FIGURES

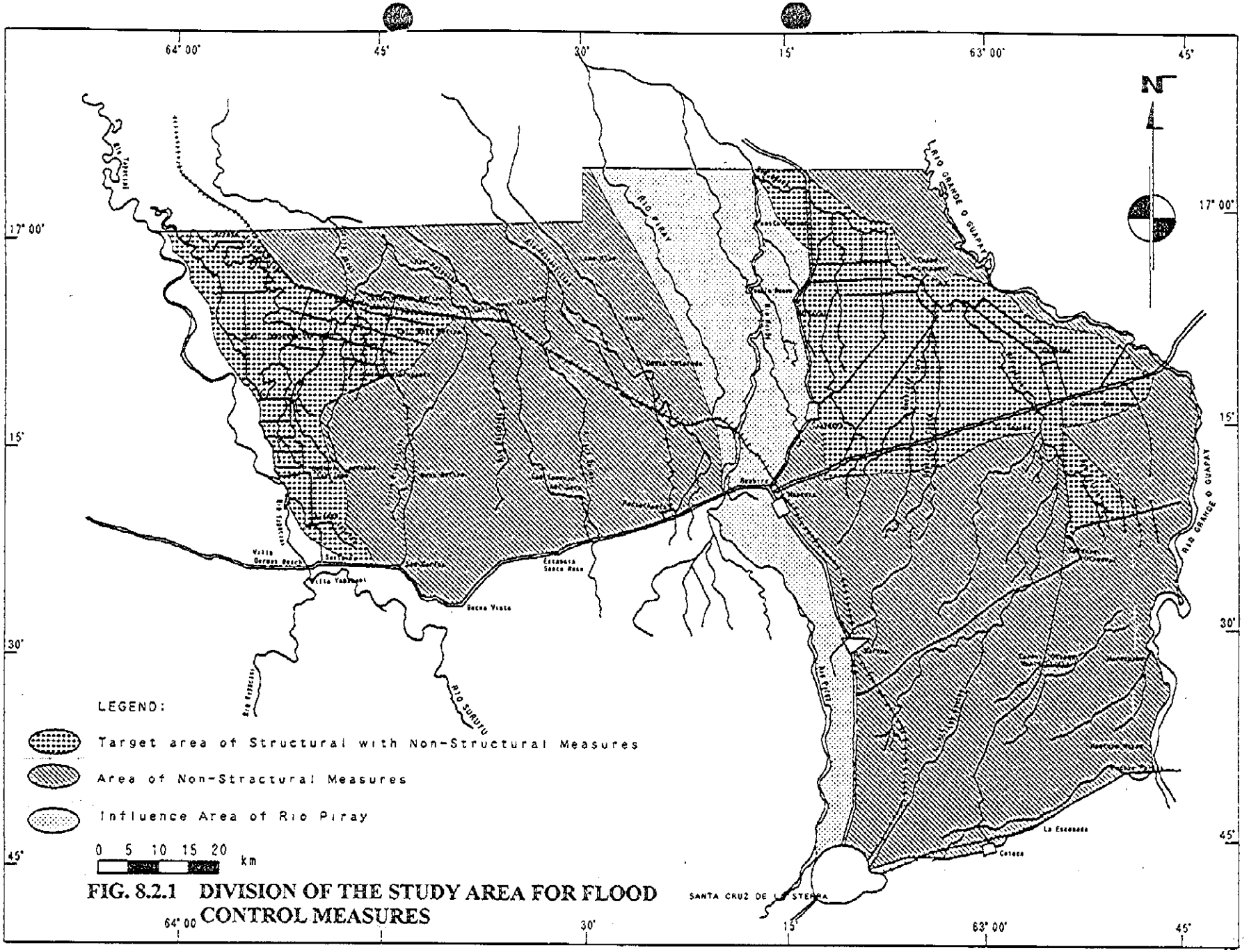


FIG. 8.2.1 DIVISION OF THE STUDY AREA FOR FLOOD CONTROL MEASURES

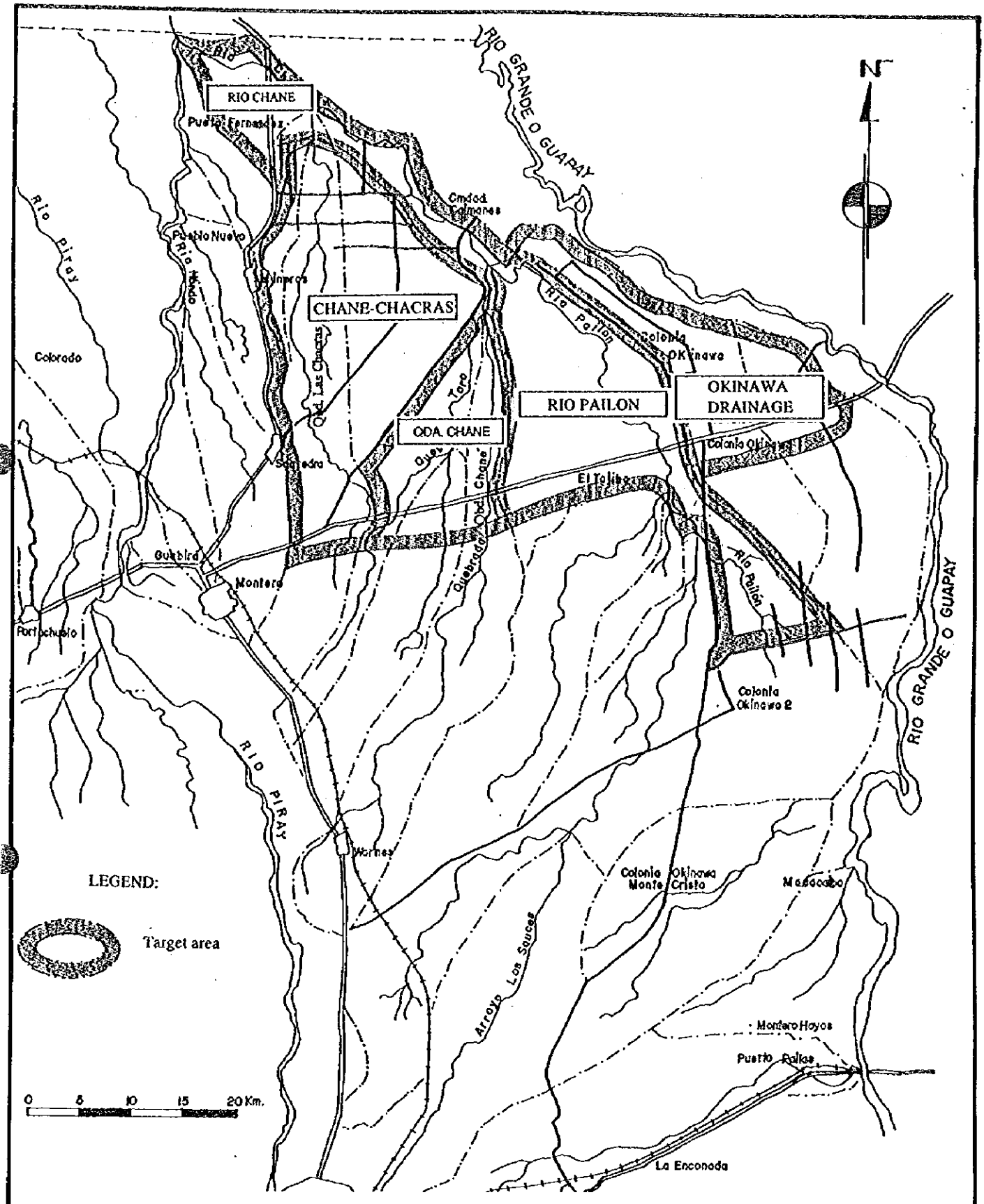


FIG. 8.2.2 TARGET AREA OF FLOOD MITIGATION AND DRAINAGE IMPROVEMENT MEASURES - CHANE - PAILON AREA

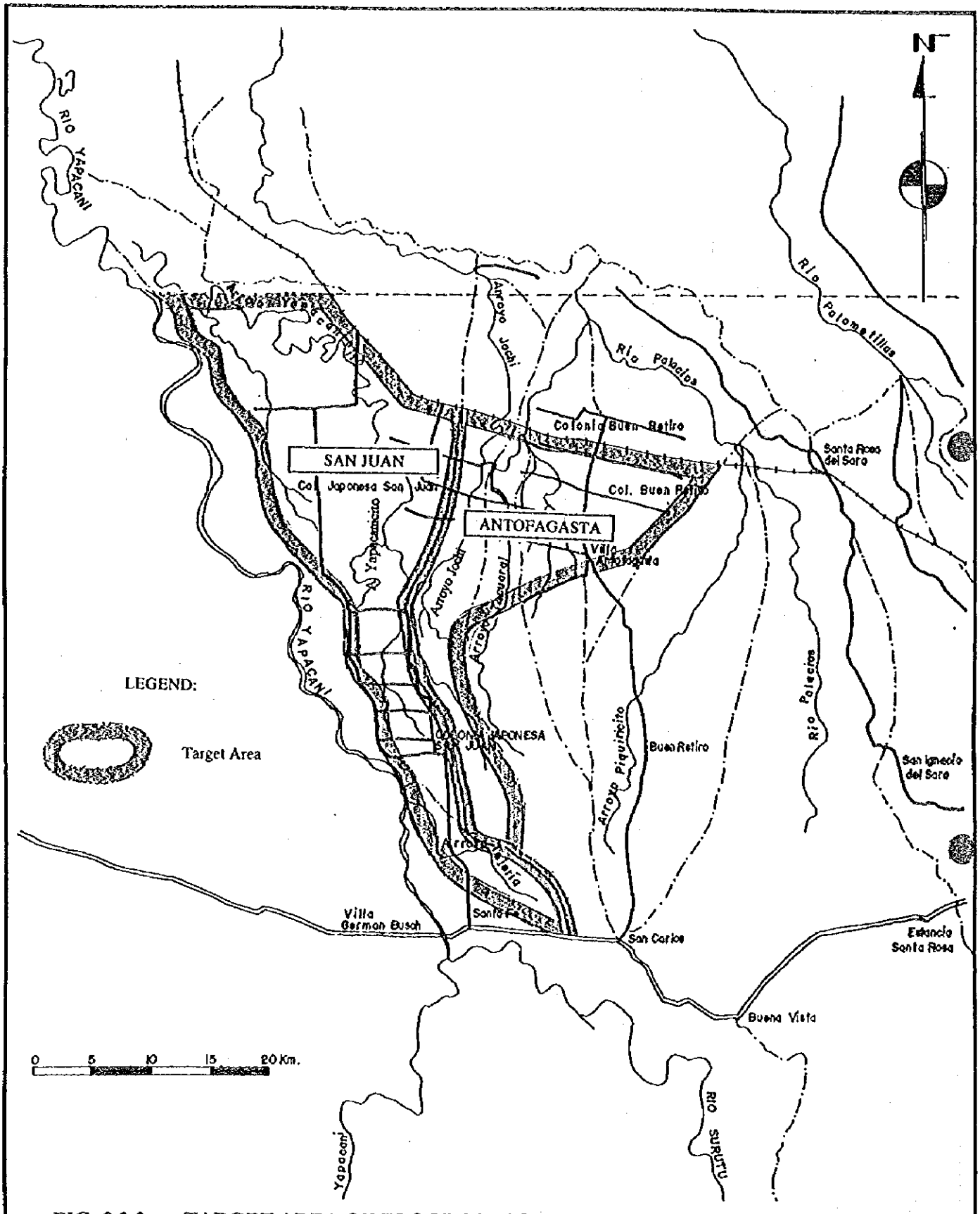
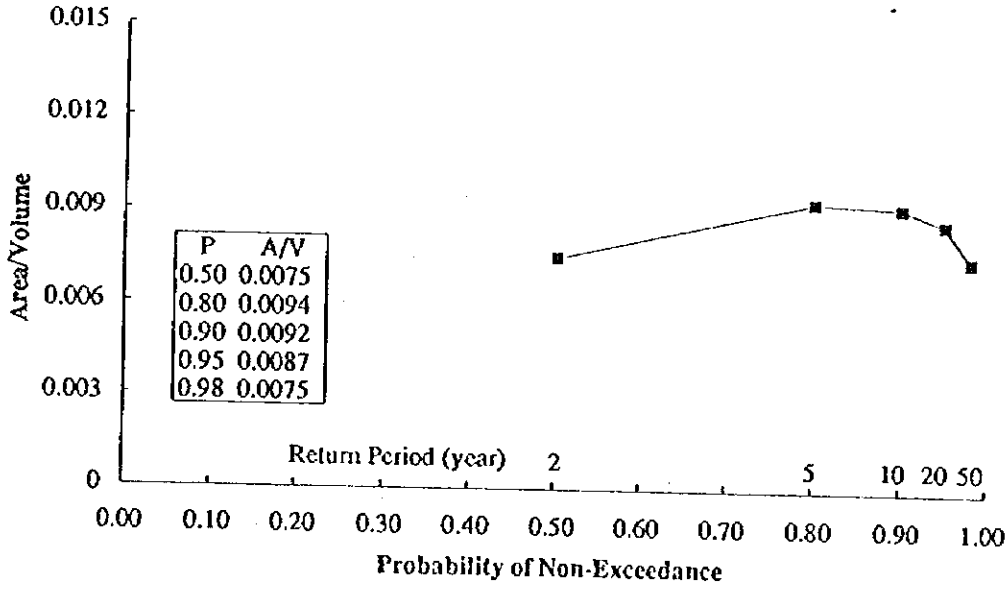
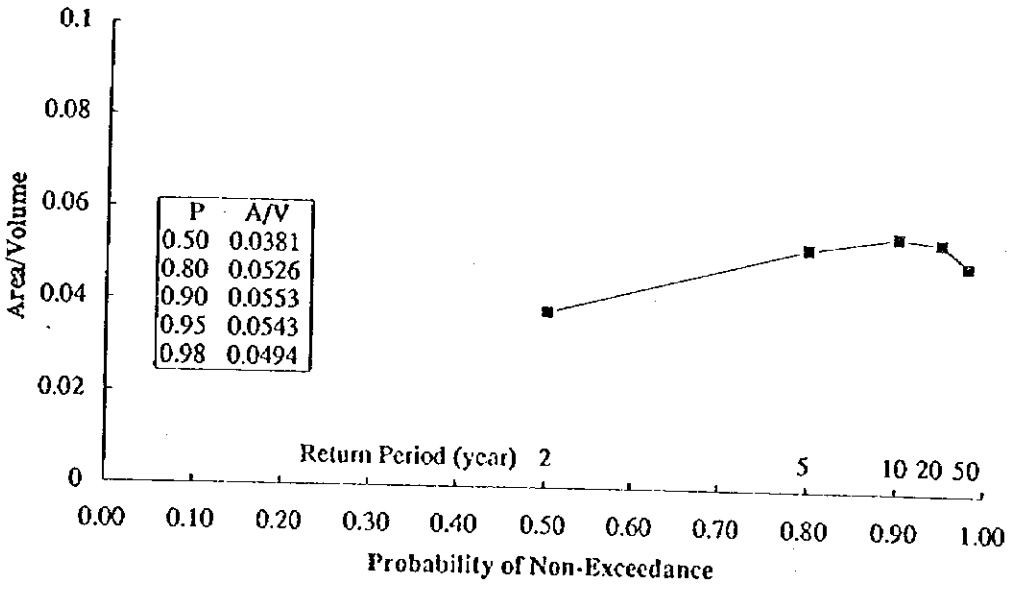


