PART III

FEASIBILITY STUDY

ON

LAOAG CITY URBAN DRAINAGE IMPROVEMENT

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CHAPTER I STUDY AREA

1.1 Drainage Basin

The urban area of Laoag City is located on the right bank of the Laoag River eight (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 drained directly into the Laoag River. Hence, the study area for the Laoag City Urban Drainage Improvement covers the Daorao-Tupec Creek Basin.

The Basin has a total catchment area of 38.79 km^2 with hilly areas accounting for 11.31 km^2 or around 30% of the whole basin. The Basin occupies 36% of the city area of 107.51 km^2 and it is bounded by the two (2) municipalities of Bacarra and Vintar on the north.

The Daorao-Tupec Creek originates from a hilly land with an elevation of approximately 100 m in the north and northeast of the City. The main river course is called Tupec in the upper reaches and Daorao in the middle and lower reaches. The Daorao-Tupec Creek joins the two (2) major tributaries of the San Isidro and Pandan creeks in the middle reaches.

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. The Daorao Creek runs through the northern outskirts of the urban area from east to west and follows a meandering course to the west until 1.5 km upstream from the river mouth. Thereafter, it turns toward the north and, after passing through the sand dune, finally empties into the South China Sea.

The river mouth is usually clogged by sand drifts along the seacoast. The river water flows down toward the north through a small stream along the eastern fringe of the sand dune to the southern outlet of the Bacarra River. However, at a big flood time the river water directly discharges into the sea by flushing the sediment deposits in the river mouth.

The Laoag-Vintar Irrigation Canal diverts irrigation water from the Bacarra-Vintar River Basin to the Daorao-Tupec Creek Basin. It originates from the Vintar Intake located 6 km upstream of Vintar Town and conveys water to the Daorao-Tupec Creek Basin running around the fringe of the hilly land located in the north and northeast of Laoag City. The irrigation canal serving the rice fields developed in the Basin also drains local storm runoff of the urban area.

Salient topographic features of the Basin are shown in Fig. III.1.

1.2 Administration and Population

Laoag City covers a total administrative area of 107.51 km^2 and governs 80 barangays. Among the 80 barangays, 29 barangays are located within the city proper area (urban area) of 10.94 km^2 and the remaining 51 barangays are situated in the rural area of 96.57 km^2.

The Daorao-Tupec Creek Basin with an area of 38.79 km^2 is entirely located within the territory of Laoag City and extends over 50 barangays including 29 barangays in the city proper area as shown in Fig. III.2.

According to the 1995 census, the total population of Laoag City is 88,336 with an average population density of 822 persons/km^2. Out of this total, 40,717 or 46% reside in the city proper area with an average population density of 3,722 persons/km^2.

The total population of the Basin is estimated at 57,883 with an average population density of 1,492 persons/km^2. The population of the city proper area is mostly included in the Basin. The average family size in the Basin is 5 persons/family.

The future population of the City will reach 111,400 in 2020, according to the projection of NEDA. The urban population in 2000 is estimated to be 49,800, by assuming that the same growth trend as that of 1990-1995 will take place in the future. The remaining population of 61,600 is allocated to the rural population. The existing and future populations of the City are compared as shown below.

	1995	2020
Total Population	88,336	111,400
Urban Population	40,717	49,800
Rural Population	47,619	61,600

1.3 Land Use

1.3.1 Existing Land Use

The existing land use of the Basin consists of residential area, tree area, orchard, grassland, paddy field, upland crops area, riverbed and sand dune. The respective land use areas are summarized below.

Classification	Area (ha)	Ratio (%)
Residential Area	431	11.1
Tree Area	1,148	29.6
Orchard	20	0.5
Grass Land	37	1.0
Paddy Field	1,925	49.6
Upland Crops Area	231	6.0
River Bed	32	0.8
Sand Dune	55	1.4
Total	3,879	100.0

The existing land use distribution of the Basin is shown in Fig. III.3.

1.3.2 Future Land Use

According to the land use plan of the City, the commercial zone expansion is planned in a width of 100-200 m along major road networks such as the Manila North National Road, Laoag Airport National Road, Laoag-Paoay National Road and Laoag-Vintar Provincial Road. The industrial zone is planned in the southern area of the City. The residential zone expansion will be located on the north of the existing built-up areas and in the left bank of the Laoag River.

Among the above urban expansions, the more prominent are the commercial zone expansion along the Manila North National Road and Laoag-Vintar Provincial Road, and the residential zone expansion on the north of the existing built-up areas. The future land use distribution of the Basin is shown in Fig. III.4.

However, the urban expansion areas in the vicinity of the Daorao-Tupec Creek are habitually flooded at present. Improvement of the existing drainage system is necessary for the development of commercial and residential lands in these areas.

CHAPTER II EXISTING URBAN DRAINAGE SYSTEM

2.1 General

The urban area of Laoag City is drained by two (2) drainage systems consisting of creeks, drainage mains, secondary drains and tertiary drains. One system drains most of the urban area into the sea through tertiary drains, secondary drains, drainage mains, San Isidro Creek, Tupec Creek and Daorao Creek. Another system discharges the remaining small part directly into the Laoag River through tertiary drains, secondary drains and drainage mains.

2.2 Conditions of Creeks

2.2.1 Morphological Features

Most of the urban storm water of Laoag City is finally drained by San Isidro Creek and Daorao-Tupec Creek. The morphological characteristics of these creeks are described below.

(1) Daorao-Tupec Creek

The Daorao-Tupec Creek is very gentle in slope and very narrow in width. The creek meanders at many locations. No dike is provided along the creek. One (1) control gate is provided at 13.3 km distance from the mouth of the creek to supply irrigation water to rice fields in dry season.

The alignment, slope, width and other features of the creek are shown in Fig. III.5 and summarized below:

Location (km)	Slope of Riverbed	Width (m)	Remarks
0.0 - 1.4	level	33 - 81	sand dune
1.4 - 4.5	level	23 - 38	1 big bend
4.5 - 8.0	1/2300	25 - 38 *	3 bends
8.0 - 10.5	1/2300	11 - 27	2 bends
10.5 - 13.4	1/800	6 - 22	4 bends

Note: * Excluding the width of Casili Bridge (6.68 km from mouth): 14.0 m

(2) San Isidro Creek

Storm and waste waters from the urban residential area are drained mainly by the San Isidro Creek. The creek greatly meanders at the section 0.3 km upstream from the junction with the Daorao Creek. The San Isidro Creek is much affected by the backwater of the Daorao Creek. No dike is provided along the creek.

The alignment, slope, width and other features are shown in Fig. III.6 and summarized below.

Location (km)	Slope of River Bed	Width (m)	Remarks
0.0 - 0.8	1/270	7 - 15	except one section*
0.8 - 1.19	1/270	0.9 - 3.8	
1.19 - 1.48	1/650	1.5	box culvert

Note: * The width at Giron Street: 2.4 m

2.2.2 Flood Carrying Capacity

The existing flood carrying capacities of the two (2) creeks, Daorao-Tupec Creek and San Isidro Creek, were assessed through the non-uniform flow calculation by assuming the

Manning's roughness coefficient is n = 0.035. In this calculation, the flood carrying capacity was assumed as the bankful capacity of channel sections. The flood carrying capacities by channel section are estimated as follows:

(1) Daorao-Tupec Creek

Channel Section (km)	Discharge Capacity (m^3/s) Left Bank	Right Bank	Remarks
0.0 - 1.4	46 - 123	28 - 875	sand dune
1.4 - 2.4	15 - 18	21 - 33	
2.4	114	114	Cataban Bridge
2.4 - 5.3	38 - 112	37 - 66	
5.3	273	273	Pila Bridge
5.3 - 6.68	36 - 44	35 - 52	
6.68	60	60	Casili Bridge
6.68 - 8.0	35 - 55	32 - 34	
8.0	123	123	Daorao Bridge
8.0 - 9.35	15 - 98	20 - 66	
9.35	100	100	San Isidro Bridge
9.35 - 10.97	16 - 100	19 - 69	
10.97	88	88	Bacarra Road
10.97 - 13.43	4 - 27	11 - 36	

(2) San Isidro Creek

Location (km)	Discharge Capacity (m^3/s) Left Bank	Right Bank	Remarks
0.0 - 0.58	16 - 37	14 - 66	excluding bridge*
0.58 - 1.0	2 - 16	2 - 14	
1.0 - 1.48	2 - 3	2 - 3	

Note: * Flood carrying capacity at San Isidro Bridge, 0.2 km, is 138 m^3/s

2.2.3 Mouth Clogging of Daorao Creek

The mouth of Daorao-Tupec Creek is clogged all year round except during big floods. According to the interviews with the residents of Barangay Cataban, the flood water of 1967 Typhoon Gening opened an outlet by flushing sand drift deposits at 1.0 km upstream from the present mouth. During big floods, the residents usually dredge a narrow channel by using hand shovels to accelerate the outlet opening of flush water. The downstream of Daorao Creek is subject to the backwater effect of the small mouth at flood time.

2.3 Division of Urban Drainage Area

The urban drainage system of Laoag City is illustrated in Fig. III.7 and the direction of drainage flow is schematically presented in Fig. III.8. The drainage system is of combined type, and collects the sewage and storm water in all the urban area of the City. The 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 urban drainage area is divided into 11 sub-drainage areas as shown below.

Drainage Area (ha)		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	

Among the above, 404.0 ha (DA-1 to DA-8) or 80% are drained by the Daorao-Tupec Creek system. The remaining area of 97.4 ha (DA-9 to DA-11) or 20% are drained directly into the Laoag River.

The San Isidro Creek shoulders 199 ha (DA-1 to DA-5) or 40% of the total urban drainage area of 501.4 ha, serving a built-up area of 169 ha. The central drainage areas of DA-2 and DA-3 are drained into the San Isidro Creek through two (2) drainage mains after passing under Laoag-Vintar Irrigation Canal by box culvert.

The Laoag-Vintar Irrigation Canal also drains storm water in the urban areas. Storm water in the catchment area of DA-1 flows into the Laoag-Vintar Irrigation Canal through the drainage channels/pipes or rice fields. Excessive flood water over the capacity of the irrigation canal spills over the bank to the San Isidro Creek. According to the interviews with residents, the irrigation canal overflowed at the site of check gate during the 1996 Typhoon Gloring. The check gate controls flood water of the irrigation canal.

The areas of DA-6, DA-7 and DA-8 are drained into the Daorao Creek through the drainage channels/pipes and rice fields.

The existing built-up area of 333.7 ha are mostly covered by the drainage main, secondary drain or tertiary drain. Their structure is open channel or pipe. Their lengths are summarized below.

Drainage Main	Secondary Drain	Tertiary Drain
6.53 km	22.38 km	56.33 km

CHAPTER III FLOOD DAMAGE ANALYSIS

3.1 Flood Damage of 1996 Typhoon Gloring

Laoag City was ravaged by Typhoon Gloring in July 1996. The JICA Study Team conducted a detailed flood damage survey through interviews with the barangay captains and residents. On the other hand, the flood damage data were also obtained from the Office of Civil Defense.

The flood damages of Typhoon Gloring are estimated by combining the data of the above two (2) sources as shown below.

	Laoag City	The Basin		
		City Proper	Rural	Total
(1) Affected (Inundated)				
(a) Person	19,697	7,890	3,369	11,259
(b) Family	4,592	1,860	747	2,607
(c) Dwelling Unit	3,636	1,503	545	2,048
(d) Inundation Area (ha)	NA	336	699	1,035
(e) Industrial Establishment (no.)	300	296	3	299
(f) Educational Facility (no.)	43	34	5	39
(g) Health Facility (no.)	9	6	2	8
(h) Road Length (km)	130	100	26	126
(2) Damage Value (Peso)				
(a) Infrastructure	12,138,340	NA	NA	NA
(b) Industrial Establishment	NA	NA	NA	NA
(c) Agriculture	1,009,132	900	351,064	351,964
(d) Fisheries	59,860	9,000	4,500	13,500
(e) Livestock &Poultry	863,600	0	19,400	19,400

NA: Not Available

For the breakdown by barangay, see the Supporting Report, Chapter III.

Fig. III.9 shows the distribution of inundation area and depth in the Basin. The total inundation area of the Basin is estimated at 1,035 ha, equivalent to 27% of the total land area of the Basin. Among them, the inundation area of the city proper accounts for 336 ha or 62% of the total city proper area of 540 ha.

According to the interview survey, the magnitude of this flood is considered as large as a flood in every 2 to 3 years in the urban areas of the Basin. However, it is the largest since 1992 in the downstream of the Basin.

During Typhoon Gloring, the Laoag River overflowed its right banks at the western fringe of the urban area into the Daorao-Tupec Creek Basin. It further worsened the flooding situation in the downstream areas of Daorao-Tupec Creek. The flood flow route is shown in Fig. III.9.

The higher land in the urban areas suffered from scattered local floods. However, the low-lying areas along the San Isidro Creek were seriously inundated. The duration of inundation in these areas was around six (6) hours. The inundation in the downstream of the Daorao Creek lasted about 12 hours.

3.2 Flood Damage Analysis

3.2.1 Cause of Flooding

Severe floods of the Basin are usually caused by heavy rainfall brought by typhoon. Rainfall except those caused by typhoon bring about only small local floods in some limited urban areas.

The flooded area of the Basin is divided into four (4) districts as shown below (see, Fig. III.10).

Districts	Main Causes of Flood Damage	Remarks
City Proper I	- Overflow from Laoag River	
City Proper II	- Poor flow capacity of San Isidro Creek - Backwater of Daorao Creek	San Isidro Creek Basin
City Proper III	- Poor flow capacity of Daorao-Tupec Creek - Backwater of Daorao Creek	
Rural Area	- Overflow from Laoag River - Mouth clogging of Daorao Creek - Poor flow capacity of Daorao Creek	

3.2.2 Effects of Laoag River Overflow and Daorao Creek Mouth Clogging

The downstream of the Daorao Creek was widely and deeply inundated by Typhoon Gloring, as shown in Fig. III.11. This severe inundation was caused by the lack of flood carrying capacity of the Daorao Creek, overflow of the Laoag River and mouth clogging of the Daorao Creek. The total inundation area and volume are estimated to be 676 ha and 5.46 million m^3, respectively.

On the other hand, the overflow of the Laoag River will be prevented by the flood protection dikes proposed in the Feasibility Study for the Sabo and Flood Control in the Laoag River Basin. Further, the creek mouth may be easily opened prior to the coming of flood by some small maintenance works because the required opening length is minimal.

The total inundation volume will be reduced to 1.71 million m^3 by the above flood protection dikes and creek mouth opening. As a result, the total inundation area will be decreased to 265 ha. The duration of flood of more than 50 cm in depth will be shortened from 12 hours to 4-5 hours. The mitigated flooding conditions are also shown in Fig. III.11. The inundation area by inundation depth with/without project are summarized below.

Inundation Depth (m)	0-0.5	0.5-1.0	1.0-2.0	Total
Without Project (ha)	291	224	161	676
With Project (ha)	150	111	4	265

Note: Project includes flood protection dikes of Laoag River and mouth opening of Daorao Creek.

3.2.3 Distribution of Flood Damage

The flood damages of Typhoon Gloring by district in the Basin are roughly estimated as follows.

(thousand pesos)

Property Item	City Proper I	City Proper II	City Proper III	Rural Area
Residential	1,139	1,960	193	597
Commercial/Industrial	4,566	27,289	436	217
Hospital	400	600	200	600
Education	944	3,505	134	1,079
Agriculture/Fisheries	10	0	0	375
Total	7,059 (16.0%)	33,354 (75.3%)	963 (2.2%)	2,868 (6.5%)
Grand Total	44,244 (100%)			

The above flood damages include those caused by the overflow of the Laoag River and mouth clogging of the Daorao Creek. The above flood damages will be reduced as follows if the construction of the flood protection dikes of Laoag River and the maintenance works for the mouth opening of Daorao Creek are realized.

(thousand peso)

City Proper I	City Proper II	City Proper III	Rural Area
10 (0.1%)	33,354 (94.5%)	963 (2.7%)	956 (2.7%)
Total		35,283 (100%)	

After the improvement of Laoag River and the establishment of a maintenance system for the mouth of Daorao Creek, flood damage will concentrate on the City Proper II which is drained by the San Isidro Creek.

CHAPTER IV URBAN DRAINAGE IMPROVEMENT

4.1 Target Area of Project

The San Isidro Creek Basin is selected as the target area for the urgent urban drainage improvement of Laoag City, based on the flood damage analysis in the previous chapter. The objective catchment area is 1.99 km^2.

The northeastern area of 0.83 km^2 adjacent to the San Isidro Creek is expected to be developed for residential use in the future. Drainage improvement of this area will become necessary.

For the urban drainage of the above target areas, the improvement of the following creeks and drainage mains will be necessary:

(1) San Isidro Creek

(2) Upstream of Daorao Creek having backwater effects on the San Isidro Creek and new residential area

(3) Two (2) drainage mains, DM1 and DM2, connected to the San Isidro Creek

(4) Drainage main (DM3) to drain the new residential area

Locations of the above target areas are shown in Fig. III.12.

4.2 Design Flood Discharge

4.2.1 Design Flood Probability

The design flood probability of the Laoag City Urban Drainage Improvement is determined by referring to similar projects in the Philippines. The proposed design flood probability should cover the flood probability of Typhoon Gloring in 1996.

(1) The Study on the Flood Control for Rivers in Selected Urban Centers by JICA in 1994 prepared a number of urban drainage improvement plans in four (4) regional cities. In the study, a 5-year return period was applied for drainage systems with an area of more than 0.5 km^2, while a 3-year return period was adopted for drainage systems covering an area of less than 0.5 km^2. These are summarized below.

City	Drainage Area (km^2)	Return Period	Population (thousand)
Cebu	0.65 - 2.78	5-year	662
Iloilo	0.50 - 8.02	5-year	335
Tacloban	1.21 - 5.12	5-year	167
	0.14	3-year	
Ormoc	1.03	5-year	144
	0.32	3-year	

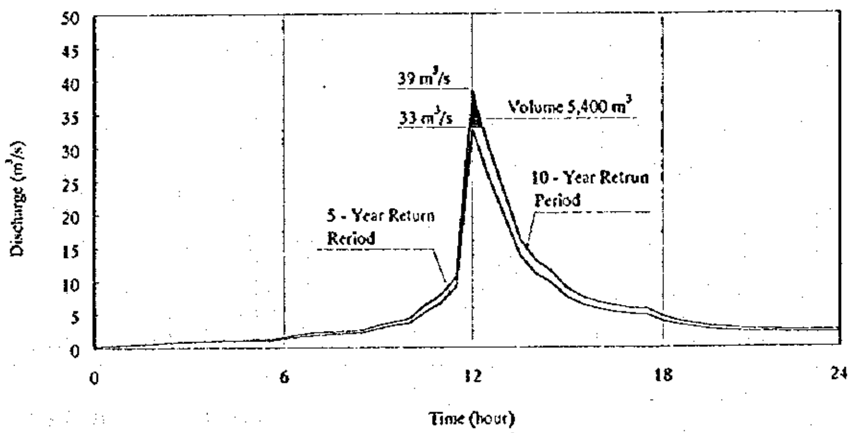
Source: National Statistics Office, 1995 Population Census

The drainage system in Metro Manila has been improved by two (2) criteria of design flood probability as follows.

Project Area	Return Period
Central Metro Manila	10-year
West of Mangahan Floodway	5-year

(2) The rainfall intensity of Typhoon Gloring during a short period was not so deep, although it brought about a large total rainfall over the Laoag River Basin. The flood concentration time of this urban drainage project area is estimated to be 0.5-1.0 hour. The observed maximum half-hour and one-hour rainfall at Laoag City during Typhoon Gloring were 30 mm and 55 mm, respectively. These rainfalls are equivalent to around a 2-year return period. Therefore, the flood probability of Typhoon Gloring in the project area is considered to have been a 2-year return period.

(3) From the above, the design flood return period of 5-year or 10-year is applicable for the drainage improvement of San Isidro Creek Basin (1.99 km^2) and the new residential area (0.83 km^2). The typical flood hydrographs of 5-year and 10-year return periods in San Isidro Creek are compared as shown below.



As shown in the above figure, if the San Isidro Creek is improved for a 5-year flood, it will be able to discharge safely most of the 10-year flood. The total inundation volume of a 10-year flood in the project area is estimated to be only 5,4000 m^3. The average inundation depth for the potential flood area (approximately 100 ha) in the project area is less than 1.0 cm. The drainage improvement by the 10-year design flood will produce no significant additional benefit although it increases the required channel capacity by 20%.

Hence, the design flood frequency of 5-year is applied for the drainage improvement of San Isidro Creek Basin and the new residential area.

4.2.2 Design Rainfall

The rainfall intensity-duration-frequency curves at Laoag City were prepared by PAGASA in 1996, based on the rainfall records during 40 years from 1955 to 1995. The rainfall intensity-duration curve of 5-year frequency is summarized below.

Duration	Intensity (mm)	Duration	Intensity (mm)	Duration	Intensity (mm)
5 min.	20.3	45 min.	74.9	150 min.	142.8
10 min	31.0	60 min.	84.8	3 hrs.	157.5
15 min.	40.4	80 min.	101.1	6 hrs.	209.3
20 min.	48.5	100 min.	114.2	12 hrs.	267.1
30 min.	62.0	120 min	125.1	24 hrs.	314.7

A model hyetograph of central concentration type with a 5-year return period is prepared by using the above rainfall intensity -duration curve. In preparation of the model hyetograph, the time interval of rainfall distribution is set at 30 minutes considering the fact that flood concentration time of the San Isidro Creek Basin and new residential area are 36 and 30 minutes, respectively.

The proposed model hyetograph with a 5-year return period is shown in Fig. III.13.

The above model hyetograph is a point rainfall. The basin average rainfall of the Daorao-Tupec Creek Basin is calculated by multiplying an aerial conversion factor. The factor is assumed to be 0.83 based on the Horton's Formula.

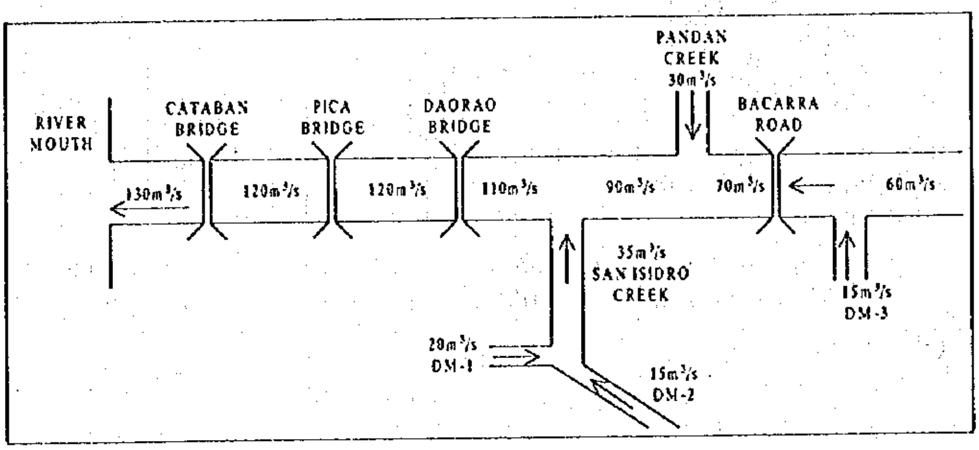
4.2.3 Flood Runoff Simulation

The Storage Function Method is employed for the flood runoff simulation of the Daorao-Tupec Creek Basin. The Basin is divided into 10 sub-basins and the Creek is also divided into six (6) sections to construct the flood runoff simulation model. The model of river system for the flood runoff simulation is shown in Fig. III.14.

The simulation model was constructed by calibrating it based on the rainfall and discharge (estimated from the trace of peak flood water level) of Typhoon Gloring.

4.2.4 Design Flood Discharge Distribution

The design flood discharge is obtained by putting the model hyetograph of basin average into the simulation model. The computed design flood discharge at the respective creek sections are shown below.



4.3 Master Plan of Urban Drainage Improvement

4.3.1 Alignment, Longitudinal Profile and Cross Section of Channel

(1) Alignment

The upper Daorao Creek and San Isidro Creek will be improved along the existing channel courses except two (2) heavily meandered sections.

The existing course of the upper Daorao Creek heavily meanders around the confluence with the San Isidro Creek (lower meander) and around the junction with the Pandan Creek (upper meander). These meandered channel sections will be cut off to secure a smooth flood flow confluence of the main channel and tributaries as shown in Fig. III.15.

The cutoff of the lower meander will shorten the channel length from 290 m to150 m and that of the upper one will reduce the channel distance from 330 m to 70 m.

The proposed alignment of the Daorao Creek, San Isidro Creek and drainage mains (DM1, DM2, DM3) are shown in Fig. III.16.

(2) Longitudinal Profile

The dotted line in Fig. III.17 shows the water level of the design flood in the existing Daorao and San Isidro Creeks. As evident from the figure, the urban area of Laoag City is much affected by the backwater of the Daorao Creek. Hence, dredging of the Daorao Creek is essentially necessary along with that of the San Isidro Creek to lower the water level of the San Isidro Creek. Further, the bottlenecks at bridges such as Daorao Bridge, Vira Bridge, San Isidro Bridge, Giron Bridge, etc., need to be removed.

The dredging of the Creek is proposed for 1.8 km distance starting from DA 9.0 km. The channel bed profile is designed so that the high water level will not exceed the ground elevation of the urban areas along the San Isidro Creek as shown in Fig. III.17.

