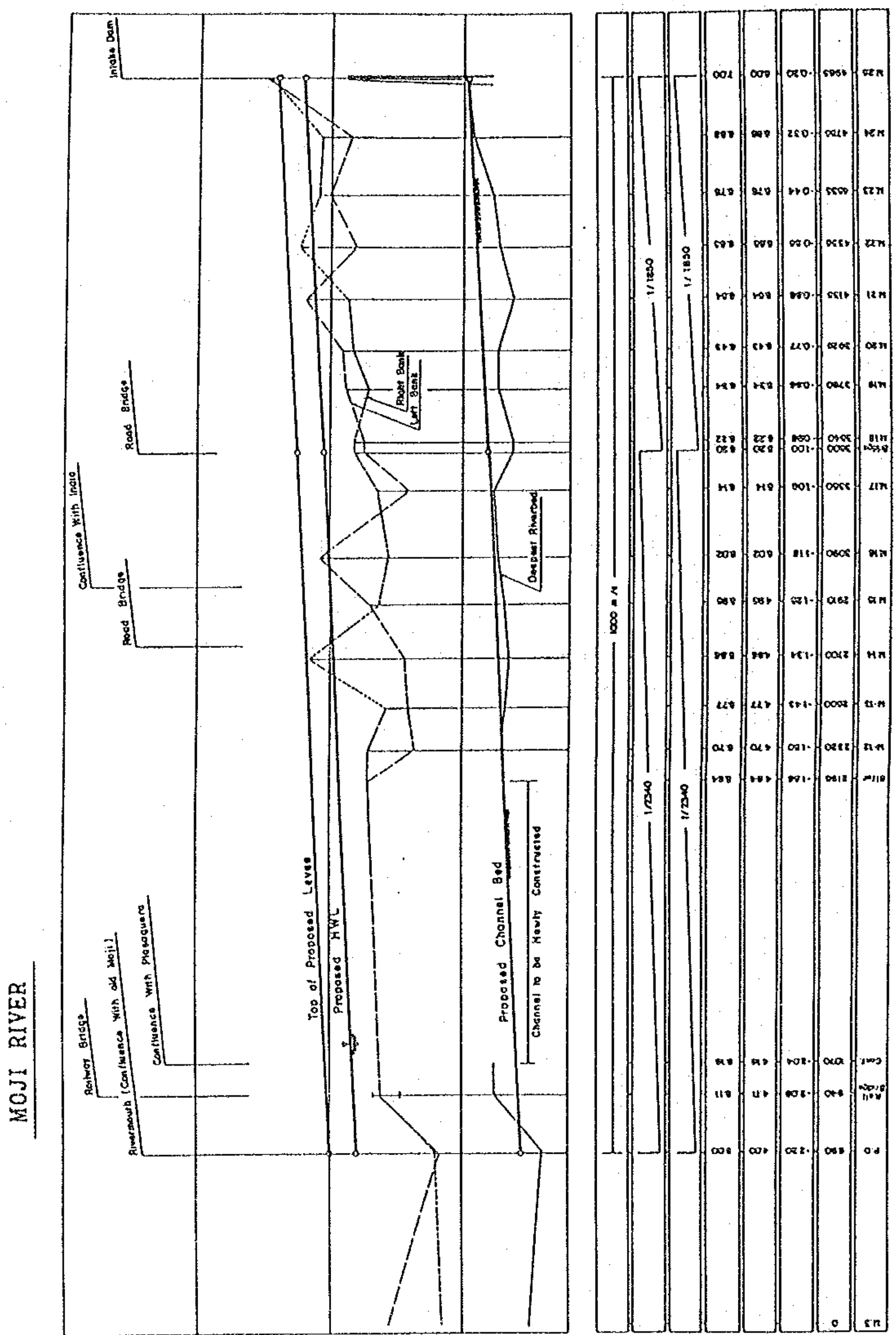
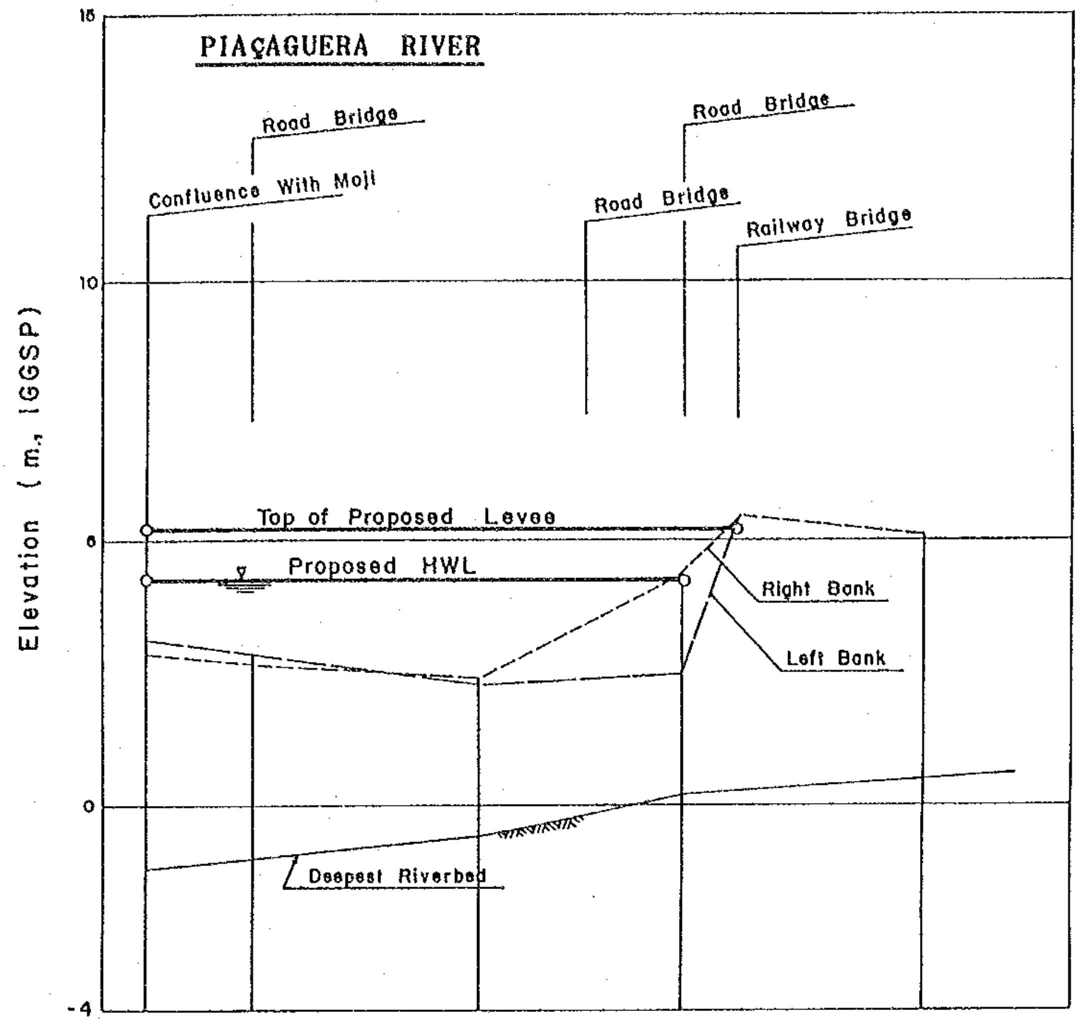


FIG. 1.26 (1/2)
PROPOSED LONGITUDINAL PROFILE
OF PRIORITY PROJECT

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



Design Flood Discharg (m^3/s)					
Gradient of HWL	Level				
Gradient of Channel Bed	Existing				
Top of Proposed Levee (m, IGGSP)	5.20	5.20	5.20	5.20	
Proposed HWL (m, IGGSP)	4.20	4.20	4.20	4.20	
Proposed Channel Bed (m, IGGSP)	Existing				
Distance (m)	0	190	610	980	1420
Section Nº	P1+130	P2	P3	P4	P5

FIG. I.26 (2/2)
PROPOSED LONGITUDINAL PROFILE
OF PRIORITY PROJECT

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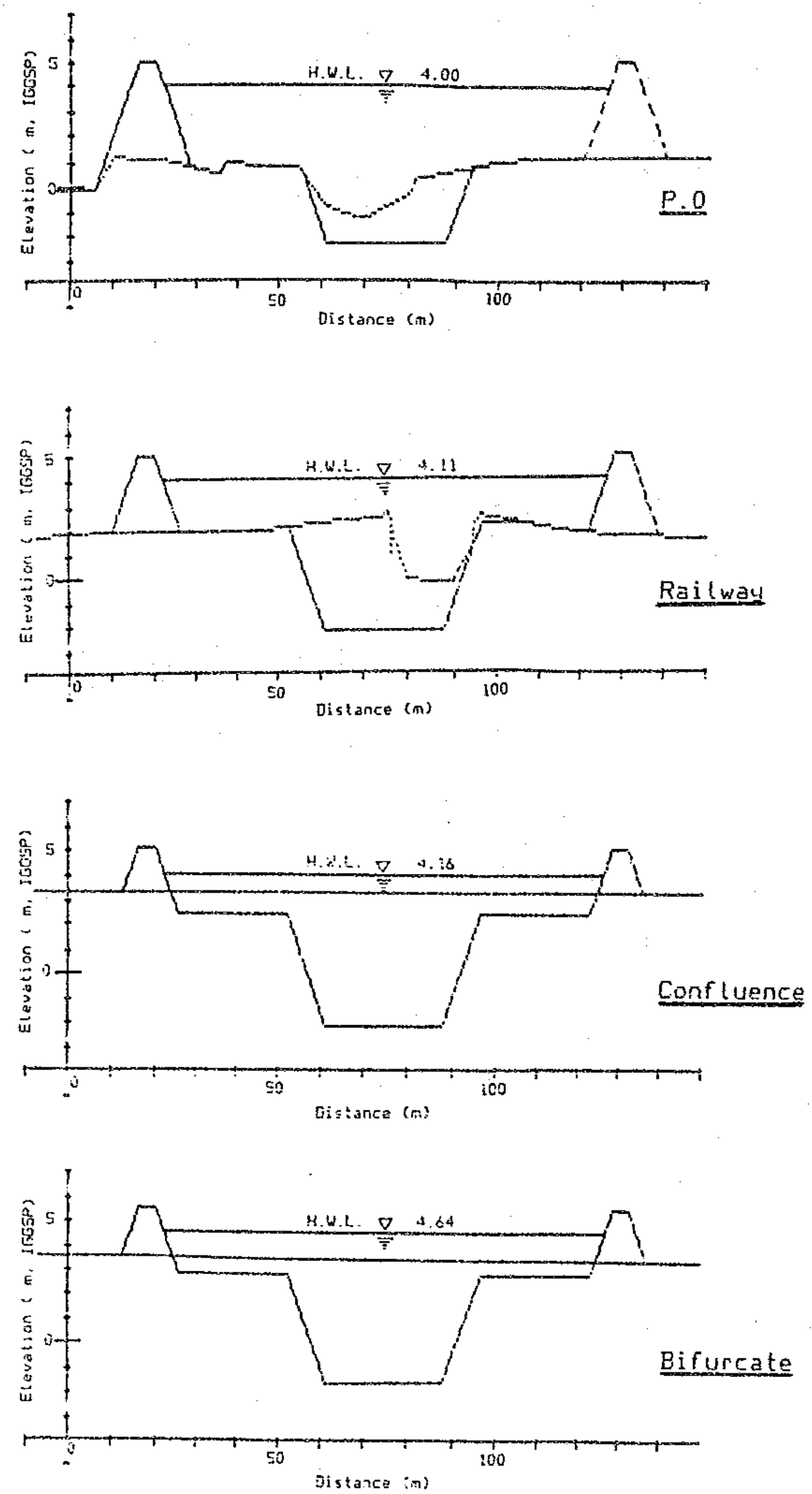
JAPAN INTERNATIONAL COOPERATION AGENCY



Note : Right dike at P.0 dose not construct.

FIG. I.27
PROPOSED CROSS SECTIONS
OF CHANNEL (1/5)

GOVERNMENT OF FEDERATIVE
REPUBLIC OF BRAZIL
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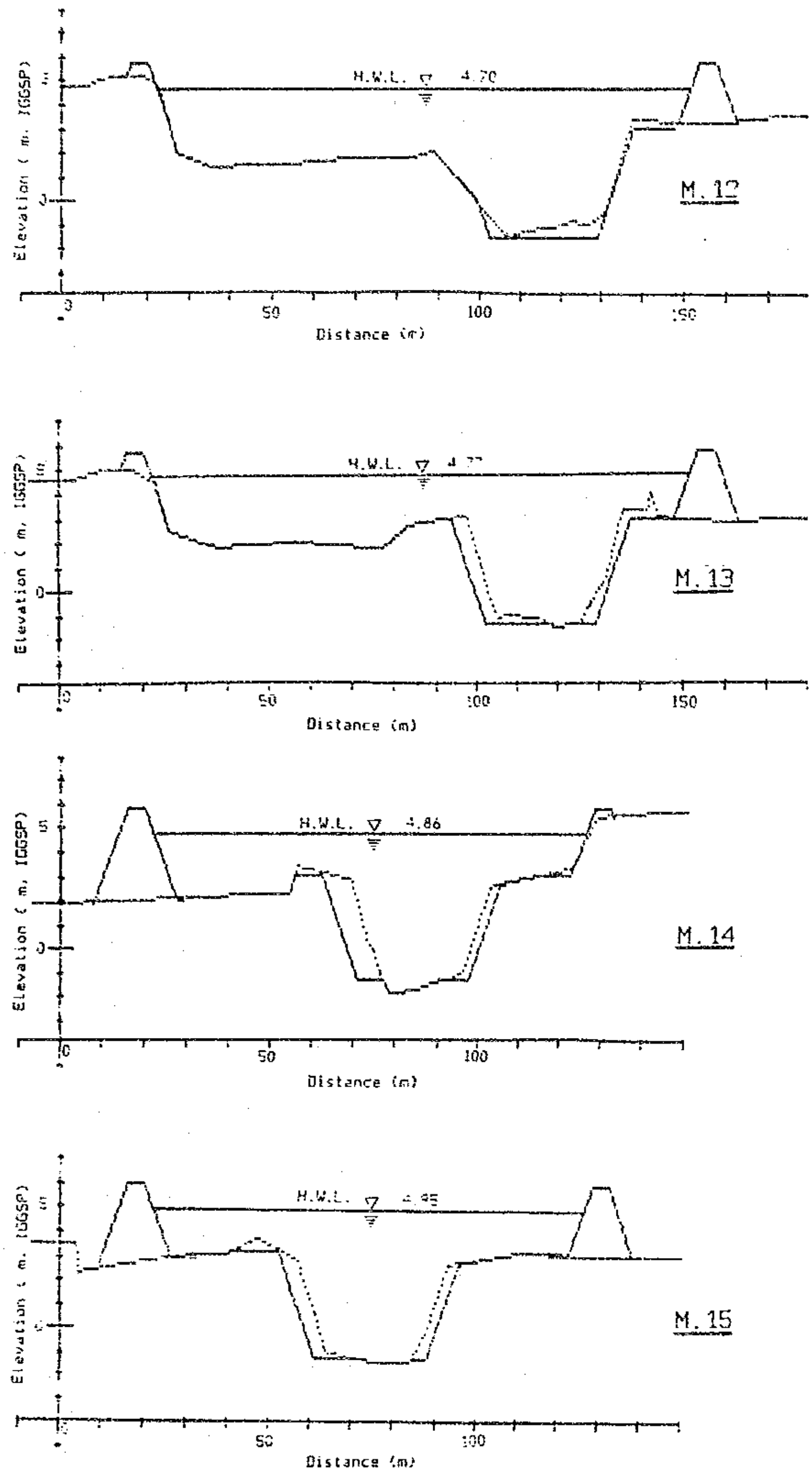

FIG. I.27
PROPOSED CROSS SECTIONS
OF CHANNEL (2/5)

GOVERNMENT OF FEDERATIVE
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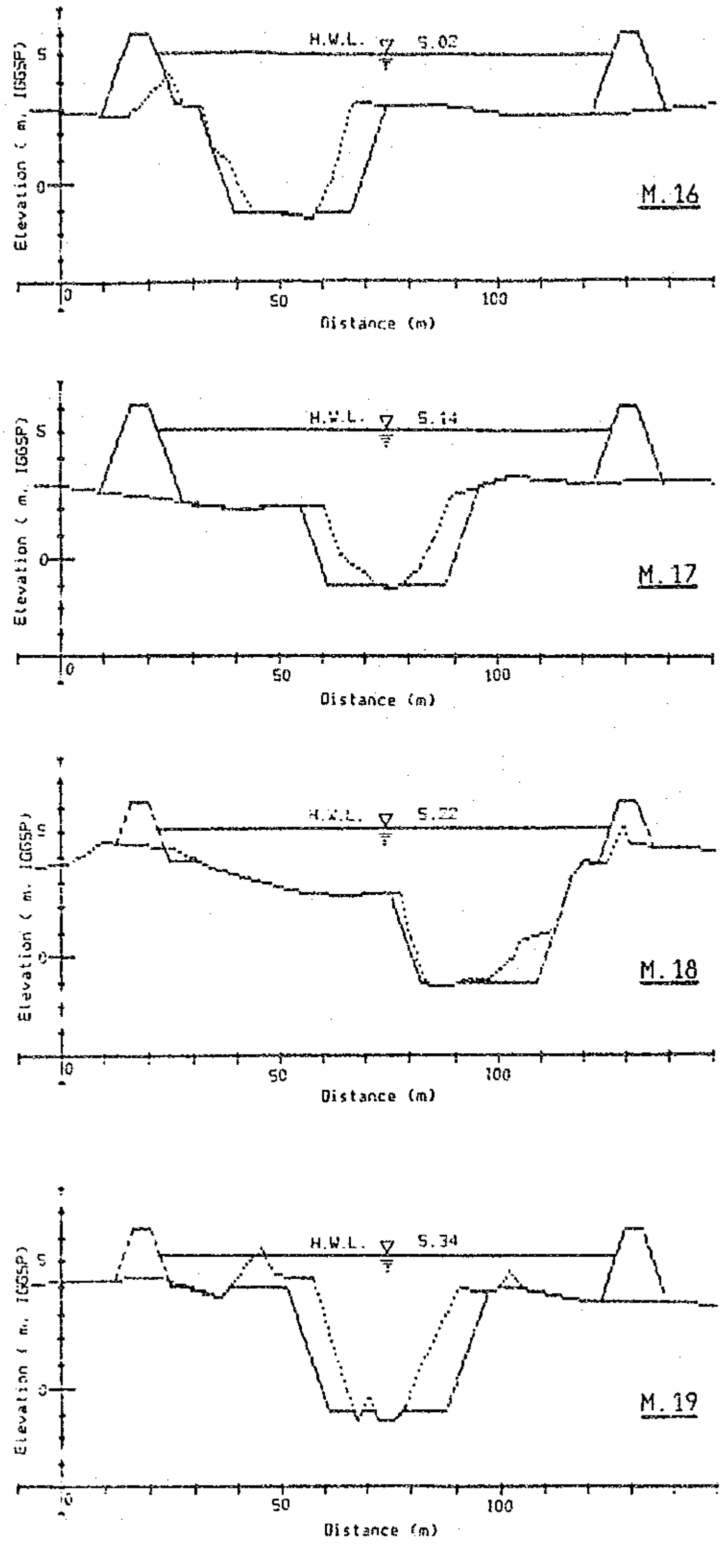

Note : Left dike upstream of M.18 dose not construct.

