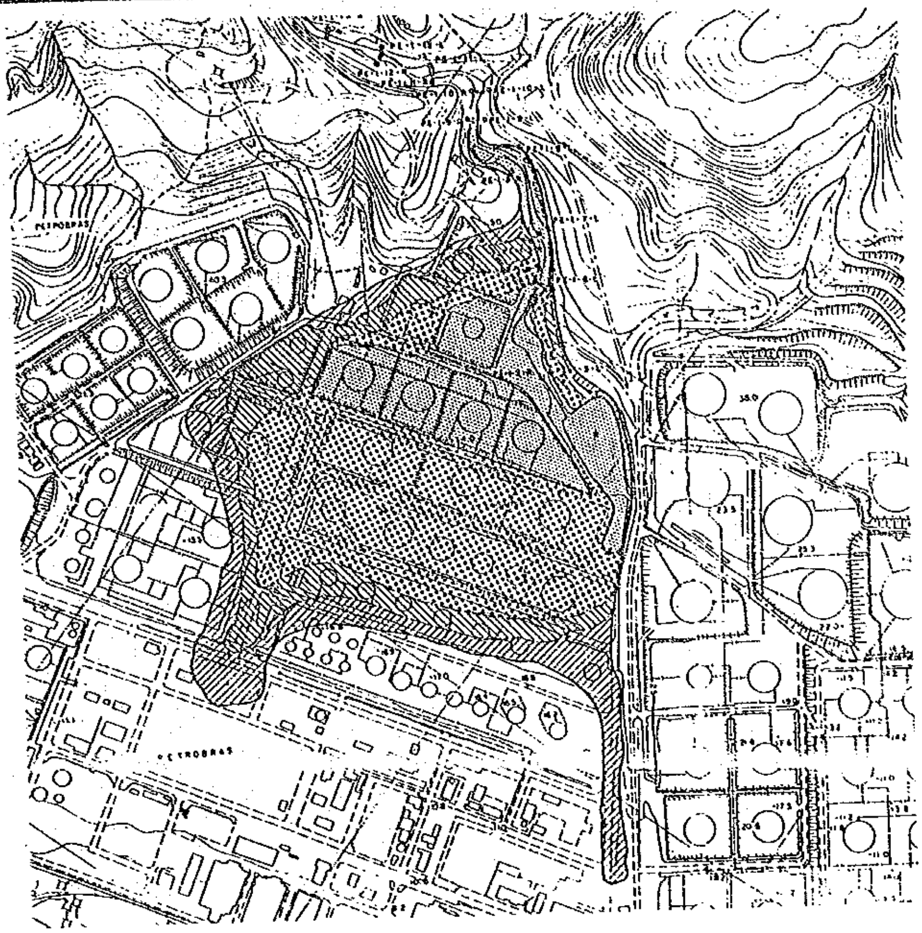

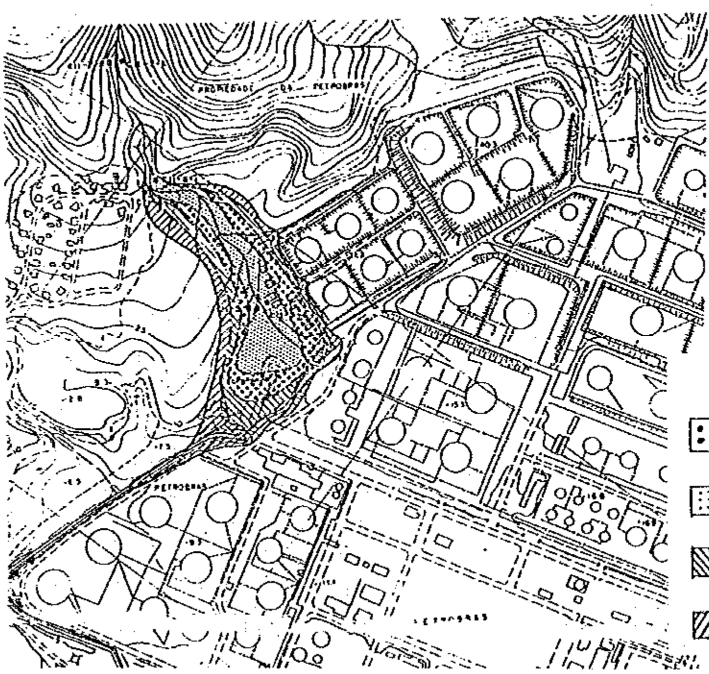

LEGEND

- Inundation area (1/ 5)
- Inundation area (1/25)
- Inundation area (1/50)
- Inundation area (1/100)

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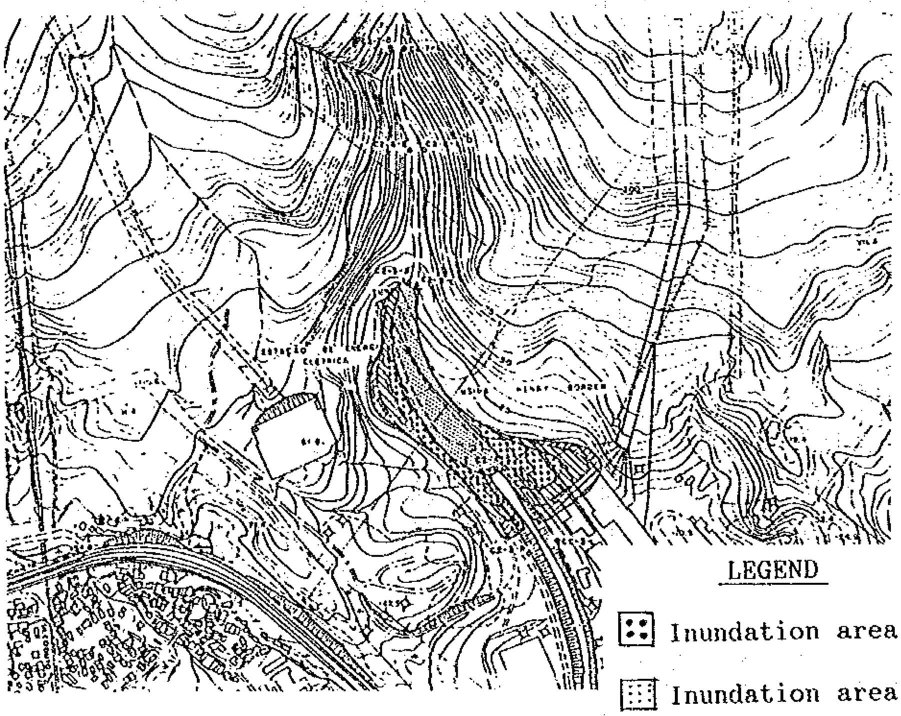
FIG.H.21
INUNDATION AREA OF DESIGN SEDIMENT RUN-OFF DISCHARGE (Sub basin 7 and 8)

Sub basin 9



Sub basin 10

LEGEND

Inundation area (1/ 5)

Inundation area (1/25)

Inundation area (1/50)

Inundation area (1/100)

FIG.H.22
INUNDATION AREA OF DESIGN SEDIMENT
RUN-OFF DISCHARGE (Sub basin 9 and 10)

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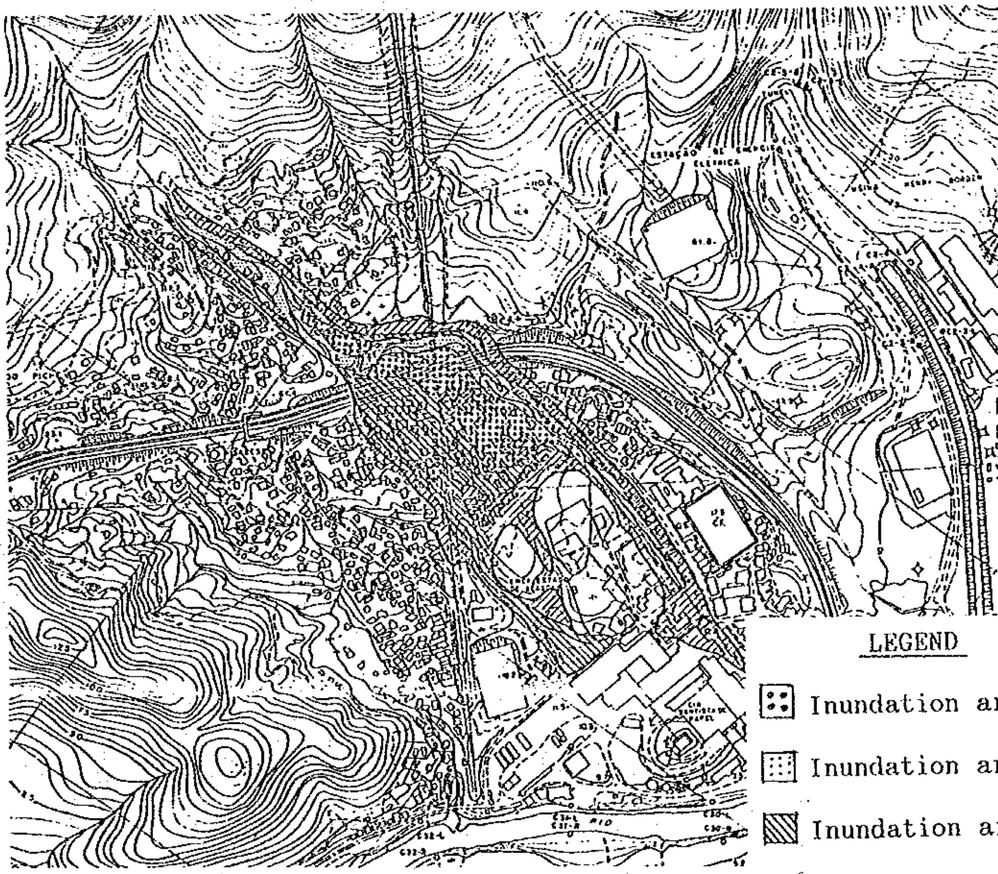
Sub basin 11



Sub basin 12

LEGEND

- Inundation area (1/ 5)
- Inundation area (1/25)
- Inundation area (1/50)
- Inundation area (1/100)

FIG.H.23
INUNDATION AREA OF DESIGN SEDIMENT
RUN-OFF DISCHARGE (Sub basin 11 and 12)

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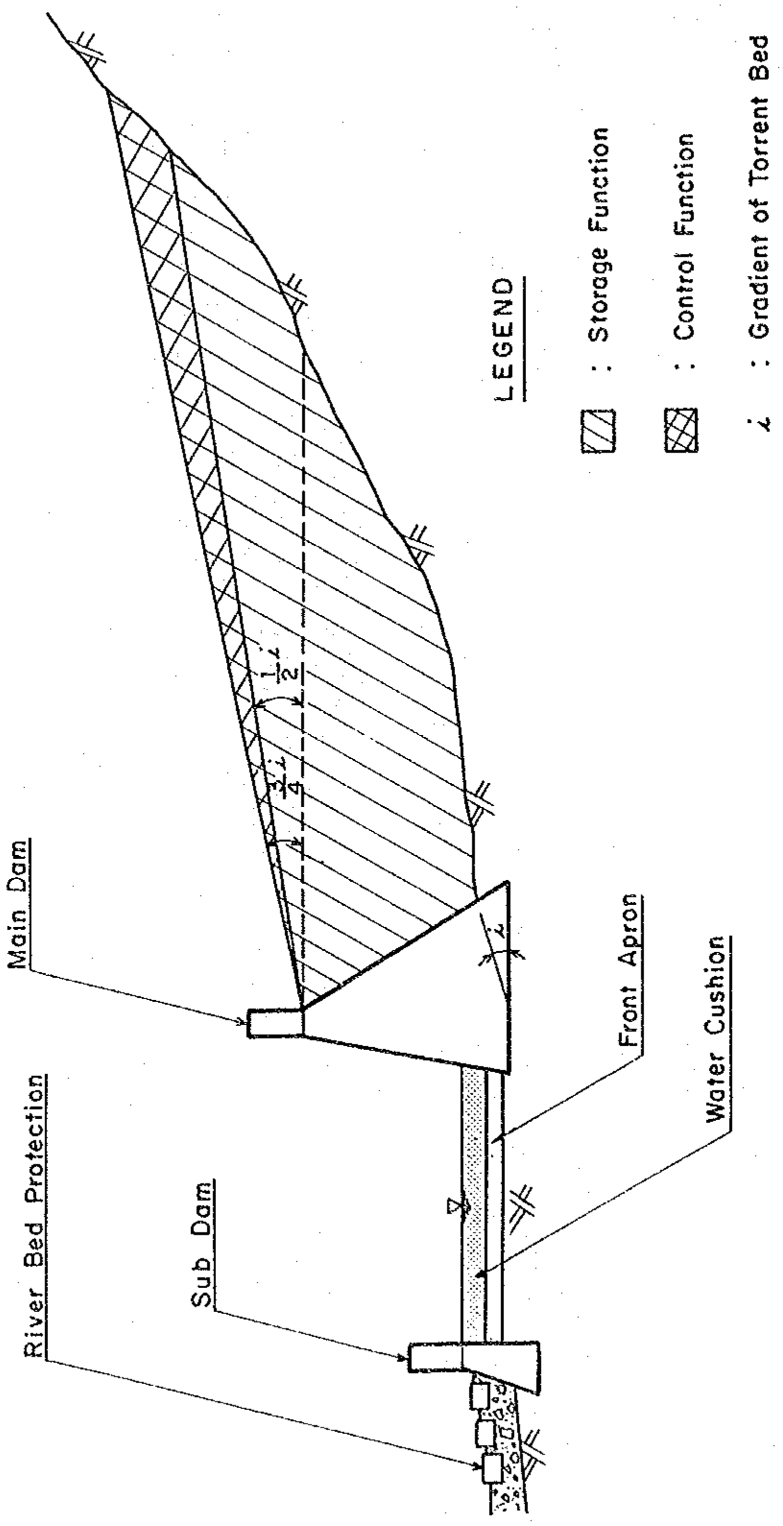

FIG.H.24
FUNCTION OF SABO DAM

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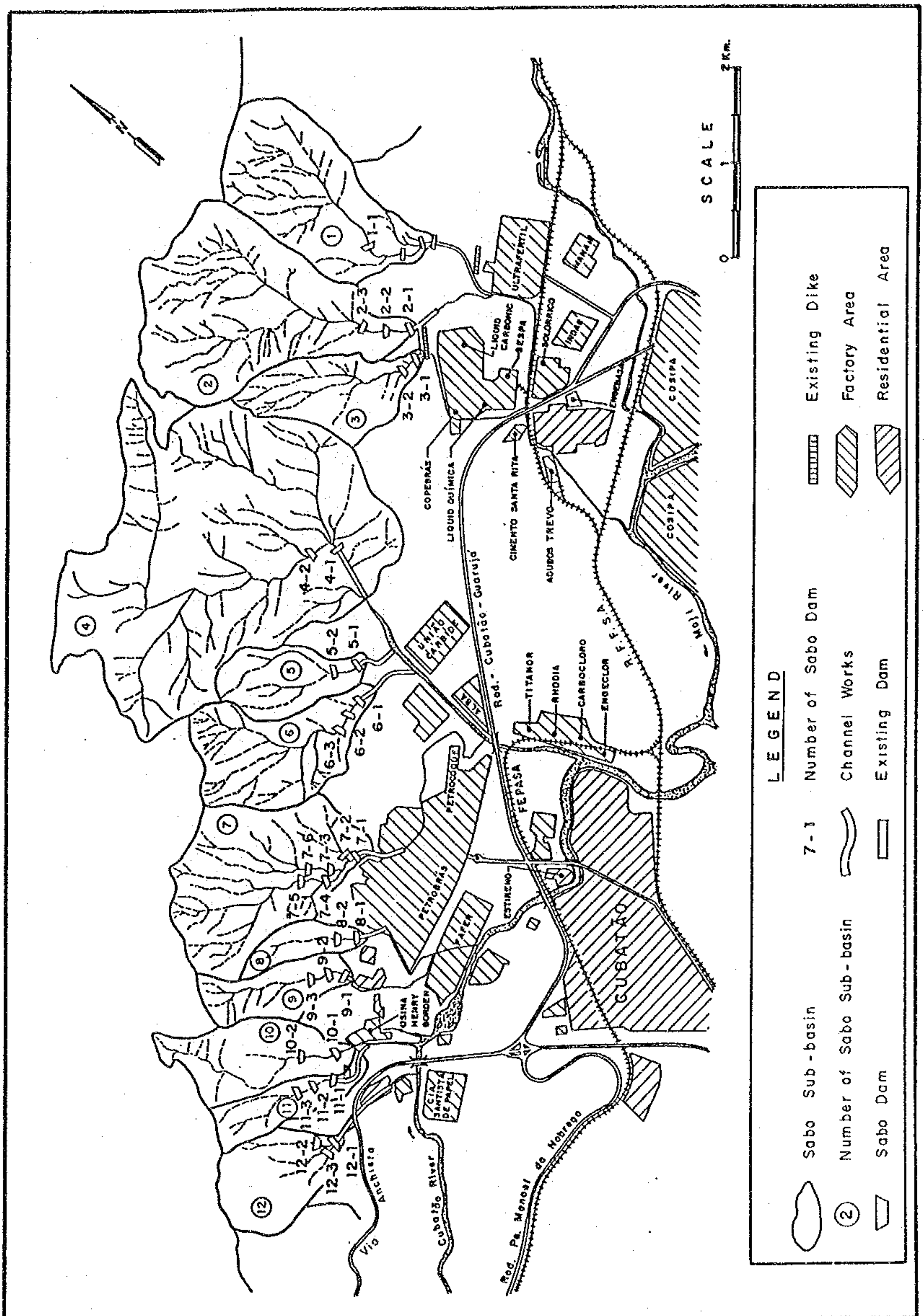

FIG.H.25
STRUCTURAL LAYOUT OF SEDIMENT RUN-OFF PREVENTATION PLAN IN MASTER PLAN

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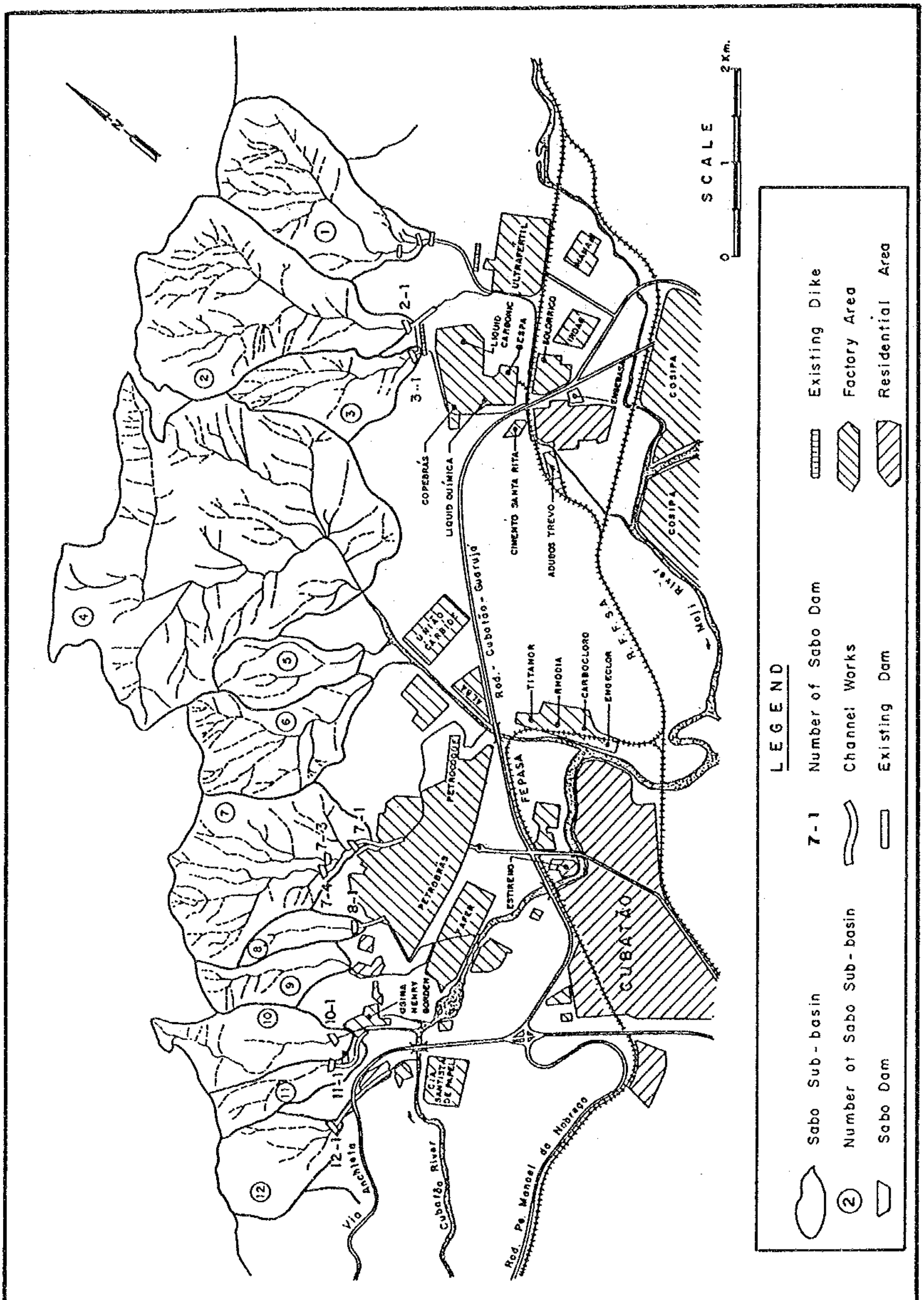

FIG.H.26
STRUCTURAL LAYOUT OF
PRIORITY PROJECT

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ANNEX I

FLOOD DISASTER PREVENTION STUDY

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1. INTRODUCTION

This ANNEX-I presents the study results on flood disaster prevention countermeasures consisting of a master plan and an urgent plan selected within the schemes of the master plan formulated.

Present conditions and characteristics of the rivers are described first based on the site reconnaissance and existing available detain order to clarify the present situation of the subject rivers. Existing flooding problem is then scrutinized. Subsequently, flood disaster prevention countermeasures are developed and a flood prevention master plan is selected and formulated among the alternative countermeasures. A priority project as the urgent plan is selected within the formulated master plan. Finally, a feasibility study on the priority project is conducted in the final stage.

The study was carried out divided into 2 phases of phase 1 and phase 2. The phase 1 covers clarification of present conditions and formulation of master plan. The phase 2 covers the feasibility study.

The study was progressed in accordance with work flow chart as presented in Fig.I.1.

2. PRESENT CONDITIONS OF BASIN AND RIVERS

2.1 River Basin and System

2.1.1 River basin

The objective river basin is located among the south-west slopes of the coastal mountain area of Serra do Cubatão which is a part of Serra do Mar and its plain area, 60 km south of São Paulo city. The total basin area of the study area is approximately 247 km2.

The main rivers in the study area are the Cubatão and Moji rivers and its river basin is given in Fig.I.2 and these general river profiles are presented in Fig.I.3.

The Cubatão and Moji rivers flows at the bottom of valley formed in Serra do Cubatão which is a part of Serra do Mar. On the mountain slopes, isolated taluses exist along the river course. At the outlets from the mountain, small scale alluvial deposits are found. These are formed as a result of collapses of mountain slopes and transportation by flow. At the bottom of the valley, a plain of fluvial deposits develops. Most of the industrial factories and town of Cubatão are located on this wider plain. On the sea side of the fluvial plain, swampy areas extend extensively towards Santos estuary.

The river basin is administratively divided into the 3 cities of Cubatão, São Vicente and São Bernardo do Campo. Out of the above cities, it is mostly occupied by Cubatão city in which about 300 industrial estates exist.

There are four trunk roads of Imigrantes, Anchieta Caminho do Mar and Cubatão-Guaruja which connect with both the gate way of São Paulo and Santos. There are also some railways operating industrial use. The Santos- Jundiai railway line which is located on the outside edge of the fluvial plain functions as a tide protection wall having an average embankment height of 1 to 1.5 m.

2.1.2 River system

The river system in the objective basin is divided into two main rivers of the Cubatão and the Moji as shown in Fig.I.2. The total catchment area is about 247 km2 consisting of 182.7 km2 in the Cubatão river system and 64.3 km2 in the Moji river system. An outline of each river system is given below and major dimensions are presented in Table I.1.

(1) Cubatão River System

The Cubatão river originates near the Billings reservoir on the plateau of Serra do Cubatão at an altitude of EL 700m. From there, it flows down gently southwards for about 15 km until it reaches the cliff and steep valley areas of the said mountains.

It then passes through the above cliff and valleys and turns towards the north-east and flows down along Serra do Cubatão up to Cubatão industrial and urban zones on the fluvial plain.

In Cubatão urban area, the river joins the left tributary of the Pereque which is the largest of the Cubatão river. Finally, it pours into the Santos estuary with some distributaries in the marsh area.

The average slopes of the Cubatão river are 1/274 in the plateau, 1/10 in the mountain and valley areas of Serra do Cubatão and 1/87 to 1/525 in the middle and lower reaches of the Cubatão river,as shown in Fig.I.3. The total catchment area and river length of the Cubatão are 182.7 km2 and 39 km, respectively.

The Cubatão river and its tributaries are characterized by steep slopes, and torrential flows influenced by heavy rainfall. As soon as heavy rain falls in the mountain areas, the water stage rises rapidly in the middle and lower reaches, and the floods are considerably flashy.

The lower and middle reaches of the Cubatão river were channelized by DAEE in the 1970s for about 2.5 km from its mouth up to the road bridge of Cubatão-Guaruja. On the right bank of the said reaches, a continuous low dike was provided with an average height of 0.8 m.