The channel beds of the drainage mains DM1 and DM2 are also to be deepened to lower the design high water levels below the ground elevations along the drainage mains.

On the other hand, the design channel bed of the Daorao Creek for the upstream reaches from the confluence of the San Isidro Creek is set along the existing bed elevation to minimize channel dredging as shown in Fig. III.18(1). As a result, the design high water level will exceed the ground elevation in some lower part of the residential expansion area. Some embankment works may be required for this channel section in the future.

The channel bed of the drainage main DM3 is designed so that the high water level will not exceed the ground elevation of the residential expansion area along the drainage main.

The proposed longitudinal profile of the Daorao Creek, San Isidro Creek and drainage mains (DM1, DM2, DM3) are shown in Fig. III.18(1) to Fig. III.18(3).

(3) Cross Section

The channel beds of the Daorao, San Isidro, DM1, DM2 and DM3 are all to be deepened and widened to carry the design flood discharge below the design high water level determined above.

Single cross section of trapezoidal shape is proposed for all the channel sections as a standard. Steep bank slope with revetment is applied for the residential areas, while gentle slope with no protection is applied for the farmland areas.

The proposed standard cross sections of the Daorao Creek, San Isidro Creek and drainage mains (DM1, DM2, DM3) are shown in Fig. III.19.

In designing the above channel improvements, the flood water level was calculated by non-uniform flow analysis, assuming Manning's roughness coefficient as follows:

Channel Type	Roughness Coefficient
Existing (both bed and bank slope unlined)	0.035
Improved (bed unlined but bank slope lined)	0.030
Improved (both bed and bank slope lined)	0.025

4.3.2 Mouth Opening of Daorao Creek

The mouth of the Daorao Creek must be excavated prior to the onset of a typhoon. The required mouth opening volume is estimated to be 900 m^3 (length: 30 m, width: 20 m, depth: 1.5 m) every time. A set of backhoe (0.6 m^3) and bulldozer (15 ton) will be provided for this maintenance work.

4.3.3 Environmental Consideration

The existing drainage channels collect not only storm water but also wastewater. In dry season, the stagnant wastewater in the open channels affects the environment of the built-up areas, emitting foul odor. Sewer pipes to intercept the wastewater and transfer it downstream will be provided on the back of the proposed revetment of the San Isidro Creek and the drainage mains (DM1, DM2) to improve the environment of built-up areas.

4.3.4 Proposed Improvement Plan

The master plan of the urban drainage improvement was prepared in consideration of the future land use plan. It consists of the improvement of the Daorao Creek, San Isidro Creek and drainage mains (DM1, DM2, DM3). The proposed alignments, longitudinal profiles and standard cross sections are shown in Fig. III.16, Figs. III.18(1) to III.18(3) and Fig. III.19.

Further, the river mouth opening of the Daorao Creek and interceptor construction along the San Isidro Creek and drainage mains (DM1, DM2) are included.

The proposed improvement works are summarized as follows. For details of the improvement/reconstruction of the bridges and culverts, see Supporting Report, Chapter IV.

Item	Quantity	Contents
Daorao Creek		
Earth Work	1,800 m	Excavation and embankment (DA9.00 - DA10.80)
Revetment	1,060 m	Left bank (DA9.74 - DA10.80) Bank slope lining, 1 : 1.5, wet masonry type
Bridge Work	3 sites	Improvement of Daorao Br. and reconstruction of Vira Br. and Tupec Br.
Sluice	1 site	Placing under the proposed embankment
Mouth Opening	1 set	Procurement of one (1) set of backhoe (0.6 m3) and bulldozer (15 ton)
San Isidro Creek		
Earth Work	930 m	Excavation and filling (SA0.00 - SA0.93)
Revetment	1,740 m	Bank slope lining, 1 : 1.5, wet masonry type (SA0.06-SA0.93)
Bridge Work	3 sites	Reconstruction of San Isidro Br., a pedestrian Br., and Giron Street Br.
Drainage Main: DM1		
Earth Work	140 m	Excavation and filling (DM1-0.00 - DM1-0.14)
Revetment	280 m	Bank slope lining, 1 : 0.5, wet masonry type; bed lining
Box Culvert Work	1 site	Reconstruction of culvert under irrigation canal
Drop Work	1 site	Approach to the Bengang Creek
Drainage Main: DM2		
Earth Work	440 m	Excavation and filling (DM2-0.00 - DM2-0.44)
Revetment	880 m	Bank slope lining, 1 : 0.5, wet masonry type; bed linin
Box Culvert Work	4 sites	Reconstruction of culverts under 4 streets
Drainage Main: DM3		
Earth Work	700 m	Excavation and filling (DM3-0.00 - DM3-0.70)
Revetment	1,400 m	Bank slope lining, 1 : 0.5, wet masonry type; bed lining
Box Culvert Work	1 site	Reconstruction of a culvert under one street
Wastewater Interceptor	2,550 m	Placing of wastewater pipe along the improved channel

4.3.5 Estimated Cost

The total project cost of the master plan is estimated at 191 million pesos at June 1997 prices with the following breakdown. For details, see Supporting Report, Chapter IV.

Work Items	Quantity	Amount (million peso)
1. Construction Cost		135.65
1.1 Preparatory Works (10% of 1.2 and 1.3)		12.33
1.2 Main Works		112.11
(1) Earth Work		19.61
Excavation	158,746 m^3	18.26
Embankment/Filling	15,919 m^3	1.35
(2) Revetment Work	5,420 m	41.29
(3) Bridge and Culvert Work		40.62
Bridge	6 sites	36.50
Box Culvert	6 sites	4.12
(4) Others		10.59
Drop	1 site	0.22
Sluice	1 site	0.25
Wastewater Interceptor	2,550 m	5.02
Mouth Opening	LS	5.10
1.3 Miscellaneous Works (10% of 1.2)		11.21
2. Compensation Cost		12.05
2.1 Land Acquisition	5.65 ha	11.60
2.2 House Resettlement	3 houses	0.45
3. Administration Cost (3% of 1 and 2)	LS	4.43
4. Engineering Service Cost (16% of 1)	LS	21.70
5. Physical Contingency (10% of 1, 2, 3 and 4)	LS	17.39
Total		191.22

4.4 Urgent Plan of Urban Drainage Improvement

4.4.1 Improvement Plan

The urgent urban drainage improvement works necessary to meet the flood problems in the existing built-up areas are selected from the master plan. The plan includes the improvement of part of Daorao Creek, almost the whole San Isidro Creek and the whole drainage mains DM1 and DM2. The mouth opening of the Daorao Creek is also necessary to attain the full efficiency of the urgent urban drainage improvement. Further, the wastewater interceptor will be constructed together with the revetment works of San Isidro Creek and drainage mains (DM1, DM2).

The alignment, longitudinal profiles and standard cross sections of the proposed urgent urban drainage improvement of the Daorao Creek, San Isidro Creek and drainage mains (DM1, DM2) are shown in Fig. III.20, Figs. III.21(1) to III.21(2) and Fig. III.22.

The proposed urgent drainage improvement works are summarized below.

Item	Quantity	Contents
Daorao Creek		
Earth Work	900 m	Excavation (DA9.00 - DA9.90)
Bridge Work	2 sites	Improvement of Daorao Br. and reconstruction of Vira Br.
Mouth Opening		Acquisition of one set of backhoe (0.6 m^3) and bulldozer (15-ton)
San Isidro Creek		
Earth Work	360 m	Excavation (SA0.00 - SA0.36)
Earth Work	570 m	Excavation and filling (SA0.36 - SA0.93)
Revetment	1,140 m	Bank slope lining, 1 : 1.5, wet masonry type (SA0.36 - SA0.93)
Bridge Work	3 sites	Reconstruction of San Isidro Br., a pedestrian Br., and Giron Street Br.
Drainage Main: DM1		
Earth Work	140 m	Excavation and filling (DM1-0.00 - DM1-0.14)
Revetment	280 m	Bank slope lining, 1 : 0.5, wet masonry type; bed lining
Box Culvert Work	1 site	Reconstruction of culvert under irrigation canal
Drop Work	1 site	Approach to the Bengang Creek
Drainage Main: DM2		
Earth Work	440 m	Excavation and filling (DM2-0.00 - DM2-0.44)
Revetment	880 m	Bank slope lining, 1 : 0.5, wet masonry type; bed lining
Box Culvert Work	4 sites	Reconstruction of culverts under 4 streets
Wastewater Pipe	2,550 m	Placing of waste water pipe along the improved channel

4.4.2 Structural Design

(1) Bank Slope Protection Works

The bank slope of channel is covered with revetment to prevent bank erosion. Two (2) types of bank protection works are proposed as shown in Fig. III.23. Type-RA is applied for the San Isidro Creek where the design channel depth is large and comparatively wider channel lands are available.

Type-RB is adopted for the drainage mains (DM1, DM2) where the design channel depth is small and available channel lands are limited.

For location of the bank protection works, see Fig. III.20.

(2) Bridge

The existing two (2) bridges (Daorao Br., Vira Br.) in the Daorao Creek and three (3) bridges (San Isidro Br., Pedestrian Br., Giron Br.) in the San Isidro Creek need to be improved or reconstructed to carry the design flood of the channels safely.

The carrying capacity at the Daorao Bridge site will be increased by reconstructing the abutments and by deepening the foundation of the piers. On the other hand, all the other bridges are to be reconstructed to extend their bridge length.

Salient features of the existing and proposed bridges are shown below. For location of the bridges, see Fig. III.20. The standard structural design of the proposed bridges are shown in Fig. III.24.

No.	Name	Existing			Proposed		
		Width (m)	Length (m, span)	Type	Width (m)	Length (m, span)	Type
Br.1	Daorao	5.0	39.5, 3 spans	RC	5.0	39.5, 3 spans	RC
Br.2	Vira	5.0	15.0, 1 span	RC	5.0	38.2, 1 span	PC
Br.3	San Isidro	8.5	12.5, 1 span	RC	8.5	29.7, 1 span	PC
Br.4	Pedestrian	2.0	14.5, 1 span	Steel	2.0	24.5, 1 span	PC
Br.5	Giron	7.5	2.5, 1 span	Culvert	7.5	23.3, 1 span	PC

(2) Box Culvert

The existing five (5) box culverts in the drainage mains (DM1, DM2) are also to be reconstructed to meet the design flood discharge of the drainage mains. Salient features of the existing and proposed culverts are compared as shown below. For location of the box culverts, see Fig. III.20.

No.	Crossing Structure	Existing			Proposed		
		Width (m)	Height (m)	Nos. of Box	Width (m)	Height (m)	No. of Box
Box 1	Irrigation Canal	4.0	1.2	1	5.0	2.8	1
Box 2	Mackinley Street	2.5	1.4	1	5.2	2.7	1
Box 3	V. Lagasca Street	2.0	1.9	1	5.1	2.6	1
Box 4	A.Castro Street	1.5	1.0	1	5.0	2.5	1
Box 4	Bacarra Road	3.0	0.5	1	5.0	2.5	1

CHAPTER V COST ESTIMATE OF URGENT PLAN

5.1 Construction Work Volume

The construction works are summarized as follows:

Work Items	Quantity
1. Construction Main Works	
(1) Earth Work	
Excavation	98,000 m^3
Filling	8,000 m^3
(2) Revetment Work	2,300 m
(3) Bridge and Culvert Work	
Bridge	5 sites
Box Culvert	5 sites
(4) Others	
Drop	1 site
Wastewater Pipe	2,550 m
Mouth Opening (backhoe and bulldozer)	1 set
2. Compensation	
(1) Land Acquisition	2.71 ha
Farmland/Open Space	2.70 ha
Residential Land	0.01 ha
(2) House Resettlement	None

5.2 Construction Plan and Schedule

Channel improvement works are generally executed from the downstream to the upstream. However, some channel improvement works in the upstream may be executed ahead, provided that the works will not bring about a large imbalance in flow capacity between the upper and downstream stretches.

The whole filling works will be conducted using selected excavation soils. Therefore, the dumping volume of the excavated soils is estimated as follows:

(1) Excavation Volume	98,000 m^3
(2) Filling Volume	8,000 m^3
(3) Dumping Volume : (1) - (2)	90,000 m^3

A land of 4.5 ha is required to dump 90,000 m^3 by assuming the filling height is 2 m. The following three (3) potential dumping sites were identified near the construction site.

Dumping Site		Existing Land Use	Distance*
Site-A	1.28 ha	Farmland / open space in residential area	0 km
Site-B	5.60 ha	Farmland in future residential expansion area	1 km
Site-C	3.83 ha	Garbage disposal area / open space	2 km

* Average distance from construction site

The soil dumping of 90,000 m^3 is assumed to be distributed to the above sites. This dumping will disturb the existing land use. On the other hand, it will contribute to the development of residential land. The location of these sites are shown in Fig. III.25.

All the construction works will be completed within two (2) years. The channel improvement works and culvert construction will be completed within one (1) year. The overall construction schedule is shown in Fig. III.26.

5.3 Cost Estimation Criteria

The project cost is estimated based on the following assumptions and conditions.

(1) Constitution of Project Cost

The project cost is composed of construction cost, compensation cost, administration cost, engineering service cost and physical contingency cost. The construction cost includes preparatory works, main works and miscellaneous works. The compensation cost includes land acquisition cost and house resettlement cost.

(2) Price Level

Price level is as of June, 1997.

(3) Currency Conversion Rate

Currency conversion rates among US Dollar (US$), Philippine Peso (₱) and Japanese Yen (¥) are as follows.

US$1.00 = ₱26.00 = ¥115.00

(4) Currency of Cost Estimate

The construction cost is estimated in foreign currency and local currency. Their portions by cost item are assumed as follows.

Items	Foreign	Local
1. Materials		
Cement	0.7	0.3
Re-bar	0.8	0.2
Soil, Sand, Gravel, Boulder	0.4	0.6
Fuel, Lubricant	0.7	0.3
2. Construction Equipment	0.7	0.3
3. Labor	0.0	1.0
4. Compensation Cost	0.0	1.0
5. Administration Cost	0.0	1.0
6. Engineering Cost	0.9	0.1

(5) Construction Cost

Construction cost consists of labor rate, materials cost and equipment cost.

(6) Compensation Cost

Compensation cost is estimated based on actual records in the past, land/house tax and market prices.

(7) Government Administration Cost

The cost of project management or administration by the government is assumed at 3% of the construction cost and compensation cost.

(8) Engineering Services Cost

Detailed design and construction supervision are to be carried out by an engineering consultant. The cost of engineering services adopted is 16 % of the construction cost.

(9) Physical Contingency

Physical contingency is estimated to be 10% of the foreign and local costs.

(10) Price Contingency

Price escalation rate is assumed to be 7% per annum for local currency and at 2.0% per annum for foreign currency.

(11) Value Added Tax

Value added tax is estimated to be 10% and it is included in the construction cost, except direct foreign currency.

5.4 Project Cost

The total project cost is estimated at 118.0 million pesos at 1997 prices and 134.8 million pesos including price contingency. These are broken down by work item and currency portion as follows. For details, see Table III.1.

Description	Quantity	Amount (million peso)		
		Foreign Currency	Local Currency	Total
1. Construction Cost		44.54	41.48	86.02
1.1 Preparatory Works (10% of 1.2 and 1.3)		4.05	3.77	7.82
1.2 Main Works		36.81	34.28	71.09
(1) Earth Works		7.65	4.24	11.89
Excavation	98,000 m^3	7.20	4.02	11.22
Filling	8,000 m^3	0.45	0.22	0.67
(2) Revetment Works	2,300 m	3.23	13.24	16.47
(3) Bridge and Culvert		18.13	14.26	32.39
Bridge	5 sites	16.00	12.58	28.58
Culvert	5 sites	2.13	1.68	3.81
(4) Other Works		7.80	2.54	10.34
Drop	1 site	0.18	0.04	0.22
Wastewater Interceptor	2,550 m	3.78	1.24	5.02
Mouth Opening	1 site	3.84	1.26	5.10
1.3 Miscellaneous Works (10% of 1.2)		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
6. Total (1+2+3+4+5)		62.22	55.75	117.97
7. Price Contingency		3.98	12.83	16.81
8. Grand Total (6+7)		66.20	68.58	134.78

5.5 Disbursement Schedule

The annual disbursement schedule of the urgent project is summarized as follows. For details, see Table III.2.

(Unit: million pesos)

Year	Foreign Currency Portion	Local Currency Portion	Total
1999	8.17 (8.50)	7.13 (8.16)	15.30 (16.66)
2000	39.47 (41.89)	37.28 (45.67)	76.75 (87.56)
2001	14.98 (16.21)	10.95 (14.36)	25.93 (30.57)

Note: Costs not in parentheses are at 1997 prices, while costs in parentheses include price contingency.

5.6 Operation and Maintenance

The total annual operation and maintenance cost of the project is assumed to be 0.5% of the construction cost. It amounts to 0.43 million pesos after the project is completed in 2001.

CHAPTER VI PROJECT EVALUATION OF URGENT PLAN

6.1 Project Benefit

The proposed urgent project will reduce the existing flood damage in the urbanized San Isidro Creek Basin. The flood mitigation benefits in financial terms under the existing socio-economic conditions are discussed below.

6.1.1 General

The existing flood damage consists of direct damage and indirect damage. Direct damages include the damage on the following properties. However, there is no substantial agricultural production damage.

(1) Housing units and their household effects.

(2) Commercial establishments and factories including buildings, machinery, equipment and inventory stocks.

(3) Social infrastructures including educational and medical facilities, and physical infrastructures including roads, water supply, electricity, telephone and irrigation facilities.

Indirect damages comprise the costs for the following activities.

(1) opportunity losses of business and production activity
(2) emergency activities
(3) medical care and cure for flood victims
(4) preventive activities against crimes

The direct damages except for physical infrastructures are estimated as a product of the number of facilities inundated by flood in an affected area, the economic value of inundated property and damage rate in accordance with inundated depth. The physical infrastructure damage is assumed to be 20% of the above direct damages, referring to similar projects in the Philippines.

The indirect damage is assumed to be 10% of the above direct damages.

6.1.2 Flood Damage Estimation

(1) Inundated Property by Flood Return Period

The project is planned to meet the design flood with a 5-year return period. Hence, the possible inundation area and inundated number of property by the design flood was estimated by flood simulation. On the other hand, the Typhoon Gloring in 1996 is assumed to be a flood of 2-year return period, based on the probability analysis of the rainfall records at the Laoag Station. Hence, the actual inundated area and inundated number of property at that time are regarded as the possible inundation area and inundated number of property by a 2-year flood.

From the above, the possible inundation area and inundated number of property by floods with 2 and 5-year return periods are summarized below.

Return Period	2-year	5-year
1. Inundated Area (ha)	109	122
2. Affected Population	4,475	5,265
3. Inundated Property (No.)	1,175	1,354
Housing Units	895	1,040
Commercial/Factory	251	280
Educational Facility	26	30
Hospital/Health Facility	3	4

(2) Estimated Flood Damage

The present unit values of the damageable properties in financial terms are assumed as follows.

(Unit: peso/unit)

Property	Durable Assets	Movable Assets	Total
Housing Unit	126,000	38,000	164,000
Commercial/Industrial	448,000	210,000	658,000
Education Facilities	569,000	250,000	819,000
Hospital/Health Facilities	680,000	600,000	1,280,000

The flood damage is estimated by multiplying the quantity of the damageable property by its unit value and damage rate. For the damage rate, refer to the Master Plan Study, Supporting Report, Appendix C.

The flood damage by item in the inundation area corresponding to each flood return period under the present socio-economic conditions are estimated as follows.

(Unit: million pesos)

Return Period	2-year	5-year
1. Direct Damage	39.3	53.8
Housing Units	1.7	3.3
Commercial/Factory	26.9	36.1
Infrastructure	10.6	14.4
2. Indirect Damage	3.9	5.4
3. Total	43.2	59.2

For details, see Supporting Report Chapter VI.

6.1.3 Annual Flood Mitigation Benefit

The average annual flood damage is calculated by using the following formula.

$$D = \sum 1/2[D(Qi\text{-}1) + D(Qi)]\cdot[P(Qi\text{-}1) - P(Qi)]$$

where;

D	:	average annual flood damage
D(Qi-1), D(Qi)	:	flood damage caused by flood with Qi-1 and Qi discharge, respectively
P(Qi-1), P(Qi)	:	probabilities of occurrence of Qi-1 and Qi discharge, respectively

The average annual flood damage of the project area under the present socio-economic situation for the floods below 5-year return period is estimated to be 21.8 million pesos.

The project is planned to meet the design flood with a 5-year return period. Therefore, the project will produce an annual flood mitigation benefit of 26.2 million pesos in financial terms under the existing socio-economic situation.

6.2 Economic Evaluation

6.2.1 Basic Conditions of Economic Evaluation

(1) The economic viability of the proposed project is checked by calculating its economical internal rate of return (EIRR). Besides EIRR, net present value (NPV) and cost-benefit ratio (B/C) are presented as supplementary indices, for which costs and benefits are discounted at 15% per annum.

(2) In economic evaluation, the values of costs and benefits must be counted in real economic value. Economic costs and benefits are different from financial ones because the former is evaluated at real resource cost, while the latter is resource cost evaluated at market price. Therefore, the financial costs and benefits of the project are converted to the economic ones by using conversion factors.

The conversion factors for material cost, machinery/equipment rental cost, labor cost, indirect cost, government expenditure and engineering cost are calculated by applying shadow wage rate, shadow exchange rate, and by eliminating national and local taxes. They are shown below.

Item	Local Portion	Foreign Portion
1. Materials		
Cement	0.53	1.04
Aggregate	0.68	1.06
Steel	0.24	1.06
Fuel/Lubricant	0.05	1.21
Lumber	0.80	1.04
Others	0.72	1.05
2. Machinery/Equipment Rental	0.26	1.11
3. Labor		
Skilled	0.93	-
Unskilled	0.60	-
4. Indirect Cost		
Overhead, Miscellaneous	0.86	-
Profit	0.65	-
5. Government Expenditure	0.95	-
6. Engineering Services	-	1.22

These conversion factors will be used in the calculation of the economic project costs and the economic values of the damageable properties and facilities.

(3) The value of the land to be used for the project is evaluated through crop production lost by the land acquisition as negative benefit.

(4) Economic life is 50 years.

(5) The basic price level for estimates is set at June, 1997. The prevailing exchange rate is set at US$1.00 = 26 Pesos = 115 Yen. The shadow exchange rate is assumed to be 1.20 times of the prevailing market rate.

(6) The economic benefits of the project are estimated for the present and future socio-economic conditions. The benefits are assumed to increase in the future in proportion to the increase of the flood damage potential. The flood damage potential is further assumed to increase in proportion to the growth of the population and GRDP. The average annual growth rates of the population and GRDP of the project area are assumed as follows.

(a) Population: 0.93% up to 2020

(b) GRDP: 6.2% up to 2000, 4.65% for 2000 to 2010 and 3.1% for 2010 to 2020

6.2.2 Economic Benefit

(1) Flood Mitigation Benefit

The flood mitigation benefits were estimated in financial terms in Section 6.1. These benefits are converted into real economic values by applying the above-mentioned conversion factors. The integrated conversion factor of the damageable properties of housing unit, commercial/industrial, education facilities and hospital/health facilities is in the range of 0.82 and 0.84, averaging 0.83. Hence, the economic values of the above damageable properties are estimated by using the conversion factor of 0.83.

The existing unit values of the damageable properties in economic terms are estimated as follows.

(Unit: Peso/unit)

Property	Durable Assets	Movable Assets	Total
Housing Unit	104,600	31,500	136,100
Commercial/Industrial	376,300	176,400	552,700
Education Facilities	472,300	207,500	679,800
Hospital/Health Facilities	571,200	504,000	1,075,200

For the estimation of conversion factors for damageable properties, see the Feasibility Study for the Laoag River Sabo and Flood Control, Appendix E.

The average annual flood mitigation benefit by the proposed project in economic terms is estimated in the same way as the financial one. The benefits are assumed to accrue in proportion to the progress of the construction works. The full benefits will accrue immediately after the completion of the entire works. The full annual benefit of the project under the present socio-economic situation is estimated to be 21.8 million pesos and it is expected to accrue in 2002.

The benefits under the future socio-economic condition are expected to increase in proportion to the economic growth and population expansion in the project area although they are assumed to keep constant after the target year of 2020.

(2) Negative Benefit

Some farmlands will be appropriated for the sites of river channel and related works. The crop production in these areas will diminish as a negative benefit. The total annual negative benefit of the project under the present socio-economic condition is estimated to be 0.02 million pesos. The benefit under the future socio-economic condition is expected to increase in proportion to the economic growth in the project area although it is assumed to keep constant after the year of 2020.

6.2.3 Economic Cost

The financial project cost estimated in Chapter V is converted into the economic cost by using the conversion factors assumed in Section 6.2.1. The integrated conversion factors of the respective work items are summarized below.

Work Item	Conversion Factor	Work Item	Conversion Factor
Earth Works	0.83	Land Acquisition	0.00
Revetment Works	0.69	House Resettlement	0.83
Bridge/Culvert Works	0.79	Administration Cost	0.95
Other Works	0.93	Engineering Cost	1.10
		Physical Contingency	0.80

The economic project cost is estimated to be 94.7 million pesos with the following breakdown in comparison with the financial one.

