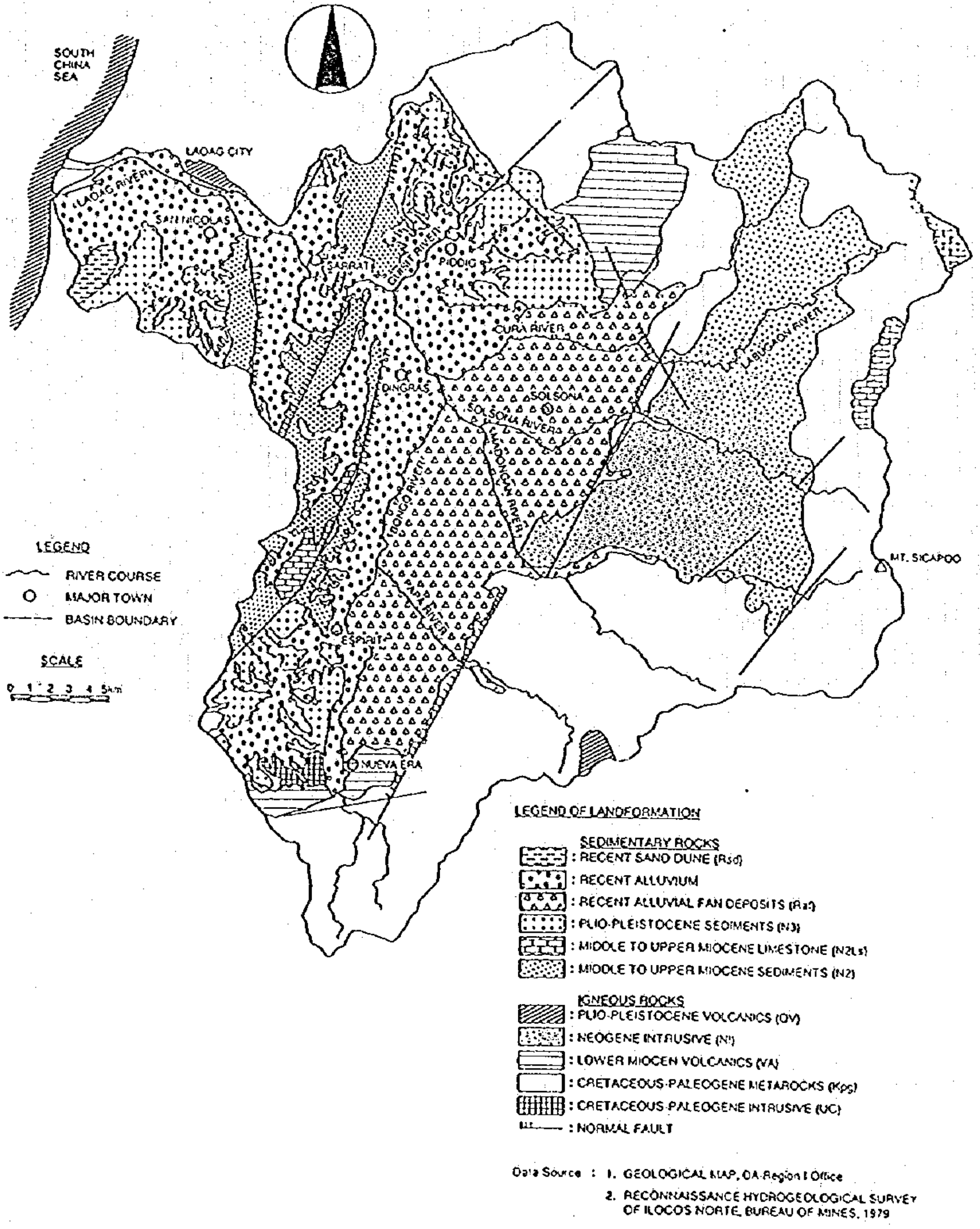
Tamarindus indica	Sampalok	Young leaves, flowers and pods are used for seasoning foods; fruit used in the manufacture of jams, sweets and drinks; bark is source of ink; seed is source of oil/varnish; street ornamental plant
Manihot esculenta	Kamoteng kahoy	Fruit/root is edible
Musa sapientum	Banana	Fruit is used as food; the inner core, trunk and flowers are used as vegetables
Swietenia macrophyla	Mahogany	Wood used for construction purposes
Pterocarpus indica	Narra	Wood for carvings and decorative uses; for wood finish
Casuarina equisetifolia	Agoho	Wood used for light construction
Gliricidia sepium (Jacq.) Steud. (Leguminoseae)	Kakawate	Ornamental and very good fence material. The branches are used as firewood and the juice of the leaves is used to cure itches and wounds
Shorea guisok	Guiho	Wood used for light construction
Leucaena Leucocephala	Ipil-ipil	Wood is good for firewood and charcoal; bark produces a brown dye; leaves can be used as animal feeds; seeds used as substitute for coffee
Macaranga grandifolia	Takip asin	Wood can be used for fuel; resin is used a astringent
Colocasia esculentum	Gabi	Fruit/root is used as food

B. Bamboo

Schizotachyum lumanpao	Kawayan/Buho	Wood used for light construction
Bambusa arundinacea	Kawayan	Young shoots are edible
Bambusa blumeana	Kawayan	Young shoots are edible

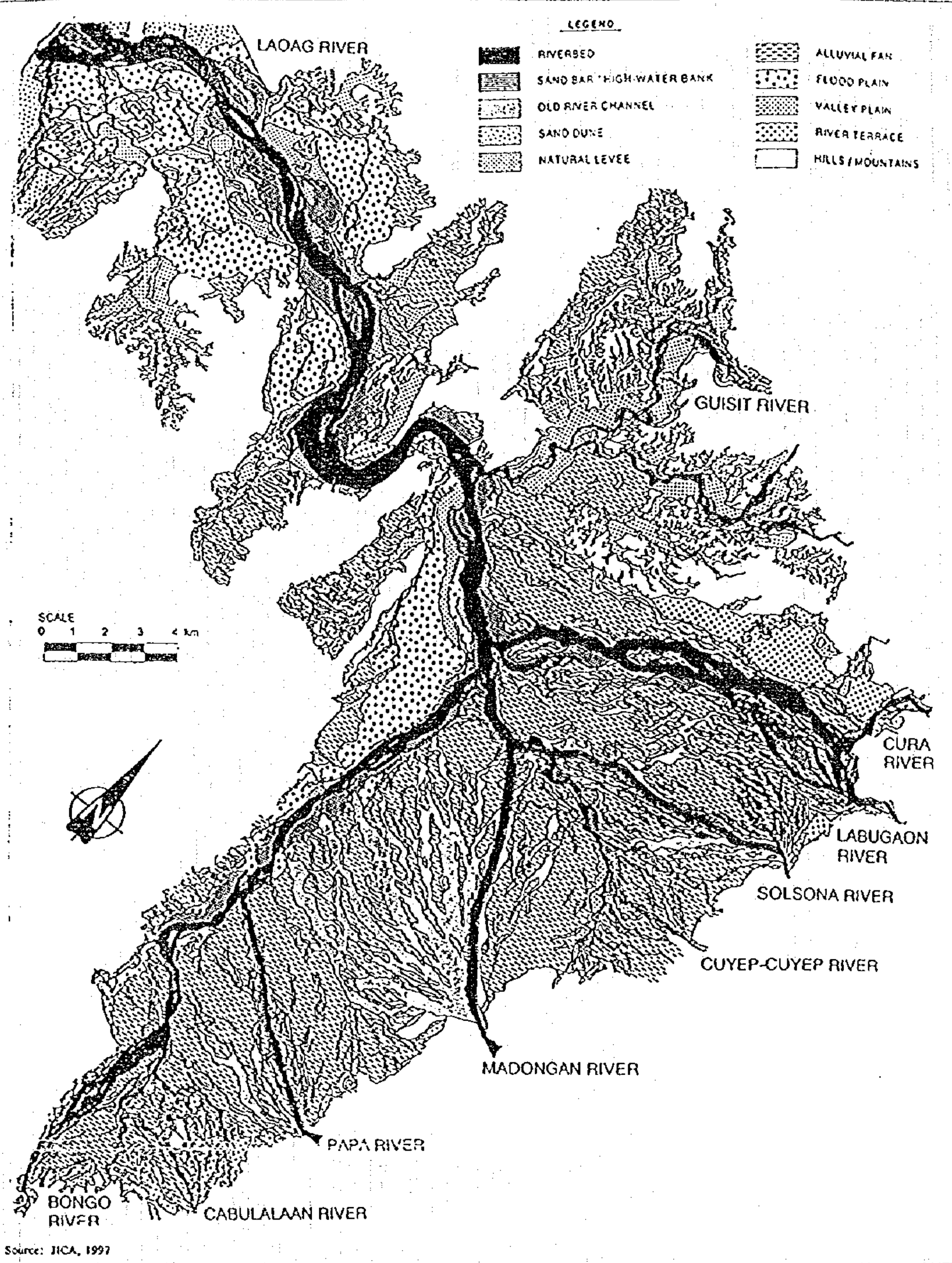
C. Grasses

Imperata cylindrica	Kogon	Pseudostachym polymorphum
Brachiaria reptans	Marakauayan	Good fodder for stock animals



