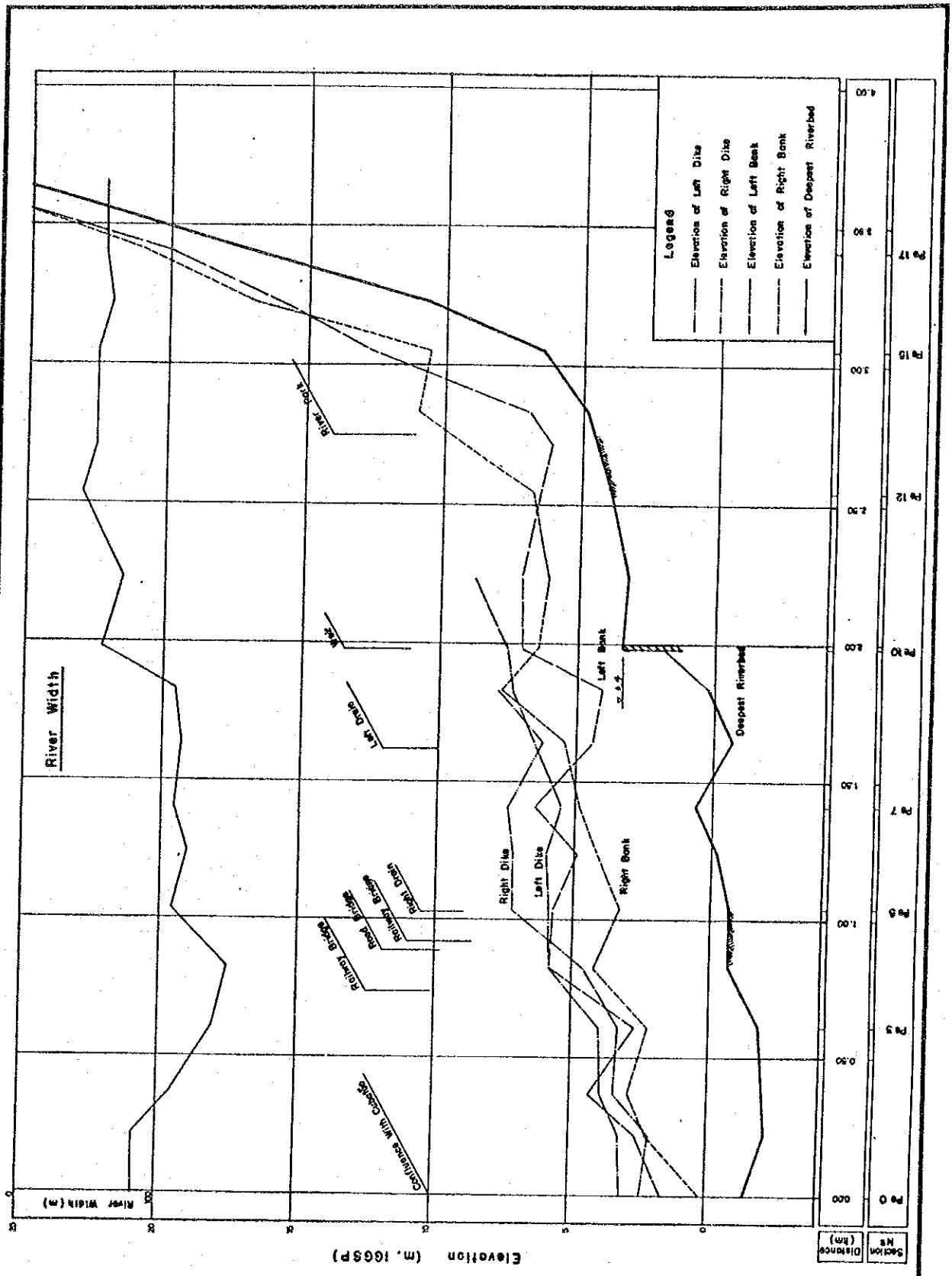


FIG. 3.1
LONGITUDINAL PROFILE OF EXISTING PEREQUE RIVER

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

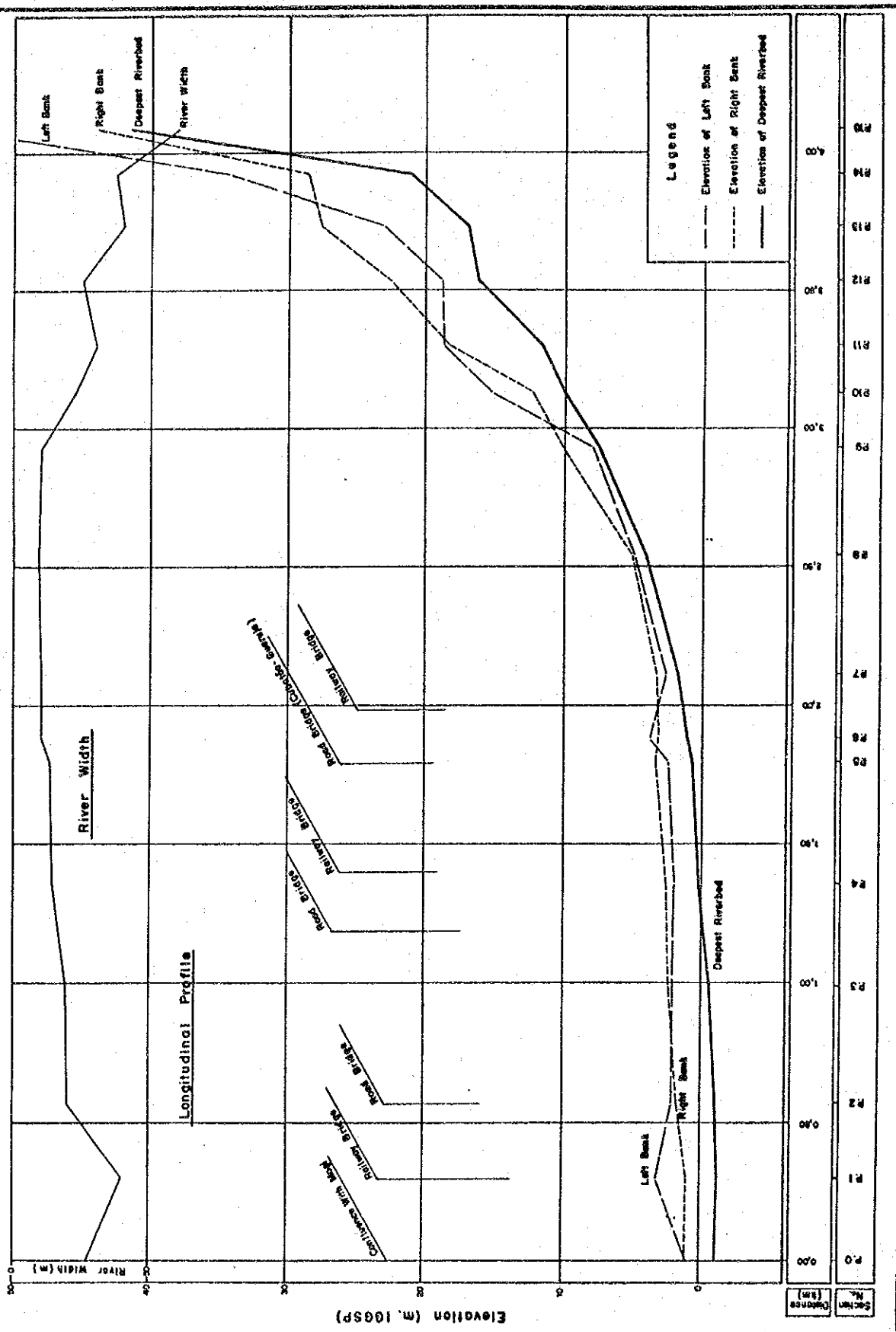


FIG. 3.2
LONGITUDINAL PROFILE OF EXISTING PIAÇAGUERA RIVER

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

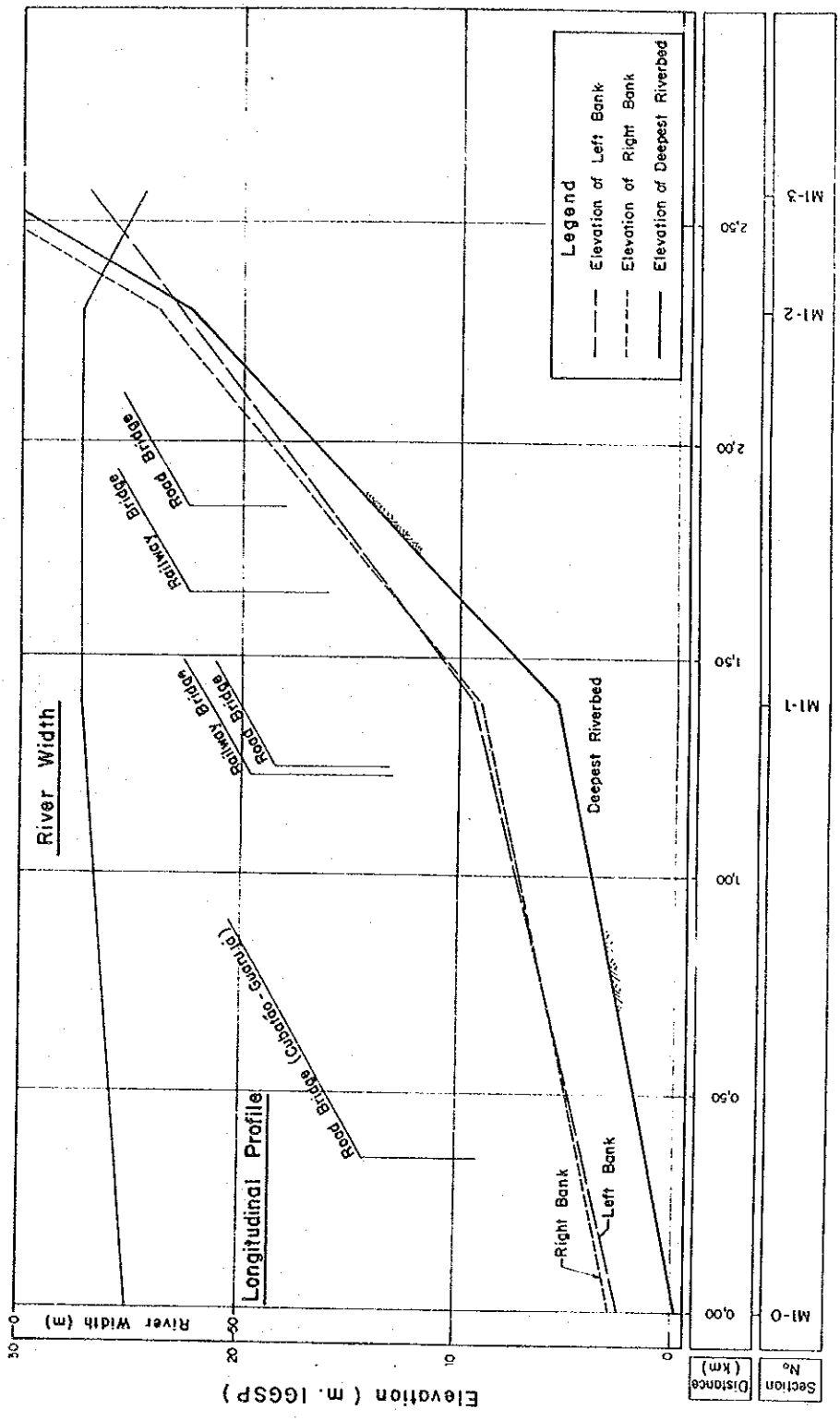


FIG. 3.3
LONGITUDINAL PROFILE OF EXISTING INDIO RIVER

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

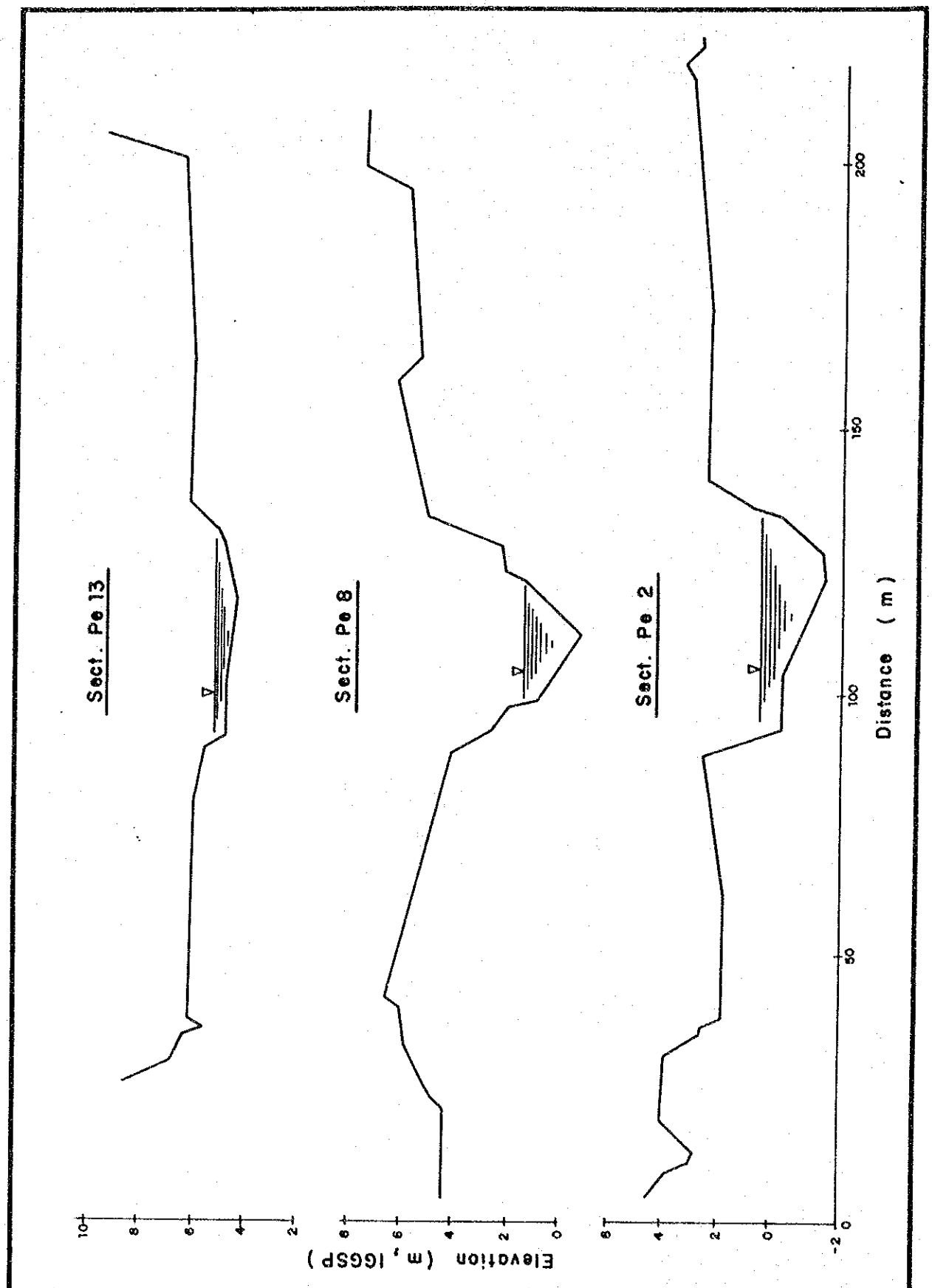


FIG. 3.4
TYPICAL CROSS SECTIONS OF EXISTING PEREQUE RIVER

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

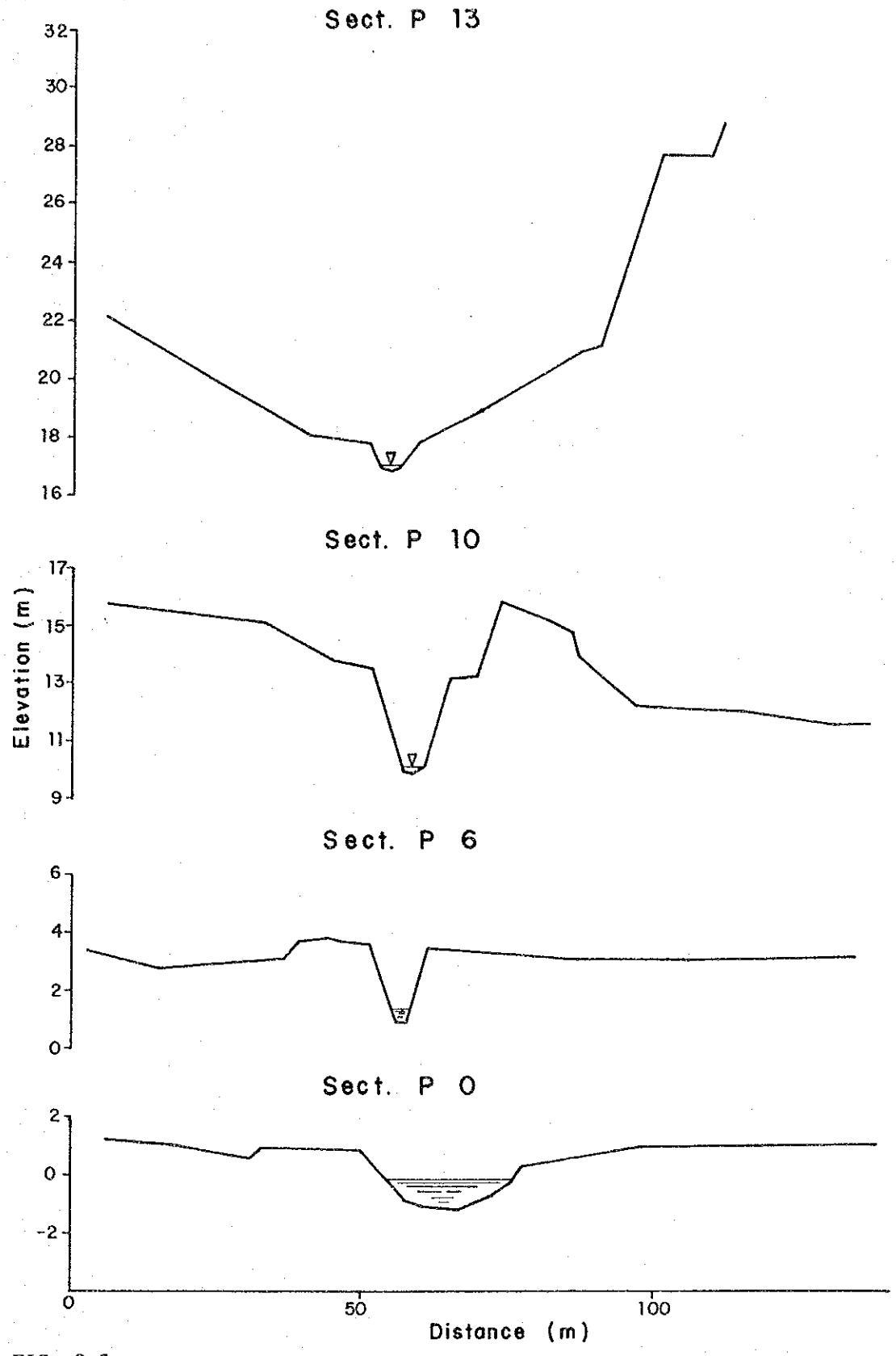


FIG. 3.5
TYPICAL CROSS SECTIONS OF EXISTING PIAÇAGUERA RIVER

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

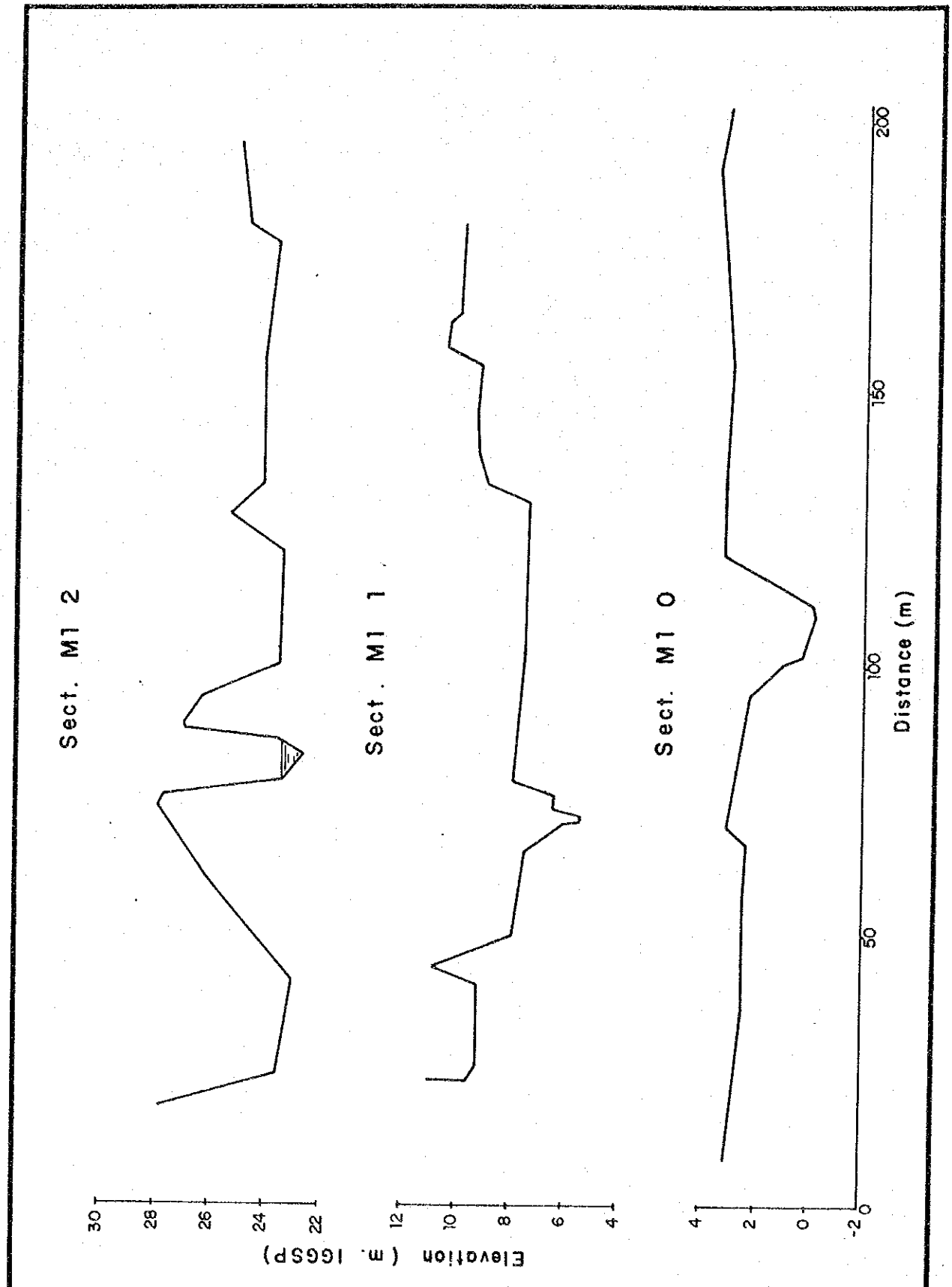


FIG. 3.6