(Unit: million peso)

Item	Financial Cost	Economic Cost
1. Construction Cost	86.0	68.4
1.1 Preparatory Works	7.8	6.2
1.2 Main Works	71.1	56.5
1.3 Miscellaneous Works	7.1	5.7
2. Compensation Cost	4.7	0.0
3. Administration Cost	2.7	2.6
4. Engineering Services Cost	13.8	15.1
5. Physical Contingency	10.7	8.6
Total	118.0	94.7

The disbursement schedule of the economic cost is summarized below.

Year	Annual Disbursement (million peso)
1999	11.0
2000	62.1
2001	21.6
Total	94.7

The total annual operation and maintenance cost (O&M cost) of the project is assumed to be 0.5% of the construction cost. It amounts to 0.34 million pesos after the project is completed in 2001.

6.2.4 Economic Evaluation

(1) Economic Viability

The economic internal rate of return (EIRR) of the project under the future socio-economic condition is calculated to be 31.9%. The cost-benefit ratio (B/C) and net present value (NPV) discounted at 15% under the future socio-economic condition are also calculated to be 2.45 and 105 million pesos. They are summarized below in comparison with those under the present socio-economic condition.

Particulars	EIRR (%)	B/C	NPV (million peso)
Under Future Condition	31.9	2.45	105
Under Present Condition	22.0	1.47	34

The economic cost and benefit streams of the project under the present and future socio-economic conditions are shown in Table III.3 and III.4, respectively.

(2) Sensitivity Test

The sensitivity test of the economic efficiency is performed for the following four (4) cases.

(a) 10% higher than the cost estimated

(b) 10% lower than benefits expected

(c) High economic growth scenario: 8.90% up to 2000; 6.68% in 2000-2010; 4.45% in 2010-2020

(d) Low economic growth scenario: 4.9 % up to 2000; 3.68% in 2000-2010; 2.45% in 2010-2020

The results are summarized below.

Particulars	EIRR (%)	B/C	NPV (million peso)
Base Condition	31.9	2.45	105
(a) 10% Cost Up	29.5	2.23	98
(b) 10% Benefits Down	29.2	2.21	87
(c) High Growth Scenario	36.6	3.10	152
(d) Low Growth Scenario	29.8	2.19	87

From the above, the proposed project is considered economically viable.

6.3 Social Evaluation

(1) Creation of Job Opportunity and Activation of Regional Economy

The proposed project creates opportunities for temporary jobs during the construction period. The requirement of temporary laborers is estimated at 65,000 man-days in total, i.e., 13,000 man-days of skilled laborers and 52,000 man-days of unskilled laborers during the two (2) years between 2000 and 2001.

Besides these temporary workers, some support services for the construction works will be required in the project area. These support services will create another job opportunity and it will contribute to activation of the regional economy.

(2) Improvement of Social Amenity and Public Hygiene

The people in the project area are exposed to the danger of flood disasters and public hygiene after the floods. The proposed project will relieve the people from the menace of floods and waterborne diseases. As a result, they could enjoy their improved living conditions.

CHAPTER VII ENVIRONMENTAL IMPACT ASSESSMENT OF URGENT PLAN

7.1 General

The potential impacts of the proposed project to the environment during the construction and operation phases were predicted and assessed. The construction phase will include channel excavation, earth filling and the construction of revetment, bridge, culvert, etc. These structures are all relatively small earth/aggregate/concrete structures along the riverbanks or within the riverbeds. On the other hand, the operation phase will be the use of these passive structures.

Identification of the potential environmental impacts was done by evaluating the project's features and operations against the known list of potential impacts identified by various sources for this type of project.

The above prediction and assessment presents the effects of the unmitigated impacts. The necessary measures to reduce or eliminate the impacts are proposed in the environmental management plan.

7.2 Prediction and Assessment of Impacts

7.2.1 Construction Phase Impacts

The identified potential impacts during the construction phases are water pollution, air pollution, noise generation, soil erosion, fish and wildlife disturbance, vegetation loss, land acquisition/house resettlement, loss of archaeological/historical assets, traffic disturbance and local labor employment. Most of these impacts are short-term in nature.

(1) Water Pollution

The existing average water quality during dry season in the Daorao Creek is estimated based on the tests conducted in the course of the Feasibility Study and shown as follows:

Water Quality Parameter	Daorao Creek
pH	7.4
Conductivity	162
Total Phosphorus (mg/l)	0.28
BOD (mg/l)	1.8
Total Dissolved Solids (mg/l)	287
Total Suspended Solids (mg/l)	32
Nitrate (NO^3) (mg/l)	0.98
Oil and Grease (mg/lq)	2.6
Dissolved Oxygen (mg/l)	5.9
Coliforms (MPN/100 ml)	260

Note: Water qualities except Coliforms were observed in Feb.-Mar. 1997. Coliform was observed in June 1997

Water pollution sources would be the dewatering work for structural foundations and earth work operations in the channel. However, water pollution due to these works is considered not heavy since their work volumes are comparatively small.

(2) Air Pollution

Air pollution would come from the use of heavy construction equipment and dust generation activities. However, this will be minimal since the number of heavy construction equipment to be used in the project is limited.

(3) Noise Generation

Operation of the various construction equipment will be the major source of noise. However, this noise will not be significant since the number of construction equipment to be used in the project is limited.

(4) Soil Erosion

Soil erosion might occur due to various earth moving activities. However, this erosion is considered small since the clearing of sites of vegetation is limited.

(5) Fish and Wildlife Disturbance

Inland fishery production in the Daorao Creek is very low and it is limited to the downstream reaches. The existing fish species are Tilapia, Catfish, Mudfish, Eel and Gurami, all of which are not threatened, endangered or rare species.

No wildlife has been identified in the project sites.

During construction, a small number of fishes in the downstream might be affected by the water pollution caused by the construction works. However, this impact is expected to be only during construction period and normal condition will be restored after construction.

(6) Vegetation Loss

There are some bushes and small trees along the banks of the Creek. Water hyacinth and other floating vegetation are identified within the creek. No threatened, endangered or rare species of plant and vegetation are identified among them. No significant negative impact is expected in terms of vegetation cover since the clearing of the vegetation is small.

(7) Land Acquisition and House Resettlement

The required land acquisition and house resettlement for the project are estimated as follows.

Item	Quantity
Land Acquisition (ha)	2.71
Farmland/Open Space	2.70
Residential Land	0.01
House Relocation (No.)	none

These land acquisitions are considered small compared to the beneficial land area of the project.

(8) Loss of Archaeological and Historical Assets

No stone age remains have been found in Ilocos Norte. Some Chinese historical properties in Tang, Sun, Yuan and Ming ages have been found along the coastal areas. However, no historical site in the project area is registered in the National Historical Institute.

(9) Traffic Disturbance

Traffic disturbance would come from the transportation of excavated soils. However, the impact on traffic is considered negligible, since the existing traffic volume in the project area and soil transportation volume are small.

(10) Local Labor Improvement

The project creates opportunities of temporary jobs during the construction period. The requirement of temporary laborers during the 2-year construction period is estimated as follows.

Kind of Labor	Labor Force (man-days)
Skilled Labor	13,000
Unskilled Labor	52,000
Total	65,000

Besides these temporary workers, some support services for the construction works will be required in the project area. These support services will create another job opportunity.

The environmental impacts of the project during the construction phase are summarized in Table III.5.

7.2.2 Operation Phase Impacts

The identified potential impacts during the operation phase are described below.

(1) Hydrological and River Morphological Changes

The project will not cause hydrological and river morphological changes.

(2) Water Pollution, Air Pollution and Noise

The project will not generate water pollution loads, air pollution loads and noise during the operation phase.

(3) Geological Destruction

No geological destruction is expected during the operation phase since the proposed structures are small.

(4) Ecological Loss and Disturbance

(a) Loss of Wildlife Habitat

There is no wildlife habitat in the project area.

(b) Disruption of Fish Spawning Grounds

The concrete lining of the riverbanks may reduce the spawning grounds of fish. However, the revetment works are limited to the San Isidro Creek (a tributary of Daorao Creek) where no fish is identified.

(5) Aesthetic Impairment

(a) Aesthetic Impairment of Landscape

The proposed structures will not impair the landscape since they are small in size.

(b) Visual Impairment of Historical and Cultural Resources

There are no historical and cultural resources in the project area.

(6) Loss of Natural Resources Use

(a) Loss of Fishing Area

There is no fishing area around the proposed structure sites.

(b) Impairment of Navigation

There are no navigation activities in the project area.

(c) Damage to Economically Valuable Natural Resources

The project will not cause damage to the other economically valuable natural resources.

(7) Socio-economic Impact

(a) Reduction of Economical Loss

The project will reduce the existing flood damages on house buildings, household effects, commercial and industrial properties, physical and social infrastructures, etc.

(b) Reduction of Heath Risk

Floodwaters carry toilet wastes, garbage and mud to the houses every flood time. Waterborne diseases frequently break out from these deposits. The project will reduce such health risk.

(c) Increase of Available Residential Land

According to the land use plan of the City, the residential area expansion is expected on the north of the existing built-up areas. However, this area is subject to flooding of the Daorao Creek at present. The project will enhance the residential land development.

The environmental impacts of the project during the operation phase are also summarized in Table III.5.

7.2.3 Environmental Management Plan

Water pollution during the construction phase is considered the only negative impact which shall be eliminated or mitigated as shown in Table III.5. 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 site if necessary.

All the other negative impacts during construction and operation phases are minimal or none. Hence, no special environmental management plan is proposed for these impacts.

CHAPTER VIII RECOMMENDATION

The proposed urgent urban drainage improvement project is technically and economically feasible. Environmentally, it will generate no significant adverse effect. Urgent implementation of the project is recommended in consideration of the recurrent serious floods in Laoag City. The required financial sources also should be arranged as soon as possible.

TABLES

Table III.1 Estimated Cost of Urgent Plan

Work Items	Unit	Unit Cost (Pesos)	Quantity	Amount (1000 Pesos)
I. Construction Cost				86,020
1.1 Preparatory Works (10% of 1.2 and 1.3)				7,820
1.2 Main Works				71,091
(1) Earth work				11,893
Excavation	m3	115	97,528	11,216
Filling	m3	85	7,970	677
(2) Revetment Work (L=2,300 m)				16,473
Revetment Type RA				
Gravel	m3	510	2,381	1,214
Top Concrete	m3	2,500	205	513
Base Concrete	m3	3,500	536	1,876
Wet Masonry	m3	1,950	2,649	5,166
			Sub-total	8,769
Gabion Mattress	m3	1,300	639	831
Revetment Type RB				
Gravel	m3	510	1,427	728
Top&backfill Concrete	m3	2,500	962	2,405
Base Concrete	m3	3,500	254	889
Wet Masonry	m3	1,950	1,462	2,851
			Sub-total	6,873
(3) Bridge and Culvert Work				32,390
Bridge				28,582
Br1 (W=5m,L=39.5m)	m2	25,000	237	5,925
Br2 (W=5m,L=38.2m)	m2	28,000	229	6,412
Br3 (W=8.5m,L=29.7m)	m2	28,000	252	7,056
Br4 (w=2m,L=24.5m)	m2	28,000	98	2,744
Br5 (w=7.5m,L=23.3m)	m2	28,000	175	4,900
Removal of Existing Bridge	m3	3,000	515	1,545
Box Culvert				3,808
Box1 (5.0*2.8*6.0)	pcs	282,000	1	282
Box2 (5.2*2.7*30.0)	pcs	1,434,000	1	1,434
Box3 (5.1*2.6*7.0)	pcs	328,000	1	328
Box4 (5.0*2.5*25.0)	pcs	1,144,000	1	1,144
Box5 (5.0*2.5*10.0)	pcs	458,000	1	458
Removal of Existing Box Culvert	m3	3,000	54	162
(4) Others				10,335
Waste Water Interceptor				5,015
RC Pipe 0.6m	m	1,900	1,700	3,230
RC Pipe 0.8m	m	2,100	850	1,785
Drop	pcs	220,000	1	220
Mouth Opening				5,100
Backhoe (0.6m3)	pcs	2,200,000	1	2,200
Bulldozer (15t)	pcs	2,900,000	1	2,900
1.3 Miscellaneous Works (10% of 1.2)				7,109
II. Compensation Cost				4,740
2.1 Land Acquisition				4,740
Farm/Open Space	ha	1,700,000	2.7	4,590
Residential Area	ha	15,000,000	0.01	150
2.2 House Resettlement	houses	150,000	0	0
III. Administration Cost (3% of I and II)				2,723
IV. Engineering Service Cost (16% of I)				13,763
Total of I, II, III and IV				107,246
V. Physical Contingency (10% of I, II, III and IV)				10,725
Grand Total				117,971

Table III.2 Annual Disbursement Schedule of Urgent PLan

(million pesos)

Description	TOTAL			1999			2000			2001		
	F.C.	L.C.	Total	F.C.	L.C.	Total	F.C.	L.C.	Total	F.C.	L.C.	Total
1. Construction Cost	44.54	41.48	86.02	0.00	0.00	0.00	33.40	32.71	66.11	11.14	8.77	19.91
1.1 Preparatory Works (10% of 1.2 and 1.3)	4.05	3.77	7.82	0.00	0.00	0.00	4.05	3.77	7.82	0.00	0.00	0.00
1.2 Main Works	36.81	34.28	71.09	0.00	0.00	0.00	26.68	26.31	52.99	10.13	7.97	18.10
(1) Earth Works	7.65	4.24	11.89	0.00	0.00	0.00	7.65	4.24	11.89	0.00	0.00	0.00
Excavation	7.20	4.02	11.22	0.00	0.00	0.00	7.20	4.02	11.22	0.00	0.00	0.00
Filling	0.45	0.22	0.67	0.00	0.00	0.00	0.45	0.22	0.67	0.00	0.00	0.00
(2) Revetment Work	3.23	13.24	16.47	0.00	0.00	0.00	3.23	13.24	16.47	0.00	0.00	0.00
(3) Bridge and Culvert Work	18.13	14.26	32.39	0.00	0.00	0.00	8.00	6.29	14.29	10.13	7.97	18.10
Bridge	16.00	12.58	28.58	0.00	0.00	0.00	8.00	6.29	14.29	8.00	6.29	14.29
Box Culvert	2.13	1.68	3.81	0.00	0.00	0.00	0.00	0.00	0.00	2.13	1.68	3.81
(4) OtherWorks	7.80	2.54	10.34	0.00	0.00	0.00	7.80	2.54	10.34	0.00	0.00	0.00
Drop	0.18	0.04	0.22	0.00	0.00	0.00	0.18	0.04	0.22	0.00	0.00	0.00
Waste Water Intercepter	3.78	1.24	5.02	0.00	0.00	0.00	3.78	1.24	5.02	0.00	0.00	0.00
Mouth Opening	3.84	1.26	5.10	0.00	0.00	0.00	3.84	1.26	5.10	0.00	0.00	0.00
1.3 Miscellaneous Works (10% of 1.2)	3.68	3.43	7.11	0.00	0.00	0.00	2.67	2.63	5.30	1.01	0.80	1.81
2. Compensation Cost	0.00	4.74	4.74	0.00	4.74	4.74	0.00	0.00	0.00	0.00	0.00	0.00
3. Administration Cost	0.00	2.72	2.72	0.00	0.91	0.91	0.00	0.91	0.91	0.00	0.91	0.91
4. Engineering Service Cost	12.38	1.38	13.76	7.43	0.83	8.26	2.48	0.27	2.75	2.48	0.27	2.75
5. Physical Contingency	5.30	5.43	10.73	0.74	0.65	1.39	3.59	3.39	6.98	1.36	1.00	2.36
Sub-Total (1 to 5)	62.22	55.75	117.97	8.17	7.13	15.30	39.47	37.28	76.75	14.98	10.95	25.93
5. Price Contingency	3.98	12.83	16.81	0.33	1.03	1.36	2.42	8.39	10.81	1.23	3.41	4.64
6. Total (1+2+3+4+5)	66.20	68.58	134.78	8.50	8.16	16.66	41.89	45.67	87.56	16.21	14.36	30.57

Table III.3 Economic Cost and Benefit Stream of Flood Control Urgent Plan in Laoag City under Present Conditions

(Unit : Million Pesos)

Serial Year	Year	Cost			Benefit			Balance
		Construction	O&M	Total	Flood Control	Negative	Total	
1	1999	11.06		11.06			0.00	-11.06
2	2000	62.07		62.07		0.02	-0.02	-62.07
3	2001	21.62	0.26	21.88	16.75	0.02	16.73	-5.12
4	2002		0.34	0.34	21.80	0.02	21.78	21.46
5	2003		0.34	0.34	21.80	0.02	21.78	21.46
6	2004		0.34	0.34	21.80	0.02	21.78	21.46
7	2005		0.34	0.34	21.80	0.02	21.78	21.46
8	2006		0.34	0.34	21.80	0.02	21.78	21.46
9	2007		0.34	0.34	21.80	0.02	21.78	21.46
10	2008		0.34	0.34	21.80	0.02	21.78	21.46
11	2009		0.34	0.34	21.80	0.02	21.78	21.46
12	2010		0.34	0.34	21.80	0.02	21.78	21.46
13	2011		0.34	0.34	21.80	0.02	21.78	21.46
14	2012		0.34	0.34	21.80	0.02	21.78	21.46
15	2013		0.34	0.34	21.80	0.02	21.78	21.46
16	2014		0.34	0.34	21.80	0.02	21.78	21.46
17	2015		0.34	0.34	21.80	0.02	21.78	21.46
18	2016		0.34	0.34	21.80	0.02	21.78	21.46
19	2017		0.34	0.34	21.80	0.02	21.78	21.46
20	2018		0.34	0.34	21.80	0.02	21.78	21.46
21	2019		0.34	0.34	21.80	0.02	21.78	21.46
22	2020		0.34	0.34	21.80	0.02	21.78	21.46
23	2021		0.34	0.34	21.80	0.02	21.78	21.46
24	2022		0.34	0.34	21.80	0.02	21.78	21.46
25	2023		0.34	0.34	21.80	0.02	21.78	21.46
26	2024		0.34	0.34	21.80	0.02	21.78	21.46
27	2025		0.34	0.34	21.80	0.02	21.78	21.46
28	2026		0.34	0.34	21.80	0.02	21.78	21.46
29	2027		0.34	0.34	21.80	0.02	21.78	21.46
30	2028		0.34	0.34	21.80	0.02	21.78	21.46
31	2029		0.34	0.34	21.80	0.02	21.78	21.46
32	2030		0.34	0.34	21.80	0.02	21.78	21.46
33	2031		0.34	0.34	21.80	0.02	21.78	21.46
34	2032		0.34	0.34	21.80	0.02	21.78	21.46
35	2033		0.34	0.34	21.80	0.02	21.78	21.46
36	2034		0.34	0.34	21.80	0.02	21.78	21.46
37	2035		0.34	0.34	21.80	0.02	21.78	21.46
38	2036		0.34	0.34	21.80	0.02	21.78	21.46
39	2037		0.34	0.34	21.80	0.02	21.78	21.46
40	2038		0.34	0.34	21.80	0.02	21.78	21.46
41	2039		0.34	0.34	21.80	0.02	21.78	21.46
42	2040		0.34	0.34	21.80	0.02	21.78	21.46
43	2041		0.34	0.34	21.80	0.02	21.78	21.46
44	2042		0.34	0.34	21.80	0.02	21.78	21.46
45	2043		0.34	0.34	21.80	0.02	21.78	21.46
46	2044		0.34	0.34	21.80	0.02	21.78	21.46
47	2045		0.34	0.34	21.80	0.02	21.78	21.46
48	2046		0.34	0.34	21.80	0.02	21.78	21.46
49	2047		0.34	0.34	21.80	0.02	21.78	21.46
50	2048		0.34	0.34	21.80	0.02	21.78	21.46
51	2049		0.34	0.34	21.80	0.02	21.78	21.46
52	2050		0.34	0.34	21.80	0.02	21.78	21.46
53	2051		0.34	0.34	21.80	0.02	21.78	21.46

NPV: 33.9 B/C: 1.47 EIRR : 22.0%

Table III.4 Economic Cost and Benefit Stream of Flood Control Urgent Plan in Laoag City under Future Conditions

(Unit : Million Pesos)

Serial Year	Year	Cost			Benefit			Balance
		Construction	O&M	Total	Flood Control	Negative	Total	
1	1999	11.06		11.06			0.00	-11.06
2	2000	62.07		62.07		0.03	-0.03	-62.07
3	2001	21.62	0.26	21.88	20.92	0.03	20.89	-0.96
4	2002		0.34	0.34	28.47	0.03	28.45	28.13
5	2003		0.34	0.34	29.78	0.03	29.76	29.44
6	2004		0.34	0.34	31.15	0.03	31.13	30.81
7	2005		0.34	0.34	32.59	0.03	32.56	32.25
8	2006		0.34	0.34	34.09	0.03	34.06	33.75
9	2007		0.34	0.34	35.66	0.03	35.62	35.31
10	2008		0.34	0.34	37.30	0.03	37.26	36.95
11	2009		0.34	0.34	39.01	0.03	38.98	38.67
12	2010		0.34	0.34	40.81	0.04	40.77	40.46
13	2011		0.34	0.34	42.06	0.04	42.03	41.72
14	2012		0.34	0.34	43.36	0.04	43.32	43.02
15	2013		0.34	0.34	44.70	0.04	44.66	44.36
16	2014		0.34	0.34	46.08	0.04	46.03	45.73
17	2015		0.34	0.34	47.50	0.04	47.45	47.15
18	2016		0.34	0.34	48.96	0.04	48.92	48.62
19	2017		0.34	0.34	50.47	0.04	50.42	50.13
20	2018		0.34	0.34	52.02	0.05	51.98	51.68
21	2019		0.34	0.34	53.63	0.05	53.58	53.29
22	2020		0.34	0.34	55.28	0.05	55.23	54.94
23	2021		0.34	0.34	55.28	0.05	55.23	54.94
24	2022		0.34	0.34	55.28	0.05	55.23	54.94
25	2023		0.34	0.34	55.28	0.05	55.23	54.94
26	2024		0.34	0.34	55.28	0.05	55.23	54.94
27	2025		0.34	0.34	55.28	0.05	55.23	54.94
28	2026		0.34	0.34	55.28	0.05	55.23	54.94
29	2027		0.34	0.34	55.28	0.05	55.23	54.94
30	2028		0.34	0.34	55.28	0.05	55.23	54.94
31	2029		0.34	0.34	55.28	0.05	55.23	54.94
32	2030		0.34	0.34	55.28	0.05	55.23	54.94
33	2031		0.34	0.34	55.28	0.05	55.23	54.94
34	2032		0.34	0.34	55.28	0.05	55.23	54.94
35	2033		0.34	0.34	55.28	0.05	55.23	54.94
36	2034		0.34	0.34	55.28	0.05	55.23	54.94
37	2035		0.34	0.34	55.28	0.05	55.23	54.94
38	2036		0.34	0.34	55.28	0.05	55.23	54.94
39	2037		0.34	0.34	55.28	0.05	55.23	54.94
40	2038		0.34	0.34	55.28	0.05	55.23	54.94
41	2039		0.34	0.34	55.28	0.05	55.23	54.94
42	2040		0.34	0.34	55.28	0.05	55.23	54.94
43	2041		0.34	0.34	55.28	0.05	55.23	54.94
44	2042		0.34	0.34	55.28	0.05	55.23	54.94
45	2043		0.34	0.34	55.28	0.05	55.23	54.94
46	2044		0.34	0.34	55.28	0.05	55.23	54.94
47	2045		0.34	0.34	55.28	0.05	55.23	54.94
48	2046		0.34	0.34	55.28	0.05	55.23	54.94
49	2047		0.34	0.34	55.28	0.05	55.23	54.94
50	2048		0.34	0.34	55.28	0.05	55.23	54.94
51	2049		0.34	0.34	55.28	0.05	55.23	54.94
52	2050		0.34	0.34	55.28	0.05	55.23	54.94
53	2051		0.34	0.34	55.28	0.05	55.23	54.94