While, low flow in the middle and lower Cubatão is 100 to 160 m3/s, mainly from the two outlets of the electric power station of Eletropaulo. The monthly discharges at Ponte Preta (A=133 km2)just downstream of the Imigrantes bridge varies from 12.2 m3/s in February to 4.0 m3/s in August, as shown below according to the study report on Works for the Cubatão River Use and Control prepared by Departamento de Aguas e Energia Eletrica (DAEE) in 1973.

Monthly Discharge in Upper Cubatão (m3/s)

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
10.3	12.2	12.0	8.1	6.2	4.8	4.1	4.0	4.8	6.3	7.4	9.1

The main related facilities in the Cubatão river are the two intake weirs administrated by the oil refinery company of Petrobras and the municipal water supply authority of Sabesp and the two outlets of the Eletropaulo hydroelectric power station by Eletricidade de São Paulo (Henry Borden).

The main tributaries of this river are the Pereque, Rio das Pedras and Piloes rivers in the left bank. The main dimensions of the rivers are presented in Table I.1.

The outline of the main tributaries are explained below.

Pereque River

The Pereque river issues from the culverts of the Billings reservoir (Rio Pequeno reservoir) and the Rio das Pedras reservoir of the Billings reservoir system(see ANNEX-C 3.2). From there, it flows towards the south-east passing through the plateau and valley areas for about 7 km. During floods in the Pereque river, it has been reported that the said culverts have never been opened up to now.

About 5 km upstream from its confluence with the Cubatão, the Pereque river joins the right tributary and turns to the south. After flowing down in the valley and plain areas for about 5 km, it joins with the main river of the Cubatão.

The average river slopes of the Pereque are 1/250 on the plateau, 1/5.9 in the mountain slope and 1/100 in the plain area. The total catchment area and river length of the Pereque are 35.7 km2 and 10.5 km, respectively.

In the lower Pereque, there are the four stone dikes across the river which act as the drop structures to adjust the river bed gradient and the one intake weir(fixed dam) administered by the industrial estate of Union Carbide.

Rio das Pedras

The Rio das Pedras issues from throughout the spillway of the Rio das Pedras reservoir as seen in Fig.I.4 and flows rapidly down on the southern slope of the said mountains, and joins the Cubatão river 4.8 km upstream from the river mouth at the railway bridge. The total catchment area and river length are 1.7 km2 and 3 km, respectively.

Piloes River

The Piloes river has the two tributaries, the Marcelino(Piloes) on the left, and Passareuva on the right. Both the rivers originate in the Billings reservoir, but both are closed by the dikes constructed along the reservoir rim.

These rivers run for about 10 km on the plateau and valley areas and then joint each other 2.5 km upstream of their confluence with the Cubatão. Finally, it joins with the main channel of the Cubatão.

The average slopes of the Piloes are 1/250 on the plateau, 1/7.5 on the valley area and 1/100 in the lower reaches. The total catchment area and river length are 41.3 km2 and 11.5 km, respectively.

At their confluence with the Cubatão, small alluvial fan has been formed although the surface is covered by rich vegetation.

In the lower reaches of the Piloes, there is an intake weir constructed by SABESP for municipal water supply use in Cubatão city.

(2) Moji River System

The Moji river rises on the north-east mountain slope of Serra do Cubatão at an altitude of EL 800 m and flows for about 10 km in a south-east direction in the valley between Serra do Cubatão and Serra do Morrao, and down to the plain (See Fig.I.2).

While passing the estate of the steel production company COSIPA, the river is jointed by the right tributary, the Indio river, and subsequently the Piaçaguera which is the largest tributary of the Moji river. Below its confluence with the Piaçaguera, the Moji is locally known as the Piaçaguera river. Finally, the Moji river debouches into the Santos estuary with some distributaries in the marsh area.

The average slopes of the Moji are 1/6.5 in the mountain and valley areas, 1/42 in the middle reaches and 1/490 on the plain. The total catchment area and river length are 64.3 km2 and 18 km, respectively.

The Moji and its tributaries are characterized by steep slopes, and torrential flows influenced by heavy rainfall. As a whole, river slopes in the Moji river system are steeper than those in the Cubatão river system and the flood flows in the Moji are flushy.

Lowflow in the Moji river is meager. According to observed data in 1988 at São Marcos(A= 10 km2) on the Moji, the monthly average flow was 9.6 m3/s in January and February, and 0.1 m3/s in September and October,as described below.

Monthly Discharge in Upper Moji at Intake Weir (m3/s)

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
9.6	9.6	5.8	5.2	4.1	2.3	1.9	1.9	0.1	0.1	1.9	1.5

In the Moji river system, there have been many artificial channel shiftings, especially in the lower Moji and in the Piaçaguera rivers. Such shiftings are all understood to have caused by industrial companies.

In the upper reaches of the Moji, there are the four stone dikes across the river to trap the debris and mud flows. Near the railway bridge in São Marcos, there are a fixed type intake weir and the three pump stations for industrial use.

The principal tributaries of the Moji are the Piaçaguera, Indio and Onça rivers on the right bank. The main dimensions of the rivers are summarized in Table I.1.

The principal tributaries are explained below.

Piaçaguera river

The upper reaches of the Piaçaguera river are called the Cachoeira which means fall or cascade. The Cachoeira river originates on the southern mountain slope of Serra do Cubatão and rapidly flows south-eastwards for approximate 3.5 km to the gorge point.

At the gorge point after collecting the right valley, it flow through in the Copebras industrial estate area and then along the railway for about 4.5 km until it joins the main river of the Moji river near its river mouth.

The average river slopes of the Piaçaguera are 1/3.6 in the valley area and 1/500 in its lower reaches. The total catchment area and river length are 11.4 km2 and 8 km, respectively.

At the gorge, there are two stone dikes and two earth dikes to regulate flow direction as well as for trapping of debris and mud flows and one spillway culvert. Such facilities were constructed by Copebras(chemical and fertilizer company) to protect its industrial estate.

Indio River

The upper reaches of the Indio river are called the Engenho river. The Engenho rises on the southern slope of Serra do Cubatão.

After its gorge, the river runs through the industrial estate area of the Ultrafertil(fertilizer company) and joins the main stream of the Moji.

At gorge, three gabion dams have been constructed to protect the said estate from debris and mud flows. In the lower reaches of the Indio, it was improved for about 300 m and two culverts were constructed.

The catchment area of the Indio is 3.7 km2 and its river length is around 6 km.

Onça River

The Onça river also originates in the southern slope of Serra do Cubatão and flows rapidly down into the Moji river.

The average river slopes of the Onça are 1/6.3 in the upper mountain area and 1/56 in the lower area. The total catchment and river length are 11.6 km2 and 3 km, respectively.

2.2 Characteristics of River Channel

2.2.1 Existing river channel

The river cross-sections have been surveyed in order to clarify the present condition of the existing channels and river topographic maps have been prepared based on the aerial photos in addition to the above survey results. The details of surveying are mentioned in ANNEX B.

By using the surveyed cross-sections of river channels, longitudinal profiles have been prepared for the lower and middle reaches of the major rivers. Such longitudinal profiles and typical cross-sections of Cubatão and Moji are presented in Figs.I.5 to I.6 and others are presented in Data Book.

According to the above figures, the main features of the river channels are outlined below.

Cubatão river

- River width : 130 - 50 m
- Water depth : 4.5 - 10 m
- River slope : 1/3000 - 1/400
- Cross-section of channel : single with trapezoidal
- Tidal reach : 3 km upto intake weir by Petrobras from the railway bridge downstream

Moji river

- River width : 90 - 30 m
- Water depth : 4 - 6 m
- River slope : 1/1900
- Cross-section of channel : single with trapezoidal
- Tidal reach : 4 km upto downstream of intake weir from Cosipa Bridge in the lowerend

2.2.2 Flood carrying capacity of channel

The flood carrying capacity of the existing channels is estimated by means of non-uniform flow method and by using the survey data of river cross sections surveyed in 1990 by JICA.

In these calculations, Manning's coefficient of roughness is taken as 0.03 in the channel and at 0.07 in the flood plain considering present channel carrying conditions. Sea water level at Santos is adopted at 0.49m IGGSP which is a mean high water of spring tide. Further, flow area consisting of low water channel and flood plain is assumed in the marsh area. Finally, discharge rating curves at the respective river mouths are estimated as shown in Fig.I.7. Based on the above rating curves, water levels for respective discharges at each section are estimated. The estimated water levels are shown in Figs.F.18 to F.20 in ANNEX-F.

From the estimated water levels at each section, bankful carrying capacities of the existing channels are calculated. The bankful carrying capacity is defined as a capacity of the channel below the lower elevation of both river banks. The estimated bankful capacities are shown in Fig.I.8 and Data Book.

According to the above figure, average bankful capacity of the Cubatão is from 800 to 1000 m3/s although that of Anchieta bridge and Sabesp weir is less than 500 m3/s. The bankful capacity in the Pereque is less than 200 m3/s in the downstream reach of the railway bridge and about 500 m3/s in the upstream of the above bridge. While that in the Moji is estimated small below 300 m3/s.

3. MAJOR FLOODS AND DAMAGE IN THE PAST

3.1 Flood Characteristics

The basin is situated in the heavy rainfall zone of the subtropical region and is characterized by the topographic features of a small basin and a river channels with steep slopes, so called torrential rivers, and by geological features allowing little infiltration. Such basin circumstances cause frequently inundation in lowlying areas of the fluvial plain of the basin.

In Cubatão region, the wet season occurs from September or October to March. Major floods appear during the three months from December to February. As soon as heavy rain falls in the mountain areas, the water stage rises rapidly in the lower reaches within 2 to 6 hours and the rivers overtop their banks. From the above topographic and hydrological features in the basin, the floods are considered to be flashy or torrential. The duration of floods is short, but the dispersion of flood water in the respective lower reaches is frequently aggravated by high tides.

The Santos-Jundiai railway is running located on the edge of the fluvial plain of the Cubatão and Moji rivers, with an average embankment top elevation height of 4.5 m IGGSP. This embankment provides protection against sea water intrusion. Along this embankment, there are only two drainage outlets without gates.

The flooding on the fluvial plain thus may be caused by the following factors and/or their combinations.

- Overbank flow of flood water from the main river
- Insufficient capacity of the drainage system
- Backwater effect of flood water in the tide level and sea water intrusion

The flood prone area(inundation area due to the past floods) and typical flow directions are presented in Fig.I.9. The flood prone area is estimated at about 11 km2.

3.2 Major Floods in the Past

According to the data on the past remarkable hyetographs and floods collected from DAEE and informations from local people during the survey period, major floods in the past were the floods in Feb. 1971, Jan.1973, Jan. 1976 (two times), Nov. 1979, Jan. 1983, Jan. 1985 and Dec. 1988. The total rainfall of 2 days duration observed at E3-153 station (Curva da Onça, El=500m) was as follows.

Rainfall Amount of 2 Day Duration

Rainfall	Flood							
	Feb`71	Jan`73	Jan14`76	Jan4`76	Nov`79	Jan`83	Jan`85	Dec`88
2 days amount (mm)	350.6	330.0	408.7	428.4	309.2	328.7	211.1	338.6

From the above table and information obtained from local people, it is recognized that the Feb. 1971 flood was the most serious one in flooding scale, and the Jan. 1985 flood was the most destructive one in terms of sediment runoff disaster.

In Feb. 1971 flood, the urban area of Cubatão was mostly inundated due to flood water from the Cubatão and Pereque river channels. In addition,sea water intruded in the lowlying areas near the marsh and aggravated the effects of flood water and local rain waters. Consequently, inundation or flooding in the urban area continued for around 4 days with an approximate maximum water depth of 3 m.

On the right bank of the lower Moji river Vila Parisi inundated frequently due to overflowed river waters and local rain waters. It is reported that 12 persons or more died in Vila Parisi area due to flooding in Feb.1971. According to the local inhabitants, Vila Parisi area was inundated for a period of 4 to 5 days with a maximum inundation depth of 2 to 3 m as a result of overflowed river waters and local rain waters in 1972 and 1976.

4. EXISTING AND PROPOSED FLOOD DISASTER PREVENTION WORKS

4.1 General

The study area has been suffered from debris and mud flows and floods due to heavy rainfalls. Chief amongst the places to suffer has been Cubatão city itself and industrial estates.

Cubatão city has been under continuous development as an urban and industrial zone since its initiation in 1950s. Most industrial estates are located on the fluvial plain. These industrial estates are some of the most important in the state of São Paulo if not in Brazil. At present, nearly 300 estates have been operated. In order to protect the people and properties and industrial estates from disasters, the authorities in the state and private companies have already been carrying some disaster prevention works.

In 1985, a special commission was instituted by the state of São Paulo. Firstly, the commission prepared a program to protect urban area and industrial estates from recurrent debris and mud flows and floods, and to restore the vegetation in Serra do Mar. The program consists of urgent and long term plans and/or structural and nonstructural measures. Subsequently,most of the program was implemented and the activities by the commission are still continued.

Previous works in the study area have been mostly carried out as part the series of the above program although some work was done in the 1970s.

In this chapter, such existing and proposed flood disaster prevention works are introduced.

4.2 Existing Works and Proposed Plan for Flood Disaster Prevention

4.2.1 Existing works

The main existing works completed so far are presented in Fig.I.10. Such works are listed below and the detailed explanation is presented in the Data Book.

1) Channelization of Lower Cubatão River (1970-1975)

2) Land Reclamation in Lowlying Area (1975-1978)

3) Construction of Rock and Earth Dikes and Riprap Cross Dam in the Cachoeira River of the Piaçaguera River (1976-1978)

4) Dredging of Lower Cubatão, Pereque and Piaçaguera River and Moji River (1980-1988)

5) Construction of Riprap Cross Dam in the Upper Pereque River (1985)

6) Construction of Riprap Cross Dams in the Upper Moji River (1985-1986)

7) Construction of Gabion Dam in the Rio Pedras River (1985-1986)

8) Construction of Gabion Dams in the Engenho of the Indio River (1986-1987)

9) Channelization of Lower Indio River (1988)

10) Restoration of Fixed Intake Dam in the Moji River (1989)

11) Periodical Dredging in Sedimentation Basin of Cosipa

4.2.2 Previous studies and proposed plans

Previous Studies

The following are the main previous studies and these detailed explanation is presented in the Data Book.

1) Study on Works for Cubatão Use and Control by DAEE

2) Study on Flood Protection of Cubatão Industrial Complex by Copebras

3) Water Development of Municipal Use

Proposed Plan

A macro drainage plan in Cubatão region has been considered by DAEE. This plan has the following themes.

1) Study on flood potential

2) Regulation of torrential rivers

3) Modeling of rainfall, runoff and sediment

4) Study on boundary conditions to sea and tide

In addition to the above structural measures, a hydrological network system will be improved connecting with radar and existing telemetering systems.

According to DAEE,it is scheduled that the channelization and embankment works in the middle Moji river and periodical dredging in the lower reaches of the main rivers are to be implemented as a part of the macro drainage plan. These works are outlined below.

1) Channelization and embankment (See Data Book)
- Location : downstream of flyover in the middle reach
- Length to be improved : 250 m
- Design discharge : 200 m3/s
- Channel top width : 25 m
- Channel bottom width : 12 m
- Channel depth : 4 m
- Dike top width : 6 m
- Dike height : 4 m

2) Periodical Dredging
- Object rivers : Cubatão, Moji and Piaçaguera
- Proposed volume : 600,000 m3
- Implementation year/agency : 1990/DAEE

Cosipa has also been considering to shifting the lower Moji river course to the west side of the existing railway line. However, this plan is not yet formulated due to financial and other constraints.

4.3 Agencies and Budget Concerned with Flood Disaster Prevention

In the São Paulo state, Secretaria de Energia e Saneamento (Secretariat of Energy and Sanitation) is in charge of public works for flood disaster prevention.

The organization chart is given on Fig.I.11. Under a Technical Assistant Chief, Department of Water, Energy and Electric (DAEE) has been organized. The catchment area in the São Paulo state is administrately divided into seven hydrological regions. DAEE is further divided into 11 sections as shown in Fig.I.11.

In DAEE, Diretoria da Bacia do Alto Tiete e Baixada Santista (BAT) is directly concerned with the disaster prevention in Serra do Cubatão region as a part of Bacia do Alto Tiete e Baixada Santista, in close cooperation with Diretoria da Engenharia (DEN) and Diretoria Centro Tecnologico de Hidraulica (CTH).

The following are their respective duties for flood disaster prevention.

- Bacia do Alto Tiete e Baixada Santista (BAT) : Survey, study and planning on flood control and drainage
- Diretoria da Engenharia (DEN) : Design and construction
- Diretoria Centro Tecnologico de Hidraulica (CTH) : Hydraulic laboratory

The budget for flood control and erosion control in the past in the São Paulo state has been as follows.

Budget in the Past (Unit= US$)

Year	Flood Control	Erosion Control
1984	13,619,000	70,000
1985	36,586,000	1,037,000
1986	67,109,000	86,945
1987	103,104,000	1,047,000
1988	110,056,000	411,000
1989	130,000,000	—

4.4 Planning Criteria

In São Paulo state, a "Project Manual for Urban Drainage" was prepared and published by DAEE and CETESB in 1980. This manual provides guide lines on planning and design for drainage projects in urban areas.

With regard to the return period of design discharge to be estimated, the following basic guide lines have been indicated in the said manual.

Design Return Period for Flood Control and Drainage

River/Structure	Return Period (year)
Major river	100
Semi major river (Catchment area is less than 100 km2)	50
Drainage structure	2 - 10

Specific discharges obtained from the rivers in São Paulo state are given in Fig.I.12. According to the said figure, it can be said that such specific discharges be small since rivers in the question have relatively gentle slopes and large catchment in the plain areas.

5. PROBLEMS AND CONSTRAINTS WITH FLOOD PREVENTION

Problems and constraints with regard to flood control and drainage in the basin may be summarized as follows.

(1) Carrying Capacity of Major Channels

Carrying capacities of the major channels of the Cubatão, Pereque and Moji are small compared with median scale floods and design discharges to be estimated. Increasing of channel capacity is needed.

(2) Urban Drainage in Cubatão City

Cubatão urban area is surrounded by the Cubatão river in the north and east, by the marsh area in the south with railway embankment in order to protect intrusion of high tide and by mountain in the west.

There are the three main drainage channels in the urban area. One discharges into the lower Cubatão channel. The other two channels are directly discharging into the marsh throughout ungated culverts. Such channels are easily subject to clogging by tidal action. The southern area along the said railway embankment is easily inundated due to the back water of high tides. It also seems that the channel sizes are insufficient in view of their catchment area.

(3) Local Drainage in Industrial Areas

Drainage in the Cubatão and Pereque rivers has been systematically and well provided. However, the local drainage system in the Moji river, especially those in the Piaçaguera, is not clear and of poor quality. For this reason, swampy areas can be observed here and there in the lower reaches of the Moji and in the middle and upper reaches of the Piaçaguera.

(4) Related Facility

Major fundamental related facilities are the Sabesp intake dam and Petrobras intake weir in the Cubatão, Union Carbide intake weir in the Pereque river, and intake dam of Ultrafertil in the Moji river. Local scouring just downstream of such facilities can be observed. Especially those in the Moji river are severe as seen at the scoured bridge piers of railway.

Further, the direction of the dam axis of the Sabesp intake is not appropriate for flow direction upstream.

(5) Marsh Area at Rivermouth of Cubatão and Moji

The Cubatão and Moji rivers transport bed load, suspended load and wash load from these watersheds. For such transported sediment, the marsh functions as a natural sedimentation basin for the Santos estuary in which there is an international port.

The lower reaches of the Cubatão and Moji rivers are influenced by tidal action and saltwater intrusion. The lower Moji river is particularly strongly influenced. The existing marsh area, however some extent, functions as a barrier against saltwater intrusion into these river channels. Accordingly, special attention should be paid in the event that excavation of the marsh area is considered.

(6) Water Supply of Municipal and Industrial Uses

At present, municipal water in Cubatão and Santos and the surrounding areas has been supplied mostly from Sabesp intake weir and plant which are located in the middle reaches of Cubatão river. However, the existing facilities will be insufficient in capacity for the demand in the year of 2000. According to the Sabesp, it is reported that new water resources will be developed in the Branco river which runs in the southern area of the Cubatão basin. Accordingly, it is not necessary to produce an additional water for municipal use in the present study.

On the other hand, the steel production company of Cosipa has been suffering from water shortage and saltwater intrusion especially in the dry season. In order to solve this problem, an agreement has been made between Cosipa and Henry Borden for supply of water from the power station. According to the agreement, a minimum discharge of 60 m3/s will be supplied through the Cubatão and Moji rivers. This supply of waters will also act as a barrier against saltwater intrusion in the marsh area.

6. FLOOD CONTROL MASTER PLAN

6.1 General

Based on the results of the field investigation and the study on the present conditions and with due consideration of the review results on the previous disaster prevention works and studies, conceivable alternative flood control plans are developed, and a master plan is formulated aiming at the year of 2000.

6.2 Basic Conditions of Master Plan

(1) Objective Area and Stretches to be Protected by Master Plan

The lower and middle basins of the Cubatão and Moji rivers have been developed as an urban area and an industrial zone.

In the present study, the flood control master plan is formulated to protect the existing urban and industrial areas on the fluvial plain from flooding and inundations. Stretches to be improved by the master plan are determined with due consideration of their river banks and land use conditions. These stretches to be improved are presented in Fig.I.13 and are summarized below.

- Cubatão river : Railway bridge near its rivermouth to upstream of Sabesp dam
- Pereque river : Confluence with Cubatão to intake dam
- Moji river : Road bridge near its rivermouth to intake dam
- Piaçaguera river: Confluence with Moji to Copebras spillway at gorge
- Indio river : Confluence with Moji to gabion dam at gorge

(2) Design Return Period of Flood Control Master Plan

Design floods are actually adopted at the levels of a 50 year flood for the middle scale rivers and a 100 year flood for the large rivers for flood control and drainage projects in São Paulo state. Also a 50 year flood has been adopted to drainage projects of the urban areas in Rio de Janeiro state.

In consideration of the above circumstances and balance between both the states, the following levels are taken into the present master plan study.

Design Return Period

River	Return Period
Cubatão and Moji	1/50
Pereque, Piaçaguera and Indio	1/25

6.3 Alternative Schemes and Design Flood

6.3.1 Flood control method in basin

An optimum measure should be adopted as the flood control method taking account of the regional characteristics of river basins such as topography, catchment size, type of flood runoff, flooding conditions, etc. The following measures are generally considered as the flood control method.

Upper basin : Flood regulation by reservoir

Middle basin : Flood retardation by retarding basin and flood prevention by existing channel improvement

Lower basin : Flood diversion by diversion channel tunnel and flood prevention by existing channel improvement

6.3.2 Alternative schemes

With due consideration of the regional characteristics of the objective basins, channel improvement to increase the carrying capacity is required by means of excavation of channel, construction of dike, heightening of the existing dike, construction of new channel and their combinations. Considering the existing condition of valley areas, dam reservoir scheme may not be taken up in these basins. From the above, conceivable alternative schemes thus set up are as follows.

(1) Cubatão River System (see Fig.I.14)

<u>Scheme C-1</u>

(a) Middle Cubatão upstream of Sabesp Dam

The flood dike will be constructed on the right bank upstream of the Sabesp dam. The existing channel may not be excavated.

(b) Lower Cubatão

The existing channel will be widened and the flood dike with low-height will be employed to increase the carrying capacity of the channel.

(c) Pereque

The existing channel will be dredged and the flood dike will be constructed in the lower reaches near the Cubatão confluence.

Scheme C-2

(a) Diversion Tunnel

In order to avoid a large scale improvement of the Cubatão river, a diversion of runoff is considered at the gorge of valley area by means of a new tunnel. The route of the tunnel is proposed at Route 1 as shown in Fig.I.15 considering outlet conditions of geology and topography and workability for construction.

The alternative C-2 is further divided into 2 schemes of C-2(1) with a diversion discharge of 1,250 m3/s and C-2(2) with a diversion discharge of 900 m3/s.

The diversion channel consists of an open channel and a tunnel which will be constructed upstream of Imigrantes road bridge. The diversion tunnel is designed for 130 % of the design diversion discharge considering reliability against abnormal big floods.

(b) Middle and Lower Cubatão

The middle and lower Cubatão river may be partly improved by means of the minor works such as repair of the existing flood dikes and bank protections.

(c) Pereque

Same as Scheme C-1

(d) Moji River System (see Fig.I.14)

Scheme M-1

The existing river channels will be improved by means of excavation of channel and construction of dike. Since the existing river systems in the middle reaches of the Piaçaguera river is not clear and meager, these reaches will be shifted to the left side of the railway line.

Scheme M-2

The lower reaches of the existing Moji river will be shifted to the right side of the existing railway line. The others are the same as those of Scheme M-1.

6.3.3 Design flood for alternative schemes

Based on the results of the flood runoff analysis described in ANNEX-F, the design discharges for each alternative scheme are determined as shown in Fig.I.16.

6.4 Preliminary Designs and Selection of Optimum Plan

6.4.1 Design criteria

The following are the criteria applied to the design of river channel improvements.

(1) A series of the topographic maps of 1/5000 scale prepared by the study team are used for the design of channels and dike alignments.

(2) The river channel cross sections surveyed by the study team are used for the design of river channels.

(3) With regard to Manning's coefficient of roughness "n" for the design, 0.03 for low water channels and 0.027 for channels with linings on both the banks are adopted.

(4) The following dimensions are applied to the design of dike cross sections as standard.

Design Discharge (m3/s)	Free Board (m)	Crest Width (m)	Side Slope w/o Bank Protection	Side Slope w/ Bank Protection
less than 200	0.6	3.0	1:2	1:1.5-0.5
200 to 500	0.8	3.0	1:2	1:1.5-0.5
500 to 2000	1.0	4.0	1:2	1:1.5-0.5
more than 2000	1.2	5.0	1:2	1:1.5-0.5

6.4.2 Planned river channel improvement

Based on the design criteria, the river channels are designed considering the existing conditions. The outline of the planned river channels are as follows. The longitudinal profiles and typical cross sections by preliminary design of each scheme is presented in Data Book.