TYPICAL CROSS SECTIONS OF EXISTING INDIO RIVER

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

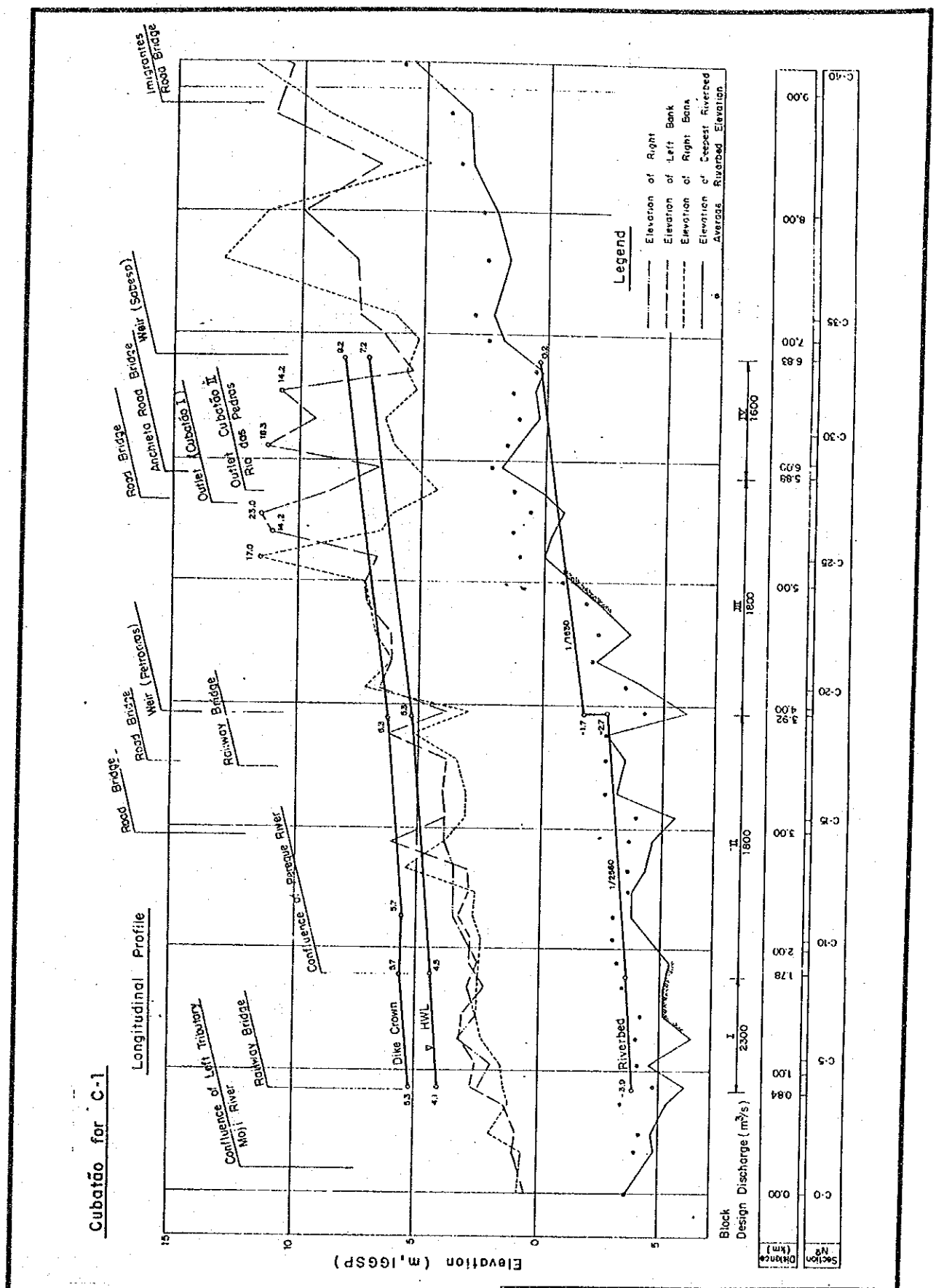


FIG. 3.7
PROPOSED LONGITUDINAL PROFILE OF CUBATÃO RIVER (1/3)

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

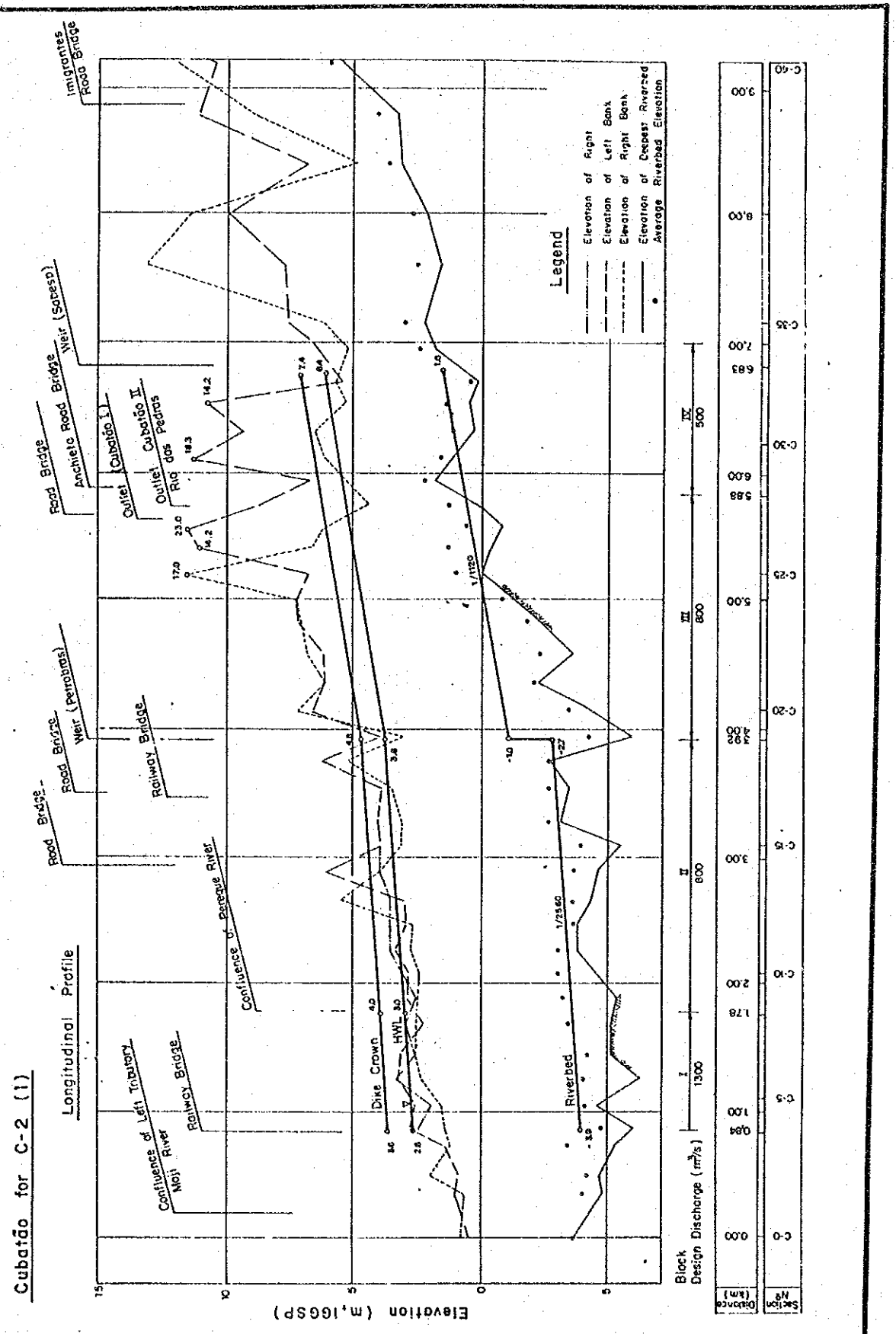


FIG. 3.7
PROPOSED LONGITUDINAL PROFILE OF CUBATÃO RIVER (2/3)

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

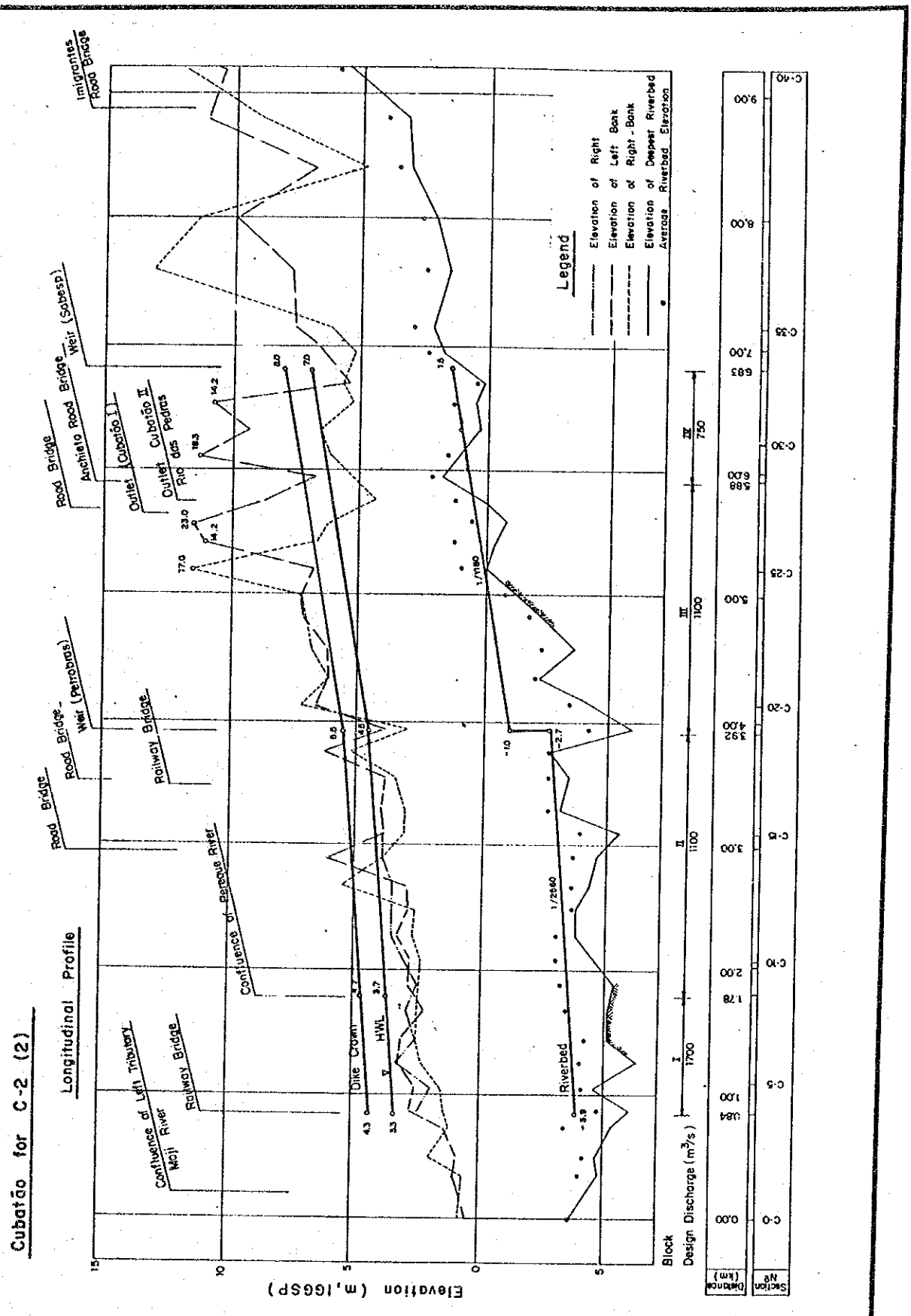


FIG. 3.7
PROPOSED LONGITUDINAL PROFILE OF CUBATÃO RIVER (3/3)

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

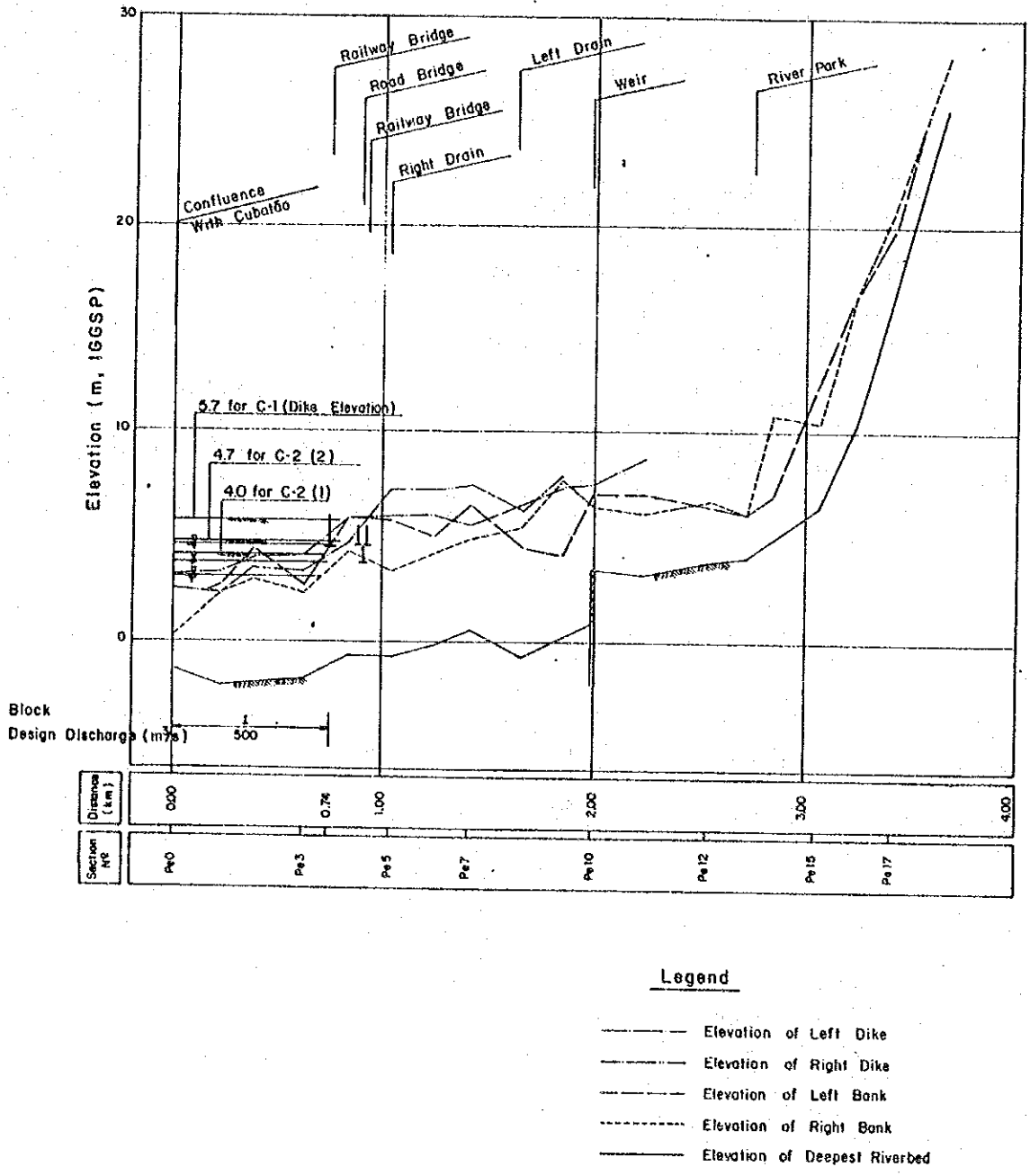


FIG. 3.8
PROPOSED LONGITUDINAL PROFILE OF PEREQUE RIVER

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

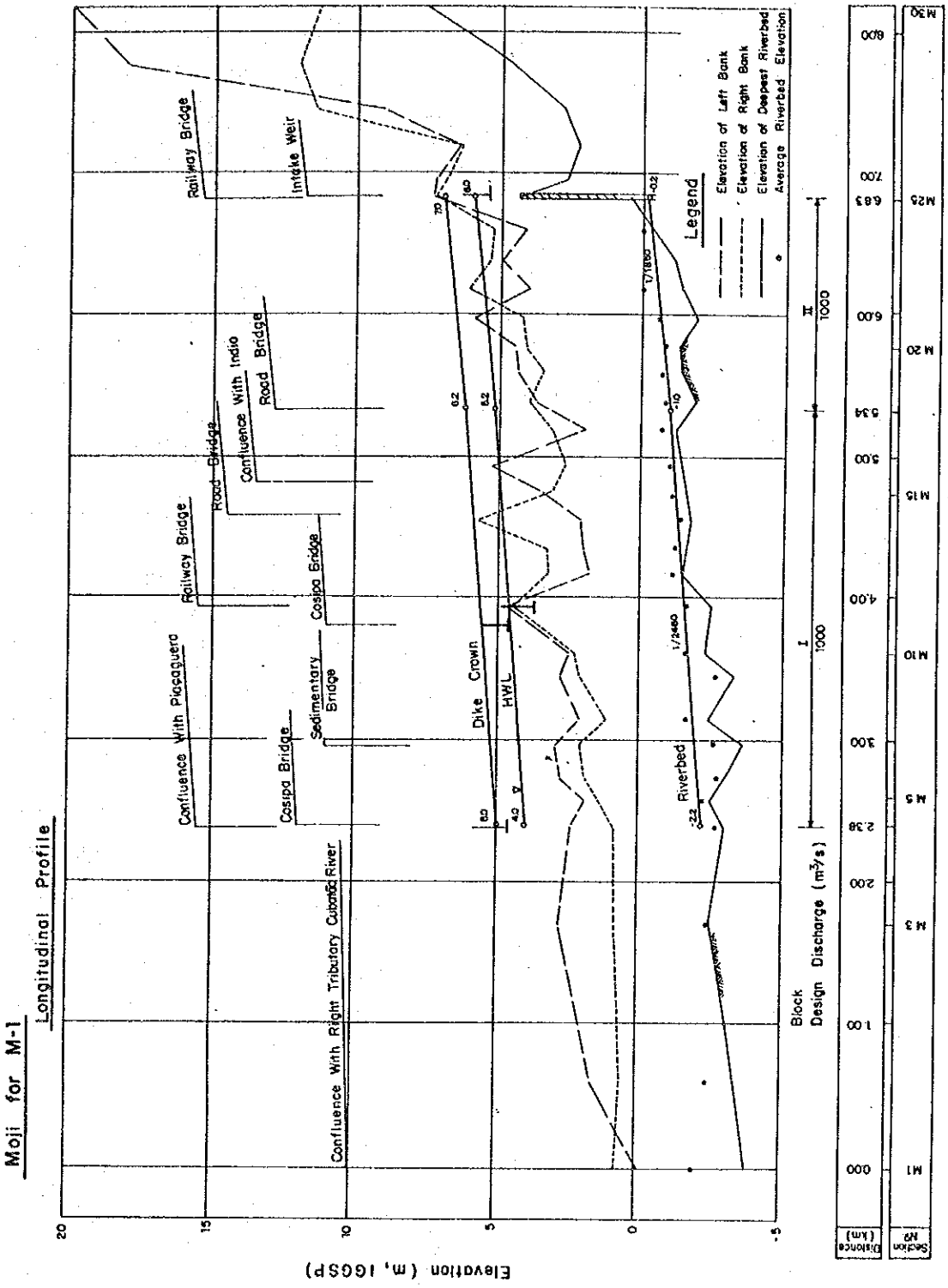


FIG. 3.9
PROPOSED LONGITUDINAL PROFILE OF MOJI RIVER (1/2)