FIG. I.27
PROPOSED CROSS SECTIONS
OF CHANNEL (3/5)

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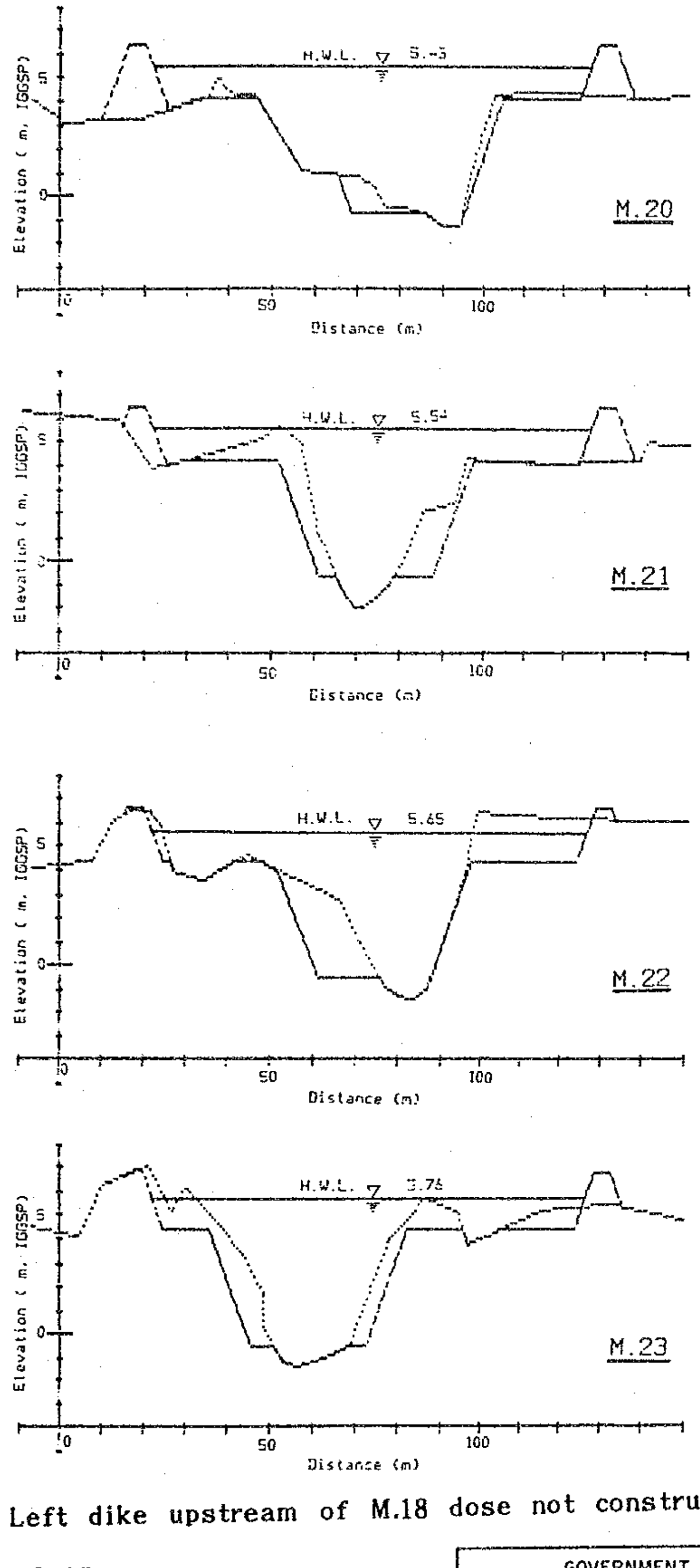
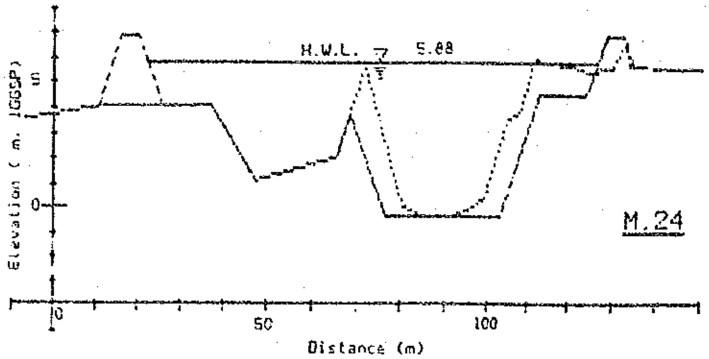
JAPAN INTERNATIONAL COOPERATION AGENCY

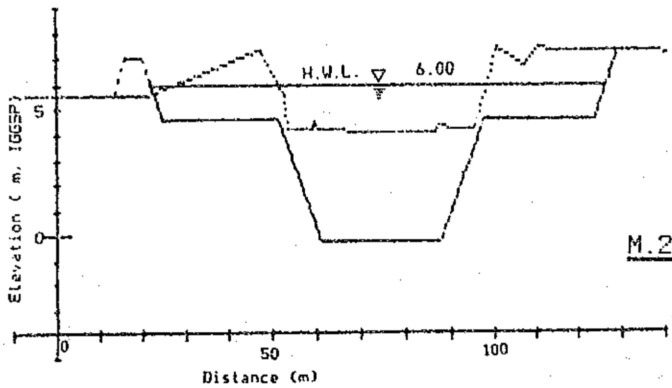


Note : Left dike upstream of M.18 dose not construct.

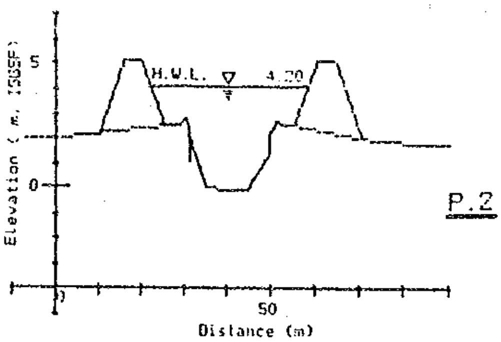
FIG. I.27
PROPOSED CROSS SECTIONS
OF CHANNEL (4/5)

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 : Left dike upstream of M.18 dose not construct.



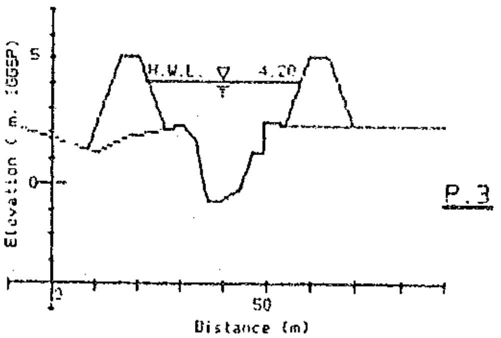


FIG. I.27
PROPOSED CROSS SECTIONS
OF CHANNEL (5/5)

GOVERNMENT OF FEDERATIVE
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DRAINAGE CULVERT (2.0m x 2.5m)

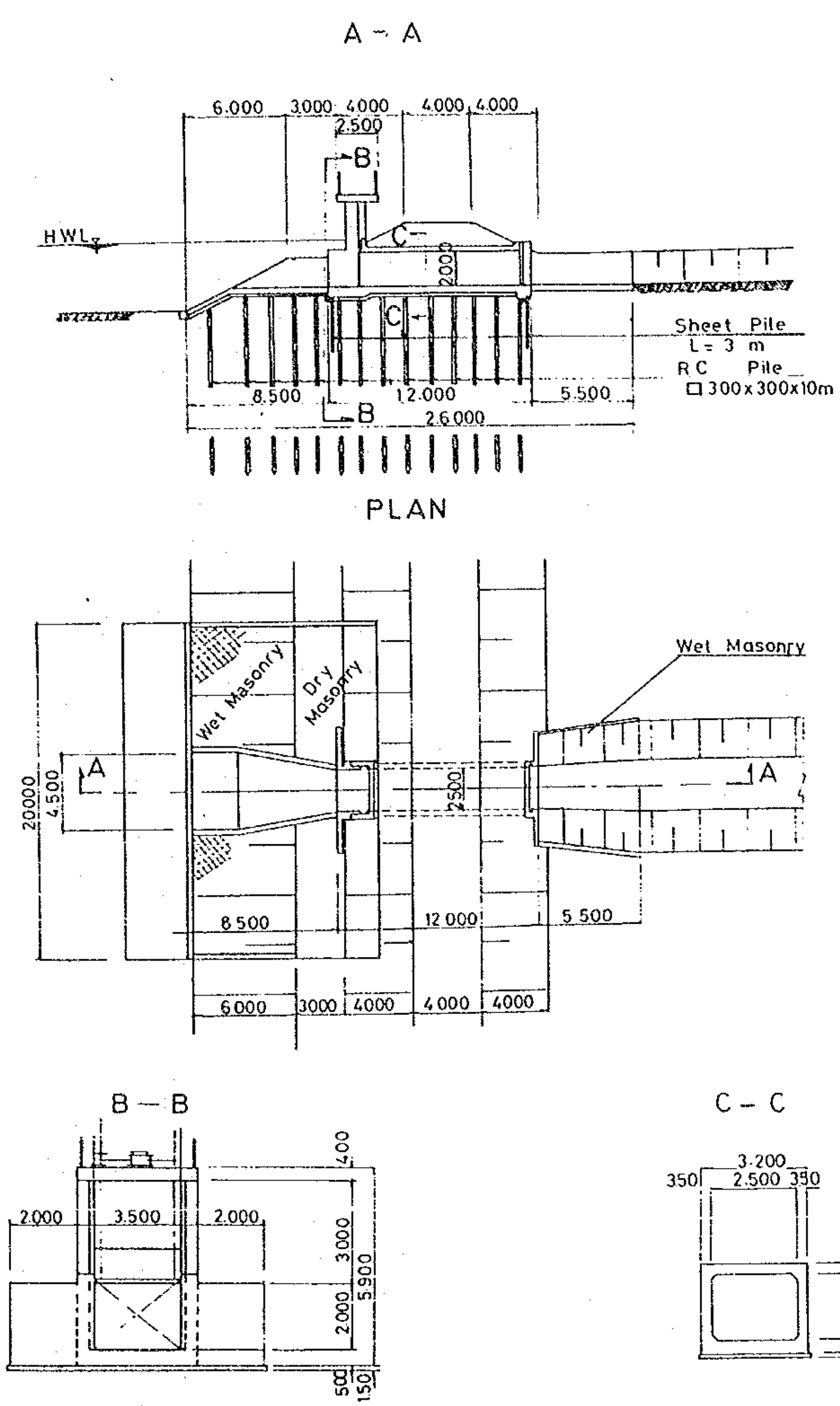

FIG. I.30 (1/2)
PROPOSED DRAINAGE CULVERT

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

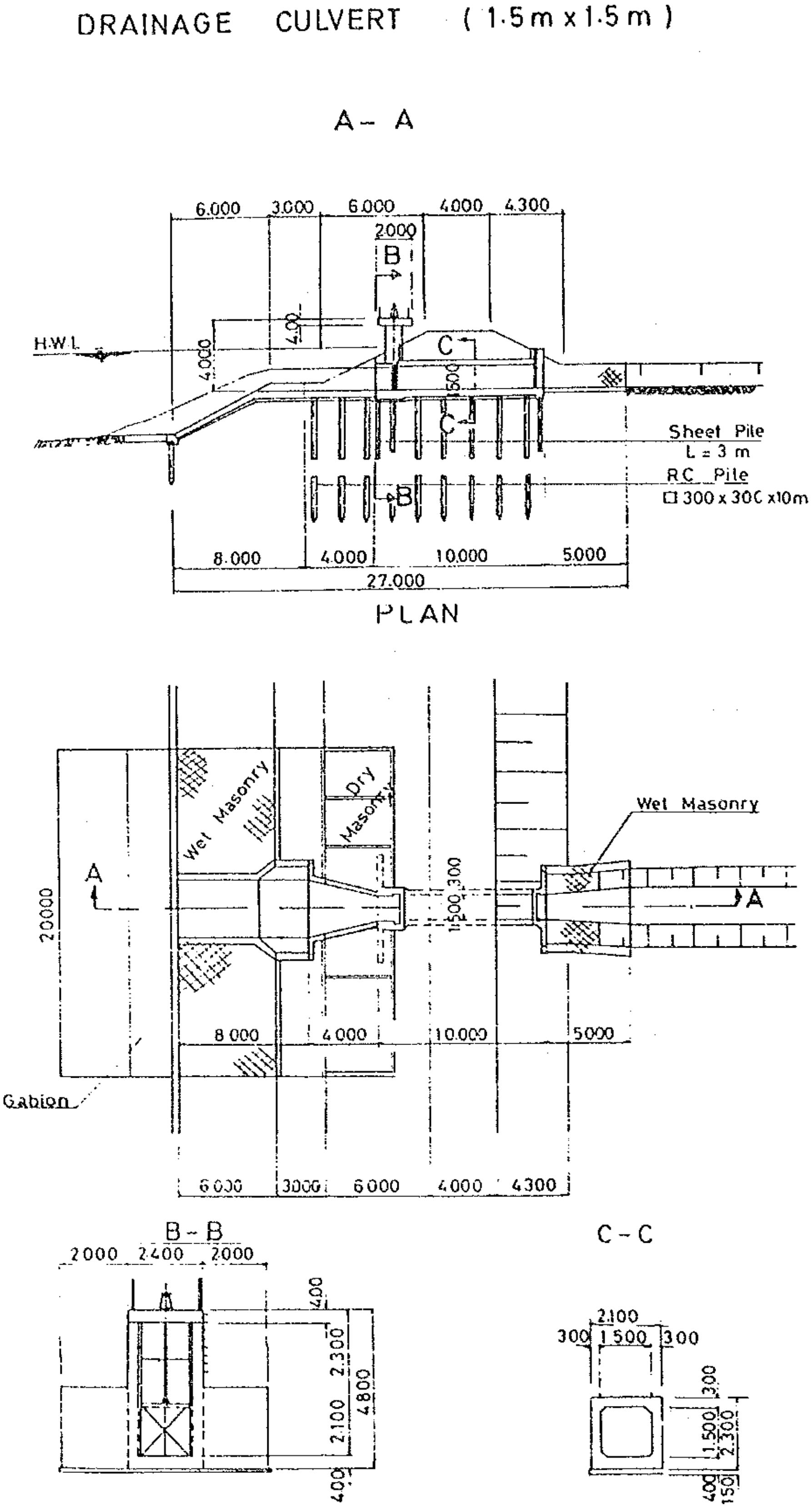

FIG. I.30 (2/2)
PROPOSED DRAINAGE CULVERT

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

ANNEX J

VEGETATION AND SOIL

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

1. INTRODUCTION

This ANNEX-J presents the survey on vegetations in the study area. The vegetation survey was carried out over four and half months in total, three months from the middle of November 1989 to the middle of February 1990, and one and half month from the middle of July 1990 to the end of August 1990.

The purpose of this survey was to understand the present conditions of the damaged forests and the process of change, and the relationship between changes in vegetation and natural disasters in order to provide the basic data required for the study on sediment and flood run-off prevention in the study area.

The analysis was made mainly by using the data provided by CETESB and IBT. In this Interim Report, the collected data and the field survey results are mentioned and those of evaluation and recommendation on vegetation will be given in the Draft Final Report.

2. CONDITIONS OF VEGETATION IN THE CUBATÃO REGION

2.1 Existing Conditions

2.1.1 Vegetation

(1) Result of the Existing Study

CETESB and IPT have been making studies of vegetation conditions in the study area to prepare a vegetation map at an interval of about five years from 1962. Later, various kinds of study related to the vegetation such as a study for selection of tolerant tree species against air pollution have been conducted by CETESB and IBt. In this study, therefore, vegetation conditions were studied mainly by using data obtained from CETESB and IBT and the results of the field survey conducted during the study period of this vegetation and soil study.

Since the study area is endowed rich rainfall and rather warm air temperature, as the tropical rain forest which is characterized by abundant species numbers. The forest structure consists of three strata:

of high tree, subhigh tree, and shrub. The study area is widely covered by coppices (Capoeira) including some subhigh trees of Tibouchina sp. The major species of the trees are as follows:

a. **High Tree Stratum**

LAURACEAE	.Cryptocarya moschata Nees et Mart. ex Nees
LEGUMINOSAE	.Pithecellobium sp
MORACEAE	.Ficus spp
MYRYSTICACEAE	.Virola gardneri A. DC.

b. **Subhigh Tree Stratum**

MELASTOMATACEAE	.Tibouchina sp
	.Miconia sp
MLIACEAE	.Cabralea sp
EUPHORBIACEAE	.Hyeronyma alchorneoides Fr. Allem

c. **Shrub Stratum**

RUBIACEAE	.Psychotria spp

The vegetation map of the study area was prepared by CETESB and IPT in 1985. The area may be generally divided into two (2) zones A and B namely the Moji, the Perequê and the lower Cubatão rivers and the upper and middle reaches of the Cubatão river. Zone A consists mainly of secondary forest and shrub with some plant forest including Eucalyptus sp While, Zone B consists of coppices which are developed after decay of the high trees. Also, some deterioration can be found widely in this area.

Occurence of trees such as Tibouchina, pulchra, Miconia, pyrifolia, Leandra mosenii can be observed at the site of slope failures. In the herbaceous stratum, the dominant ones are mainly ZINGIBERACEAE (Costus sp) and include MELASTOMATACEAE, ARACEAE, PTERIDOPHYTA. The vegetation is characterized by Tibouchina and Miconia of the MELASTOMATACEAE showing high frequency and dense coverage.

(2) Results of the Field Survey

A field survey was carried out in order to confirm the present conditions of vegetation and soils in the study area. The survey was made at the five sites as shown on Fig. J.1 in close cooperation with CETESB and IBt. The area of spot surveys was around 20m X 20m. The results are described hereunder.

The present vegetation conditions at the survey spots was formed to be follows:

a) Site No. 1 (EL 720m)

Site No.1 is located in a forest which is administrated by IBt, near Paranapiacaba. At this spot, thick dead standing and fallen trees can be observed. Three (3) dead trees with diameters of 20 to 20 cm were still standing and two (2) are fallen. The average height of living trees was about 5m.

In the subhigh tree stratum, the forest floor is covered by shrubs of ONAGRACEAE and SOLANACEAE, however, the MELASTOMATACEAE could not be observed. The ONAGRACEAE is a kind of liane shrub. It seems that the ONAGRACEAE prevails by increased light supply after the upper storey dies back. In addition, CYATHEACEAE and MELASTOMATACEAE were observed on the forest floor.

b) Site No. 2 (EL 740m)

At this spot located in reserve of Paranapiacaba, there were five (5) living trees of 10m high including one of Tapirira guianensis of the ANACARDIACEAE of 18m high.

10 trees of Tibouchina sp and Miconia sp of the MELASTOMATACEAE occupied the subhigh tree stratum. Further, coverage of Palmae was around 3m. Also, dead standing trees with diameter of 22 to 24cm can be observed.

Since the upper tree fell and the light supply had increased, Hedychium coronarium of the ZINGIBERACEAE and Calathea sp of the MARANTACEAE are prevailing on the forest floor.

c) Site No. 3 (EL 80m)

This spot is located near the industrial zone and is characterized by poor upper storey and no high trees. There are about 20 trees of Tibouchina sp and Miconia sp of the MELASTOMATACEAE and 18 trees of Palmae with heights of 1 to 3 m.

On the forest floor, there were Tetrapterys of the MALPIGHIACEAE, and Calathea of the MARANTACEAE, Trichipteris atrovirens of the GYATHEACEAE and Costus in the ZINGIHERACEAE. The old leaves, and new small leaves of a light green colour could be observed in the shrubs of the MELASTOMATACEAE.

d) Site No. 4 (EL 460m)

This spot and its surrounding areas are rather steep with gradients of 40 to 45 degrees. The survey spot area was about 5m X 5m.

In the surrounding area, some dead standing trees could be observed. It seems that such trees died 2 to 3 years ago.

There were four (4) trees with tree heights of 10 to 14m consisting of Heisteria, silvianii of the OLACACEAE, and seven (7) trees of Miconia sp of the MELASTOMATACEAE. In the leaves of the shrub tree, discoloration could be observed in places. Ferns were dominant on the forest floor.

e) Site No. 5(EL 140m)

This spot is typical of secondary forest. There are the three (3) species of the LEGUMINOSAE in the high tree stratum and eleven trees of Tibouchina sp and Miconia sp of the MELASTOMATACEAE in the subhigh tree stratum. Pteropsida and the MUSACEAE are prevalent on the forest floor, however, their dominant ration is relatively low.