FIG. 8.2.3 TARGET AREA OF FLOOD MITIGATION AND DRAINAGE IMPROVEMENT MEASURES - SAN JUAN - ANTOFAGASTA AREA

Determination of Design Scale for Chane-Paiton



Determination of Design Scale for San Juan - Antofagasta



Note: Area - Annual Average Protected Area
Volume - Excavation Volume

FIG.8.2.4 DETERMINATION OF DESIGN SCALE

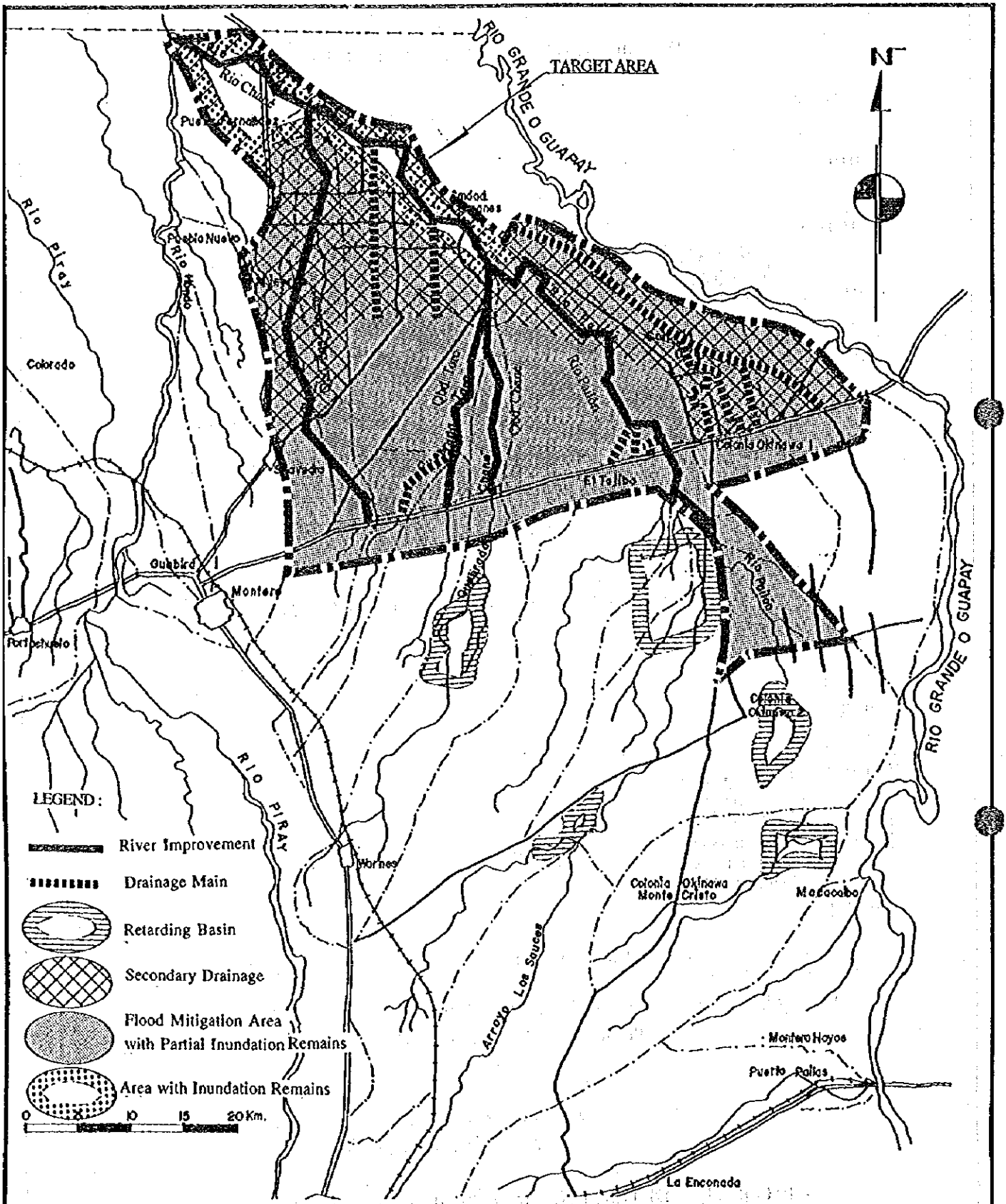


FIG. 8.3.1 CONCEPT OF FLOOD MITIGATION AND DRAINAGE IMPROVEMENT FOR TARGET AREA - CHANE - PAILON AREA : ALTERNATIVE I

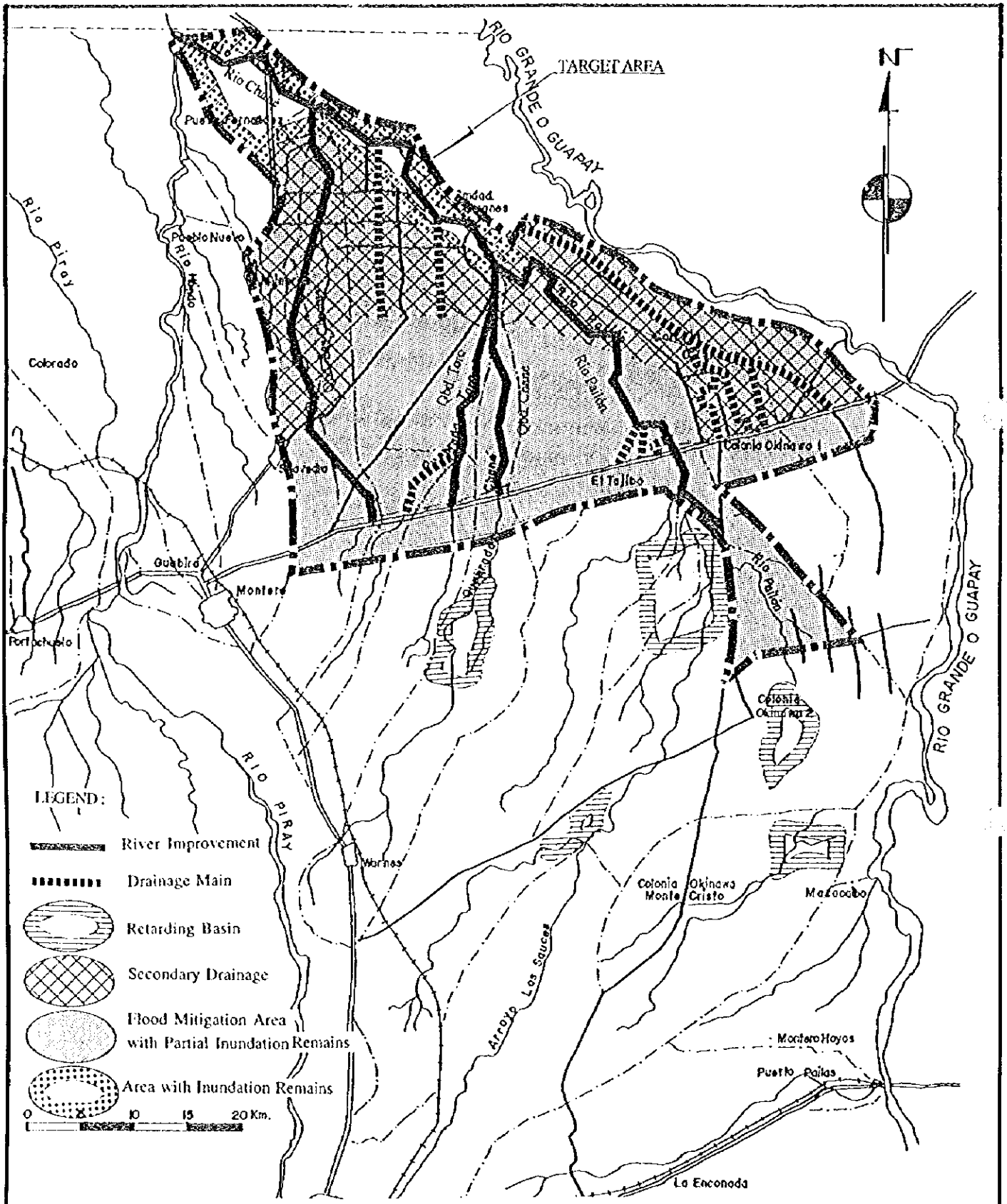