(1) Channel and dike alignments: Since the existing channels bend extremely in several locations, it is planned to moderate to secure the stability of the channels.

(2) Profile of channels: The longitudinal profiles of the river channels are planned based on the average river bed elevations considering easy maintenance and ground slopes of the river banks. The design high water levels are determined lower as much as possible in view of the local drainage.

(3) Cross sections of channel and dike: The single cross section with banquette is applied to channel sections. Banquette width varies from 10 to 1m depending on channel size. The low height dike is

constructed on the banks in order to increase channel capacities.

(4) Diversion tunnel: Flood water is planned to divert through an overflow dike. A horse-shoe type is adopted to the tunnel section.

6.4.3 Selection of optimum plan

From the aspect of the technical and the least cost basis, the most optimum plan is selected among the alternative schemes.

The required quantities of the construction works, land acquisition and compensation are counted for each alternative scheme. The construction costs are estimated multiplying work quantities by their unit costs. The direct construction costs consist of the costs for civil works and the costs required for land acquisition and compensation. The work quantities are shown in Table I.2 and the cost estimate is presented in ANNEX-M.

According to the cost estimate, the following are the estimated financial costs excluding price contingency for each alternative scheme.

Construction Cost

(US$ 1000)

River	Alternative Scheme		
Cubatão	C-1	C-2(1)	C-2(2)
	48,400	46,040	33,940
Moji	M-1	M-2	
	22,680	18,560	

The comparative study on the technical and the least cost basis makes it clear that for Cubatão system, the Scheme C-2 (2) be lower than others and the Scheme M-2 be lower than the Scheme M-1 and that both the Scheme C-2 (2) and Scheme M-2 involve little resettlement of private houses or industrial plants.

Therefore, it is considered reasonable to select the Case C-2 (2) and the Case M-2 as the optimum plan.

6.5 Proposed Flood Disaster Prevention Master Plan

Based on the comparative study on the alternative schemes of flood disaster prevention, an optimum master plan was selected. The proposed master plan is described in the following.

6.5.1 Design flood discharge

The master plan has been formulated on the levels of 50 yr design flood for the Cubatão and Moji rivers and 25 yr for their tributaries. The design discharge distributions for the above levels are presented in Fig.I.17.

6.5.2 Proposed plan

(1) Outline of Proposed Plan

An outline of the proposed plan is schematically presented in Fig.I.18. The plan consists of the channel improvement of the Cubatão, Moji and their tributaries and construction of a flood diversion tunnel in the upper Cubatão river.

Cubatão River Improvement Plan

The flood diversion tunnel with a design discharge of 900 m3/s is proposed to discharge the flood coming from the upper basin directly to the marsh area. The diversion tunnel consists of an inlet open channel (l=400m), two-lanes tunnel (l=600m) and an outlet open channel with dikes (l=200m). The flood coming from the upper basin is diverted into the tunnel through the overflow dike.

The existing Cubatão and lower reaches of the Pereque river are to improve mainly by means of heightening of the existing dike and construction of new dikes.

The proposed longitudinal profiles, cross sections and tunnel dimensions are presented in Figs.I.19 and I.21(The details are presented in Data Book).

Moji River Improvement Plan

The lower reaches of the Moji river are shifted to the north of the existing railway line of RFFSA. In order to provide a main drainage channel in the middle reaches of the Piaçaguera river, new channel are provided partly and connected with the existing channels in the upper reaches.

The proposed longitudinal profiles and cross sections are presented in Fig.I.20 (The details are presented in Data Book).

(2) Required Construction Works and Costs

The required construction works are summarized below (see Table I.2).

Required Construction Works of Master Plan

Works	Unit	Cubatão River System	Moji River System
1. Land acquisition			
and compensation	ls	1	1
2. Civil works			
Preparatory	ls	1	1
Excavation/dredging	m3	511,000	1,430,000
Embankment	m3	157,000	250,000
Bank protection	m2	6,700	24,800
Drainage culvert	No	11	7
Road bridge	No	---	4
Railway bridge	No	---	3
Repair weir/riprap dam	No	---	4
Drop structure	No	---	4
Riverbed protection	No	1	---
Miscellaneous	ls	1	1
3. Construction of tunnel			
Preparatory	ls	1	---
Outlet facility of tunnel	ls	1	---
Open channel	m	600	---
Tunnel (2 lanes)	m	600	---
Road bridge	No	2	---
Railway bridge	No	1	---
Miscellaneous	ls	1	---

The estimated direct costs and these breakdown are present in ANNEX-M.

7. SELECTION OF PRIORITY PROJECT

7.1 Necessity of Priority Project

The flood disaster prevention master plan is formulated aiming at mitigation of flood damage in the existing urban and industrial estates against 50 year return period for mainstreams of the Cubatão and Moji, and 25 year return period for their tributaries of the Pereque, Piaçaguera and Indio. The economic viability of the plan is not so high, and also much fund will be required to implement such a big project. Therefore, the time has not come yet to implement the master plan at present.

However, the lower parts of the fluvial plain, especially in the lower reaches of the Moji river suffers from habitual flood damage which cannot be overlooked any longer. Realization of a priority countermeasures is required aiming at mitigation of flood damage in the subject areas.

For this reason, urgent flood control plan based on the master plan as shown in Fig.I.18 is studied to formulate a priority project for immediate implementation in consideration of the urgency of countermeasures, as well as the technical and economical effectiveness of the project.

7.2 Selection of Priority Project

From a view point of the carrying capacities of the subject river systems, mainstreams of the Cubatão and Moji rivers are principally required to increase their channel capacities to raise safety level against unexpected flood which occurs once in 10 years or more.

The Cubatão river was improved in 1975 immediately after the destructive flood in 1971 and its channel capacity is around 1/5 or more. While, those in the Moji is quite meager.

According to the economic evaluation of the master plan, economic viability of the Moji river system improvement (EIRR= 9%) is higher than those of the Cubatão (EIRR= 5%).

Therefore, channel improvement and flood dike construction of the Moji river including lower reaches of the tributaries are selected as priority project in consideration of technical, social and economical viewpoint.

Urgent flood control plan as the priority project is designed for 10 year return period. Length to be improved is around 4.3 km from its rivermouth to Ultrafertil weir.

8. FEASIBILITY STUDY OF PRIORITY PROJECT

8.1 General

For the selected priority project aiming at the target year of 1995, a feasibility study was conducted. The priority project was designed for 10 year return period based on the design criteria and the results are outlined below.

8.2 Design Flood

The design discharge of the Moji river is determined at 600 m^3/s under a design scale of 10 year return period (see Fig.I.22).

8.3 Proposed Priority Project

8.3.1 River stretches of priority project

Considering the carrying capacity and river bank condition of the Moji river, the river to be improved by priority project is determined for a stretch from river mouth to the existing intake dam. The upstream end of the flood dike is determined at the existing embankment of the RFFSA railway. The stretches to be improved by priority project are shown in Fig.I.23.

The right tributary of the Piaçaguera river is improved up to downstream of the RFFSA railway bridge and road bridge in order to protect the riparian area from back water effect in the Moji river. In the same, the lower reach of the Indio near the confluence with the Moji is to be improved up to the existing culvert.

8.3.2 Improvement plan of priority project

(1) Design criteria

The following criteria is applied to design of river channel improvement.

- The topographic maps of 1/5000 scale are used for channel and dike alignment.

- The river cross sections surveyed by JICA study team are used for design of channel section.

- The water level at river mouth of the Moji is set at 2.78 m IGGSP based on the discharge rating curve shown in Fig.I.7. Manning`s coefficient of roughness is adopted at 0.03.

- The dike section as shown in Fig.I.24 is applied to the dike design.

(2) Improvement plan of priority project

Within the overall scheme of the proposed master plan, river channel and related structures are designed based on the design criteria. The proposed alignment of river channel and longitudinal profiles are presented in Figs.I.25 to I.27. The basic points of the design are as follows.

- River width and dikes are designed with dimensions proposed by the master plan.

- Low water channel is excavated so as to flow the design discharge.

- On the proposed dike, inspection road is provided for O/M works.

- The lower reaches of the Piaçaguera and Indio are improved only by embankment which was proposed by the master plan.

The outline of the plan for each river is as follows.

Moji river

In the lower reach, a new channel is proposed to be constructed on the right side of the existing RFFSA railway and the riverbed elevation is set at that of the master plan so as to connect smoothly rivermouth with upper reaches.

The dike on the right bank is proposed to be continuously constructed to the upper end of the existing RFFSA railway embankment (total l= 4.3 km). While, the dike on the left bank is to be constructed in line with the existing RFFSA railway embankment and this dike is to be constructed to Rodovia road bridge (l= 2.8 km).

The existing RFFSA railway bridge near rivermouth is proposed to be reconstructed as shown in ANNEX L. Also the existing intake dam at the upper end is to be reconstructed as shown in ANNEX L. For drainage of the local rain water, three (3) drainage culverts are proposed to construct. The typical drawings are shown in ANNEX L.

Lower Piaçaguera

The lower Piaçaguera river is proposed to improve by constructing the flood dikes to protect riparian areas from high water in the Moji river. No excavation is considered to the existing low water channel.

On the upper right bank, concrete parapet wall is to be constructed for a length of 150 m to avoid resettlement of building in the establishment.

The existing road bridge is to be reconstructed as shown in ANNEX L as standard drawing. For drainage of local rain water, three (3) drainage culverts are to be constructed.

Indio river

In the lower Indio, flood dikes only are proposed to construct for an around 150 m in length with the same top elevation of Moji river dike at confluence. One (1) drainage culvert is proposed in the right side.

8.3.3 Proposed project works

The required project works in the priority project are as follows.

Moji river

- Length to be improved	:	4.3	km
- Length of flood dike			
Left bank	:	2.8	km
Right bank	:	4.3	km
- Excavation	:	470,000	m^3
- Embankment	:	182,000	m^3
- Bank protection			
Length	:	1,450	m
Area	:	15,500	m^2
- Construction of drainage culvert			
Type I (1.5 * 1.5 m * 1)	:	3	places
- Reconstruction of bridge			
Railway	:	1	place
- Reconstruction of intake dam	:	1	place
- Construction of inspection road			
Left bank	:	2.8	km
Right bank	:	4.3	km

Piaçaguera river

- Length to be improved	:	1	km
- Length of flood dike			
Left bank	:	1	km
Right bank	:	850	m

- Parapet wall : 150 m
- Embankment : 52,000 m^3
- Construction of drainage culvert
  - Type I (1.5 * 1.5 m * 1) : 2 places
  - Type II (2.0 * 2.5 m * 1) : 1 place
- Construction of inspection road
  - Left bank : 1 km
  - Right bank : 0.85 km

Indio river

- Length to be improved : 0.2 km
- Length of flood dike
  - Left bank : 0.2 km
  - Right bank : 0.15 km
- Embankment : 2,100 m^3
- Construction of drainage culvert
  - Type I (1.5 * 1.5 m * 1) : 1 place
- Construction of inspection road
  - Left bank : 0.2 km
  - Right bank : 0.15 km

8.4 Operation and Maintenance

(1) General

River channel consisting of low water channel, banquette and dike is generally constructed using the existing material of soil in the site.

Such soil structures are apt to be deteriorated due to reccurent flooding as well as due to harmfull acts such as taking sand from dike or banquette, etc.

Therefore, daily maintenance and rehabilitation become an important activity and for this matter, periodical inspection is required under both ordinanary and emergency river conditions in order to check the extent and scale of damage as well its cause.

River channel and structures to be constructed should be well maintained after those constructions so as to keep those functions involved.

In this stage, basic idea for operation and maintenance for facilities is introduced and it is to be finalized as operation and maintenance manual throughout the construction stage.

(2) Outline of Operation and Maintenance

1) Periodical Inspection

Periodical inspection should be made to check the conditions of river channel and related structures whether those be in good condition or not. Such periodical inspection is needed as well in view of preventing river channel from the harmful act such as disposal of solid waste, taking sand in the dike, etc.

2) Periodical Cross Section Survey and Hydrological Observation

Cross sections of the river channel to be improved/constructed are necessary to be periodically surveyed in order to check carrying capacity. Further, hydraulic observations such for rainfall, water level, discharge, etc., are required by using the existing observation stations and staff gages to be newly installed, if required.

Integration of the above data will contribute to operation and maintenance of river channel and other facilities as well reviewing and revision of present plan for future.

3) Repair of River Channel and Structures

Since dike is constructed by excavated materials of sand and soil, it is occasionally subject to collapse. On the other hand, structural material of revetment will superannuate as time goes by. Such structural damage should be promptly repaired or replaced by new ones.

4) Harmful Acts

Such behavior as throwing garbage into the channel, taking sand from dike, etc., can be seen here and there. Such harmful acts become unexpected obstacles in maintaining of function of channel in good condition. Especially, this problem of throwing garbage into the channel gets in the way. Such harmful acts should be prohibited under the consentaneous guideline.

LIST OF REFERENCES AND DATA COLLECTED

No.	Title	Issued on	Issued by
I01	Pesquisa Sobre os Prejuizos Causados por Eventuais Enchentes Ás Indústrias da Baixada Santista	Apr. 1986	Special Commission
I02	Bacia do Alto Tietê - Cubatão Cadastro das Obras Hidràulicas em Operação	July 1978	DAEE
I03	Desenvolvimento Global dos Recursos Hídricos Das Bacias do Alto Tietê e Cubatão - Plano Diretor de Obras	Mar. 1980	DAEE
I04	Obras de Aproveitamento e Controle do Rio Cubatão	Dec. 1972	DAEE
I05	Obras de Aproveitamento e Controle do Rio Cubatão	Oct. 1973	DAEE
I06	Retificação e Canalização do Rio Cubatão (1 : 2,000)	Nov. 1977	DAEE

TABLES

TABLE I.1 CATCHMENT AREA OF CUBATÃO AND MOJI RIVERS

River	Point	Cathement Area (Km2)		Accumulative River Length
		Single	Accumulative	(Km)
Cubatao River System				
Cubatao do Cima	- lower end of plateau	40.4	40.4	16.0
Cubatao	- before Piloes	42.9	83.3	
Piloes	- confluence	41.3		29.0
Cubatao	- after Piloes		124.6	
	- Imigrantes road bridge	5.8	130.4	31.5
	- Anchieta road bridge	6.1	136.5	34.5
	- before Pereque	10.0	146.5	
Pereque	- confluence	35.7		38.5
Cubatao	- after Pereque		182.2	
	- river mouth at confluence with Moji	0.5	182.7	40.0
Moji River System				
upper Moji	- intake weir	39.1	39.1	9.9
	- before Indio	2.6	41.7	
Indio	- confluence	3.7		12.0
Moji	- after Indio		45.4	
	- before Piasaguera	4.0	49.4	
Piasaguera	- confluence	11.4		14.4
Moji	- after Piasaguera		60.8	
	- river mouth at confluence with Cubatao	3.5	64.3	17.8

TABLE I.2 WORK QUANTITY OF ALTERNATIVE SCHEMES

Cubatao River System

Work Item	Unit	Alternative Scheme C-1	Alternative Scheme C-2(1)	Alternative Scheme C-2(2)
1. Land Acquisition and Compensation				
Land acquisition	ls	1	1	1
House/plant	ls	1	1	1
		1	1	1
2. Channel Improvement				
Preparatory	ls	1	1	1
Excavation	m3	1,429,000	454,000	511,000
Dredging	m3			
Embankment	m3	257,000	107,000	157,000
Bank protection	m2	28,000	6,700	6,700
Drainage culvert				
Type I w/gate	No	9	9	9
Type II w/gate	No	2	2	2
Road bridge	m2(No)	3100(2)	0	0
Weir	m	210(2)	0	0
Pipeline bridge	m2(No)	1,100	0	0
3. Construction of Diversion Channel				
Preparatory	ls	--	1	1
Excavation I	m3	--	69,000	53,000
(Dredging) II	m3	--	67,000	55,000
Tunnel	m	0	600*3	600*2
Fixed weir	m	0	15	30
Overflow dike	m	0	60	45
Bank protection	m2	0	3,000	3,000
Road bridge	m2(No)	0	250(1)	200(1)
Protection of roa	m (No)	0	50(1)	40(1)
Railway bridge	m2(No)	0	300(1)	300(1)

Moji River System

Work Item	Unit	Alternative Scheme M-1	Alternative Scheme M-2
1. Land Acquisition and Compensation			
Land acquisition	ls	1	1
House/plant	ls	1	1
2. Channel Improvement			
Preparatory	ls	1	1
Excavation	m3	1,166,000	1,430,000
Dredging	m3		
Embankment	m3	300,000	250,000
Drop structure	No	4	4
Bank protection	m2	26,000	25,000
Drainage culvert			
Type I w/gate	No	8	6
Type II w/gate	No	1	1
Bridge			
Road	m2(No)	3535(6)	1335(4)
Railway	m2(No)	1620(3)	1500(3)
Fixed intake dam	No	1	1
Repair of riprap dam	No	3	3

FIGURES

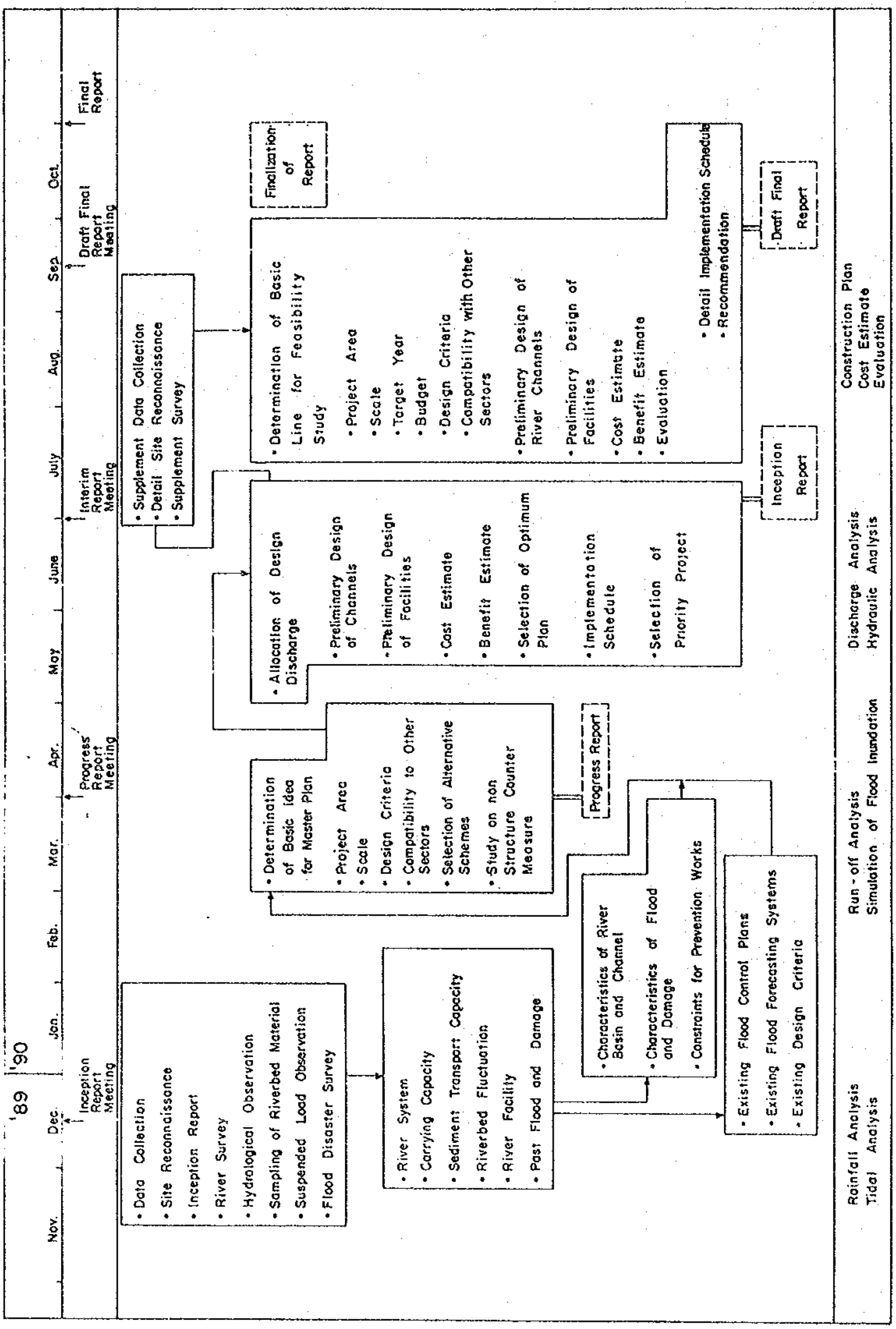

FIG. I.1
WORK FLOW CHART

GOVERNMENT OF FEDERATIVE REPUBLIC OF BRAZIL

THE STUDY ON THE DISASTER PREVENTION AND RESTORATION PROJECT IN SERRA DO MAR, CUBATÃO REGION, STATE OF SÃO PAULO

JAPAN INTERNATIONAL COOPERATION AGENCY

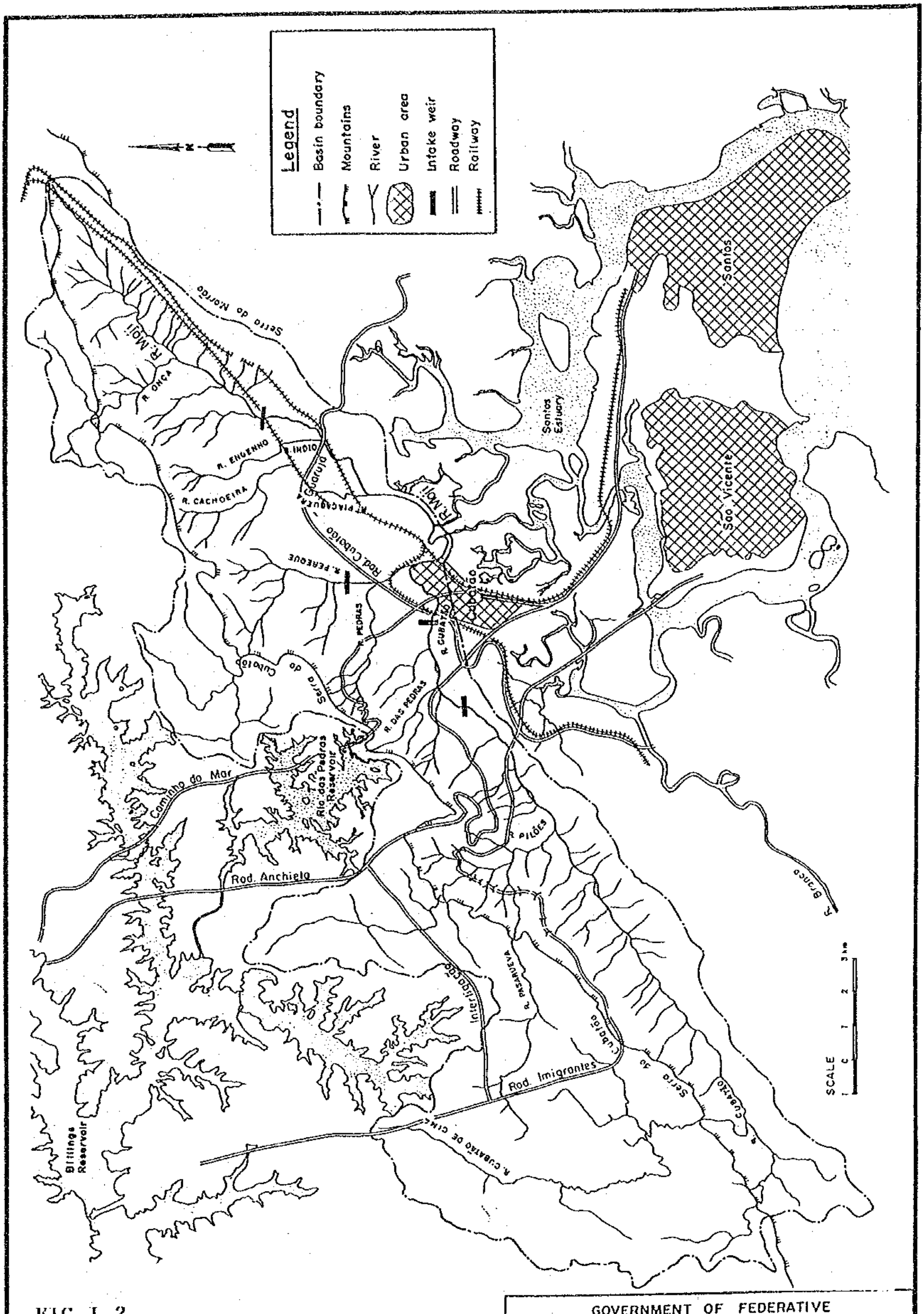

FIG. I.2
RIVER BASIN AND SYSTEM

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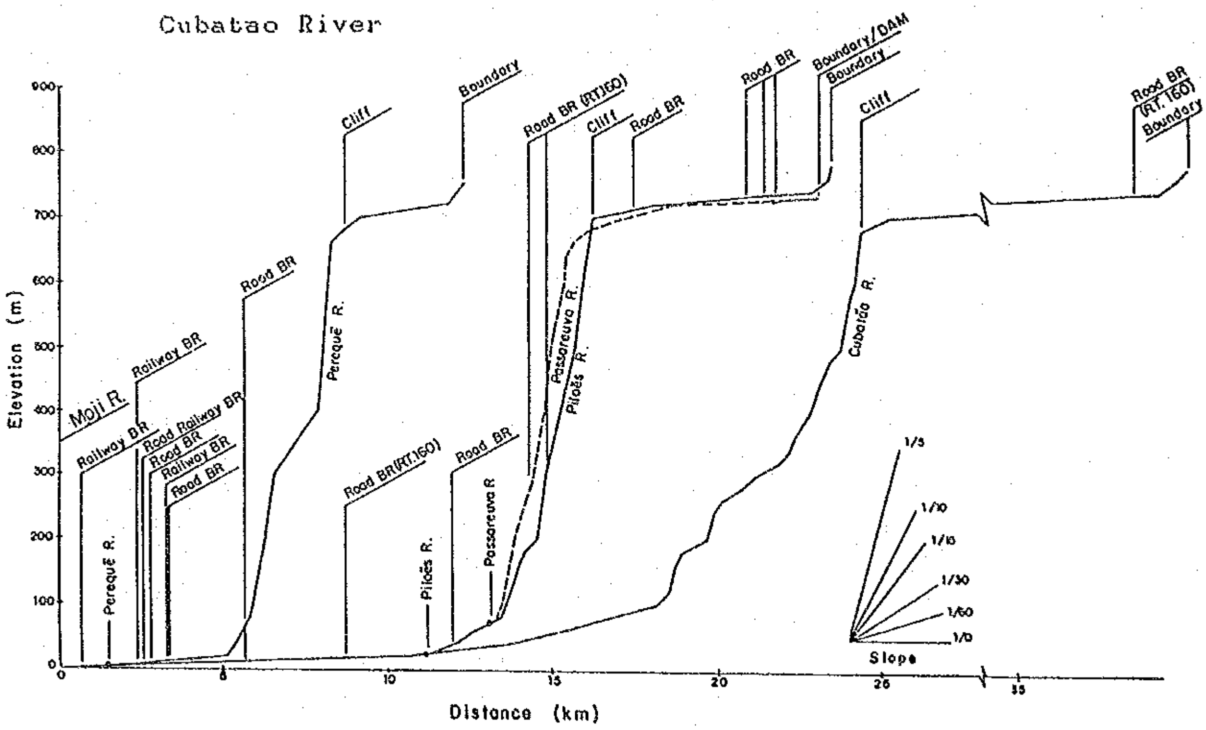