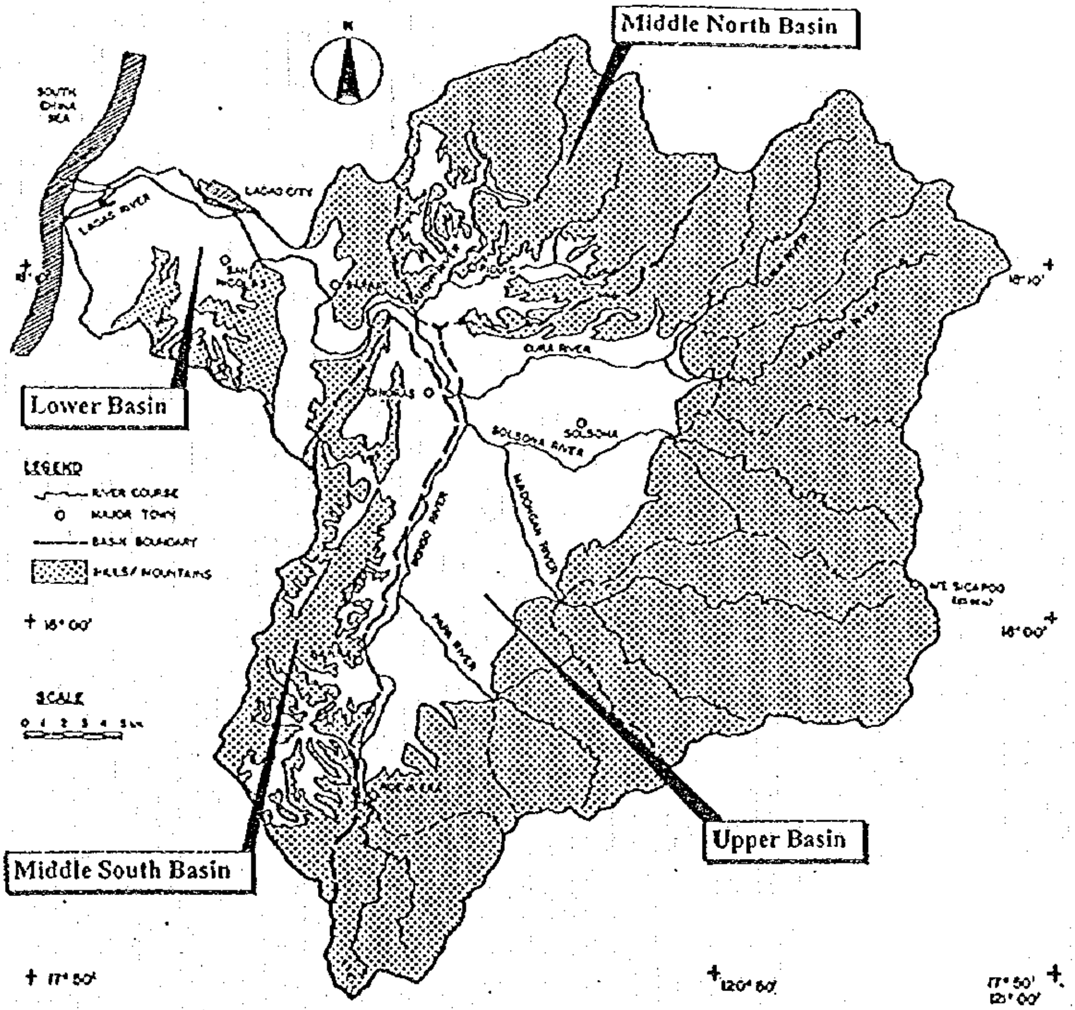
Source: JICA, 1997

ENVIRONMENTAL IMPACT STATEMENT OF THE SABO AND FLOOD CONTROL PROJECT OF THE LAOAG RIVER BASIN	Figure B.1 GEOLOGICAL MAP OF LAOAG RIVER BASIN



Source: JICA, 1997

ENVIRONMENTAL IMPACT STATEMENT OF THE SABO AND FLOOD CONTROL PROJECT OF THE LAOAG RIVER BASIN	Figure B.2 GEOMORPHOLOGICAL FEATURES OF LAOAG ALLUVIUM



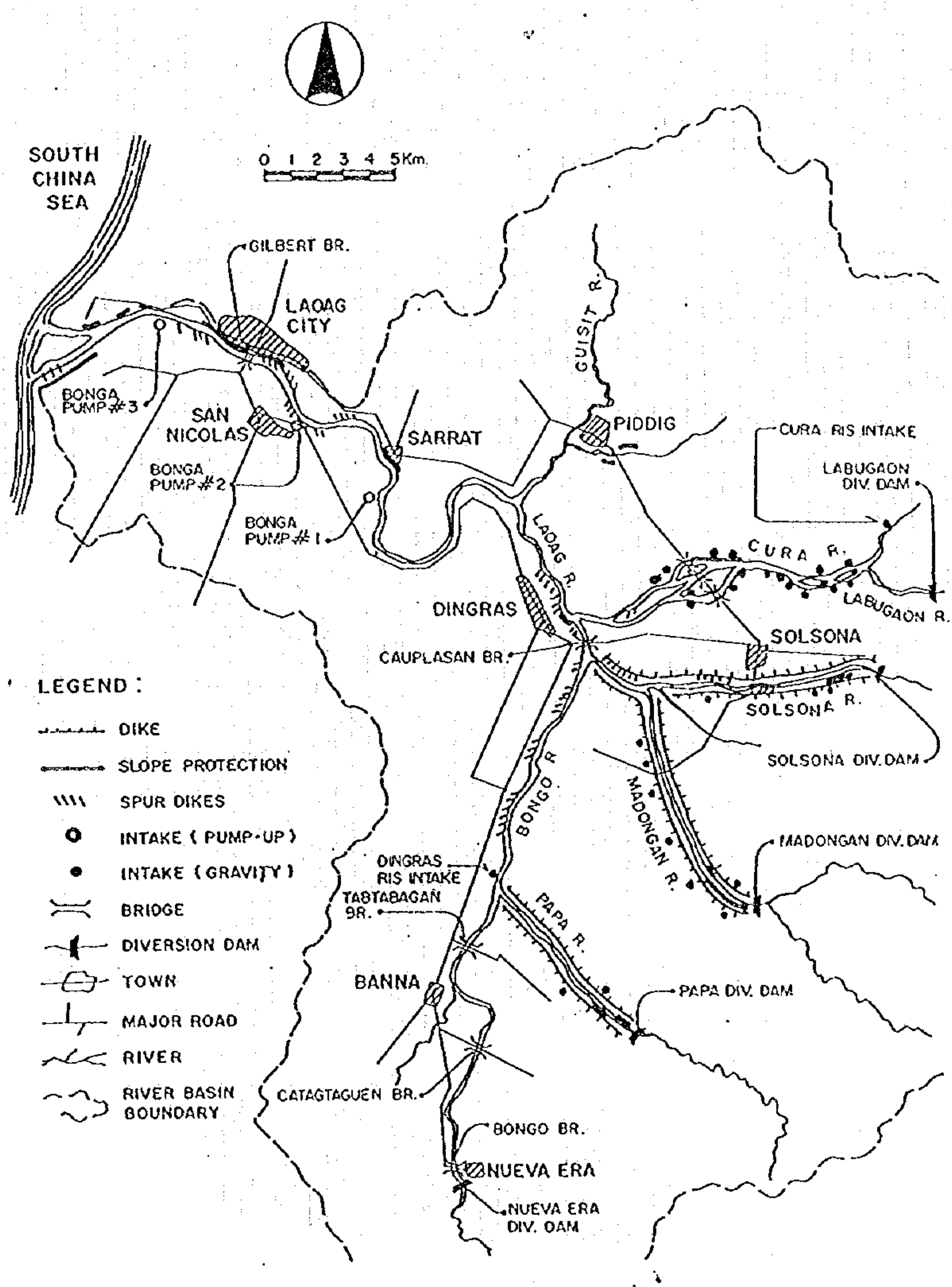
Sub-Basin	Topographic Components	Area	Remarks (Major Tributaries)
Upper Basin	Mountains/Hills	633.9 km²	Cura R., Labugaon R.,
	Alluvial Fan	201.1 km²	Solsona R., Madongan R.,
	Total	835.0 km²	Papa R., Bongo R.
Middle South Basin	Hills	109.0 km²	Magalis C., Suyo C.
	Alluvial Plain	51.0 km²	
	Total	160.0 km²	
Middle North Basin	Mountains/Hills	135.5 km²	Guisit R.
	Alluvial Plain	42.8 km²	
	Total	178.3 km²	
Lower Basin	Hills	57.2 km²	
	Alluvial Plain	101.6 km²	
	Total	158.8 km²	
Whole Basin	Mountains/Hills	935.6 km²	(70.2 %)
	Alluvial Fan	201.1 km²	(15.1 %)
	Alluvial Plain	195.4 km²	(14.7 %)
	Total	1332.1 km²	