FIG. 8.3.1 CONCEPT OF FLOOD MITIGATION AND DRAINAGE IMPROVEMENT FOR TARGET AREA - CHANE - PAILON AREA : ALTERNATIVE I

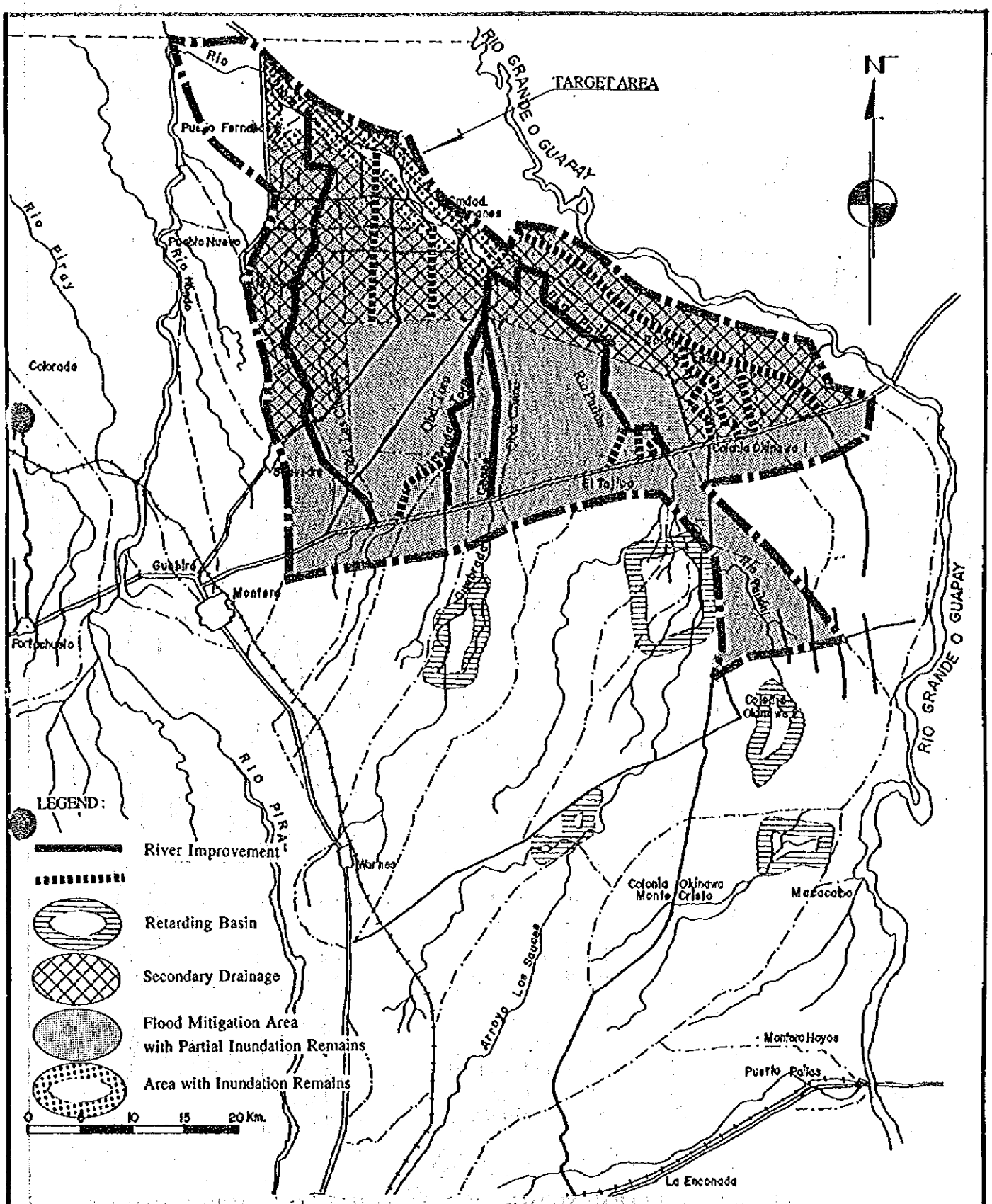


FIG. 8.3.2 CONCEPT OF FLOOD MITIGATION AND DRAINAGE IMPROVEMENT FOR TARGET AREA - CHANE - PAILON AREA : ALTERNATIVE II

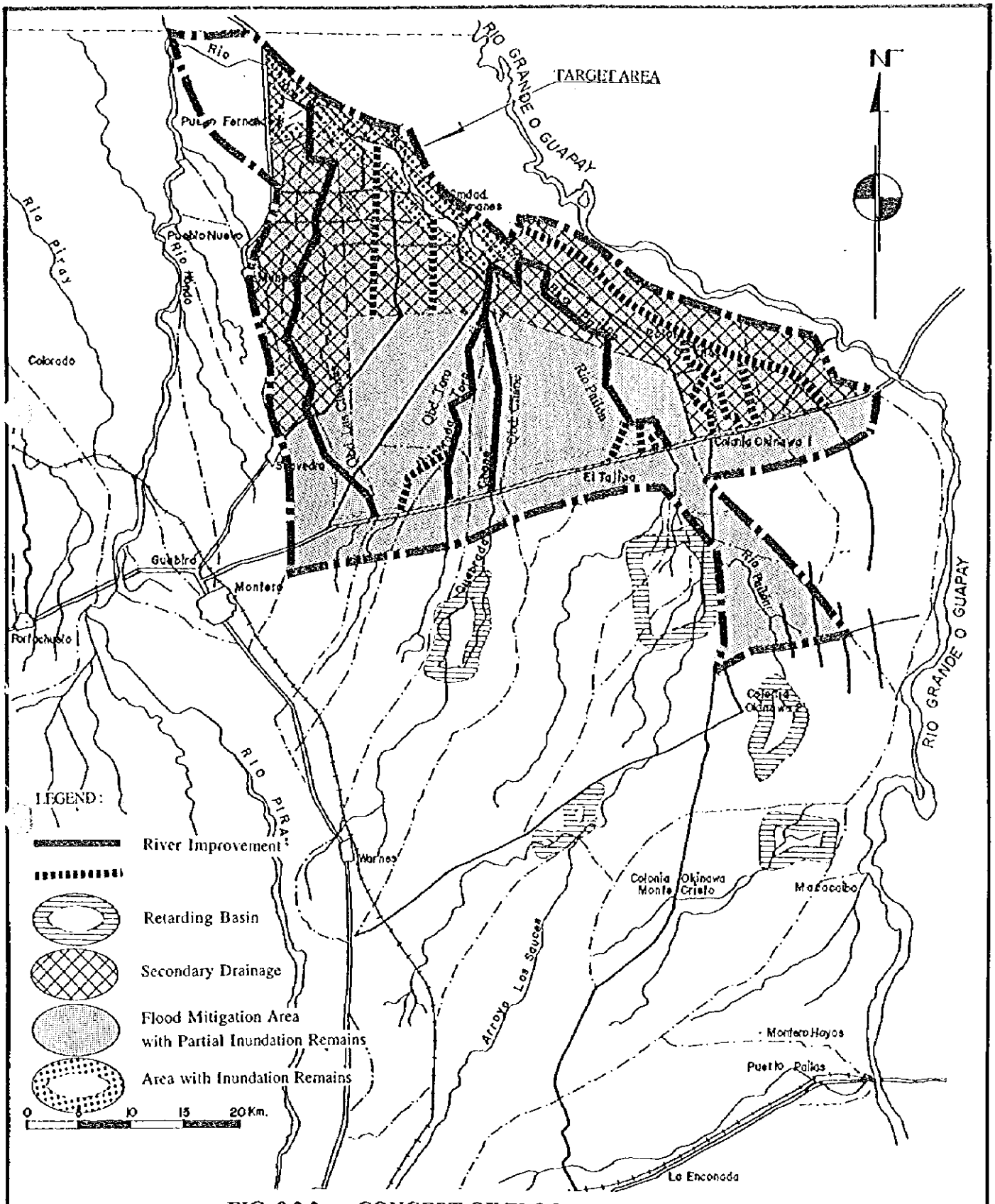


FIG. 8.3.2 CONCEPT OF FLOOD MITIGATION AND DRAINAGE IMPROVEMENT FOR TARGET AREA - CHANE - PAILON AREA : ALTERNATIVE II

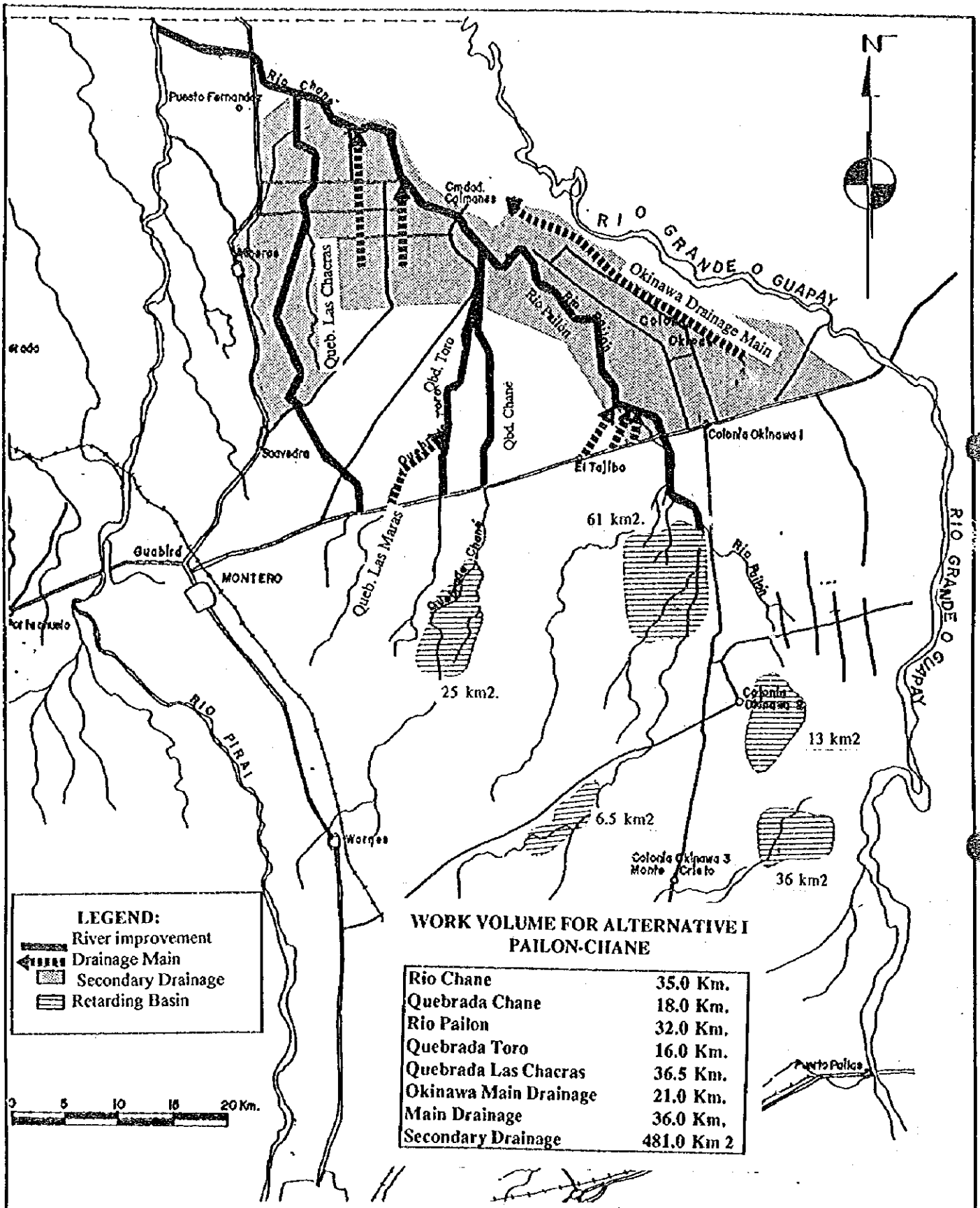


FIG. 8.3.3 FLOOD MITIGATION AND DRAINAGE IMPROVEMENT - CHANE - PAILON AREA : ALTERNATIVE I)