NPV: 105.1 B/C: 2.45 EIRR : 31.9%

Table III.5 Scaling Checklist for Environmental Impacts

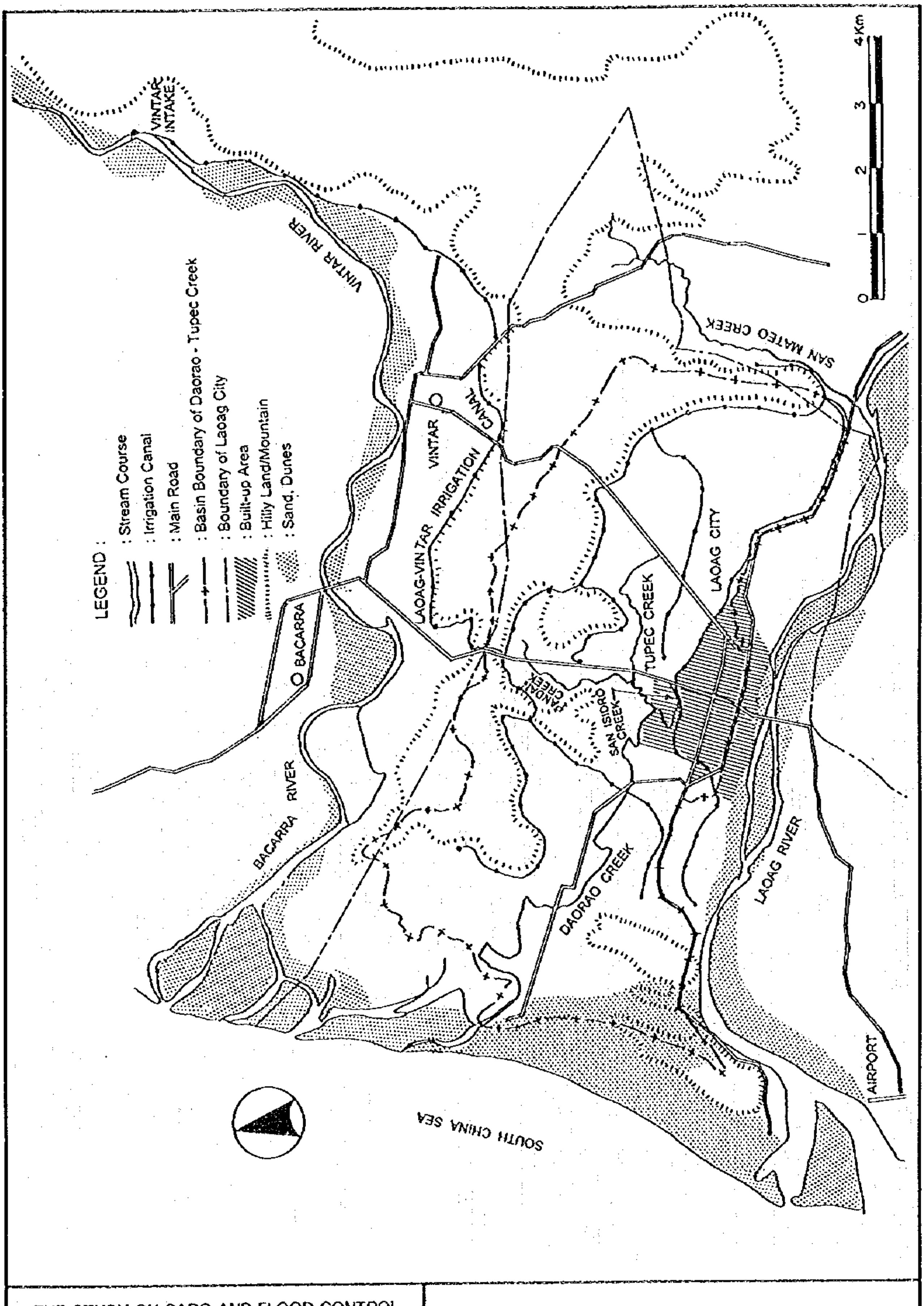
(Construction Phase)

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

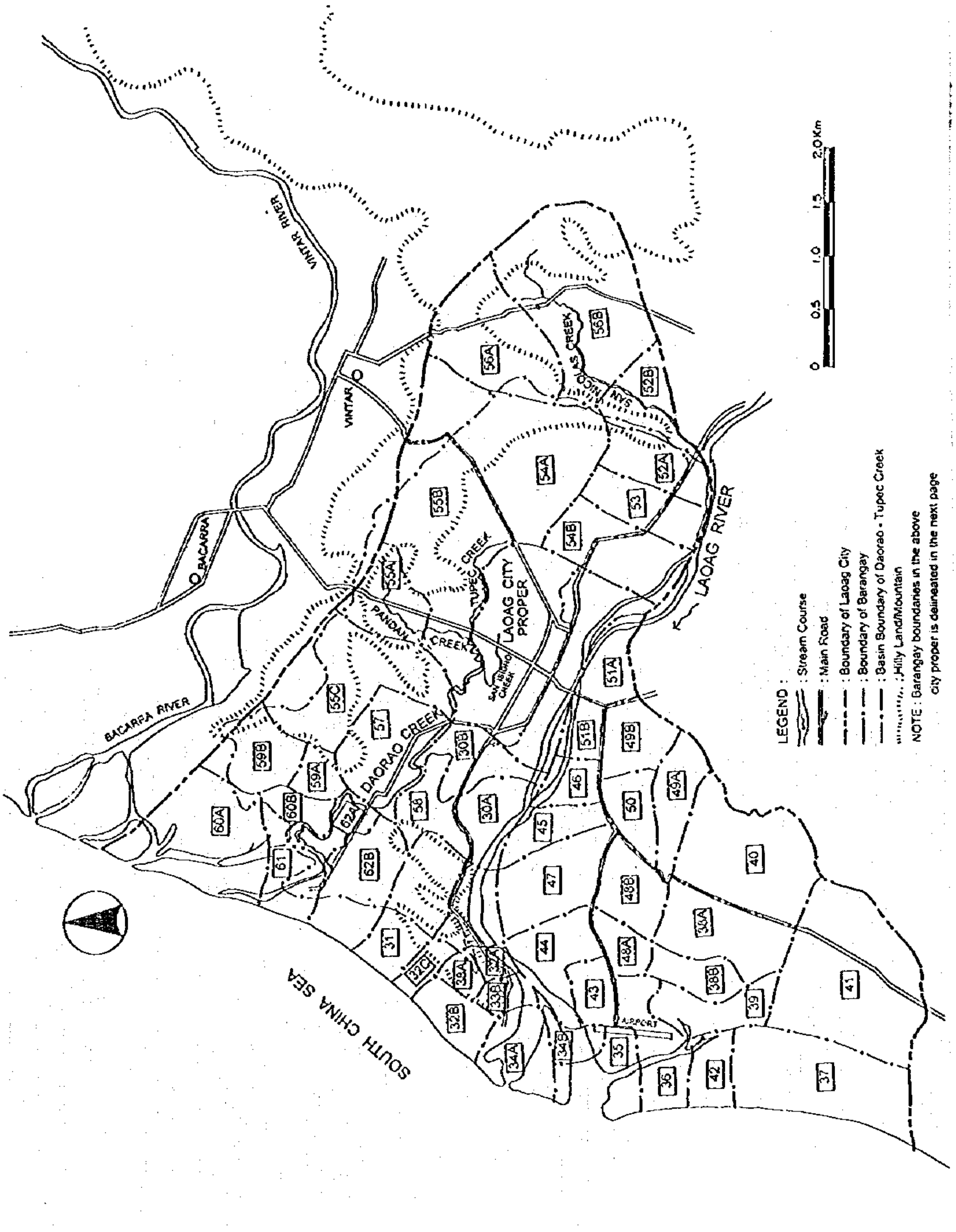
(Operation Phase)

Impact Area	Direct Impact	Nature	Magnitude
Hydrology/River Morphology	Hydrological/River Morphological Change	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	No Effect
Aesthetics	Aesthetic Impairment of Landscape	Negative	No Effect
	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 Residential Land	Positive	Significant

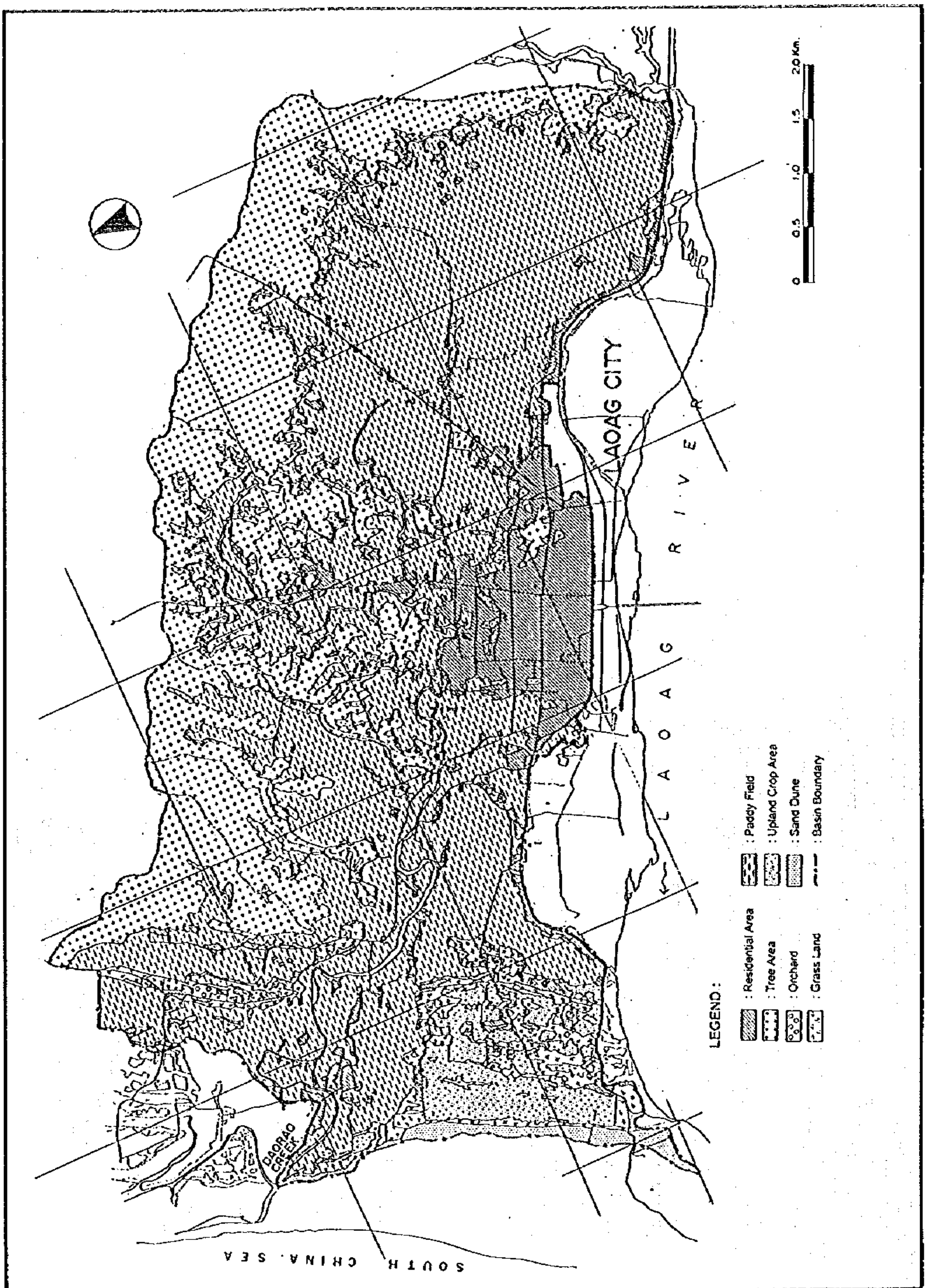
FIGURES



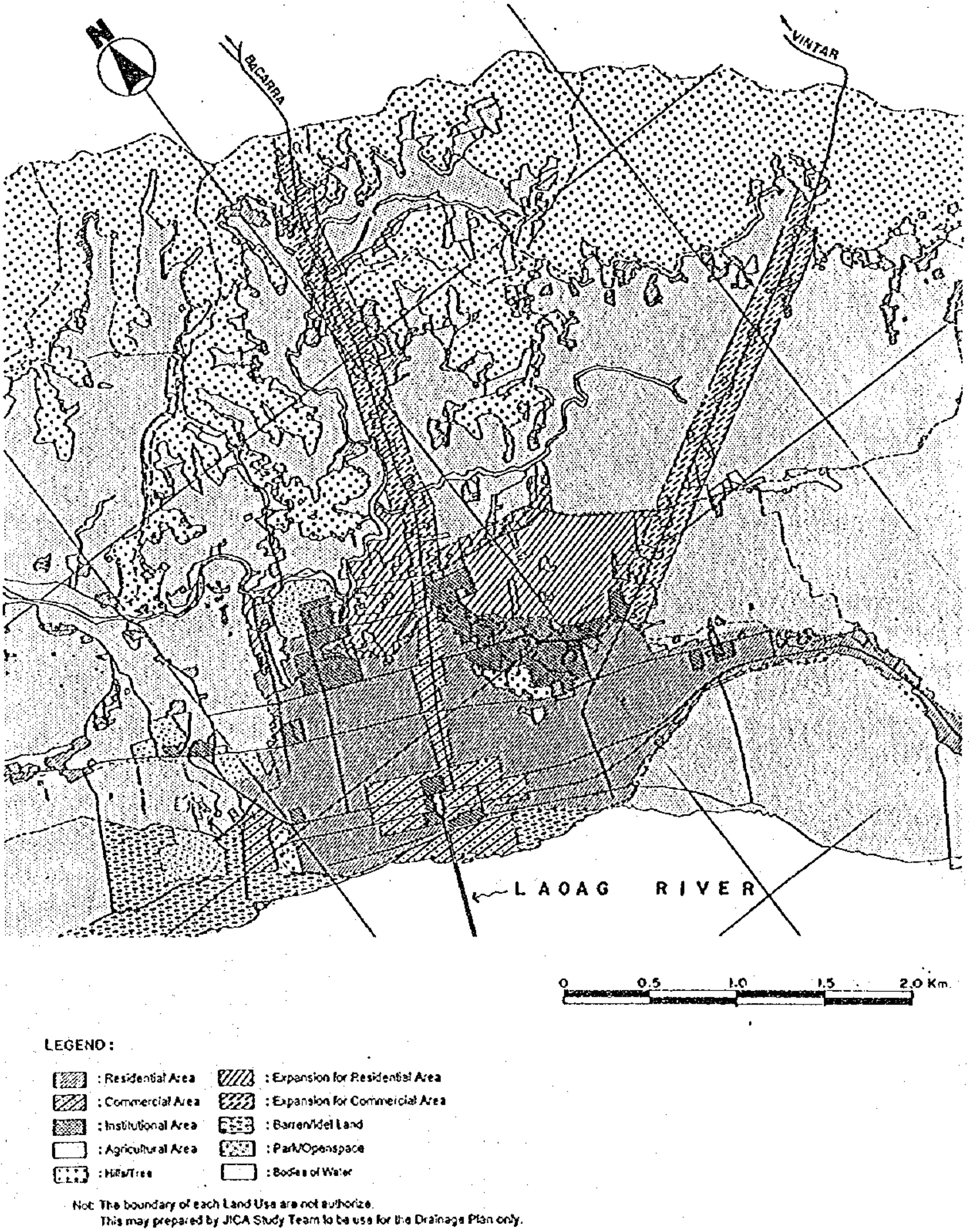
THE STUDY ON SABO AND FLOOD CONTROL IN THE LAOAG RIVER BASIN JAPAN INTERNATIONAL COOPERATION AGENCY	Fig. III.1 Salient Topographic Features of the Basin



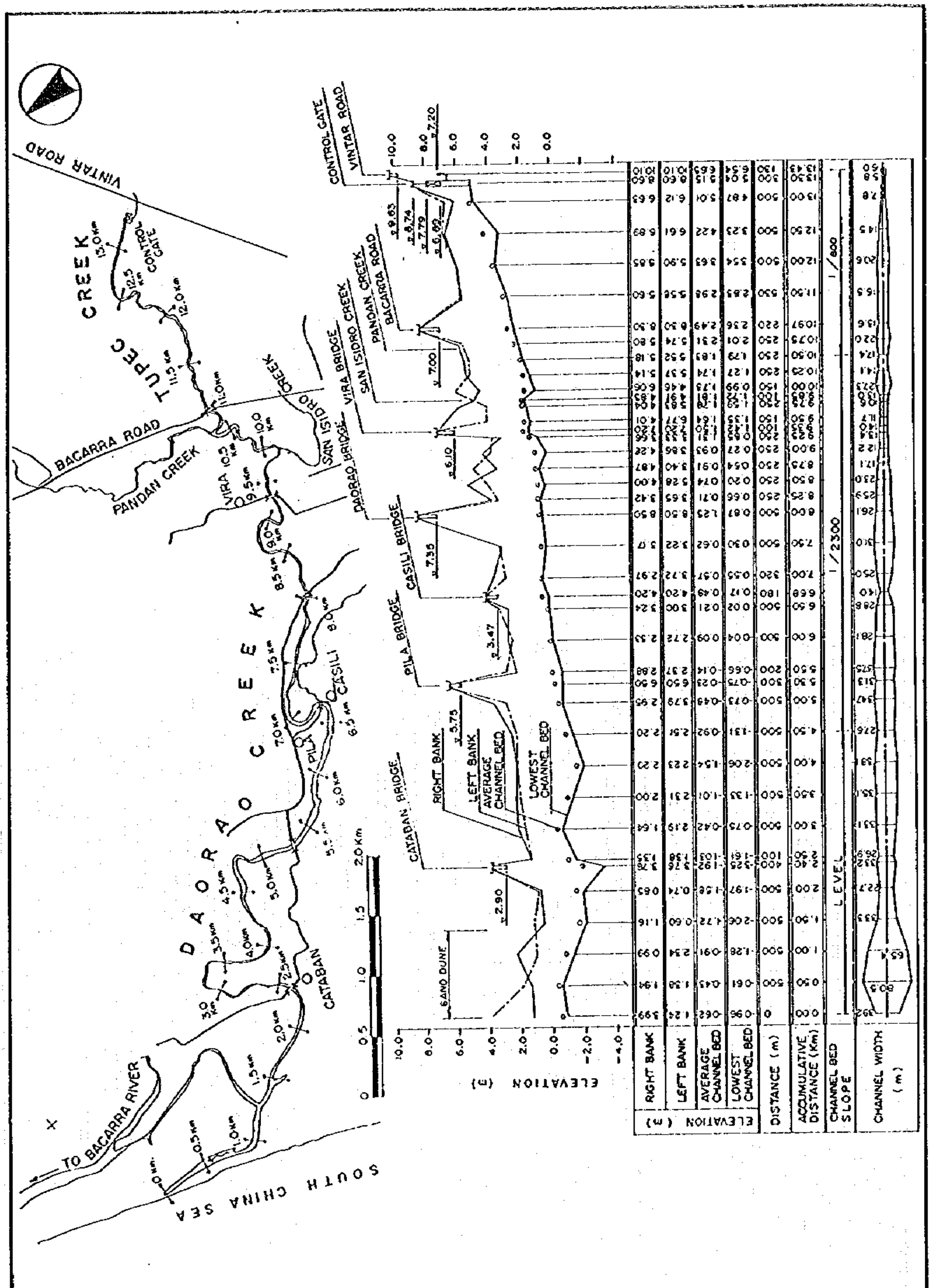
THE STUDY ON SABO AND FLOOD CONTROL IN THE LAOAG RIVER BASIN	Fig. III.2
JAPAN INTERNATIONAL COOPERATION AGENCY	Administrative Boundary of Laoag City



THE STUDY ON SABO AND FLOOD CONTROL IN THE LAOAG RIVER BASIN JAPAN INTERNATIONAL COOPERATION AGENCY	Fig. III.3 Existing Land Use Map of the Daorao-Tupec Creek Basin



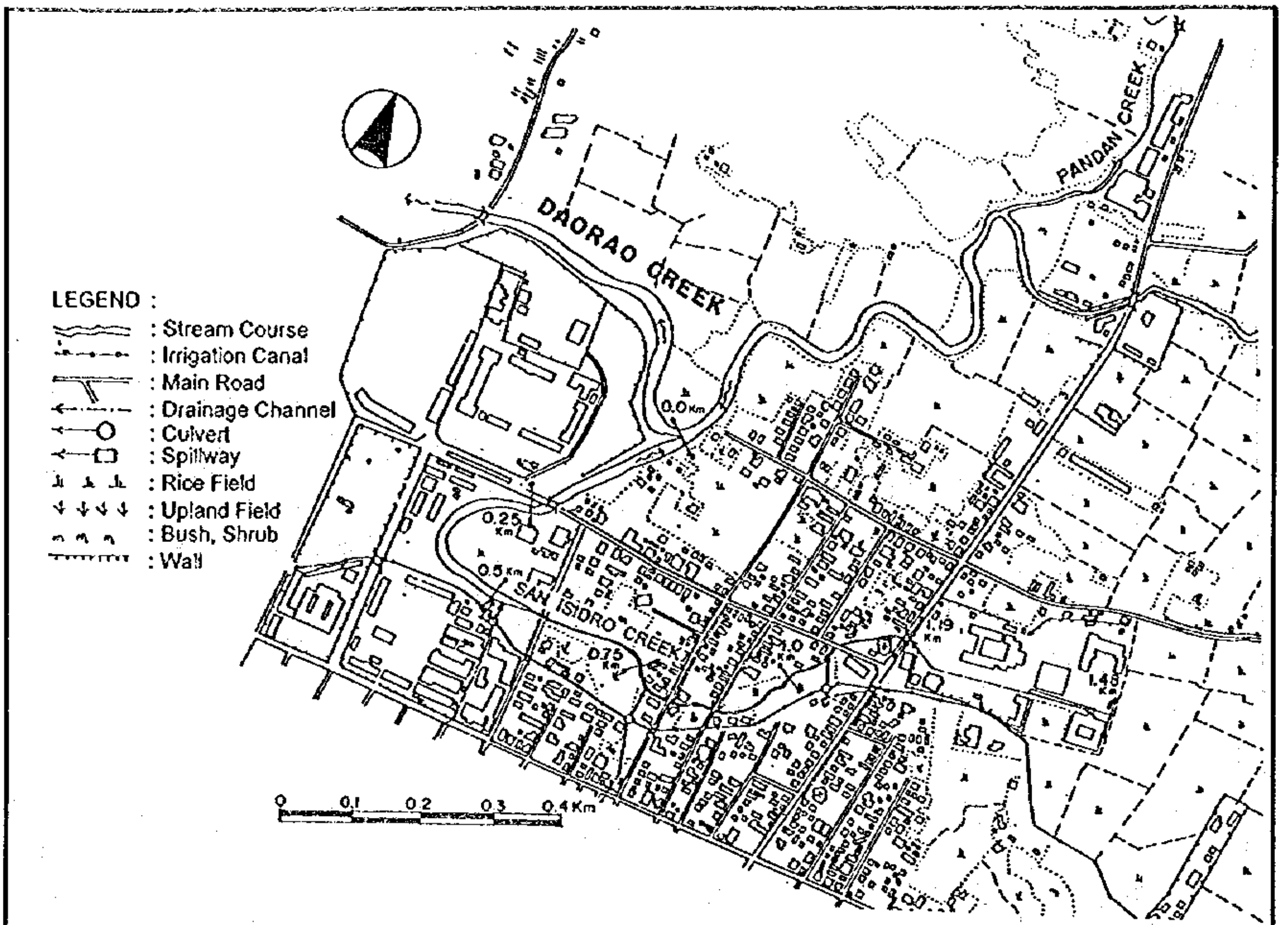
THE STUDY ON SABO AND FLOOD CONTROL IN THE LAOAG RIVER BASIN JAPAN INTERNATIONAL COOPERATION AGENCY	Fig. III.4 Future Land Use Map of the Daorao-Tupec Creek Basin