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

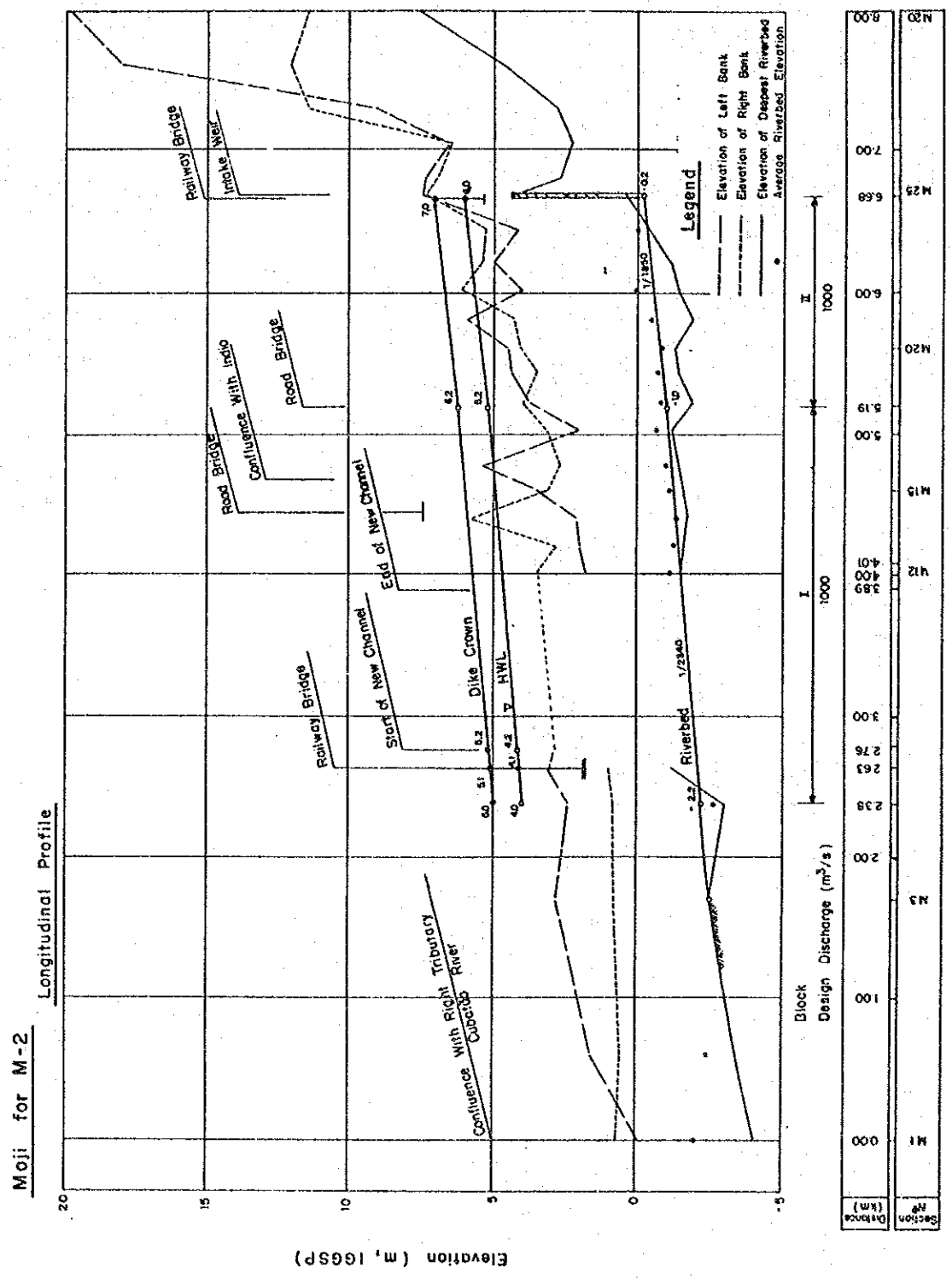


FIG. 3.9
PROPOSED LONGITUDINAL PROFILE OF MOJI RIVER (2/2)

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

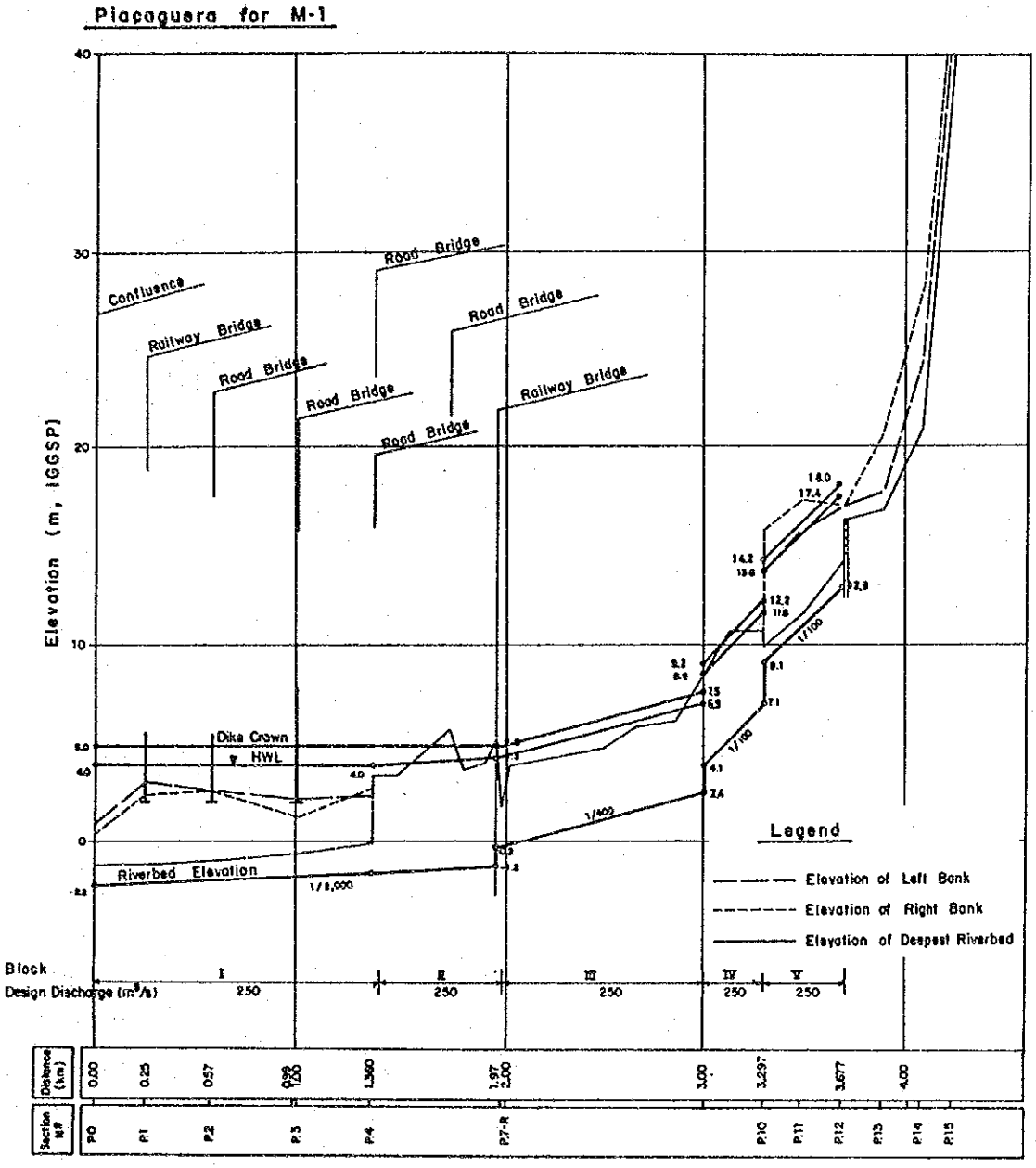


FIG. 3.10
PROPOSED LONGITUDINAL PROFILE OF PIAÇAGUERA RIVER (1/2)

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

D87

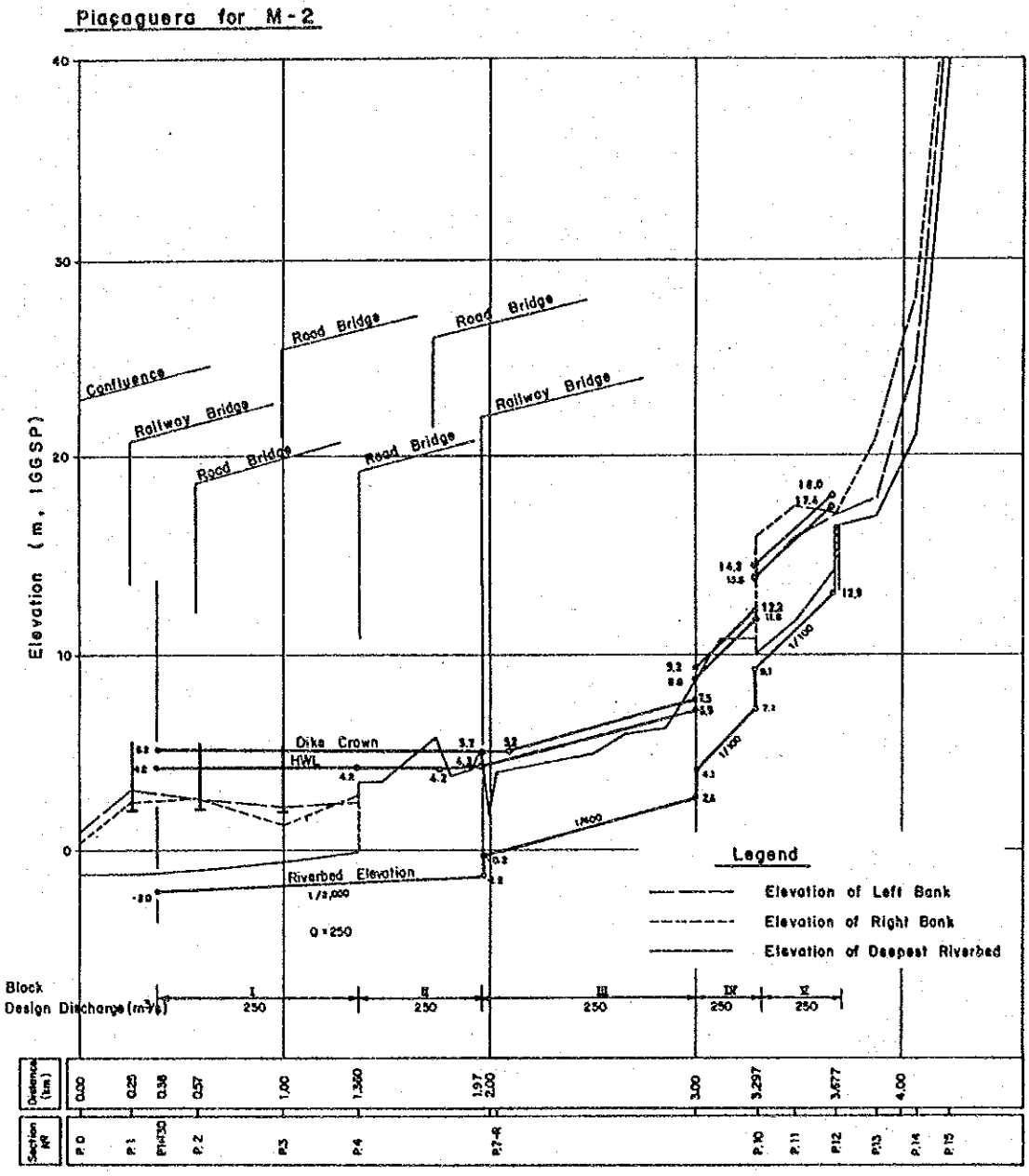


FIG. 3.10
PROPOSED LONGITUDINAL PROFILE OF
PIAÇAGUERA RIVER (2/2)

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

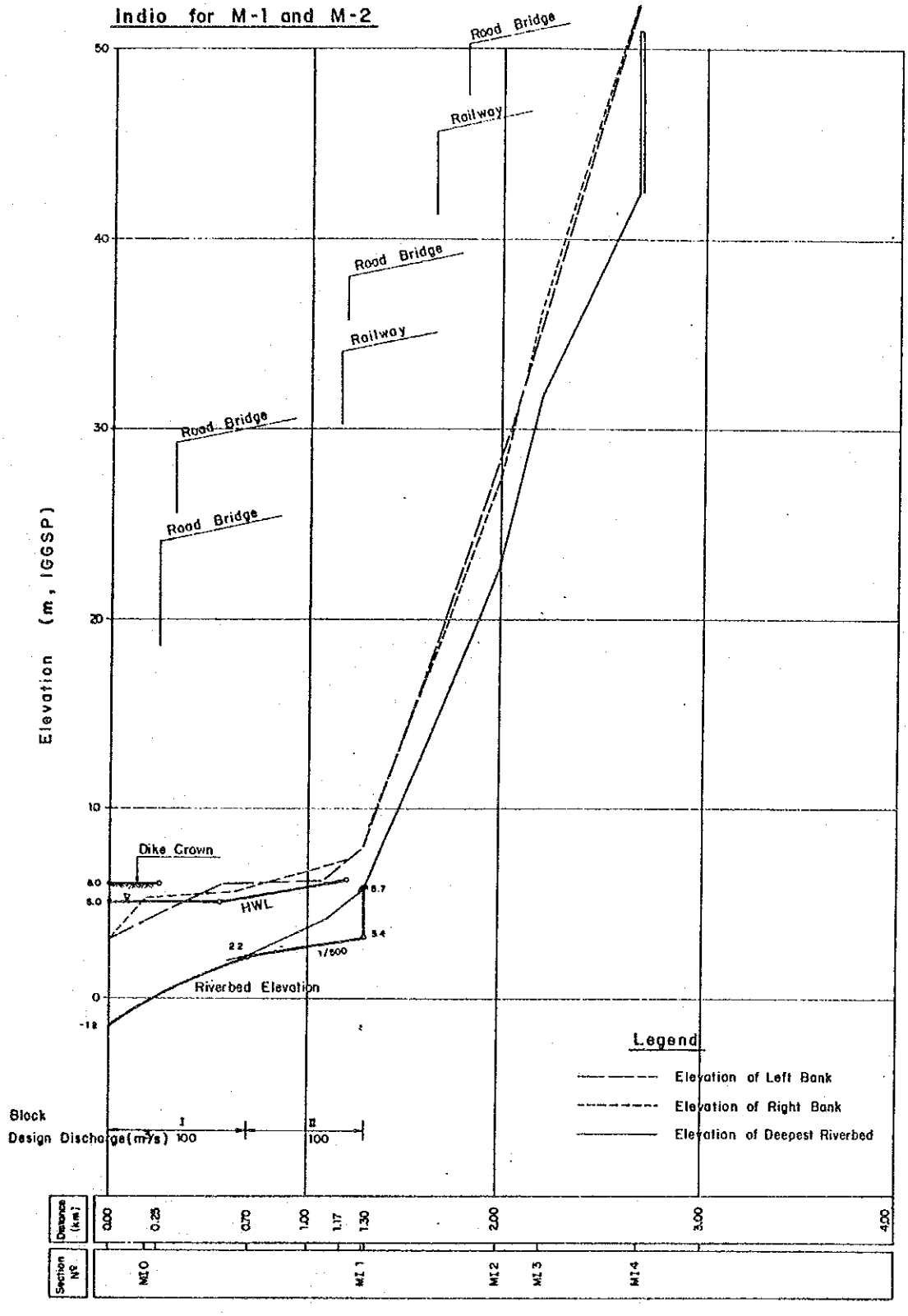


FIG. 3.11
PROPOSED LONGITUDINAL PROFILE OF INDIO RIVER

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

D89

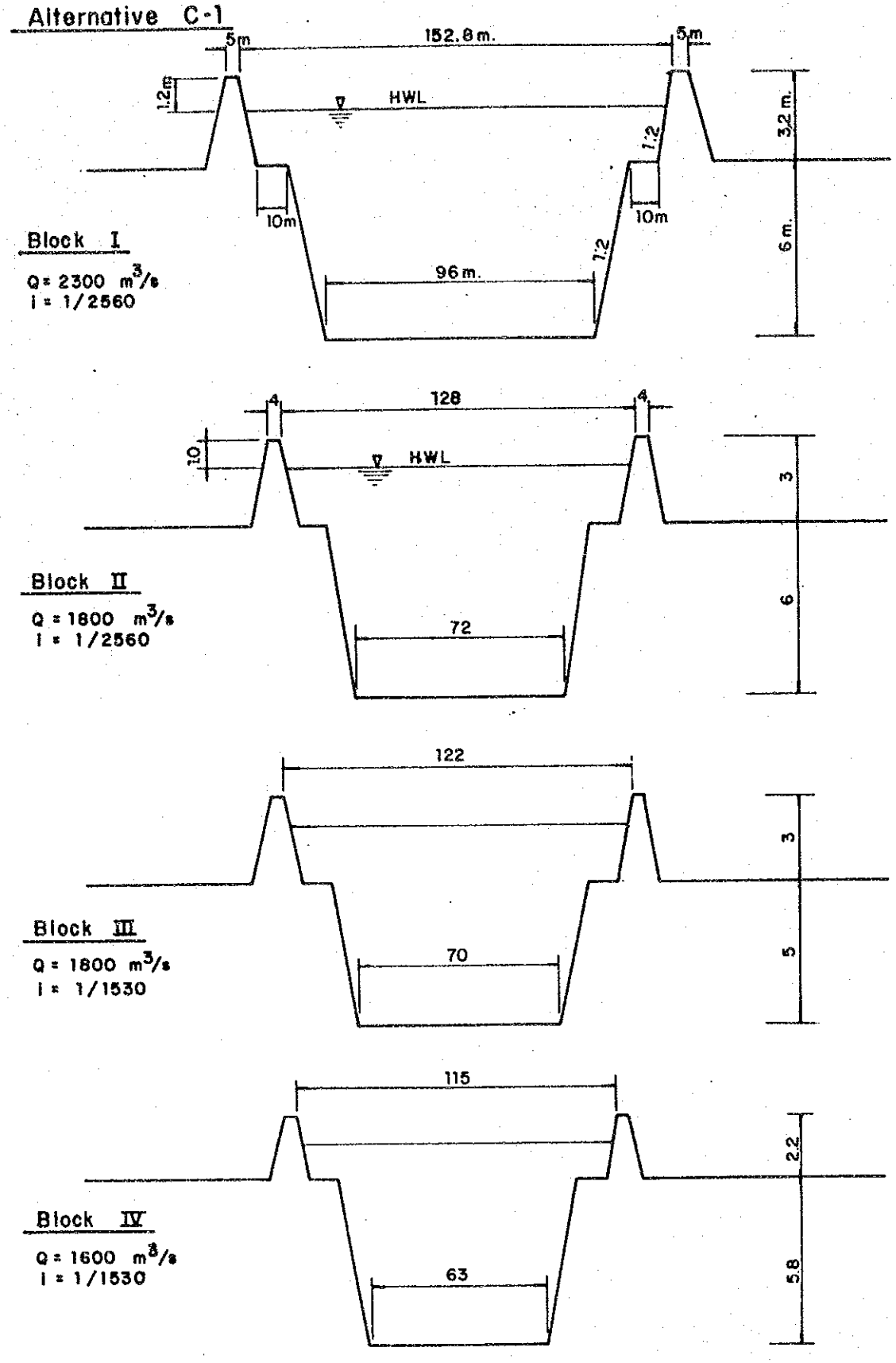


FIG. 3.12
TYPICAL CROSS SECTIONS OF ALTERNATIVE SCHEMES IN CUBATÃO RIVER (1/3)

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

Alternative C - 2 (1)