2.1.2 Soil conditions

According to IBt, soil types in the study area are approximately as follows.

(a) Alic Red-Yellow Latosol

(b) Alic Red-Yellow Podzolic Soil

(c) Dystrophic Cambisol

(d) Alic Red-Yellow Latosol intergrade to Alic Red-Yellow Podzolic Soil

The above types are widely and irregulary distributed over the study area. Besides, Gleysols in hydromorphic soil are distributed in the gentle undulating land of 800 m in elevation, and lithic and immature soil, in the steep slope areas. Further, soils which are of neutral property can be observed. The highly weathered materials of granite and migmatite, which are an origin of parent materials of soil, have been changed to sand or sandyloam, and to clay or clayloam.

The pH of the soil was checked at 5 sites which were the same areas of the vegetation survey. The measurement of pH was made with the cooperation of CETESB. Based on these measurement, soil profile of survey area was prepared. Such results are given in Table J.1. From the above table, it will be seen that the pH of the soil ranges from 3 to 4.

2.2 Remote-sensing Analysis

2.2.1 Objectives

The objectives of the Remote-sensing analysis is to identify the conditions of forest degradation, spatially and annually by using the existing Remote-sensing data in the study area.

2.2.2 Methodology

(1) Remote-sensing Data

The Remote-sensing data used in this study are the following LANDSAT Data, and SPOT Data.

LANDSAT 1 MSS	1973/JUL/80	285-77	240MM COLOR POSI FILM
LANDSAT 2 MSS	1981/MAR/11	235-77	CCT
LANDSAT 2 MSS	1981/MAR/11	235-76	CCT
LANDSAT 5 MSS	1986/JUN/08	219-77	CCT
LANDSAT 5 MSS	1986/JUN/08	219-76	CCT
SPOT HRV-XS	1986/MAY/30	717-398	CCT B1 VERTICAL-ANGLE=22.0E

Note: CCT (Computer Compatible Tape)

(2) Index of Vegetation

In general, vegetation has stronger band reflection in Infrared zone than that of in Visible ray zone. Thus, an index defined by an operation ratio between infrared band and red zone band can be used as a measure of vegetation viability.

In order to avoid an error read by shadow parts of slope areas, an appropriate off-set adjustment is adopted by examining the distribution of infrared and red bands on dual-dimension hystogram of data. But, slope areas which are too dark to read the band are omitted in this analysis.

Since LANDSAT-CCT data in 1973 could not be obtained, a coloured posi-film is used to analyze in this study. Although the coloured posi-film was analyzed by a filter of colour-scanner, its accuracy was not enough compared with the output from LANDSAT-CCT data because the ratio operation adopted to this study is apt to emphasizing a noise from unclear coloured data. Therefore, the raw data of infrared band are used for evaluation of comparison analysis of the annual ratio operation outputs. But it must be noted that the raw data of infrared band could be biased by direction of slope areas.

(3) Spatial Overlay of Data

The analyzed data of each year are overlayed on a same picture for examination of annual and spatial change of the vegetation viability.

(4) Histogram Conversion of Data

The dates of collected LANDSAT data vary by each year due to the existence of clouds on the pictures. So, a histogram conversion of data is conducted in this study to ensure the accurancy of comparison analysis by setting up a common range of the ratio operation values. Thus, the annual change of vegetation viability can be followed by substruction of the overlayed data.

2.2.3 Result of the analysis

The results are shown in Fig.J.2, J.3 and J.4.

(1) Annual Change of Vegetation Viability

The following results are obtained from the Remote-sensing analysis:

. In 1973, a notable deterioration of the vegetation can be found in and around areas in the Moji Valley. The edge areas of plateau of the Moji river basin show the moderately damages of vegetation.

. In 1981, the vegetation viability in the seriously damaged areas in 1973 had been considerably recovered and there are no areas which have notably low vegetation viability.

. The Moji river basin shows rather low viability in 1981, especially in the belt area from the confluence point to the Cubatão river to about 4 km upstream areas along the Moji river. The moderately damaged areas on the plateau increased gradually compared with in 1973.

. In 1986, the relatively high vegetation viability can be observed in the plateau area and the upper most area of the Moji river basin.

. Meanwhile, in the nearby areas from the industrial complex, the vegetation viability has been relatively low, and the worst conditions can be found in 1981.

(2) Relationship between Vegetation Viability and Air Pollution.

As for the relationship between vegetation viability and air pollution, the following points can be observed by the result of this Remote-sensing study:

. In 1973, the air pollution had damaged to the vegetation in the study area. The damages were serious in the slope areas of the Moji river and slight in the plateau.

. The recovery of viability in 1981 suggests that the pollution sensitive high trees were deteriorated at first, and they were replaced by the successive trees with rather high tolerance to pollution. As a consequence, the viability of vegetation increased in 1981 in spite of the continuous high air pollution levels.

. In 1986, the high viability can be observed mainly due to the pollution implementation of control program. However, the nearby area of the industrial complex still has relatively low vegetation viability, and this infers that the air pollution is an impediment factor of vegetation viability in the study area.

3. RELATIONSHIP BETWEEN VEGETATION AND SLOPE FAILURES

3.1 Vegetation and Air Pollution

(1) Air Pollution and Vegetation Map

About 25 major factories which include more than 10 chemical firms are located in the Cubatão region. The exhausted gases such as SOx, NOx, HF and hydrocarbon from these factories are dispersed by the prevailing wind along the Moji river and the Perequê river, and those gases have affected the forest especially high tree stratum. Thus the forest in this region has changed from dense forest to shrub and/or grass.

Causes which brought about forest damages in the study area are generally defined by the concerned agencies such as CETESB. According to the existing reports, the conceitable damaging process of forests in the region is as follows:

- Prevailing wind in the region blows the direction from S or W to N or NE, just along the Moji river.
- Diffusion of emission gases is limited mainly due to the topographical conditions.
- Accumulation effect of emission gases in the air can be considered especially during the fine or fair days with gentle wind.

- Thus, the Moji river basin becomes a corridor of high concentrated emission gases.
- A mist often appears in the region and it causes wash-out effects of the aerosol with very low pH.
- Therefore, the forest deterioration results in a complex effect of those conditions.

CETESB has prepared a vegetation map to show the deteriorated condition of the forests in the region by using an index of stratification of trees. The community types of vegetation in the study area is classified as shown below, based on the CETESB criteria.

Community Type	Definition	Symbol
1.Forest	: hight more than 20m, diameter more than 30cm, high density of high trees	M
2.Forest-slightly degradated	: hight between 10-20 m	M-Fr
3.Forest-moderately degradated	: hight between 10-20 m	M-Me
4.Forest-strongly degradated	: hight between 10-20m	M-Fo
5.Coppice-old	: hight less than 20m, diameter more than 20 cm	Cp-A
6.Coppice-new	: hight less than 20m, diameter between 10-20 cm	Cp-N
7.Coppice-slightly degradated	: hight less than 20m, diameter between 5-10 cm	Cp-Fr
8.Coppice-strongly degradated	: hight less than 20m, diameter less than 5cm	Cp-Fo

Source: CETESB

Based on a set of vegetation maps prepared by CETESB, changes of vegetation have been studied as shown on Fig. J.5. According to the above figure, vegetation conditions have been remarkably degraded since last half of 1970's mainly due to the air pollution. The relationship of air pollution and the vegetation changes, assessed by CETESB is shown in the following table;

Degree of Degradation	Community Type
Not affected	M, Cp
Moderately affected	M-Fr,Cp-A,Cp-N
Affected	M-Me,M-Fo,Cp-Fr
Strongly affected	Cp-Fo,Cp-N-Re

(2) Damages to the Vegetation

A pilot forest (about 300ha) managed by IBT is situated in the area of gentle undulation with about 800m above sea level near Paranapiacaba. Many dead standing trees especially high trees can be found in this forest though no visible damages can be observed on MELASTOMATACEAE and herbs. This infers that there may be a time lag of pollution damages by the location of the pilot forest and the escarpment of the Moji river.

On the other hand, in the nearby areas of Ultrafertil, a name of the fertilizer factory, various types of visible damage such as necrosis and chlosis on leaves, multiform trees of the MELASTOMATACEAE and falling of immature seeds could be observed. Palmae with necrosis and chlosis on leaves, herbs with patches, and weakened Cecropia species could be also found in the same area.

In the areas around REFINARIA, the MELASTOMATACEAE with necrosis on leaves and young trees with chlorosis could be observed by the field survey. Leaves of those damaged trees were not fallen out, so these are considered the incidents which might be occurred in the recent months.

According to the study report prepared by the Special Commission in 1985, it was identified that the following tree species had disappeard from the pilot forest;

LAURACEAE	. Cryptocarya moschata Nees et Mart. ex Nees
	. Persea sp
	. Nectandra sp
	. Ocotea sp
MYRTACEAE	. Eugenia sp
	. Psidium sp

A tree species, Miconia sp of the MELASTOMATACEAE, which has rather high tolerance against air pollution, was also damaged. The reason of this incident is considered that double impacts, insect damage and pollution damage, have occurred on the tree species. One species of LEGUMINOSAE, which is a tolerant tree, was also disappered especially in the highly polluted area. Therefore, to control of air pollution is still urgent matter for forest restoration in the region.

3.2 Vegetation and Slope Failures

The Moji river records the highest number of slope failures since 1962 in the study area. Slope failures have occurred both in forest and shrub areas by torrential rainfall. Therefore, no clear relation between a forest coverage and a slope failure can be found in the region.

Taking into the existing information related to the vegetation and slope failure, the following characteristics can be pointed out on the relation of vegetation and slope failure;

. Roots of damaged trees are rotted out gradually,
. Soils which ties fast around roots loosen by rotting,
. Thus, water can easily penetrate into the soil, and the saturated conditions of soil easily causes slope failures.

A restoration process in slope failure sites succeeds quickly in the study area. A site which is covered by residual weathering layer is usually regenerated by Pteropsida or shrubs until 2 or 3 years after the occurrence of slope failure due to fairly good climate conditions for vegetation. The existing vegetation maps and aerophotographs prove this restoration process.

3.3 Case Study of Forest Restoration in Japan

3.3.1 Asio copper mine forest restoration project

(1) Historical Background

Asio copper mine had been operated from the end of 1600's to 1973. A vast forest area around the mine was lost during its operation period, about 400 years, by the emission gases from the copper refinery plant. Continuous soil erosion and slope failure around the refinery site had caused notorious floods and serious damages to the local people living in the downstream areas.

Though the replanting activities had been carried out in several times from 1880, these were not workable without effective emission control. In 1957, a comprehensive forest restoration program was prepared to deal with serious deterioration of the national lands about 7,600ha. It includes sabo dams in the main channel, various channel works in the tributaries, hillside works in terracing slopes for prevention of debris flow, and replanting works for regreening besides the emission gas treatment.

(2) Replanting Works in Ashio

To achieve the objectives of the Ashio Forest Restoration Project, the following technical methods have applied;

i) Preparation of plant plates, plant bags and plant sandbags,
   - prepare a set of seed, fertilizer and manure, and mix them,
   - prepare a wooden case (30cm X 20 cm X 6 cm) for plant plate, a cotton bag (30cm x 20cm x 5cm) for plant bag a sandbag (25 cm x 30cm) for plant bag,
   - put a mixed set into the each case/bag, then press it,
   - bery a plate/bag along contour line and drive in a pile to fix a plate/bag,

ii) Aeroplanting by helicopter,

- spray soil conditioners, fertilizers, and wet seeds,
- spray asphalt latexes to fix the sprayed seeds,

iii) Replanting of trees,

- replant trees by the following steps;
  - . 1st year: to be a stable condition of slope by sheathing and hillside works,
  - . 2nd year: to conduct land preparation works,
  - . 3rd year: to plant young trees,

- no. of planting trees is 5,000-7,000 per ha, and about 40-50% of trees must be replanted in the next year.

(3) Result of the Project

Almost 84% of the total area was covered by grasses in 14 years later, and trees, which were planted in areas with good site conditions, grew up to 10m in hight and 15cm in diameter during 30 years. However, larger part of the project area is still under fixing stage of grasses. So, it may take much longer time to restore forest completely.

3.3.2 Kosaka copper mine forest restoration project

The operation of the copper refinary facilities in Kosaka had degradated forests around the factory about 50 km^2 mainly due to harmful gases such as SOx. The forest restoration activities were started in 1979. The result of the project is likely to be successful because of the fairly good conditions of soil. But still now, there are lot of difficulties to restore forests in the seriously damaged areas because of low pH (less than 4) of soil.

4. FOREST RESTORATION PLAN FOR THE CUBATÃO REGION

4.1 Replanting Trees

In the Cubatão region, a lot of high tree stratum have been damaged mainly due to serious air pollution. Even some LEGUMINOSAE, more tolerant to an pollution, has been suffered by the pollution. Thus, it is considered that the replanted young trees may be damaged more or less for the time being. Therefore, the MELASTOMATACEAE such as Tibouchina sp and Miconia sp are recommendable as the introducing trees in the restoration areas because these are commonly found in the Cubatão region and also these have high tolerance to air pollution. Needless to say, the vegetation restoration activities should be conducted with the further pollution control activities.

As for the kinds of replanting trees, Cecropia sp which often appears in the first stage of plant succession of bare lands in the tropical rain forests, is not suitable because it is likely to have low tolerance to air pollution. Salix sp is used as a garden tree in the factories in the region. Therefore, it may be worth to test whether Salix sp is useful as a replanting tree because of its swelling tendency.

According to the study reports by IBt, slope failure sites are usually covered with Pteropsida (samambaia) dominantly in two or three years after the occurrence of slope failure. IF recommended that Ricinus communis is suitable as a replanting shrub because of its root swelling and high prolificacy.

In general, planted forests are apt to be damaged by vermin and tree diseases. For example, in the tropical rain forests, a proliferation of Hypsipyla (a kind of moth) sometimes causes serious damage on replanting trees. So, the adoption of various kind of trees for the tests of reforestation, seeding afforestation, land preparation and tending methods to deal with expected issues mentioned above.

4.2 Aeroplantation

In the Cubatão region, the following characteristics about forest restoration can be pointed out;

i) Region is in areas with high air temperature and much precipitation.
ii) Herbs are dominant in areas with low densed forests.
iii) Serious damages to vegetation by air pollution can be found.
iv) Region has poor accessibility.

In the Cubatão region, aeroplantation activities of seeds by using a helicopter have been conducted by CETESB to restore forests as shown in Fig. J.6. Coating processed seeds of tree species such as Tibouchina which are formed around shape, are used for aeroplantation from 1988 to 1990. However, the following constraints can be pointed out through the viewpoint of the natural conditions in the region;

a) A site which newly experienced a slope failure usually has steep slope with hard and tight soil conditions. So, a fixation of round coating seeds to the steep slope is likely to be difficult in the region.

b) Due to the high temperature and humidity, a proliferation of grasses is rapid so that regeneration of seeding trees must be under tight competition among flora species. Thus these conditions control budding and growing processes of the seeded trees.

In 1989, a monitoring survey was conducted by CETESB in 21 test points in order to evaluate the results of aeroplantation. The results are shown in Table J.2 and J.3, and summarized as follows;

- Areas with dense vegetation (grass, shrubs or ferns) could not obtain good results in compared with the others mainly due to the tight competition between seedlings and herbs or shrubs.

- Areas which are bare lands or covered by coppices could get relatively good results.

- The average number of fixed seedlings in the 21 tests points is over 1 per m^2, and their growth are about 2 - 20 cm per month during the period from sixth to ninth month. This is the almost same results of seedling replantation areas in general.

Therefore, it is considered that the aeroplantation of seeds is rather effective as a measure for restoration of vegetation in the Cubatao region.

4.3 Outline of the Forest Restoration in the Cubatão Region

4.3.1 General

The Cubatão region can be classified to the following three areas through the viewpoint of forest restoration and slope failure prevention.

(1) Slope Failure Sites ---------	Denuded areas after slope failures
(2) Areas in Danger of Slope ---- Failures	Slopes with more than 30 degrees of slope
(3) Other Areas -----------------	Slopes with less than 30 degrees of slope

Since those areas have different needs for disaster prevention, for example the major objective of zone (1) is prevention of soil erosion and slope failures, zone (2) is prevention of land devastation, and zone (3) is watershed conservation, the proper approach to the forest restoration must be applied for each area.

(1) Slope Failure Sites

The following characteristics can be found in slope failure sites of the Cubatão region;

- Slope failure sites are mainly located in the upper most area of tributaries,
- Access to slope failure sites is very difficult because of no roads and foot paths,
- Slope failure sites are likely to be hard for fixing of seed and for conducting nursery stock due to steep slopes,
- Slope failure sites are usually covered by herbs within 2 or 3 years after the occurrence of slope failures.

A goal of replanting in slope failure sites is a restoration of root swelling tree species. In the middle and lower range of each slope, seedings are available for replantation. But the upper range is to be a natural regeneration because of the difficulties of accessibility. Since the detailed techniques and methods for restoration depend on the conditions of each slope failure site, such as soil properties, it is not practical to specify standardized works and methods for each slope failure site at present.

(2)Areas in Danger of Slope Failures

High potential slope failure areas are with steep slopes which are sparsely covered by shrubs and coppices. Therefore, a goal of restoration plan for those areas is to replant root swelling trees for prevention of slope failure rather than prevention of sheet erosion.

The concerned agencies such as CETESB with cooperation of IPT, IBt and IF have conducted the air spray of coating seeds on the potential slope failure areas.

(3) Other Areas

"Other Areas" are to be restored for the watershed conservation of the Cubatão river and its tributaries taking into account the pollution issues. At present, it is recommendable to plant MELASTOMATACEAE species as well as in the areas of zone (2) "Areas in Danger of Slope Failures".

4.3.2 Outline of the forest restoration plan for the Cubatão region

CETESB in cooperation with IBt, has prepared a forest restoration plan for the Cubatão region, and its outline is shown in Fig. J.7. Since the forest restoration in the region must be based on and be conducted with the implementation of the pollution control plan, the outline is delineated with the relation of the pollution control.

The measures for forest restoration in the outline is broadly divided into two (2) stages, namely the first stage and the second stage. The measures in the first stage are urgent because the target of this stage is to restore coppices as quickly as possible in the areas both slope failure sites and seriously deteriorated vegetation (shrubs and herbs). The measures in second stage is to be started after the achievement of the target which is set up in the first stage. Since this stage includes the planting of seedlings and the cultivation of tree species, a considerable improvement of the pollution to the vegetation should be achieved by the time of implementation of those measures.

Since the outline is considered very reasonable through the viewpoint of the natural characteritics in the region, it should be further promoted for the forest restoration. The effectiveness of the forest restoration in the Cubatão region depends on the condition of pollution. Therefore, a monitoring of damages to the vegetation by pollution is indispensable for the effective implementation of the restoration activities.

MELASTOMATACEAE could be an index of pollution damages to the vegetation. If any visible damages would be found on MELASTOMATACEAE, it proves that the present condition is not suitable to replant seedlings of high tree species. So, it is recommendable to implement the high tree cultivation when no visible pollution damages can be seen on MELASTOMATACEAE. Thus, the following damages should be monitored;

- abnormally few leaves on a tree,
- brown-coloured spots on a leaf, fading of leaf margin, and spots on leaf brade,
- withering of a big branch with discoloration,
- liane type tree crown of a branch,
- dropping out of immature seeds,
- less viability of young trees.

5. FORMULATION OF MASTER PLAN

5.1 Basic Considerations

(1) Present conditions

The present forest restoration plan, identified as long-term plan, can be divided into two (2) stages as shown in Fig. J.7.

First stage comprises planting and aeroseeding of the pioneer species over the degradated area aiming at creating capoeiras that protect from soil erosion and slope failures. Second stage is replantation of the climax species in the capoeira areas in order to accelerate the regeneration process of the Atlantic forest.