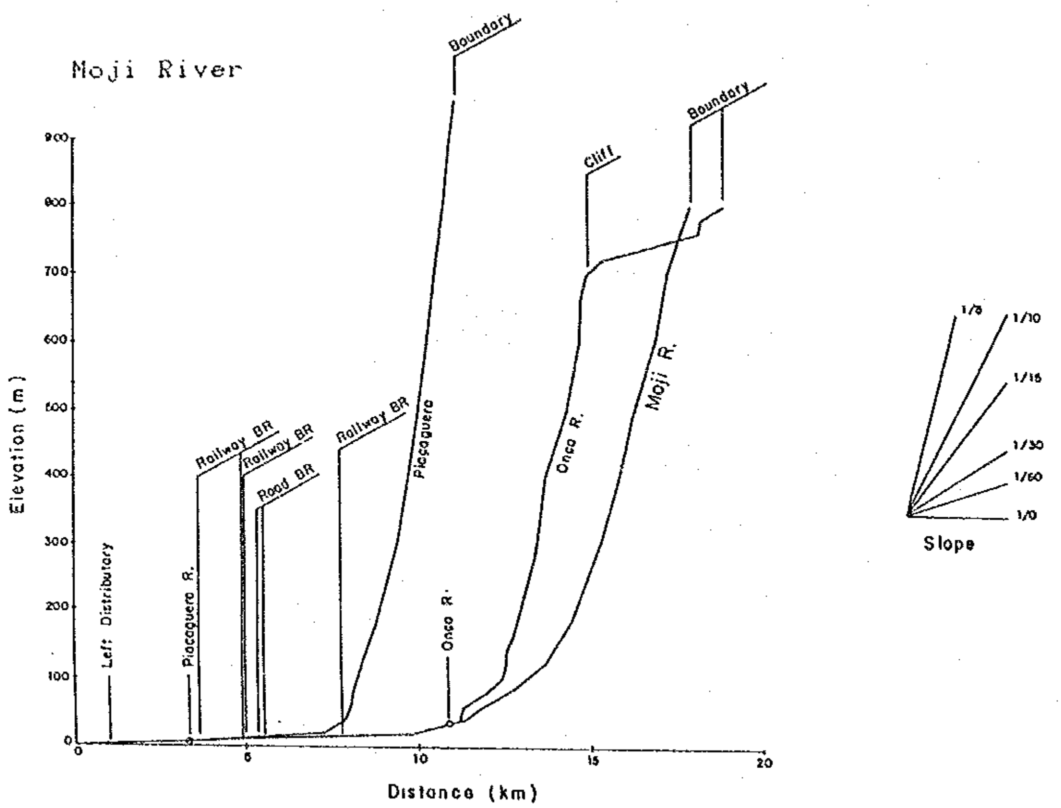

FIG.1.3
GENERAL RIVER PROFILES OF CUBATAO AND MOJI SYSTEMS

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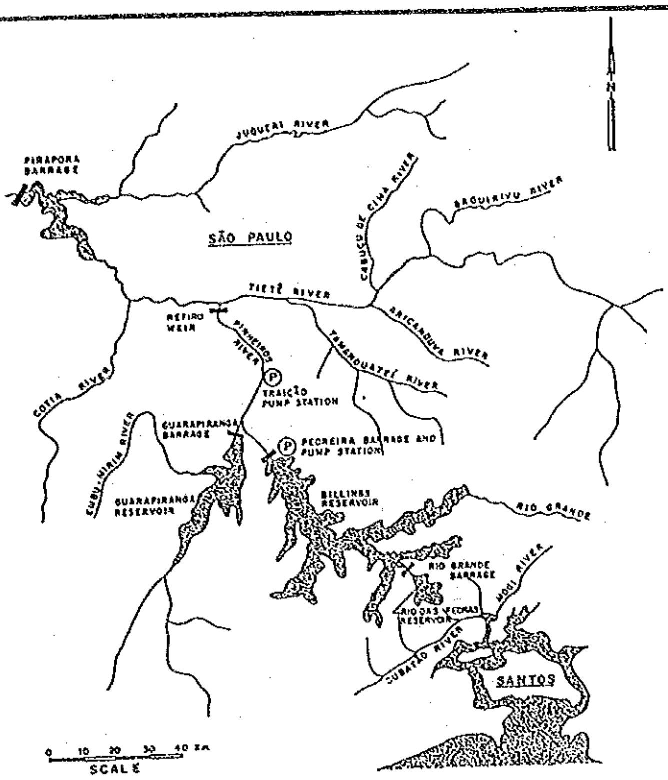

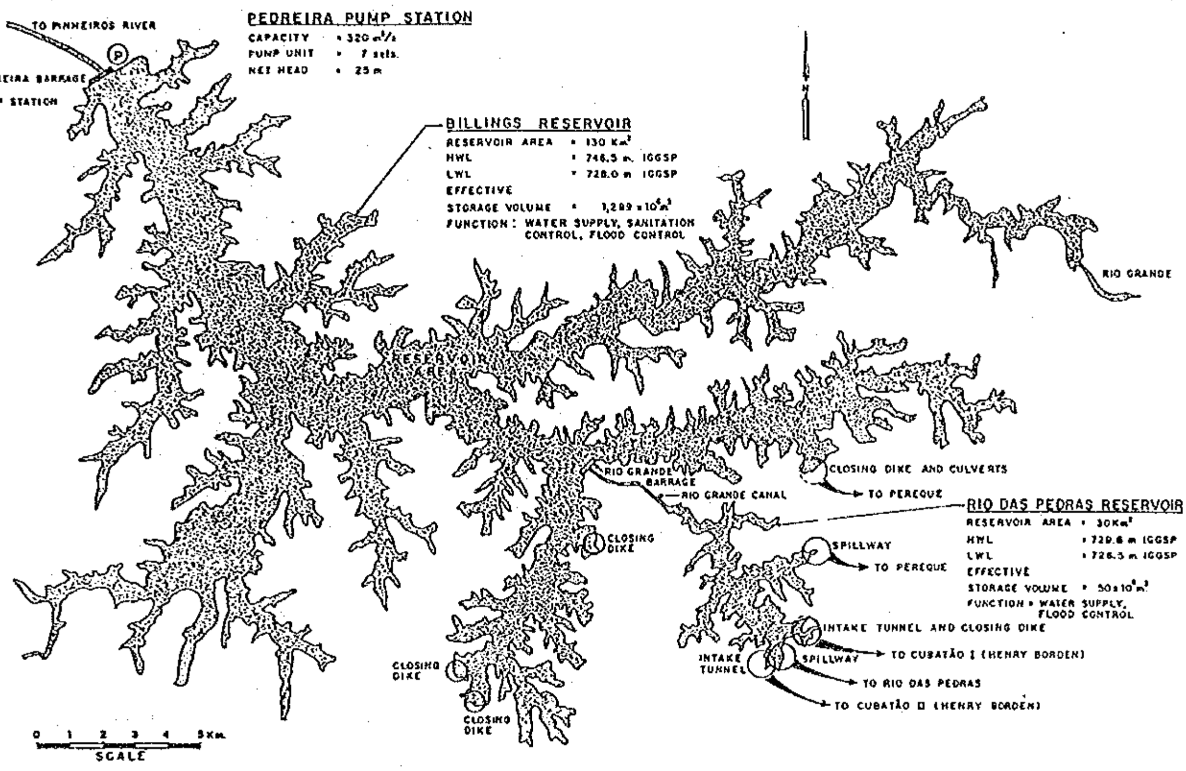

Source : Desenvolvimento Global dos Recursos Hídricos das Bacias do Alto Tietê e Cubatão, 1980/DAEE

FIG.1.4
BILLINGS AND RIO DAS PEDRAS RESERVOIRS

GOVERNMENT OF FEDERATIVE REPUBLIC OF BRAZIL
THE STUDY ON THE DISASTER PREVENTION AND RESTORATION PROJECT IN SERRA DO MAR, CUBATÃO REGION, STATE OF SÃO PAULO
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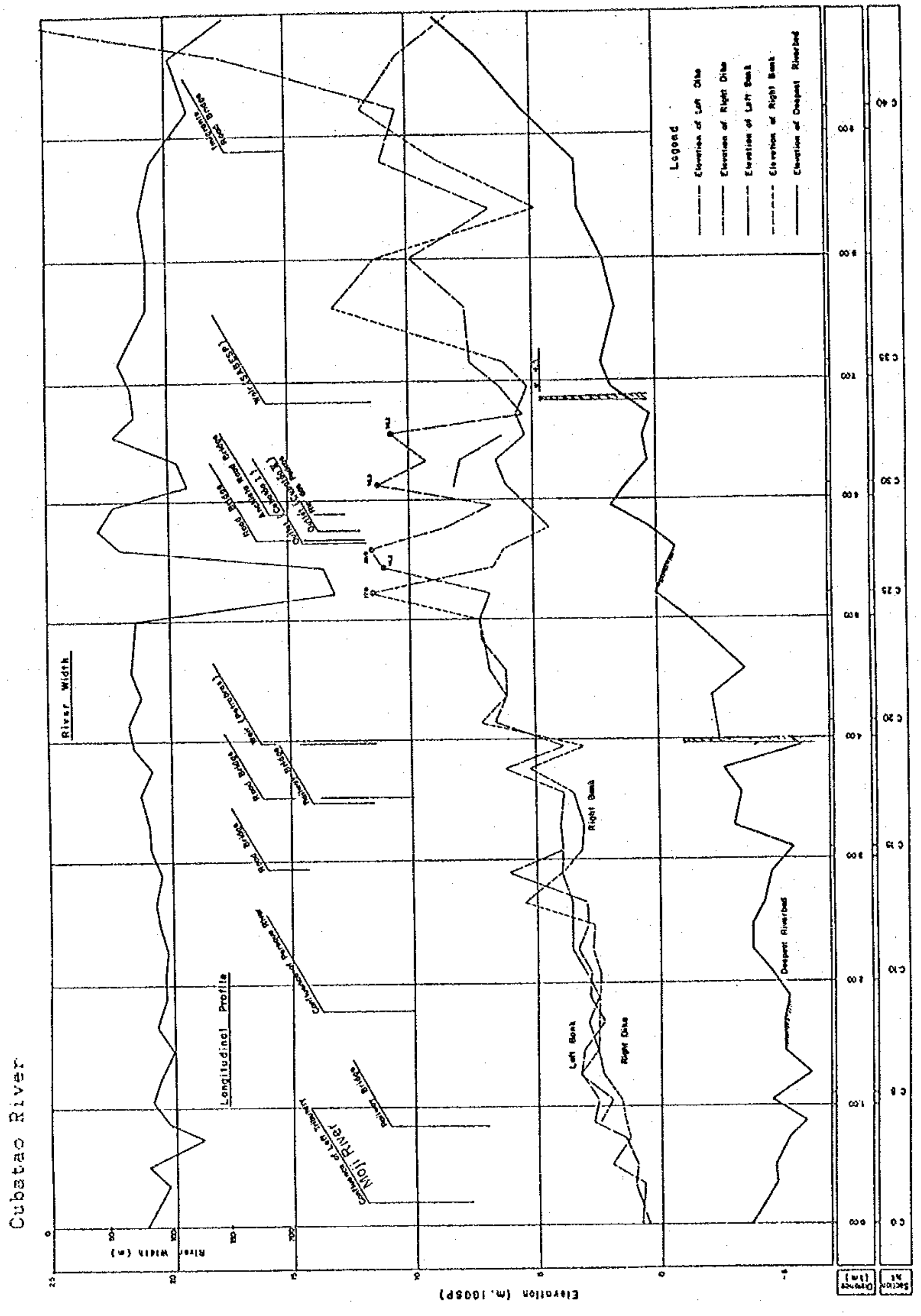

FIG.1.5 (1/2)
LONGITUDINAL PROFILE OF EXISTING
CUBATAO AND MOJI RIVERS

GOVERNMENT OF FEDERATIVE
REPUBLIC OF BRAZIL

THE STUDY ON THE DISASTER PREVENTION AND
RESTORATION PROJECT IN SERRA DO MAR,
CUBATÃO REGION, STATE OF SÃO PAULO

JAPAN INTERNATIONAL COOPERATION AGENCY

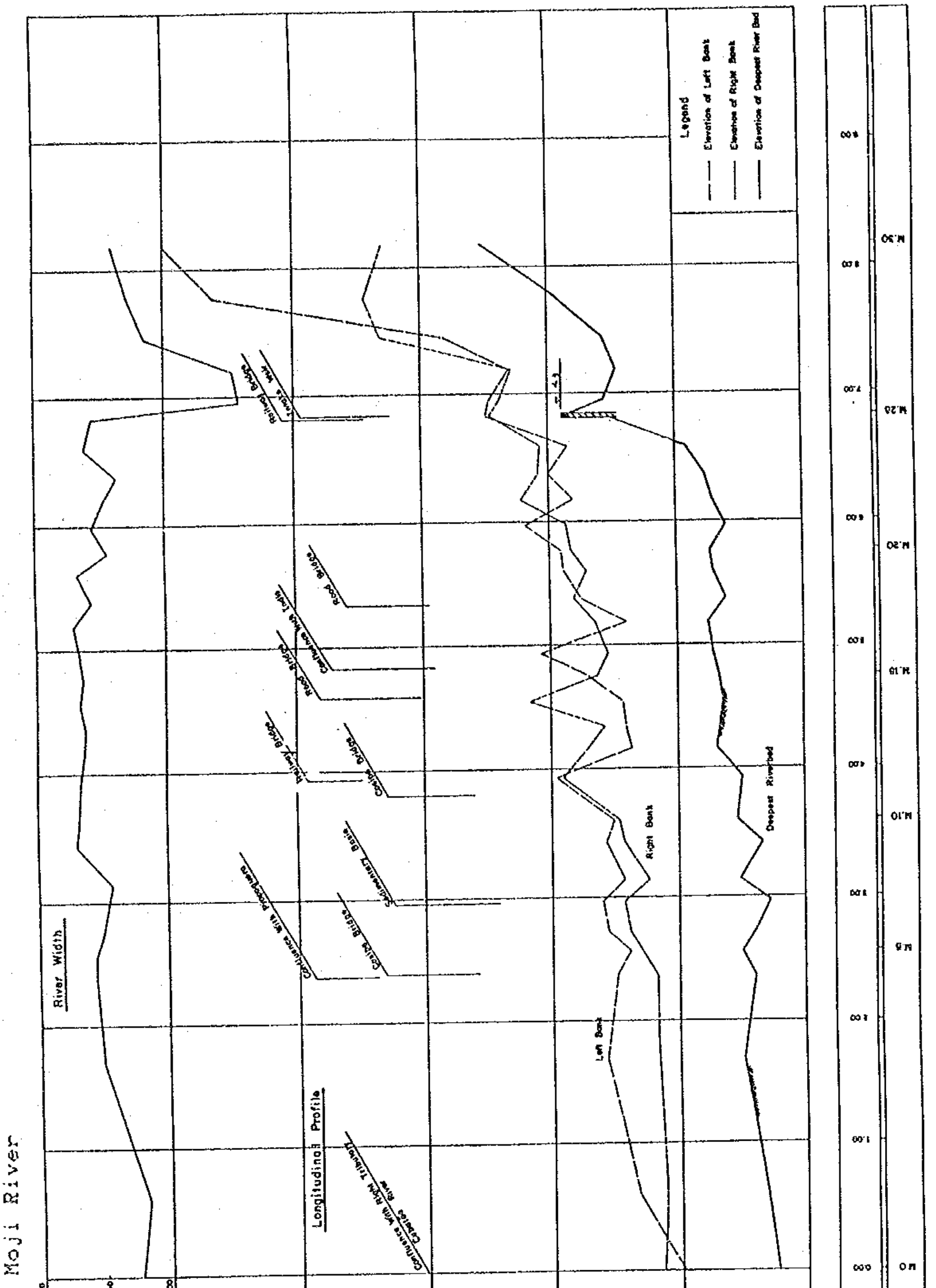

FIG.I.5 (2/2)
LONGITUDINAL PROFILE OF EXISTING
CUBATAO AND MOJI RIVERS

GOVERNMENT OF FEDERATIVE
REPUBLIC OF BRAZIL
THE STUDY ON THE DISASTER PREVENTION AND
RESTORATION PROJECT IN SERRA DO MAR ,
CUBATÃO REGION, STATE OF SÃO PAULO

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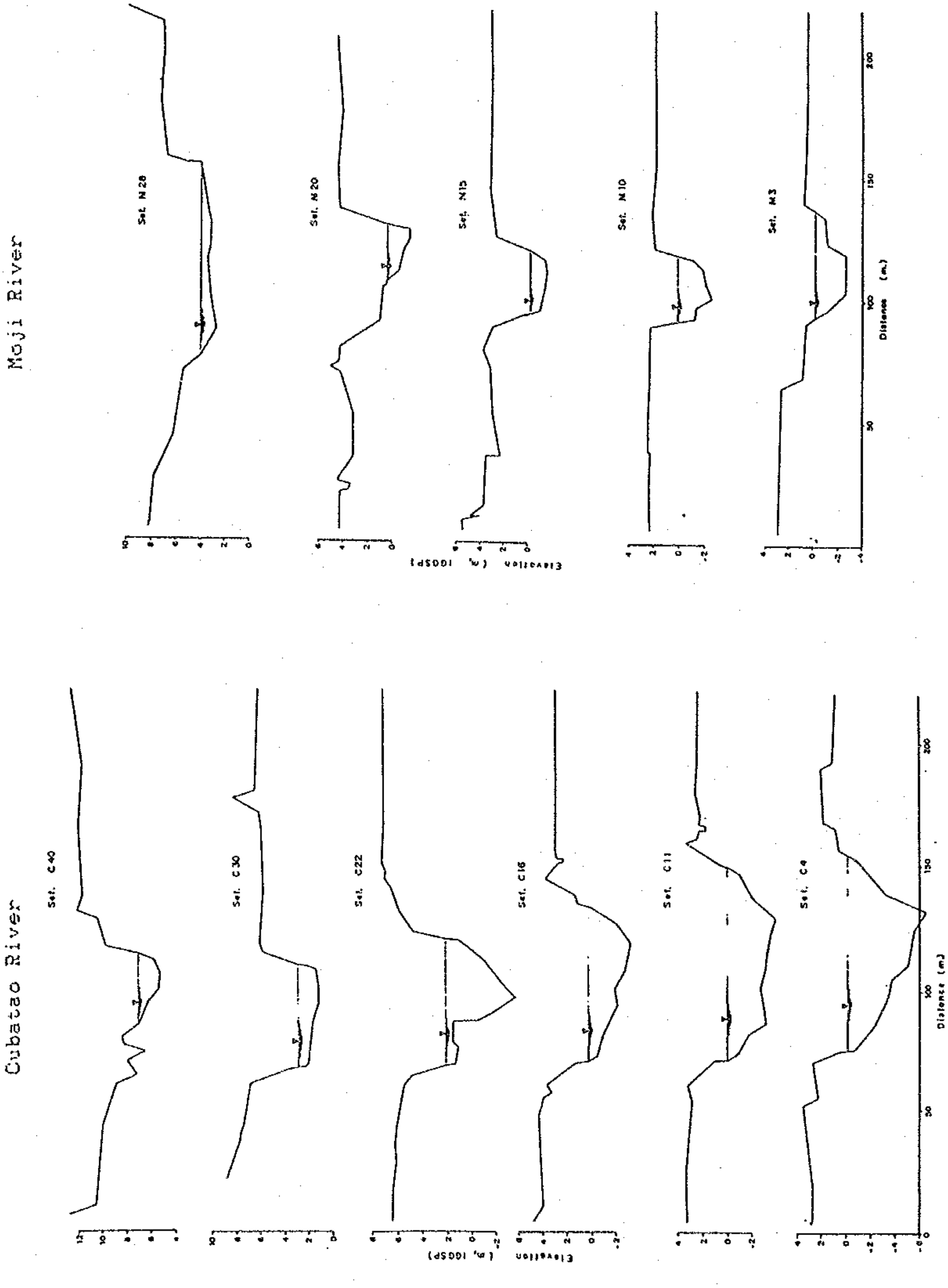

FIG.I.6
TYPICAL CROSS SECTIONS OF
EXISTING CUBATAO AND MOJI RIVERS

GOVERNMENT OF FEDERATIVE
REPUBLIC OF BRAZIL
THE STUDY ON THE DISASTER PREVENTION AND
RESTORATION PROJECT IN SERRA DO MAR,
CUBATÃO REGION, STATE OF SÃO PAULO

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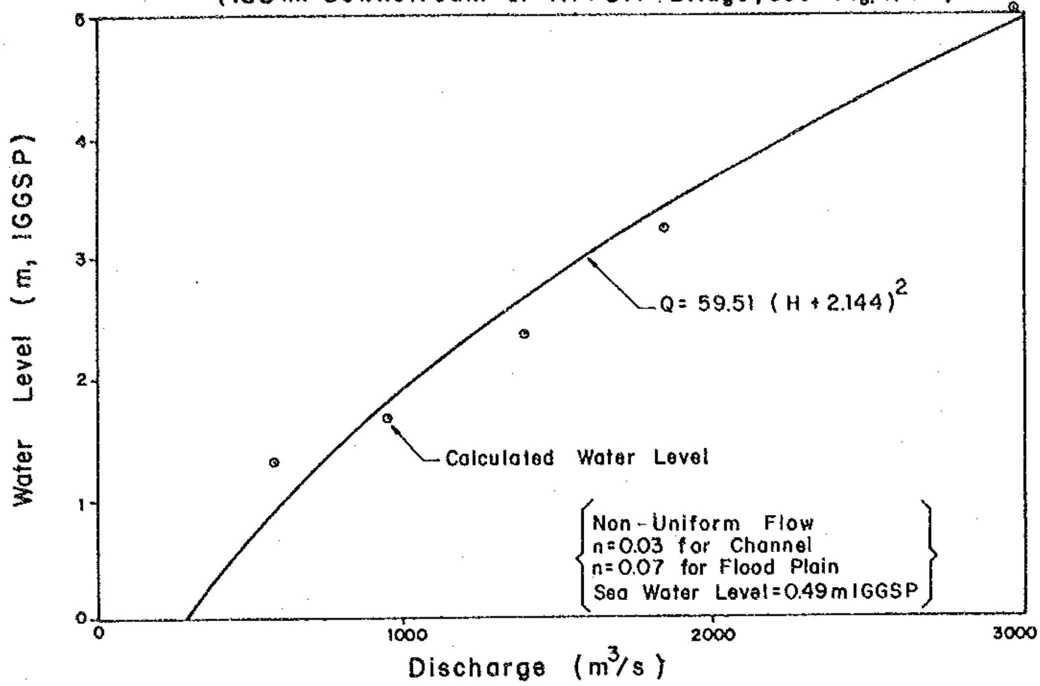
Discharge Rating Curve at C3 in Cubatão River
(100 m. Downstream of RFFSA Bridge, see Fig. F.18)



Discharge Rating Curve at M3 in Moji River
(900 m. Downstream of RFFSA Bridge, see Fig. F.19)