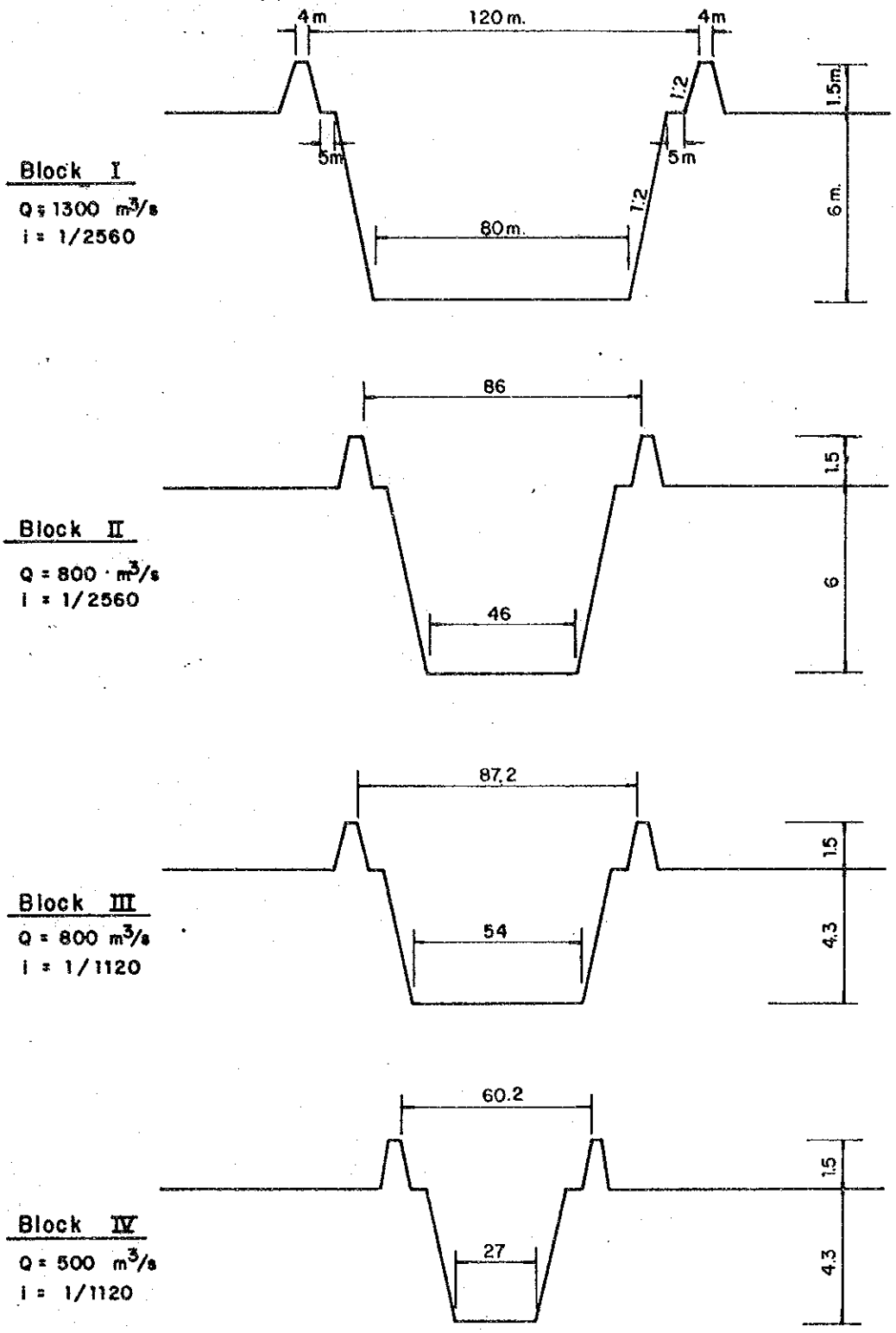


FIG. 3.12
TYPICAL CROSS SECTIONS OF ALTERNATIVE SCHEMES IN CUBATÃO RIVER (2/3)

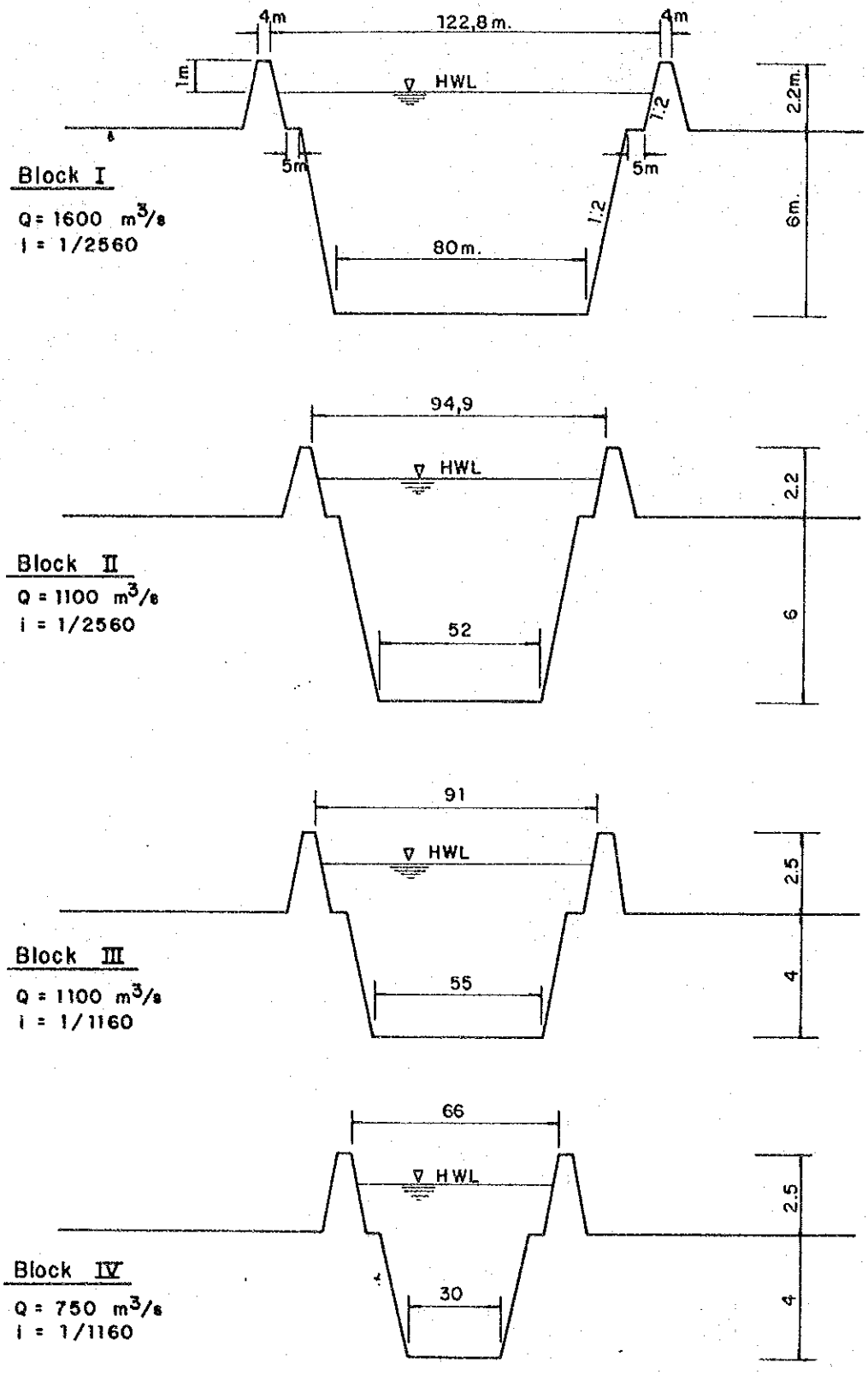


FIG. 3.12
TYPICAL CROSS SECTIONS OF ALTERNATIVE SCHEMES IN CUBATÃO RIVER (3/3)

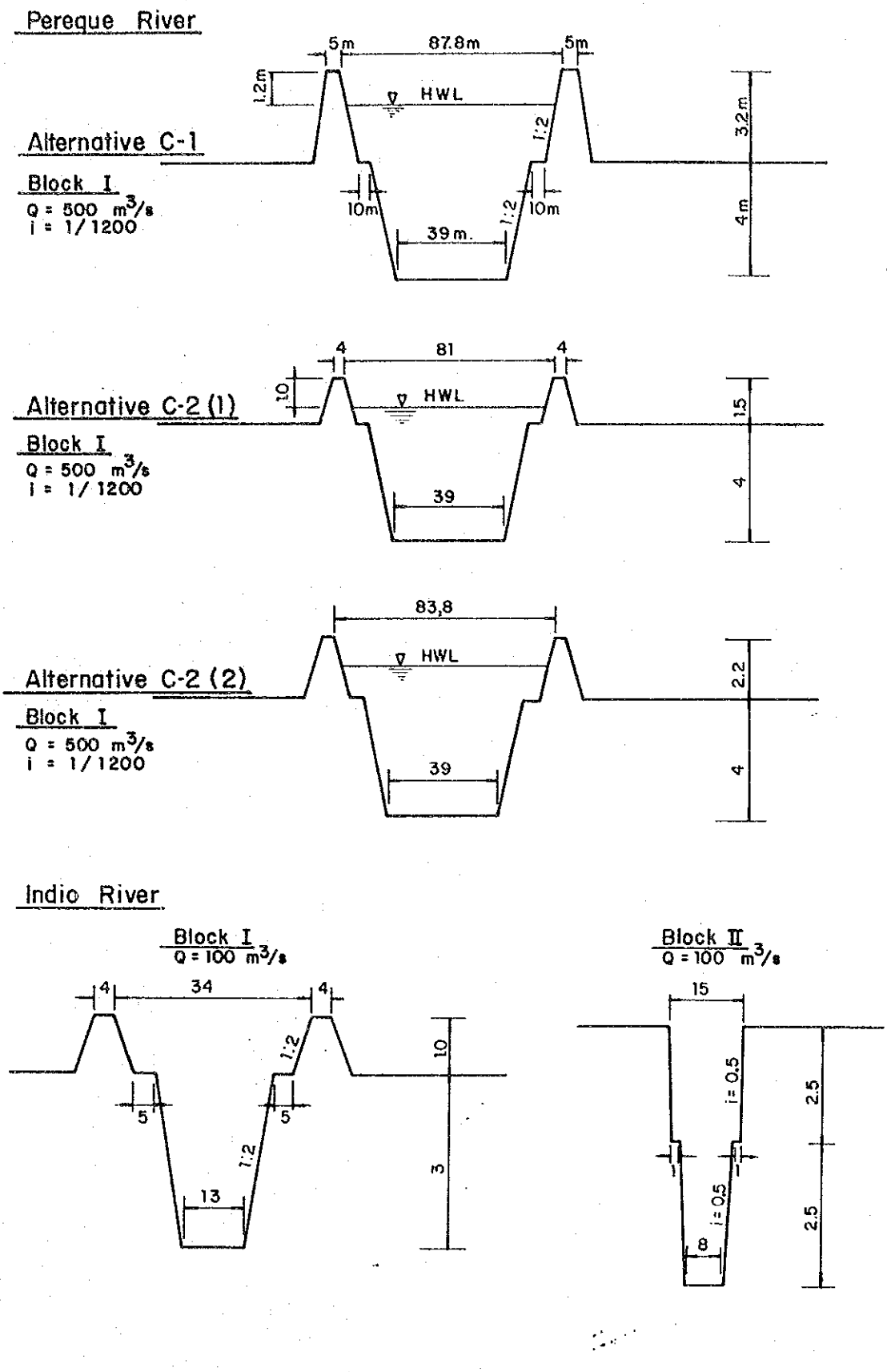
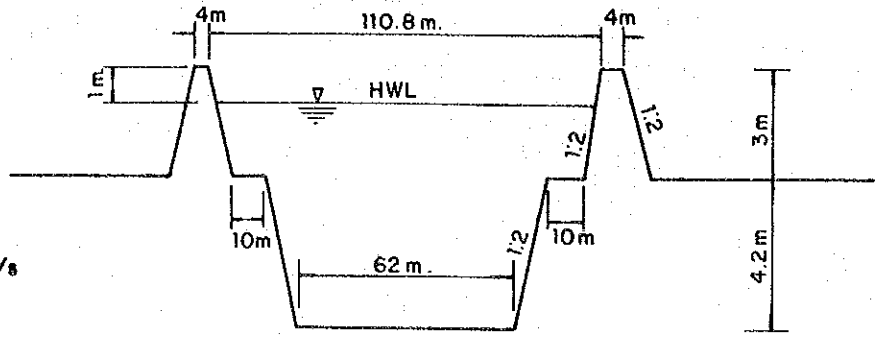


FIG. 3.13
TYPICAL CROSS SECTIONS OF ALTERNATIVE SCHEMES IN PEREQUE AND INDIO RIVER

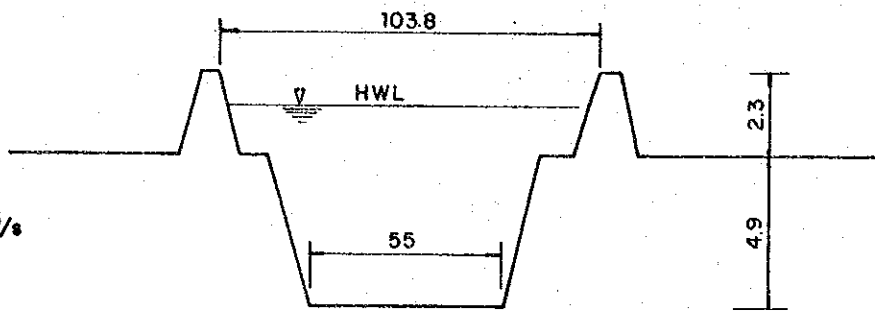
GOVERNMENT OF FEDERATIVE REPUBLIC OF BRAZIL
THE STUDY ON THE DISASTER PREVENTION AND RESTORATION PROJECT IN SERRA DO MAR, CUBATÃO REGION, STATE OF SÃO PAULO
JAPAN INTERNATIONAL COOPERATION AGENCY

Alternative M-1



Block I

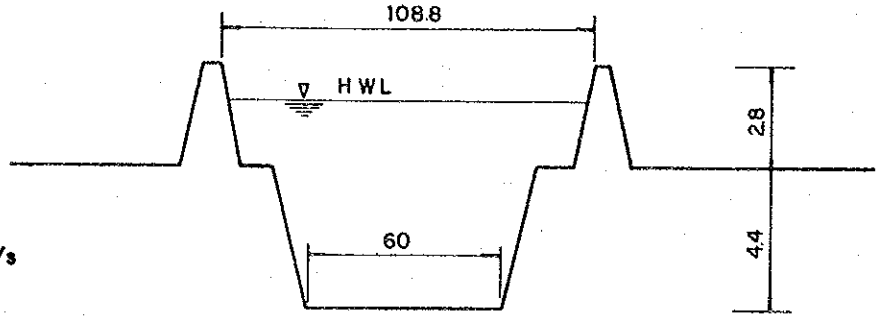
Q = 1000 m^3/s
I = 1/2460



Block II

Q = 1000 m^3/s
I = 1/1850

Alternative M-2



Block I

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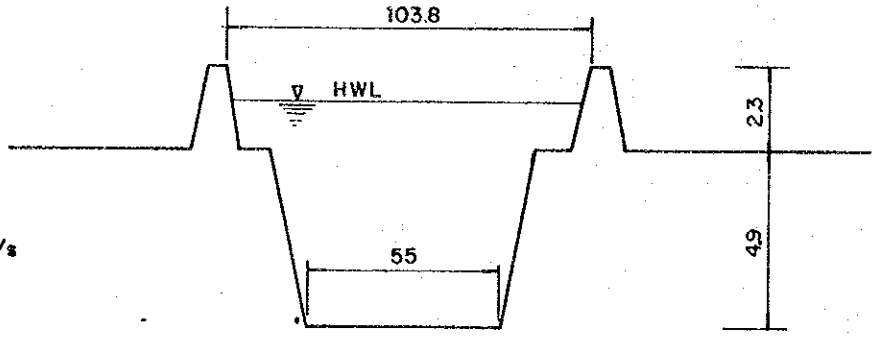

Block II

Q = 1000 m^3/s
i = 1/1850

FIG. 3.14
TYPICAL CROSS SECTIONS OF ALTERNATIVE SCHEMES IN 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

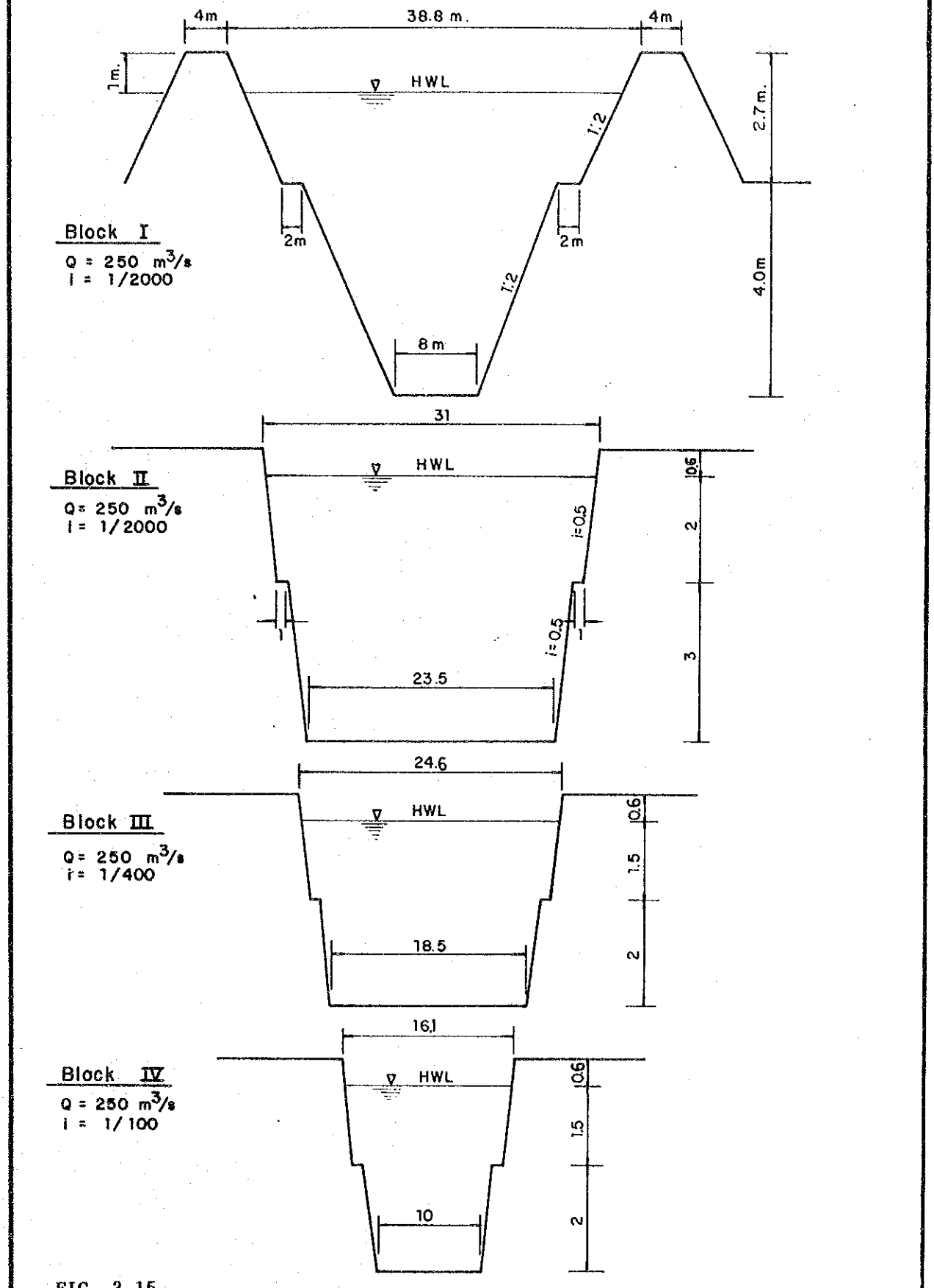

FIG. 3.15
TYPICAL CROSS SECTIONS OF ALTERNATIVE SCHEMES IN PIAÇAGUERA RIVER

1. Existing Works and Proposed Plan for Flood Disaster Prevention

1.1 Existing Works

Major existing works completed so far are presented on Fig.I.10 in ANNEX I and outlined below.

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

This works were carried out by DAEE after the destructive flood damage in Feb. 1971. The works consist of 1)dredging of the channel, 2)construction of right flood dike including drain ditch and 3)regulation of confluence with the Pereque river.

According to DAEE, it is reported that the works were designed for 25 year flood. The basic condition of the above works is as follows.

Major Condition of Channelization

Item	Condition
Design flood	25 year flood
Design discharge	600 m3/s
Length improved	about 2.5 Km
Channel width	about 80-100 m
Channel Bottom width	about 75-85 m
Cross-section of channel	trapezoidal(Fig.A.1)
Dike height	0.8 m
Crown width of dike	1 m
Slope gradient	1/2 - 1/3

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

Lands in the marsh area of Casqueiro were reclamated in order to provide residential areas. New residential areas of Bonao VIII and Vila Natal Casqueiro areas were created in the marsh areas.

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

This construction works were carried out by the industrial company of Copebras after the recurrent floods in March 1968, Feb. 1971 and Jan. 1976.

The construction consists of 1)two earth dikes and 2)three riprap cross dan and 3)two spillways. The purpose of this works is to regulate floods coming from the Cachoeira and its right tributary and to trap debris and mud flows at the gorge of the Cachoeira river.

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

This dredging works have been carried out by DAEE as maintenance work for the major channels of the Cubatão, Pereque, Piaçaguera and Moji rivers.