According to the monitoring survey conducted by CETESB on February 1990, it is concluded that the planting and the aeroseeding at the first stage brought effective results and will warrant the creation of capoeira formation in the next five (5) to eight (8) years.

Therefore, the first stage is judged to have been established satisfactorily.

The second stage can be identified and initiated as the master plan project simultaneously to the implementation of the sediment run-off and flood disaster prevention plan.

(2) Replantation area

Replantation areas of twenty (20) woods located at strategic points with a catchment area of 40m x 100m, 0.4 ha, respectively, were selected by CETESB and IBt as shown in Fig. J.8.

5.2 Forest restoration plan

The forest restoration plan with a target year of 2000 consists of selection of climax species, seedlings production, service road restoration, topographic works, planting works, maintenance works and support works as shown in Fig. J.9. One thousand trees will be planted in each wood area after selection of climax species by conventional technics.

5.3 Project Cost

The project cost of the master plan in accordance with the forest restoration plan was estimated approximately at US$ 2,000 thousand covering 10-year period up to the target year 2000. Direct cost for implementing project components was estimated to amount to US$ 1,661 thousand, including management and monitoring works.

The project cost is tabulated below.

(Unit : US$ 1,000)

Item	Project Cost
(1) Direct Cost	
. Service road	175
. Topographic works	70
. Seeding production	96
. Planting works	80
. Maintenance works	20
. Management works	1,100
. Monitoring by aerophotos	120
Sub-total	1,661
(2) Contingency (20%)	339
Total	2,000

6. SELECTION OF PRIORITY PROJECT

Forest restoration works to be done by 1995 were selected in accordance with the implementation program of the master plan. The work items are as follows:

- Selection of climax species
- Seedling production
- Service road restoration
- Topographic works
- Planting works

- Maintenance works
- Support works

6.1 Work Items

The detailed work items of the priority project to 1995 are summarized as follows:

- Selection of climax species

  The late secondary and climax tree-species for the replantation will be selected among the species groups of the primitive Atlantic forest in the south Brazil listed in Table J.4. The final selection will be made on the basis of evaluation results on the pollutant level of 1991/92 foreseen in the pollution control

- Seedling production

  Twenty-four thousand (24,000) seedlings of the selected species will be produced and distributed in the replantation areas. Of them, 1,000 seedlings will be used for each area, 20,000 in total, 4,000 for eventual loss.

  Official green house of the State of São Paulo will be responsible for seedling production.

- Service road restoration

  Service road restoration including roadbed regularization and small drainage works is planned for smooth transportation to the replantation area. The total length of service road to be restored is 35km as shown Fig. J.8.

- Topographic works

  Topographic works such as topographic mapping will be conducted in order to demarcate the replantation areas.

- Planting works

  The seedlings with their hight of 0.4 to 1m will be planted regularly taking into account fertilization related to the soil conditions.

- Maintenance works

  Maintenance works such as disease and curse control, and substitution of the dead seedlings will be planned during one year just after completion of planting works.

- Support works

  This works are the project management and the replantation activities monitoring.

6.2 Quantities of the works

The quantities of the forest restoration works in the priority project is summarized below:

Item	Quantity
Selection of climax species	-
Seedling production	24,000 units
Service roads restoration	35km
Topographic works	80,000 m^2
Planting works	20,000 units
Maintenance works	20,000 units
Support works	-

6.3 Project costs

The project cost for the priority project was estimated approximately at US$ 1,325 thousand on the basis of the restoration plan in the mater plan; direct cost of US$1,101 thousand and contingency of US$ 224 thousand. Of the direct cost, US$ 501 thousand would be earmarked to the core activities of the forest restoration plan, whereas US$ 600 thousand was estimated for management works including monitoring in field.

The project cost for the priority project is summarized below.

(Unit : US$ 1,000)

Item	Project Cost
(1) Direct Cost	
. Service road	175
. Topographic works	70
. Seeding production	96
. Planting works	80
. Maintenance works	20
. Management works	600
. Monitoring by aerophotos	60
Sub-total	1,101
(2) Contingency (20%)	224
Total	1,325

6.4 Project justification

The priority project of the forest restoration project would be justified from the grounds below.

(1) From the aeroseeding experiments in the fields which would be satisfactory results, the "capieiras" species was proved to promote to prevent erosion reduction of sediment run-off. This positive phenomenon would be considered more effective and efficient in the middle and long term.

(2) The forest restoration plan would be appreciated as one of the most effective means complementary to the aeroseeding project conducted by CETESB. These integrated activities would lead to recover the natural forest of the Serra do Mar.

(3) Consequently, this project would be concluded to be complementary and compatible to the sediment run-off and flood disaster prevention works, ultimately aiming at preserving the native Atlantic forest in the region.

LIST OF REFERENCES AND DATA COLLECTED

No.	TITLE	ISSUED ON	ISSUED BY
J01	SURVEY OF VEGETAL SPECIES THAT OFFER TOLERANCE TO ATMOSPHERIC POLLUTION OF INDUSTRIAL REGION OF CUBATÃO	1988	CETESB
J02	ACTION OF THE CETESB IN CUBATÃO	1989	CETESB
J03	PHYTOSOCIOLOGICAL ASPECTS OF VEGETATION DAMAGED BY ATMOSPHERIC POLLUTION OF CUBATÃO - SP	1989	CETESB
J04	EVALUATION OF THE DEGRADATION IN THE SERRA DO MAR - CUBATÃO - SP	1986	CETESB
J05	15th NATIONAL BOTANIC CONGRESS, CUIABA CITY, STATE OF MATO GROSSO	1989	IBt
J06	AGRARIOAN PEDOLOGY AND FERTILITY OF THE SOIL	1988	IBt
J07	BOTANIC RESUMUS - VOLUME I	1989	IBt
J08	BOTANIC RESUMUS - VOLUME II	1989	IBt
J09	MODEL OF RESTORATION IN SERRA DO MAR	1990	CETESB
J10	MONITORING DATA FOR AERIAL SOWING AT 21 CONTROL POINTS IN THE SERRA DO MAR	1990	CETESB
J11	RESUMU OF DATA MONITORING FOR AERIAL SOWING IN THE FIRST STAGE, SERRA DO MAR IN CUBATÃO	1990	CETESB
J12	AERIAL SOWING OF THE SERRA DO MAR IN CUBATÃO	1989	CETESB
J13	RECOVERY OF THE VEGETATION COVER OF THE SERRA DO MAR ATMOSPHERICALLY POLLUTED BY THE CUBATÃO INDUSTRIAL ESTABLISHMENTS	1989	CETESB
J14	MASS MOVEMENT RISK ZONING-PRIORITY AREAS OF THE VEGETATION OF SERRA DO MAR SLOPE AT THE CUBATÃO AREA, SÃO PAULO STATE, BRAZIL		

TABLES

TABLE J.1 pH OF SOIL IN SURVEY AREA

Survey Site	Horizon	pH(H2O)
1	A	4.10
	B	4.88
	A	3.87
2	A-B	3.96
	B	4.11
	A1	3.69
3	A2	3.78
	C	3.97
	A	3.62
4	A-B	3.53
	C	3.98
	A	3.89
5	B1	4.11
	B2	4.64

Source : CETESB, 1989

TABLE J.2 RESULTS OF AEROPLANTATION

Test Point	Elevation(m)	Slope	Type of Vegetation	Number of Seedling(m^2)
1. CAMINHO DO MAR	140	>100%	Bare Land	2.1
2. CAMINHO DO MAR	140	10-30%	Bare Land	4.8
3. CAMINHO DO MAR	300	>100%	Bare Land	0.5
4. CAMINHO DO MAR	300	>100%	Bare Land	0.8
5. CAMINHO DO MAR	300	>100%	Bare Land	0.6
6. CAMINHO DO MAR	300	>100%	Bare Land	0.7
7. CAMINHO DO MAR	300	>100%	Bare Land	0.8
8. CAMINHO DO MAR	300	>100%	Bare Land	0.5
9. CAMINHO DO MAR	300	>100%	Bare Land	0.7
10. PEREQUE	780	<10%	Coppices	1.8
11. ULTRAFERTIL	100	<10%	Grass Land	1.1
12. ULTRAFERTIL	100	<10%	Grass Land	1.5
13. ULTRAFERTIL	80	30-100%	Coppices	2.0
14. ULTRAFERTIL	80	30-100%	Coppices	0.9
15. ULTRAFERTIL	50	>100%	Shrubs (Tetrapterys)	0.0
16. ULTRAFERTIL	50	>100%	Ferns	0.2
17. ULTRAFERTIL	50	>100%	Dense Grass Land	0.0
18. ULTAFERTIL	140	>100%	Ferns	0.4
19. ULTRAFERTIL	140	>100%	Dense Grass Land	0.6
20. ULTRAFERTIL	140	>100%	Grass Land	1.5
21. ULTRAFERTIL	140	>100%	Bare Land	1.7
AVERAGE	-	-	-	1.1

Source: CETESB, 1990

TABLE J.3 GROWTH CONDITIONS IN SLOPE FAILURE SITES

Area	Species	Height (cm)	
		6 months	9 months
Middle part of slope	Tibouchina	6	20
	Miconia	7	20
	Leandra	5	10
Lower part of slope	Cecropia	25	85
	Miconia	10	60
	Tibouchina	5	43
	Leandra	5	23

Source : CETESB, 1990

TABLE J.4 LATE SECONDARY AND CLIMAX SPECIES FOR THE REPLANTATION

SPECIE	FAMILY
Alchornea triplinervia	EUPHORBIACEAE
Aspidosperma olivaceum	APOCYNACEAE
Cabralea canjerana	MELIACEAE
Cariniana estrellensis	LECYTHIDACEAE
Chrysophyllum flexuosum	SAPOTACEAE
Chrysophyllum viride	SAPOTACEAE
Cordia ecalyculata	BORAGINACEAE
Coussarea nodosa	RUBIACEAE
Cryptocarya moschata	LAURACEAE
Cupania oblongifolia	SAPINDACEAE
Didymopanax calvum	ARALIACEAE
Drymis brasiliensis	WINTERACEAE
Eriotheca pentaphylla	BOMBACACEAE
Eugenia brasiliensis	MYRTACEAE
Eugenia cerasifolia	MYRTACEAE
Eugenia involucrata	MYRTACEAE
Eugenia myrtifolia	MYRTACEAE
Eugenia pyriformis	MYRTACEAE
Euplassa cantareirae	PROTEACEAE
Euterpe edulis	PALMAE
Guatteria australis	ANNONACEAE
Guatteria dusenii	ANNONACEAE
Guatteria polycarpa	ANNONACEAE
Hieronyma alchorneoides	EUPHORBIACEAE
Hyrtella hebeclada	CHRYSOBALANACEAE
Ilex paraguariensis	AQUIFOLIACEAE
Ilex theezans	AQUIFOLIACEAE
Inga sessilis	LEG.-MIMOSOIDEAE
Licania kunthiana	CHRYSOBALANACEAE
Lonchocarpus denudatus	LEG.-FABOIDEAE
Manilkara subsericea	SAPOTACEAE
Matayba guianensis	SAPINDACEAE
Matayba junglandifolia	SAPINDACEAE
Maytenus evonymoides	CELASTRACEAE
Micropholis cuneata	SAPOTACEAE
Nectandra puberula	LAURACEAE
Nectandra rigida	LAURACEAE
Ocotea aciphylla	LAURACEAE
Ocotea catharinensis	LAURACEAE
Ocotea elegans	LAURACEAE
Ocotea odorifera	LAURACEAE
Ocotea paranapiacabensis	LAURACEAE
Ocotea paulensis	LAURACEAE
Ocotea porosa	LAURACEAE
Ocotea pulchella	LAURACEAE
Ocotea teleiandra	LAURACEAE
Paivaea langsdorfii	MYRTACEAE
Pera glabrata	EUPHORBIACEAE
Persea alba	LAURACEAE
Podocarpus sellowii	PODOCARPACEAE
Posoqueria acutifolia	RUBIACEAE
Pouteria torta	SAPOTACEAE
Prunus sellowii	ROSACEAE
Pseudobombax grandiflorum	BOMBACACEAE
Roupala brasiliensis	PROTEACEAE
Schizolobium parahyba	LEG.-CAESALPINOIDEAE
Sclerolobium denudatum	LEG.-CAESALPINOIDEAE
Siparuna brasiliensis	MONIMIACEAE
Sloanea guianense	ELAEOCARPACEAE
Sloanea monosperma	ELAEOCARPACEAE
Swartzia langsdorfii	LEG.-FABOIDEAE
Syagrus pseudococus	PALMAE
Tabebuia alba	BIGNONIACEAE
Tabebuia heptaphylla	BIGNONIACEAE
Tapirira guianensis	ANACARDIACEAE
Virola gardneri	MYRISTICACEAE
Virola oleifera	MYRISTICACEAE
Vochysia magnifica	VOCHYSIACEAE
Vochysia selloii	VOCHYSIACEAE
Xylopia brasiliensis	ANNONACEAE

FIGURES

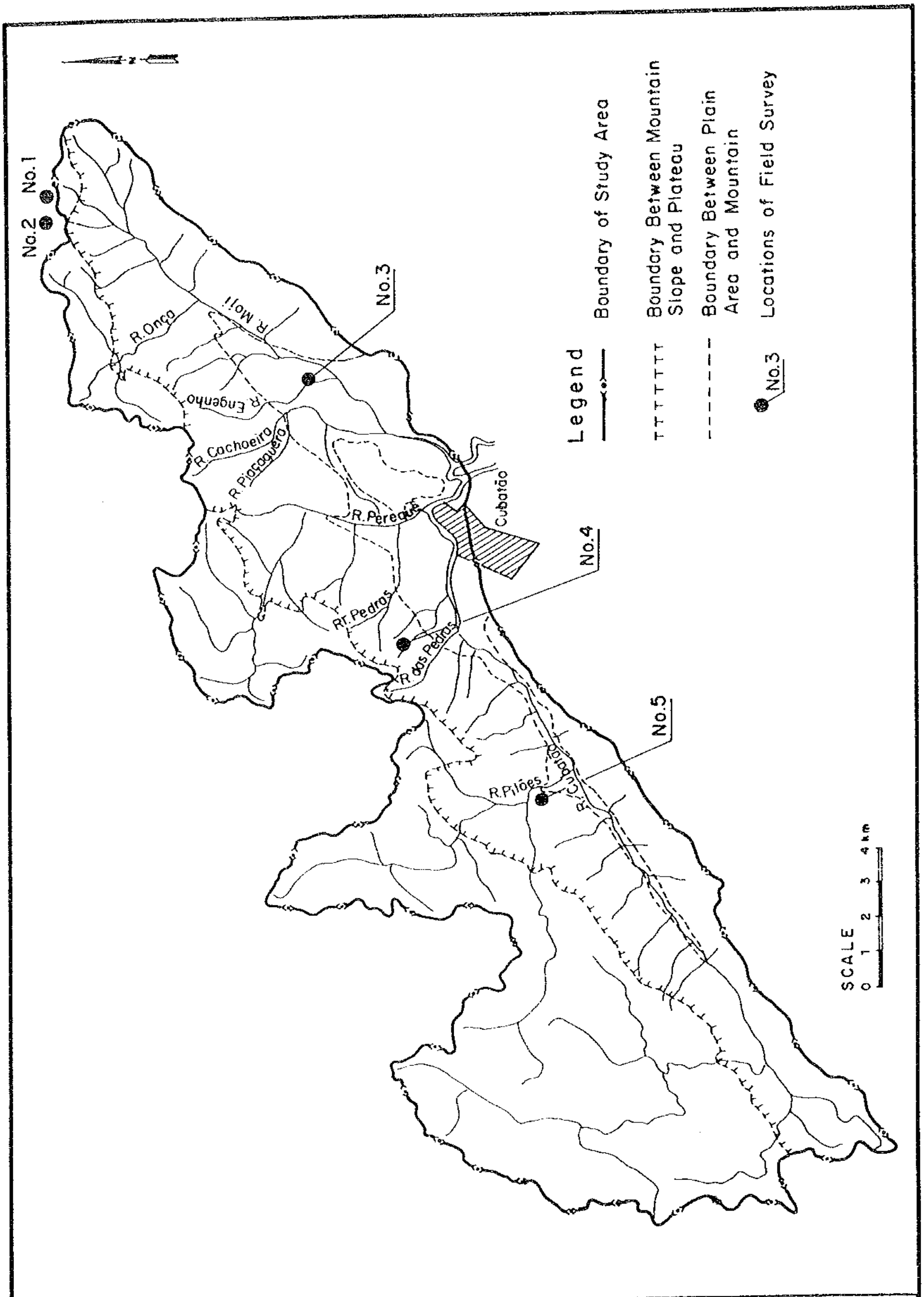

FIG J.1
LOCATION MAP OF FIELD SURVEY

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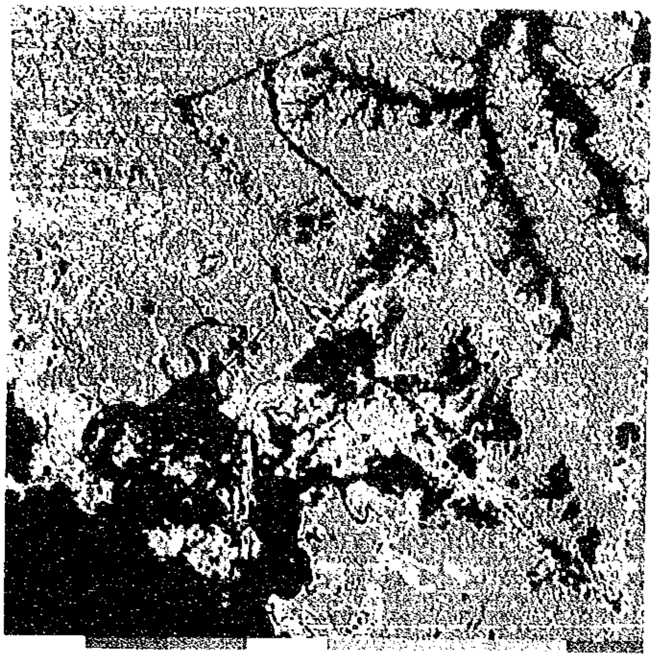
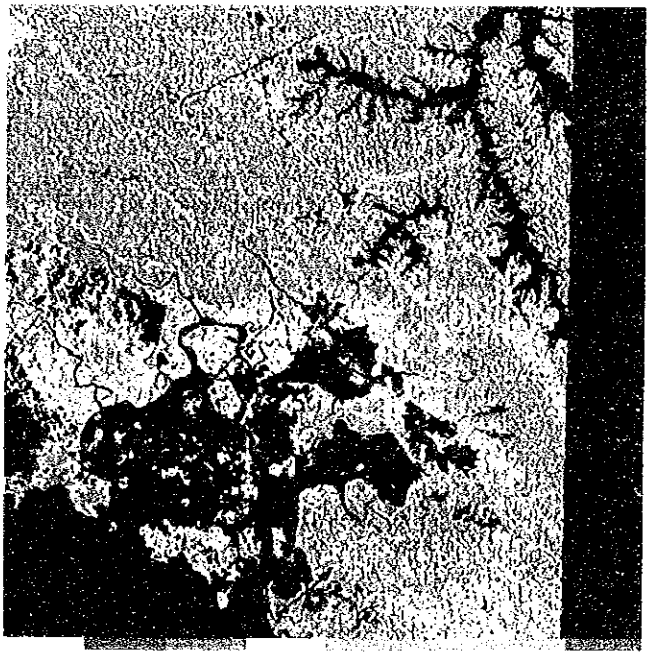


1973/JUL/30 MSS
Vegetation-Index(IR/R)
in Vegetation Covered Area
PSEUD COLOR

FIG J.2
LANDSAT IMAGE COLOUR(1973)



1981/NOV/03 MSS
Vegetation-Index(IR/R)
in Vegetation Covered Area
PSEUD COLOR

FIG J.3
LANDSAT IMAGE COLOUR(1981)