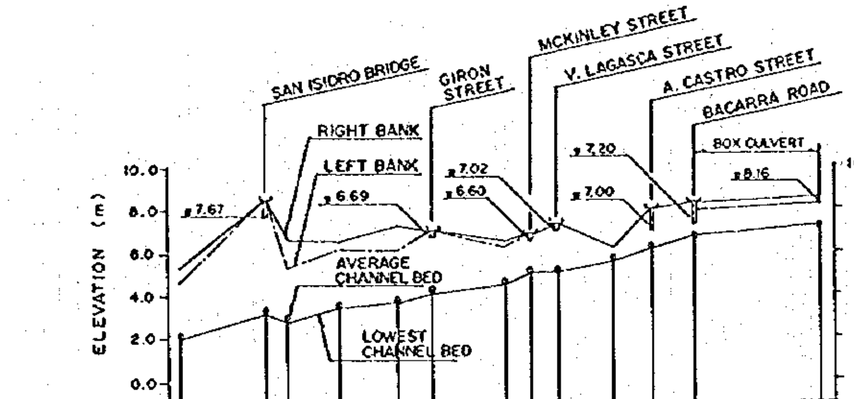


THE STUDY ON SABO AND FLOOD CONTROL IN THE LAOAG RIVER BASIN

JAPAN INTERNATIONAL COOPERATION AGENCY

Fig. III.5
Profile of Daorao-Tupec Creek





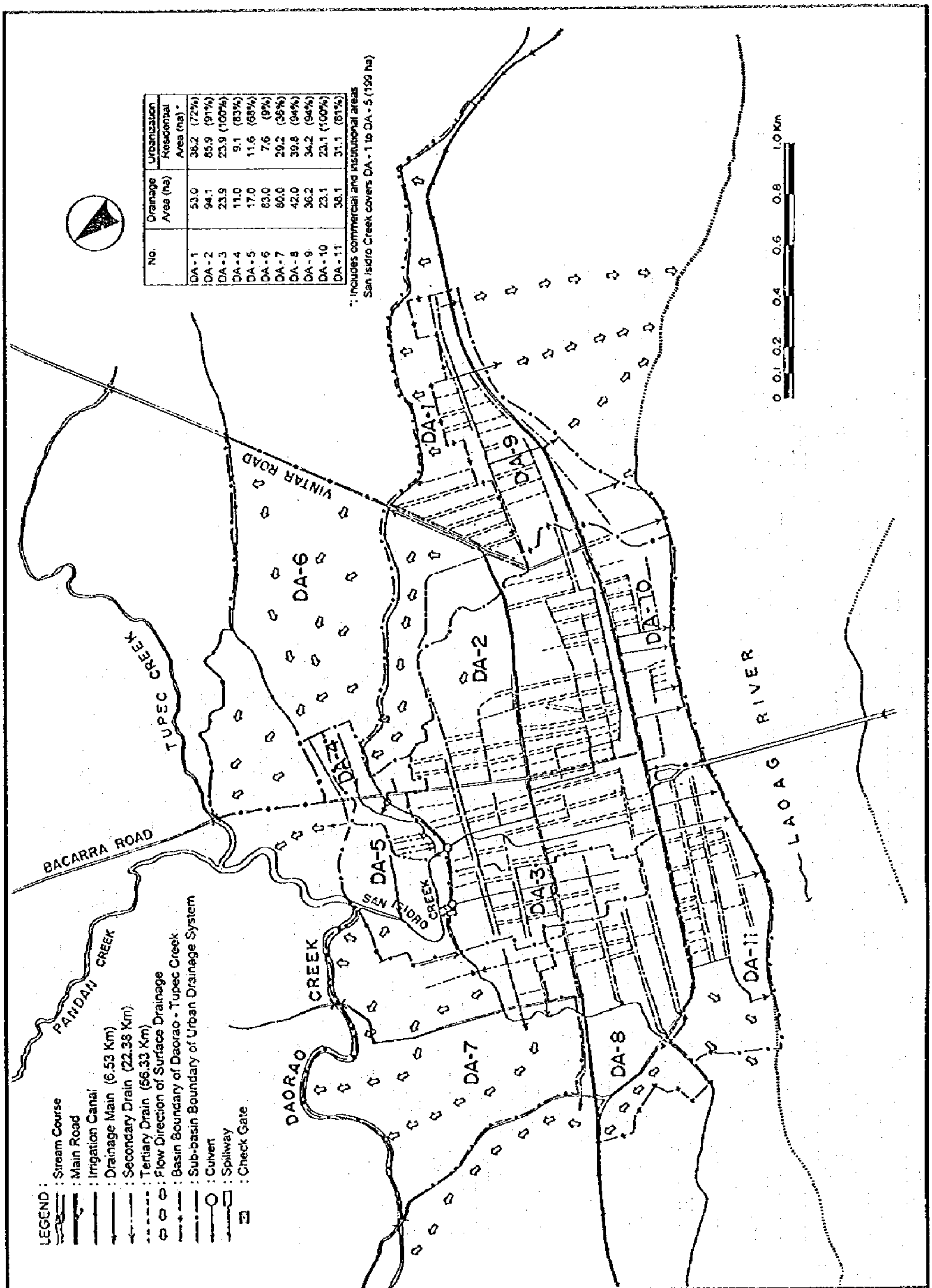
Accumulative Distance (Km)	Distance (m)	Elevation (m): Right Bank	Elevation (m): Left Bank	Elevation (m): Average Channel Bed	Elevation (m): Lowest Channel Bed	Channel Width (m)
0.00	0	5.41	4.73	2.12	2.04	14.6
0.20	200	6.50	6.50	3.28	3.23	6.4
0.25	50	6.59	5.32	2.98	2.77	6.6
0.37	120	6.60	6.19	3.51	3.43	14.0
0.50	130	7.21	6.11	3.79	3.67	10.5
0.58	80	7.00	7.00	4.27	4.21	2.4
0.75	170	6.49	6.29	4.61	4.57	14.3
0.81	60	6.90	6.90	5.11	5.11	1.9
0.87	60	7.31	7.31	5.14	5.14	1.4
1.00	130	6.20	6.18	5.61	5.54	3.6
1.09	90	7.99	7.99	6.10	6.10	0.9
1.19	100	8.28	8.28	6.70	6.70	2.8
1.48	290	6.55	6.55	7.15	7.15	1.5

Channel Bed Slope: 1/270 (0.00–1.19 Km); 1/650 (1.19–1.48 Km)

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

JAPAN INTERNATIONAL COOPERATION AGENCY

Fig. III.6
Profile of San Isidro Creek



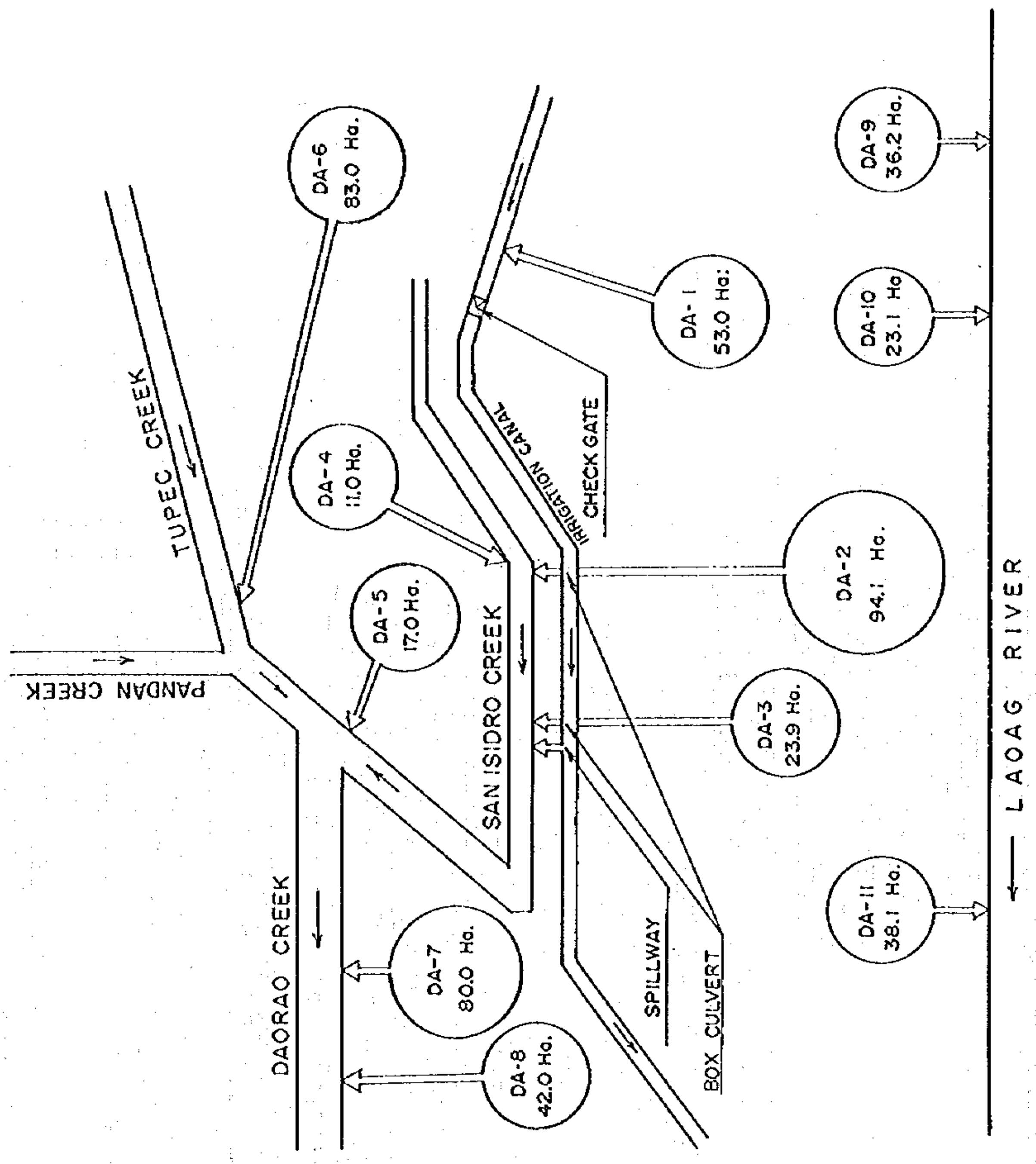
No.	Drainage Area (ha)	Urbanization Residential Area (ha) *
DA - 1	53.0	38.2 (72%)
DA - 2	94.1	85.9 (91%)
DA - 3	23.9	23.9 (100%)
DA - 4	11.0	9.1 (83%)
DA - 5	17.0	11.6 (68%)
DA - 6	83.0	7.6 (9%)
DA - 7	80.0	29.2 (36%)
DA - 8	42.0	39.8 (94%)
DA - 9	36.2	34.2 (94%)
DA - 10	23.1	23.1 (100%)
DA - 11	38.1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

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

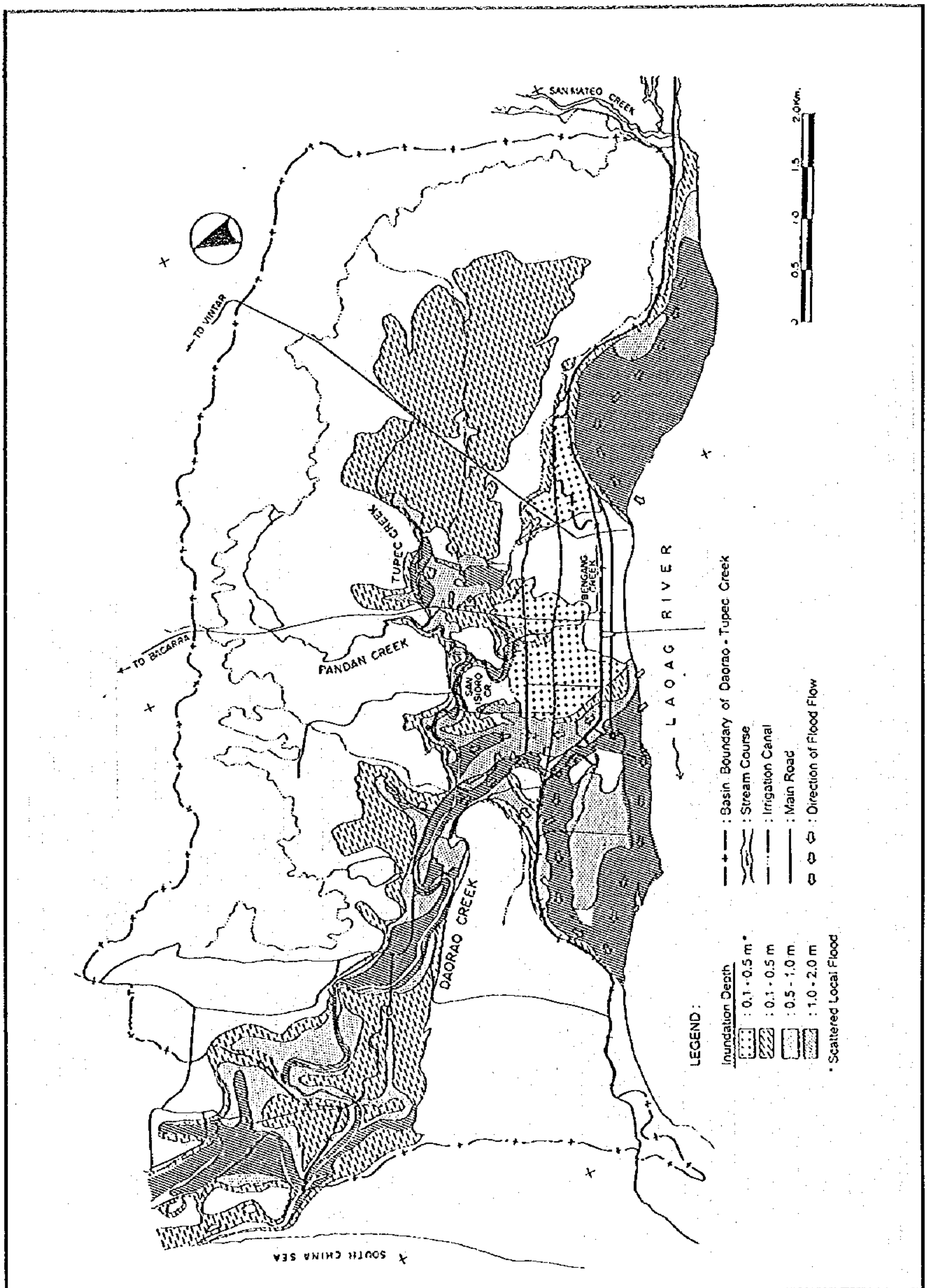
THE STUDY ON SABO AND FLOOD CONTROL IN THE LAOAG RIVER BASIN

JAPAN INTERNATIONAL COOPERATION AGENCY

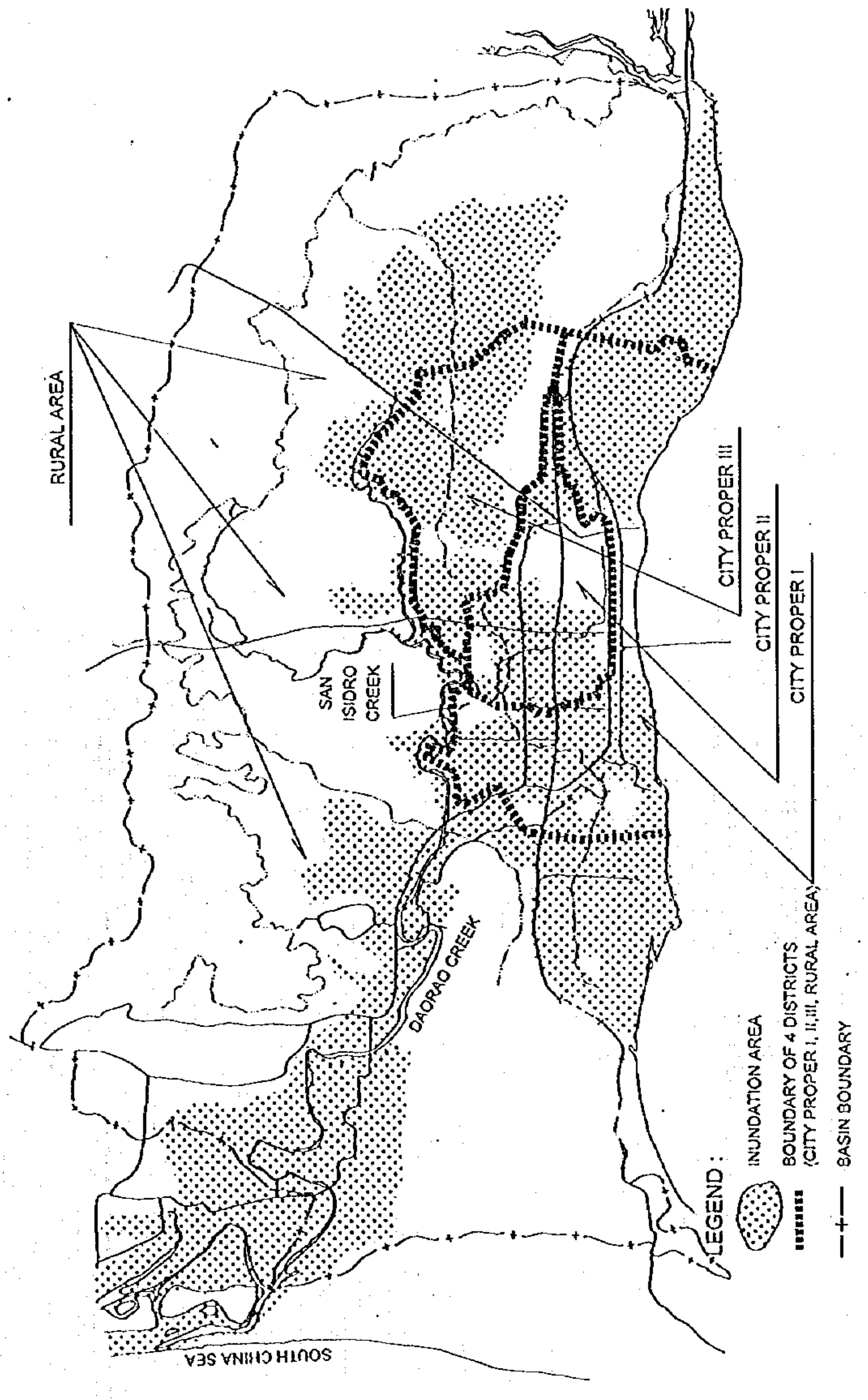
Fig. III.7
Division of Laoag Urban Drainage Area



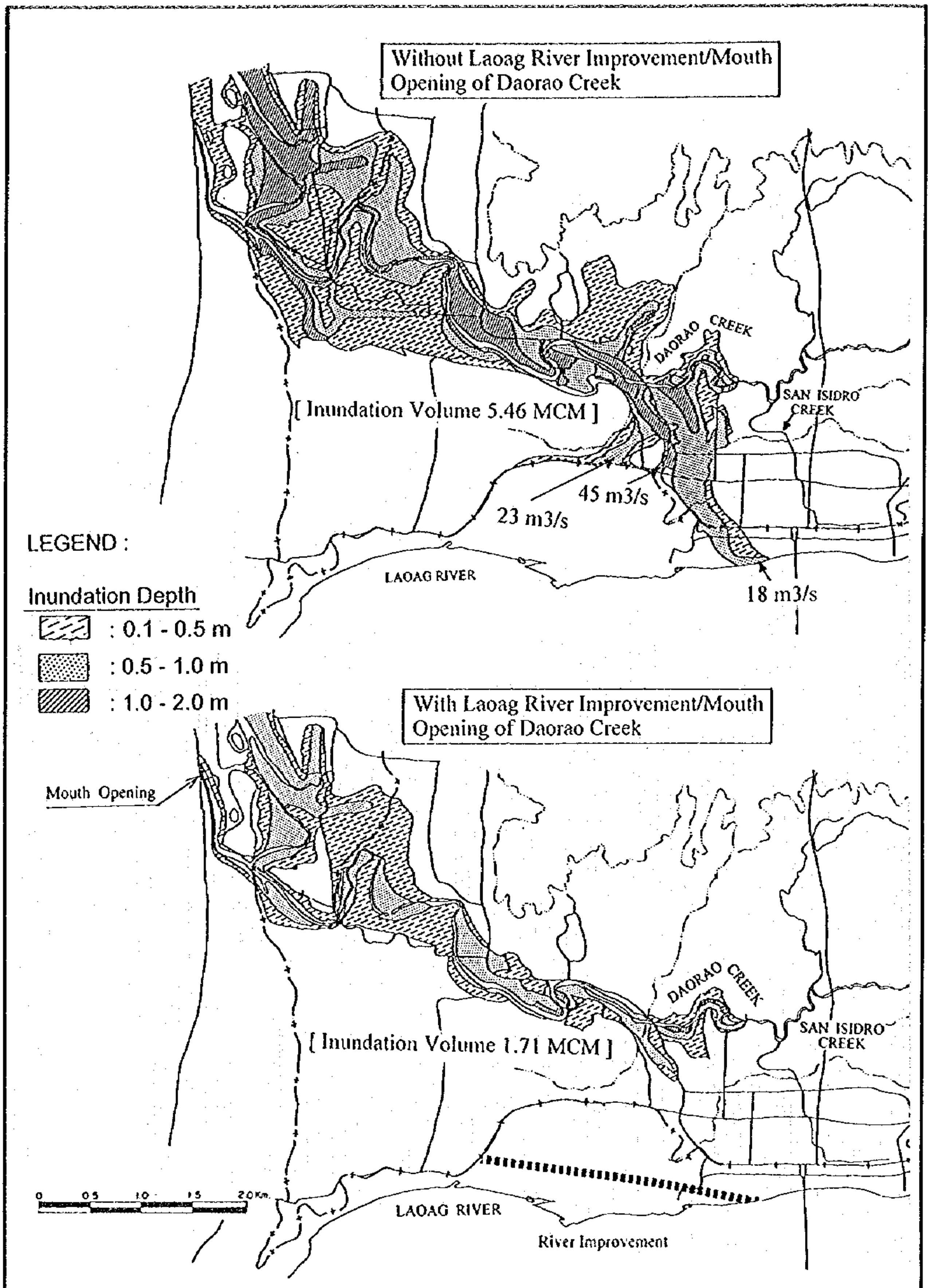
THE STUDY ON SABO AND FLOOD CONTROL IN THE LAOAG RIVER BASIN JAPAN INTERNATIONAL COOPERATION AGENCY	Fig. III.8 Schematic Diagram of Laoag Urban Drainage



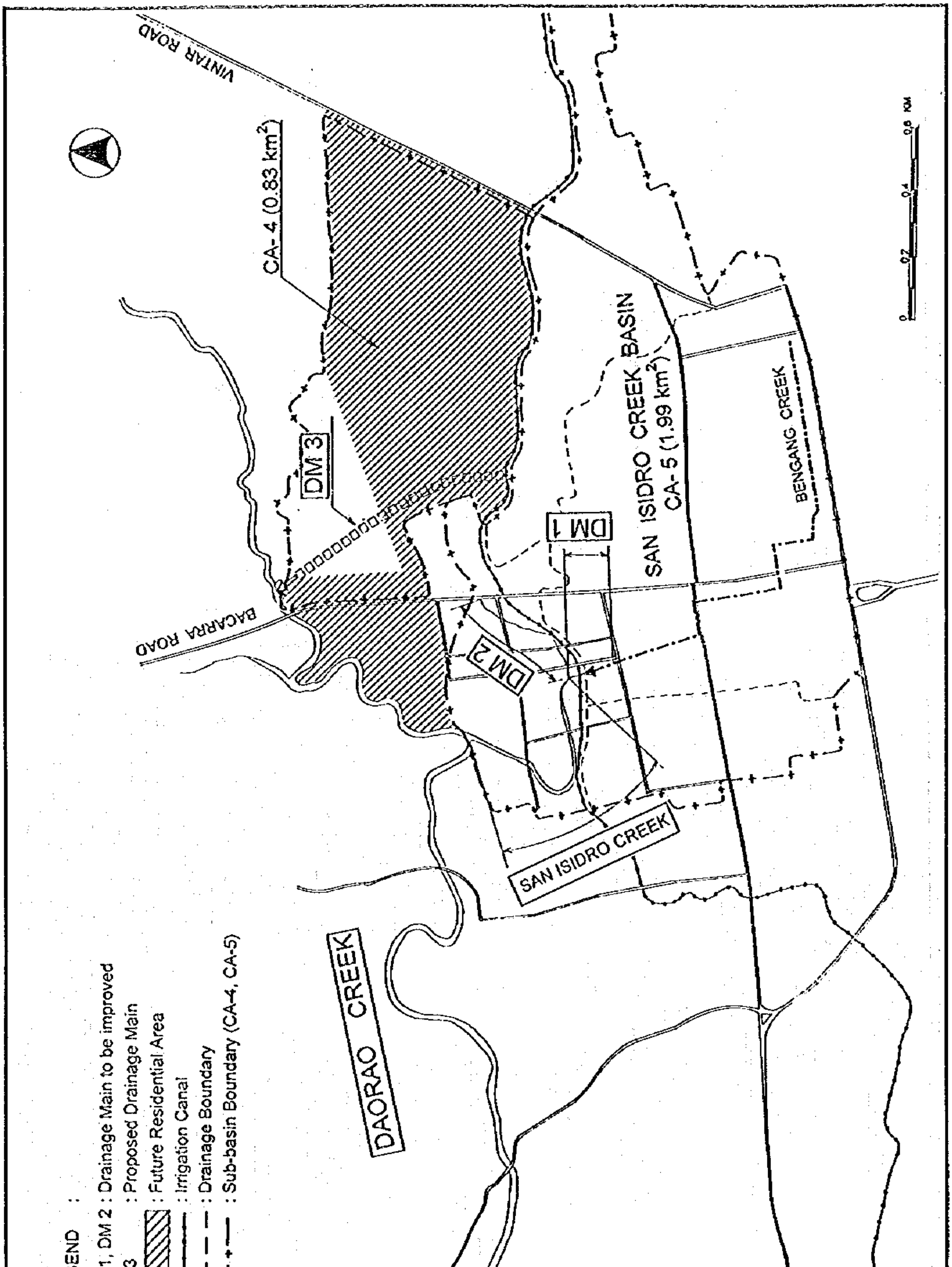
THE STUDY ON SABO AND FLOOD CONTROL IN THE LAOAG RIVER BASIN	Fig. III.9 Flood Inundation Map of Laoag City by 1996 Typhoon Gloring
JAPAN INTERNATIONAL COOPERATION AGENCY	



THE STUDY ON SABO AND FLOOD CONTROL IN THE LAOAG RIVER BASIN	Fig. III.10
JAPAN INTERNATIONAL COOPERATION AGENCY	Division of Inundation Area

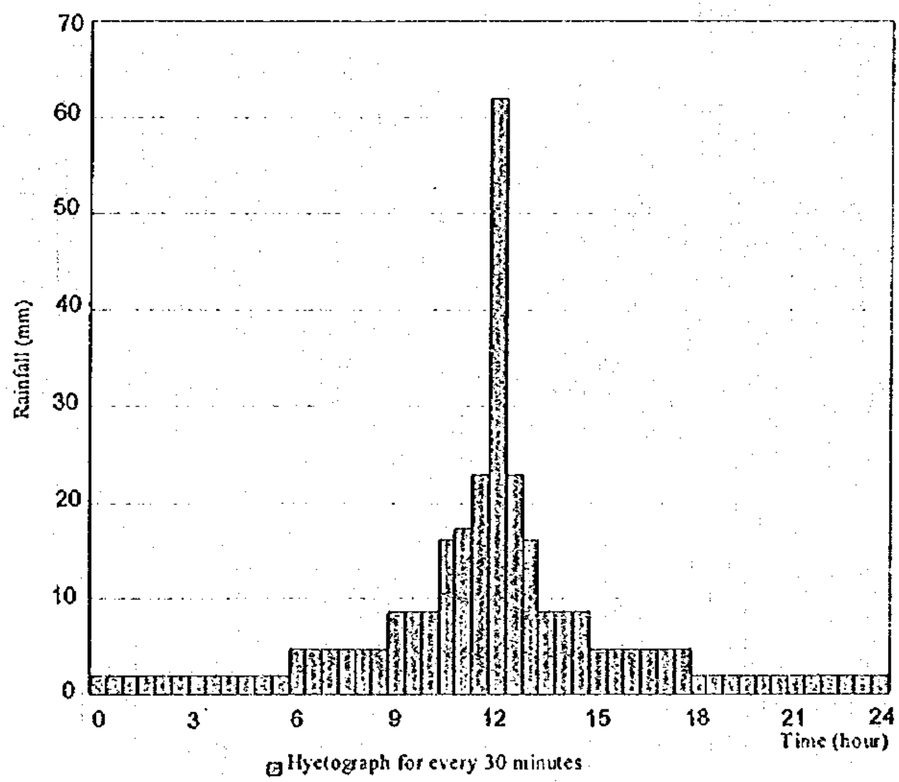


THE STUDY ON SABO AND FLOOD CONTROL IN THE LAOAG RIVER BASIN	Fig. III.11
JAPAN INTERNATIONAL COOPERATION AGENCY	Inundation With/Without the Laoag River Improvement/Mouth Opening of Daorao Creek