According to DAEE, it is reported that such dredgings for maintenance of the channel were recently carried out for the lower reaches of the Cubatão, Pereque and Piaçaguera rivers in 1985 and 1988. The dredged volumes are as follws.

Dredged Volume in 1985 and 1988

River	Volume (m3)	
	1985	1988
Cubatão river	69.000	125,900
Pereque	100.000	96,000
Piaçaguera	21.000	14,600
Moji	400.000	—

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

The works were made by the Union Carhbide company. The works are of four cross dams which function as the drop structure as well as trapping of debris and mud flows. Average dike length is 30 m respectively.

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

The works were made by DAEE after the serious flood in 1985. In this works, the four cross dams across the Moji river were provided to adjust the river slope and to trap the debris and mud flows.

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

The works were proceeded by the oil refinery company of the Petrobras in order to protect the oil tanks in the estate from the destructive debris and mud flows coming from the upper steep valleys. The nine gabion dam were constructed as step dam.

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

The construction works were made by the IPT and the fertilizer company of the Ultrafertil with the purpose of trapping of the debris and mud flows.

At the gorge of the Engenho river, three gabion dams were constructed across the valley. The total length of the dam is about 40 m and the average height is from 7 m to 9 m.

(9) Channelization of Lower Indio River (1988)

The channelization of the lower Indio was carried out by DAEE. The improved reaches are from the downstream of the estate of the Ultrafertil to the confluence with the main channel of the Moji river. The total length is about 300 m.

The channel was designed for the discharge of 15 m3/s. The works consist of 1)channel improvement and 2)construction of culvert. The major dimensions of the works are as follws.

Major Dimensions of the Works

Item	Dimension
Design discharge	15 m3/s
Channel improvement	
- Length improved	250 m
- Cross-section	trapezoidal
- Channel bottom width	8 m
- Channel width	10 m
- Channel depth	3 m
- Bank slope	1:2.5
Culvert	
- Length	27 m
- Height	2.5 m
- Width	6 m

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

In order to supply water to the pump stations operated by the Ultrafertil and the Copebras, the fixed dam was constructed about 15 years ago. In the Dec. 1988 flood, this dam was destroyed. The dam was restorated by DAEE in 1989.

The total length and heigth of the dam are approximately 50 m and 2 m, respectively.

(11) Periodical Dredging in Sedimentation Basin of COSIPA

Sedimentation basin in intake system by pump station in the industrial estate of COSIPA has been periodically dredged by COSIPA. The sedimentation basin is given on Fig.A.2.

According to COSIPA, the periodic dredging is carried out at every 2 years when the basin bed elevation exceeds the elevation of 1m in IGGSP. Approximate volume is around 500 m3 with 1 year duration. Cost required for the dredgins is estimated at around US$ 2/m3.

1.2 Previous Studies and Proposed Plans

(1) Previous Studies

(A) Study on Works for Cubatão Use and Control by DAEE

Immediately after the Feb.25,1971 flood, DAEE carried out the study on Works for the Cubatão Use and Control in October 1973. The study was made to clarify the present conditions and flood damages, and to provide comparative plans of the flood control in the Cubatão river at a preliminary level for the further stage. The outline of the results on flood control scheme is as follows based on the said study report.

Estimation of Probable Basic Discharges

The probable basic discharges were estimated by unit hydrograph method and described below.

Basic Discharges

Return Period (year)	Basic Discharge (m3/s)	
	Site A	Site B
10	636	720
20	757	866
50	930	1070
100	1080	1213
500	1400	1595

The location of the above Site A and Site B is as follows.

Site A : middle reach of the Cubatão river
Site B : downstream of confluence with Pereque river

Comparative Plan

The following four components were taken up for the comparison.

1) Alternative 1 : Flood control dam with diversion tunnel

- Return period : 1/10000
- Discharge : 1950 m3/s
- Location of dam axis : Axis I (see Fig.A.3)
- Dam type : Earth dam
- Dam height : 21.5 m
- Bottom discharge pipe : 2 m diameter
- Diversion tunnel : 7.75 m diameter * 2 * 800 m
- Contruction cost : Cr$ 95.2 million in Oct.1973 price

2) Alternative 2 : Flood control dam

- Return period : 1/10000
- Discharge : 1950 m3/s
- Location of dam axis : Axis IA (see Fig.A.3 and 4)
- Dam type : Earth dam
- Dam height : 51.5 m
- Spillway : 10 m wide
- Bottom discharge pipe : 2 m diameter * 2 units
- Construction cost : Cr$ 70.2 million

3) Alternative 3 : Channelization

The channelization is considered for the following comparative discharges.

Case	Design Discharge (m3/s)	construction cost (cr$ million)
1	500	73
2	600	83
3	660	88

4) Alternative 4 : Flood control dam with channelization

This scheme is considered as combination of flood control dam in Alternative 2 and channelization for the following discharges.

Case	Dam Cost (Cr$ million)	Channelization		Total Cost (Cr$ million)
		Discharge (m3/s)	Cost (Cr$ million)	
1	70.2	200	36	106.2
2	70.2	300	50	120.2
3	70.2	360	57	127.2

Conclusion and Recommendation

- Alternative plan of channelization only is recommendable in view of cost and technical aspects as well as Cubatão urban development aspect.
- Alternative by dam is costly one and involves problem in slope stabilization around reservoir.
- The following investigation and study are further required.

  - Detail hydrological study
  - Soil-mechanic study
  - Construction method
  - Others

(B) Study on Flood Protection of Cubatão Industrial Complex by COPEBRAS

This study was made by COPEBRAS in order to produce schemes which enable selecting the most advantageous alternatives to protect the industrial complex of COPEBRAS from flood and sediment flows coming from Cachoeira and Braco Norte rivers in the upper Piaçaguera.

The purpose of the works was to divert flood and sediment flows into the eastern stream/side of the complex. The study was made in 1976 and consists of hydrological and geological studies ,and alternative study of protection works. The outline of the studies are as follows based on the said report.

Hydrological features and design discharges

The design discharges were estimated by means of unit hydrograph with rainfall duration of 2 hours for the two return periods.

Hydrological Features

Basin	Drainage Area (km2)	2-Hour Rainfall (mm)		Design Discharge (m3/s)	
		1/50	1/100	1/50	1/100
Cachoeira	4.0	146	170	85	97
Braco Norte	1.6	146	170	34	39

Alternative schemes

The following the three basic alternatives were taken up and studied. The return period applied is unknown in this report.

1) Alternative 1 (see Fig.A.5)

- Construction of small dam/dike at gorge of Braco Norte (about 100m long)
- Construction of diversion channel into Cachoeira (about 300m long)
- Construction of small dam/dike at gorge of Cachoeira (about 100m long)
- Construction of four debris barriers in eastern stream

2) Alternative 2 (see Fig.A.6)

- Construction of flood dike with lined diversion channel into eastern stream (about 350m long)
- Construction of diversion channel (about 150m long)

3) Alternative 3 (see Fig.A.7)

- Construction of four debris barriers and construction of culvert in Braco Norte
- Construction of small dam/dike at gorge of Cachoeira (about 100m long)
- Construction of four debris barriers in eastern stream

Selection of appropriate scheme

Alternative 2 was selected as proposed one with due consideration of cost and safety degree aspects. Carrying out detailed study with other variation within the slected scheme was recommended.

(C) Water Development of Municipal Use

According to SABESP which is the water supply agency in Sap Paulo, municipal water demand in the year of 2000 is estimated at 11 m3/s in total. In order to fulfill the said demand, SABESP studied the following development schemes.

- Scheme 1 : Construction of dam including flood control space in the upper Cubatão(prospective development capacity= 4 m3/s)
- Scheme 2 : Full utilization of outflow from Henry Borden power station (available firm water= 70 m3/s)
- Scheme 3 : Construction of dam including flood control space in the Rio Branco river located in the southern area of the Cubatão basin(prospective development capacity=13 m3/s)

From the above, Scheme 3 has been selected as the future plan in view of the following considerations.

- Development capacity by Scheme 1 is small against objective capacity of 7 m3/s.
- In case of Scheme 2, water quality of the outflow is not accepted.

For reference, proposed features of the Scheme 3 are as follows.

- Water resources : Rio Branco
- Dam dimension
  - Dam type : Earth dam
  - Dam length : 1520 m
  - Dam volume : 1.4 million m3
  - Top elevation : 22 m IGGSP
- Water level and reservoir dimension
  - Max.water level : 20.6 m IGGSP
  - High water level : 19.5 m IGGSP
  - Low water level : 13.0 m IGSSP
  - Total reservoir capacity : 394 million m3
  - Effective reservoir capacity : 220 million m3
  - Flood control space : 82 million m3
  - Dead capacity : 92 million m3
  - Spillway capacity : max.80 m3/s

2) Proposed Plan

At present, macro drainage plan in Cubatão region has been considered by DAEE. This plan consists of the following themes.

- Study on flood potential
- Regulation of torrential rivers
- Modelling of rainfall, runoff and sediment
- Study on boundary conditions to sea and tide

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

According to DAEE,it is scheduled that the channalization 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.

Channelization and embankment(See Fig.A.8)

- Location	: downstream of flyover in the middle reach
- Length to be improved	: 250 m
- Design return period	: 50 yrs
- 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

Periodical Dredging

- Object rivers	: Cubatão Moji Piaçaguera
- Proposed volume	: 600,000 m3
- Implementation year	: 1990
- Implementation agency	: DAEE

Moreover, COSIPA has been considered to shift the lower Moji river course into west side of the existing railway. However, this plan is not yet formulated due to the financial and other constraints.

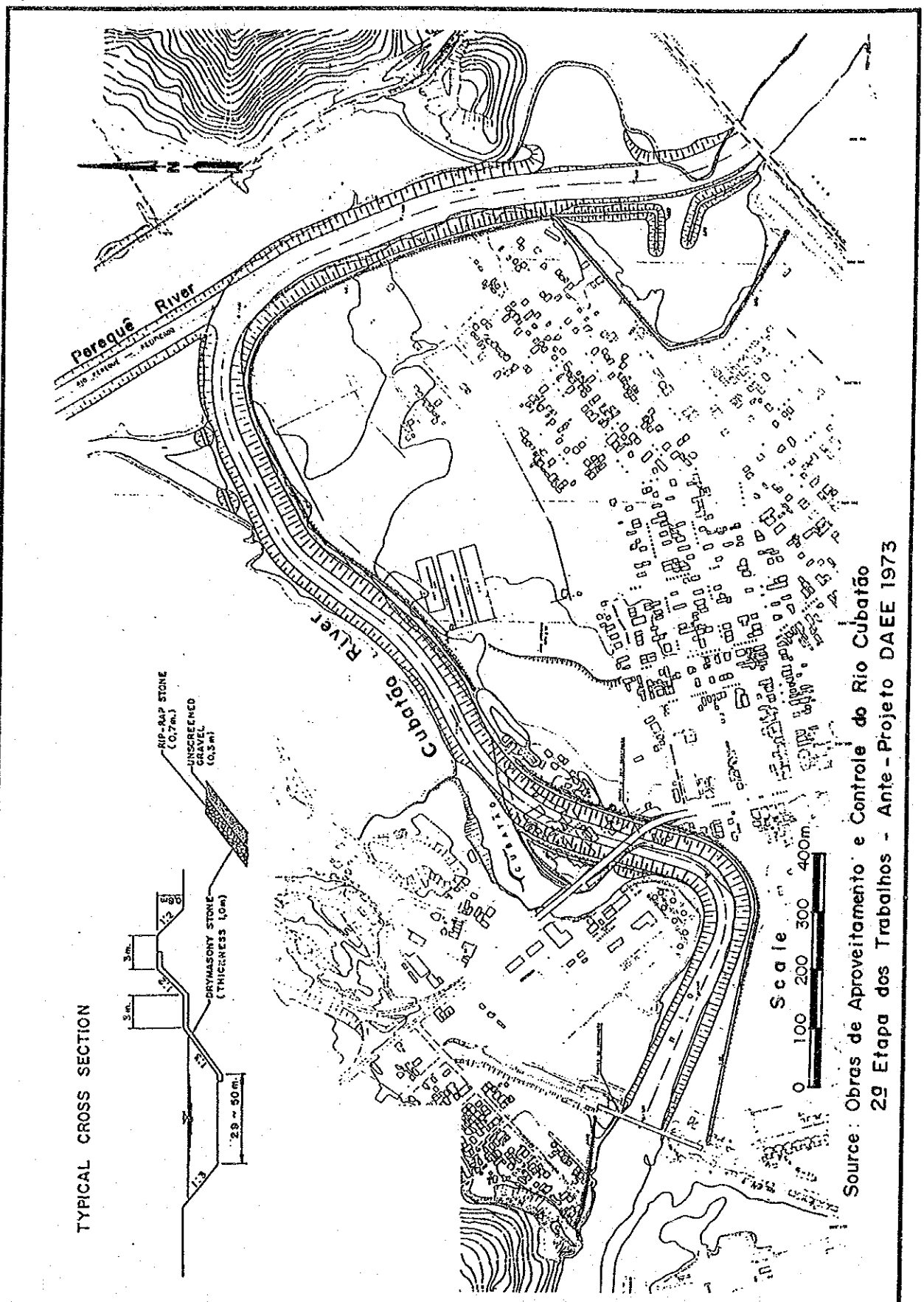

FIG. A.1
RIVER IMPROVEMENT PLAN FOR
600m^3/s OF CUBATÃO RIVER

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D107

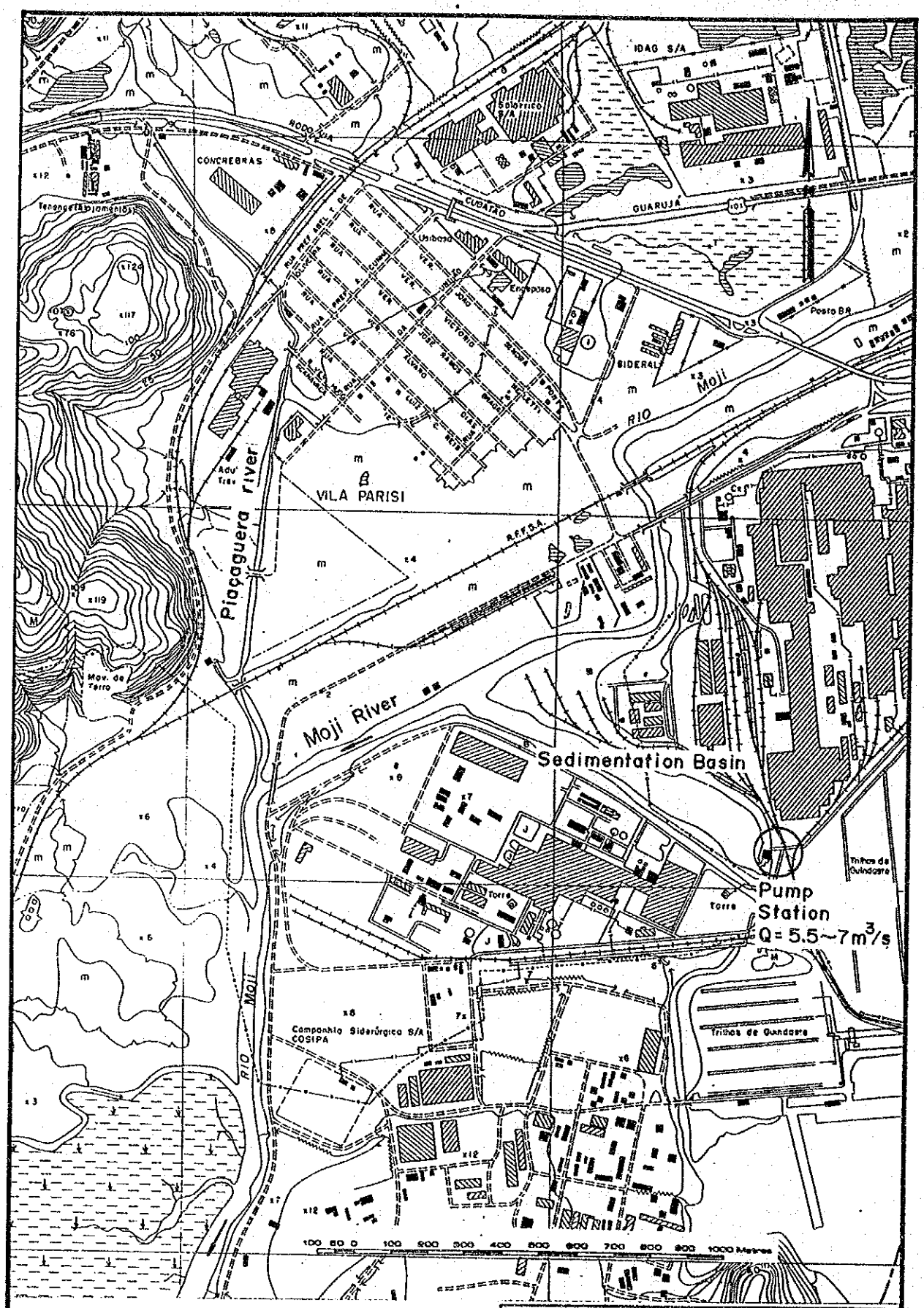

FIG. A.2
SEDIMENTATION BASIN AND PUMP STATION OF COSIPA

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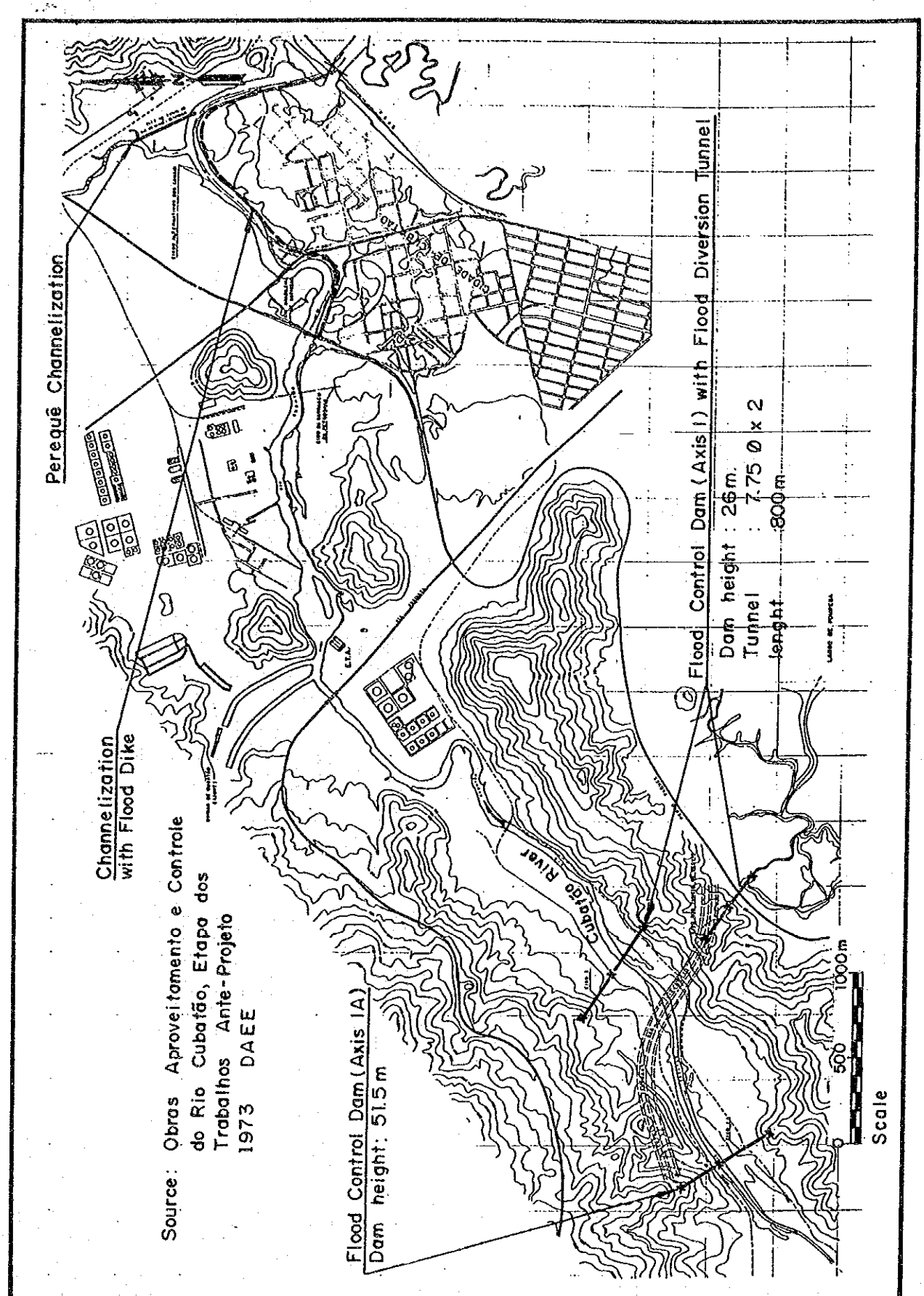