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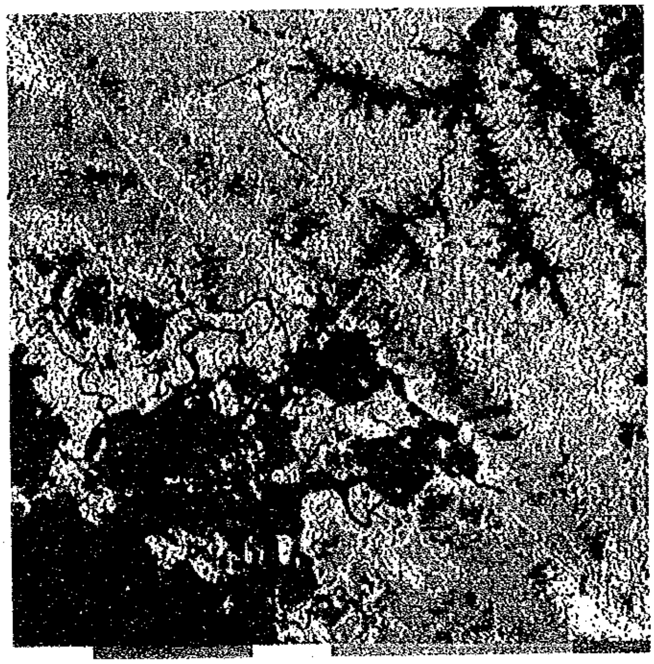

1986/JUN/08 MSS
Vegetation-Index(IR/R)
in Vegetation Covered Area
PSEUD COLOR

FIG J.4
LANDSAT IMAGE COLOUR(1986)

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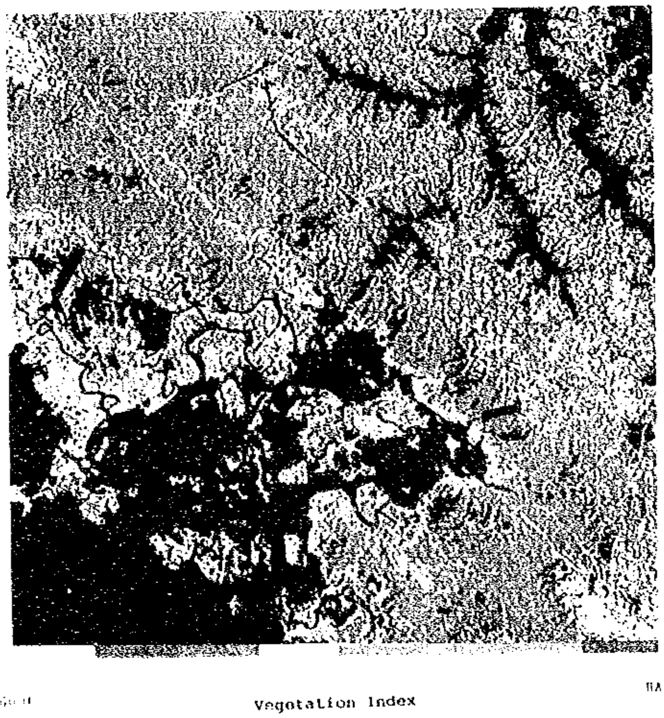

1986/JUN/08 MSS
Vegetation-Index(IR/R)
in Vegetation Covered Area
PSEUD COLOR

FIG J.4
LANDSAT IMAGE COLOUR(1986)

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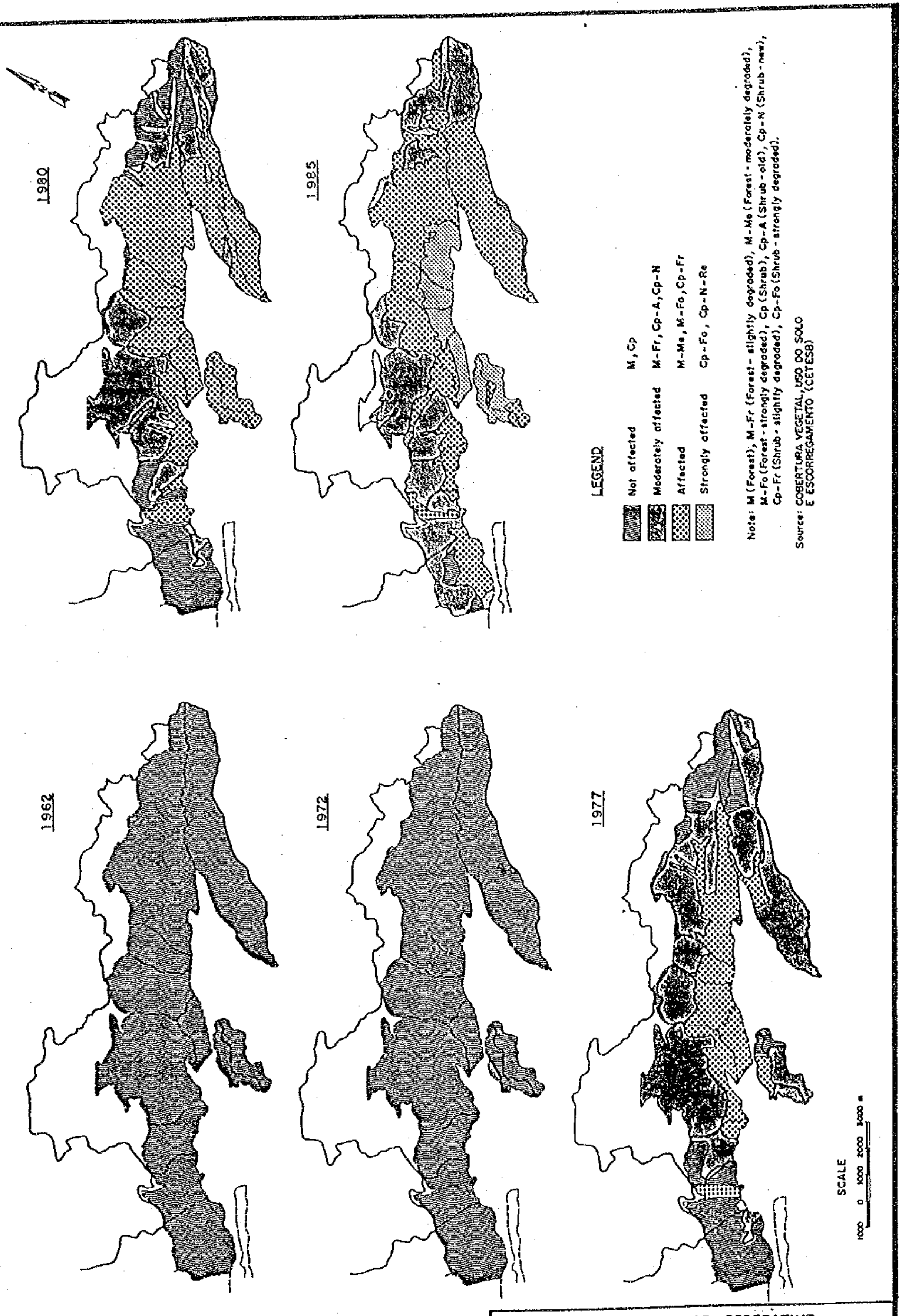

FIG J.5
MAP OF VEGETATION CHANGE BY AIR POLLUTION IN 1962-1985

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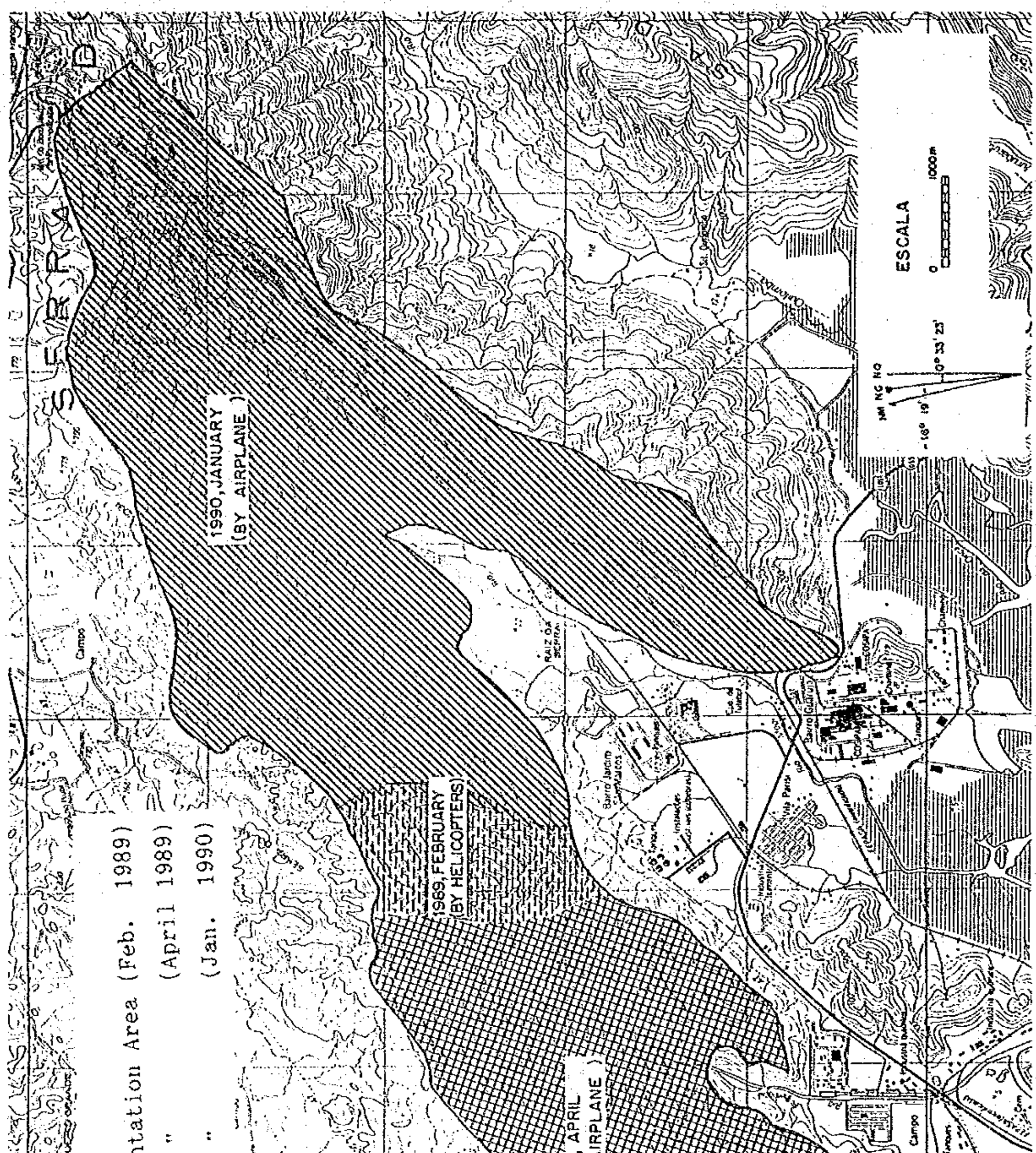

FIG. J. 6

LOCATION MAP OF AEROPLANTATION ACTIVITIES

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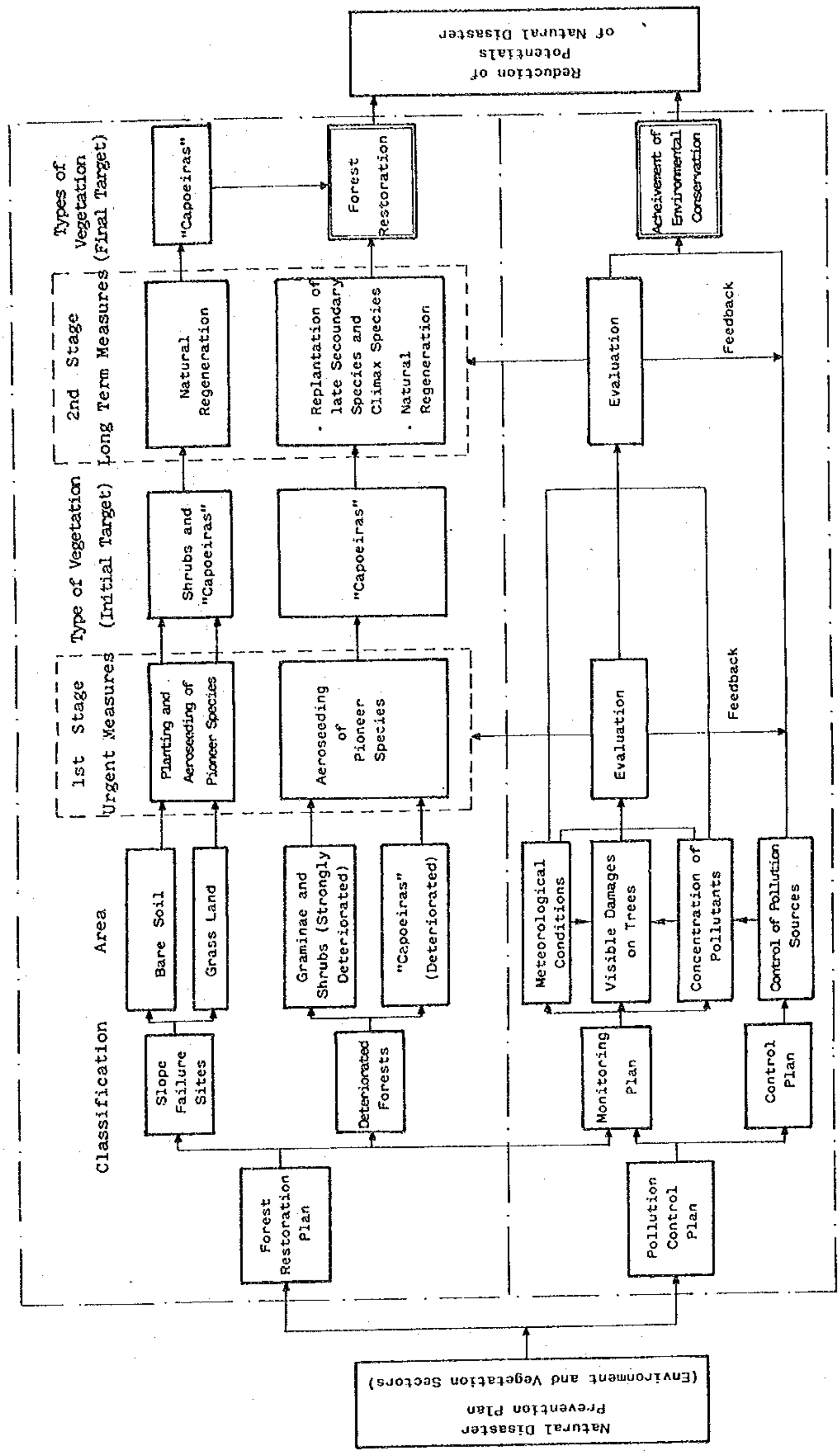

FIG.J.7
OUTLINE OF FOREST RESTORATION PLAN FOR CUBATÃO REGION

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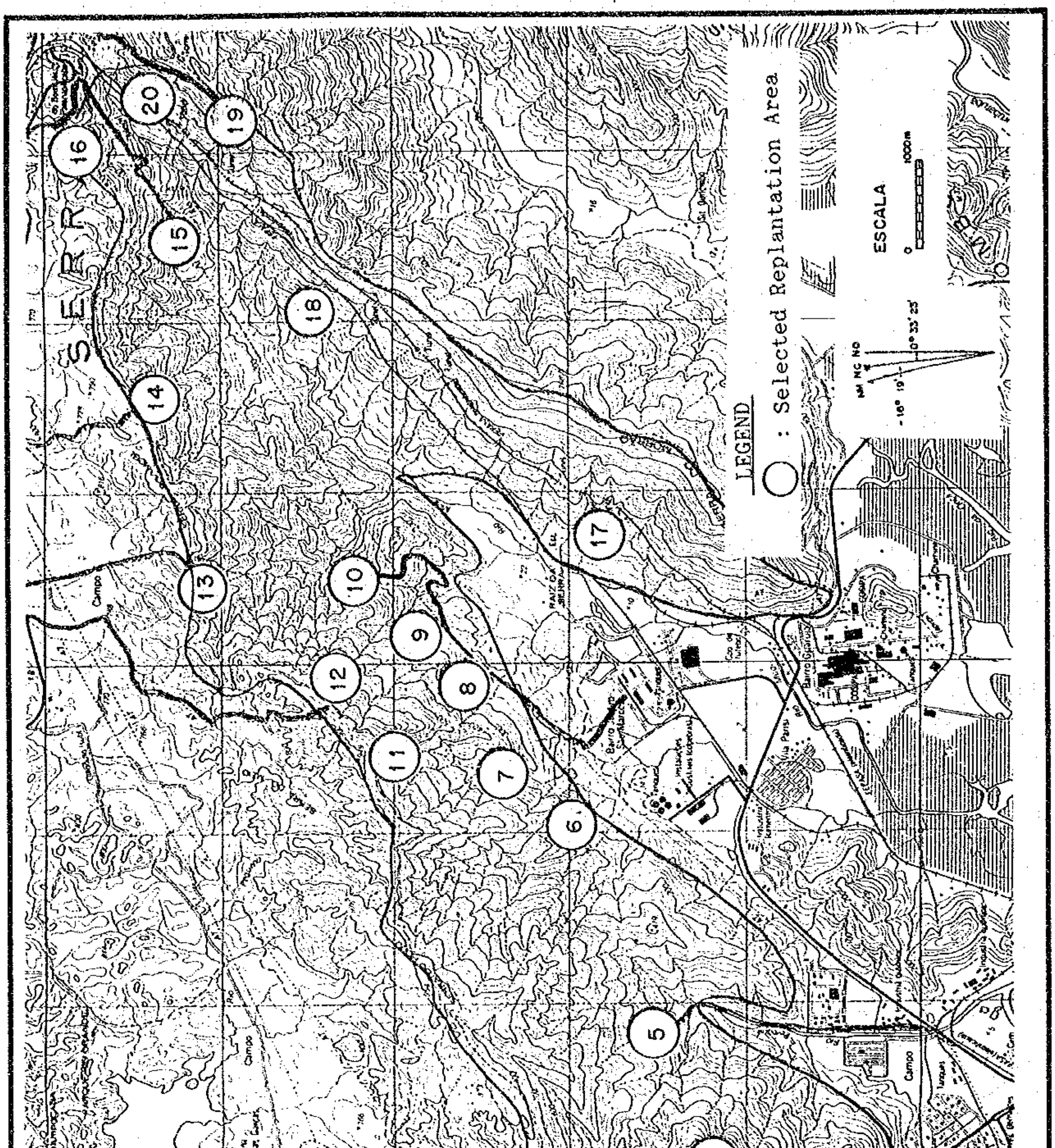

FIG.J.8

SELECTED REPLANTATION AREAS

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JAPAN INTERNATIONAL COOPERATION AGENCY