THE STUDY ON SABO AND FLOOD CONTROL IN THE LAOAG RIVER BASIN JAPAN INTERNATIONAL COOPERATION AGENCY	Fig. III.12 Target Area for Drainage Improvement

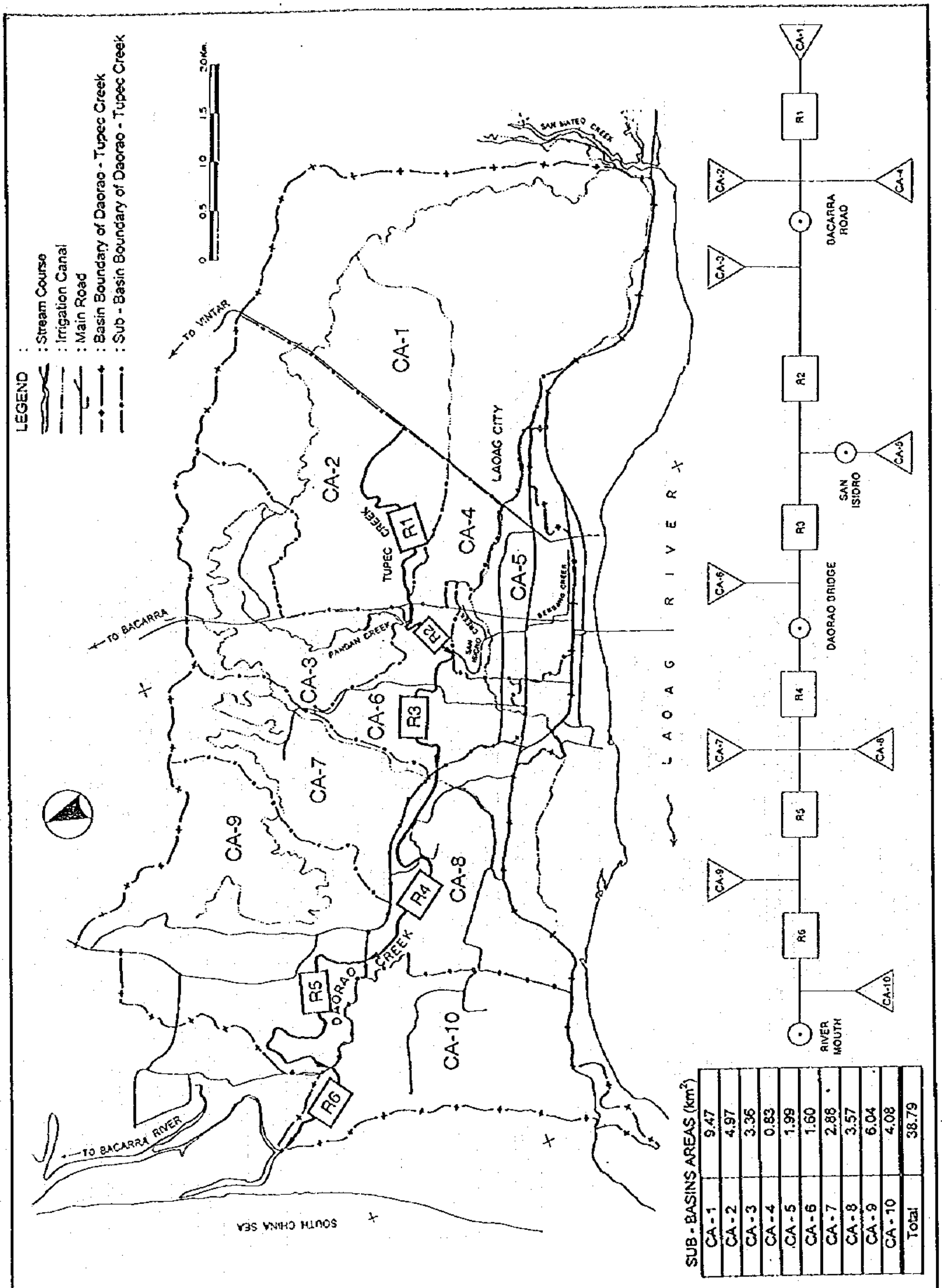
Time (hour)	Rainfall (mm)	Time (hour)	Rainfall (mm)	Time (hour)	Rainfall (mm)	Time (hour)	Rainfall (mm)
0.5	2.0	6.5	4.8	12.5	62.0	18.5	2.0
1.0	2.0	7.0	4.8	13.0	22.9	19.0	2.0
1.5	2.0	7.5	4.8	13.5	16.2	19.5	2.0
2.0	2.0	8.0	4.8	14.0	8.6	20.0	2.0
2.5	2.0	8.5	4.8	14.5	8.6	20.5	2.0
3.0	2.0	9.0	4.8	15.0	8.6	21.0	2.0
3.5	2.0	9.5	8.6	15.5	4.8	21.5	2.0
4.0	2.0	10.0	8.6	16.0	4.8	22.0	2.0
4.5	2.0	10.5	8.6	16.5	4.8	22.5	2.0
5.0	2.0	11.0	16.2	17.0	4.8	23.0	2.0
5.5	2.0	11.5	17.4	17.5	4.8	23.5	2.0
6.0	2.0	12.0	22.8	18.0	4.8	24.0	2.0
Total = 314.7mm							



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

JAPAN INTERNATIONAL COOPERATION AGENCY

Fig. III.13
Model Hyetograph (Point Rainfall)

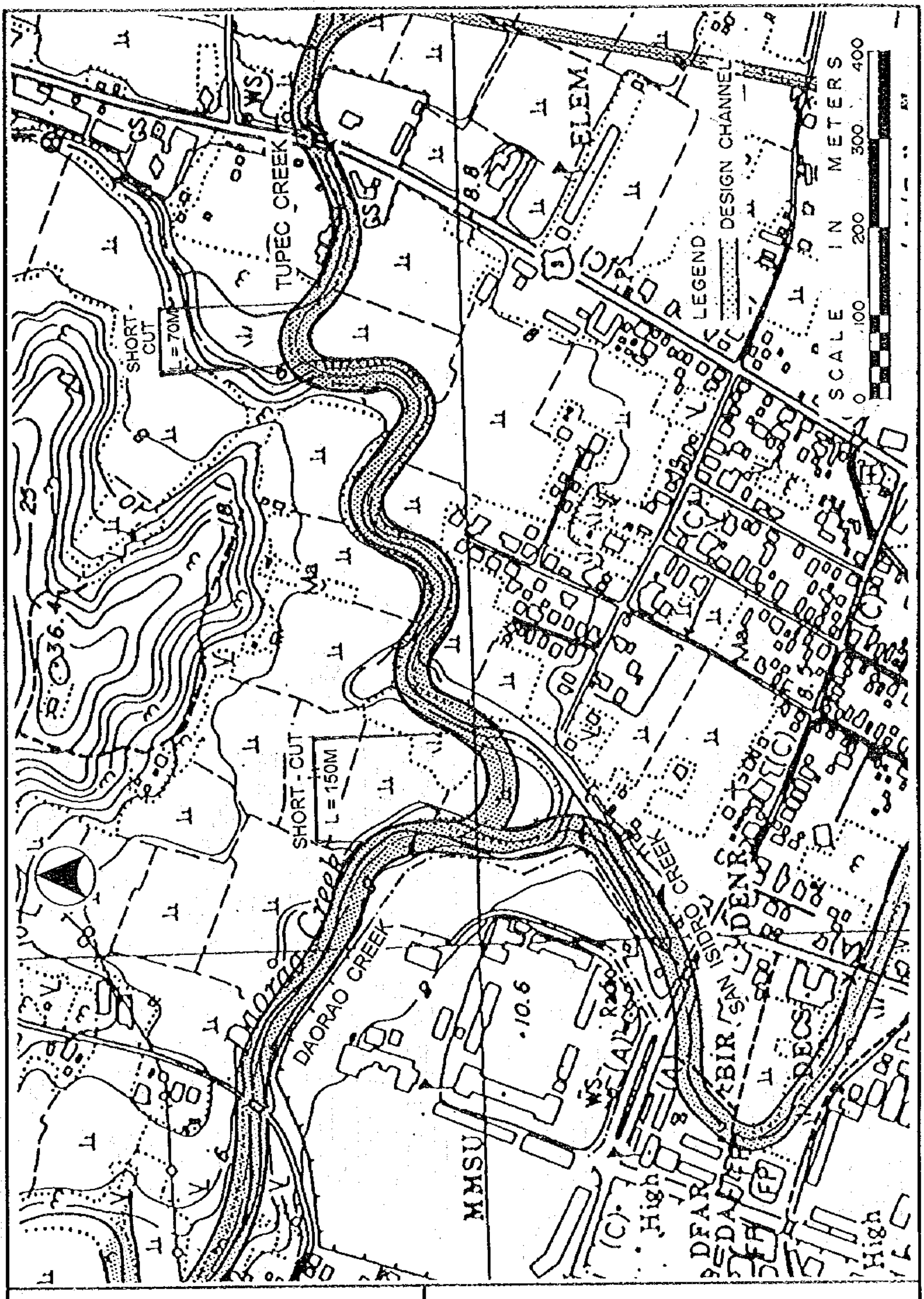


SUB - BASINS	AREAS (km^2)
CA - 1	9.47
CA - 2	4.97
CA - 3	3.36
CA - 4	0.83
CA - 5	1.99
CA - 6	1.60
CA - 7	2.88
CA - 8	3.57
CA - 9	6.04
CA - 10	4.08
Total	38.79

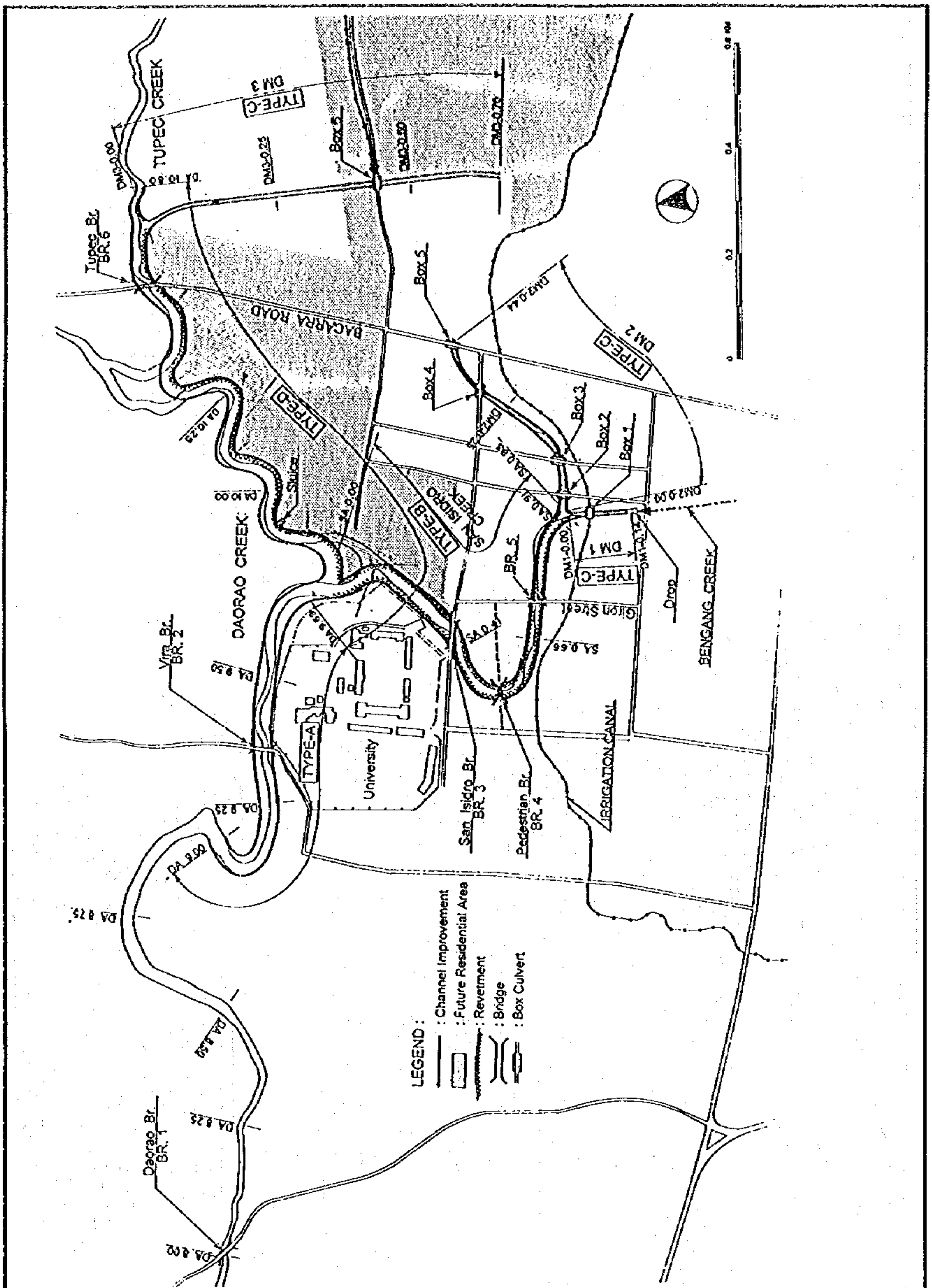
THE STUDY ON SABO AND FLOOD CONTROL IN THE LAOAG RIVER BASIN

JAPAN INTERNATIONAL COOPERATION AGENCY

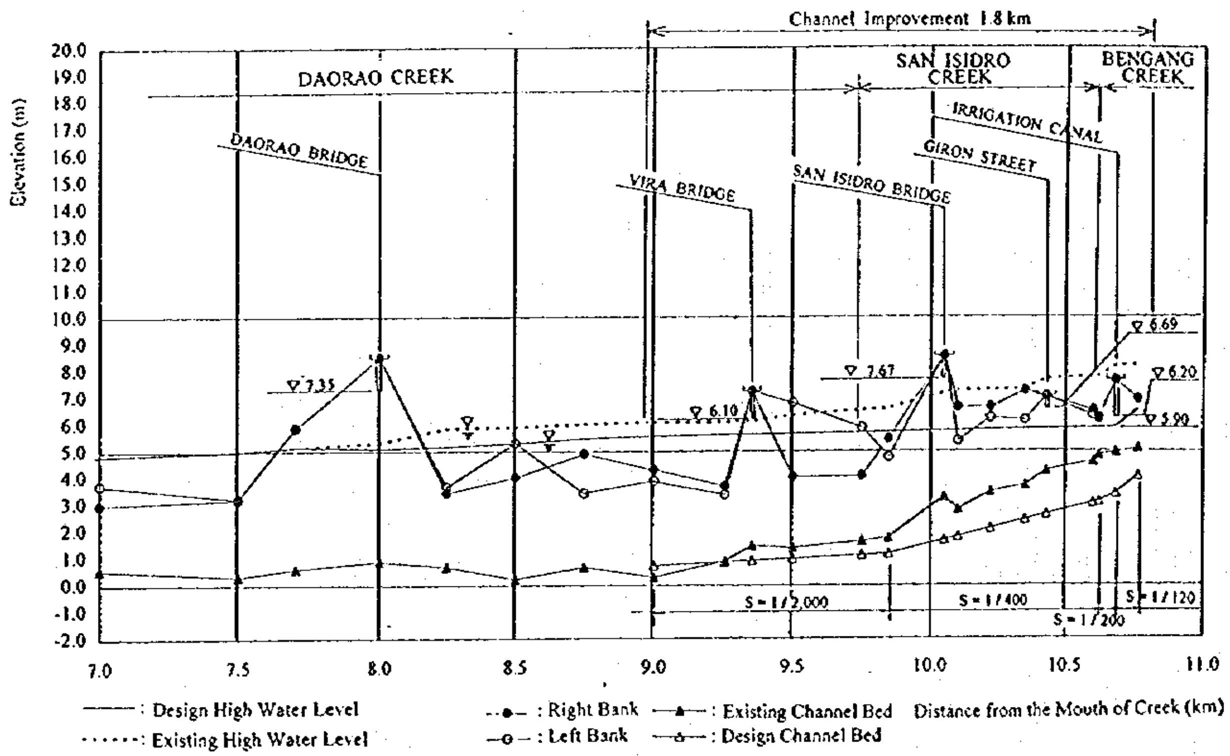
Fig. III.14
River System Model

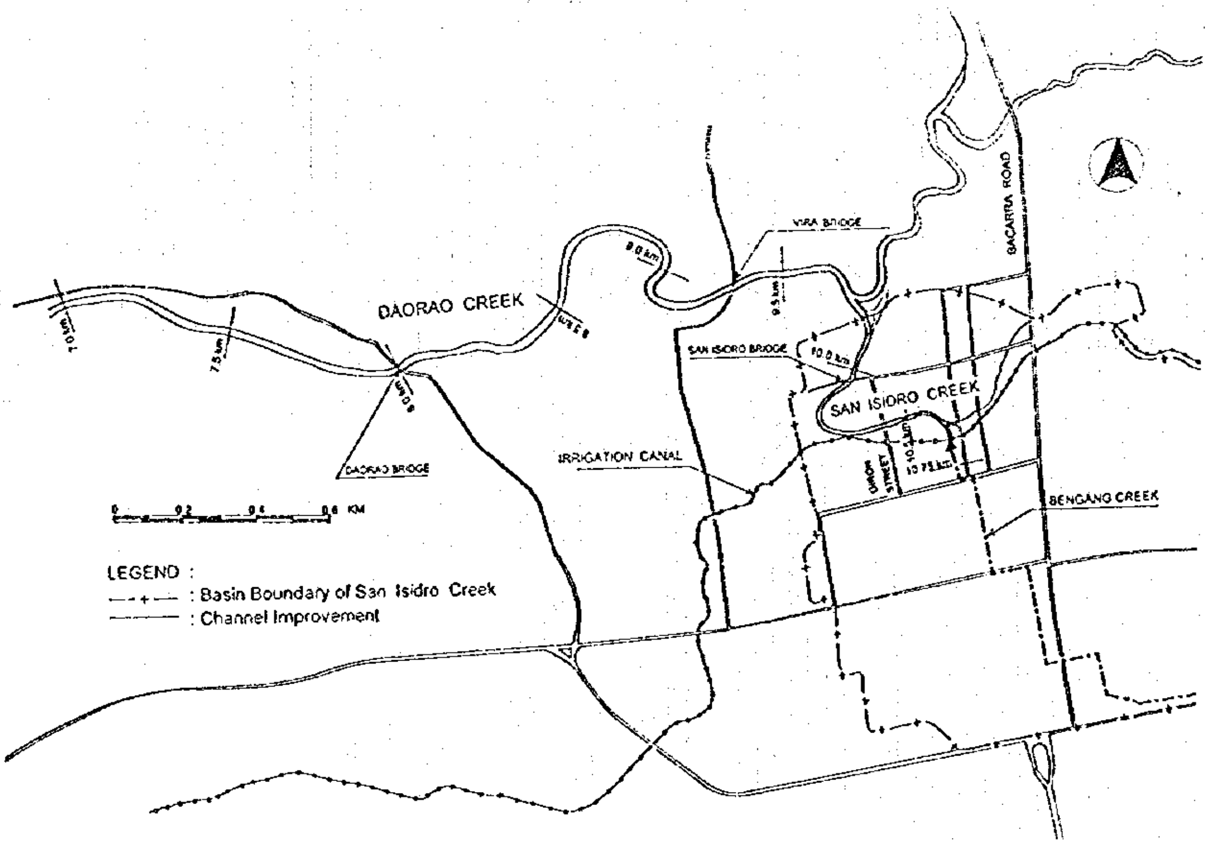


THE STUDY ON SABO AND FLOOD CONTROL IN THE LAOAG RIVER BASIN	Fig. III.15
JAPAN INTERNATIONAL COOPERATION AGENCY	Location of Cut-off Channel



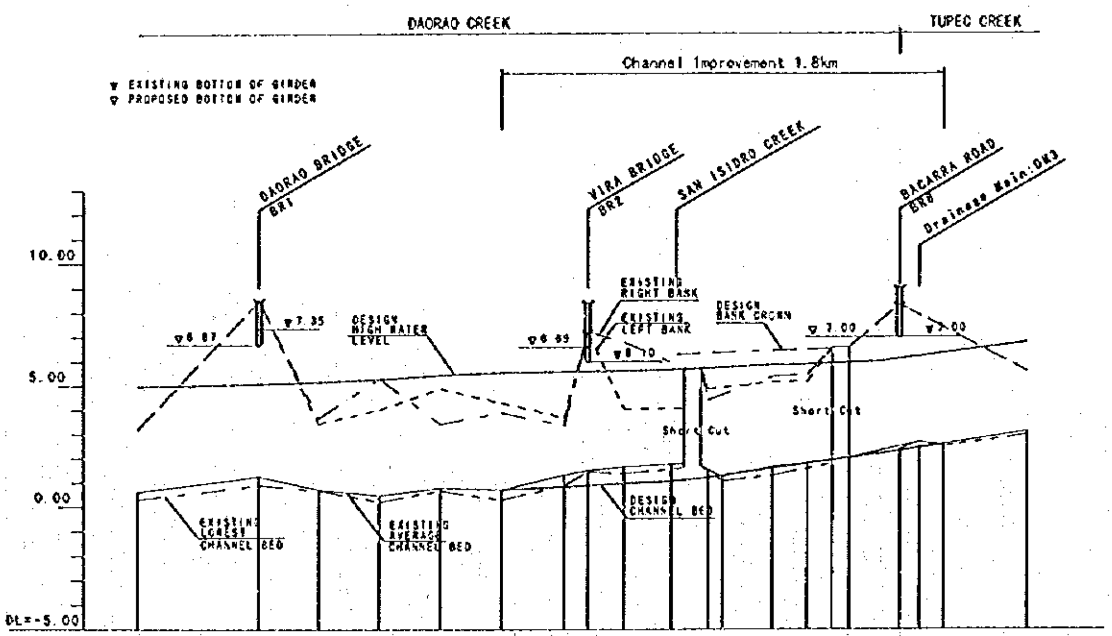
THE STUDY ON SABO AND FLOOD CONTROL IN THE LAOAG RIVER BASIN	Fig. III.16
JAPAN INTERNATIONAL COOPERATION AGENCY	Alignment of Improved Creeks and Drainage Mains in the Master Plan





THE STUDY ON SABO AND FLOOD CONTROL IN THE LAOAG RIVER BASIN	Fig. III.17
JAPAN INTERNATIONAL COOPERATION AGENCY	Comparison of Existing and Design High Water Level