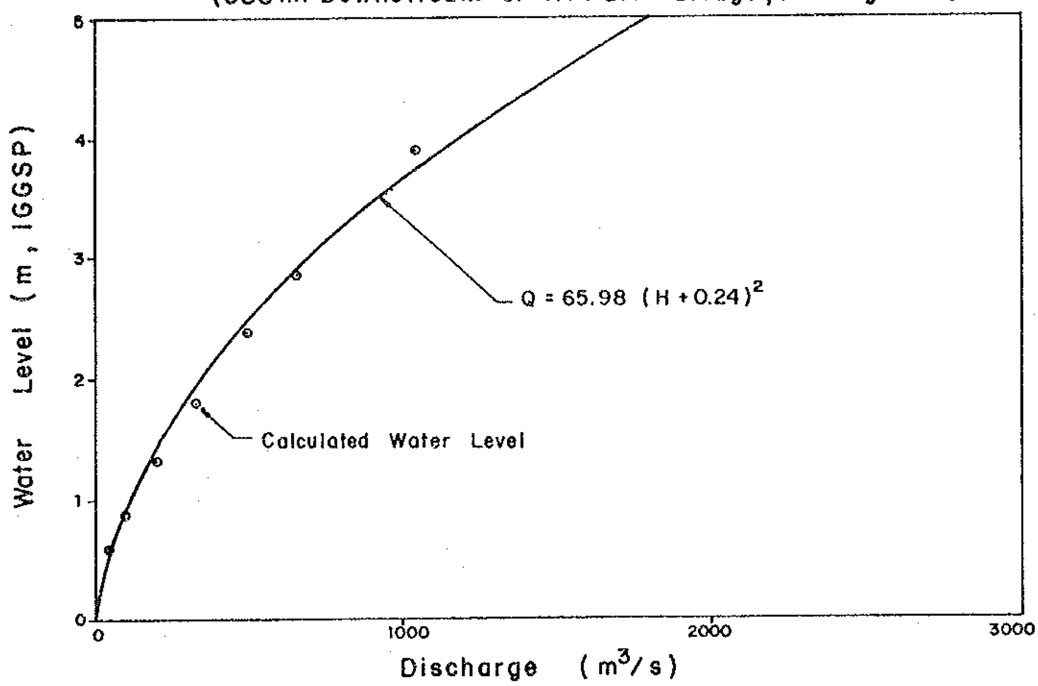
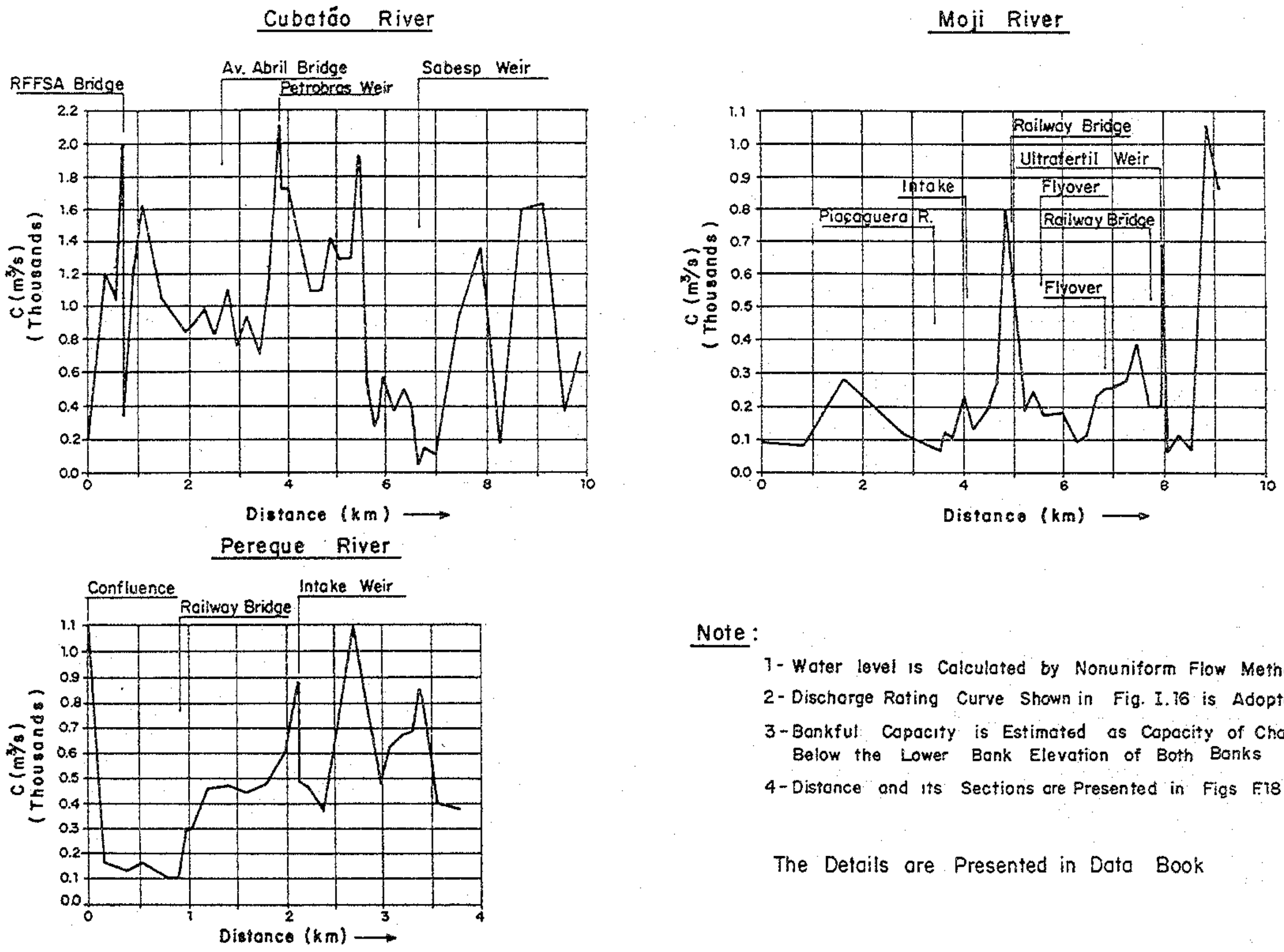


FIG. I.7
DISCHARGE RATING CURVE AT RIVERMOUTH OF CUBATÃO AND MOJI RIVERS

GOVERNMENT OF FEDERATIVE REPUBLIC OF BRAZIL
THE STUDY ON THE DISASTER PREVENTION AND RESTORATION PROJECT IN SERRA DO MAR, CUBATÃO REGION, STATE OF SÃO PAULO
JAPAN INTERNATIONAL COOPERATION AGENCY



Note :

1 - Water level is Calculated by Nonuniform Flow Method.

2 - Discharge Rating Curve Shown in Fig. I.16 is Adopted.

3 - Bankful Capacity is Estimated as Capacity of Channel Below the Lower Bank Elevation of Both Banks

4 - Distance and its Sections are Presented in Figs F18 and F19

The Details are Presented in Data Book

FIG. I.8
ESTIMATED BANKFUL CARRYING CAPACITY OF CHANNEL

GOVERNMENT OF FEDERATIVE REPUBLIC OF BRAZIL
THE STUDY ON THE DISASTER PREVENTION AND RESTORATION PROJECT IN SERRA DO MAR, CUBATÃO REGION, STATE OF SÃO PAULO

JAPAN INTERNATIONAL COOPERATION AGENCY

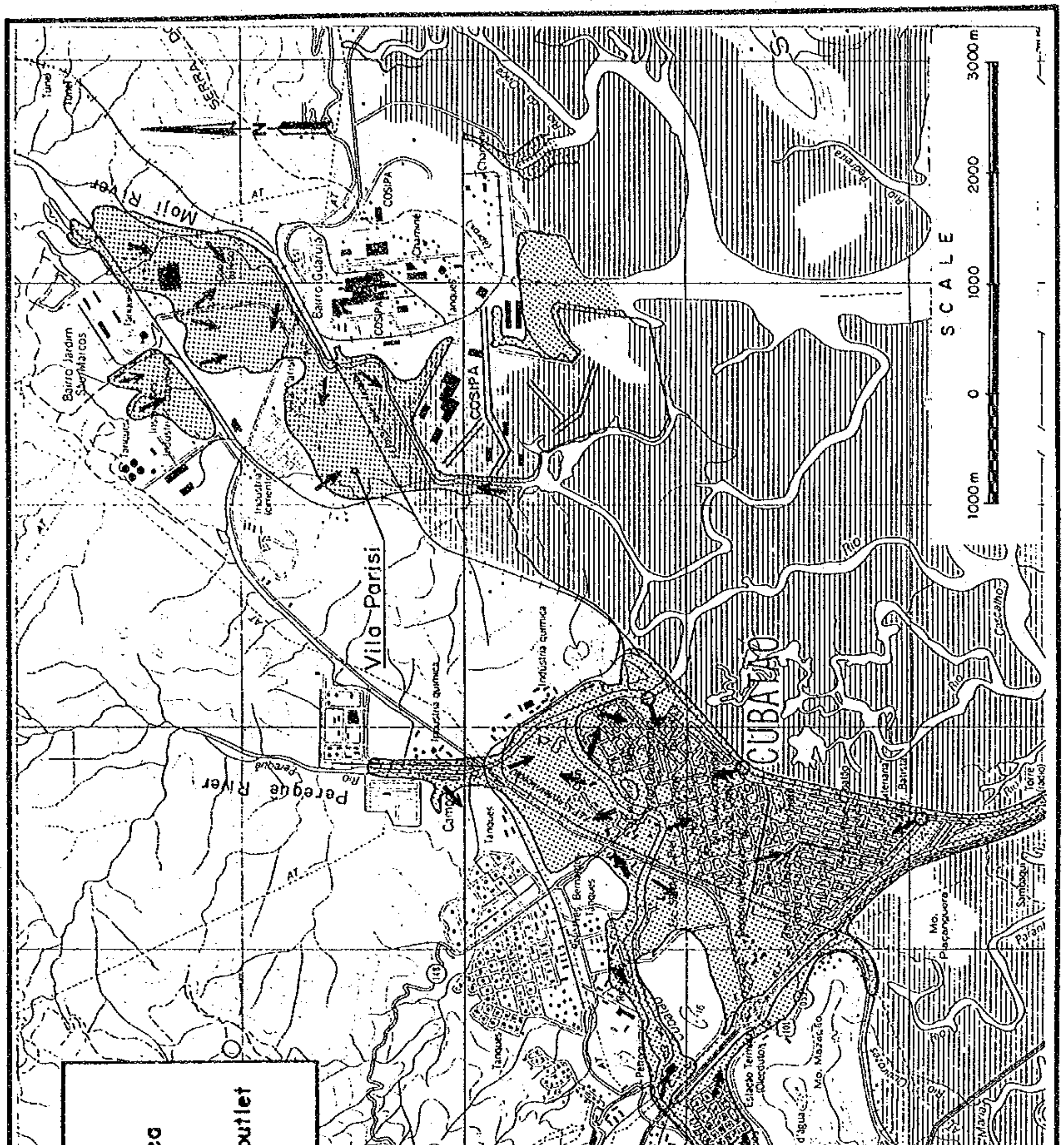


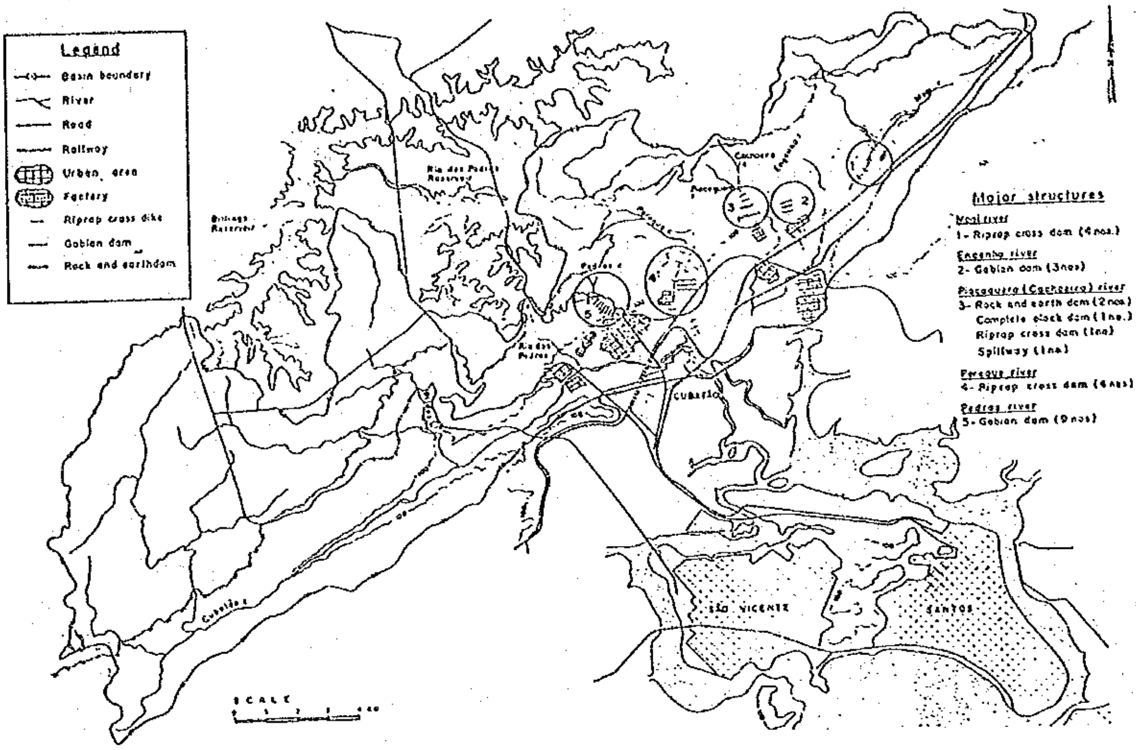
FIG.1.9
FLOOD PRONE AREA

GOVERNMENT OF FEDERATIVE
REPUBLIC OF BRAZIL

THE STUDY ON THE DISASTER PREVENTION AND RESTORATION PROJECT IN SERRA DO MAR, CUBATÃO REGION, STATE OF SÃO PAULO

JAPAN INTERNATIONAL COOPERATION AGENCY

Sediment Runoff Control



Flood Control

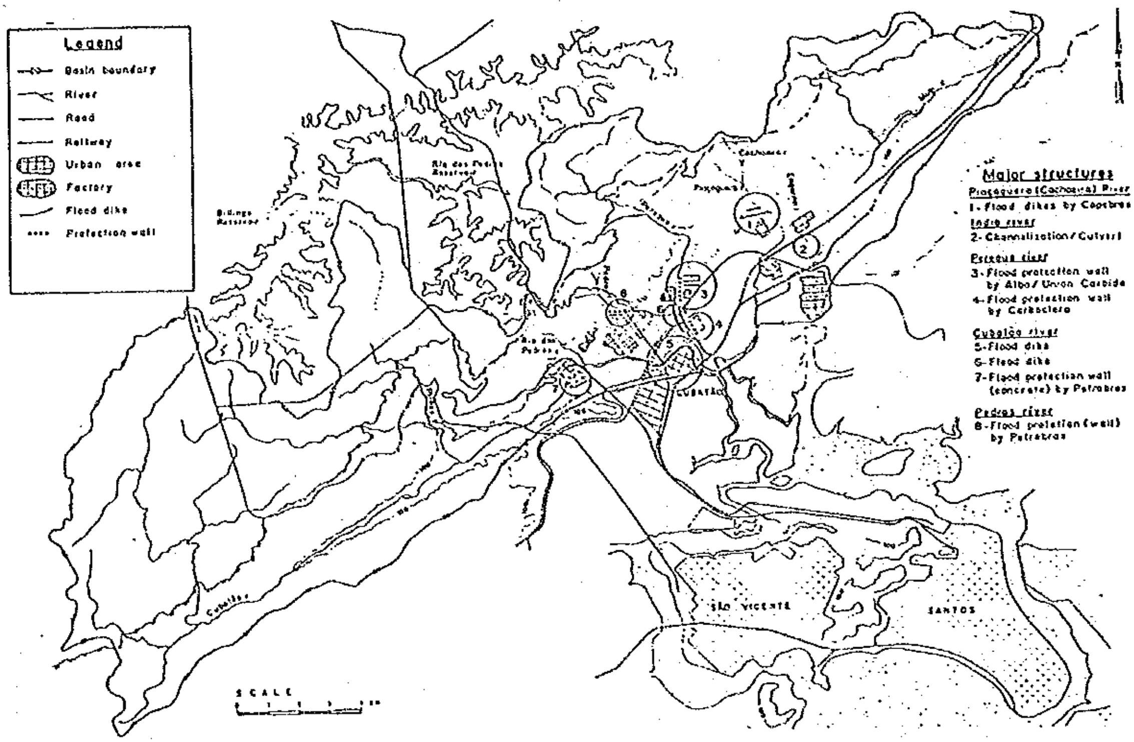
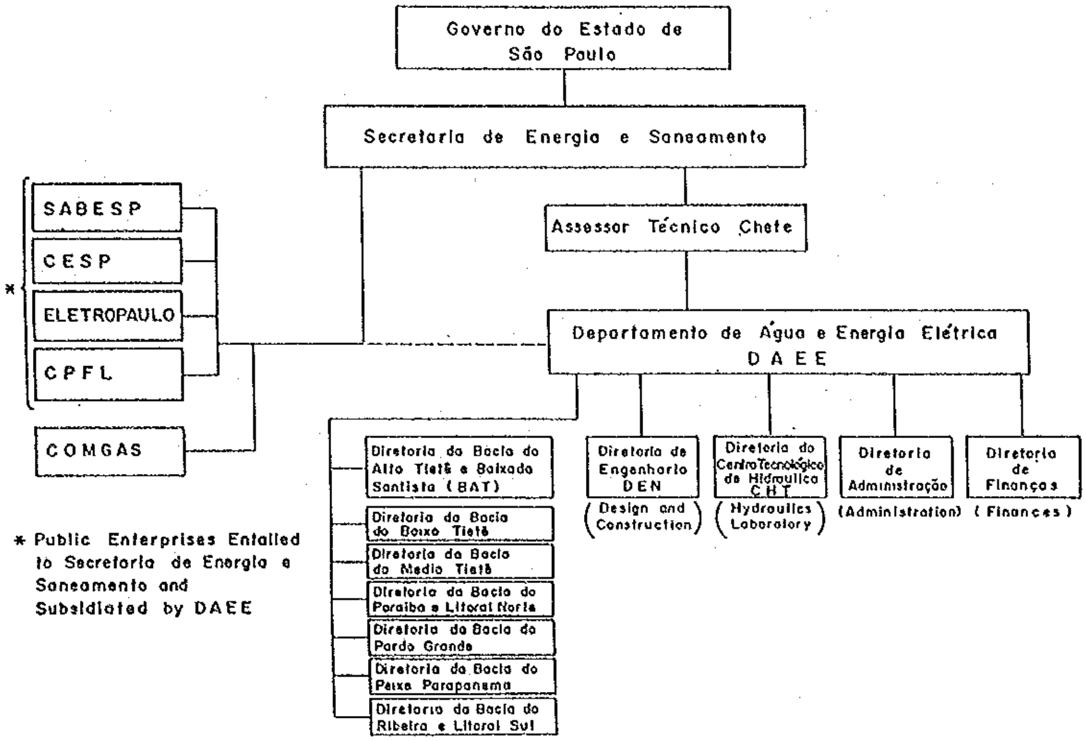


FIG.1.10
LOCATIONS OF EXISTING DISASTER PREVENTION WORKS FOR SEDIMENT RUNOFF AND FLOOD CONTROL

GOVERNMENT OF FEDERATIVE REPUBLIC OF BRAZIL

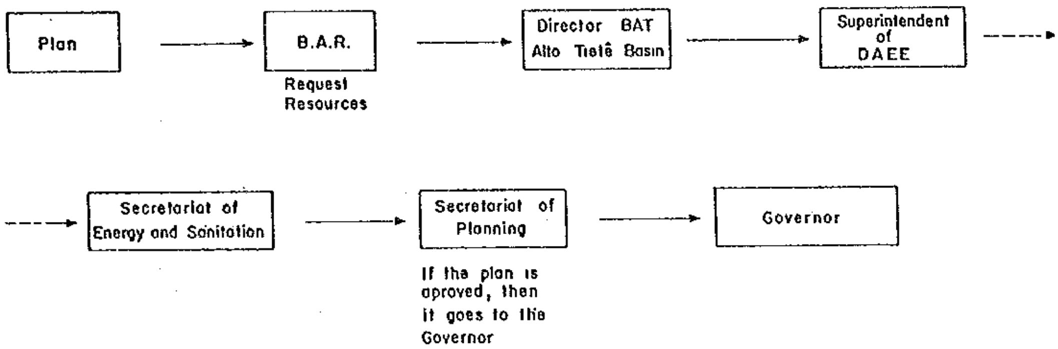
THE STUDY ON THE DISASTER PREVENTION AND RESTORATION PROJECT IN SERRA DO MAR, CUBATÃO REGION, STATE OF SÃO PAULO

JAPAN INTERNATIONAL COOPERATION AGENCY



* Public Enterprises Entailed to Secretaria de Energia e Saneamento and Subsidiated by DAEE

BUDGETING FLOW CHART IN DAEE



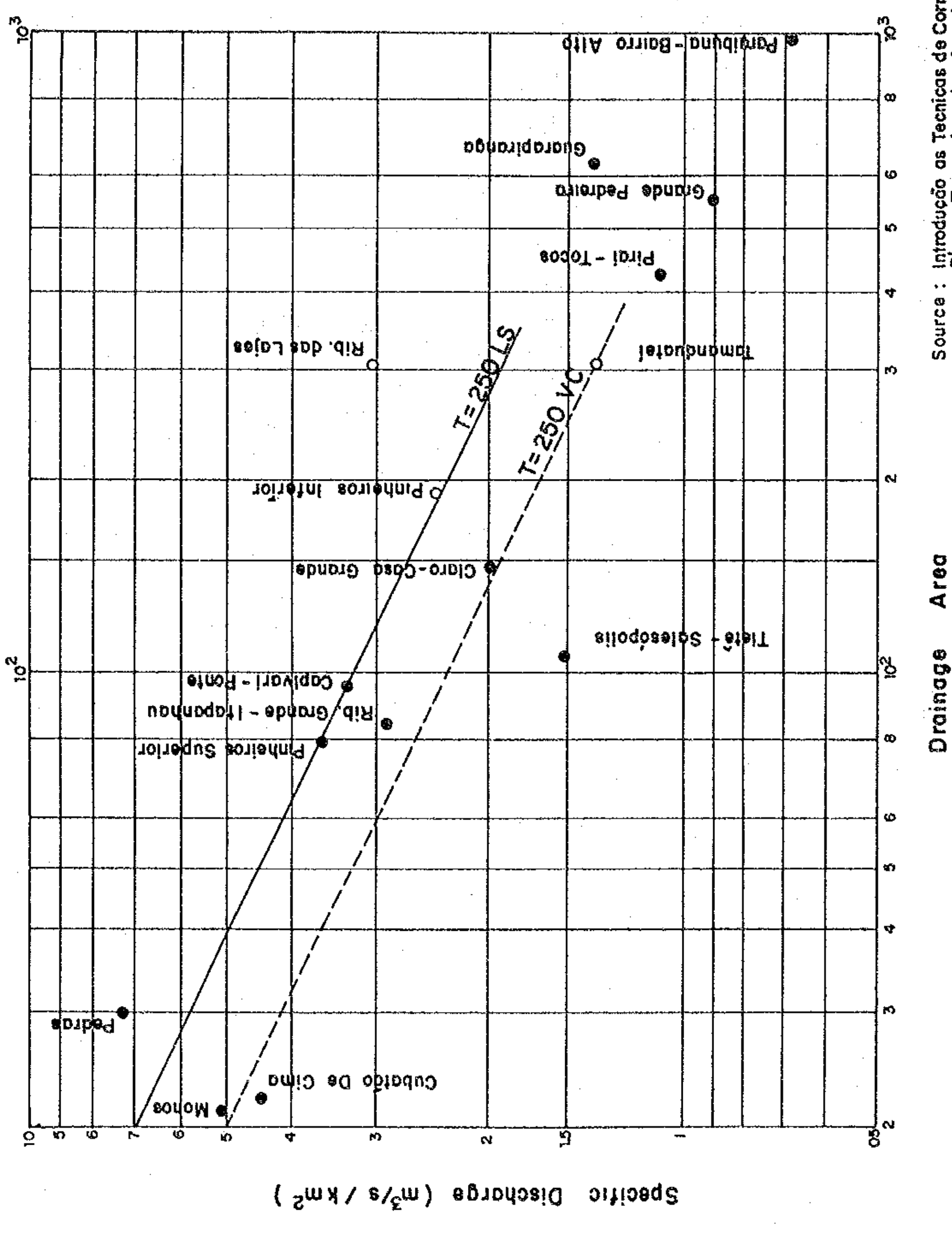
BAR → Water Resources Division of the Water Resources Management Center

Source: Bacia do Alto Tietê e Baixada Santista (BAT) in DAEE

FIG. I. 11
ORGANIZATION CHART OF SECRETARIAT OF ENERGY AND SANITATION

GOVERNMENT OF FEDERATIVE REPUBLIC OF BRAZIL
THE STUDY ON THE DISASTER PREVENTION AND RESTORATION PROJECT IN SERRA DO MAR, CUBATÃO REGION, STATE OF SÃO PAULO

JAPAN INTERNATIONAL COOPERATION AGENCY



Source : Introdução as Tecnicas de Correção de Cursos D'agua Torrenciais by Angelo Raffaele Cuomo and Marco Antonio Palermo 1967 Centro Tecnologico de Hidraulica / DAEE