Source: JICA, 1997

ENVIRONMENTAL IMPACT STATEMENT OF THE SABO AND FLOOD CONTROL PROJECT OF THE LAOAG RIVER BASIN

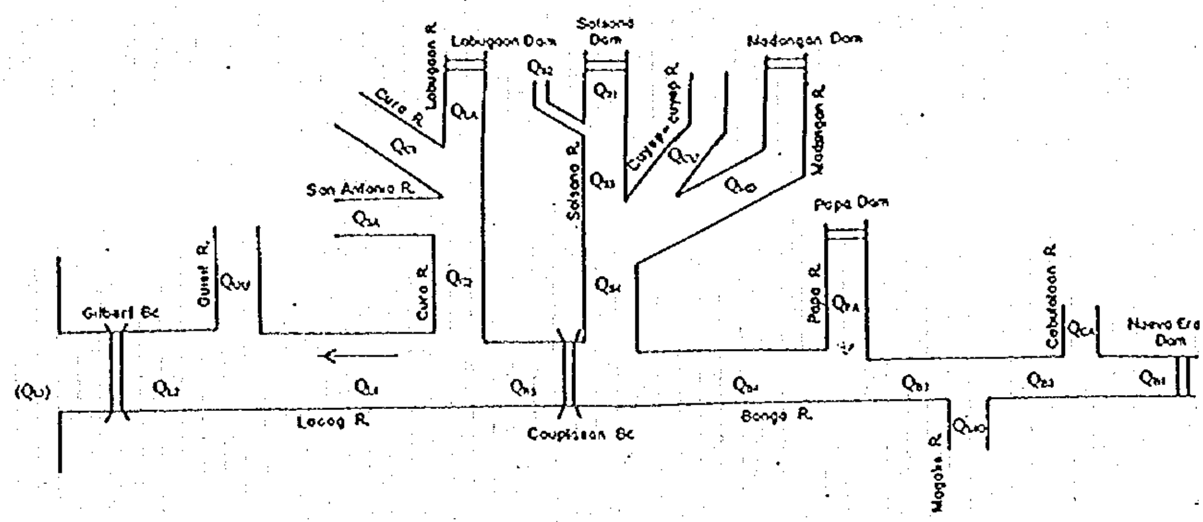
Figure B.3

RIVERS AND SUB-BASINS OF THE LAOAG RIVER BASIN



Source: JICA, 1997

ENVIRONMENTAL IMPACT STATEMENT OF THE SABO AND FLOOD CONTROL PROJECT OF THE LAOAG RIVER BASIN	Figure B.4 EXISTING RIVER STRUCTURES

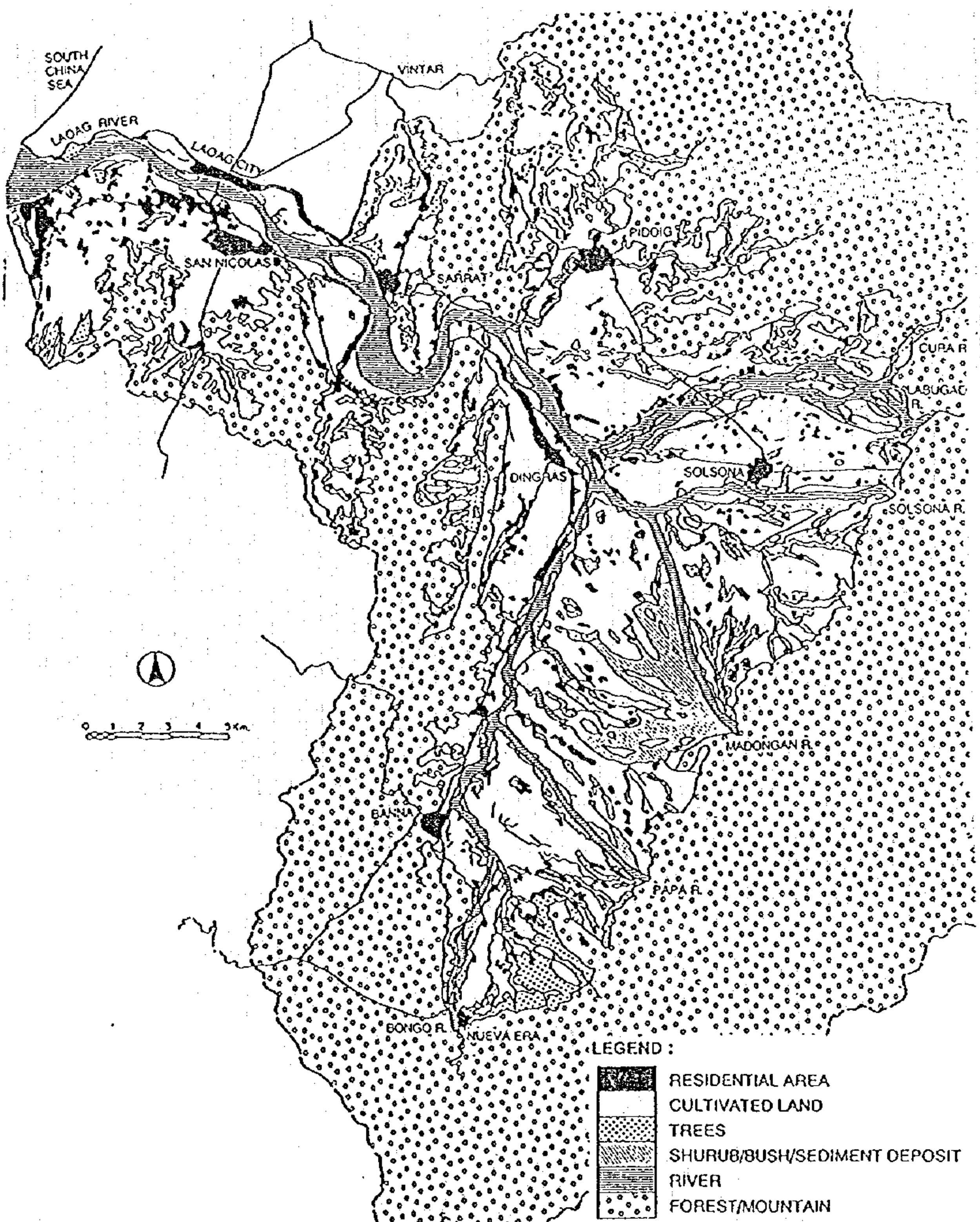


	Probable Flood Discharge (m³/s)					
	2-year	5-year	10-year	25-year	50-year	100-year
Q_{B1}	340	510	620	750	830	920
Q_{CA}	190	300	360	440	490	540
Q_{B2}	520	790	960	1,160	1,300	1,440
Q_{MO}	280	450	540	660	740	820
Q_{B3}	860	1,340	1,640	2,000	2,240	2,480
Q_{PA}	310	470	570	690	770	850
Q_{B4}	1,380	2,150	2,630	3,220	3,620	4,020
Q_{MD}	880	1,320	1,610	1,970	2,220	2,470
Q_{S1}	460	690	840	1,030	1,150	1,280
Q_{S2}	40	70	90	120	130	150
Q_{S3}	490	760	920	1,120	1,250	1,390
Q_{CU}	170	290	360	460	530	590
Q_{S4}	1,500	2,330	2,860	3,490	3,920	4,360
Q_{B5}	2,810	4,390	5,400	6,500	7,000	8,200
Q_{C1}	380	580	700	850	960	1,060
Q_{LA}	560	850	1,020	1,260	1,410	1,570
Q_{SA}	130	190	230	280	310	350
Q_{C2}	1,050	1,580	1,930	2,360	2,650	2,940
Q_{L1}	3,760	5,800	7,100	8,700	9,800	10,900
Q_{GU}	470	840	1,080	1,390	1,590	1,800
Q_{L2}	4,500	7,200	8,900	10,900	12,300	13,700
Q_{L3}	4,580	7,300	9,100	11,200	12,700	14,200