Daorao－Tupec Creek



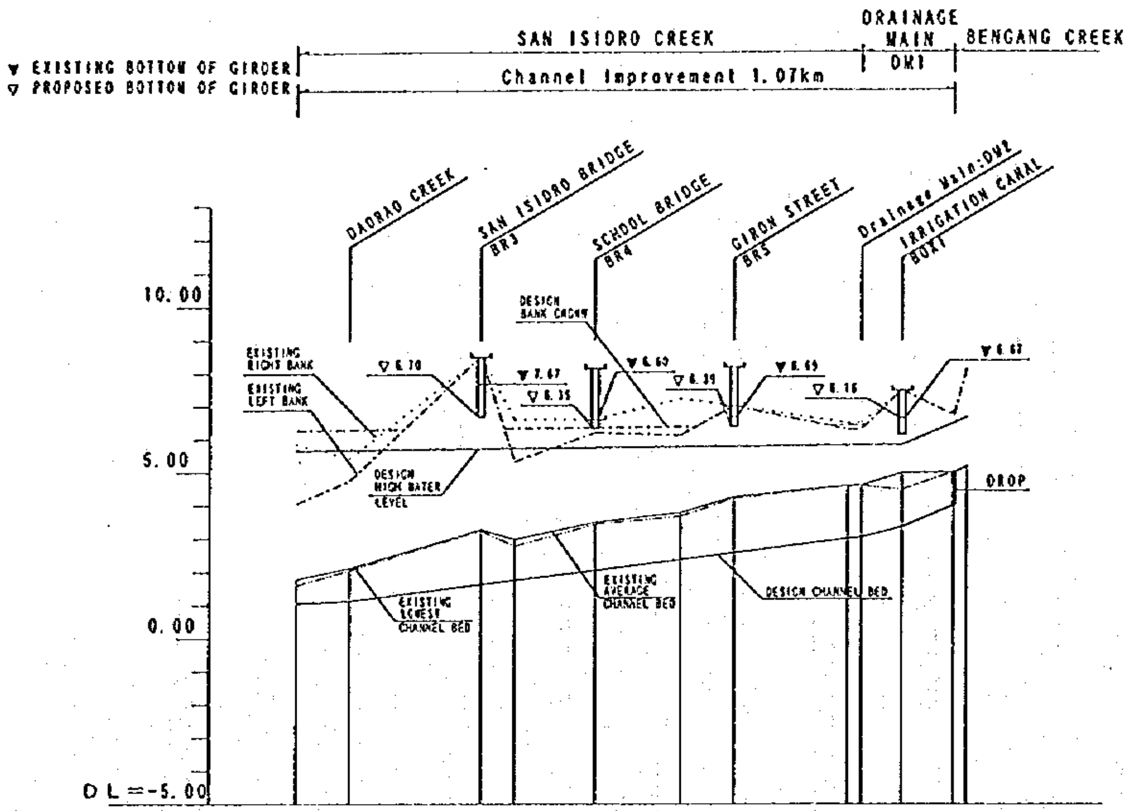
		DA-7.50	DA-8.00	DA-8.25	DA-8.50	DA-8.75	DA-9.00	DA-9.25	DA-9.35	DA-9.50	DA-9.69	DA-9.84	DA-10.11	DA-10.25	DA-10.35	DA-10.42	DA-10.62	DA-10.70	DA-10.80	DA-11.15
DESIGN	GRADIENT OF DESIGN CHANNEL BED						1/2,000				1/1,000	1/700								
	BANK CROWN												6.402	6.436	6.573	6.550				
	HIGH WATER LEVEL	4.970	5.080	5.150	5.270	5.430	5.530	5.571	5.586	5.612	5.644	5.670	5.802	5.836	5.924	5.956	6.115	6.214	6.339	
	CHANNEL BED						0.700	0.825	0.875	0.950	1.045	1.195	1.561	1.761	1.924	2.024	2.301	2.424	2.508	
EXISTING	AVERAGE CHANNEL BED	0.62	1.25	0.71	0.47	0.78	0.70	1.31	1.50	1.64	1.78	1.53	1.86	1.79	1.88	2.04	2.49	2.67	2.57	2.98
	LOWEST CHANNEL BED	0.30	0.87	0.66	0.20	0.64	0.27	0.85	1.42	1.35	1.59	1.48	1.77	1.56	1.77	1.94	2.36	2.67	2.47	2.43
	RIGHT BANK	3.17	6.50	3.42	4.00	4.87	4.78	3.48	7.20	4.01	5.93	4.84	5.14	5.45	6.57	6.57	6.30	7.89	7.38	5.60
	LEFT BANK	3.27	4.50	3.65	5.78	3.40	3.48	3.33	7.20	6.77	4.03	4.39	5.37	5.16	5.57	5.57	4.30	7.89	7.34	5.58
	DISTANCE(m)	0	500	250	250	250	250	250	100	150	190	150	270	140	100	70	200	80	100	350
	STATION NO.	DA-7.50	DA-8.00	DA-8.25	DA-8.50	DA-8.75	DA-9.00	DA-9.25	DA-9.35	DA-9.50	DA-9.69	DA-9.84	DA-10.11	DA-10.25	DA-10.35	DA-10.42	DA-10.62	DA-10.70	DA-10.80	DA-11.15

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

JAPAN INTERNATIONAL COOPERATION AGENCY

Fig. III.18 (1)
Longitudinal Profile of Improved Channels in the Master Plan

San Isidro Creek, Drainage Main : DM1

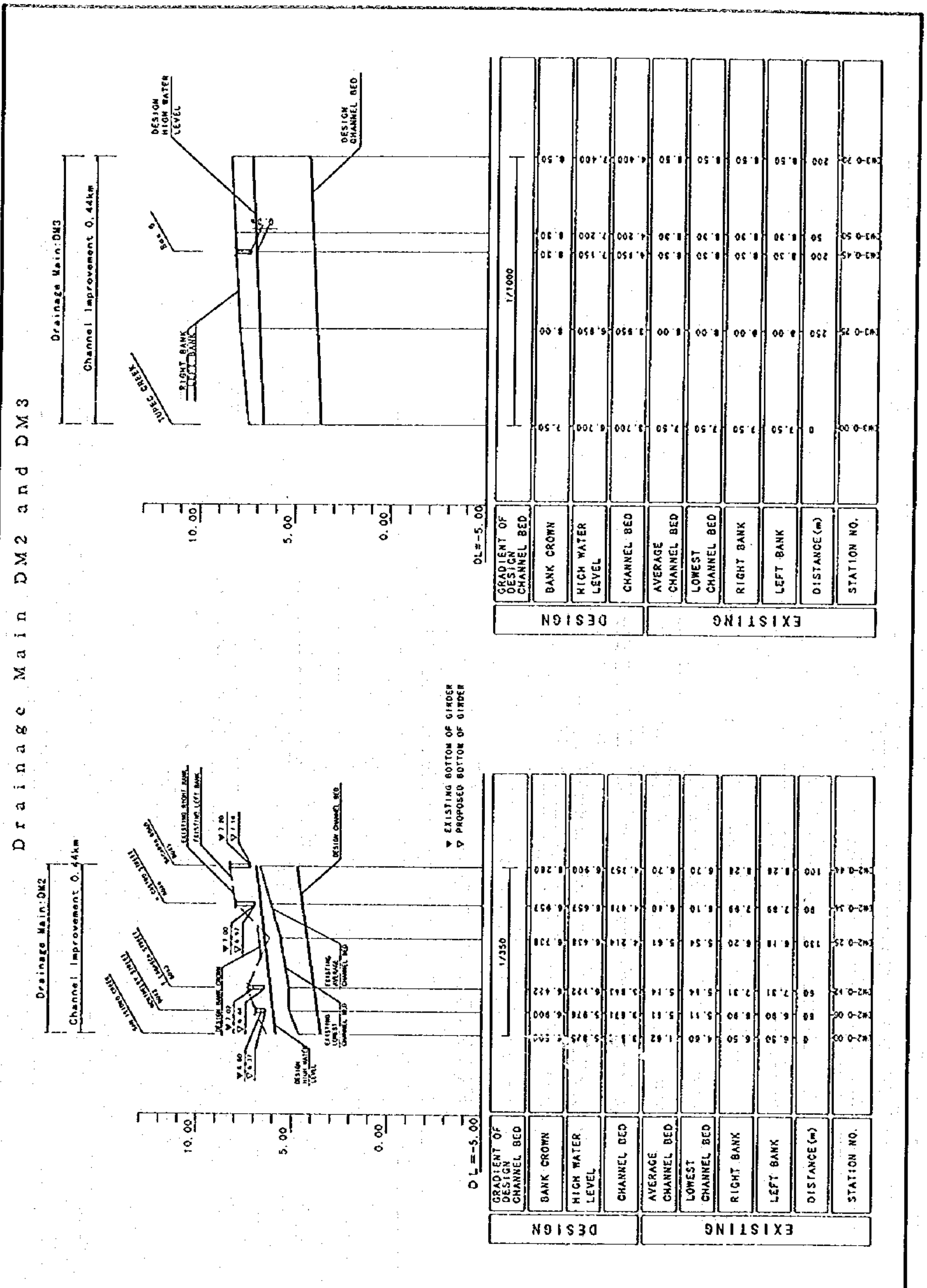


		SA-0.00	SA-0.16	SA-0.36	SA-0.41	SA-0.53	SA-0.66	SA-0.74	SA-0.91	SA-0.93 / DM1-0.00	DM1-0.06	DM1-0.14	DM1-0.18
DESIGN	GRADIENT OF DESIGN CHANNEL BED	1/800	1/410							1/220	1/120		
DESIGN	BANK CROWN	6.224	6.265	6.307	6.317	6.342	6.369	6.386	6.421	6.425	6.450	6.817	6.984
DESIGN	HIGH WATER LEVEL	5.644	5.665	5.707	5.717	5.742	5.769	5.786	5.821	5.825	5.850	6.517	6.684
DESIGN	CHANNEL BED	1.045	1.245	1.732	1.855	2.147	2.415	2.660	3.074	3.123	3.396	4.063 / 5.063	5.185
EXISTING	AVERAGE CHANNEL BED	1.78	2.12	3.28	2.98	3.51	3.79	4.27	4.61	4.62	5.00	5.03	5.19
EXISTING	LOWEST CHANNEL BED	1.59	2.04	3.23	2.77	3.43	3.67	4.21	4.57	4.60	4.48	5.03	5.19
EXISTING	RIGHT BANK	4.04	5.41	8.50	6.59	6.60	7.21	7.00	6.49	6.50	7.50	6.73	8.18
EXISTING	LEFT BANK	5.83	4.73	8.50	5.32	6.19	6.11	7.00	6.29	6.30	7.50	6.73	8.18
EXISTING	DISTANCE(m)	0	160	200	50	120	130	80	170	20	60	80	40
EXISTING	STATION NO.	SA-0.00	SA-0.16	SA-0.36	SA-0.41	SA-0.53	SA-0.66	SA-0.74	SA-0.91	SA-0.93 / DM1-0.00	DM1-0.06	DM1-0.14	DM1-0.18

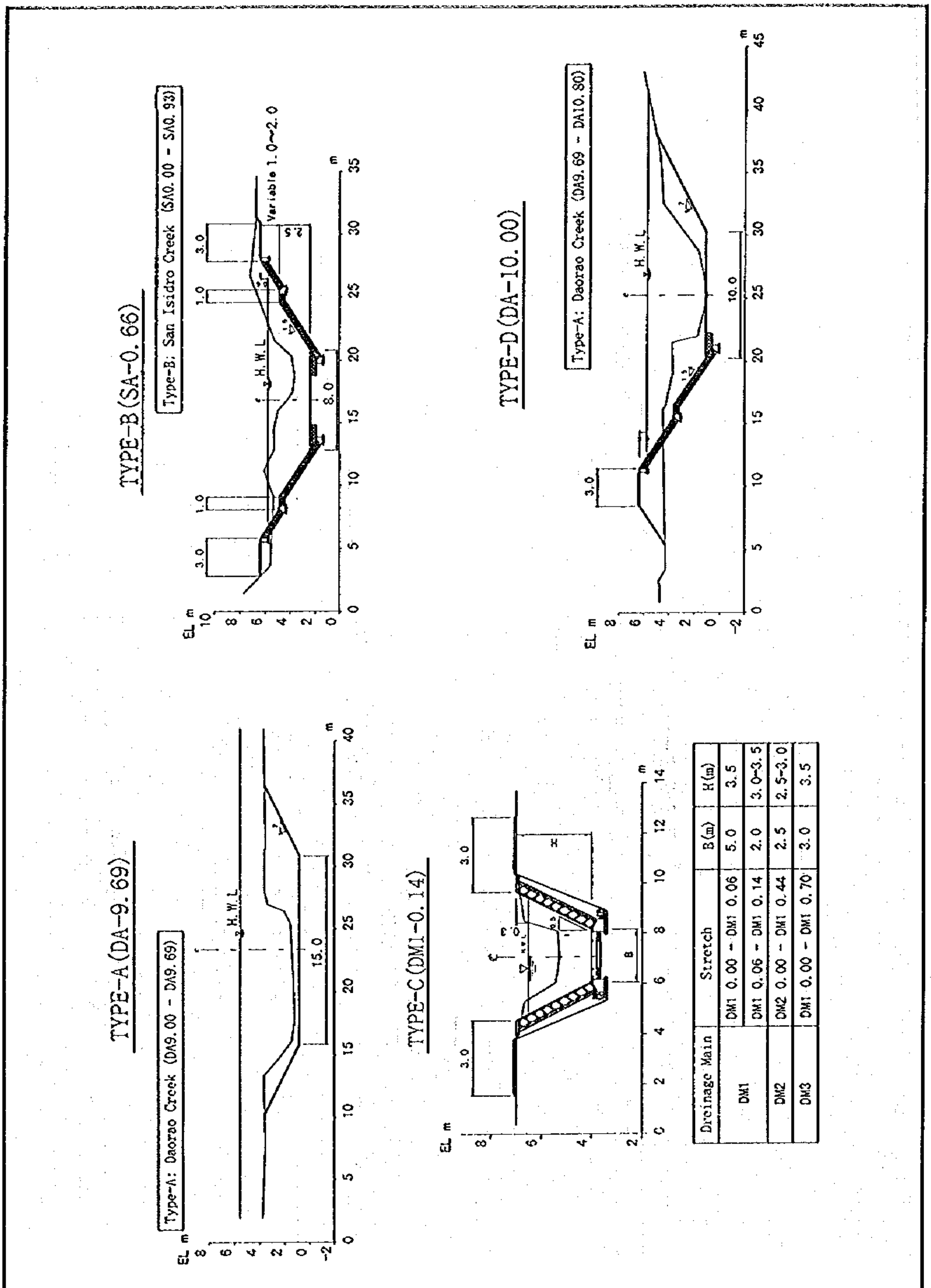
THE STUDY ON SABO AND FLOOD CONTROL IN THE LAOAG RIVER BASIN

JAPAN INTERNATIONAL COOPERATION AGENCY

Fig. III.18 (2) Longitudinal Profile of Improved Channels in the Master Plan



THE STUDY ON SABO AND FLOOD CONTROL IN THE LAOAG RIVER BASIN JAPAN INTERNATIONAL COOPERATION AGENCY	Fig. III.18 (3) Longitudinal Profile of Improved Channels in the Master Plan

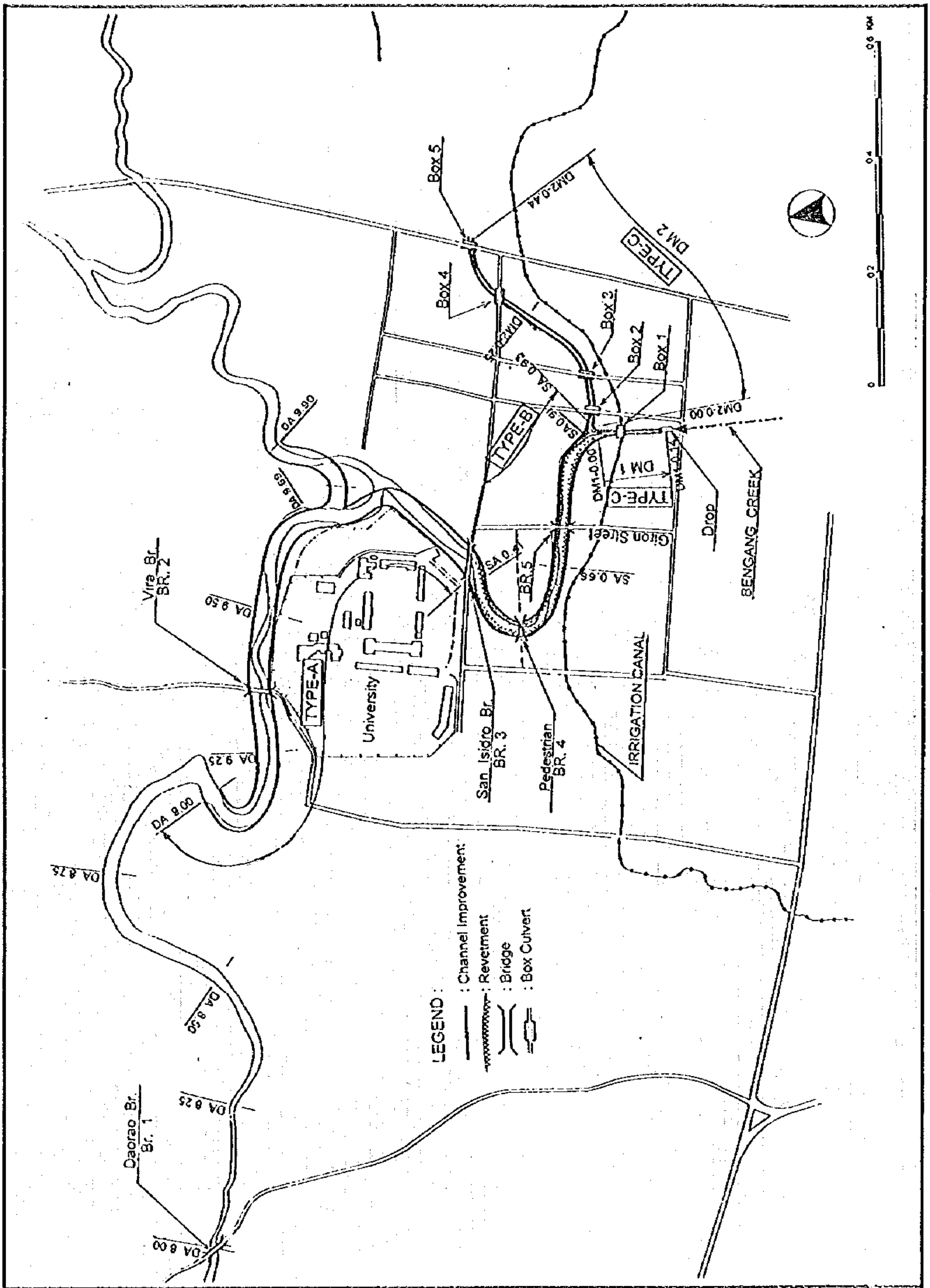


Drainage Main	Stretch	B(m)	H(m)
DM1	DM1 0.00 - DM1 0.06	5.0	3.5
	DM1 0.06 - DM1 0.14	2.0	3.0~3.5
DM2	DM2 0.00 - DM1 0.44	2.5	2.5~3.0
DM3	DM1 0.00 - DM1 0.70	3.0	3.5

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

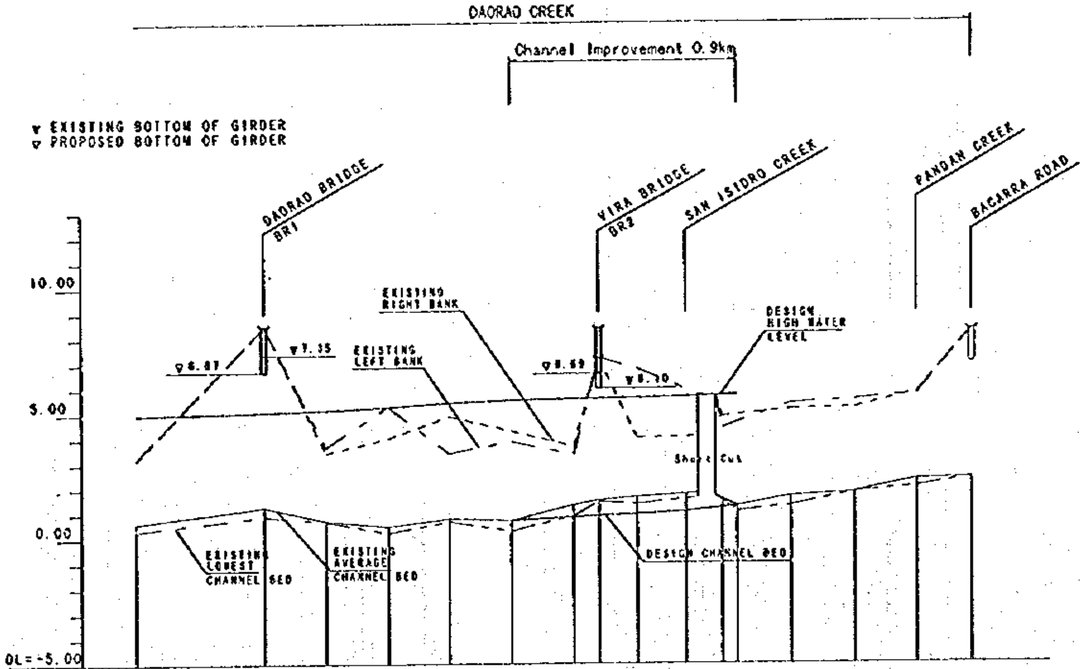
JAPAN INTERNATIONAL COOPERATION AGENCY

Fig. III.19
Cross Section of Improved Channels in the Master Plan



THE STUDY ON SABO AND FLOOD CONTROL IN THE LAOAG RIVER BASIN JAPAN INTERNATIONAL COOPERATION AGENCY	Fig. III.20 Alignment of Improved Creeks and Drainage Mains in the Urgent Plan

Daorao Creek

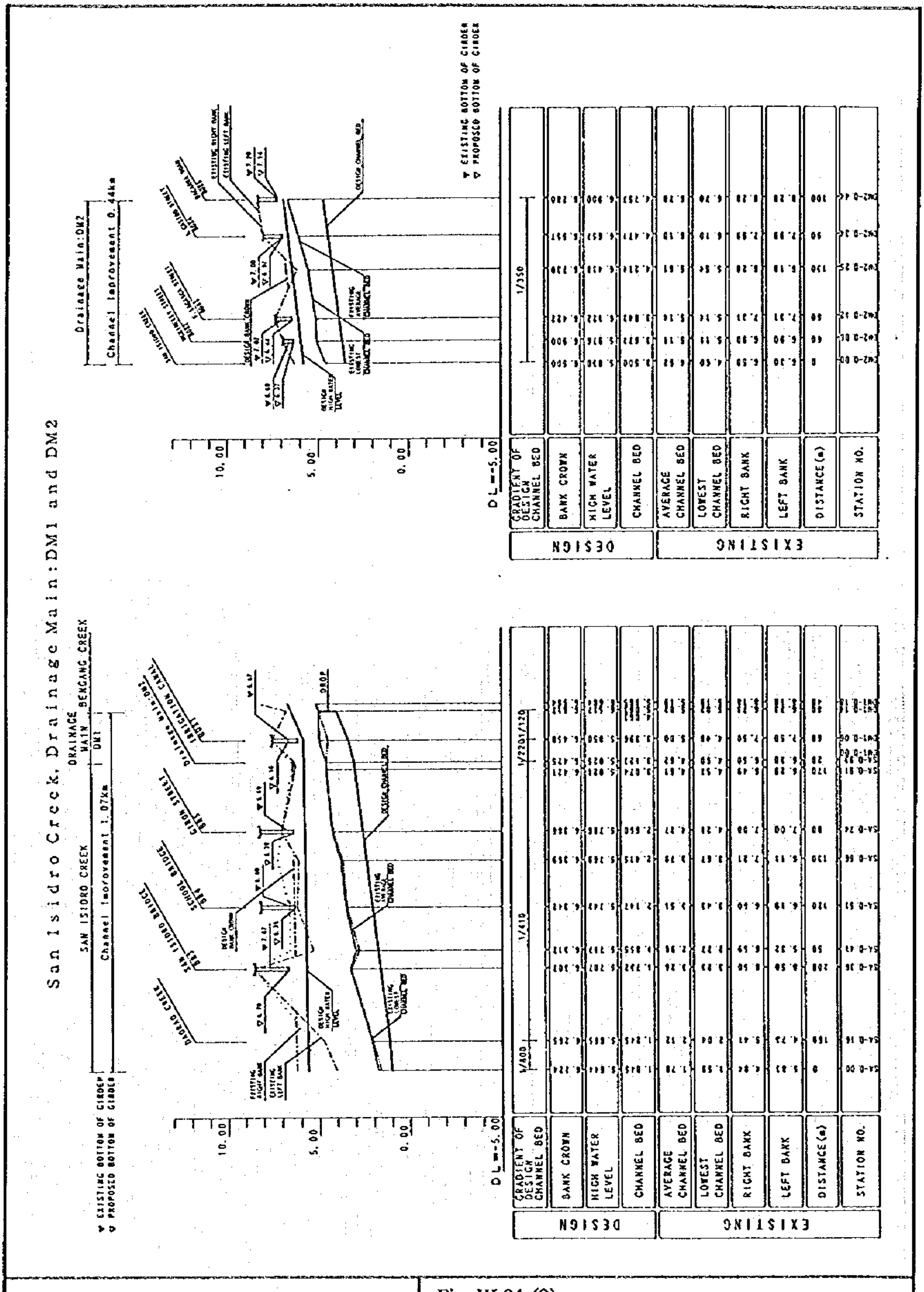


		DA-7.50	DA-8.00	DA-8.25	DA-8.50	DA-8.75	DA-9.00	DA-9.25	DA-9.35	DA-9.50	DA-9.69	DA-9.84	DA-9.90	DA-10.11	DA-10.36	DA-10.61	DA-10.83
DESIGN	GRADIENT OF DESIGN CHANNEL BED						1/2,000				1/1,000						
DESIGN	BANK CROWN																
DESIGN	HIGH WATER LEVEL	4.970	5.080	5.150	5.270	5.430	5.530	5.571	5.588	5.612	5.644	5.670	5.620				
DESIGN	CHANNEL BED						0.700	0.825	0.875	0.950	1.045	1.195	1.255				
EXISTING	AVERAGE CHANNEL BED	0.62	1.25	0.71	0.47	0.78	0.70	1.31	1.50	1.64	1.78	1.53	1.28	1.88	1.83	2.31	2.38
EXISTING	LOWEST CHANNEL BED	0.30	0.87	0.66	0.20	0.04	0.27	0.65	1.42	1.35	1.59	1.48	1.03	1.27	1.79	2.01	2.49
EXISTING	RIGHT BANK	3.17	6.50	3.42	4.00	4.87	4.28	3.88	7.20	4.01	5.93	4.84	4.91	5.14	5.18	5.80	6.30
EXISTING	LEFT BANK	3.22	6.50	3.65	5.28	3.40	3.48	3.33	7.20	6.77	4.03	4.39	4.61	5.37	5.52	5.74	6.30
EXISTING	DISTANCE(m)	0	500	250	250	250	250	250	100	150	190	150	60	210	250	250	220
EXISTING	STATION NO.	DA-7.50	DA-8.00	DA-8.25	DA-8.50	DA-8.75	DA-9.00	DA-9.25	DA-9.35	DA-9.50	DA-9.69	DA-9.84	DA-9.90	DA-10.11	DA-10.36	DA-10.61	DA-10.83