FIG. A.3
OUTLINE OF COMPARATIVE FLOOD CONTROL PLANS OF CUBATÃO RIVER

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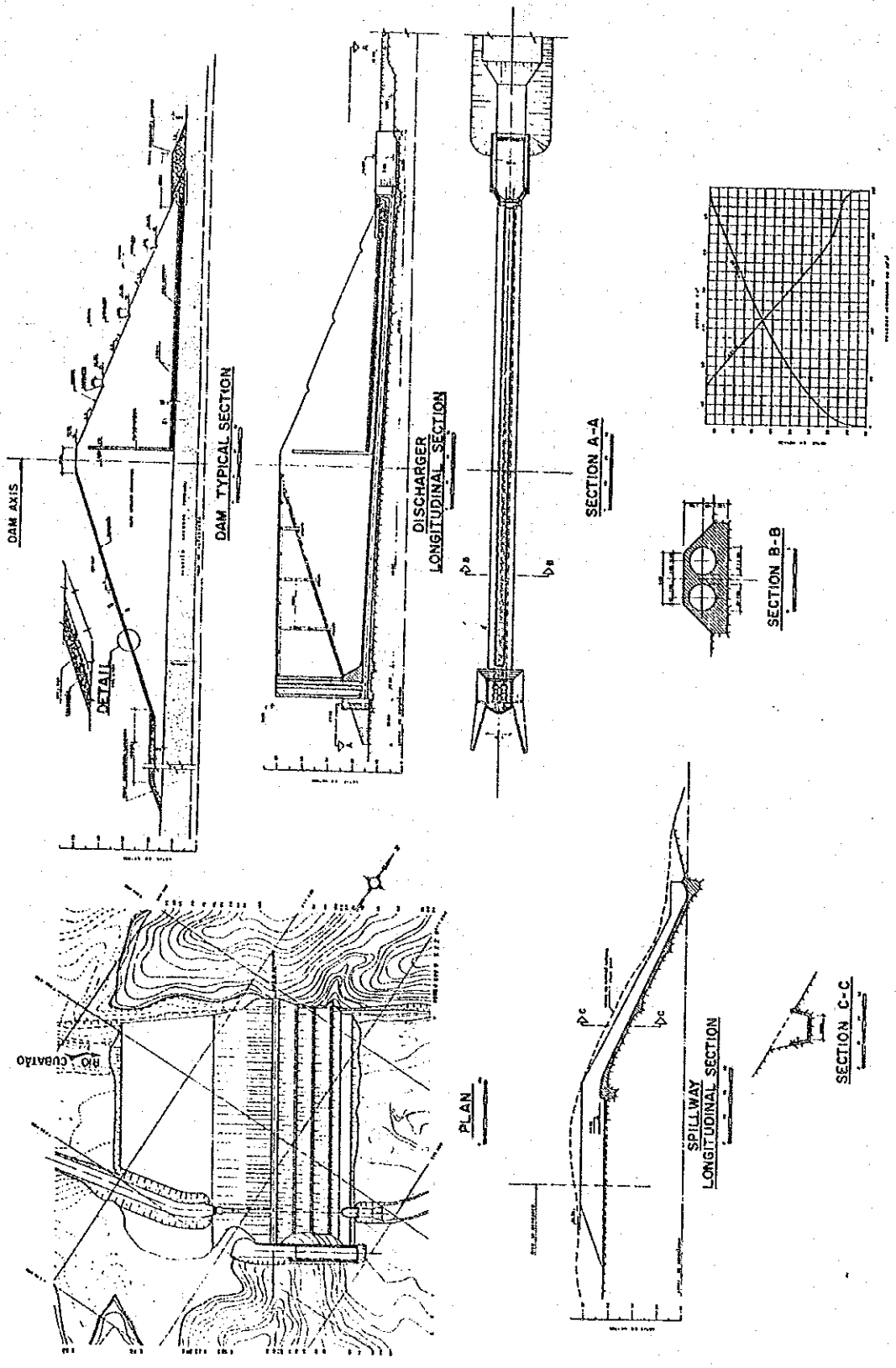

FIG. A.4
OUTLINE OF FLOOD CONTROL DAM
(ALTERNATIVE 2)

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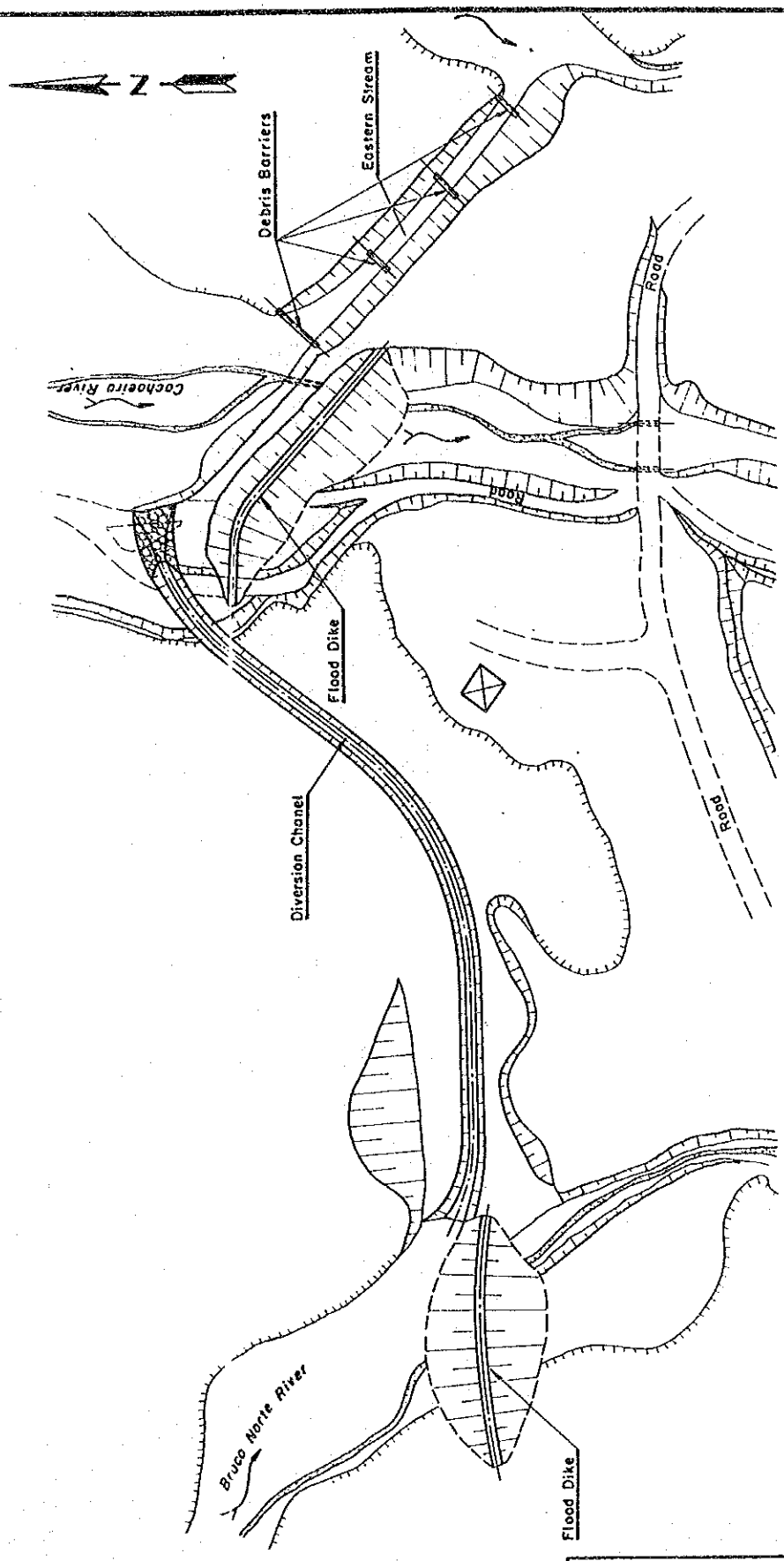

FIG. A.5
ALTERNATIVE PLAN(1) OF FLOOD CONTROL BY COPEBRAS

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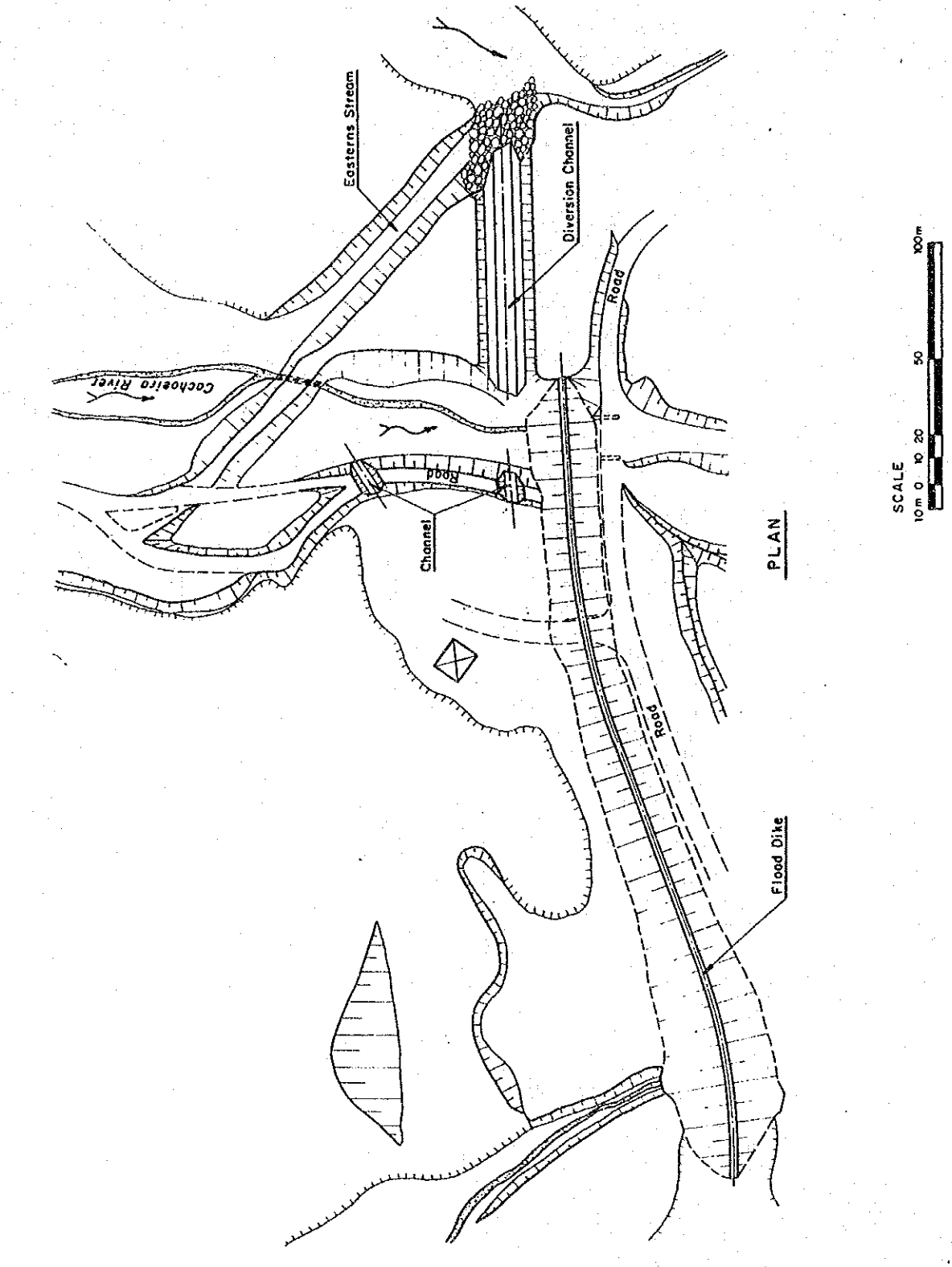

FIG. A.6
ALTERNATIVE PLAN(2) OF FLOOD CONTROL BY COPEBRAS

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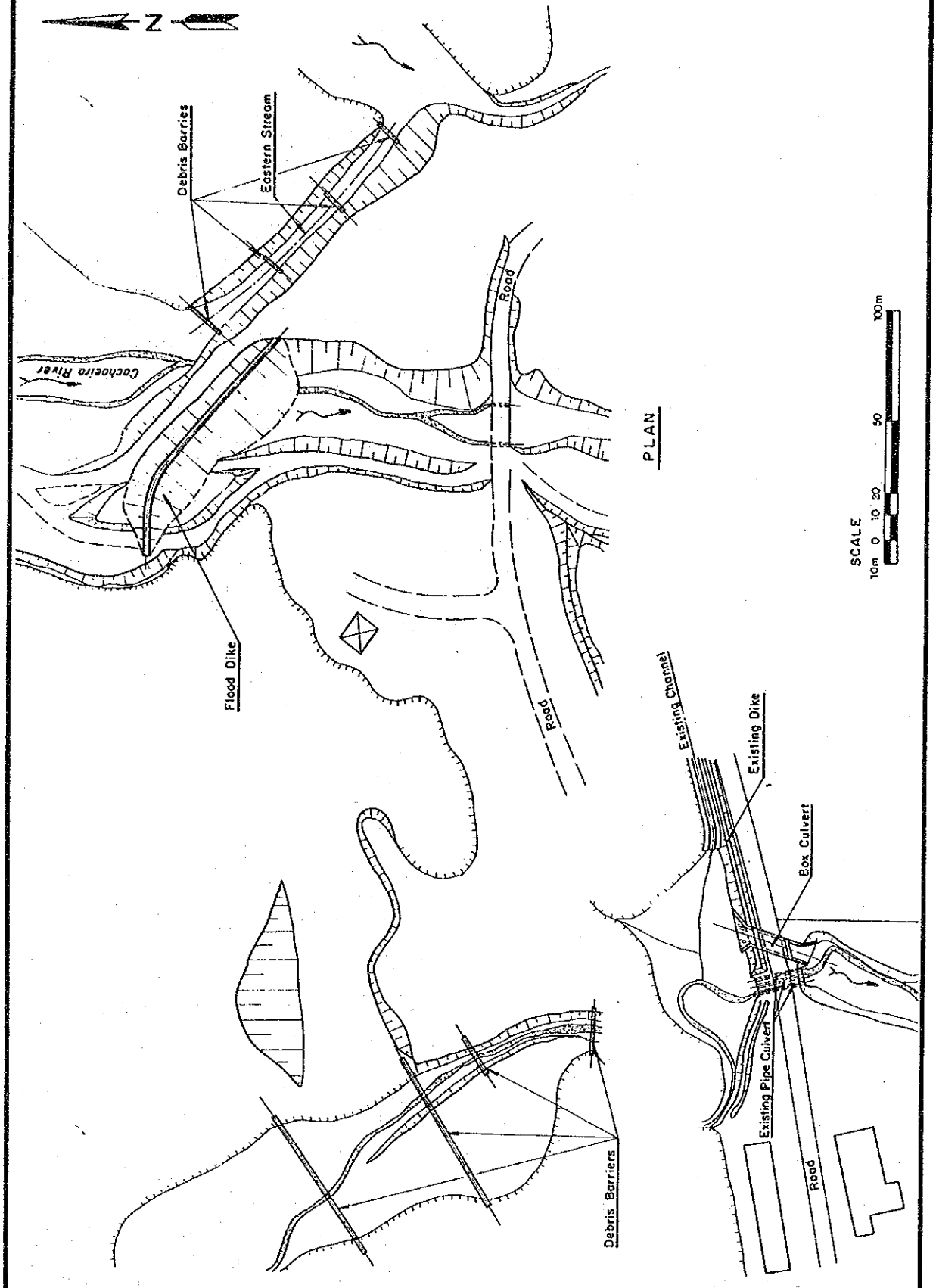

FIG. A.7
ALTERNATIVE PLAN(3) OF FLOOD CONTROL BY COPEBRAS

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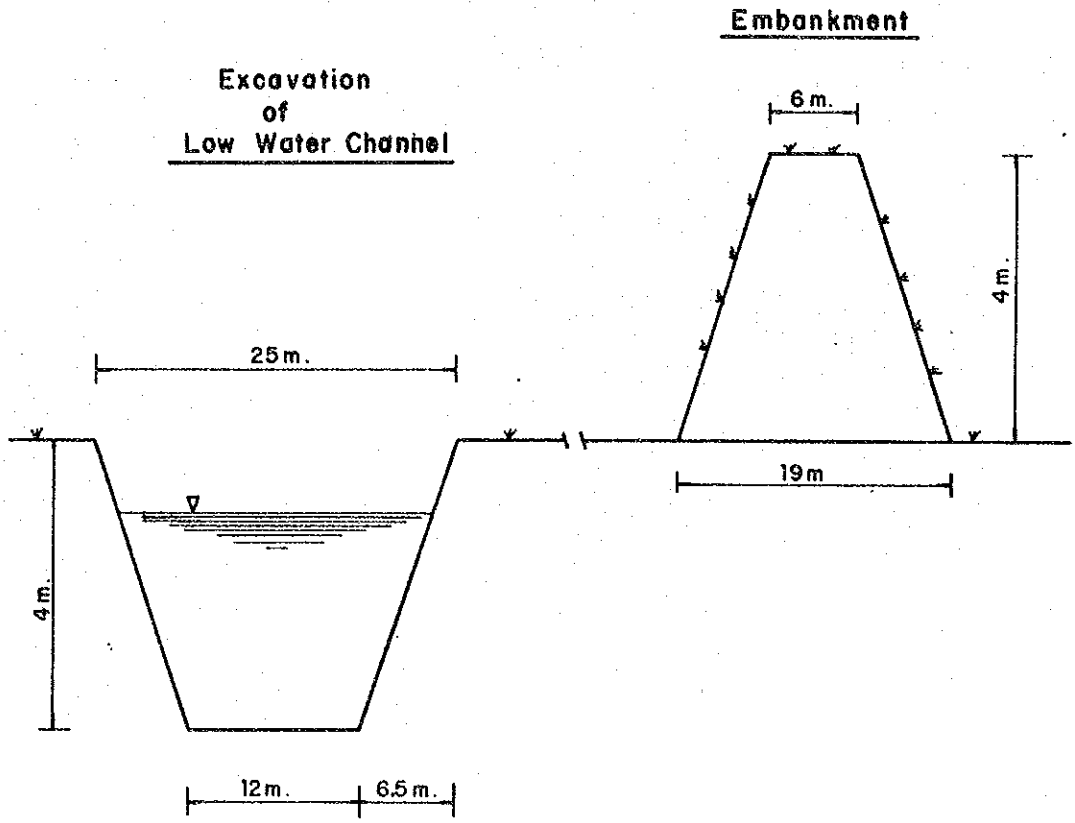