* : (Q_{L3}) is flood discharge at river mouth

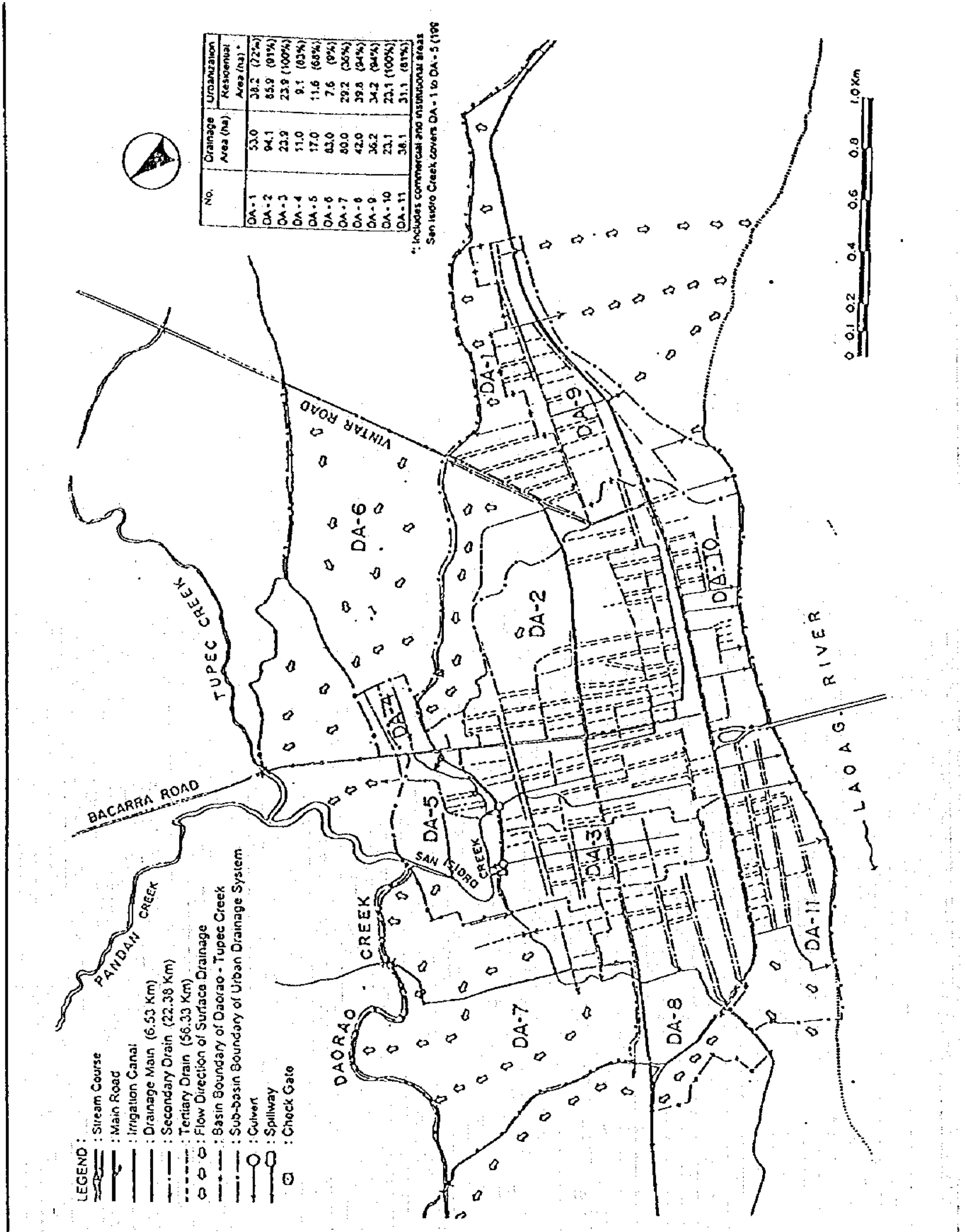
Source: JICA, 1997

ENVIRONMENTAL IMPACT STATEMENT OF THE SABO AND FLOOD CONTROL PROJECT OF THE LAOAG RIVER BASIN	Figure B.5 PROBABLE FLOOD DISCHARGE



Source: JICA, 1997

ENVIRONMENTAL IMPACT STATEMENT OF THE SABO AND FLOOD CONTROL PROJECT OF THE LAOAG RIVER BASIN	Figure B.6 PRESENT LAND USE MAP OF THE LAOAG RIVER BASIN

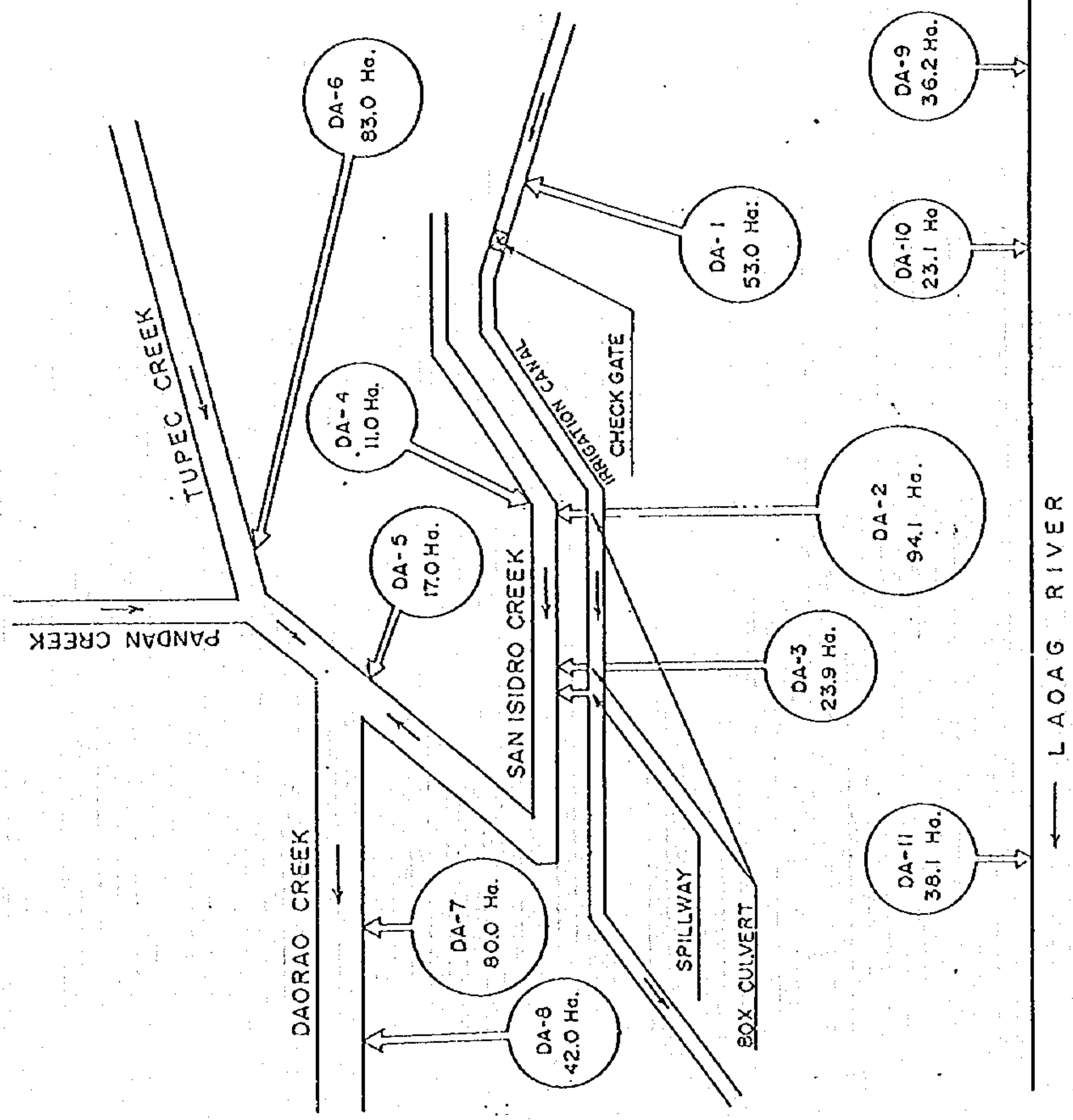


No.	Drainage Area (ha)	Urbanization Residential Area (ha) *
DA - 1	53.0	38.2 (72%)
DA - 2	94.1	85.9 (91%)
DA - 3	23.9	23.9 (100%)
DA - 4	11.0	9.1 (83%)
DA - 5	17.0	11.6 (68%)
DA - 6	83.0	7.6 (9%)
DA - 7	80.0	29.2 (36%)
DA - 8	42.0	39.8 (94%)
DA - 9	36.2	34.2 (94%)
DA - 10	23.1	23.1 (100%)
DA - 11	38.1	31.1 (81%)

*: Includes commercial and institutional areas
San Isidro Creek covers DA - 1 to DA - 5 (199