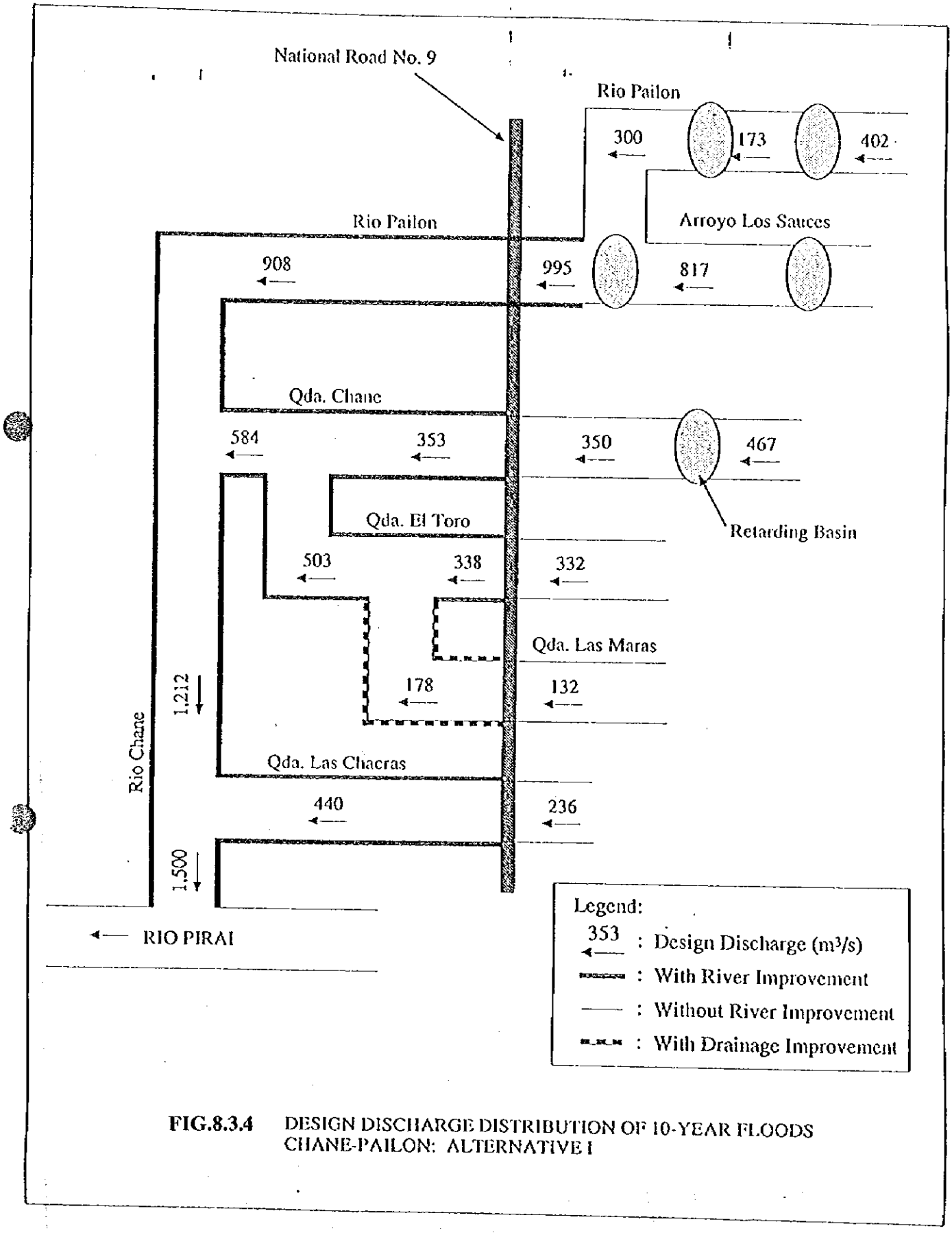


FIG.8.3.4 DESIGN DISCHARGE DISTRIBUTION OF 10-YEAR FLOODS CHANE-PAILON: ALTERNATIVE I

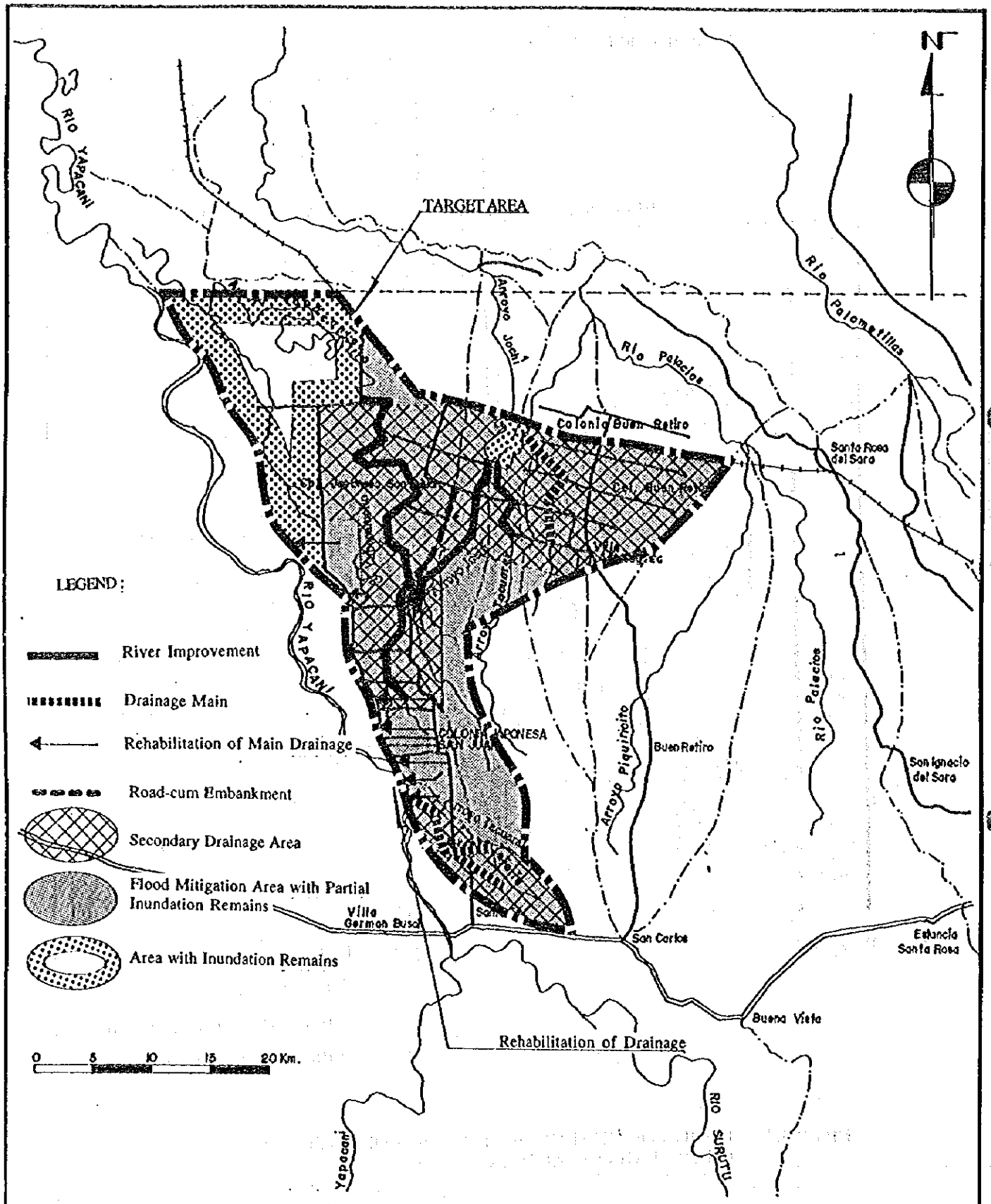


FIG. 8.3.5 CONCEPT OF FLOOD MITIGATION AND DRAINAGE IMPROVEMENT FOR TARGET AREA - SAN JUAN - ANTOFAGASTA AREA : ALTERNATIVE I

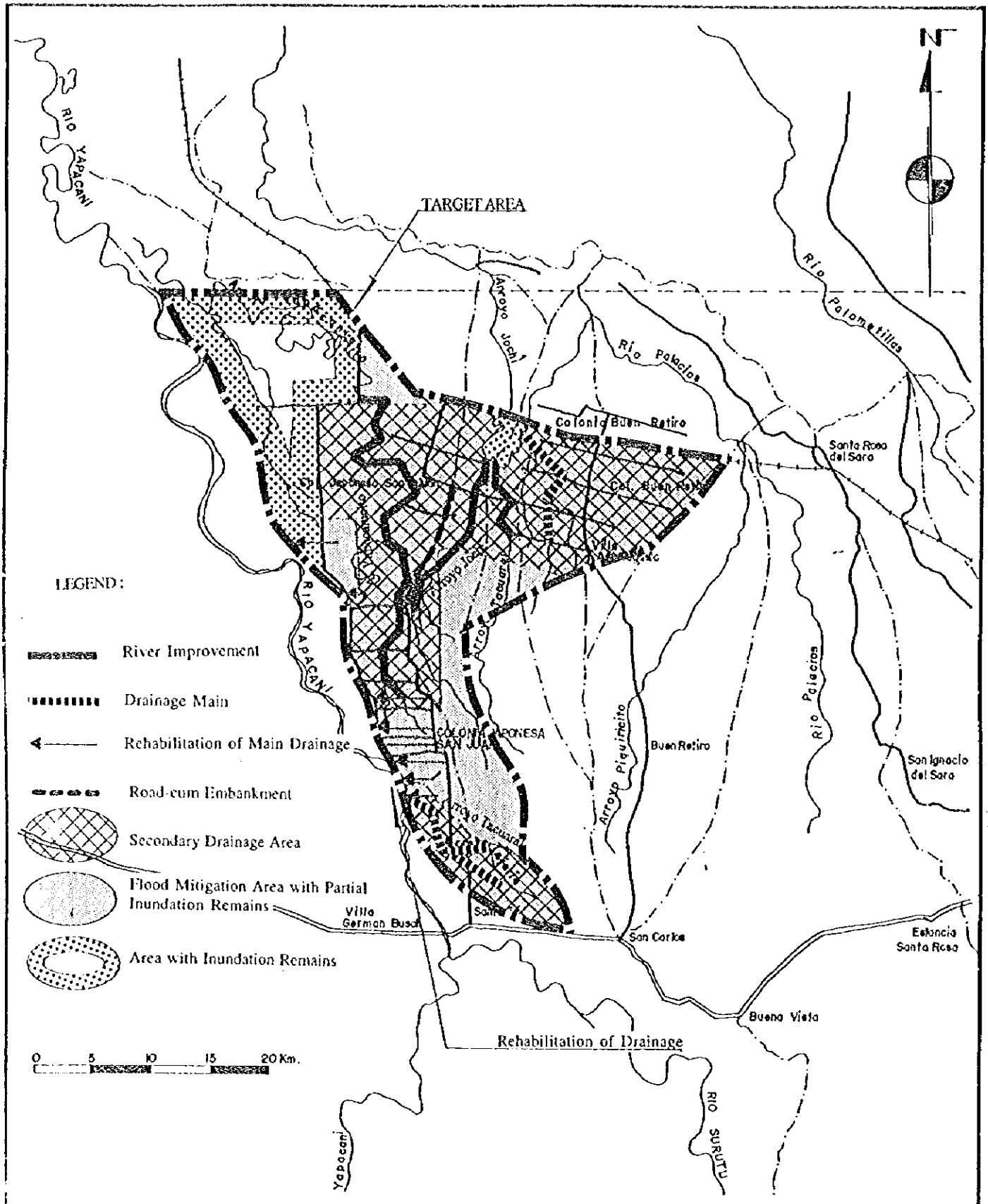


FIG. 8.3.5 CONCEPT OF FLOOD MITIGATION AND DRAINAGE IMPROVEMENT FOR TARGET AREA - SAN JUAN - ANTOFAGASTA AREA : ALTERNATIVE I