Note : Length to be Improved = 250 m
Design Discharge = 200 m^3/s

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

FIG. A.8
PROPOSED CROSS SECTION OF MIDDLE MOJI RIVER

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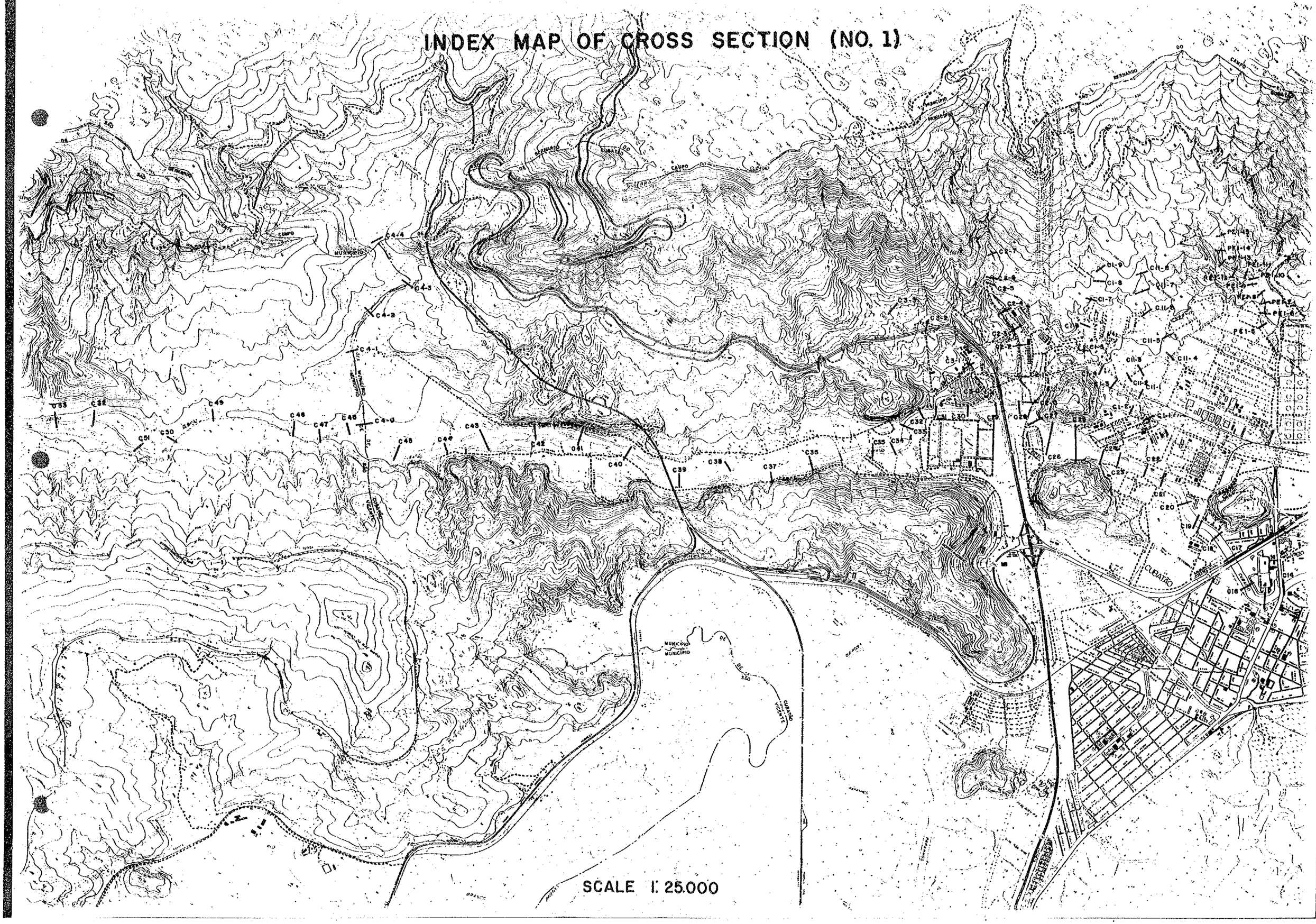
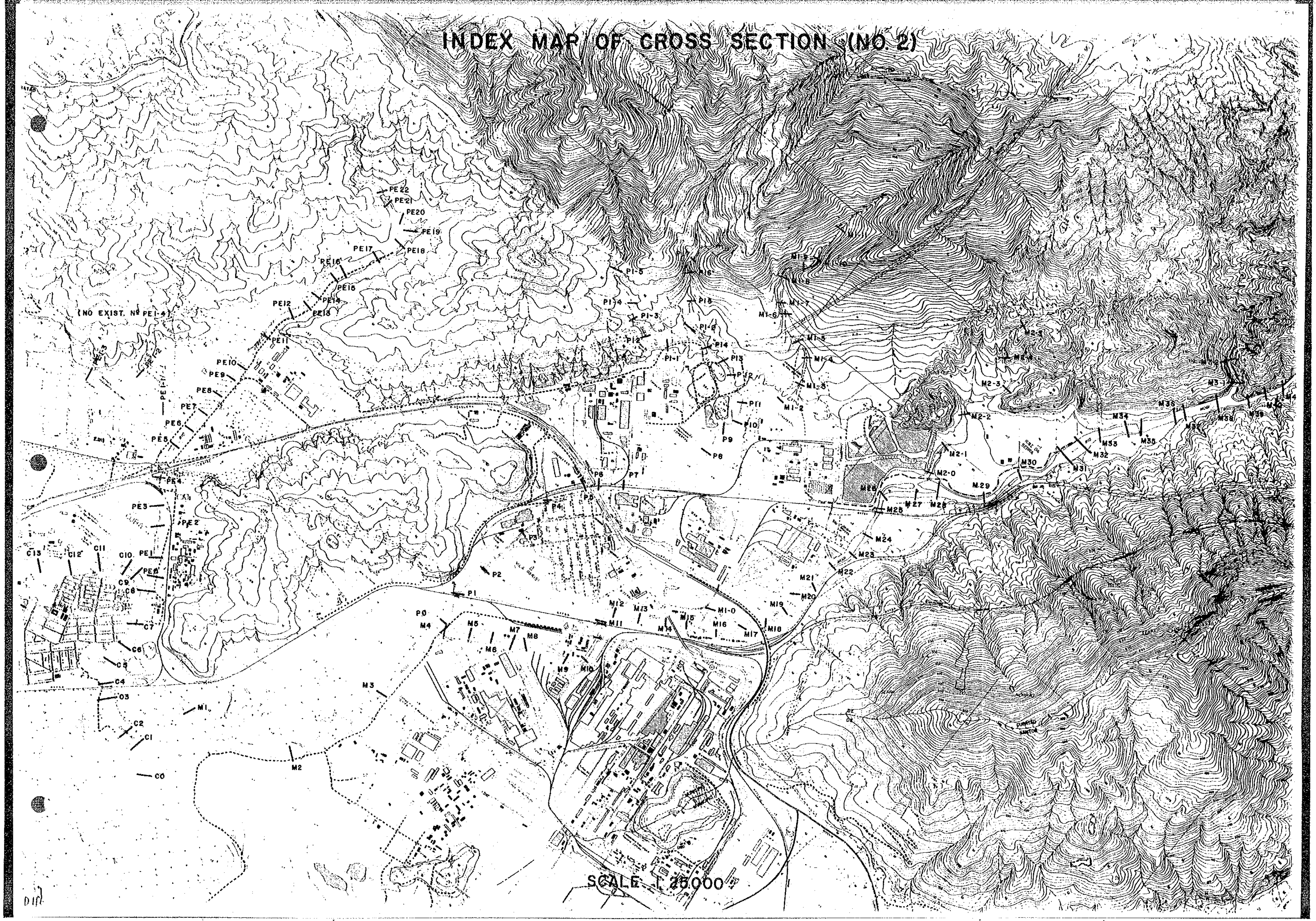
INDEX MAP OF CROSS SECTION (NO. 1)



INDEX MAP OF CROSS SECTION (NO. 2)



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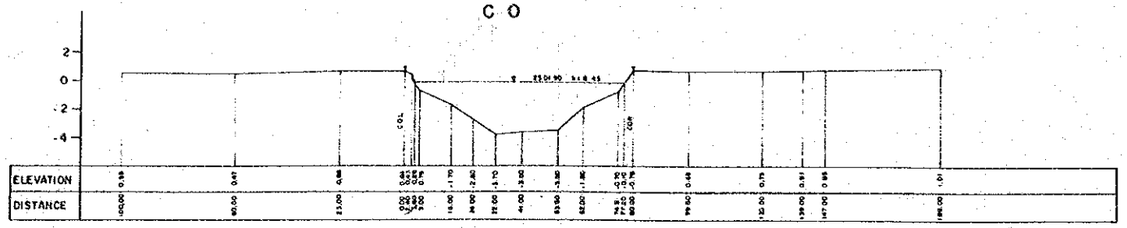

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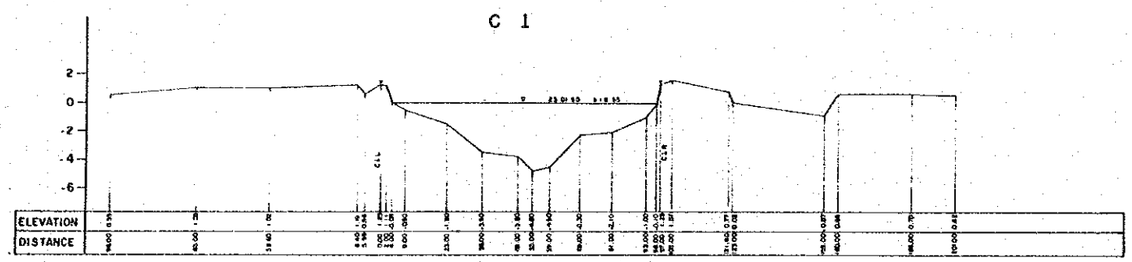

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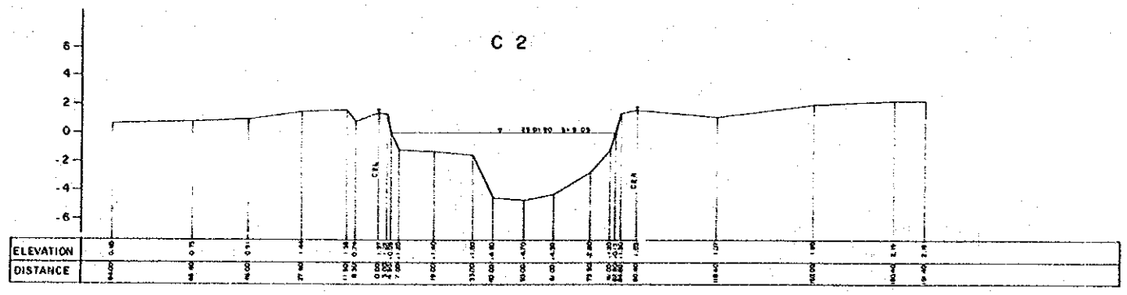

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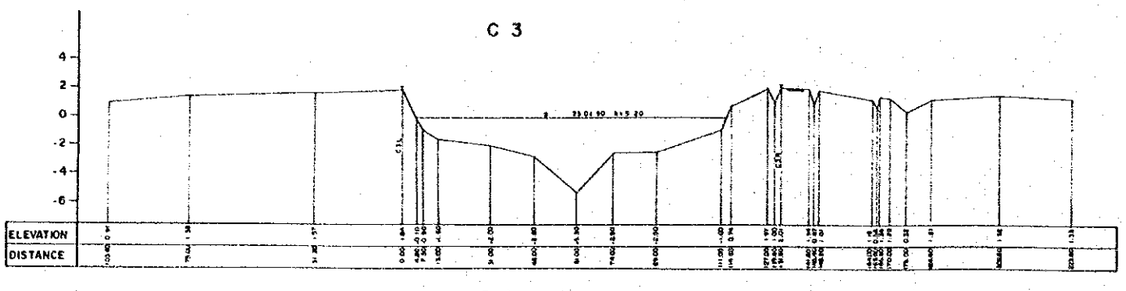

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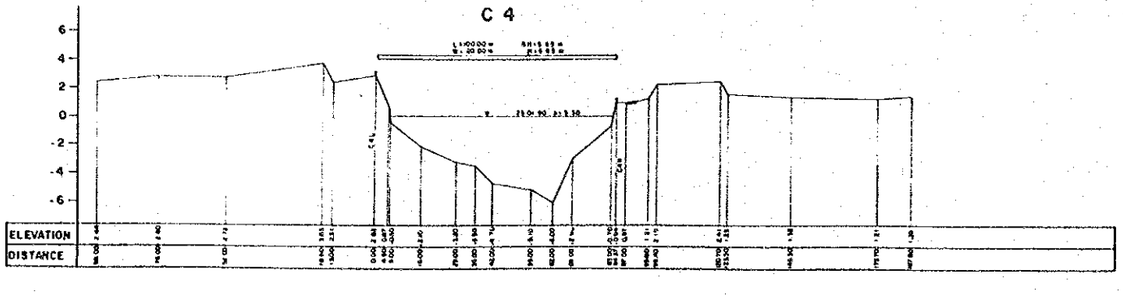

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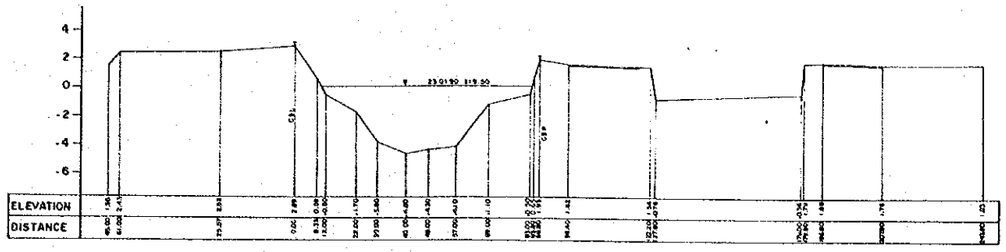

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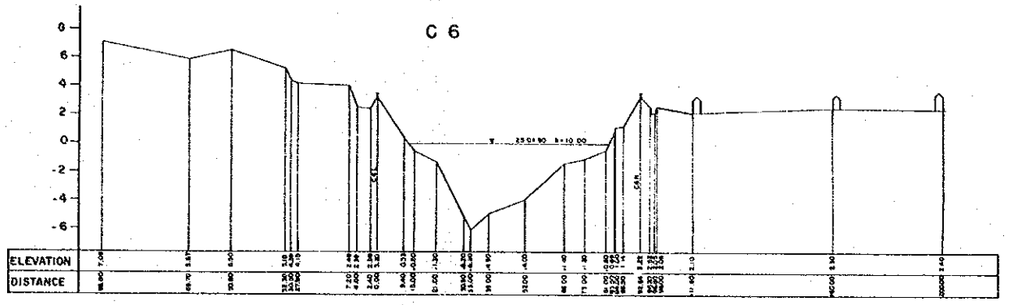

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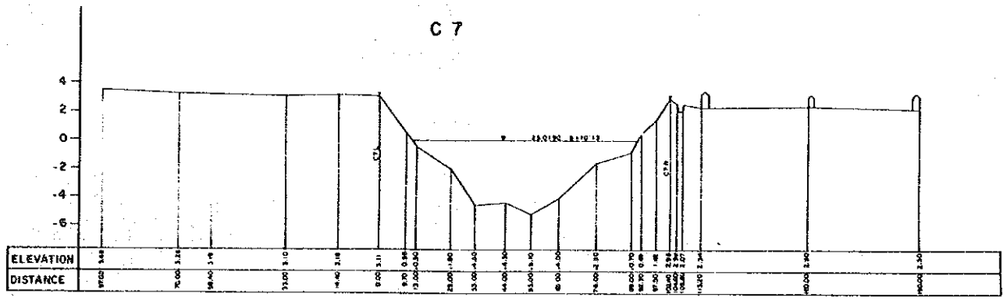

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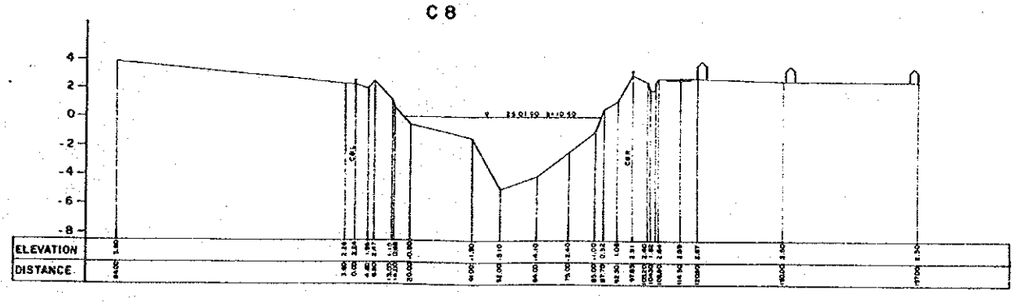

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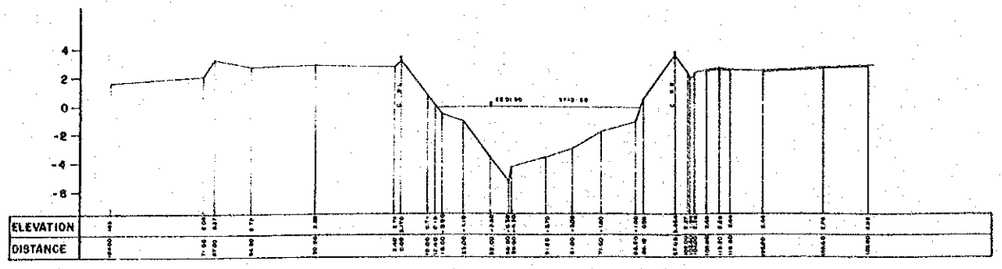

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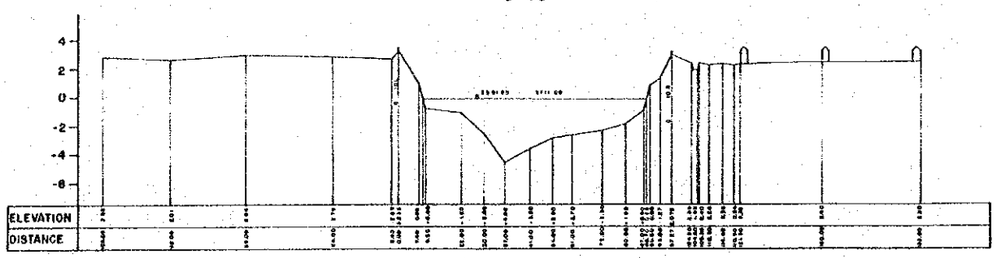

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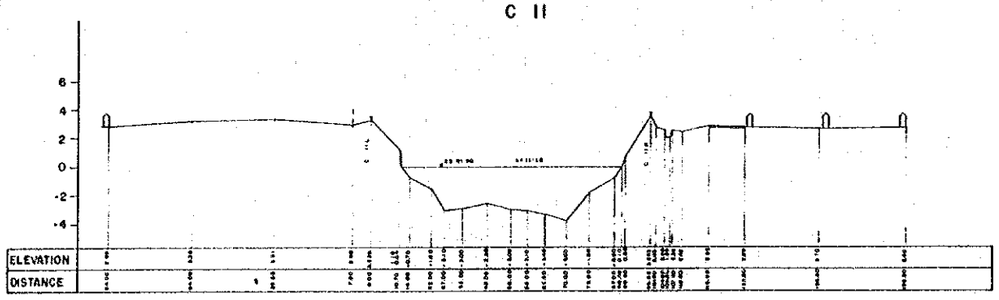

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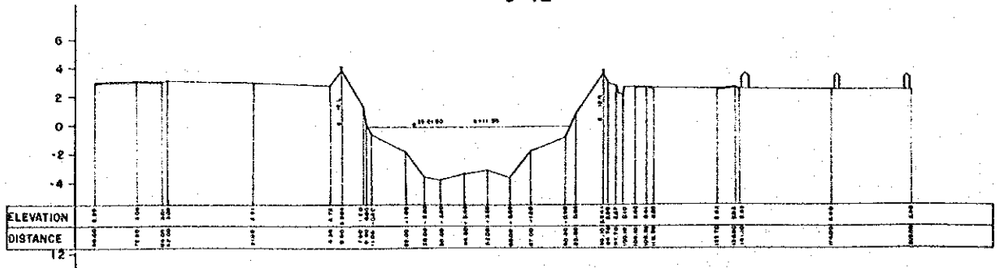

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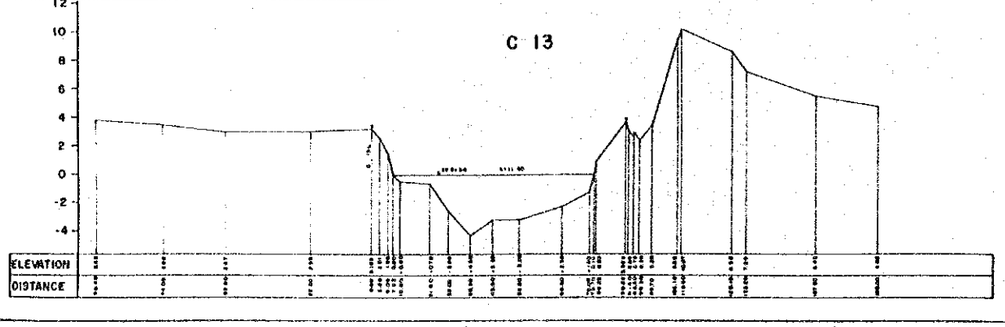

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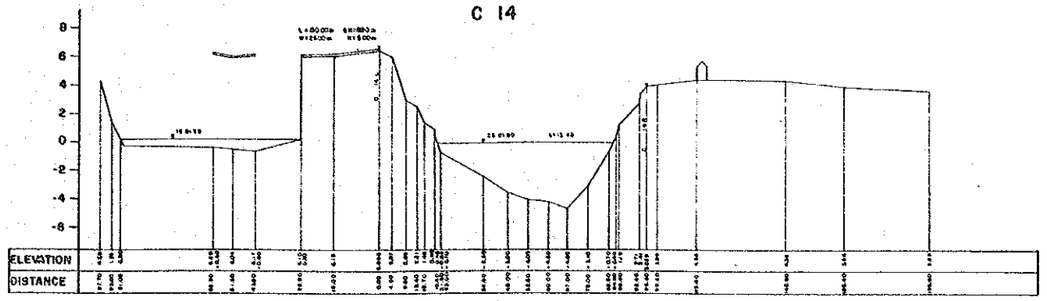

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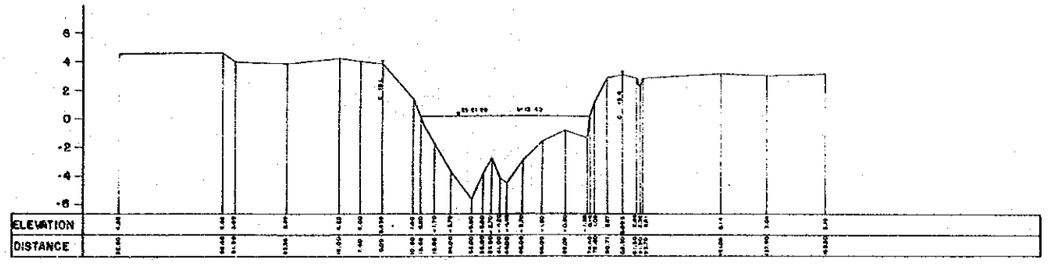