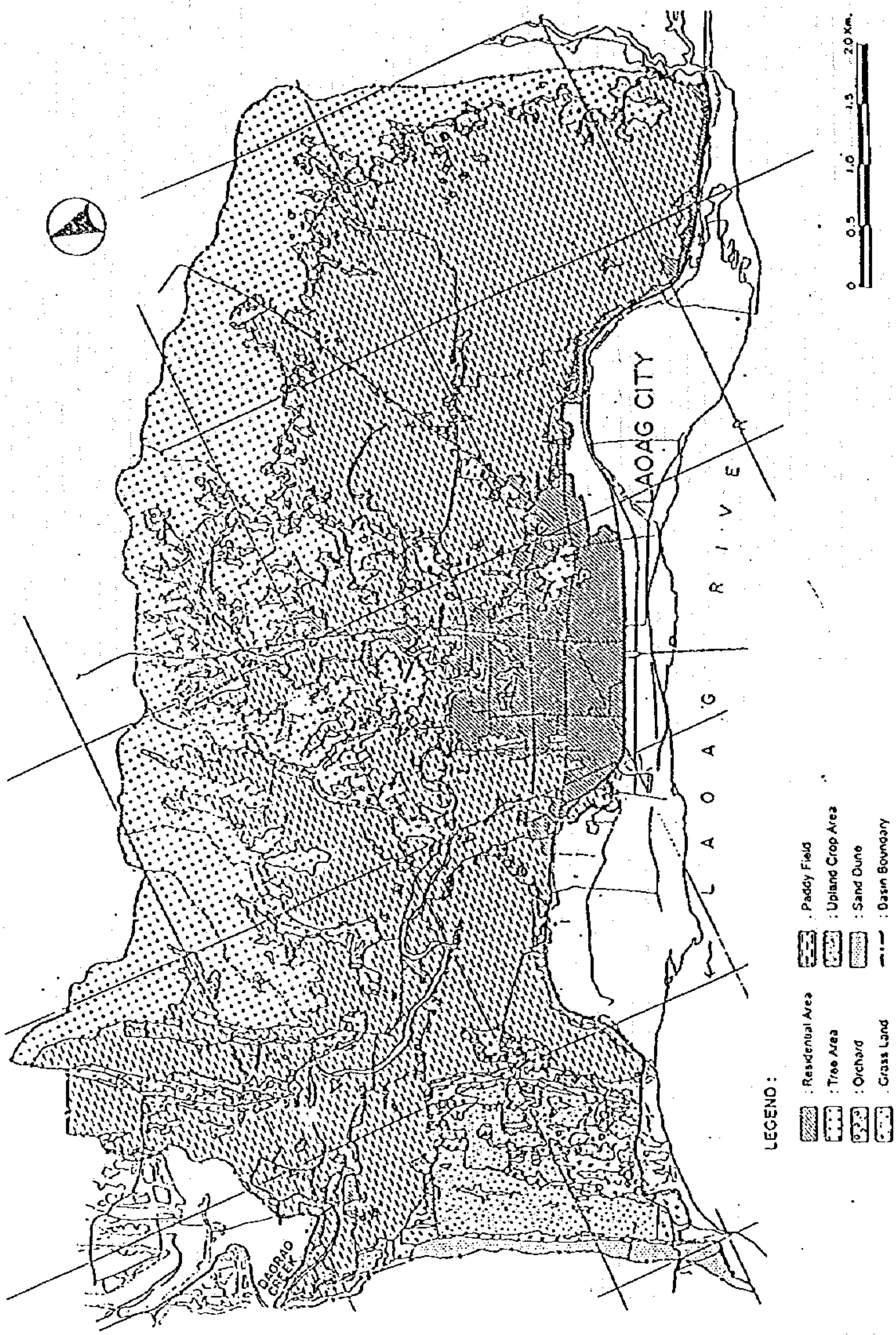
Source: JICA, 1997

ENVIRONMENTAL IMPACT STATEMENT OF THE SABO AND FLOOD CONTROL PROJECT OF THE LAOAG RIVER BASIN	Figure B.7 DIVISION OF LAOAG URBAN DRAINAGE AREA



Source: JICA, 1997

ENVIRONMENTAL IMPACT STATEMENT OF THE SABO AND FLOOD CONTROL PROJECT OF THE LAOAG RIVER BASIN	Figure B.8 SCHEMATIC DIAGRAM OF LAOAG URBAN DRAINAGE



Source: JICA, 1991

ENVIRONMENTAL IMPACT STATEMENT OF THE SABO AND FLOOD CONTROL PROJECT OF THE LAOAG RIVER BASIN	Figure B.9 PRESENT LAND USE MAP OF THE DAORAO-TUPEC CREEK BASIN

APPENDIX C

WATER QUALITY STUDY

APPENDIX C - WATER QUALITY STUDY OF THE LAOAG RIVER BASIN

EXECUTIVE SUMMARY

Survey on the water quality characteristics of the Laoag River Basin and Daorao Creek of Laoag City was conducted from 9 February to 9 March 1997. The survey was part of the environmental impact assessment study of the proposed Sabo Dams and Flood Control Project in the Laoag River Basin.

The collection of water samples and the subsequent laboratory analyses strictly adhered to the standard methods stipulated by the Department of Environment and Natural Resources (DENR). Water samples were collected from ten (10) sampling stations. The parameters analyzed are pH, water temperature, conductivity, total phosphorus, BOD, total dissolved solids, total suspended solids, nitrate, oil and grease dissolved oxygen, salinity and total coliforms.

Almost all the parameters analyzed are within the DENR standards. The rivers of the Laoag River Basin consistently showed low values of the parameters analyzed. The results of the water characterization confirms that the water quality of these rivers are still within the values of the parameters set for Class A waters. However, Daorao Creek registered relatively high values of the parameters analyzed. Compared with the rivers of the Laoag River Basin, this creek is considerably polluted.

I. INTRODUCTION

Rivers have always been a good source of food and livelihood for the communities surrounding it and contribute to agricultural development through its use in irrigation. Water quality and quantity are related to both water and land management. Poor land and water management leads to the removal of vegetation, loss of soils through erosion, destruction of wet lands and an increase in impervious surfaces. Erosion not only destroys valuable land, it pollutes rivers, streams and lakes. Alterations of stream flow can also impair the natural method of purifying runoff. Local land use and development regulations must be adopted if a community is to maintain a stable surface and ground water supply while mitigating the damage due to flooding and ground water pollution.

This study aims to establish a baseline data/information on the water quality of the various rivers in the Laoag River Basin.

II. IDENTIFICATION OF SAMPLING STATIONS

The various rivers of the Laoag River Basin were examined for their water quality characteristics. These rivers include Laoag River, Labugaon River, Madongan River, Papa River, and Solsona River. In addition, water quality investigation of Daorao Creek of Laoag City was included. All of these water bodies drain to the South China Sea.

Based on the recommendation contained in the Feasibility Study of the proposed project, ten (10) sampling stations were identified. The location of the sampling stations are shown in Figure C.1. Table C.1 presents the location of the ten (10) sampling stations.

Table C.1 LOCATION OF SAMPLING STATIONS

Station Number	Location
1	Laoag River Mainstream about 5 km from South China Sea Suyo, Laoag
2	Downstream of Laoag River Gilbert's Bridge Laoag City
3	Downstream of Laoag River about 50-100 m away from the drainage outfall of Northern Food Corporation Facility San Joaquin, Sarrat
4	Upstream of Bongo River Kauplasan Bridge, Dingras
5	Daorao Creek At bridge bordering Navotas and Cataban Laoag City
6	At bridge, downstream of Daorao Creek Pila, Laoag City
7	Upstream of Labugaon River Labugaon Diversion Dam Maananteng, Solsona
8	Upstream of Solsona River Solsona Diversion Dam Catanglaran, Solsona
9	Upstream of Madongan River Madongan Diversion Dam San Marcelino, Dingras

10	Upstream of Papa River Papa Diversion Dam Ragus, Marcos

III. SAMPLE COLLECTION AND METHODS OF ANALYSES

Water samples were collected three (3) times from each of the sampling stations in a two-week sampling interval. Collections were done on the following dates: February 9, February 23 and March 9, 1997.

During sample collection, it was always hot and sunny in the project area. There were no rain a few days before the sampling day. The collection usually starts at about 9:00 AM and lasts until 4:00 PM.

Using portable equipment, the parameters pH, temperature and conductivity were measured on site. Water samples for dissolved oxygen (DO) were fixed, preserved in an ice box and subsequently analyzed in the laboratory. All the rest of the parameters such as total phosphorus, BOD (5 days, 20°C), total dissolved solids, total suspended solids, nitrate (NO_3), oil and grease, salinity, and total coliforms were all analyzed immediately upon arrival in the laboratory..

The methods of laboratory analyses employed follow the accepted methods of analyses described in the DENR Administrative Order No. 34, otherwise known as the Revised Water Usage and Classification/Water Quality Criteria Amending Section Nos. 68 and 69, Chapter III of the 1978 NPCC Rules and Regulations. The methods used are shown in Table C.2.

Table C.2 DENR APPROVED METHOD OF ANALYSIS

PARAMETER	METHOD OF ANALYSIS
BOD5	Azide Modification
Dissolved Oxygen (DO)	Azide Modification (Winkler Method)
Nitrate	Bruccine Method
Oil and Grease	Gravimetric Method (Petroleum Ether Extract)
pH	Glass Electrode Method
Total Suspended Solids	Gravimetric Method
Temperature	Use of Mercury-Filled Thermometer
Total Coliforms	Multiple-Tube Fermentation Technique

IV. RESULTS AND DISCUSSION

The results of laboratory analyses for each sampling stations are shown in Tables C.3 to C.12. These results are compared with the DENR Standards for Class A (Public Water Supply Class II) and Class D (Water for Irrigation). The rivers of the Laoag River Basin fall under the Class A category. In DAO 34, Class A water is defined as sources of water supply that will require complete treatment such as coagulation, sedimentation, filtration and disinfection in order to meet the National Standard for Drinking Water (NSDW). Water from these rivers is also presently utilized as irrigation water.

pH

pH is the indication of the acidity or alkalinity of the system. In water bodies, the diurnal fluctuations in pH are primarily associated with the respiratory and photosynthetic activities of the phytoplankton. pH is also influenced by the presence of organic and inorganic materials entering the water bodies. Reports averred that animal dung such as cow droppings raises the pH of water rapidly. However, its effects are temporary and more acid solution are quickly restored. In some cases, the discharge of unneutralized acid or alkaline effluents greatly alters the pH of the receiving water of the river system. In this case, the effect may be adverse.

Based on the results of the laboratory analyses, pH values fall within the expected pH range (6-9) for natural body of water. The recorded values did not exceed the DENR pH standard for Class A and Class D waters which are 6.5 - 8.5 and 6.0 - 9.0, respectively. The results suggest that at least during the survey duration, the background pH is not too low nor too high and that there is no major source of acidic or basic loadings that is capable of changing the background pH values.

With the proposed project, the background pH of the water is not expected to be changed. Only Sabo Dams and related structures will be constructed during project implementation. There will be no potential source of acidic or basic loadings from the proposed project that will alter the pH of the surrounding water of Laoag River Basin.

Temperature

The temperature of river waters can be influenced by the degree of insolation, substrate composition, turbidity, ground- or rainwater inflows, wind and vegetation cover. It is common that the water temperature during dry season is higher than that of during wet season. Generally, surface-water temperatures follow the ambient air temperature fairly closely. However, during dry, hot conditions, the surface water temperature is more likely to be correlated with air-temperature minima owing to the cooling effect of evaporation.

It is expected that water in the main channel of Laoag River Basin rarely stratifies. This is due to turbulence brought about by strong mixing associated with river flow. High level of river flow is obvious based on the absence of algal growth along the main channel of the river basin.

The surface water temperature observed range from 20.5°C to a high as 32.6°C. It is generally observed that the surface temperature is lower in the morning time and higher in the afternoon.