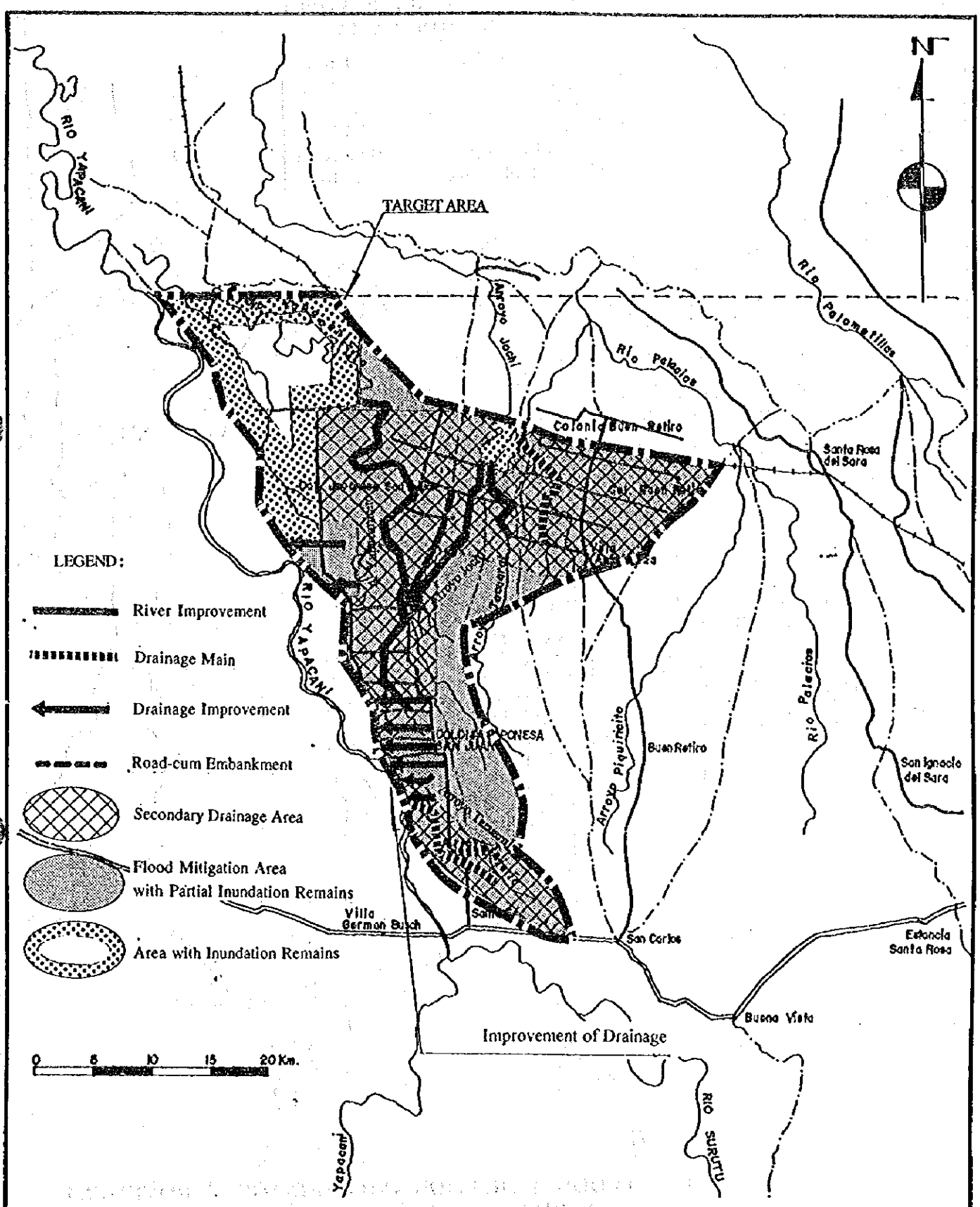


FIG. 8.3.6 CONCEPT OF FLOOD MITIGATION AND DRAINAGE IMPROVEMENT FOR TARGET AREA - SAN JUAN - ANTOFAGASTA AREA : ALTERNATIVE II

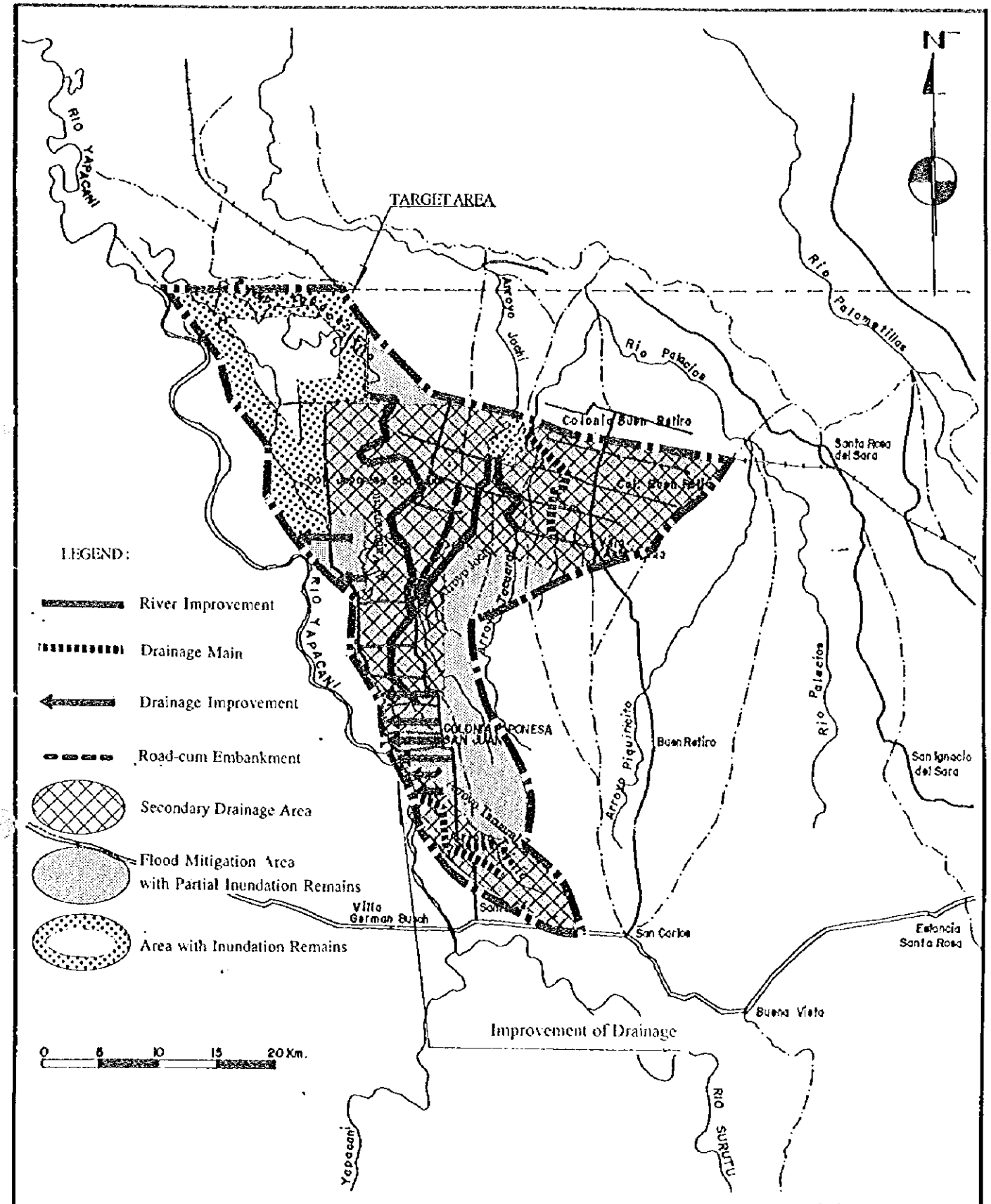


FIG. 8.3.6 CONCEPT OF FLOOD MITIGATION AND DRAINAGE IMPROVEMENT FOR TARGET AREA - SAN JUAN - ANTOFAGASTA AREA : ALTERNATIVE II

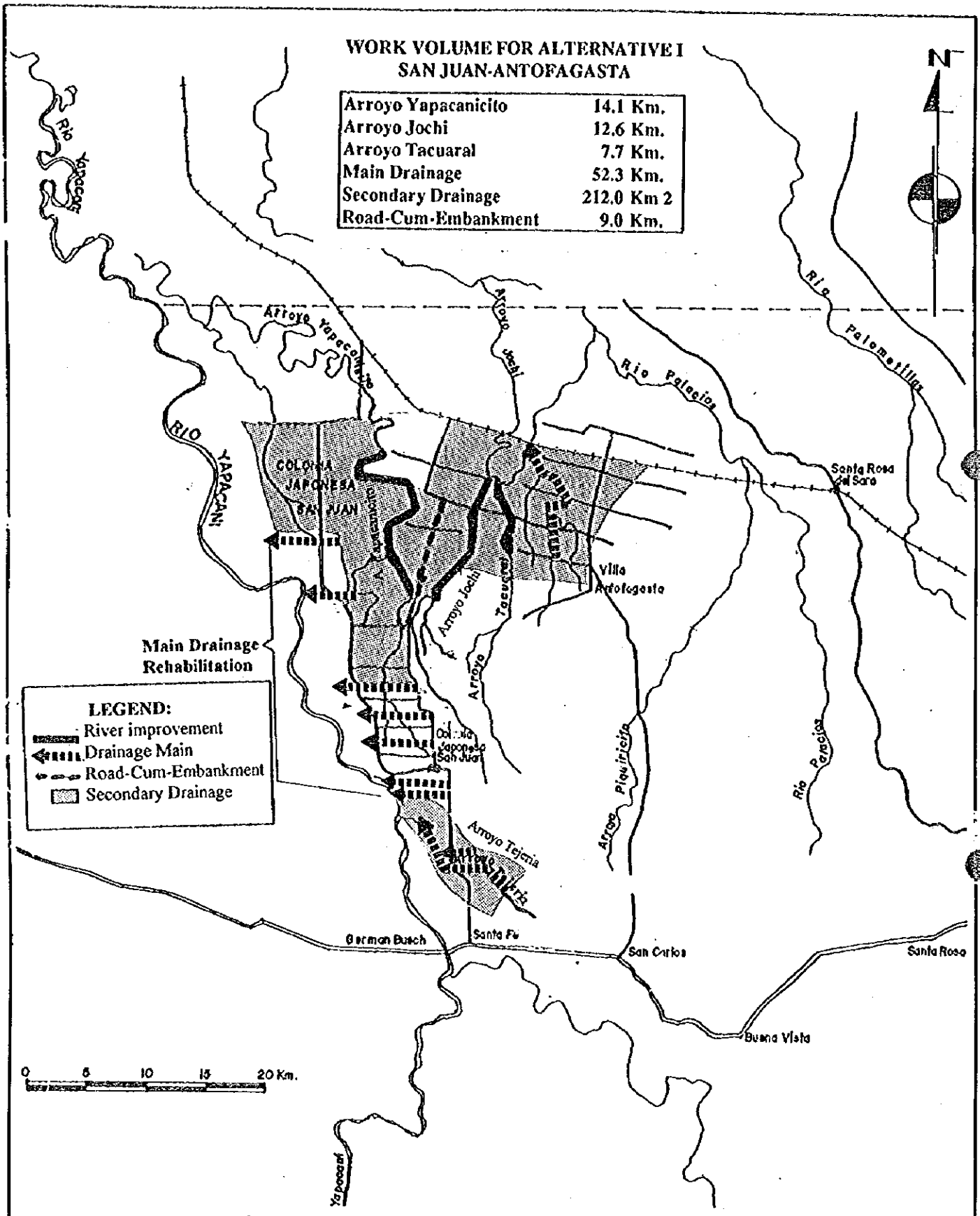
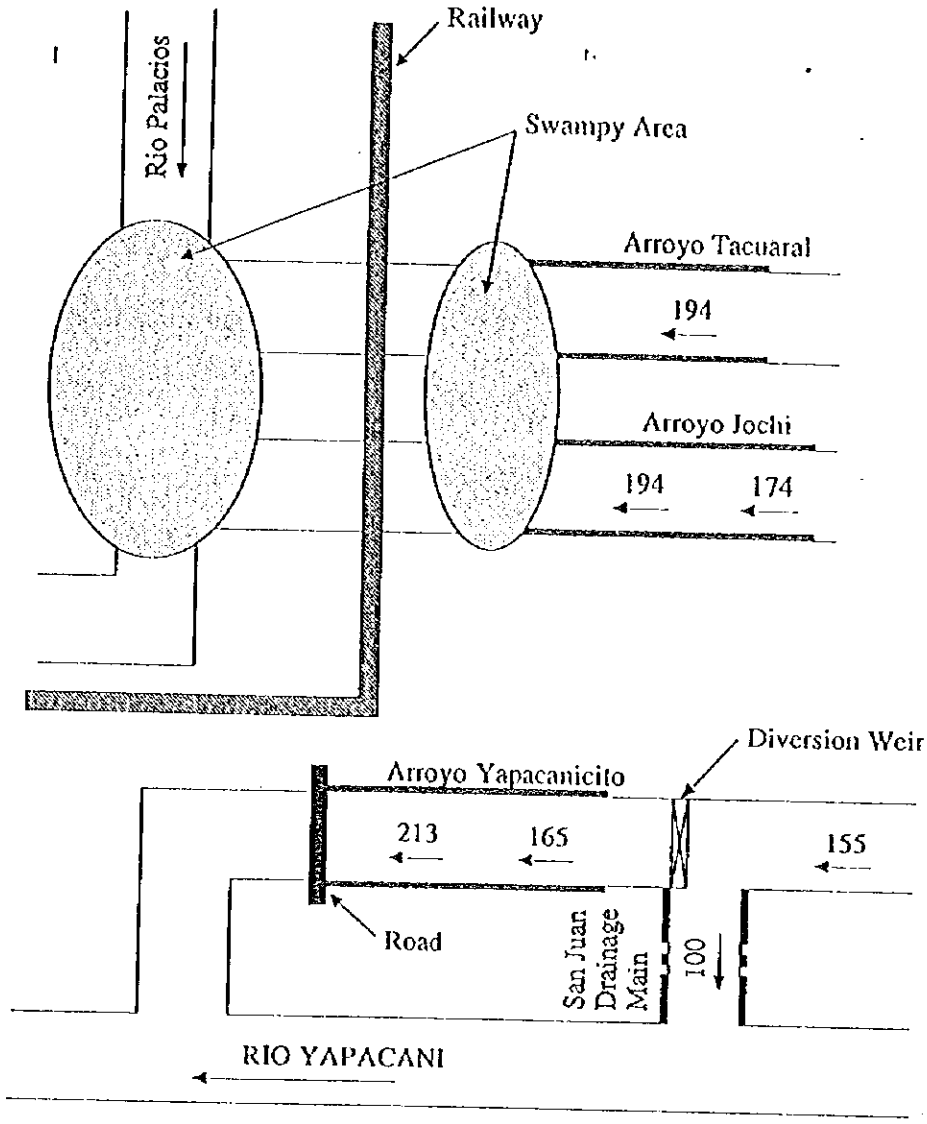