FIG.1.12
SPECIFIC DISCHARGES OF RIVERS IN SAO PAULO STATE

GOVERNMENT OF FEDERATIVE REPUBLIC OF BRAZIL

THE STUDY ON THE DISASTER PREVENTION AND RESTORATION PROJECT IN SERRA DO MAR, CUBATÃO REGION, STATE OF SÃO PAULO

JAPAN INTERNATIONAL COOPERATION AGENCY

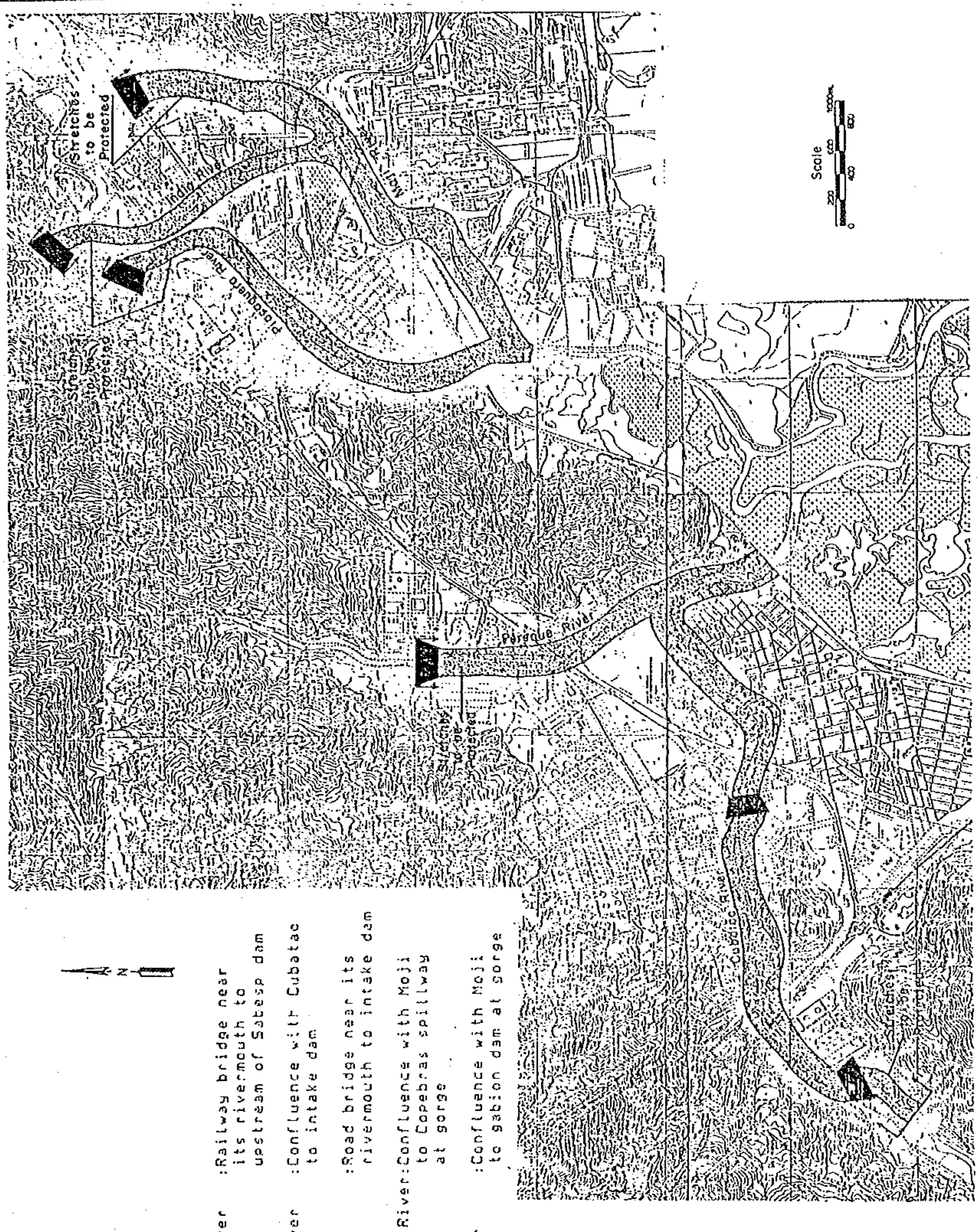


FIG. I.13
STRETCHES TO BE PROTECTED BY FLOOD CONTROL MASTER PLAN

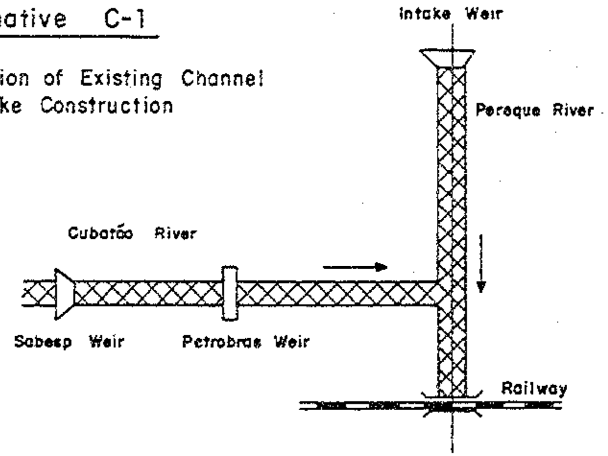
GOVERNMENT OF FEDERATIVE REPUBLIC OF BRAZIL
THE STUDY ON THE DISASTER PREVENTION AND RESTORATION PROJECT IN SERRA DO MAR, CUBATÃO REGION, STATE OF SÃO PAULO

JAPAN INTERNATIONAL COOPERATION AGENCY

Cubatão River System

Alternative C-1

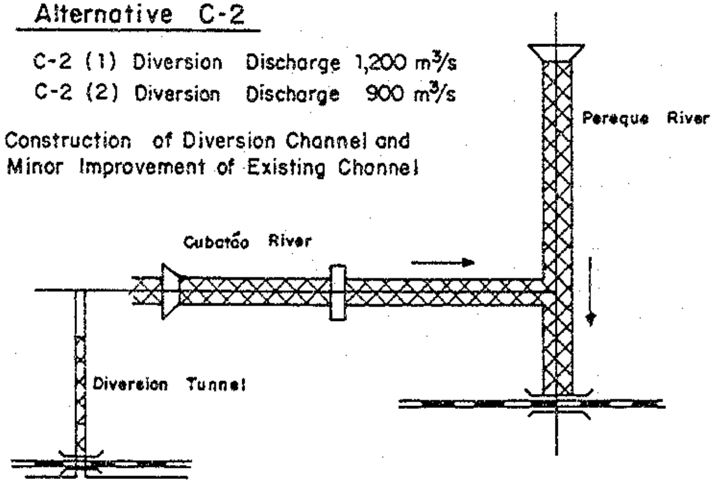
Excavation of Existing Channel and Dike Construction



Alternative C-2

C-2 (1) Diversion Discharge 1,200 m^3/s
C-2 (2) Diversion Discharge 900 m^3/s

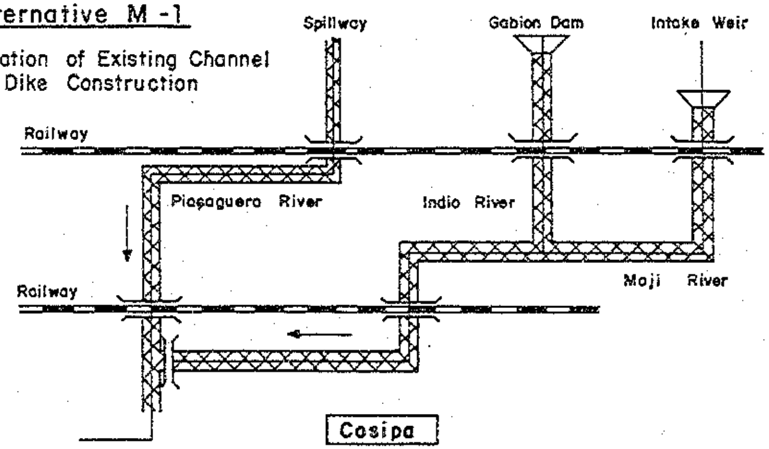
Construction of Diversion Channel and Minor Improvement of Existing Channel



Moji River System

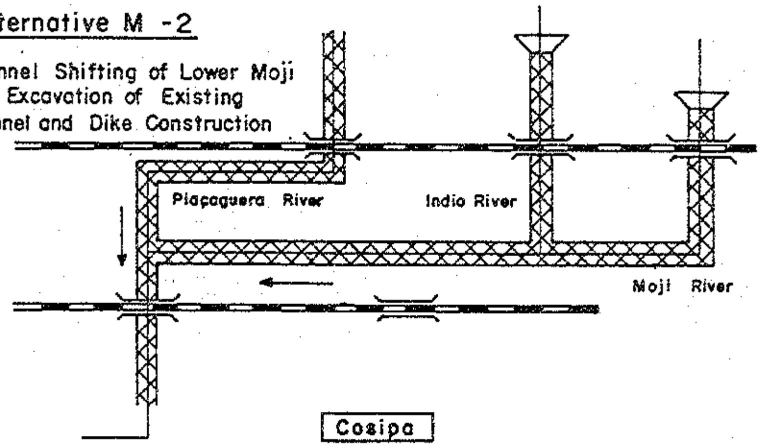
Alternative M -1

Excavation of Existing Channel and Dike Construction



Alternative M -2

Channel Shifting of Lower Moji and Excavation of Existing Channel and Dike Construction



Note : ⊠⊠⊠ Stretch to be Improved

FIG.1.14
ALTERNATIVE SCHEMES OF OPTIMUM PLAN

GOVERNMENT OF FEDERATIVE REPUBLIC OF BRAZIL
THE STUDY ON THE DISASTER PREVENTION AND RESTORATION PROJECT IN SERRA DO MAR, CUBATÃO REGION, STATE OF SÃO PAULO
JAPAN INTERNATIONAL COOPERATION AGENCY

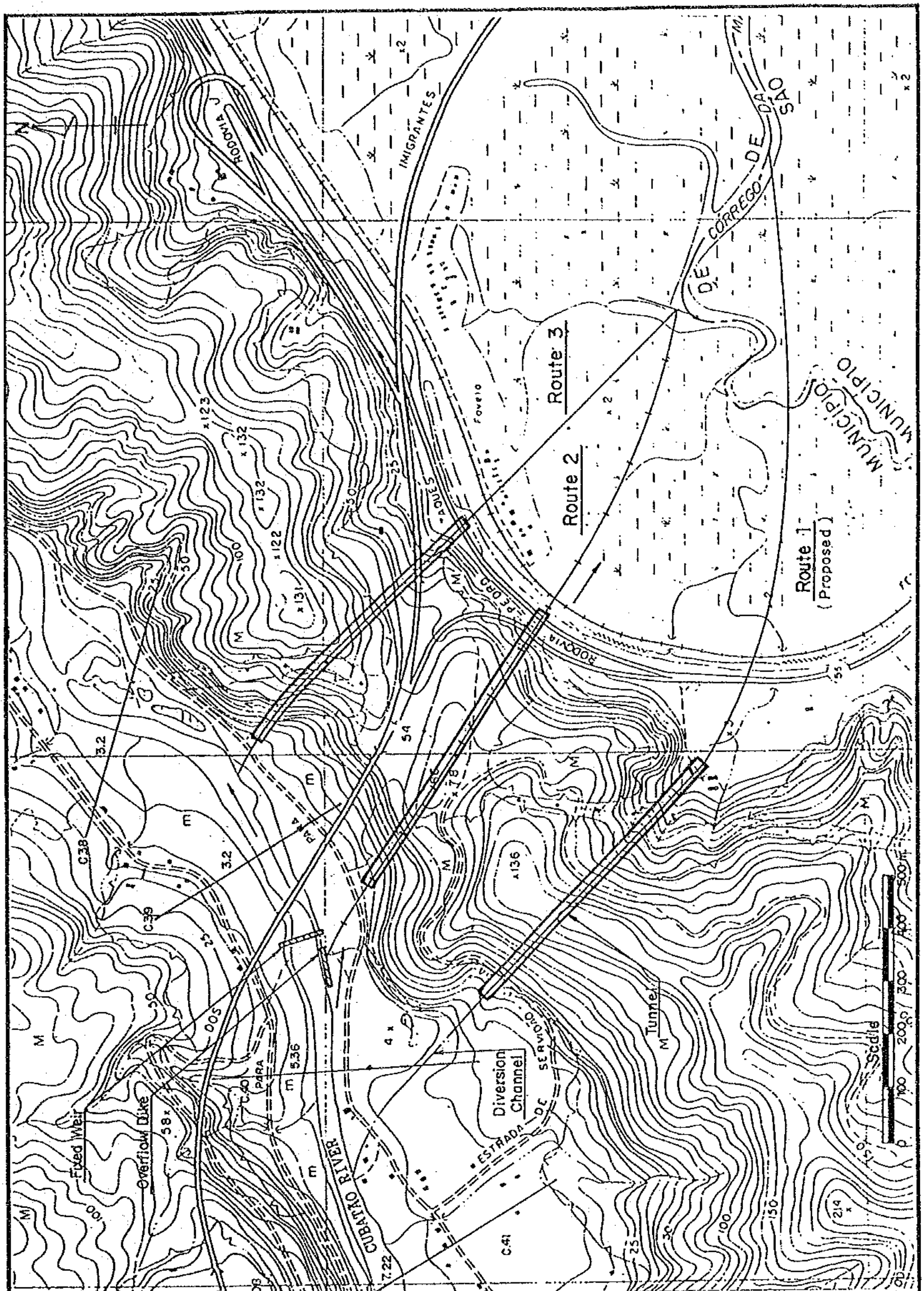


FIG.I.15
ALTERNATIVE ROUTES OF
DIVERSION TUNNEL

GOVERNMENT OF FEDERATIVE
REPUBLIC OF BRAZIL

THE STUDY ON THE DISASTER PREVENTION AND
RESTORATION PROJECT IN SERRA DO MAR,
CUBATÃO REGION, STATE OF SÃO PAULO

JAPAN INTERNATIONAL COOPERATION AGENCY

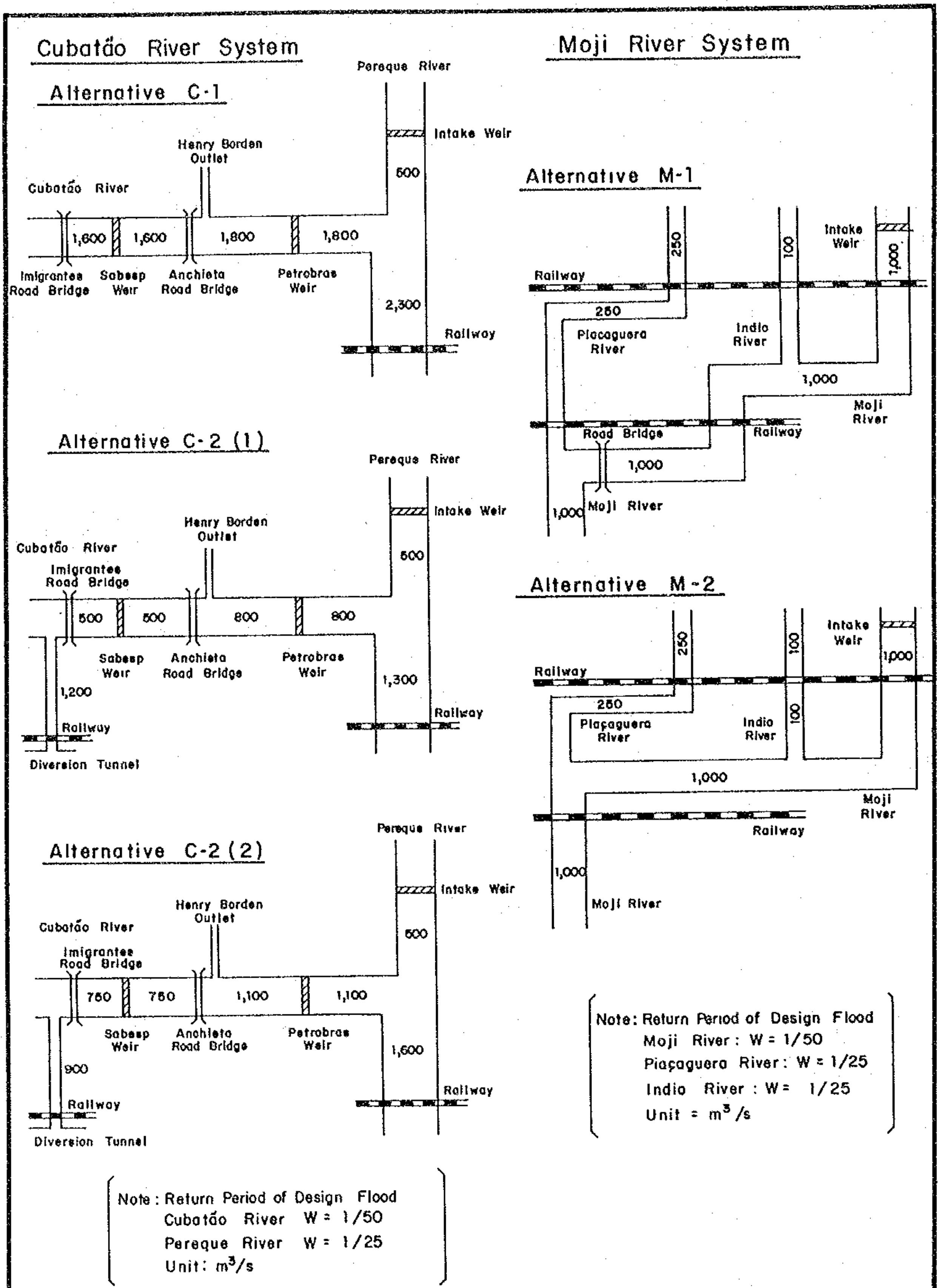


FIG. I. 16
DESIGN DISCHARGE DISTRIBUTION OF ALTERNATIVE SCHEMES

GOVERNMENT OF FEDERATIVE REPUBLIC OF BRAZIL
THE STUDY ON THE DISASTER PREVENTION AND RESTORATION PROJECT IN SERRA DO MAR, CUBATÃO REGION, STATE OF SÃO PAULO

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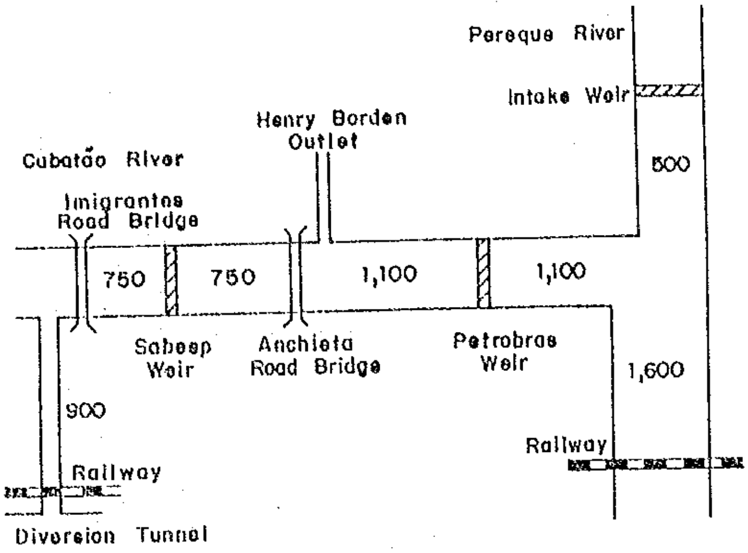
Cubatão and Pereque Rivers



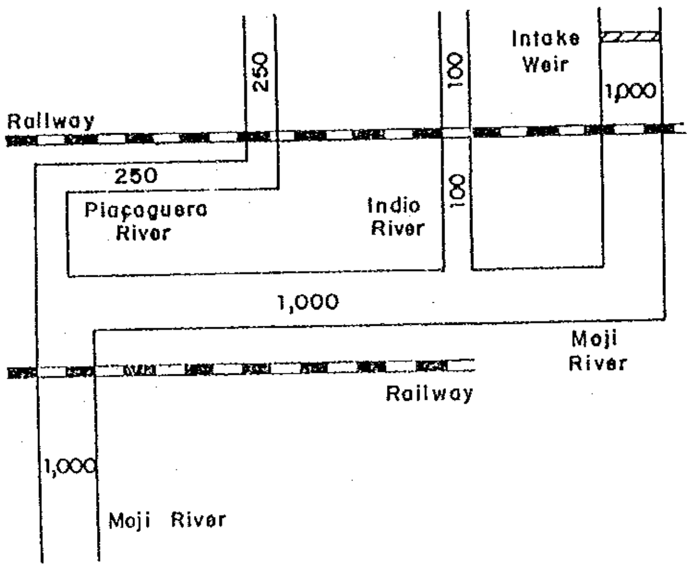
Probable Discharge

unit:m3/s

Return Period	Cubatao Before Pereque	Cubatao River Mouth	Pereque
1/100	1200 (2000)	1800 (2600)	700
1/ 50	1100 (1800)	1600 (2300)	600
1/ 25	1000 (1650)	1400 (2000)	500
1/ 10	900 (1300)	1200 (1650)	400
1/ 5	700 (1100)	1000 (1350)	350
1/ 2	500 (750)	700 (950)	250

Note:( ) indicate discharge without tunnel

Moji River and Their Tributaries



Probable Discharge

unit:m3/s

Return Period	Moji Ultrafertil Weir	Piacaguera	Indio
1/100	1100	300	-
1/ 50	1000	280	-
1/ 25	800	250	100
1/ 10	600	200	60
1/ 5	500	150	50
1/ 2	300	100	30

Note: Return Period of Design Discharge
Cubatão and Moji Rivers : W = 1/50
Pereque, Piaçaguera and Indio Rivers : W = 1/25
Unit = m^3/s

FIG.I.17
DESIGN DISCHARGE DISTRIBUTION
OF MASTER PLAN

GOVERNMENT OF FEDERATIVE REPUBLIC OF BRAZIL
THE STUDY ON THE DISASTER PREVENTION AND RESTORATION PROJECT IN SERRA DO MAR, CUBATÃO REGION, STATE OF SÃO PAULO

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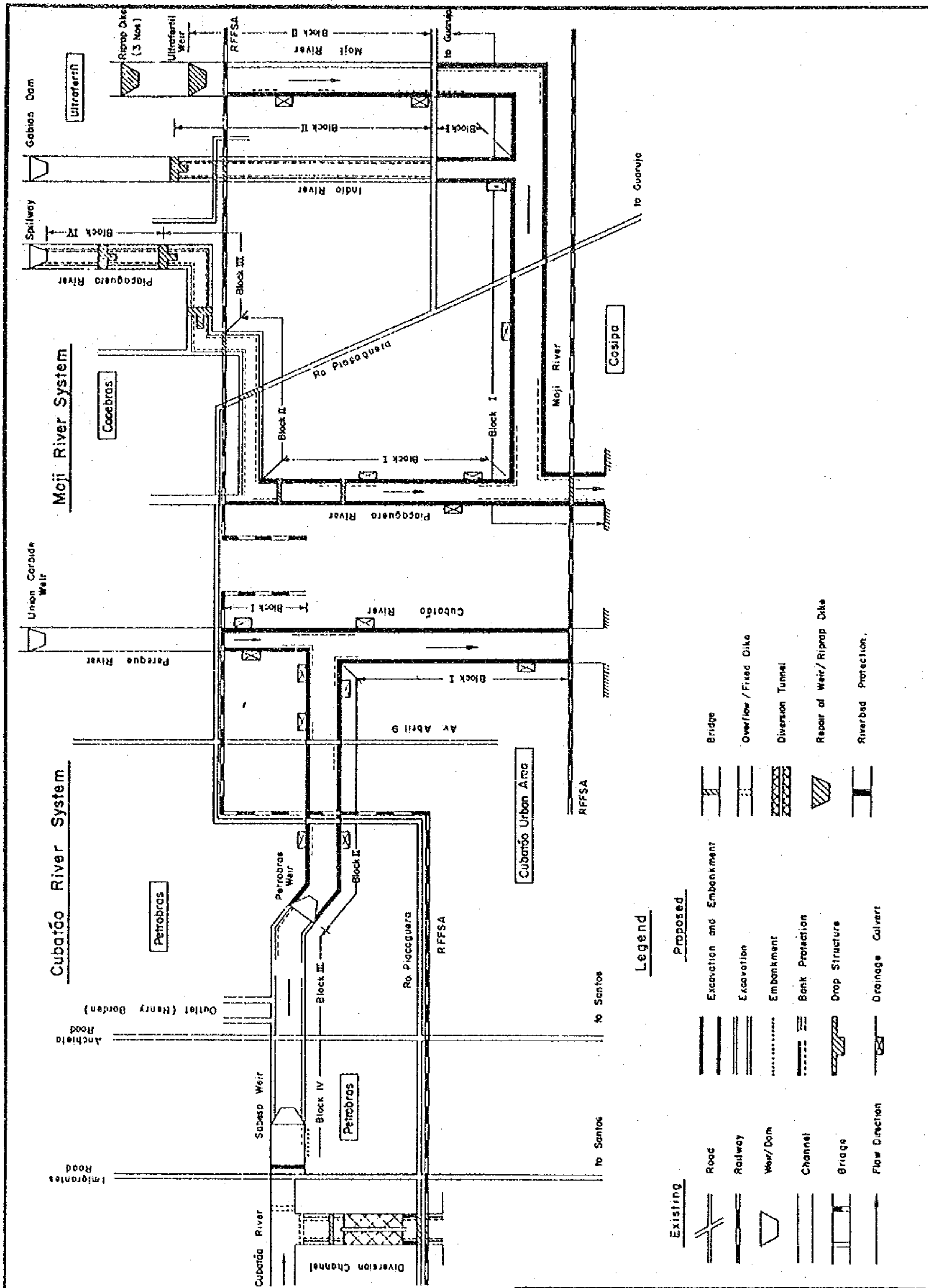