The proposed project is not expected to greatly influence the water temperature of the main channel of Laoag River Basin.

Conductivity

Conductivity is a measure of the total amount of ions present in a body of water. The parameter is therefore useful in the approximation of the water samples chemical richness. As a measure, however, it does not give an indication of the actual ionic composition of the water, and may therefore fail to convey information on limiting factors such as lack of essential nutrients.

Based on the observed values of conductivities in this study, the values are less variable and it seems that the difference are not too big. The values range from a low as 126 to a high as 208 umhos/cm. It is a known fact that conductivity of a given system changes throughout the year. Since the survey was conducted during dry season, it is expected that lower conductivities are to be obtained should the measurement had been done during the rainy season.

The broad, ionic composition of water is largely determined by four processes namely; (1) dilution effect whereby flood or rainwater with weak ionic concentration reduces conductivity, (2) solution effect, whereby salts locked on previously dry land by decaying organic matter enter solution as the flood water extend over large areas, (3) concentration by evaporation, and (4) absorption by living components. Normally, these effects combined tend to produce higher conductivities during the dry season than in the wet in the river channels, giving an inverse relationship between water depth and conductivities.

Phosphorus

Phosphorus occurs in natural waters and in wastewaters almost solely as phosphates. The classification of phosphates are orthophosphates, condensed phosphates (pyro-, meta-, and other polyphosphates), and organically bound phosphates. The occurrence of phosphate can be in the form of solution, particles or detritus, or in the bodies of aquatic organisms. These forms of phosphate arises from a variety of sources. For instance, orthophosphates are applied to agricultural or residential cultivated lands as fertilizers and is carried into surface waters with storm runoff. When water is used for laundering or cleaning purposes, a large quantity of condensed phosphate is used. Condensed phosphate is a major constituent of many commercial cleaning preparations. Organophosphates, on the other hand, is a major constituent of agro-chemicals such as pesticides and insecticides.

Phosphorus is essential to the growth of organisms and can be a nutrient that limits the primary productivity of a body of water. In instances where phosphate is a growth-limiting nutrient, the discharge of raw or treated wastewater, agricultural drainage, or certain industrial wastes to that water may stimulate the growth of photosynthetic aquatic micro- and macro-organisms in nuisance quantities. This excessive growth of organisms may lead to a phenomenon called eutrophication.

Based on the results of the phosphorus analysis of water samples taken from 10 sampling stations, the levels of phosphorus concentrations are relatively low. In most of the cases, the level of concentrations registered are within the DENR standard.

Water samples from Daorao Creek registered the highest phosphorus concentration level. It registered a concentration range of about 0.15-0.49 mg/L. Daorao Creek received domestic and commercial wastewaters from the city proper. As presented earlier, domestic wastewaters may be rich in phosphorus originating from the use of phosphorus-containing detergents by the local people. Most of the locally available cleaning detergents are still phosphorus-base reagents.

Another possible reason why Daorao Creek has the highest phosphorus content is the leaching of organophosphates from agro-chemicals and fertilizers used by the farmers. Ocular inspection showed that farming is still being practice along Daorao Creek. It is possible that its phosphorus content may come from the runoffs of these farms which are using inorganic fertilizers and organophosphates pesticides and insecticides.

Within the Laoag River Basin, agricultural practice is also rampant. Phosphorus-rich runoff may also enter the river basin. But since the river flow is big enough, flashing and dilution effect may offset the concentration levels of phosphorus in the river. These confirm the results of phosphorus analysis of water samples taken from the various rivers of the Laoag River Basin. The samples from these rivers registered very low level of phosphorus concentration. Comparing these river with Daorao Creek, the latter has relatively low water flow.

The proposed project is expected not to exert impact on the phosphorus content of the river water. However, since the secondary use of the project is for irrigation purposes, farming practices along the river basin may become more extensive. These may result to the use of more agro-chemicals by the farmers which may finally enrich the agricultural water runoff with phosphorus. These water runoff will contribute to the non-point source of phosphorus contamination of the river.

Biochemical Oxygen Demand (BOD)

The method of biochemical oxygen demand (BOD) determination consists of placing a sample in a full, airtight bottle and incubating the bottle at 20°C within 5 days. Dissolved oxygen (DO) is measured initially and after incubation. The BOD is computed from the difference between initial and final DO.

The BOD determination is an empirical test which determine the relative oxygen requirements of water samples. The test measures the oxygen required for the biochemical degradation of organic or carbonaceous materials present in the water samples. In other words, the higher the organic contamination of the sample, the higher will be its BOD value.

Based on the results of the analysis, BOD values for all the samples taken are low. The values registered are all within the DENR standard for BOD. The pristine river of Madongan, Papa, Labugaon and Solsona showed consistently low BOD levels. Samples from Daorao Creek registered the highest value of about 3.6 mg/L. Daorao Creek receives domestic and commercial wastewater from Laoag City.

Total Suspended and Total Dissolved Solids

The term solids in these water parameters refer to matter suspended or dissolved in water. These solids may affect the water quality in many ways. For instance, water with high dissolved solids generally are of inferior palatability and may induce an unfavorable physiological reaction in the water users. Highly mineralized waters also are unsuitable for many industrial applications. Waters high in suspended solids may be aesthetically unsatisfactory for such purposes as bathing.

From environmental point of view, solids analyses are important in the control of biological and physical wastewater treatment processes and for assessing compliance with the required effluent standards. From engineering point of view such as in dam projects, solids is important in determining the effective life span of dam projects with respect to its water holding capacity. It is also important in determining the rate of siltation of the dam projects.

Compared with the DENR Standard for Class A and Class D waters, the parameters total suspended solids and total dissolved solids showed relatively low values for all the samples taken for analyses. The rivers of Madongan, Papa, Labugaon and Solsona consistently showed very low concentrations of both total suspended and dissolved solids.

Samples from Daorao Creek again registered the highest level of concentrations of total suspended and dissolved solids. It may be possible that the wastewater draining to Daorao Creek has high solids content. Another possible explanation is that agricultural runoff from the nearby farmlands are rich with both suspended and dissolved solids.

It should be noted that the water quality survey was conducted during the dry season during which time, there was no record of rains and other climatic disturbance in the area. The results of the solids analyses only show that there is no sediment runoff from the mountains or upstream of the river basin at this time. However, the quality of water samples especially its solids content may have been higher had the survey been conducted during the rainy season.

During rainy season, the proposed Sabo Dam is expected to exert positive impact with respect to the solid content of the upstream and downstream river waters. The construction of this dam has sediment control effects. Specifically, the dam controls the upstream sediment runoff volume and further reduce the runoff of large size sediments. In effect, the downstream water will have less solid contents.

<u>Nitrate</u>

In waters the forms of nitrogen of greatest interest are nitrate, nitrite, ammonia and organic nitrogen. They are biochemically interconvertible and are part of the nitrogen cycle.

The total oxidized nitrogen is the sum of nitrate and nitrite nitrogen. Nitrate generally occurs in trace quantities in surface water but may attain high levels in some groundwater. Nitrate is of interest for the reason that when present in excessive amount, it contributes to the illness known as methemoglobinemia or blue baby in infants. This is the reason why a limit of 10 mg nitrate as nitrogen per liter has been imposed on drinking water to prevent this disorder.

Nitrate is found only in small amounts in fresh domestic wastewater. However, a higher concentration level at a high as 30 mg nitrate as nitrogen per liter can be found in the effluents of biological treatment plants. Like phosphorus, nitrate is an essential nutrient for many photosynthetic organisms. In some case, nitrate has been identified as the growth-limiting nutrients.

Results of nitrate analyses suggest that there is no alarming cases of nitrogen pollution in any of the sampling locations. The nitrate concentrations are all within the DENR standards. During sampling, it was observed that in almost all the sampling sites, there were patches of animal manures within the vicinity of the sampling location. It is often reported that animal manures are good source of nitrate. In this case, however, it could be deduced that these manures do not significantly contribute to the level of nitrate content of the river waters. It could be that the high flows of the rivers exert flushing and dilution effect.

Daorao Creek registered the highest level of nitrate concentration. Possible sources of these nitrates may come from the domestic wastewater being discharge from Laoag City and fertilizer runoff from nearby agricultural farmlands.

Oil and Grease

Oil and grease are groups of substances with similar physical characteristics. They are determined quantitatively on the basis of their common solubility in petroleum ether. Oil and grease, therefore, refers to the material recovered as a substance soluble in petroleum ether.

From environmental point of view, grease and oil when discharge in excessive amount may cause surface films and shoreline deposits leading to environmental degradation. Therefore, a knowledge of the oil and grease content of river is helpful in proper river management by regulating the discharge of wastewater effluents containing high concentration of oil and grease.

Based on the result of the survey, oil and grease content of all the water samples are within the standard set by DENR. Samples from the Laoag River Basin consistently showed very low to non-detectable oil and grease concentration. A relatively high concentration was observed in samples taken from Daorao Creek. It should be pointed out that water runoff from roads and other sources such as gasoline stations which drain to the creek may contribute to the observed values of oil and grease in Daorao Creek samples. This is coupled by the contribution of domestic wastewater which is also received by Daorao Creek.

Dissolved Oxygen

Dissolved oxygen (DO) levels in natural waters depends on the physical, chemical and biochemical activities in the water body. The analysis for dissolved oxygen is a key test in water pollution and waste treatment process control. High values of DO indicate that there is no alarming case of organic pollution.