FIG. 8.3.7 FLOOD MITIGATION AND DRAINAGE IMPROVEMENT - SAN JUAN - ANTOFAGASTA AREA : ALTERNATIVE I



Legend:

213 ← : Design Discharge (m³/s)

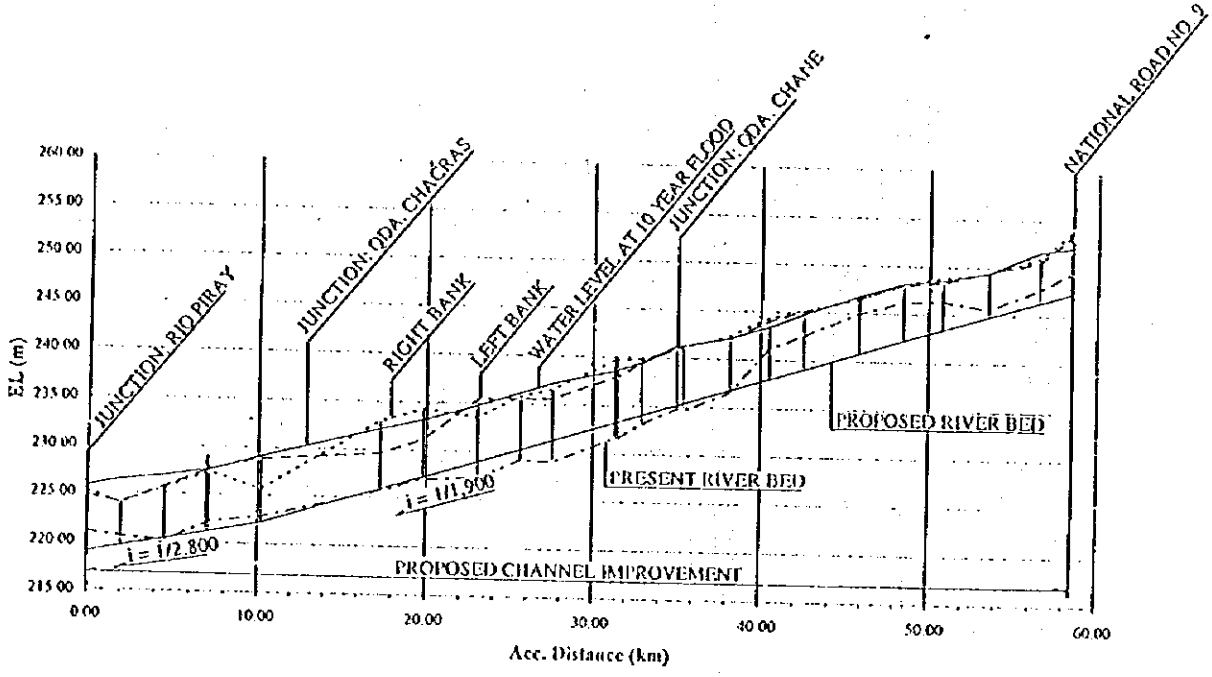
▬▬ : With River Improvement

—— : Without River Improvement

▬ ▬ : Rehabilitation of Drainage

FIG.8.3.8 DESIGN DISCHARGE DISTRIBUTION OF 10-YEAR FLOODS SAN JUAN-ANTOFAGASTA: ALTERNATIVE I

RIO CHANE - RIO PAILON



QDA. CHANE

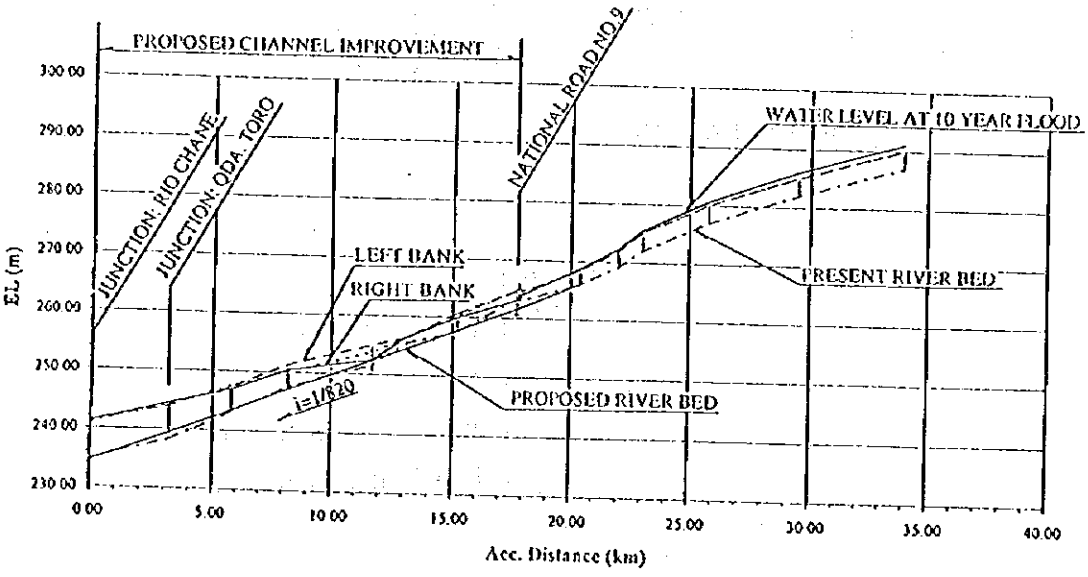


FIG.8.3.9 DESIGN LONGITUDINAL PROFILE OF THE RIVER IMPROVEMENT CHANE-PAILON: ALTERNATIVE I

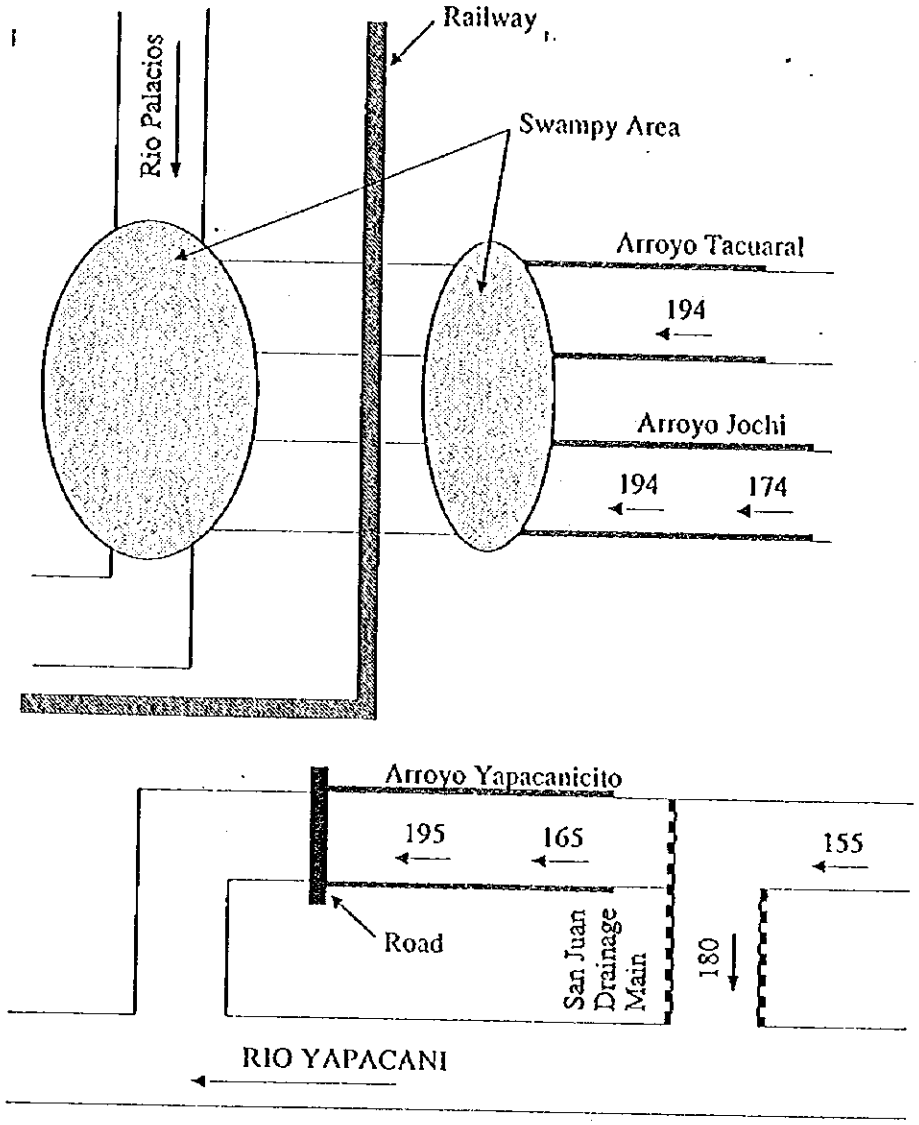


FIG.8.3.10 DESIGN DISCHARGE DISTRIBUTION OF 10-YEAR FLOODS
SAN JUAN-ANTOFAGASTA: ALTERNATIVE II

CHAPTER 9
DRAINAGE IMPROVEMENT

CHAPTER 9 DRAINAGE IMPROVEMENT

9.1 General

The drainage conditions are very poor over the study area due to the topographic and soil conditions. The topography is gentle, but bumpy, and low depressed lands and low lying lands are widely scattered. Moreover, medium and light heavy soil with low permeability is predominant. The natural streams are generally not developed over the study area and inadequate to drain effectively the storm water. These peculiar land forms in combination with the low permeabile soil worsen the drainage conditions of the study area.

In order to improve the situation, optimum drainage improvement measures are studied for the agricultural area besides flood mitigation measures.

9.2 Existing Drainage Systems and Facilities

9.2.1 Existing Condition of Drainage Systems

The drainage systems are generally not developed for the agricultural land in the study area. There are only small scale drainage canals and farm drains that were provided locally by land owners.

The major existing drainage systems developed structurally are observed only in Colonia San Juan and Okinawa.

In the remained areas, natural streams called "quebrada" serve as drains. However, at times these quebradas are reclaimed by the development activities such as farm development and road construction, resulting in worsening of the drainage conditions. The road embankment like a long dike often causes pondings at the upper side.