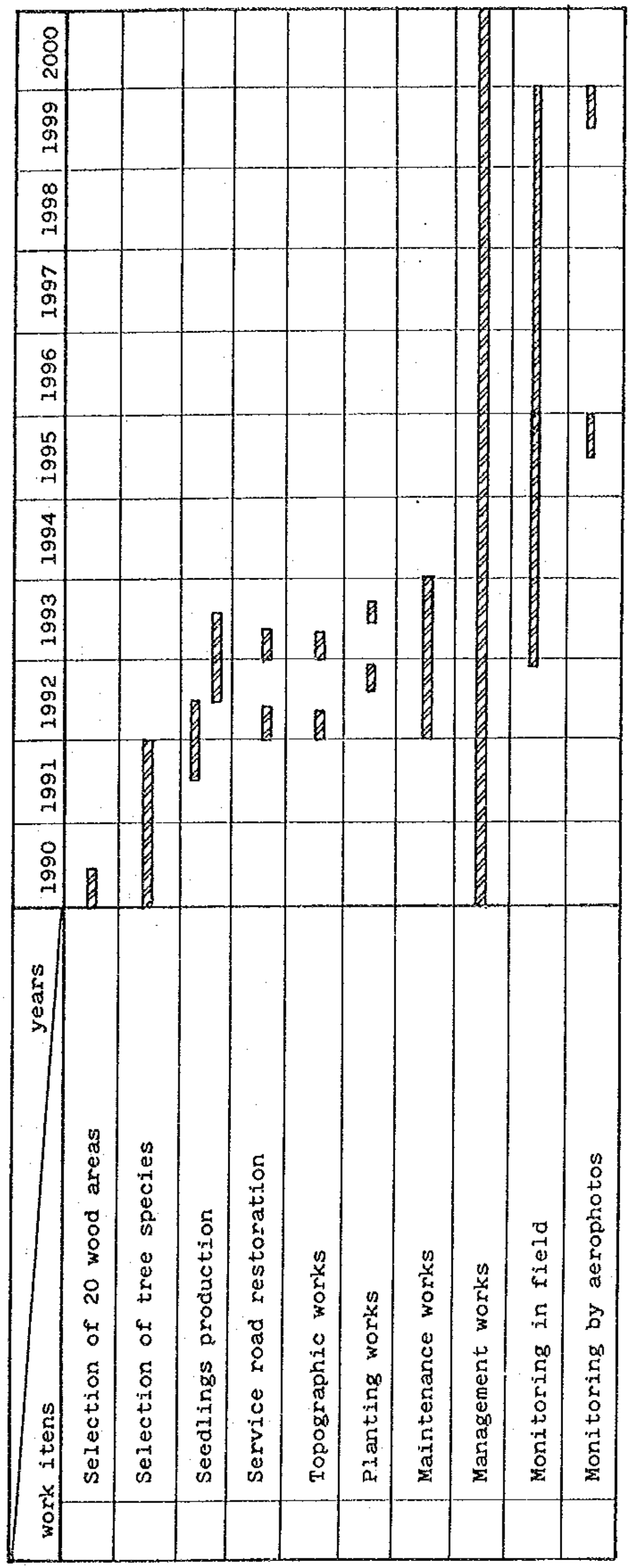

FIG.J.9

IMPLEMETATION PROGRAM

OF THE 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

ANNEX K

ENVIRONMENT

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1. INTRODUCTION

The objectives of the Environmental Study are as follows;

1) To review the conditions of air pollution for recognizing the deterioration level of vegetation,
2) To prepare an air pollution intensity map for selecting priority planning areas for forest restoration,
3) To identify impacts which could be caused to the environment by the selected priority projects,
4) To evaluate the magnitude/significance of the impacts and to recommend countermeasures,

2. AIR QUALITY CONDITIONS IN THE STUDY AREA

2.1 Climatic Characteristics

(1) Wind

The wind data, which are observed at two fixed CETESB stations in the study area located respectively close to the industrial complex (Vila Parisi) and to the urban area (Centro), revealed the possible presence of a daily cycle in the regime of the winds associated mainly with the land (nightly) and sea (diurnal) breezes, and with the following characteristics;

- Yearly predominance of winds in the North Quadrant, coming from the North and Northwest directions, with a higher frequency during the night period, between 700 and 2,000 hours annualy, and slow speeds.

- Yearly predominance of wind in the South and West Quadrants, coming from the South-Southwest and West-Southwest with a higher frequency in the diurnal period, between 800 and 1,900 hours annualy and moderate speeds, causing a concentration of pollutants in the hillsides of Serra do Mar.

- The wind regime shows similarity of directions at the two stations (Vila Parisi and Centro), and differencies in terms of speeds and relative calm frequency. For instance, the relative calm frequency is twice as high at Centro than it is in Vila Parisi, namely Centro has 37% against 18% in Vila Parisi in the winter (April-September), and Residential Cubatão has 28% and Vila Parisi 14% in the summer (October-March).

Fig. K.1 and K.2 show the predominant wind directions during the daytime and the night in and around the study area.

(2) Atmospheric thermal profile

The conditions of the atmospheric thermal profile such as vertical movements of temperature and thermal inversion are fundamental factors in the dispersion of atmospheric pollutants. Although there are no data for the study area, a few characteristics can be inferred by taking as reference the profile of São Paulo. The notable characteristics are as follows;

- The convective vertical movements evaluated through the temperature profile, could be caused by the presence of the equatorial mass, more frequently during the summer months. It may initiate conditions of thermal instability which are favorable for dispersion of pollutants.

- The sub-tropical and polar masses, caused by anti-cyclones, which characterize a thermal profile with a relative instability, generate different types of thermal inversions. In Cubatão, there may be inversion in layers above 2,000 m, and these may be of the same high frequency as in São Paulo.

- As to thermal inversions of the radiation type, Cubatão area may have higher frequency and duration than São Paulo. The winter season in which the minimum duration of solar radiation is recorded, has as the result prolonged thermal inversions almost daily. Consequently, problems of atmospheric pollution, are aggravated in the area which the radiation is even more reduced due to the influence of topographycal conditions.

- In Cubatão, the influence of the topography on the duration of the thermal inversions of the radiation type is much higher due in part to the steepness of the slopes of Serra do Mar, but mainly to the geographical disposition of this relief, roughly perpendicular to the sense of trajectory of the sun. In this situation, the thermal-dynamic stability, presents highly favorable conditions for the sharp concentration of the atmospheric problems.

(3) Precipitation and Humidity

The greatest quantity of pluviometric precipitation in the study area occurs during summer months (October-March) representing 70% of the annual average, which varies between 2,000 and 3,000 mm from one area to another. This rain is provoked usually by the equatorial mass, and is favorable to reduction of pollution because of deposition of the material in suspension and a relative reduction in the concentration of gasses, namely washout and rain out effects.

The atmosphere of the study area shows as a predominant characteristic, a high average relative humidity throughout the year, which varies between 70 and 90 %. From the point of view of atmospheric pollution, this high rate of air humidity is unfavorable due to the chemical reaction which changes in certain gaseous pollutants such as sulfur oxide and nitrogen oxide, into acidity substances which cause damage to aquatic fauna and terrestrial flora.

2.2 Air Quality in the Cubatão Region

2.2.1 Results of Air Quality Control

The study area has a remarkable agglomeration of air pollution sources represented by the industrial complex of Cubatão. These conditions , associated with the extremely high quantity of pollutants launched daily into the atmosphere, caused critical conditions in the quality of the air in the Cubatão region.

The air pollution control to the major pollution sources in the region which was started in 1984, covered 205 out of 230 factories and attained the remarkable results as shown hereunder.

	Pollution Load			
	Initial Emission	Remainings	Reduction	
Pollutant	July 84 (Kg/day)	Dec. 89 (Kg/day)	(Kg/day)	(%)
SPM (Dust)	316,350	77,949	238,401	75
Fluorides	2,620	200	2,420	92
NH_3	8,736	205	8,531	97
NOx	61,085	47,561	13,524	22
HC	90,000	11,970	78,030	86
SO_2	78,353	49,527	28,826	37
Total	557,144	187,412	369,732	66

Source: THE ACTION OF CETESB IN CUBATÃO, 1990, CETESB

The total pollution load has been reduced by 66% of the initial emission load in 1984, and the remaining emission load to be reduced is expected about 187 tons per day in 1989.

In order to understand the annual periodical changes of the air pollution in the Cubatão region, the annual data of industrial products are shown in Fig. K.3 with data of SO_2 and SO_3 concentration. The concentration of SO_3 had increased with the growth of the industrial products from 1971 to 1979. But in 1980's, the concentration of SO_2 has rapidly decreased mainly due to the introduction of the pollution control programs in the region. Therefore, it can be said that the most critical conditions of pollution could be found during the end of 1970's and the beginning of 1980's, and now the region escaped from such as serious conditions of air pollution.

These results were attained by taking the practical, effective and urgent countermeasures to the pollution sources. Thus, the number of incidents related to air pollution have also declined, and no incidents of alert or emergency levels are recorded in 1989.

2.2.2 Monitoring Stations and Air Quality Standard

At present, there are three fixed monitoring stations in the study area, namely Cubatão-Vila Nova (Vila Nova), Cubatão-Centro (Centro) and Cubatão-Vila Parisi (Vila Parisi), and their location are shown in Fig. K.5. Air quality standards and evaluation criteria have been established by the Government of Brazil and São Paulo State. These are shown in Table K.1 and K.2.

2.2.3 Air Quality Conditions

Table K.3 shows the air quality conditions during the last 5 years in the 3 monitoring stations. The main problem in Cubatão, especially at Vila Parisi, is the extremely high concentration of Suspended Particulate Matter (SPM), which can be usually found from May to September; in 1983, the level reached 1,000 ug/m3 (24 hours). The level of SO_2 has declined gradually, and it shows rather low concentration at present. Concentrations of ozone reach the attention level of the criteria shown in Table K.2, certainly due to the industrial emission.

In 1988, the air quality conditions in Vila Nova and Centro are acceptable, but Vila Parisi still shows relatively high SPM, of which the maximum concentrations do not comply with the national environmental standard. This is mainly due to the location of major pollution sources and unfavorable meteorological conditions which may cause the incidence of high concentrations of SPM.

3. AIR POLLUTION AND VEGETATION DAMAGE

3.1 Gases hazardous to the Vegetation

The gases such as i) Sulfurous oxide (SOx), ii) Fluoride ,iii) Ozone, iv) Ammonia and v) Nitrogen oxide (NOx) are considered as the major pollutants to the vegetation taking into account the types of factories located in the Cubatão industrial complex.

To examine the conditions of those gases, a specific survey was conducted by CETESB in 1985 in the Moji river basin. The result is shown in Table K.4. Based on this results, the possibility of damages to the vegetation by each pollutant is summarized hereunder by using the criteria of dose-effect relationship between pollutant and vegetation.

i) Sulfurous oxides (SOx)

Damages by the sulfurous gas to the vegetation have been widely recognized in the world and have been studied from the beginning of the 19th century. The effect on vegetation by hazardous gases normally depends on dose (concentration) and exposure period. Fig. K.4 is a dose-effect relationship between SO_2 and vegetation prepared by the U.S. Agency of Public Service in 1967, and it shows that the condition of the SO_2 concentration 0.5 ppm (= 1,429 ug/m^3) and exposure period 8 hours, the 0.2 ppm (= 571 ug/m^3) and 4 days, the 0.1 ppm (= 286 ug/m^3) and 1 month, and the 0.03 ppm (= 85 ug/m^3) and 1 year are the threshold values to vegetation damage.

According to the result shown in Table K.4, the maximum value of 3 hours mean SO_2 concentration was 754 ug/m^3, and its value was recorded at Encosta. However, this concentration is far below of the threshold value, about 1,500 ug/m^3, shown in Fig. K.4. The maximum daily mean value, 58 ug/m^3, which was obtained at Encosta; too, is also less than the threshold value. Thus, it is considered that SO_2 does not affect the vegetation seriously, at present, taking into account the recent improvement of SO_2 concentration in the study area as shown in Table K.3.

ii) Fluoride

Fluoride has high toxicity to vegetation at low concentration. Fig. K.4 is the dose-effect relation of hydrogen fluoride (HF) and types of vegetation.

In the Moji river basin, the very high concentration of fluoride gas, (10.30 ug/m^3), was observed at Terreno da Bayer in 1985. This is the value which causes a damage to fruit trees with the exposure period only several hours. Moreover, the daily mean value at Terreno da Bayer and Encosta are about 3.4 to 4.6 ug/m^3 and these are values which affect coniferous trees with one day exposure period. Therefore, fluoride is considered as the most significant hazardous gas in the study area.

iii) Ozone (O_3)

Ozone is a photochemical oxident which causes damage to vegetation especially in urban or industrial areas. The maximum daily mean data of ozone observed in 1985 do not exceed the threshold value as shown in Table K.4. However, the maximum hourly values are about 300 ug/m^3 , which cause folia damages by 5 hours exposure period, at Orfano, Vila Nova and Centro.

Therefore, ozone is also considered as an important hazardous gases to the vegetation in the study area.

iv) Nitrogen Oxide and Ammonia

The threshold values of nitrogen oxide and ammonia are usually over 1,000 ug/m^3. The concentration of nitrogen oxide and ammonia in the study area in 1985 are far below the threshold values mentioned above. Therefore, these two gases are not considered hazardous gases which cause serious effects on the vegetation in the study area.

However, the recent study reports have revealed that other pollutants such as the high concentration of Suspended Particulate Matter (SPM) which contains high level of sulfuric and nitric acid ion and the process of photochemical oxidants could be suspicious causes attributing to the of vegetation damage. Thus, the more detailed study and analysis has been just started in 1990 by the Brazilian concerned agencies such as SMA, IBt and CETESB, in cooperation with the research staff from West Germany in order to specify the main toxic pollutants and their process which have caused degradation of vegetation in the study area. This study would contribute to elaborate the existing activities for vegetation restoration.

3.2 Distribution of Pollution Intensity Level

3.2.1 Concentration of SOx and Fluoride

A spatial distribution of air pollutants is to be one of basic information for recognition of relations between air pollution and degradation of vegetation. Fig. K.5 and Fig. K.6 show a spatial distribution of polluted areas by SOx and fluoride by 1 km^2 mesh four relative degrees of pollution intensity.

3.2.2 Spatial Distribution of Pollution Intensity Level

The spatial distribution of pollution intensity level of major air pollution is prepared by the overlay method of the spatial distribution maps of SOx and fluoride.

The relative intensity levels are classified as follows:

. Most polluted area : a mesh classed the highly polluted area by both SOx and fluoride,

. Highly polluted area: a mesh classed the highly polluted area by SOx or fluoride,

. Polluted area : a mesh classed the polluted area by SOx and/or fluoride,

. Moderately polluted area: a mesh classed the moderately polluted area by SOx and/or fluoride,

. Other area : a mesh classed neither the highly polluted, the polluted and the moderately polluted area.

The result is shown in Fig. K.7, and the total number of each relative pollution intensity level of each classification is counted hereunder;

No. of mesh of each pollution intensity level

Classification	No.of mesh	%
1. Most Polluted Area	10	3.2
2. Highly Polluted Area	43	13.7
3. Polluted Area	63	20.0
4. Moderately Polluted Area	47	14.9
5. Other Area	152	48.2
TOTAL	315	100.0

Source: JICA STUDY TEAM

3.3 Air Pollution and Degradation of Vegetation

In general, there are no established ways to make clear the cause-effect relationship between air pollution and degradation of vegetation. So, a comparison method with the area of pollution intensity level and the area of degradation level of vegetation has to be devised for this study.

The periodical change of the vegetation in the study area has been studied in 1962, 1972, 1977 and 1985. The conditions of affected vegetation of each study period is presented in Fig. J.6, Annex J. By using those data, the periodic change of affected vegetation by each air pollution intensity area is shown in Table K.6 and Fig. K.8, and the following characteristics can be observed from the results:

- The number of mesh classed as "Not Affected Vegetation" had been diminished since 1972, and almost all "Not Affected Vegetation" was disappeared in 1985. Moreover, the "Strongly Affected Vegetation" can be firstly found in 1985 among the three pollution intensity levels, which are "Most Polluted", "Highly Polluted" and "Polluted". Therefore, this shows that the degradation of vegetation was continued at least until 1985, especially in the Moji river basin.

- The "Not Affected Vegetation" quickly decreased from 1972 to 1977 in the "Most Polluted Area" and "Highly Polluted Area". But in the "Polluted Area" and "Moderately Polluted Area", the decline of "Not Affected Vegetation" is notably found since 1980. Thus, this suggests that clear relationship between air pollution intensity and vegetation damage in the study area.

Consequently, the implementation of the intensive pollution control program explicitly contributes to set up the circumstances for the restoration of vegetation in the study area.

3.4 Consideration

By the implementation of the pollution control, the significant results have been achieved, and the region retrives the fairly good environmental conditions. Thus, the various activities of the pollution have no doubt contributed to escape the critical conditions of pollution and to set up the conditions for forest restoration.

However, several gases such as fluorides are still now under serious conditions for the vegetation. Visible damages to the vegetation by the suspecious substances mentioned above are found in the region, even on the trees which have rather high tolerance to the pollution. These facts suggest that further and continuous pollution control would be needed to provide satisfactory conditions for the forest restoration in the region.

The pollution intensity level map prepared in this study shows the priority areas for both pollution control and forest restoration. These areas should be included in the priority areas in the Master Plan, and various urgent measures should be planned to prevent the natural disasters in this Project.

The forest restoration is to be one of the goals for prevention of natural disaster in the region. Therefore, the integrated forest restoration plan should be urgently established for the region. At that time, it must be emphasized that the success of the integrated forest restoration plan for the region greatly depends on the progress of the pollution control. Thus, the interdisciplinary studies such as monitoring systems and evaluation systems among pollution, forest restoration and slope failures should be promoted to establish the more comprehensive and effective forest restoration plan for the Cubatão region.

4. ENVIRONMENTAL IMPACT ASSESSMENT

4.1 Selected Priority Projects

Priority projects for the target year to the mid-1990s were selected from projects in the Master Plan. The locations of the priority projects are shown in Fig. K.10.

Nine(9) Sabo dams, six(6) channel works in seven(7) subbasins including groundsills were selected as the priority projects for sediment run-off disaster prevention.

For the flood disaster prevention, channel improvement and flood dike construction of the Moji river including lower reaches of the tributaries, the Picaguera river and the Indio river were selected as the priority projects. The lower reaches of the Moji river are to be shifted to the north along the RFFSA railway line, and the middle and upper reaches are to be improved by channel works and construction of dikes including a reconstruction of the Ultrafertil intake weir. The middle reach of the Piacaguera river is to be improved by excavation, and the Indio river is also to be improved by deepening the existing channels.

4.2 Environmental Impact Assessment

4.2.1 Identification of Environmental Effects

(1) Methodology

The checklist method was applied as the basic tool for identification of impacts which may be caused by the selected priority projects. The checklist was prepared by using major items of environmental effects as rows, and components of the priority projects as columns. The environmental effects expected for each project component are classified as positive and/or negative. The 19 checklist items were selected taking the features of the selected priority projects into account.

(2) Environmental Effects

The environmental effects caused by the proposed priority projects were assessed based on existing reports and the results of the inquiry survey. The results are shown in Table K.10, and are summarized below. Since the selected priority projects are located in urbanized areas and will not change the existing river flow regime qualitively and quantitatively, no serious impacts are expected to have significant effects on the environment in and around the each project area.

A) Problems due to Location

The nine(9) checklist items, such as cultural tribes, economic activities, water use and historical values were studied to check the environmental problems due to the location of the priority projects.

No settlement areas of cultural tribes, and no forestry, fishery, mining and navigation activities are reported in and around the project areas. Although several historical remains which are located along the old national road and intake facilities for municipality water supply which are situated at the uppermost part of the proposed project areas, these will not be affected by the selected priority projects because their location are all in the upper parts of the proposed project sites.

However, all sediment run-off disaster prevention facilities which are proposed for the priority projects are located in the state park area. Therefore, some negative impacts on the state park area may be caused by implementation of the priority projects.

B) Problems in Construction Stage

The four(4) checklist items of soil erosion, water quality, precious ecology and forests were studied to check the environmental problems during the construction stage. Construction activities for the priority projects are expected to have some effects on soil erosion and forest areas, and on water quality of the downstream areas. Since no endangered species and no ecologicaly precious areas are located in and around the project sites, no effects on precious ecology are expected.

C) Problems in Operation Stage

The six(6) checklist items such as water quality, ecological conditions, vector borne disease and recreation were studied to check on any environmental problems after the construction stage. Since the proposed priority projects will not change the existing river flow regime, no effects are expected from operation and maintenance of the proposed projects. Moreover, no recreation sites are located in and around the project areas to be altered.

4.2.2 Evaluation of Magnitude of the Expected Environmental Effects and Mitigation Measures

The four(4) effects, on the state park, soil erosion, water quality deterioration and damage to the forest are only expected to be mainly caused during the construction of stage. The magnitude of these effects are assessed below.