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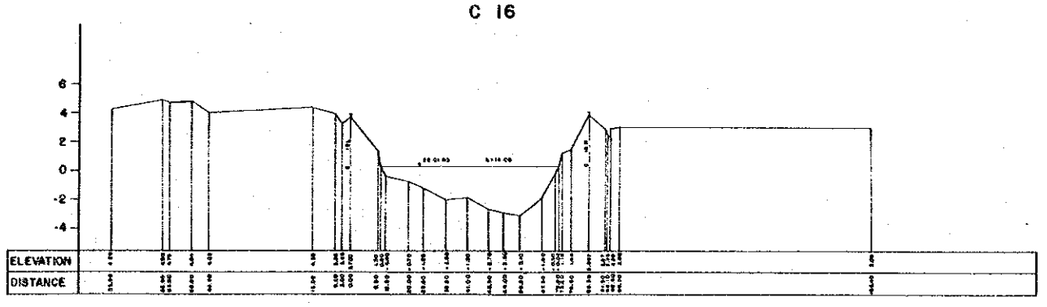

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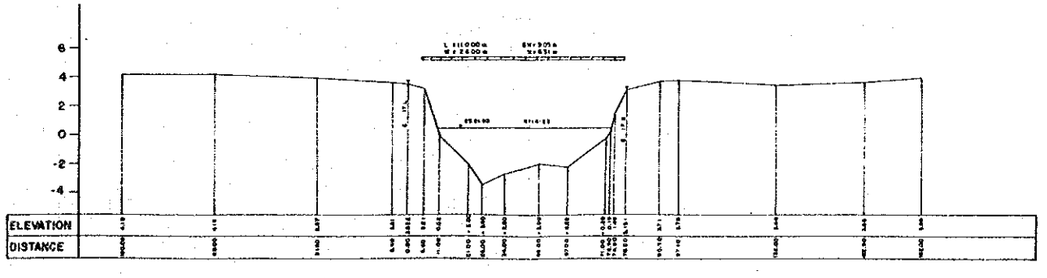

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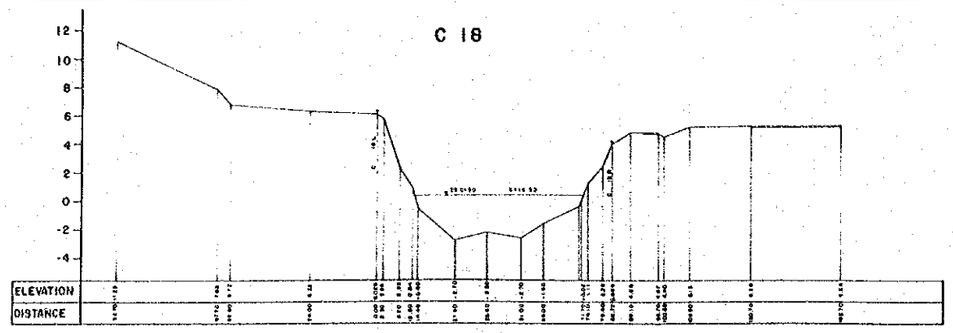

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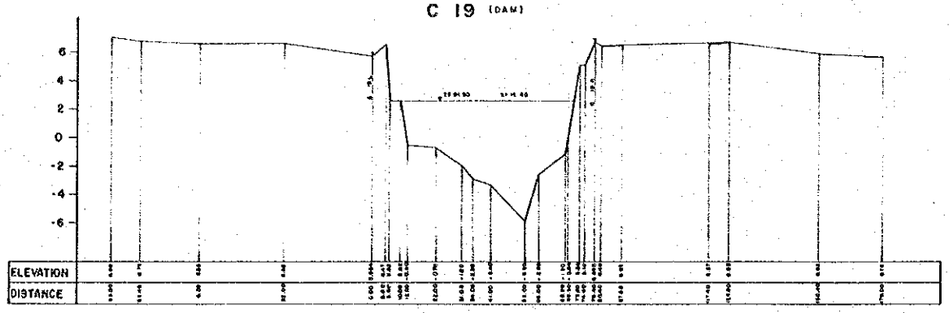

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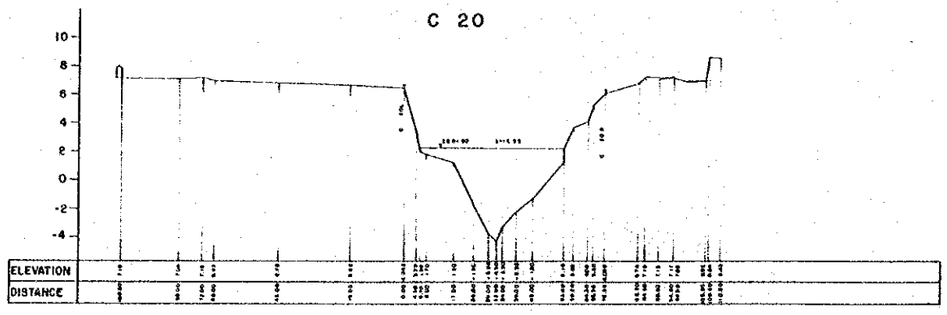

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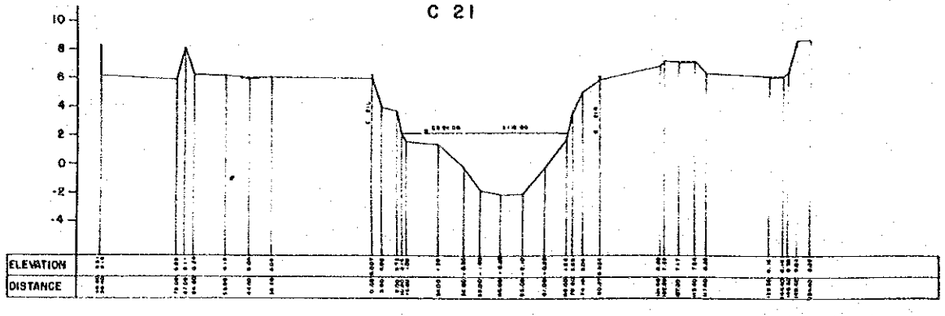

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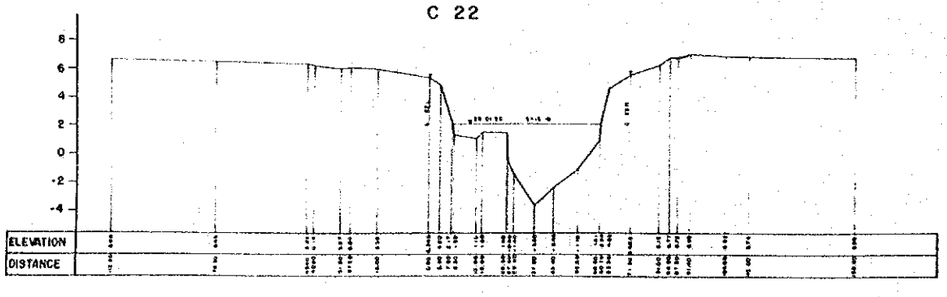

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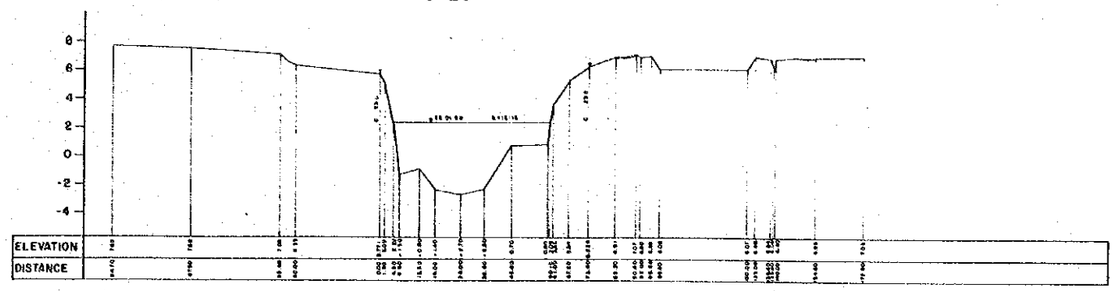

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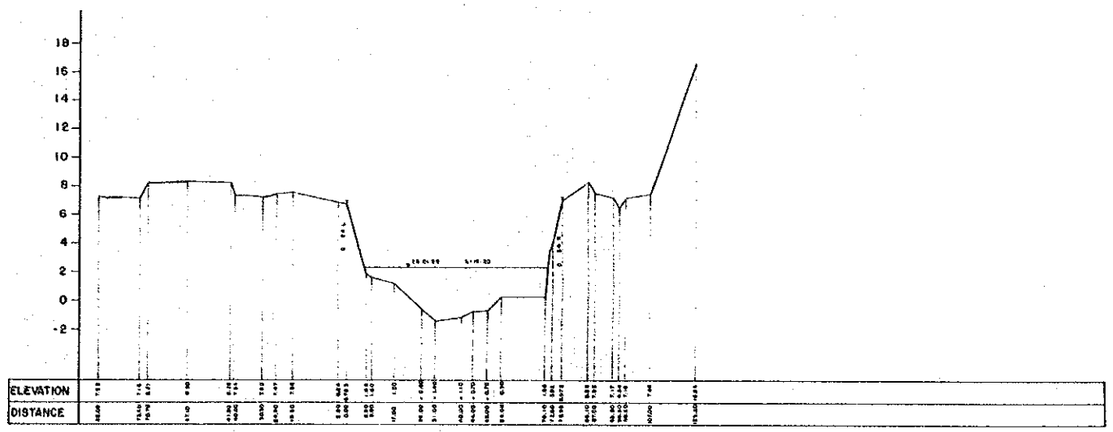

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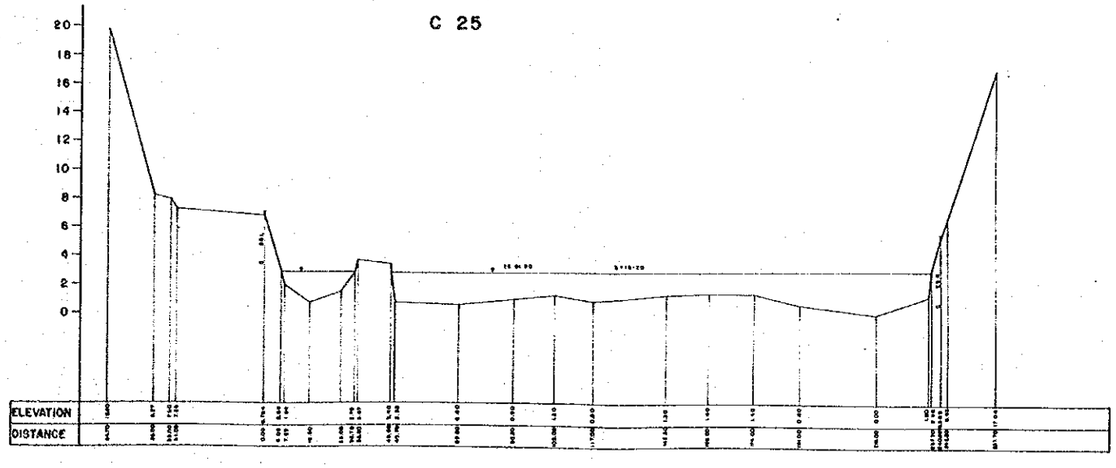

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CROSS SECTION OF RIO CUBATÃO

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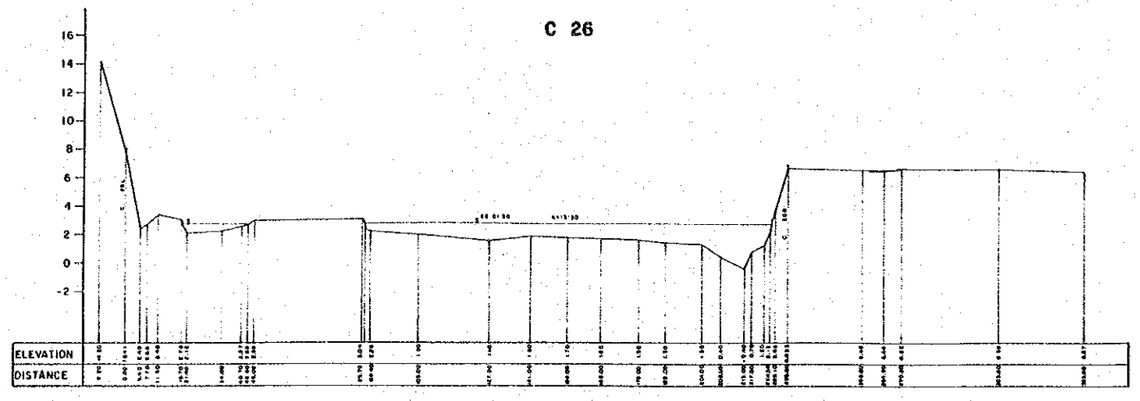

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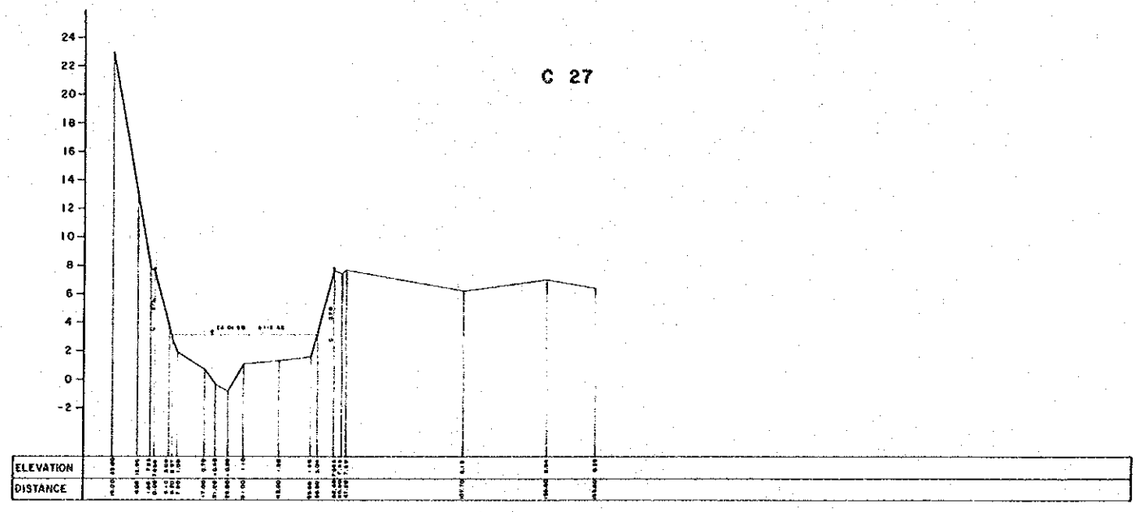

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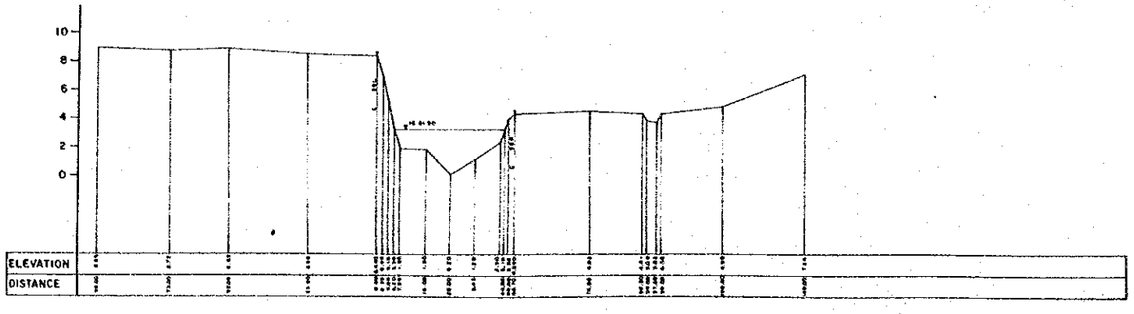

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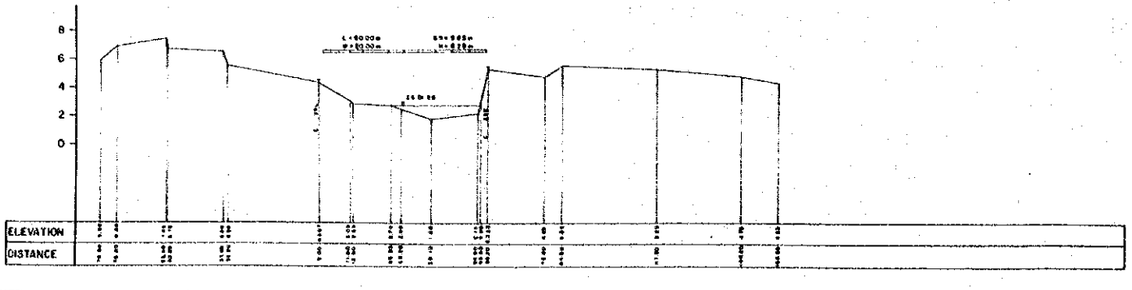

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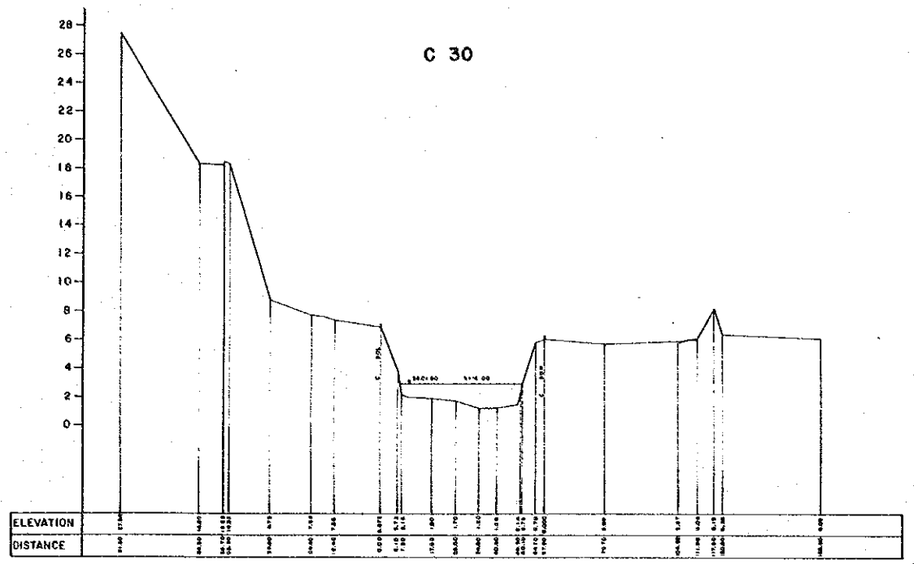

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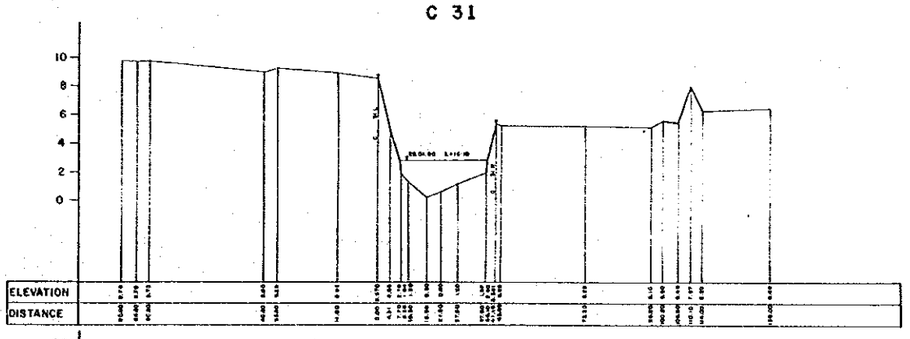

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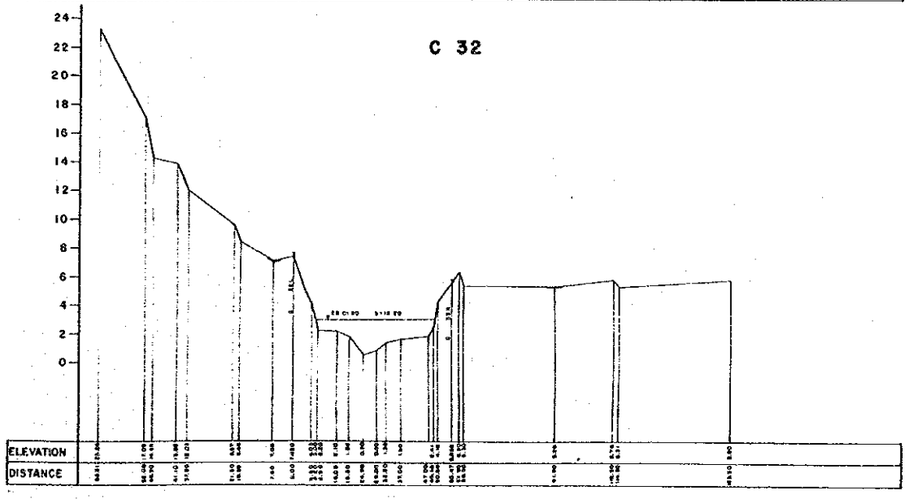

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