The observed existing dranage networks are shown in *Fig.9.1.1* and *9.1.2*.

9.2.2 Discharge Capacity of Existing Drainage System

(1) San Juan Drainage Main

San Juan area has two drainage systems composed of seven (7) drainage mains. The drainage systems have discharge capacities for 2-year probable runoff. However, the actual discharge capacities are likely less than the capacities estimated because of lack of

proper maintenance works, insufficient flow capacities of the existing culverts and outlet facilities.

(2) Okinawa Drainage Main

The discharge capacity of the drainage main of Okinawa-1 is less than 2-year probable runoff.

(3) Natural River Courses

The Arroyo Yapacanicito, Arroyo Jochi and Arroyo Tejeria are recognized as the main drainage channels in San Juan and Antofagasta. The discharge capacities of the Arroyo Yapacanicito and Arroyo Jochi are less than a half of 2-year probable runoff. The discharge capacity of the Arroyo Tejeria is about 75 % of 2-year probable runoff, but sufficient at the lower reach, because the channel becomes steep enough to discharge against the backwater of the Rio Yapacani.

9.3 Drainage Problems

9.3.1 Occurrence

(1) Ordinary Condition

The average annual rainfall varies locally between 1,300 mm and 1,800 mm in the study area, with western part receiving more rainfall than eastern part.

The average monthly rainfall varies from 40 mm to 300 mm. During the months from November to February, the monthly rainfall exceeds 150 mm, and the number of rainy days with more than 1 mm rainfall per day in these months are between 10 and 15 days per month, besides less than 10 days per month during the other months.

The drainage problem seems to occur in these four months of November, February. However, heavy rainfall with a short duration, around 1 or 2 days, sometimes occurrs even in the dry season.

(2) Heavy Rainfall

Daily rainfall of 100 mm per day or more occurs almost every year. This magnitude of rainfall likely causes inundation in depressed and low-lying areas.

9.3.2 Topographic and Soil Condition

(1) Topographic Condition

The land form in the study area is classified as an alluvial plain. The slope is distributed from 1 / 400 to gentler than 1 / 1000. The study area is classified into three slope categories as shown in *Fig. 9.3.1.* They are, northern part with less than 1 / 1000 slope, middle part with a slope range of 1 / 600 ~ 1 / 800 and southern part with a slope of 1 / 400.

The ground surface is not only very gentle, but also irregular over the study area. The depressed and low lying lands are widely scattered over the area as shown in *Fig. 9.3.2.*

(2) Soil Condition

The middle and light heavy soil, the light heavy or heavy subsoil is dominant at the alluvial plain in the study area and the soil is characteristic of poor permeability because of the soil texture.

This soil condition also causes the stagnation of water for a long time, when there is no sufficient drainage system. The soil tends to have an excessive soil moisture for cultivation in rainy season.

The identified poor drainage lands scattered over the study area are shown in *Fig. 9.3.3.*

9.3.3 Drainage Problem by Rainfall

On the basis of the results of the questionnaire survey and the study on topographic and soil conditions, the areas that are frequently inundated, with the depth more than 10 cm and for more than 1 day, have been studied. The inundated areas are scattered by small lumps. They are grouped and shown in *Fig. 9.3.4.*

In the west part of the study area, the poor drainage area is distributed along the Rio Yapacani, the lower basins of the Rio Palacios and Rio Palametillas and their tributaries. They are mostly distributed in the low lying area.

The areas along Arroyo Yapacanicito, Arroyo Jochi and Arroyo Tacuaral, are affected by floods from those rivers and also encounter drainage problems.

In the central north part, there are areas that suffer from inundation with a long duration almost over the entire area. The area between the Rio Pirai and the right bank of the Rio Chane is a heavy inundation area. The area is mostly inundated by flooding from the Rio Pirai and the Rio Chane and also suffers poor drainage of storm water.

In the central south area, the inundated areas are scattered by small lumps, but the degree of inundation, indicated by depth and duration of inundation, is comparatively low. This area has no serious drainage problems, because it has favorable topographic condition such as higher ground levels and steeper slopes.

There is an inundation area along the southern side of the national road No.9. The embankment of the national road functions as a dike against the runoff from the upper reach and causes the inundation. This condition will be improved with the bridge construction project, to construct seven (7) bridges along the national road No.9.

In the east part of the study area, there is a frequent inundation area identified along the Rio Chane and the left bank of the Rio Grande.

For the Rio Pailon basin, the area upstream of the confluence of the Rio Pailon and the Arroyo Honda is frequently inundated by floods from these rivers.

The left bank of the Rio Grande, where there is a natural levee of the Rio Grande, is a heavy inundation area with a long duration. The upper part of this area also suffers from frequent inundation, but the depth and duration are low and short.

9.4 Examination of Drainage Improvement Area

Conforming the flood mitigation plan, the drainage improvement areas are divided into the followings:

West part: San Juan Antofagasta area

-1 San Juan area, including Lower Yapacanicito area,

-2 Antofagasta area.

East part: Chane Pailon area

-3 Las Chacras-Chane area,
-4 Area along Rout No.9
-5 Pailon area
-6 Okinawa
-7 Other area

(1) West Part: San Juan Antofagasta area

1) San Juan area

The drainage problems are caused by floods from the Arroyo Yapacanicito, Arroyo Tejeria and Arroyo Jochi.

In order to improve the situation, the improvement of river channels for Arroyo Tejeria and Arroyo Yapacanicito, and the rehabilitation of the existing drainage facilities are required. However, for most part of the lower reach of Arroyo Yapacanicito, non-structural measures are required in consideration to the existing land use.

2) Antofagasta area

In order to mitigate the drainage problems of the area the improvement of river channels and natural drains, and the development of secondary drainage network are required.

The swampy area in the lower reaches of Arroyo Jochi and Arroyo Tacuaral should be used as a retarding basin in order to minimize the likely impacts by the improvement works in the downstream area.

The west part of the area has a serious drainage problem, with deep inundation and long duration. The major drainage problems are caused by floods from Arroyo Jochi and Arroyo Tacuaral and by the lack of drainage facilities.

3) Other areas

The land use of the areas, including Palasios area, is still extensive and mainly used as forest cover and grazing lands. The areas are likely protected by the non-structural measures, because the flood and drainage problems are still not that significant.

(2) East Part: Chane Pailon area

1) Las Chacras-Chane area

To improve the flood and drainage problem, the improvement of the Quebrada Las Chacras and the Rio Chane, and the development of drainage networks are required.

2) Area along Route 9

The channel improvement works for Las Maras, Rancho Chico, Chaco and El Empalme are required, because this area is expected to be influenced by some increse of runoff caused by the bridge construction project of the national road No.9.

3) Pailon area

This area is affected by floods from the Rio Pailon and the inadequate drainage facility. In order to improve the situation, besides the river improvement works for the Rio Pailon, the development of secondary drainage network is required.

4) Okinawa

This area has a drainage network, but the discharge capacity is assessed to be insufficient.

In the upstream reach along the national road No.9, the road embankment dams up and causes a deep inundation with long duration. The flood water flows over the road and causes floods in the downstream reach as well.

In order to improve the drainage problems, construction of cross drains across national road No.9 and the development of one drainage network are required. The assumed old trace of the Rio Grande should be used as a drainage main.

5) Other areas

The areas are located in the upper reach of the Rio Pailon and the tributaries of the Rio Chane. The areas also suffer from local flood and drainage problems, but the flood damages are likely not so significant as in the other areas. Some of the habitual inundation areas, or swampy areas, could be used as retarding basins. In order to improve and to stabilize these areas, non-structure measures such as proper farm land management and farming system are required.

9.5 Drainage Improvement Plan

9.5.1 Basic Concept

In order to solve the drainage problems, flood mitigation measures and drainage improvement measures should be planned in tandem.

The basic concept of the drainage improvement plan is shown in *Table 9.5.1* and *Fig. 9.5.1*.

9.5.2 Design Criteria

(1) Allowable Inundation Depth for Crop

For the drainage improvement plan, it is reasonable to consider an allowable inundation depth for crops. According to the study on the flood damage for crops by the Study Team, the allowable inundation depth is planned to be 30 cm.

(2) Design Scale

The design scale of drainage improvement is planned as follows:

- The design scale for the drainage facility is decided to be from 2-year to 5-year frequency: with no inundation depth at 2-year storm frequency and with allowable inundation depth at 5-year storm frequency.

(3) Canal Classification

The planned drainage canal is specified by its role in the drainage system. The drainage main is specified as the primary drainage canal that drains directly to the drain river, and the secondary drainage canal is the canal to drain to the drainage main.

(4) Design criteria

1) Rainfall Intensity

The rainfall intensity formulas within 24 hours are estimated from the formula in Santa Cruz and Okinawa-2 based on the hydrological study conducted by the Study Team.

2) Runoff analysis

For the runoff analysis for planning of drainage facilities the rational formula, one of the conventional methods suitable for small basins, is applied.

The lag time in the basin is estimated by the CBR formula, developed in the United States, that is applied to the hydraulic analysis of the river system.

The runoff coefficient of 0.5 is adopted to this analysis taking into account of the condition of the area, that is a plain agricultural area.

3) Flow condition analysis

The flow condition of proposed drainage canal is evaluated by the cross sectional discharge capacity. The discharge capacity is estimated by the Manning Formula. In the formula, the roughness coefficient of 0.030 is applied for the proposed canal.

9.5.3 Facility Plan for Structural Measures

(1) Drainage main

The proposed drainage mains are as follows:

- Arroyo Tejeria,
- San Juan drainage mains,
- Antofagasta drainage main,
- Chane drainage mains,
- Okinawa drainage main.

As for Sun Juan drainage mains, the following two alternatives are planned:

a) Alternative-1

The drainage mains are planned to fulfill the existing capacities by rehabilitation and the excess runoff is planned to be diverted to Arroyo Yapacanicito by diversion weirs.

b) Alternative-2

The drainage mains are planned to facilitate the discharge of the whole design runoff from ones own subcatchment.

(2) Secondary Drainage

Secondary drainage canals are planned as follows:

- Each canal length : 2-3 km long from drainage main or drainage river,
- Drainage area of each drainage canal: 5.0 sq. km,
- Canal density: 0.4 km/sq. km

The total length of drainage canal at each drainage area is estimated based on the case study conducted in the Chane Drainage Basin and Okinawa Drainage Basin.

$$\Sigma L\ km = A_{BASIN}\ km^2 \times 0.40\ km/km^2 \times 0.75$$

whereby,

ΣL : Canal Volume of Length (km)
A_{BASIN} : Area of Basin (km^2)

(3) Drainage Channels for Crossing the National Road No.9

The drainage planned to be improved or developed are as follows:

- Las Maras Channel,
- Rancho Chico Channel,
- Chaco Channel,
- El Empalme II Channel.

The drainage channels are designed as same as the drainage main.

The facility plan of drainage main, secondary drainage and drainage channel for crossing the national road No.9 are shown in *Table 9.5.2* and *Fig. 9.5.2*.

9.5.4 Non-structural Measures for Drainage Improvement

Non-structural measures aim to avoid the deterioration of the poor drainage area by proper management measures where structural measures are not feasible. The non-structural measures from the drainage improvement aspects, an introducing water proof farming system and an instruction of proper farm land management are proposed.

a. Introducing water proof farming system

It is important to introduce appropriate planting program due to the drainage situation to mitigate damages caused by the poor drainage condition.

b. Instruction of proper farm land management

An instruction of proper farm land management to improve on-farm drainage condition as follows is to be applied to the agricultural extension program.

- Conservation of natural streams and small drains in field at developing farm land
- Proper installation of cross drains for farm road not to obstruct surface drainage
- Improvement of penneability in field by altering cultivation method
- Proper land leveling and introducing ridging to prevent crop submergence

Those non-structural measures for drainage improvement are also required to be introduce in the area to be improved by structural measures.

The area to be introduced non-structural measures by itself is classified into 4 (four) groups corresponding to the land use and drainage condition.

The lower Chane basin and Okinawa 2 area are belong to Group A, which is classified as an intensive upland crop area with heavy and middle drainage problem. A farm land management and a farming system management are required as major measures.