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

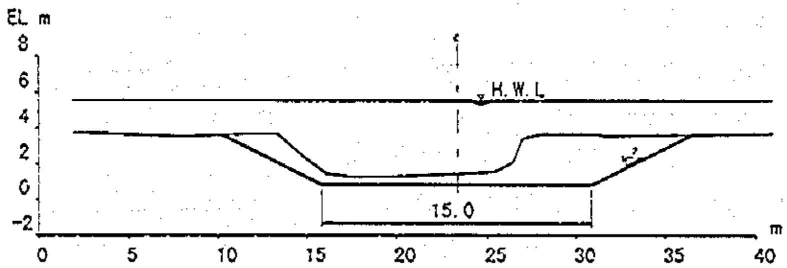
JAPAN INTERNATIONAL COOPERATION AGENCY

Fig. III.21 (1)
Longitudinal Profile of Improved Channels in the Urgent Plan



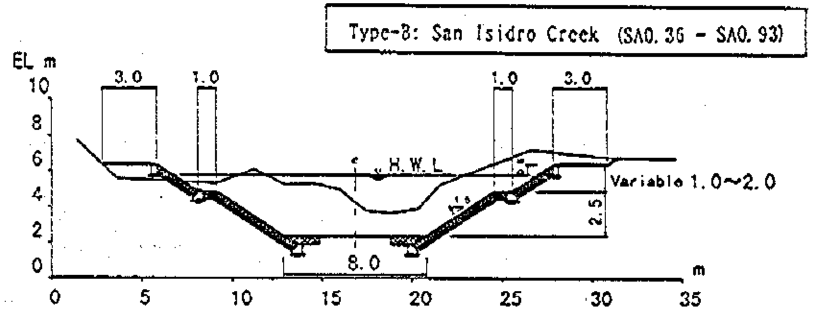
THE STUDY ON SABO AND FLOOD CONTROL IN THE LAOAG RIVER BASIN JAPAN INTERNATIONAL COOPERATION AGENCY	Fig. III.21 (2) Longitudinal Profile of Improved Channels in the Urgent Plan

TYPE-A (DA-9.69)

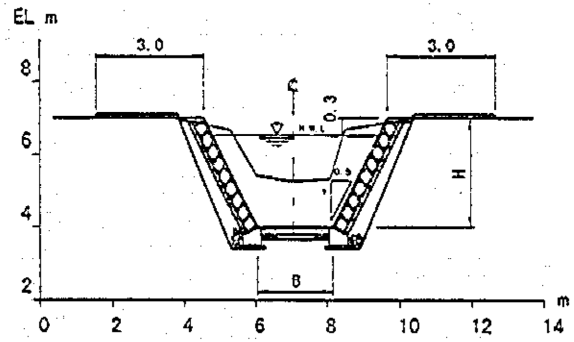


Type-A	Daorao Creek	(DA9.00 - DA9.90)
	San Isidro Creek	(SA0.00 - SA0.36)

TYPE-B (SA-0.66)



TYPE-C (DM1-0.14)



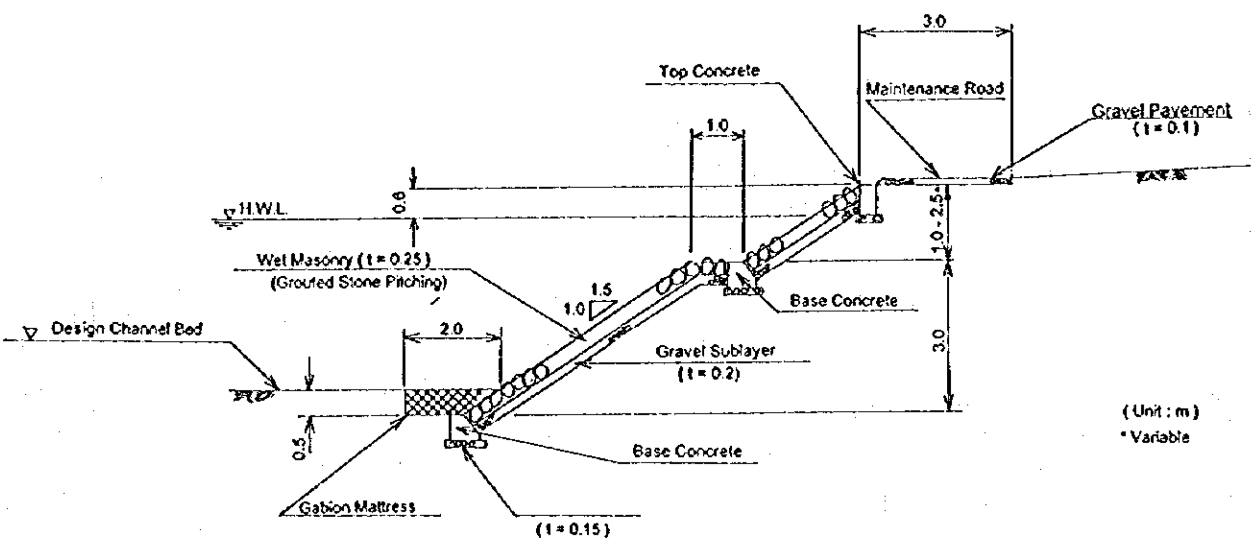
Dreinage Main	Stretch	B(m)	H(m)
DM1	DM1 0.00 - DM1 0.06	5.0	3.5
	DM1 0.06 - DM1 0.14	2.0	3.0-3.5
DM2	DM2 0.00 - DM1 0.44	2.5	2.5-3.0

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

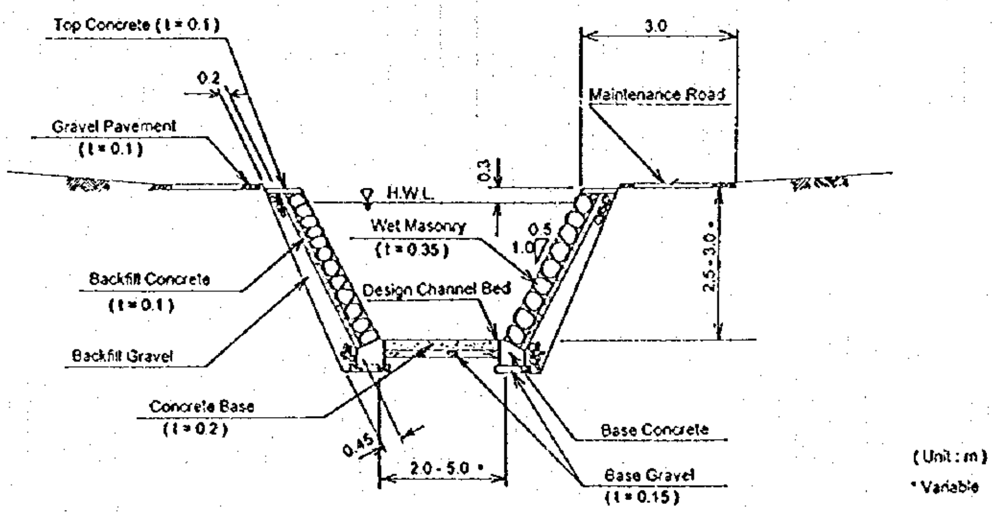
JAPAN INTERNATIONAL COOPERATION AGENCY

Fig. III.22
Cross Section of Improved Channels in the Urgent Plan

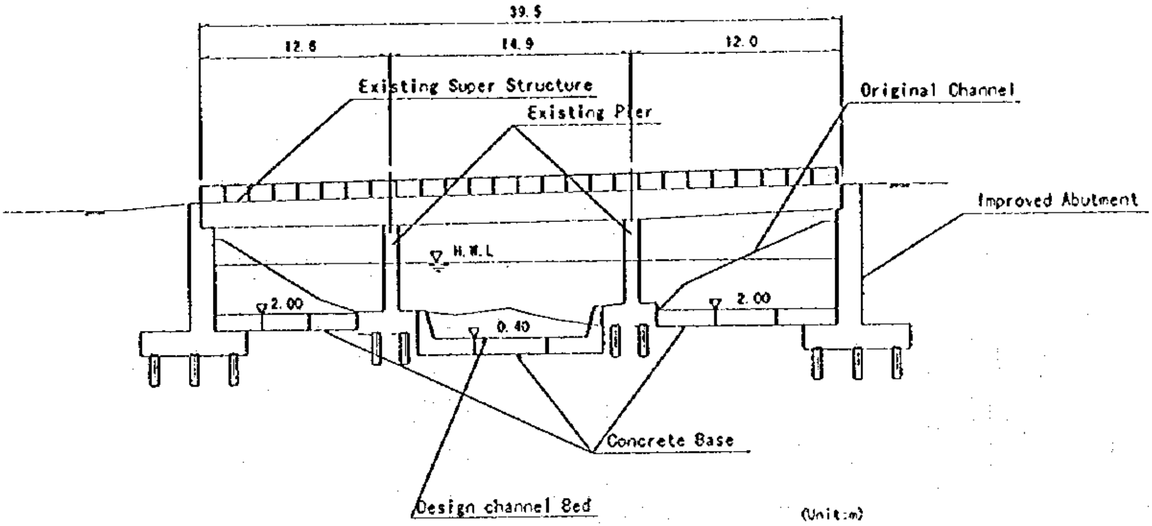
TYPE - RA



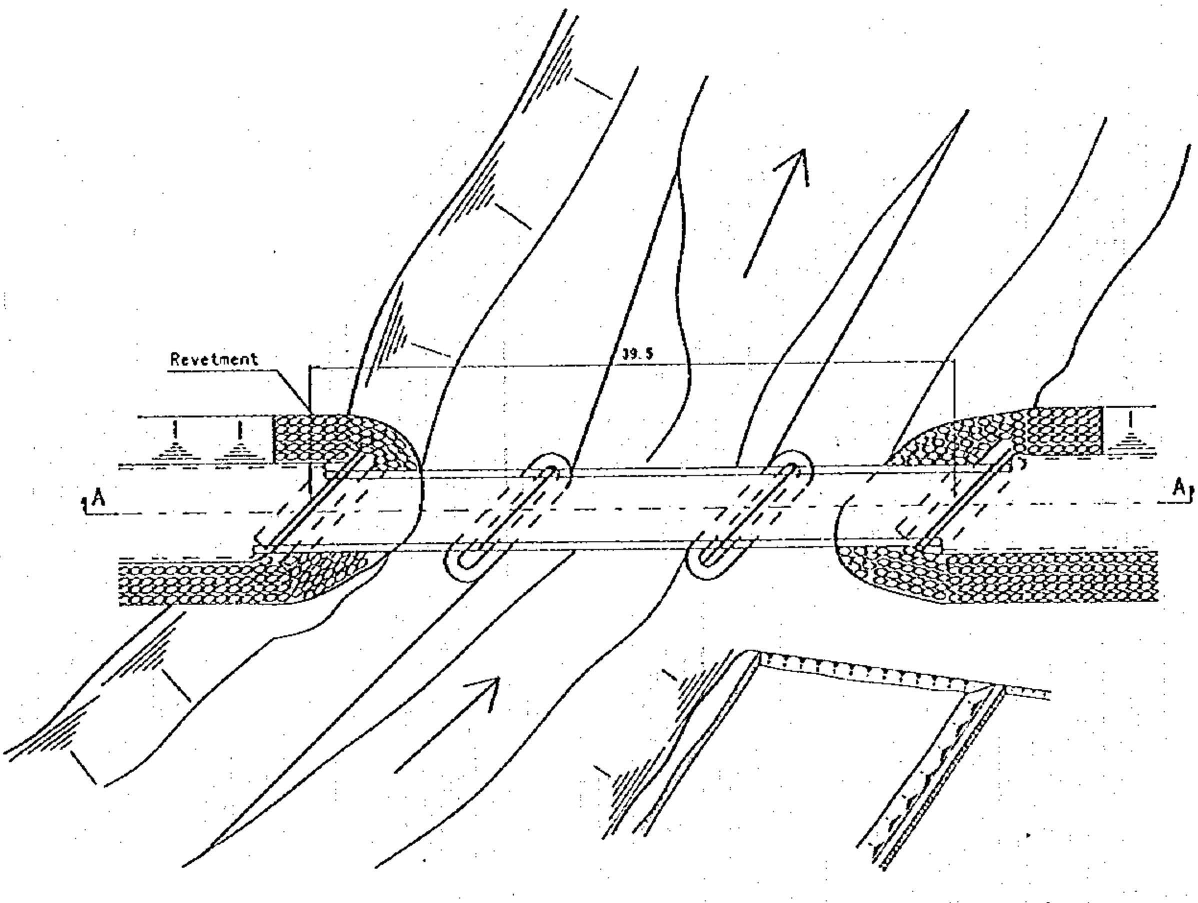
TYPE - RB



THE STUDY ON SABO AND FLOOD CONTROL IN THE LAOAG RIVER BASIN JAPAN INTERNATIONAL COOPERATION AGENCY	Fig. III.23 Proposed Structure of Bank Slope Protection Works



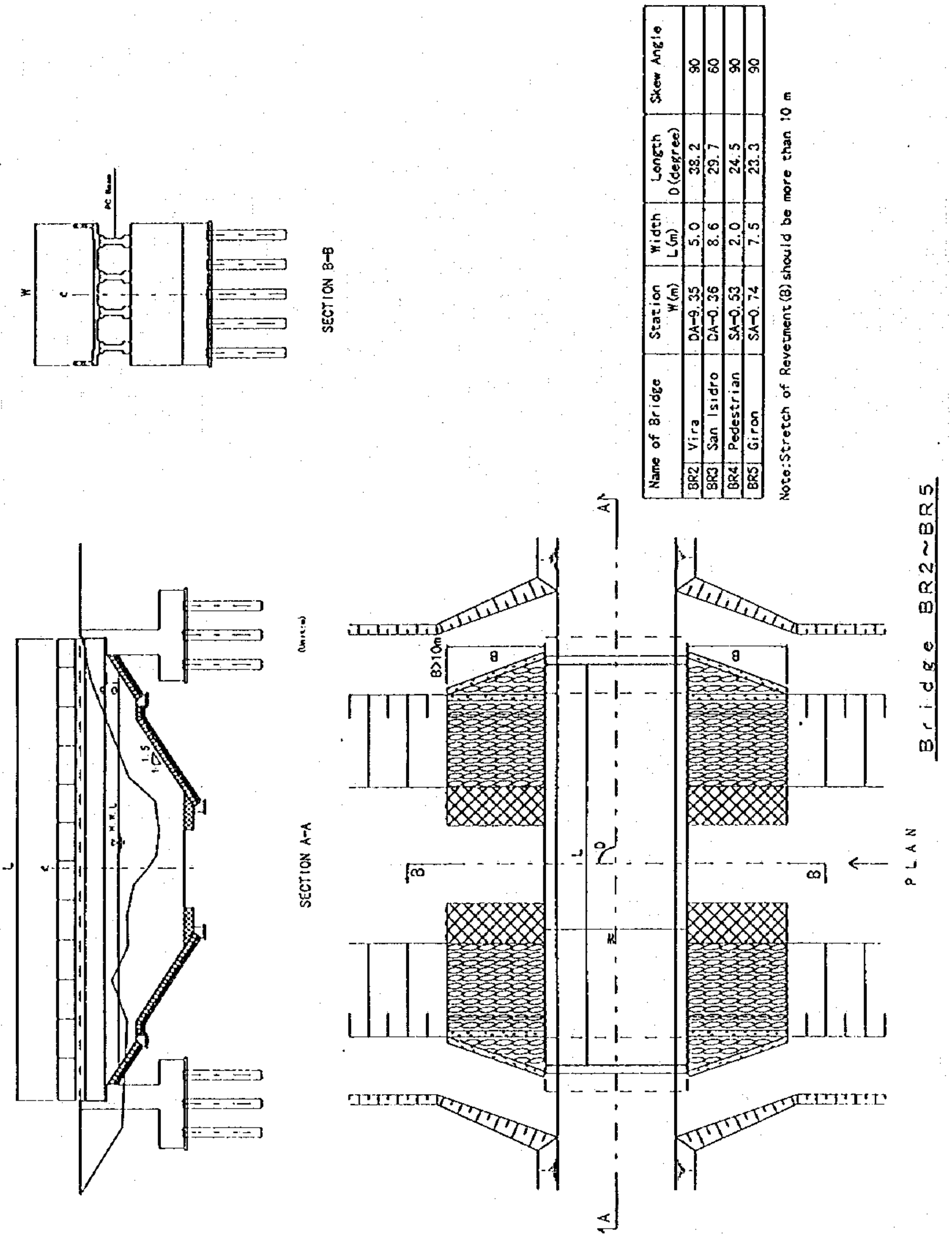
SECTION A-A



PLAN

DAORAO BRIDGE BR1 (DA-8.00)

THE STUDY ON SABO AND FLOOD CONTROL IN THE LAOAG RIVER BASIN JAPAN INTERNATIONAL COOPERATION AGENCY	Fig. III.24 (1) Proposed Plan and Section of Bridges



Name of Bridge		Station W(m)	Width L(m)	Length D(degree)	Skew Angle
BR2	Vira	DA-9.35	5.0	38.2	90
BR3	San Isidro	DA-0.36	8.6	29.7	60
BR4	Pedestrian	SA-0.53	2.0	24.5	90
BR5	Giron	SA-0.74	7.5	23.3	90

Note:Stretch of Revetment (B) should be more than 10 m

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

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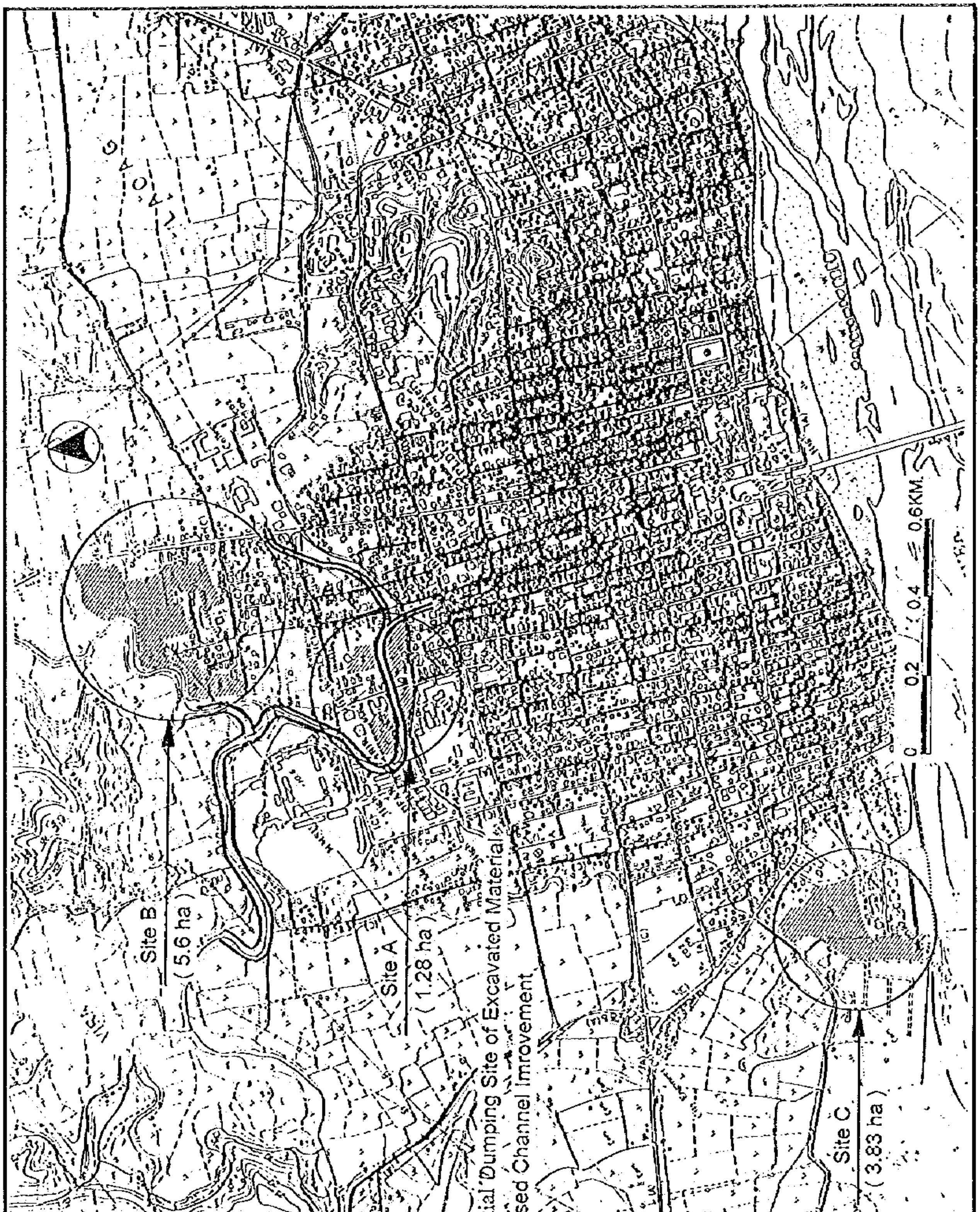
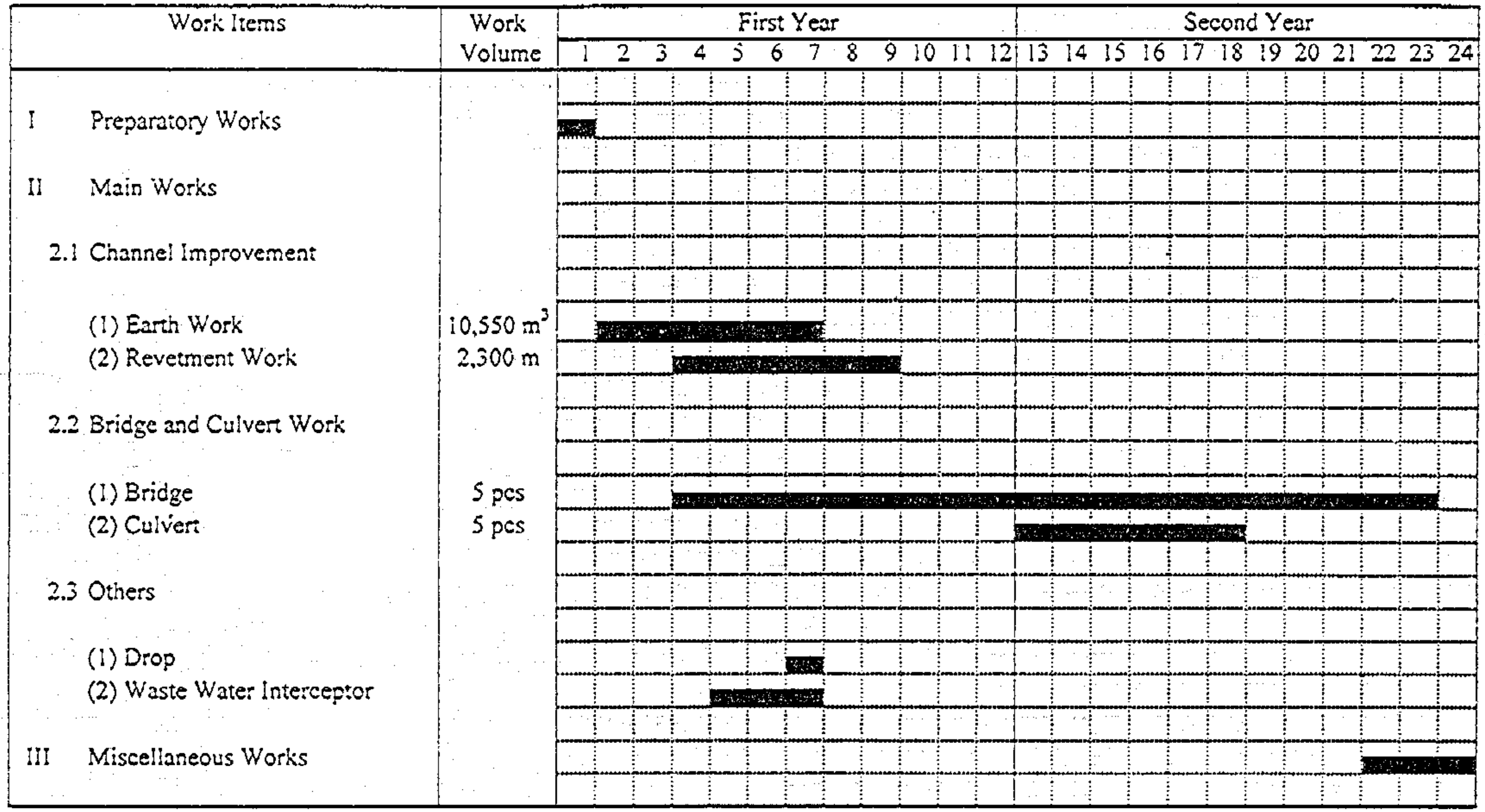
Fig. III.24 (2)
Proposed Plan and Section of Bridges



THE STUDY ON SABO AND FLOOD CONTROL IN THE LAOAG RIVER BASIN JAPAN INTERNATIONAL COOPERATION AGENCY	Fig. III.25 Potential Dumping Site of Excavated Material



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

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Fig. III.26
Construction Schedule