FIG. 1.18
OUTLINE OF FLOOD DISASTER PREVENTION MASTER PLAN

GOVERNMENT OF FEDERATIVE REPUBLIC OF BRAZIL

THE STUDY ON THE DISASTER PREVENTION AND RESTORATION PROJECT IN SERRA DO MAR, CUBATÃO REGION, STATE OF SÃO PAULO

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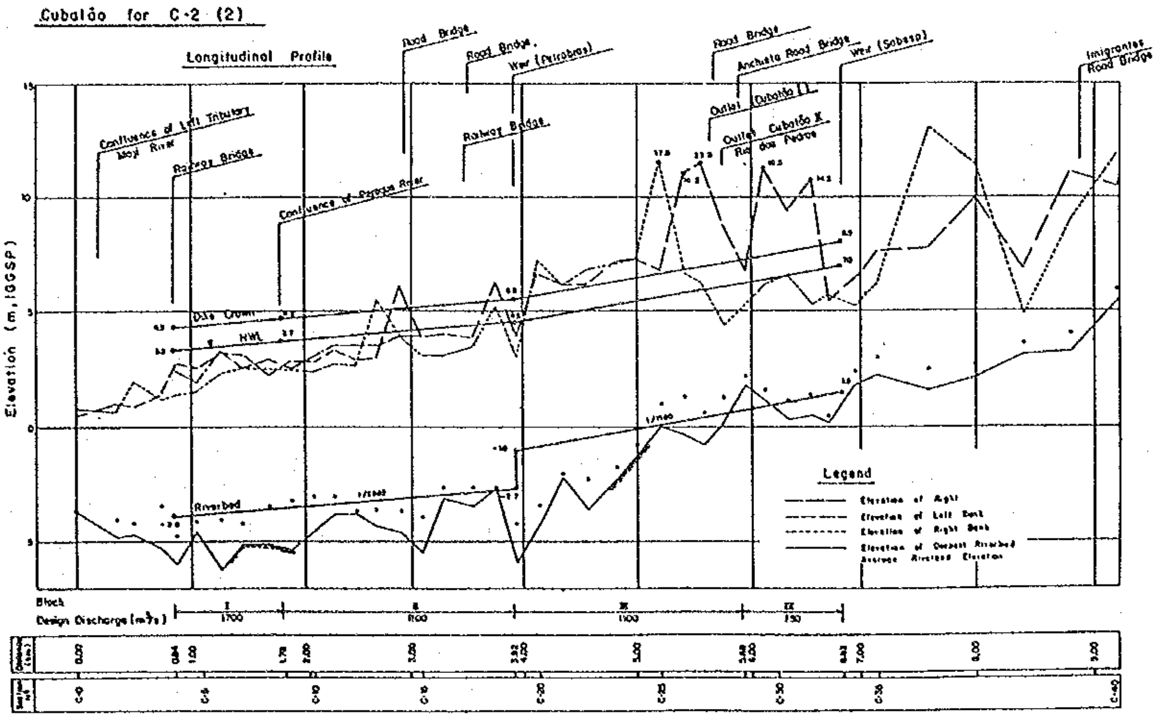

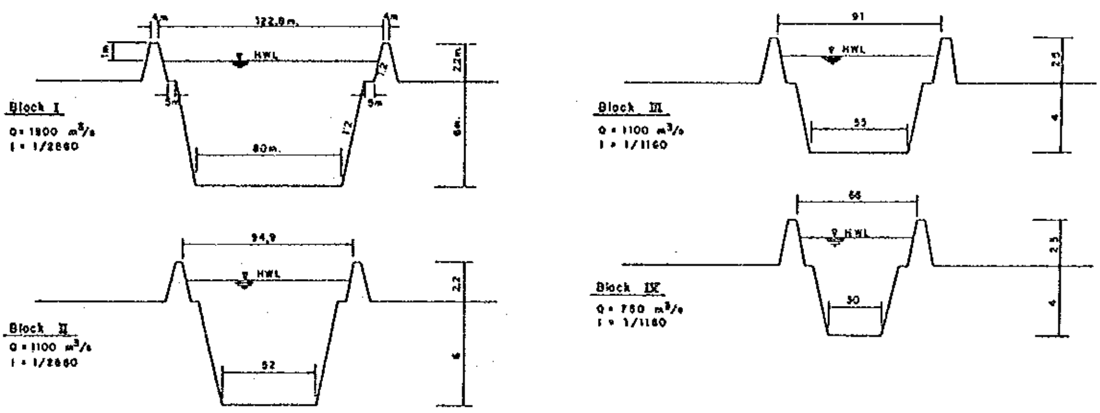

FIG. I.19 (1/2)
PROPOSED LONGITUDINAL PROFILE AND CROSS SECTION OF CUBATÃO RIVER

GOVERNMENT OF FEDERATIVE REPUBLIC OF BRAZIL
THE STUDY ON THE DISASTER PREVENTION AND RESTORATION PROJECT IN SERRA DO MAR, CUBATÃO REGION, STATE OF SÃO PAULO

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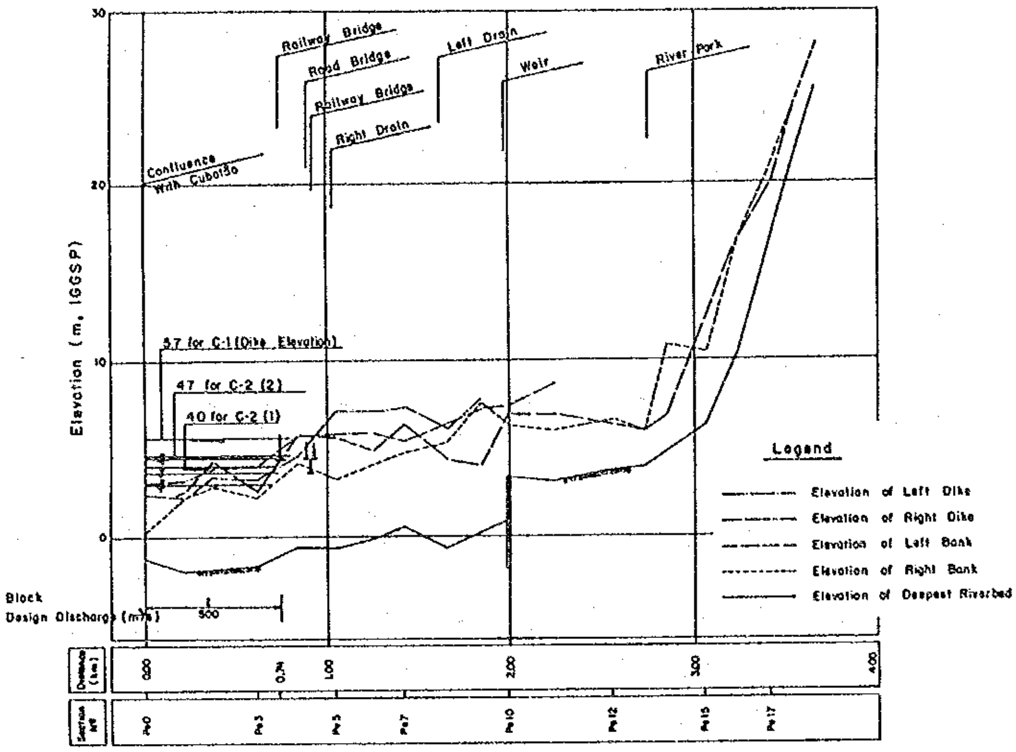
Pereque for C-1, C-2 (1) and C-2 (2)



Block I
Q = 500 m³/s
I = 1/1200

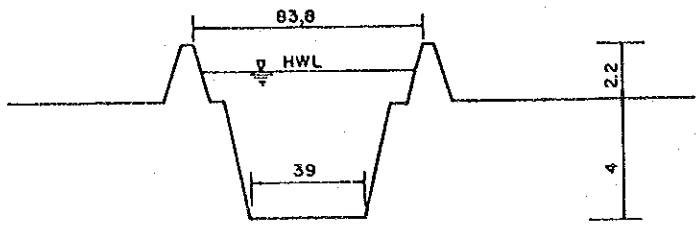


FIG. I.19 (2/2)
PROPOSED LONGITUDINAL PROFILE AND CROSS SECTION OF CUBATÃO RIVER

GOVERNMENT OF FEDERATIVE REPUBLIC OF BRAZIL
THE STUDY ON THE DISASTER PREVENTION AND RESTORATION PROJECT IN SERRA DO MAR, CUBATÃO REGION, STATE OF SÃO PAULO

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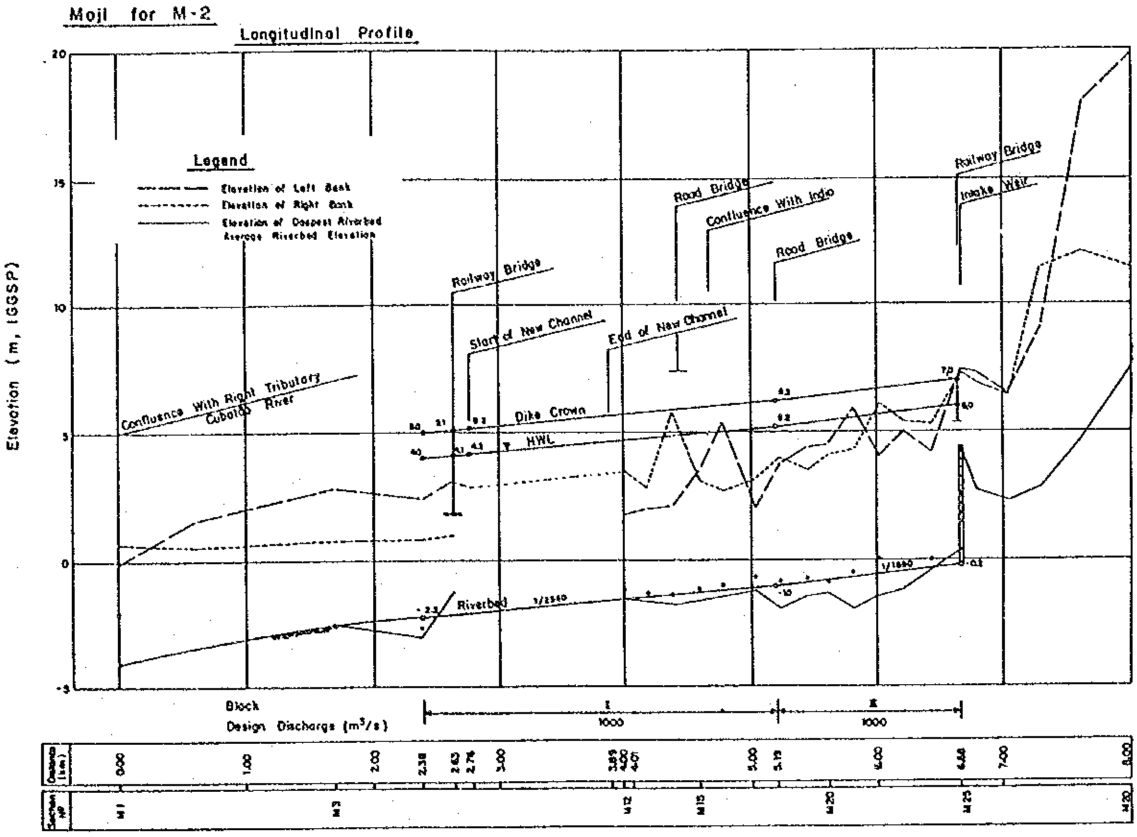


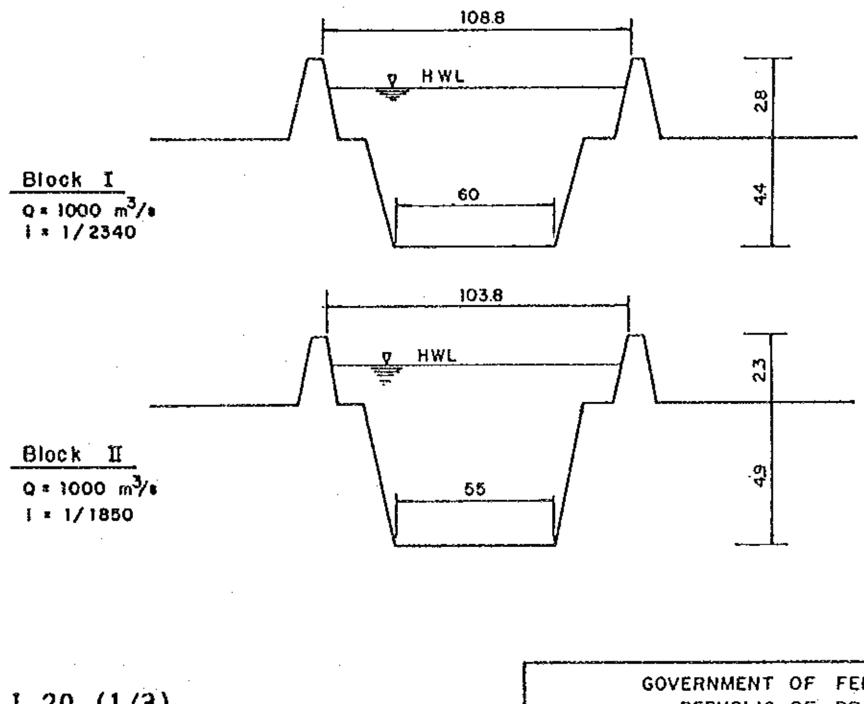


FIG. I.20 (1/3)
PROPOSED LONGITUDINAL PROFILE AND CROSS SECTION OF MOJI RIVER

GOVERNMENT OF FEDERATIVE REPUBLIC OF BRAZIL
THE STUDY ON THE DISASTER PREVENTION AND RESTORATION PROJECT IN SERRA DO MAR, CUBATÃO REGION, STATE OF SÃO PAULO
JAPAN INTERNATIONAL COOPERATION AGENCY

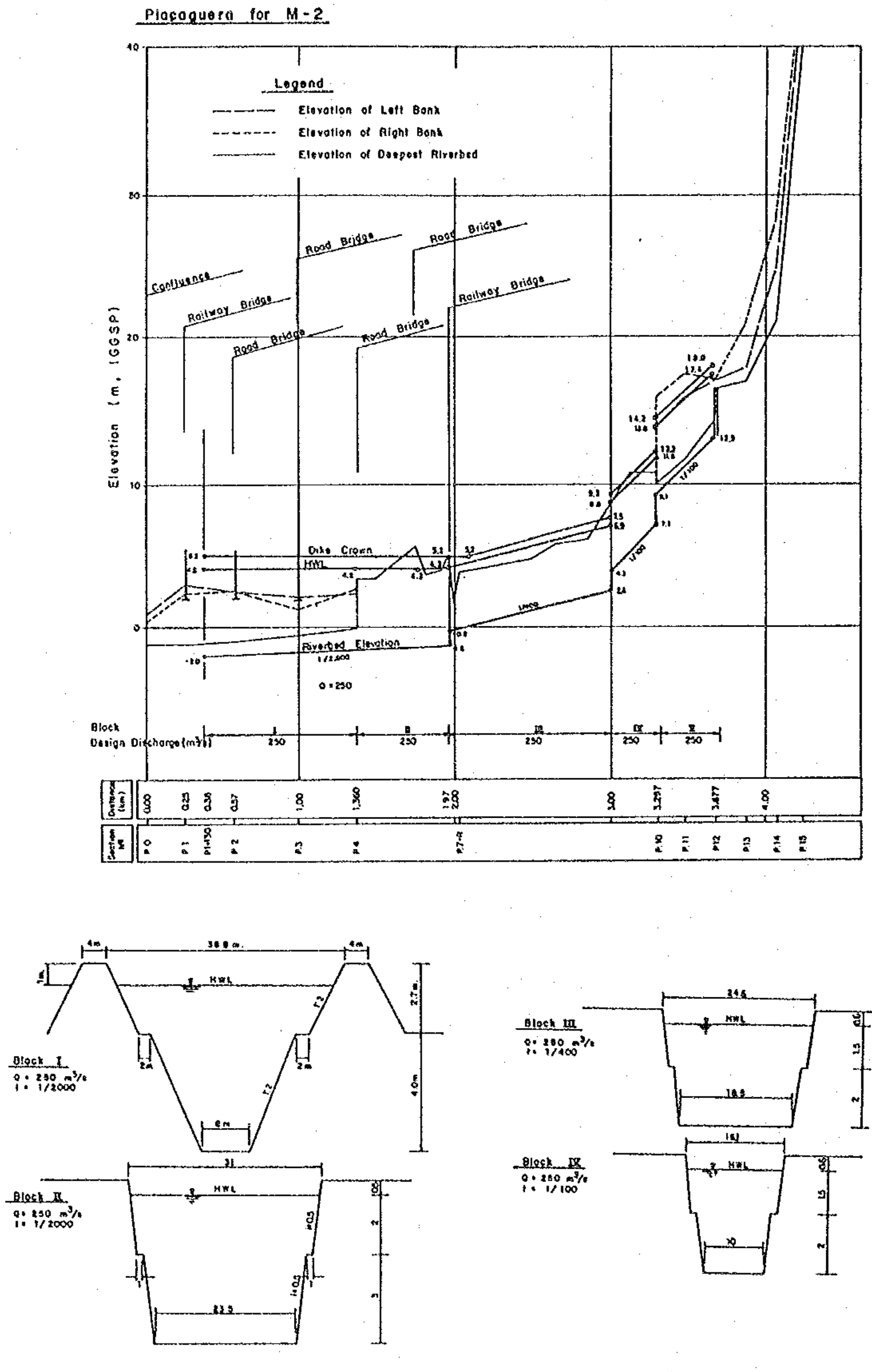
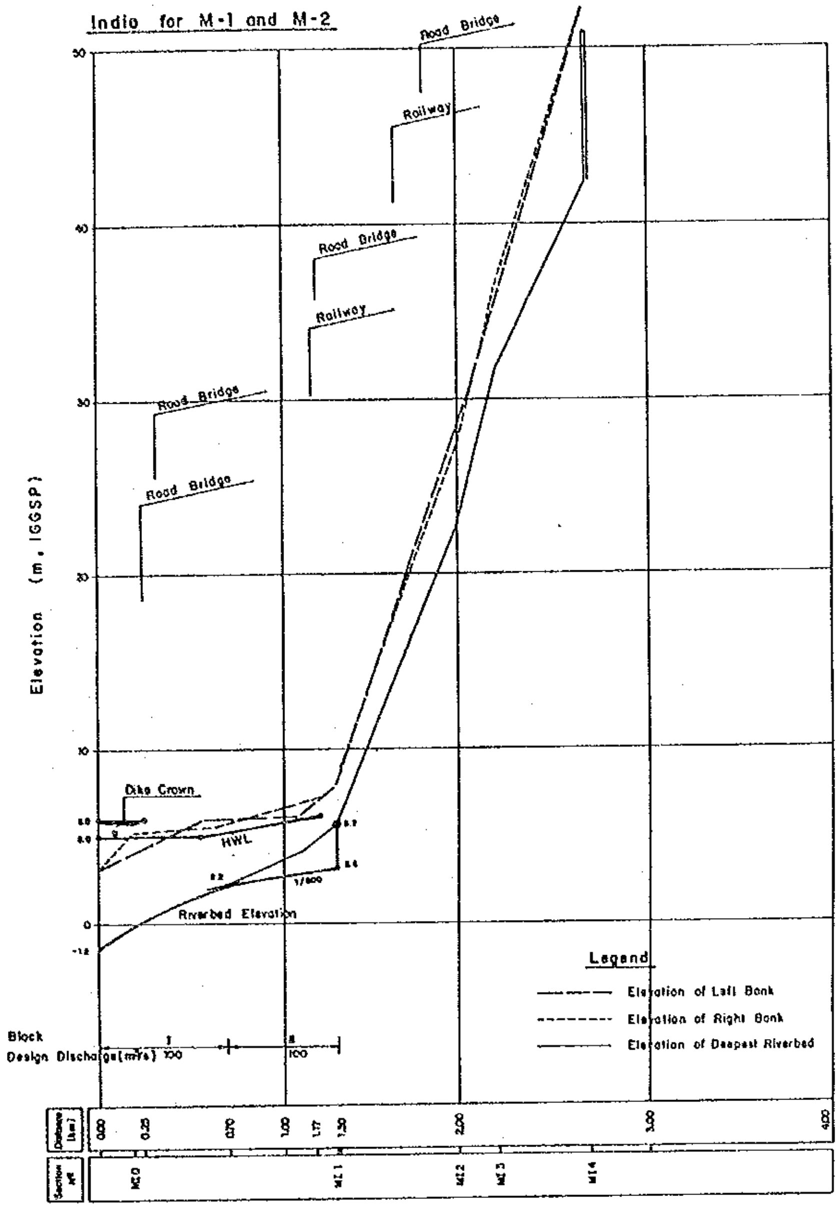
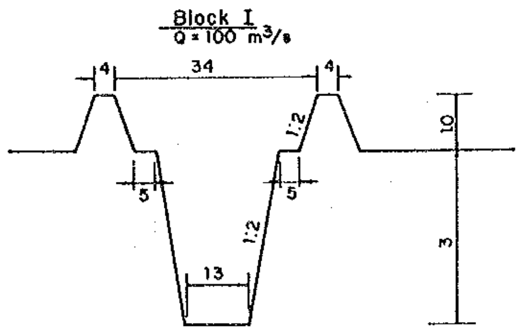


FIG. I.20 (2/3)
PROPOSED LONGITUDINAL PROFILE AND
CROSS SECTION OF MOJI RIVER

GOVERNMENT OF FEDERATIVE REPUBLIC OF BRAZIL
THE STUDY ON THE DISASTER PREVENTION AND RESTORATION PROJECT IN SERRA DO MAR, CUBATÃO REGION, STATE OF SÃO PAULO

JAPAN INTERNATIONAL COOPERATION AGENCY





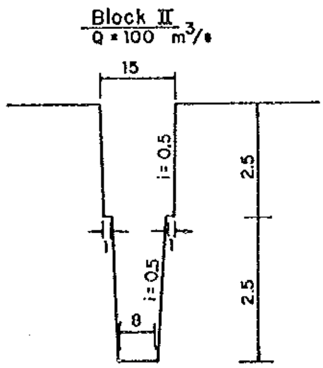
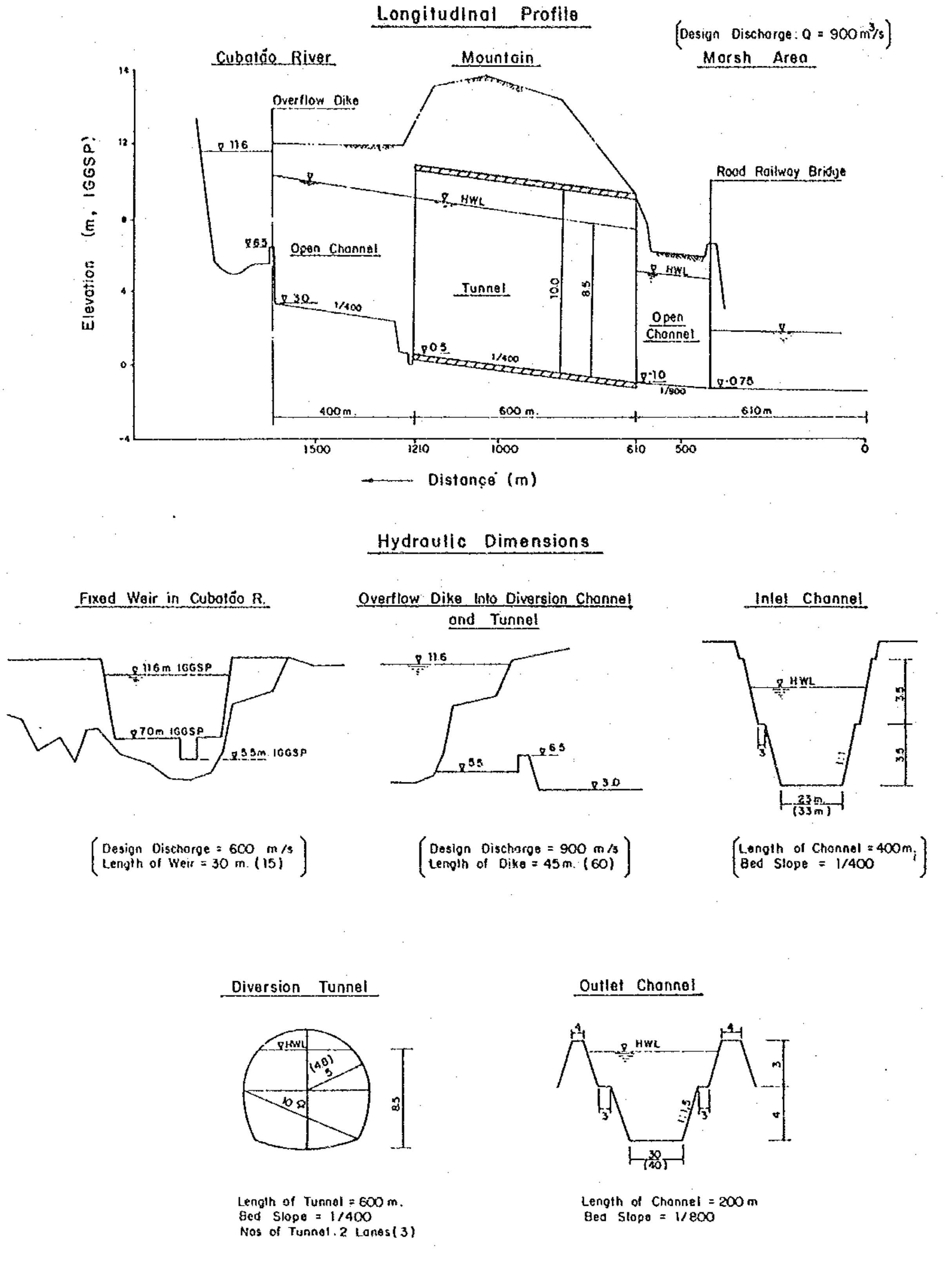


FIG. I.20 (3/3)
PROPOSED LONGITUDINAL PROFILE AND CROSS SECTION OF MOJI RIVER

GOVERNMENT OF FEDERATIVE REPUBLIC OF BRAZIL

THE STUDY ON THE DISASTER PREVENTION AND RESTORATION PROJECT IN SERRA DO MAR, CUBATÃO REGION, STATE OF SÃO PAULO

JAPAN INTERNATIONAL COOPERATION AGENCY



Note: ( ) Indicates Dimensions for Diversion Discharge of 1.200 m³/s

FIG.I.21
PROPOSED DIVERSION TUNNEL

GOVERNMENT OF FEDERATIVE REPUBLIC OF BRAZIL
THE STUDY ON THE DISASTER PREVENTION AND RESTORATION PROJECT IN SERRA DO MAR, CUBATÃO REGION, STATE OF SÃO PAULO