(1) Water Quality Degradation

The water quality degradation may be caused by high concentration of Suspended Solids (SS) during the construction stage. Based on existing SS data and the mean discharge data in the dry season, the load and concentration of SS were assessed and the results are shown below:

Assessment point	Case	Without project	During construction of the project a=1,000 (mg/l)	a=2,000 (mg/l)	a=3,000 (mg/l)
A. Cubatão r. (Before Moji r.)	load (kg/s)	19.0	19.3	19.4	19.5
	con't(mg/l)	180	182	184	185
B. Moji r. (Before Cubatão r.)	load (kg/s)	0.7	1.9	3.5	5.2
	con't(mg/l)	355	964	1,777	2,640
C. Cubatão r. (After Moji r.)	load (kg/s)	19.7	21.0	22.9	24.7
	con't(mg/l)	183	195	213	230

Note: - "a" means a concentration of SS during the construction period.
- SS concentration was estimated by a complete-mixture formula, and detailed calculation method is shown in Fig. K.13.

The above assessment shows that, the impacts on the water quality in the Cubatão river will be negligible. In the Moji river, the concentration of SS will be changed mainly due to the river improvement works. However, the concentration of SS after the confluence point with the Cubatão river will be diluted by the large amount of river water from the Henry Borden Hydropower Plant. Moreover, this impact is expected only during the construction stage, and there are no fishery and precious ecology to be affected. Therefore, the magnitude of this environmental effect is not considered to be serious.

As for mitigation measures, a construction of a sediment pond is recommended to reduce the outflow of the SS into the rivers during construction.

(2) Impacts to the State Park and Forest Area

Since almost all priority sediment run-off projects are located in the state park, excavation works, construction of access roads and cutting forests may cause some damage to the environment mainly from the aesthetic viewpoint.

According to the preliminary designs for the priority projects, not more than 20 ha of vegetated area will be damaged by the priority nine(9) sabo dams including their access roads. This will be less than 1% of the total forest areas in the Moji river basin, and being in the foothills will include shrubs and coppices. Thus, this impact may not cause serious environmental effects in and around the project areas.

Various types of regreening activities in the damaged areas would reduce the environmental effects caused by the projects.

(3) Impacts on Soil Erosion

The priority sediment run-off prevention projects especially sabo dams and their auxiliary works will be constructed in the areas with steep slopes, and about 20 ha of vegetation areas will be affected. Thus, some soil erosion may be caused by implementation of the projects. However, this impact will be limited to areas which will be directly altered by the projects, and appropriate construction methods should take into consideration the natural conditions. Therefore, no serious environmental effects are to be expected in and around the project areas.

Regreening activities will be needed for normal sheet erosion prevention after completion of the proposed facilities.

4.3 Conclusions

The environmental effects of the priority projects will be generally limited to the construction stage. However, the magnitude are expected to be small, because the impacts are tentative and effective countermeasures will be taken during construction of the projects.

LIST OF REFERENCES AND DATA COLLECTED

No.	TITLE	ISSUED ON	ISSUED BY
K01	BAIXADA SANTISTA, CARTA DO MEIO AMBIENTE E DE SUA DINÂMICA	1985	CETESB
K02	AVALIAÇÃO DA QUALIDADE DO AR NA SERRA DO MAR - 1a- ETAPA LEVANTAMENTO NO VALE DO MOJI	1986	CETESB
K03	ENVIRONMENTAL POLLUTION CONTROL IN CUBATÃO, RESULTS REPORTS Jul/83 to Jul/86	1986	CETESB
K04	ESPÈCIES ARBÒREAS DA SERRA DO MAR SENSÎVEIS A POLUIÇÃO ATMOSFÊRICA DO POLO INDUSTRIAL DE CUBATÃO	1988	CETESB
K05	INVENTÀRIO DE EMISSÕES EM FONTES ESTACIONÀRIAS DE POLUIÇÃO DO AR NA REGIÃO DE CUBATÃO	1988	CETESB
K06	PROGRAMA DE CONTROLE DA POLUIÇÃO EM CUBATÃO, RELATÒRIO TRIMESTRAL	1984	CETESB
K07	LEVANTAMENTO DE ESPÈCIES VEGETAIS RESISTENTES E TOLERANTES A POLUIÇÃO ATMOSFÊRICA DO POLO INDUSTRIAL DE CUBATÃO	1988	CETESB
K08	LEVANTAMENTO DA DISTRIBUIÇÃO DE DIÒXIDO DE ENXOFRE NA ATMOSFERA DE CUBATÃO-MAPEAMENTO	1984	CETESB
K09	AVALIAÇÃO DA QUALIDADE DO AR NO VALE DO RIO MOJI	1984	CETESB
K10	QUALIDADE DO AR EM CUBATÃO	1980	CETESB
K11	CARACTERIZAÇÃO QUÎMICA DAS ÀGUAS DE CHUVA DE CUBATÃO, IMPACTO AMBIENTAL	1985	CETESB

(to be continued)

(Continuation)

K12	RELATÔRIO CHUVAS DE CUBATÃO, CARACTERIZAÇÃO QUÍMICA DAS ÁGUAS DE CHUVA DE CUBATÃO - IMPACTO AMBIENTAL	1984	CETESB
K13	QUALIDADE AMBIENTAL	1989	CETESB
K14	QUALIDADE DO AR NA REGIÃO METROPOLITANA DE SÃO PAULO E EM CUBATÃO	1987	CETESB
K15	LEGISLAÇÃO, CONTROLE DA POLUIÇÃO AMBIENTAL ESTADO DE SÃO PAULO	1986	CETESB
K16	RELATÔRIO DE QUALIDADE DO AR NA REGIÃO METROPOLITANA DE SÃO PAULO E EM CUBATÃO - 1988	1989	CETESB
K17	THE ACTION OF CETESB IN CUBATÃO	1990	CETESB
K18	POLUIÇÃO E ESCORREGAMENTOS - CAUSA E EFEITO NA SERRA DO MAR	1986	Claudio Michael Wolle
K19	CONTROLE DA POLUIÇÃO AMBIENTAL EM CUBATÃO	1987	CETESB
K20	BOLETIM INFORMATIVO VOL. 3, 4, 5, 6, PREFEITURA MUNICIPAL DE CUBATÃO.		
K21	GUIA PARA ESTUDO DE ÁREAS DE MANGUEZAL CARIBEAN ECOLOGICAL RESEARCH	1986	Yara Schaeffer Novelli Gilberto Cintron
K22	ECOSSISTEMAS DA COSTA SUL E SUDESTE BRASILEIRA; ESTRUTURA, FUNÇÃO E MANEJO	1990	USP
K23	ESTUDO DE IMPACTO AMBIENTAL -EIA- RELATÔRIO DE IMPACTO AMBIENTAL - RIMA-, MANUAL DE ORIENTAÇÃO	1989	SMA

TABLES

Table K.1 NATIONAL ENVIRONMENTAL STANDARD OF AIR QUALITY

Item	Period	Standard (ug/m)
(1)Suspended Particulate Matter (SPM)	24 hours	240
	annual	80 (geometric ave.)
(2)Sulfur Dioxide (SO2)	24 hours	365
	annual	80 (arithmetic ave.)
(3)Carbon Monoxide (CO)	1 hour	40,000
	8 hours	10,000
(4)Photochemical Oxidant (PO)	1 hour	160

Source: CETESB

Table K.2 CRITERIA OF AIR QUALITY POLLUTION IN SAO PAULO

Item	Level		
	Attention	Alert	Emergency
(1)Suspended Particulate Matter -SPM, (ug/m3-24 hours)	375	625	875
(2)Sulfur Dioxide -SO2, (ug/m3-24 hours)	800	1,600	2,100
(3)SO2 x SPM (24 hours)	65,000	261,000	393,000
(4)Carbon Monoxide -CO, (ppm-8 hours)	15	30	40
(5)Photochemical Oxidant -PO, (ug/m3-1 hour)	200	800	1,200

Source: CETESB

TABLE K.3 AIR QUALITY IN THE STUDY AREA (1/2)

(1) St.1 Vila Nova

Item	Unit	1984 max.	1984 mean	1985 max.	1985 mean	1986 max.	1986 mean	1987 max.	1987 mean	1988 max.	1988 mean
1)S.Part'ate matter	ug/m^3	369	69	488	78	-	-	-	-	73	29
2)Sulfur Dioxide	ug/m^3	74	13	62	10	136	14	63	17	74	11
3)Carbon Monoxide	ppm	-	-	-	-	-	-	-	-	-	-
4)Ozone	ug/m^3	202	-	214	-	220	-	261	-	348	-

(2) St. 2 Centro

Item	Unit	1984 max.	1984 mean	1985 max.	1985 mean	1986 max.	1986 mean	1987 max.	1987 mean	1988 max.	1988 mean
1)S.Part'ate Matter	ug/m^3	216	43	514	45	186	46	201	49	257	64
2)Sulfur Dioxide	ug/m^3	116	36	113	31	81	23	100	27	63	10
3)Carbon Monoxide	ppm	4.6	-	-	-	-	-	-	-	-	-
4)Ozone	ug/m^3	380	-	220	-	261	-	307	-	286	-

TABLE K.3 AIR QUALITY IN THE STUDY AREA (2/2)

(3) St.3 Vila Parisi

Year		1984		1985		1986		1987		1988	
Item	Unit	max.	mean	max.	mean	max.	mean	max.	mean	max.	mean
1)S.Part'ate Matter	ug/m^3	567	167	519	140	409	139	466	133	409	104
2)Sulfur Dioxide	ug/m^3	232	50	143	37	212	28	301	22	90	14
3)Carbon Monoxide	ppm	-	-	-	-	-	-	-	-	-	-
4)Ozone	ug/m^3	-	-	-	-	-	-	-	-	-	-

Note : SPM is geometric mean and SO_2 is arithmetic mean,
-; no data

Source: Relatório de Qualidade do ar na Região Metropolitana de São Paulo em Cubatão - 1988, CETESB

TABLE K.4 QUALITY OF HAZARDOUS GASES

(unit: ug/m^3)

Item	Station: Planalto	Orfanato	Terreno da Bayer	Encosta
Sulfurous dioxide				
-max (3h mean)	362	161	706	754
-mean (daily)	20	15	48	58
Fluoride				
-max (1h)	1.50	1.78	10.30	4.68
-mean (daily)	0.67	0.61	4.64	3.44
Ozone				
-max (4h)	157	284	92	131
-mean(max.mean)	68	107	43	62
Ammonia				
-max(1h)	30	25	54	73
-mean (daily)	21	13	25	38
Nitrozen oxide				
-max (daily)	4	41	82	77
-mean (daily)	1	15	40	40

Note : sampling period, August - November, 1985
location of sampling point is shown on Fig.K.6

Source: AVALIAÇÃO DA QUALIDADE DO AR NA SERRA DO MAR -1a- ETAPA
LEVANTAMENTO NO VALE DO MOJI, 1986, CETESB

TABLE K.5 CHANGE OF AFFECTED VEGETATION AREA BY EACH POLLUTION INTENSITY LEVEL (1/2)

(1) Year of 1962 and 1972

Pollution Intensity Level		Affected Level of Vegetation (a)	(b)	(c)	(d)	(e)	Total
1.Most Polluted Area	mesh	0	0	0	6	4	10
	%	0	0	0	60	40	100
2.Highly Polluted Area	mesh	0	0	1	33	9	43
	%	0	0	1	77	21	100
3.Polluted Area	mesh	0	0	0	40	23	63
	%	0	0	0	64	36	100
4.Moderately Polluted	mesh	0	0	0	17	30	47
Area	%	0	0	0	36	64	100
5.Other Area	mesh	0	0	0	0	152	152
	%	0	0	0	0	100	100
T O T A L	mesh	0	0	1	96	218	315
	%	0	0	~0	30	70	100

(2) Year of 1977

Pollution Intensity Level		Affected Level of Vegetation (a)	(b)	(c)	(d)	(e)	Total
1.Most Polluted Area	mesh	0	3	2	1	4	10
	%	0	30	20	10	40	100
2.Highly Polluted Area	mesh	0	20	12	2	9	43
	%	0	47	28	4	21	100
3.Polluted Area	mesh	0	8	15	17	23	63
	%	0	13	24	27	36	100
4.Moderately Polluted	mesh	0	0	5	12	30	47
Area	%	0	0	11	25	64	100
5.Other Area	mesh	0	0	0	0	152	152
	%	0	0	0	0	100	100
T O T A L	mesh	0	31	34	32	218	315
	%	0	9	11	10	70	100

Note (a): Strongly Affected Vegetation
(b): Affected Vegetation
(c): Moderately Affected Vegetation
(d): Not Affected Vegetation
(e): No Data

Source; JICA Study Team

TABLE K.5 CHANGE OF AFFECTED VEGETATION AREA BY EACH POLLUTION INTENSITY LEVEL (2/2)

(3) Year of 1980

Pollution Intensity Level		Affected Level of Vegetation (a)	(b)	(c)	(d)	(e)	Total
1.Most Polluted Area	mesh	0	5	1	0	4	10
	%	0	50	10	0	40	100
2.Highly Polluted Area	mesh	0	27	6	1	9	43
	%	0	63	14	2	21	100
3.Polluted Area	mesh	0	10	13	17	23	63
	%	0	16	21	27	36	100
4.Moderately Polluted	mesh	0	3	4	10	30	47
Area	%	0	6	9	21	64	100
5.Other Area	mesh	0	0	0	0	152	152
	%	0	0	0	0	100	100
T O T A L	mesh	0	45	24	28	218	315
	%	0	14	8	8	70	100

(4) Year of 1985

Pollution Intensity Level		Affected Level of Vegetation (a)	(b)	(c)	(d)	(e)	Total
1.Most Polluted Area	mesh	2	4	0	0	4	10
	%	20	40	0	0	40	100
2.Highly Polluted Area	mesh	11	17	6	0	9	43
	%	25	40	14	0	21	100
3.Polluted Area	mesh	2	17	20	1	23	63
	%	3	27	32	2	36	100
4.Moderately Polluted	mesh	0	7	10	0	30	47
Area	%	0	15	21	0	64	100
5.Other Area	mesh	0	0	0	0	152	152
	%	0	0	0	0	100	100
T O T A L	mesh	15	45	35	1	218	315
	%	5	14	11	±0	70	100

Note (a): Strongly Affected Vegetation
(b): Affected Vegetation
(c): Moderately Affected Vegetation
(d): Not Affected Vegetation
(e): No Data

Source; JICA Study Team

Table K.6 CLASSIFICATION OF SURFACE WATER QUALITY

Item	Unit	ClassI	ClassII	ClassIII	ClassIV
(1)PH	-	6.5-9.0	-	-	-
(2)F.coli	MPN/100ml	1,000	1,000	4,000	>4,000
(3)Ba	mg/l	-	1.0	-	>1.0
(4)Cd	mg/l	0.004	0.01	-	>0.01
(5)Pb	mg/l	0.01	0.1	-	>0.1
(6)Cr	mg/l	0.05	0.05	-	>0.05
(7)Hg	mg/l	0.00005	0.002	-	>0.002
(8)Zn	mg/l	0.01	5	-	>5
(9)Cu	mg/l	0.1	1.0	-	>1.0
(10)Ni	mg/l	0.01	-	-	-
(11)NO3	mg/l	10.0	10.0	-	>10.0
(12)NO2	mg/l	1.0	1.0	-	>1.0
(13)NH4	mg/l	0.02	0.5	-	>0.5
(14)Surfactants	mg/l	0.5	0.5	>0.5	-
(15)DO(satura'n)	%	>60	-	<60	-
(16)Phenol	mg/l	0.001	0.001	-	>0.001

Note:

- Class I: to domestic use after simple treatment, to protection of aquatic ecosystem, to primary contact leisure activities,
- Class II: to domestic use after normal treatment, to protection of aquatic ecosystem, to primary contact leisure activities, to irrigation (vegetables and fruits),
- ClassIII: to domestic use after normal treatment, to agriculture (trees, cereals and forage)
- Class IV: to navigation, to harmonization of landscape, to less important water use,

Source: Decree no.8468, Spt. 1976, Chap.II, Sec.I.

Table K.7 WATER QUALITY IN THE STUDY AREA (1989)

Item	Unit	Cubatao River St.1	Cubatao River St.2	Mogi River St.3	Piacaguera River St.4	Perdas Reservoir St.5
1.W.Temp.	C	23	22	23	23	22
2.PH	-	6.7	7.1	5.8	5.5	6.3
3.Turb.	NTU	3.6	8.9	5.6	15.2	2.3
4.DO	mg/l	8.3	8.6	8.2	5.2	8.7
5.SS	mg/l	180	48	250	747	186
6.BOD	mg/l	13	2	2	5	12
7.COD	mg/l	31	19	<16	37	31
8.T-N	mg/l	4.8	0.7	23.9	6.3	4.4
9.T-P	mg/l	0.26	0.03	14.7	23.86	0.28
10.Cd	mg/l	<0.005	<0.005	<0.005	<0.005	<0.005
11.Pb	mg/l	<0.1	<0.1	<0.1	<0.1	<0.1
12.Cr	mg/l	<0.05	<0.05	<0.05	<0.05	<0.05
13.Hg	mg/l	<0.0001	<0.0001	<0.0001	<0.0002	<0.0002

Source: CETESB

Table K.8 RESULTS OF WATER QUALITY ANALYSIS IN THE ESTUARY AREA

Item	Unit	E1 Bridge on Branco R.	E2 Bridge on Santana R.	E3 Bridge on Largo de São Vicente
(1)Time	-	10:10 am	12:45 pm	12:20 pm
(2)Tide	-	ebb	ebb	ebb
(3)Air Temp.	C	19.0	20.6	19.8
(4)Water Temp.	C	20.3	20.7	20.8
(5)PH	-	7.1	7.2	7.4
(6)BOD	mg/l	3	2	2
(7)DSS	mg/l	10	6	11
(8)TSS	mg/l	17,700	20,800	23,200
(9)Cl	%	7.6	9.1	8.4
(10)EC	uS/cm	20,700	23,100	26,500

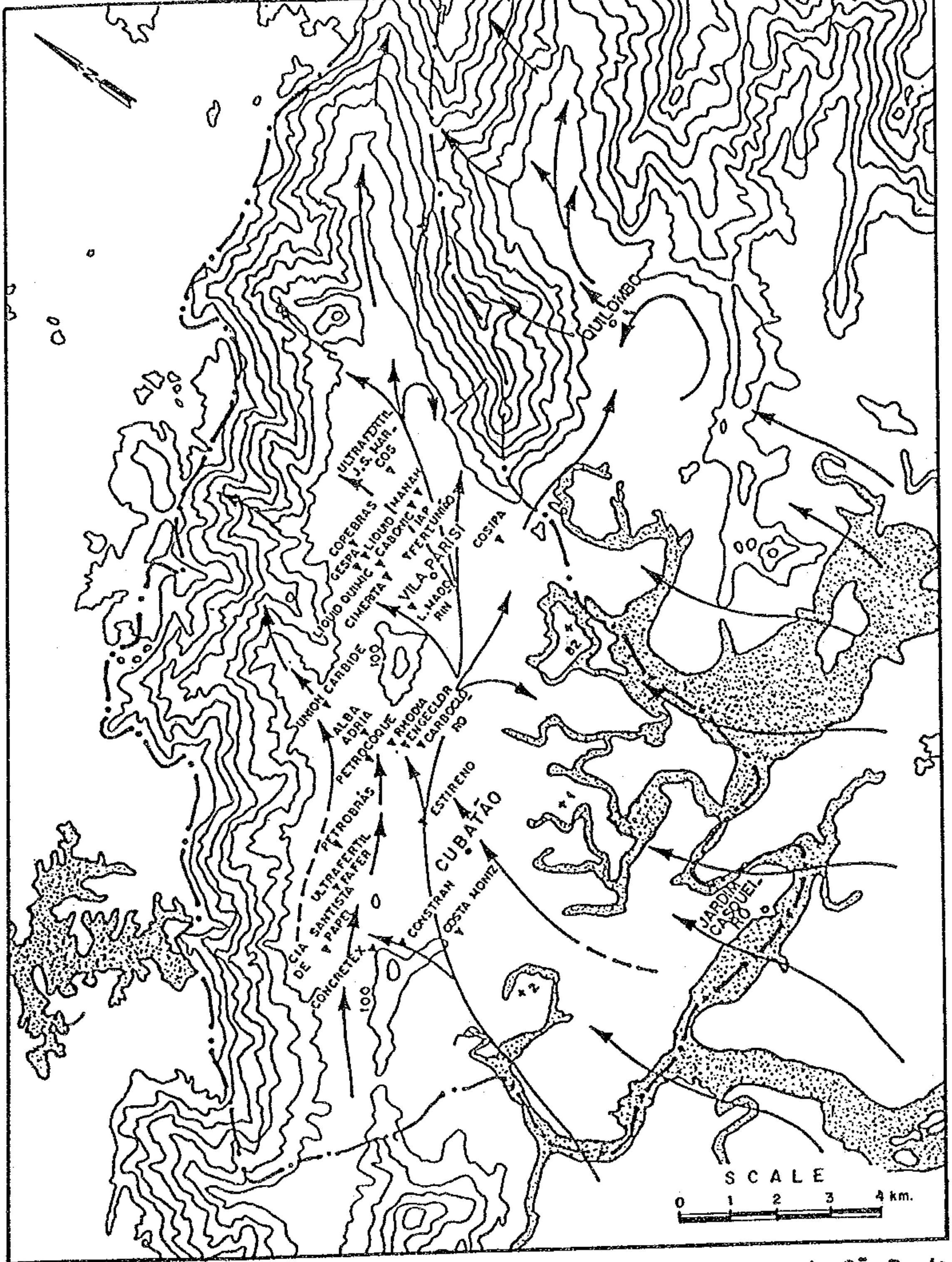
Note: Sampling was carried out on July 11th, 1990 by the Study team.
Water quality was analyzed by the laboratory of CETESB.