Based on the results of the water quality survey, the values for dissolved oxygen are high in all samples from the rivers except for samples collected from Daorao Creek. Since this creek is constantly receiving wastewater from the city proper, the DO level is expected to be low. Some of the observed values are below the DENR standards of 5 mg/L.

Total Coliform

The conduct of the total coliform tests provide indication on the extent of coliform contamination of the water samples. The bacterial concentration is usually expressed in Most Probable Number (MPN). The result of the total coliform analysis made no distinction between pathogenic (usually called fecal coliform) and non-pathogenic coliforms. Since the tributaries of the Laoag River Basin is classified as Class A river, when use as water supply source, it requires complete treatment including disinfection. Therefore, users should be cautious of not using the river as their source of drinking water to avoid incidence of water borne diseases.

Based on the results of the survey, the levels of total coliforms are consistently high in all the samples taken for analyses. During sample collection, it was observed that there were some farm animals like cows roaming around the vicinity of the rivers. It may be possible that farm animals discharging manure contribute on these observed data.

Salinity

Salinity is defined as the total solids in water after all carbonates have been converted to oxides, all bromide and iodide have been replaced by chloride, and all organic matter has been oxidized. It is usually numerically smaller than the total dissolved solids and is reported as grams per kilogram.

Salinity is an important measurement in the analysis of certain water samples such as seawater or water suspected to be contaminated or intruded with seawater. In this study, a sampling station (Station No.1) which is some 5 kilometers away from the sea was tested for salinity. The concentration range (0.06 - 0.09 g/kg) for Station No.1 indicates that the downstream reaches of Laoag River are still not influenced by seawater.

Samples from Daorao Creek were likewise subjected to the same test. Results showed a concentration range of 0.07 to 0.12 g/kg which indicates that salinity due to the enrichment of salts from fertilizers is not yet critical at this creek.

Table C.3 Water Quality Test Results for Station No.1
Laoag River, about 5 km from South China Sea, Suyo, Laoag City

Parameter	Date of Sample Collection		
	February 9, 1997	February 23, 1997	March 9, 1997
pH	8.31	8.29	8.70
Water Temperature, °C	31.4	26.7	30
Conductivity,	127.3	114.4	144.3
Total Phosphorus, mg/L	0.04	0.07	0.10
BOD (5 days, 20°C), mg/L	1.0	1.5	1.1
Total Dissolved Solids, mg/L	152	158	151
Total Suspended Solids, mg/L	4.6	16	6.0
Salinity, g/Kg	0.09	0.08	0.06
Nitrate (NO_3), mg/L	0.10	ND	1.4
Oil and Grease, mg/Lq	4.7	5.0	0.62
Dissolved Oxygen, mg/L	11.8	12.6	3.2
Coliforms, MPN/100mL	5,000	160,000	>160,000
Time of Sample Collection	2:30 PM	3:45PM	3:40PM
Weather	sunny	sunny	sunny

Notes: ND is none detected; Minimum Detection Limits: TSS, mg/L = 1.0; NO_3, mg/L = 0.01; Oil & grease, mg/L = 0.5

Table C.4 Water Quality Test Results for Station No.2
Downstream of Laoag River, Gilbert's Bridge, Laoag City

Parameter	Date of Sample Collection		
	February 9, 1997	February 23, 1997	March 9, 1997
pH	8.5	8.25	8.31
Water Temperature, °C	32.6	24.4	31.1
Conductivity,	126.2	148.1	179.4
Total Phosphorus, mg/L	0.08	0.05	0.08
BOD (5 days, 20°C), mg/L	1.3	1.8	1.0
Total Dissolved Solids, mg/L	153	152	155
Total Suspended Solids, mg/L	6.8	3.2	4.4
Nitrate (NO_3), mg/L	1.0	0.50	ND
Oil and Grease, mg/Lq	3.3	1.5	1.3
Dissolved Oxygen, mg/L	9.8	10.6	11.4
Coliforms, MPN/100mL	5,000	>160,000	>160,000
Time of Sample Collection	2:05 PM	3:20 PM	3:20
Weather	sunny	sunny	sunny

Notes: ND is none detected; Minimum Detection Limits: TSS, mg/L = 1.0; NO_3, mg/L = 0.01; Oil & grease, mg/L = 0.5

Table C.5 Water Quality Test Results for Station No.3
Downstream of Laoag River at about 100 m away from drainage outfall of Northern Food Corporation Facility, San Mateo, Sarrat

Parameter	Date of Sample Collection		
	February 9, 1997	February 23, 1997	March 9, 1997
pH	8.9	8.22	8.24
Water Temperature, °C	27.4	22.7	26.7
Conductivity	204	195.6	184.6
Total Phosphorus, mg/L	0.04	0.03	0.16
BOD (5 days, 20°C), mg/L	1.17	1.4	1.0
Total Dissolved Solids, mg/L	142	140	142
Total Suspended Solids, mg/L	2.6	ND	1.6
Nitrate (NO_3), mg/L	1.8	0.90	ND
Oil and Grease, mg/Lq	1.1	ND	1.2
Dissolved Oxygen, mg/L	9.8	11.5	10.1
Coliforms, MPN/100mL	9,000	90,000	>160,000
Time of Sample Collection	8:45 AM	9:25 AM	8:24
Weather	sunny	sunny	sunny

Notes: ND is none detected; Minimum Detection Limits: TSS, mg/L = 1.0; NO3, mg/L= 0.01; Oil & grease, mg/L = 0.5

Table C.6 Water Quality Test Results for Station No.4
Upstream of Bongo River , Kauplasan Bridge, Dingras

Parameter	Date of Sample Collection		
	February 9, 1997	February 23, 1997	March 9, 1997
pH	8.9	8.46	8.30
Water Temperature, °C	31.8	28.2	30.8
Conductivity,	133	130.9	147.4
Total Phosphorus, mg/L	0.02	0.02	0.07
BOD (5 days, 20°C), mg/L	1.6	1.5	1.0
Total Dissolved Solids, mg/L	176	151	150
Total Suspended Solids, mg/L	5.6	ND	1.0
Nitrate (NO_3), mg/L	ND	ND	ND
Oil and Grease, mg/Lq	1.8	ND	ND
Dissolved Oxygen, mg/L	10.8	11.6	11.1
Coliforms, MPN/100mL	2,300	>160,000	90,000
Time of Sample Collection	1:00 PM	2:00 PM	2:00PM
Weather	sunny	sunny	sunny

Notes: ND is none detected; Minimum Detection Limits: TSS, mg/L = 1.0; NO_3, mg/L= 0.01; Oil & grease, mg/L = 0.5

Table C.7 Water Quality Test Results for Station No.5
Daorao Creek at bridge bordering Navotas and Cataban, Laoag City

Parameter	Date of Sample Collection		
	February 9, 1997	February 23, 1997	March 9, 1997
pH	7.39	7.46	7.30
Water Temperature, °C	28.2	25.9	26.5
Conductivity,	150.2	169.5	163.3
Total Phosphorus, mg/L	0.15	0.13	0.43
BOD (5 days, 20°C), mg/L	0.9	1.0	1.0
Total Dissolved Solids, mg/L	263	292	287
Total Suspended Solids, mg/L	23	12.2	9.2
Salinity, g/Kg	0.10	0.09	0.07
Nitrate (NO_3), mg/L	4.0	0.30	ND
Oil and Grease, mg/Lq	3.2	2.8	1.0
Dissolved Oxygen, mg/L	4.9	4.5	13.4
Coliforms, MPN/100mL	5,000	160,000	>160,000
Time of Sample Collection	2:50 PM	4:17 PM	4:00
Weather	sunny	sunny	sunny

Notes: ND is none detected; Minimum Detection Limits: TSS, mg/L = 1.0; NO_3, mg/L = 0.01; Oil & grease, mg/L = 0.5

Table C.8 Water Quality Test Results for Station No.6
Downstream of Daorao Creek, Pila, Laoag City

Parameter	Date of Sample Collection		
	February 9, 1997	February 23, 1997	March 9, 1997
pH	7.58	7.4	7.47
Water Temperature, °C	28.0	25.4	26.4
Conductivity,	170	146.9	170.3
Total Phosphorus, mg/L	0.15	0.35	0.49
BOD (5 days, 20°C), mg/L	1.85	3.6	2.7
Total Dissolved Solids, mg/L	276	322	279
Total Suspended Solids, mg/L	69.2	32.	45.6
Salinity	0.10	0.12	0.08
Nitrate (NO_3), mg/L	ND	0.30	1.3
Oil and Grease, mg/Lq	3.7	5.0	ND
Dissolved Oxygen, mg/L	4.1	3.5	5.0
Coliforms, MPN/100mL	90,000	>160,000	160,000
Time of Sample Collection	3:25 PM	4:30 PM	4:20PM
Weather	sunny	sunny	sunny

Notes: ND is none detected; Minimum Detection Limits: TSS, mg/L = 1.0; NO_3, mg/L = 0.01; Oil & grease, mg/L = 0.5

Table C.9 Water Quality Test Results for Station No.7
Upstream of Labugaon River, Diverson Dam, Maananteng, Solsona