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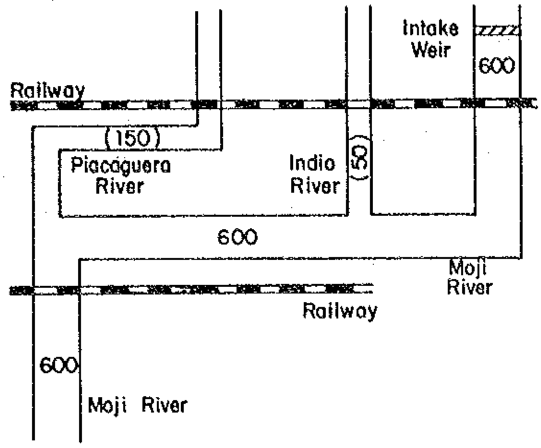
Design Discharge Distribution



Note: Return Period of Design Flood
Moji River: W = 1/10
Unit = m^3/s
( ) Means Carrying Capacity After Improvement

Typical Cross Section

Moji River

Block I
$Q = 600\ m^3/s$
$i = 1/2340$

Block II
$Q = 600\ m^3/s$
$i = 1/1850$

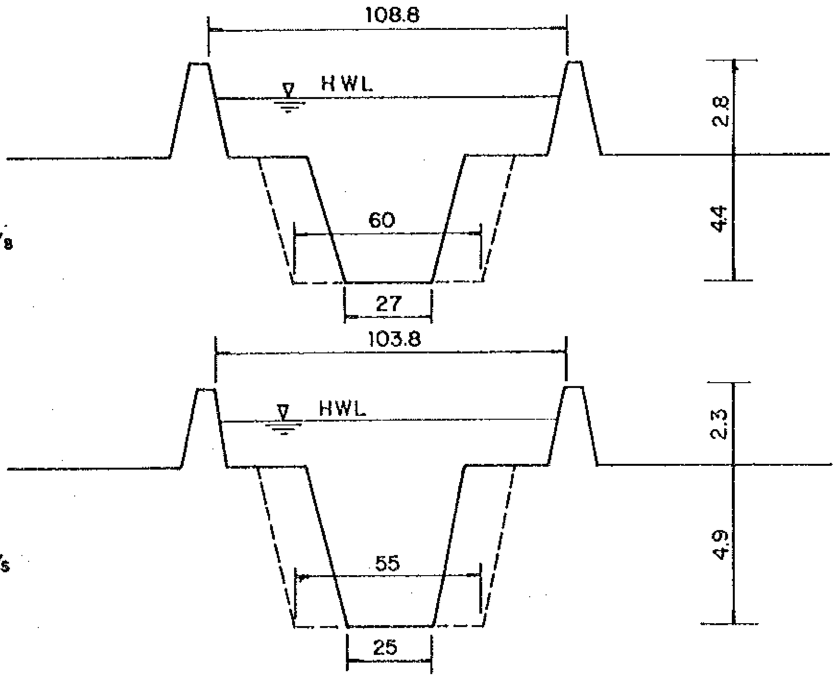


FIG. I.22
DESIGN DISCHARGE DISTRIBUTION AND TYPICAL CROSS SECTIONS OF PRIORITY PROJECT

GOVERNMENT OF FEDERATIVE REPUBLIC OF BRAZIL
THE STUDY ON THE DISASTER PREVENTION AND RESTORATION PROJECT IN SERRA DO MAR, CUBATÃO REGION, STATE OF SÃO PAULO
JAPAN INTERNATIONAL COOPERATION AGENCY

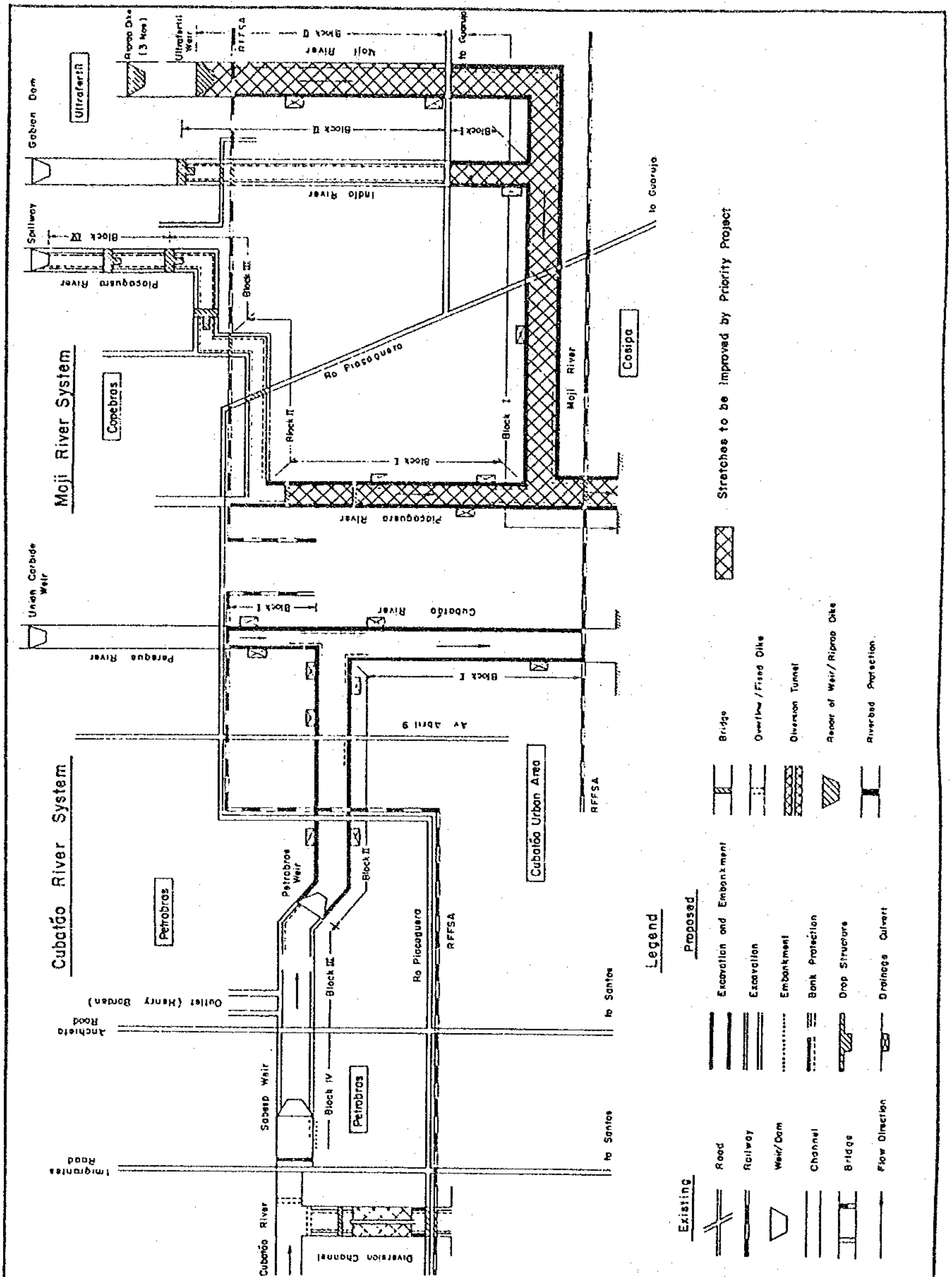


FIG. I.23
STRETCHES TO BE IMPROVED
BY PRIORITY PROJECT

GOVERNMENT OF FEDERATIVE
REPUBLIC OF BRAZIL
THE STUDY ON THE DISASTER PREVENTION AND
RESTORATION PROJECT IN SERRA DO MAR,
CUBATÃO REGION, STATE OF SÃO PAULO

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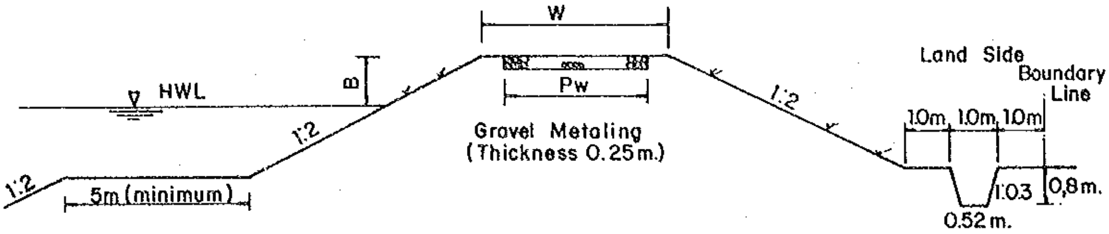
Dike Section



Dimension of Flood Dike and Inspection Road

River	Crown Width of Dike w (m)	Free Board B (m)	Pavement Width Pw (m)
Moji	4	1	3
Piacaguera	4	1	3
Indio	4	1	3

Parapet Wall

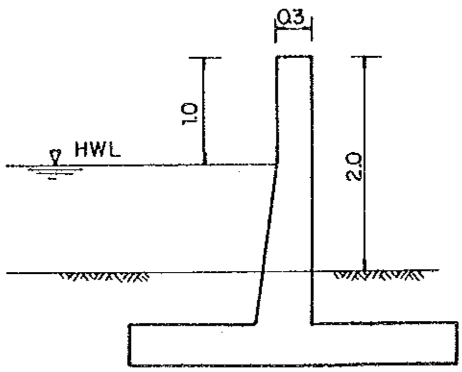


FIG. I.24
STANDARD SECTIONS OF DIKE AND PARAPET WALL

GOVERNMENT OF FEDERATIVE REPUBLIC OF BRAZIL
THE STUDY ON THE DISASTER PREVENTION AND RESTORATION PROJECT IN SERRA DO MAR, CUBATÃO REGION, STATE OF SÃO PAULO

JAPAN INTERNATIONAL COOPERATION AGENCY

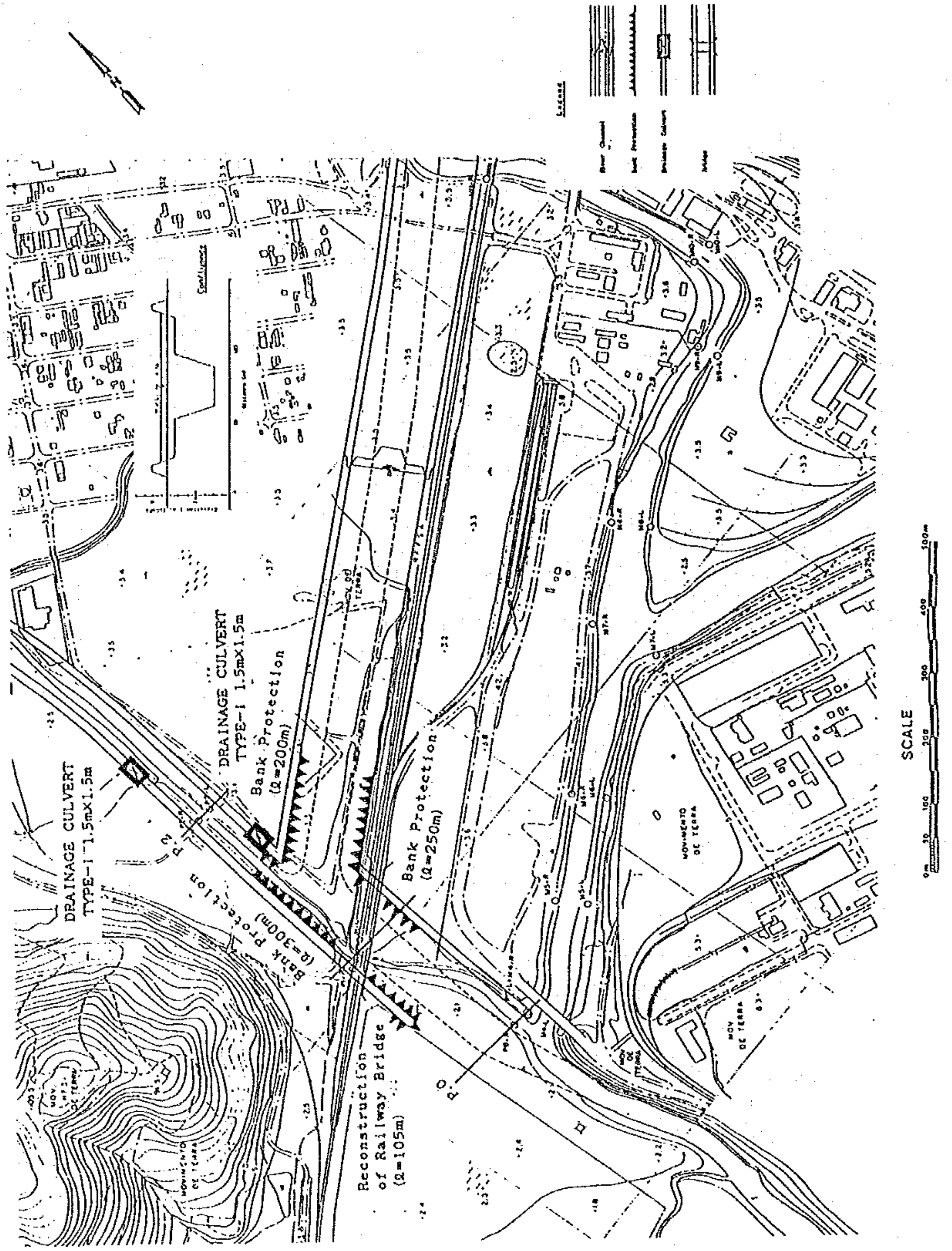


FIG. I.25
PROPOSED CHANNEL ALIGNMENT
OF PRIORITY PROJECT (1/4)

GOVERNMENT OF FEDERATIVE
REPUBLIC OF BRAZIL

THE STUDY ON THE DISASTER PREVENTION AND RESTORATION PROJECT IN SERRA DO MAR, CUBATÃO REGION, STATE OF SÃO PAULO

JAPAN INTERNATIONAL COOPERATION AGENCY

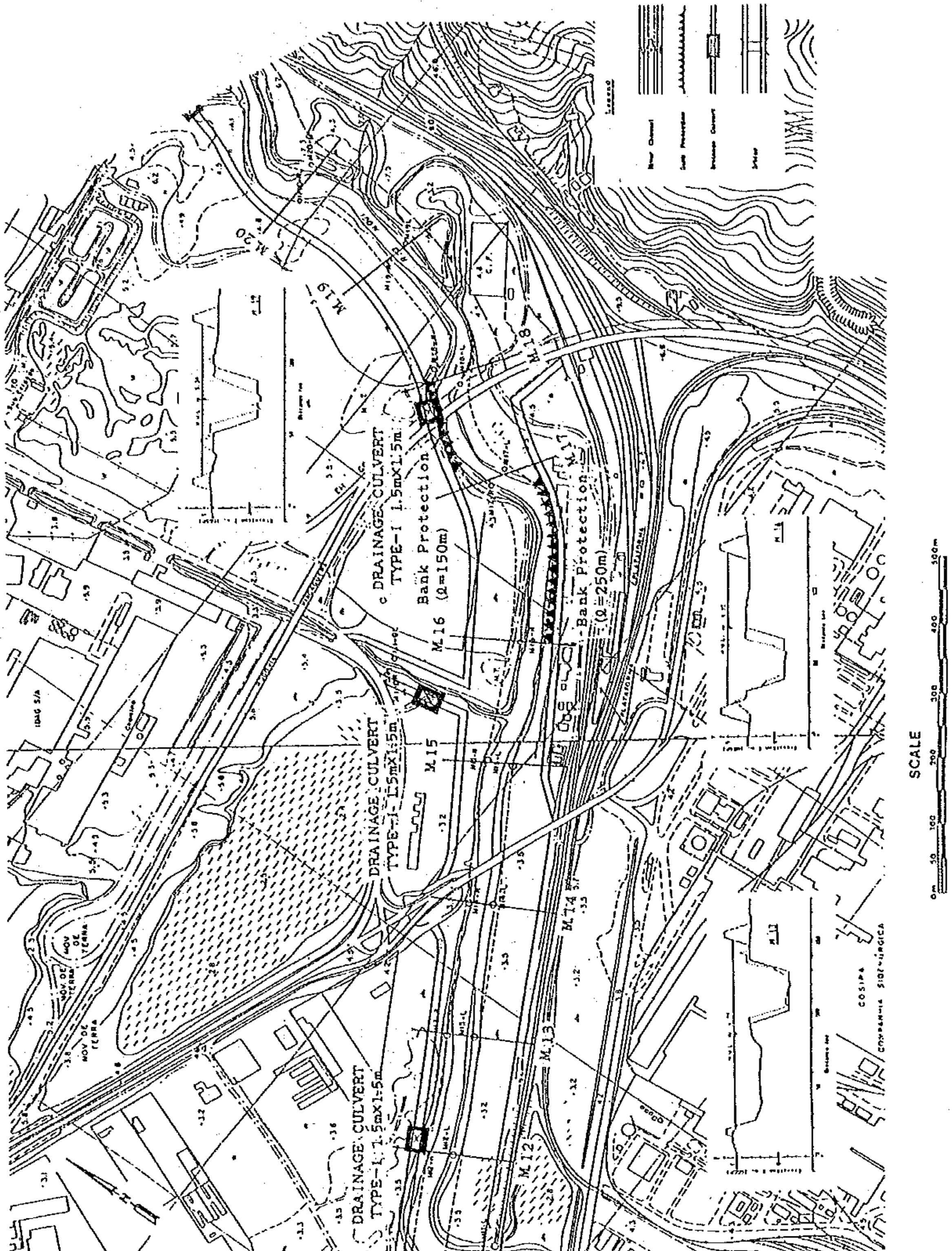


FIG. I.25
PROPOSED CHANNEL ALIGNMENT
OF PRIORITY PROJECT (2/4)

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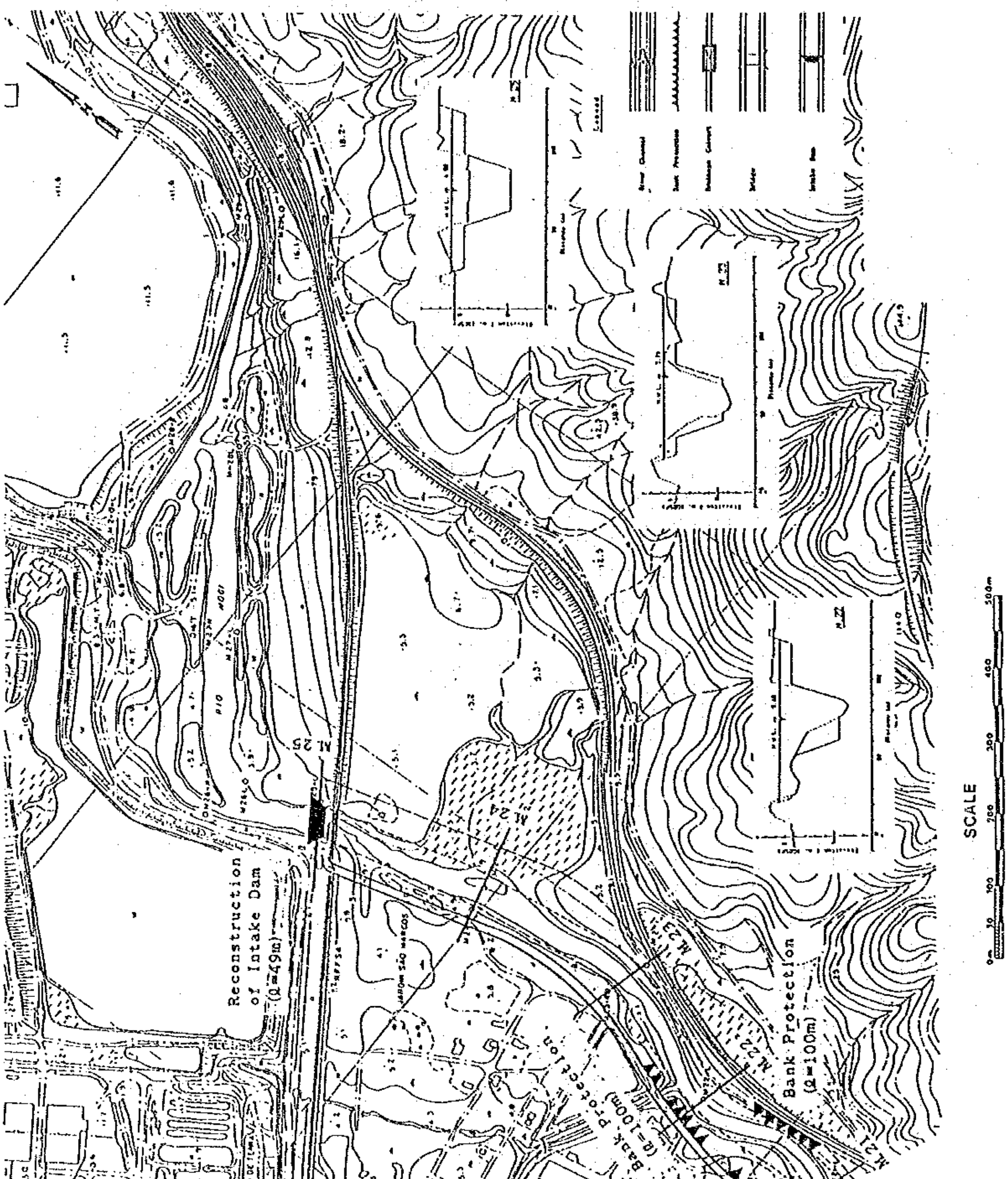

FIG. I.25
PROPOSED CHANNEL ALIGNMENT
OF PRIORITY PROJECT (3/4)

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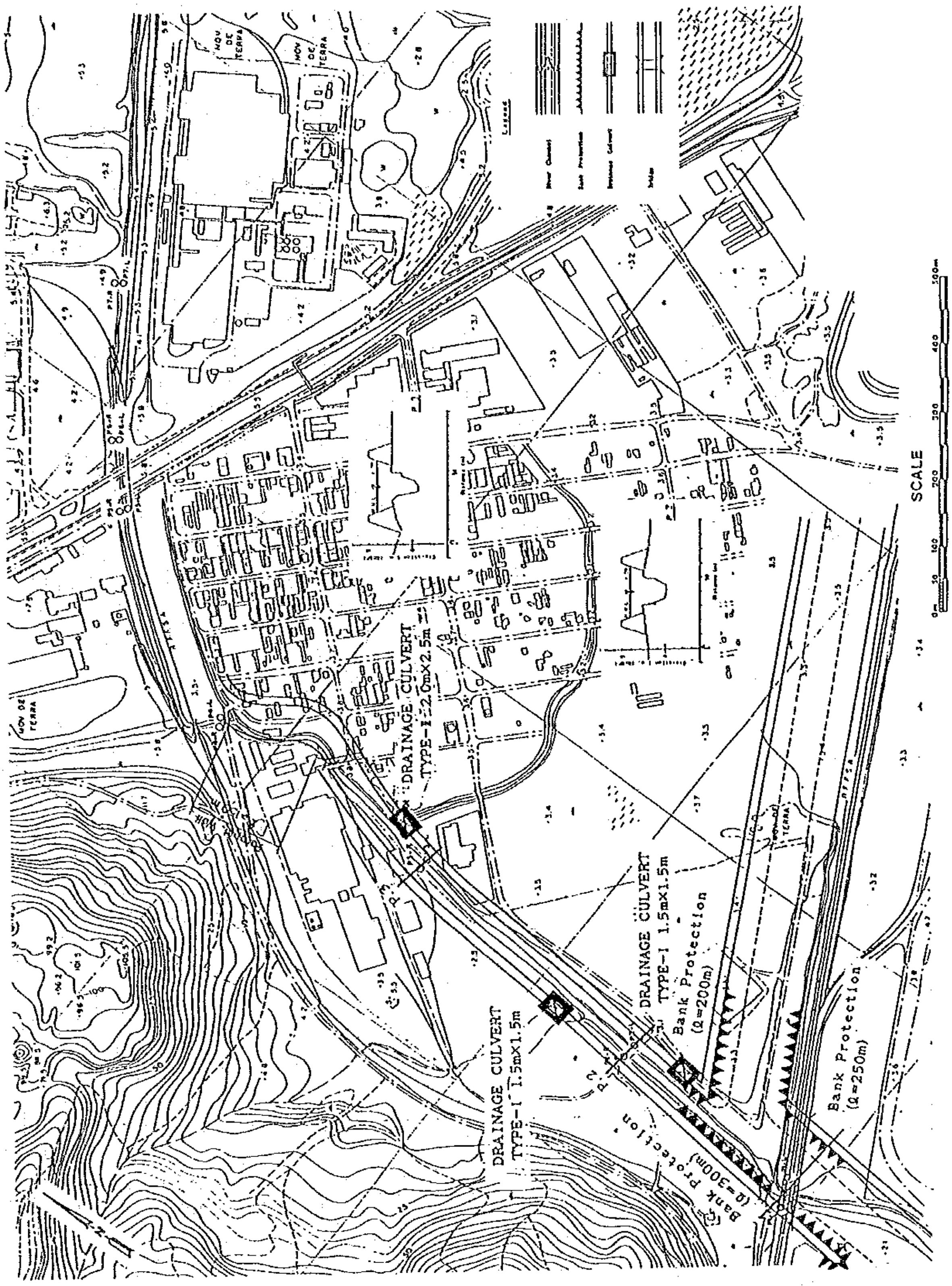

FIG. I.25
PROPOSED CHANNEL ALIGNMENT
OF PRIORITY PROJECT (4/4)

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