Table K.9 ENVIRONMENTAL EFECTS CAUSED BY THE PRIORITY PROJECTS

Checklist Item	Sediment Run-off Prev.		Flood Prevention		
	Sabo dam	Channel works	Moji R.	Piaca.R.	Indio R.
A) Problems due to the Location					
1. Encroachment of cultural tribs	o	o	o	o	o
2. Encroachment of agricultural lands	o	o	o	o	o
3. Inundation of mineral resources	o	o	o	o	o
4. Depreciation of forestry	o	o	o	o	o
5. Depreciation of fishery	o	o	o	o	o
6. Water right conflict	o	o	o	o	o
7. Damages on historical and cultural value	o	o	o	o	o
8. Impairment of navigation	o	o	o	o	o
9. Degradation of parks and nature reserves	-	o	o	o	o
B) Problems in Construction Stage					
1. Soil erosion and silt run-off	-	o	o	o	o
2. Deterioration of water quality	-	-	-	-	-
3. Impairment of forest area	-	o	o	o	o
4. Impairment of precious ecology	o	o	o	o	o
C) Problems in Operation Stage					
1. Deterioration of water quality	o	o	o	o	o
2. Intrusion of saline water	o	o	o	o	o
3. Impeirment of precious ecology	o	o	o	o	o
4. Obstruction of migratory fish	o	o	o	o	o
5. Vector disease hazard	o	o	o	o	o
6. Encroachment of recreation area	o	o	o	o	o

Note: a) o; No effect expected
b) +; Positive effect expected
c) -; Negative effect expeted

FIGURES

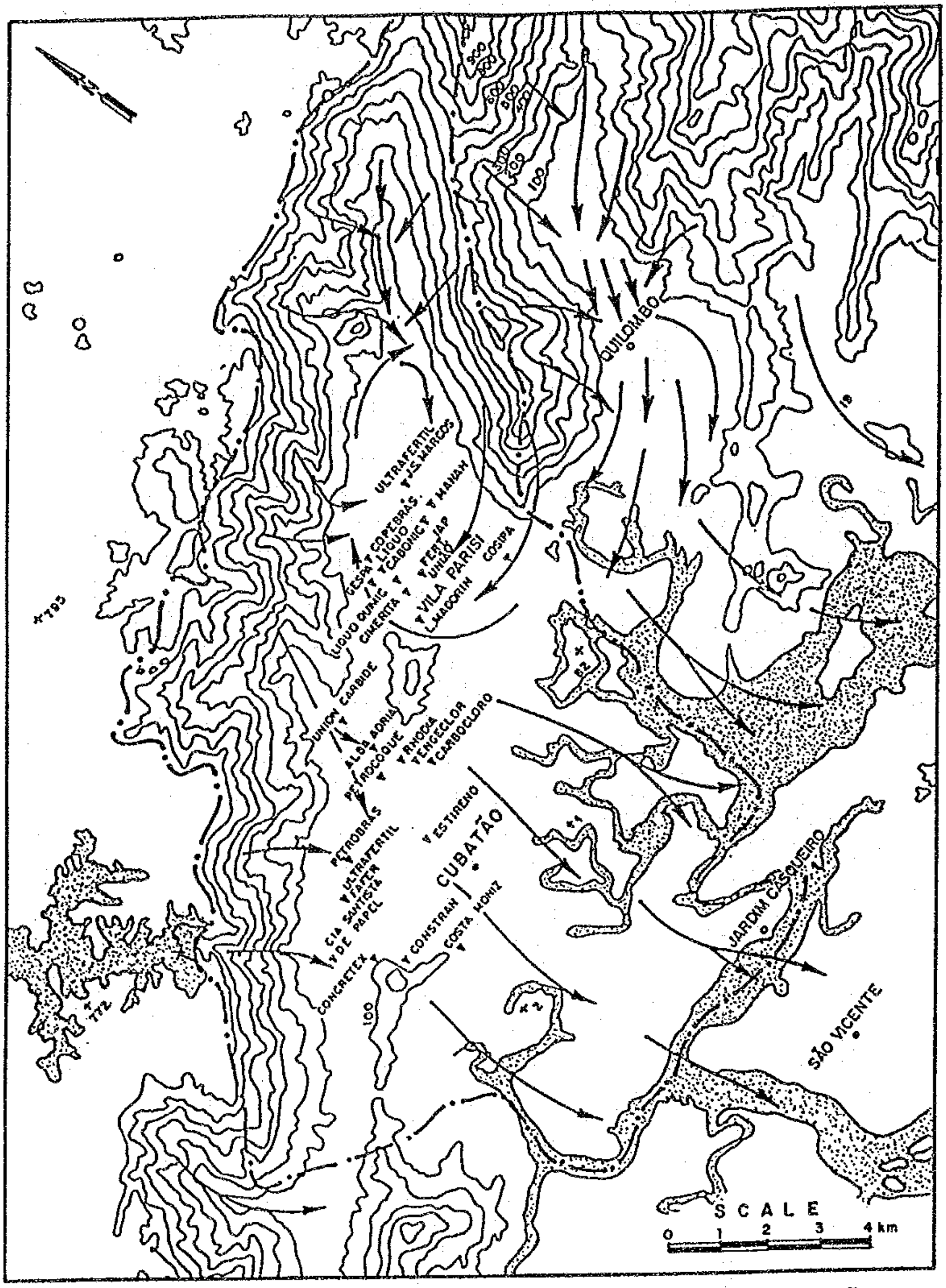


Source : Relatório de qualidade do ar na região metropolitana de São Paulo em Cubatão, 1988, CETESB

FIG.K.1
DOMINANT WIND DIRECTION
DURING THE DAYTIME
IN THE STUDY 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



Source : Relatório de qualidade do ar na região metropolitana de São Paulo em Cubatão, 1988, CETESB

FIG.K.2
DOMINANT WIND DIRECTION
DURING THE NIGHT
IN THE STUDY 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

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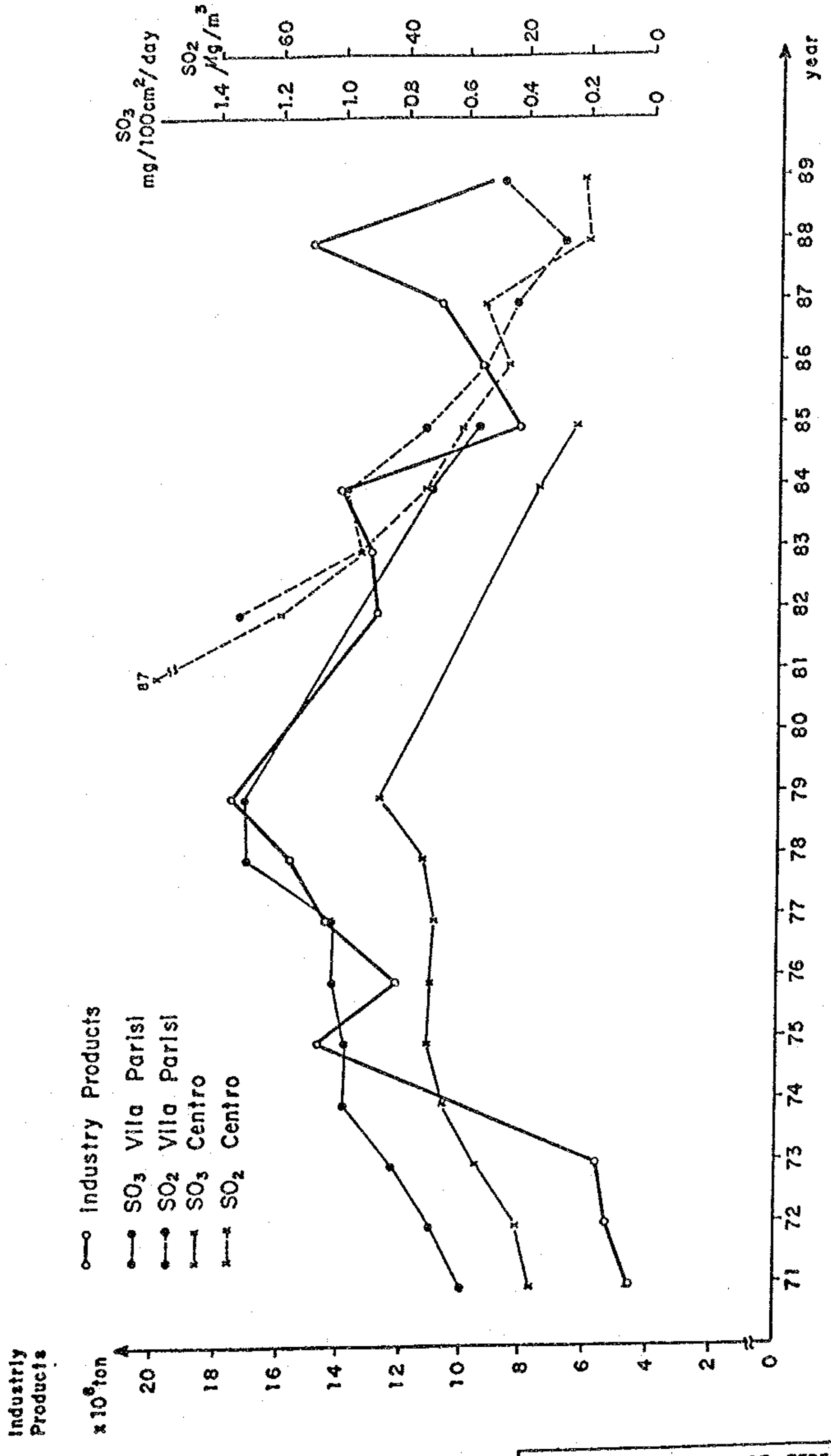

FIG.K.3
ANNUAL CHANGE OF INDUSTRY
PRODUCTS AND SO2/SO3
CONCENTRATION

GOVERNMENT OF FEDERATIVE
REPUBLIC OF BRAZIL
THE STUDY ON THE DISASTER PREVENTION AND
RESTORATION PROJECT IN SERRA DO MAR ,
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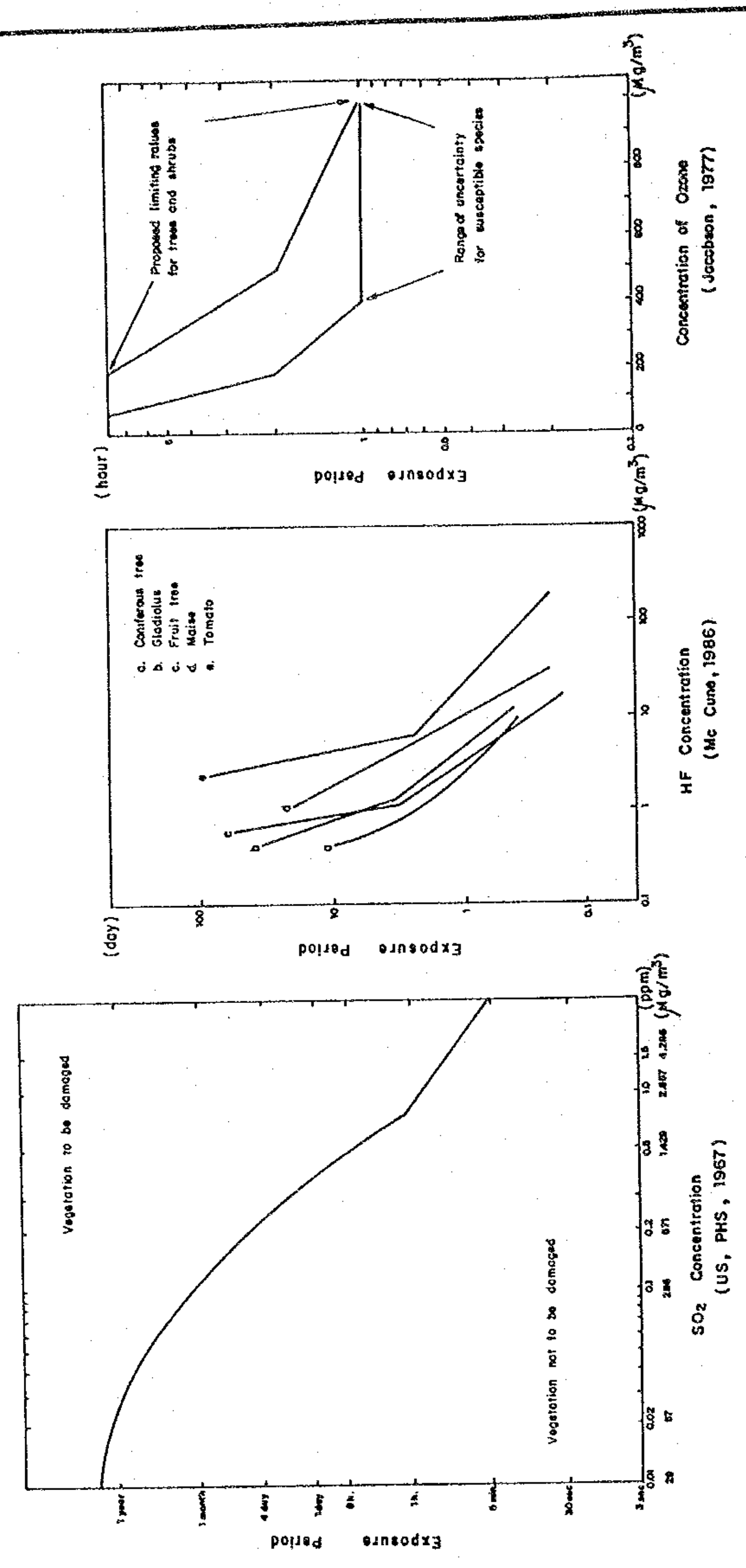

FIG.K.4
DOSE-EFFECT RELATIONSHIP

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JAPAN INTERNATIONAL COOPERATION AGENCY

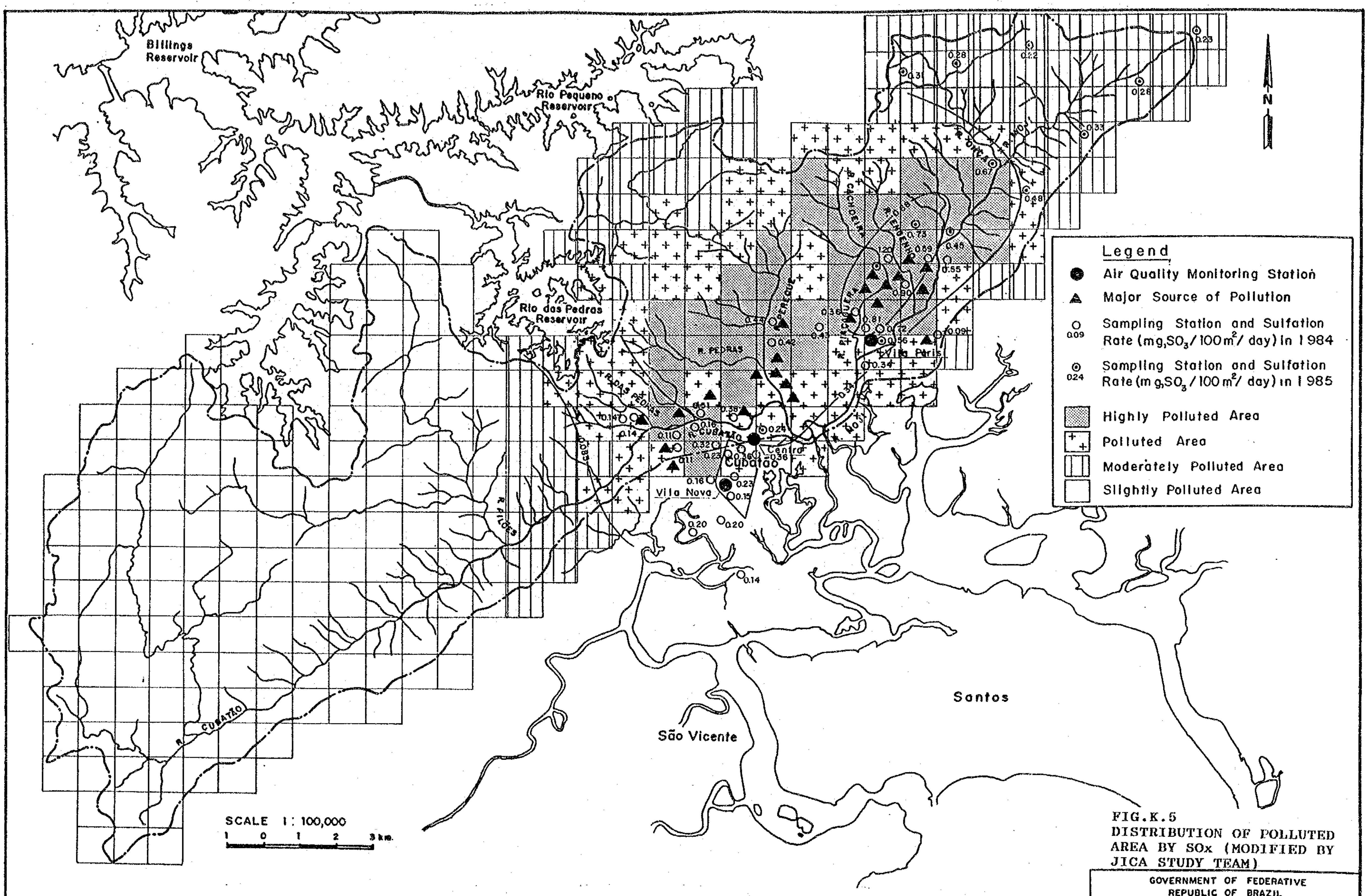

FIG.K.5
DISTRIBUTION OF POLLUTED AREA BY SOx (MODIFIED BY JICA STUDY TEAM)

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: 1) LEVANTAMENTO DA DISTRIBUIÇÃO DE DIOXIDO DE ENXOFRE NA ATMOSFERA DE CUBATÃO - MAPAMENTO, 1984, CETESB
2) AVALIAÇÃO DA QUALIDADE DO AR NA SERRA DO MAR, 1a.- ETAPA LEVANTAMENTO NO VALE DO MOJI, 1986, CETESB