Parameter	Date of Sample Collection		
	February 9, 1997	February 23, 1997	March 9, 1997
pH	8.21	8.24	8.31
Water Temperature, ^{0}C	24.4	21.5	22.7
Conductivity,	160	208.2	174.4
Total Phosphorus, mg/L	0.02	0.02	0.02
BOD (5 days, $20^{0}C$), mg/L	1.2	1.6	1.0
Total Dissolved Solids, mg/L	94.1	84.6	91.6
Total Suspended Solids, mg/L	ND	ND	ND
Nitrate (NO_3), mg/L	0.30	ND	ND
Oil and Grease, mg/Lq	1.0	0.80	0.52
Dissolved Oxygen, mg/L	11.4	12.4	9.0
Coliforms, MPN/100mL	200	30,000	1,300
Time of Sample Collection	9:55 AM	10:46 AM	10:45AM
Weather	sunny	sunny	sunny

Notes: ND is none detected; Minimum Detection Limits: TSS, mg/L = 1.0; NO_3, mg/L = 0.01); Oil & grease, mg/L = 0.5

Table C.10 Water Quality Test Results for Station No.8
Upstream of Solsona River, Diversion Dam, Catanglaran, Solsona

Parameter	Date of Sample Collection		
	February 9, 1997	February 23, 1997	March 9, 1997
pH	8.26	8.29	8.55
Water Temperature, ^{0}C	24.5	20.5	22.8
Conductivity,	140	156	161.5
Total Phosphorus, mg/L	0.02	0.02	0.02
BOD (5 days, $20^{0}C$), mg/L	0.90	1.3	1.1
Total Dissolved Solids, mg/L	105	86.1	93.0
Total Suspended Solids, mg/L	ND	ND	ND
Nitrate (NO_3), mg/L	ND	0.2	ND
Oil and Grease, mg/Lq	1.2	ND	1.1
Dissolved Oxygen, mg/L	10.9	12.6	10.1
Coliforms, MPN/100mL	800	24,000	1,700
Time of Sample Collection	10:30 AM	11:00 AM	11:10AM
Weather	sunny	sunny	sunny

Notes: ND is none detected; Minimum Detection Limits: TSS, mg/L = 1.0; NO_3, mg/L = 0.01; Oil & grease, mg/L = 0.5

Table C.11 Water Quality Test Results for Station No.9
Upstream Madongàn River, Diversion Dam, San Marcelino, Dingras

Parameter	Date of Sample Collection		
	February 9, 1997	February 23, 1997	March 9, 1997
pH	7.82	7.85	7.95
Water Temperature, °C	26.1	25.2	26.3
Conductivity,	160.7	179.9	169.9
Total Phosphorus, mg/L	0.02	0.02	0.03
BOD (5 days, 20°C), mg/L	0.9	1.2	1.0
Total Dissolved Solids, mg/L	114	111	113
Total Suspended Solids, mg/L	ND	ND	ND
Nitrate (NO_3), mg/L	ND	ND	0.70
Oil and Grease, mg/Lq	1.0	ND	1.7
Dissolved Oxygen, mg/L	11.5	10.5	9.3
Coliforms, MPN/100mL	<200	24,000	2,300
Time of Sample Collection	10:20 AM	12:32 AM	12:30PM
Weather	sunny	sunny	sunny

Notes: ND is none detected; Minimum Detection Limits: TSS, mg/L = 1.0; NO_3, mg/L = 0.01; Oil & grease, mg/L = 0.5

Table C.12 Water Quality Test Results for Station No.10
Upstream of Papa River, Papa Diversion Dam, Ragus, Marcos

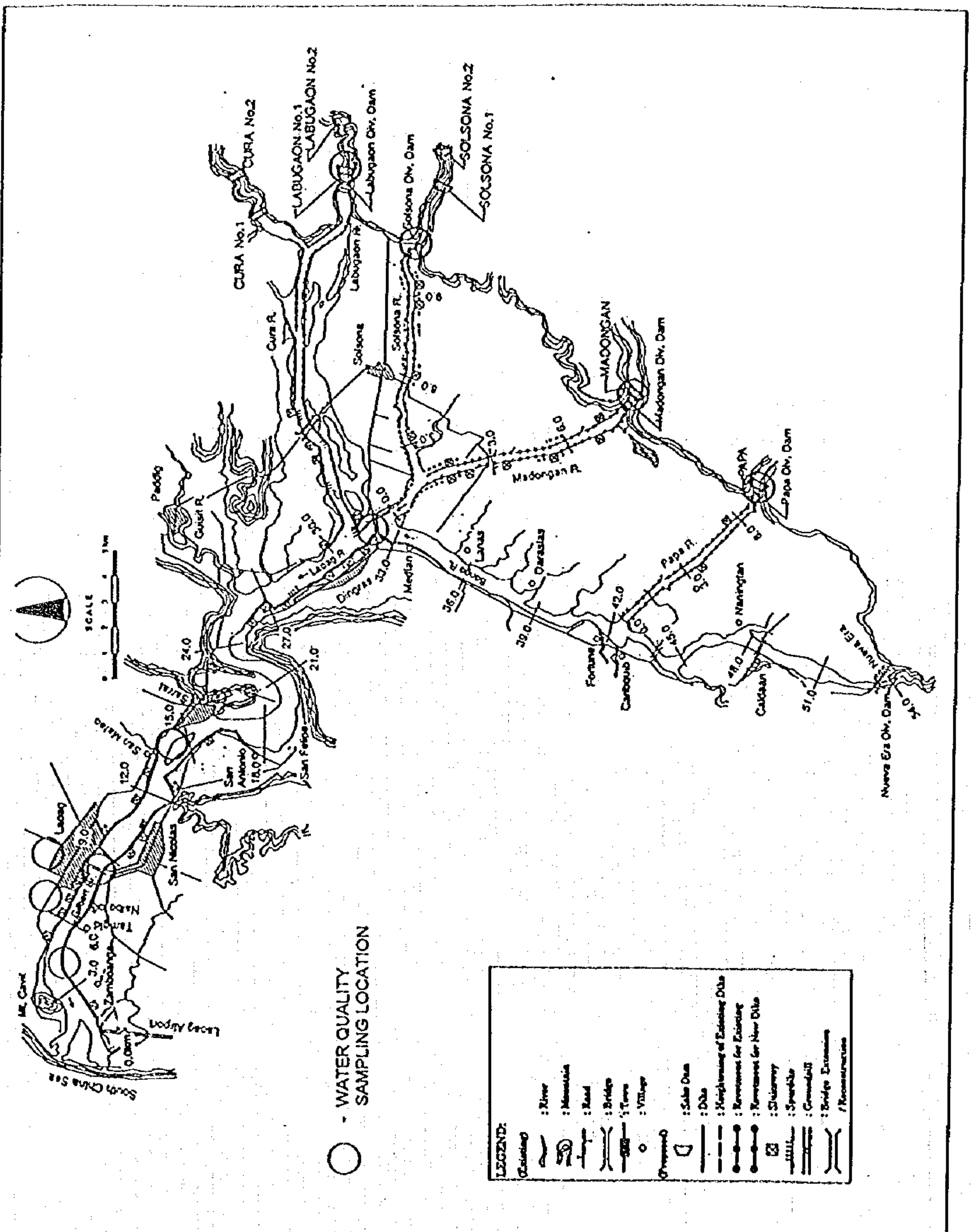
Parameter	Date of Sample Collection		
	February 9, 1997	February 23, 1997	March 9, 1997
pH	8.30	8.43	8.53
Water Temperature, °C	28.5	28.4	8.3
Conductivity,	164	135.7	131.3
Total Phosphorus, mg/L	0.04	0.02	0.13
BOD (5 days, 20°C), mg/L	0.8	1.6	1.0
Total Dissolved Solids, mg/L	152	157	154
Total Suspended Solids, mg/L	1.4	2.4	2.8
Nitrate (NO_3), mg/L	ND	ND	0.20
Oil and Grease, mg/Lq	2.1	2.8	1.1
Dissolved Oxygen, mg/L	10	13.8	10.4
Coliforms, MPN/100mL	3,000	160,000	1,300
Time of Sample Collection	12:05 AM	1:14 PM	1:09PM
Weather	sunny	sunny	sunny

Notes: ND is none detected; Minimum Detection Limits: TSS, mg/L = 1.0; NO_3, mg/L = 0.01; Oil & grease, mg/L = 0.5

Table C.13 Water Quality Criteria for Conventional and Other Pollutants Contributing to Aesthetics And Oxygen Demand for Class A and Class D Waters

PARAMETER	UNIT	CLASS A	CLASS D
pH (range)		6.5-8.5	6.0-9.0
Dissolved Oxygen (Minimum)	mg/L	5	3
5-Day 20°C BOD	mg/L	5	15
Total Suspended Solids	mg/L	50	(a)
Total Dissolved Solids	mg/L	1,000	1000
Oil and Grease (Petroleum Ether Extract)	mg/L	1	5
Nitrate (as N)	mg/L	10	(b)
Phosphate as Phosphorus	mg/L	0.1	(b)
Total Coliform	MPN/100mL	1,000[c]	--

(a) = Not more than 60 mg/L increase
(b) = Extremely low concentration and not detectable by existing equipment
(c) = These values refer to the geometric mean of the most probable number of coliform organism during a 3-month period and that the limit indicated shall not be exceeded in 20 percent of the samples taken during the same period



Source: JICA, 1997

ENVIRONMENTAL IMPACT STATEMENT OF THE SABO AND FLOOD CONTROL PROJECT OF THE LAOAG RIVER BASIN	Figure C.1 LOCATIONS OF WATER QUALITY SAMPLING STATIONS