The south-east part of the study area is grouped into Group B, that is an intensive upland crop area mainly for sugarcane with middle and clement drainage problem. In this area, farm land management such as conservation of natural streams and small drains is major measures to improve and conserve on-farm drainage condition.

The lower Palacios and Palometillas basin grouped into Group C, that is a forestry and grazing area with heavy and middle drainage problem, while the upper Palacios basin and the upper south-east part are grouped into Group D, that is a grazing and upland crop area with middle and clement drainage problem. For these groups, the proper farming system such as introducing appropriate planting program or suitable crop variety for the drainage condition is applied as major non-structural measures for drainage improvement.

Major non-structural measures proposed are shown in *Table 9.5.3* and *Fig. 9.5.3*.

TABLES

Table 9.5.1 BASIC PLAN OF DRAINAGE IMPROVEMENT

Area	Condition of Drainage	Drained River	Concept for Drainage Improvement
West Part San Juan Area	Drainage Mains are constructed by the colony which function effective for small scale runoff. Water from the outer basin makes inundation condition worse.	Rio Yapacani (Drainage Mains) Arroyo Yapacanicito	To prevent intruding water from outer basin by, •Improving the capacity of Arroyo Tejeria, •Improving the capacity of Arroyo Jochi, •Preparing dike between A. Yapacanicito and A. Jochi, To improve drainage capacity, •Improving the capacity of Arroyo Yapacanicito, •Rehabilitation of existing drainage mains, •Developing secondary canal networks.
Lower Yapacanicito Area	Flooding from A. Yapacanicito and influenced by the back water from Rio Yapacani	Arroyo Yapacanicito	Introducing non-structural measures
Antofagasta Area	Flooding from A. Jochi and A. Tacuaral. Lack of drainage network and dam up by road and railway embankment enhances inundation.	Arroyo Jochi Arroyo Tacuaral Rio Palacious	To improve drainage capacity, •Improving A. Jochi and A.Tacuaral, •Providing drainage main at central area, •Developing secondary canal networks. To prevent influence of drainage improvement to lower area, the swamp area is conserved as retarding basin.
Palacious Area		Rio Palacious A. Jochi / A. Tacuaral	Introducing non-structure measures
East Part Chacras - Chane Area	Suffered by long and deep inundation caused by flooding from Rio Chane and Quebrada Chacras. This area has a remarkably low density of drainage channel. Lower reach of Rio Chane is influenced by the back water from Rio Piray.	Rio Chane Quebrada Chacras	To improve drainage capacity, •Improving Quebrada Chacras, •Providing drainage mains connected to Rio Chane, •Developing secondary drainage networks. Lower Rio Chane area is corresponded by non-structural measures.
Area along Route 9	The condition of the upper side of Route 9 is expected to be improved remarkably by the proposed bridge project. On the other hand, the lower side of Route 9 will have increased discharge from the upper side and inundation deterioration. .		To prevent the influence of increased discharge from upper reach, •Improving existing water courses, •Preparing drainage channels connected to bridges which do not have drainage channel.

Table 9.5.1 BASIC PLAN OF DRAINAGE IMPROVEMENT

Area	Condition of Drainage	Drained River	Concept for Drainage Improvement
Southern Area of Route 9			Introducing non structural measures
Pailon Area	This area is influenced flooding from Rio Pailon caused by shortage of capacity and drainage problem caused by lack of density of drainage network in the basin.	Rio Pailon	Preparing secondary drainage network while Rio Pailon channel improvement.
Okinawa Drainage Area	Lack of density of drainage network and discharge capacity of drainage main causes clement inundation. Route 9 embankment causes dam up and makes inundation long and deep along the road.	Okinawa Drainage Main → Rio Grande Former Course	**Lower Reach from Route 9** •Providing drainage main network making full use of existing drainage channel and drain water into Rio Grande Former Course, •Extending lowest reach of drainage channel up to Rio Grande Former Course. **Along Route 9** •Improving cross drain so as to discharge stagnant water and decrease long and deep inundation, •Discharge at Route 9 is planned to be limited and regulating effect is expected so that water from the upper basin will not bear excess burden to the lower basin. **Remained Area** •The remained area of the upper basin will not benefit remarkably by the drainage main and non-structural measures is planned to be introduced in this area.

Table 9.5.2 DRAINAGE IMPROVEMENT PLAN BY STRUCTURE MEASURES

Area	Improvement Plan	Facility Plan		Remained Inundation Depth
		Drainage Main	Secondary Drainage	
SAN JUAN Tejeria Basin	Channel Improvement of Aroyyo Tejeria and replacement of cross drains at San Juan Main Road so as to discharge water and prevent water stagnating. Preparing secondary drainage network to correct rainwater and discharge to the drainage main.	Channel improvement of A. Tejeria : L = 7.1 km W = 16.0 ~ 22.0 m D = 3.0 ~ 4.0 m S = 1/2.0 Bridge Replacement 2 pcs	A = 24 km^2 L = 7 km W = 12.0 m D = 3.0m Culvert 4pcs	2-year flood no inundation 5-year flood 0.09 m
San Juan Drainage Main (Alternative 1)	Drainage Mains take charge of runoff corresponding to existing discharge capacity, and excess water is planned to overflow to the lower reach and Arroyo Yapacanicito. •Rehabilitation of existing canals Clearing in the canal section and area for maintenance Slope reforming Dredging canal bed •Preparing diversion facility to flow over the excess water to the lower reach and A. Yapacanicito	Rehabilitation of existing canal : L = 34.2 km Diversion weir : B = 8.0 ~ 15.0 m 4 pcs		2-year flood no inundation 5-year flood 0.11 m
(Alternative 2)	Improving and widening existing canal so as to discharge rainwater in own basin by the canal and not to flow over to the lower reach. •Improvement and widening existing canals •Improvement of outlet culvert to Rio Yapacani	Channel improvement : L = 34.2 km W = 14.0 ~18.0 m D = 3.0 m S = 1/2.0 Replacement of outlet culverts 3.0 m x 3.0 m x 3 ~ 3.5 m x 3.0 m x 3 5 pcs		2-year flood no inundation 5-year flood 0.15 m

Table 9.5.2 DRAINAGE IMPROVEMENT PLAN BY STRUCTURE MEASURES

Area	Improvement Plan	Facility Plan		Remained Inundation Depth
		Drainage Main	Secondary Drainage	
A. Yapacanicito Basin	A. Ypacanicito is planned to be improved in the river improvement plan. Secondary drainage network is planned to be applied.		A = 91 km2 L = 27 km W = 14.0 m D = 3.0 m Culvert 3 pcs	2-year flood no inundation 5-year flood 0.11 m
ANTOFAGATA Antofagasta Basin	A. Jochi and A. Tacuaral are planned to be improved in the river improvement plan. In the east part of Antofagasta area, drainage main is planned to be prepared using existing natural stream so that the density of drained river / drainage main is to be supplemented. Secondary drainage network is also planned to be introduced. For the east part from Antofagasta Main Road, preparing cross drains is recommended.	**Antofagasta Drainage Main** Channel Improvement of natural water course : L = 10.0 km W = 25.0 ~ 28.0 m D = 4.0 m S = 1/2.0 Bridge Replacement 1 pc	A = 97 km^2 L = 30 km W = 14.0 m D = 3.0 m Culvert 19 pcs	2-year flood no inundation 5-year flood 0.03 m
CHANE - CHACRAS Q. Chacras Basin	Q. Chacras, which is recognized as drainage main in this area, is planned to be improved in the river improvement plan. Secondary drainage network to correct rainwater and discharge to the drainage main is planned. Existing branches of the quebrada and natural streams are to be fully used for preparing secondary drainage network.		A = 140 km^2 L = 42 km W = 12.0 m D = 3.0 m Culvert 21 pcs	

Table 9.5.2 DRAINAGE IMPROVEMENT PLAN BY STRUCTURE MEASURES

Area	Improvement Plan	Facility Plan		Remained
		Drainage Main	Secondary Drainage	Inundation Depth
Chane Drainage Basin	To resolve water stagnant caused by remarkably low density of drainage network in this area, two drainage mains discharging water at Rio Chane are proposed. Secondary drainage network is also proposed to supplement the function of drainage mains.	Chane Drainage Main 1 L = 13.5 km W = 25.0 ~ 35.0 m D = 3.0 ~ 3.5 m S = 1/2.0 Bridge 6 pcs Chane Drainage Main 2 L = 8.0 km W = 25.0 ~ 35.0 m D = 3.0 ~ 3.5 m S = 1/2.0 Bridge 2 pcs	A = 144 km^2 L = 44 km W = 12.0 m D = 3.0 m Culvert 22 pcs	2-year flood no inundation 5-year flood 0.16 m
RIO PAILON Rio Pailon Basin	Rio Pailon is planned to be improved in the river improvement plan. To correct water and discharge to the drained river, secondary drainage network is proposed to be introduced in the drainage problem area.		A = 50 km^2 L = 16 km W = 12.0 m D = 3.0 m Culvert 8 pcs	
OKINAWA DRAINAGE Okinawa Drainage Basin	Rainwater in the Okinawa Drainage Basin is planned to discharge to Rio Grande Former Course through Okinawa Drainage Main. Discharge at Route 9 is planned to be limited by cross drain and regulating effect at road embankment is anticipated in the plan so as to mitigate a burden of the lower reach. Secondary drainage network is also proposed to be introduced to enhance the effect of the drainage main.	Okinawa Drainage Main L = 21.0 km W = 16.0 ~ 35.0 m D = 3.0 ~ 4.0 m S = 1/1.5 ~ 1/2.0 Bridge 2 pcs Box Culvert 4 pcs	A = 147 km^2 L = 46 km W = 12.0 m D = 3.0 m Culvert 23 pcs	Downstream R9 2-year flood no inundation 5-year flood 0.23 m Upstream R9 2-year flood no inundation 5-year flood 0.94 m

Table 9.5.2 DRAINAGE IMPROVEMENT PLAN BY STRUCTURE MEASURES

Area	Improvement Plan	Facility Plan		Remained
		Drainage Main	Secondary Drainage	Inundation Depth
DRAINAGE CHANNEL FOR JICA/SNC BRIDGE CONSTRUCTION PROJECT				
Las Maras	Channel Improvement	L = 8.0 km W = 25.0 m D = 3.0 m S = 1/2.0		
Rancho Chico	Preparing Drainage Channel	L = 1.0 km W = 30.0 m D = 3.0 m S = 1/2.0		
Chaco	Preparing Drainage Channel	L = 2.0 km W = 30.0 m D = 3.5 m S = 1/2.0		
El Empalme II	Preparing Drainage Channel	L = 3.5 km W = 18.0 m D = 3.0 m S = 1/2.0		

Table 9.5.3 NON-STRUCTURAL MEASURES FOR DRAINAGE IMPROVEMENT

Group	Classification	Major Non-structural Measures
Group A	Intensive upland crop area with heavy and middle drainage problem	Introducing appropriate planting program corresponding to the situation of inundation. Instruction of proper farm land management to improve on-farm drainage condition; Conservation of small natural streams on field. Development of cross drain of farm road. Improvement of permeability on field. Land leveling. Introducing ridging to prevent crop submergence. Stabilizing seeding and harvesting time in dry season cropping; Introducing supplemental irrigation.
Group B	Intensive upland crop area mainly for sugarcane with middle and clement drainage problem	Instruction of proper farm land management to improve on-farm drainage condition; Conservation of small natural streams on field. Development of cross drain of farm road. Land leveling. Introducing ridging to prevent crop submergence.
Group C	Forestry and grazing area with heavy and middle drainage problem	Introducing appropriate planting program corresponding to the situation of inundation. Abstention from large scale development.

Table 9.5.3 NON-STRUCTURAL MEASURES FOR DRAINAGE IMPROVEMENT

Group	Classification	Major Non-structural Measures
Group D	Grazing and upland crop area with middle and clement drainage problem	No remarkable damage from drainage problem at present condition. To preserve the present land use condition so as not to increase runoff and put a discharge to the lower reaches.
Structural Measures Introduced Area		Instruction of proper farm land management to improve on-farm drainage condition; Conservation of small natural streams on field. Development of cross drain of farm road. Land leveling. Introducing ridging to prevent crop submergence.
(Retarding Basin)		Prohibition of intensive and large scale development to conserve the function of retarding basin in the river basin.

FIGURES

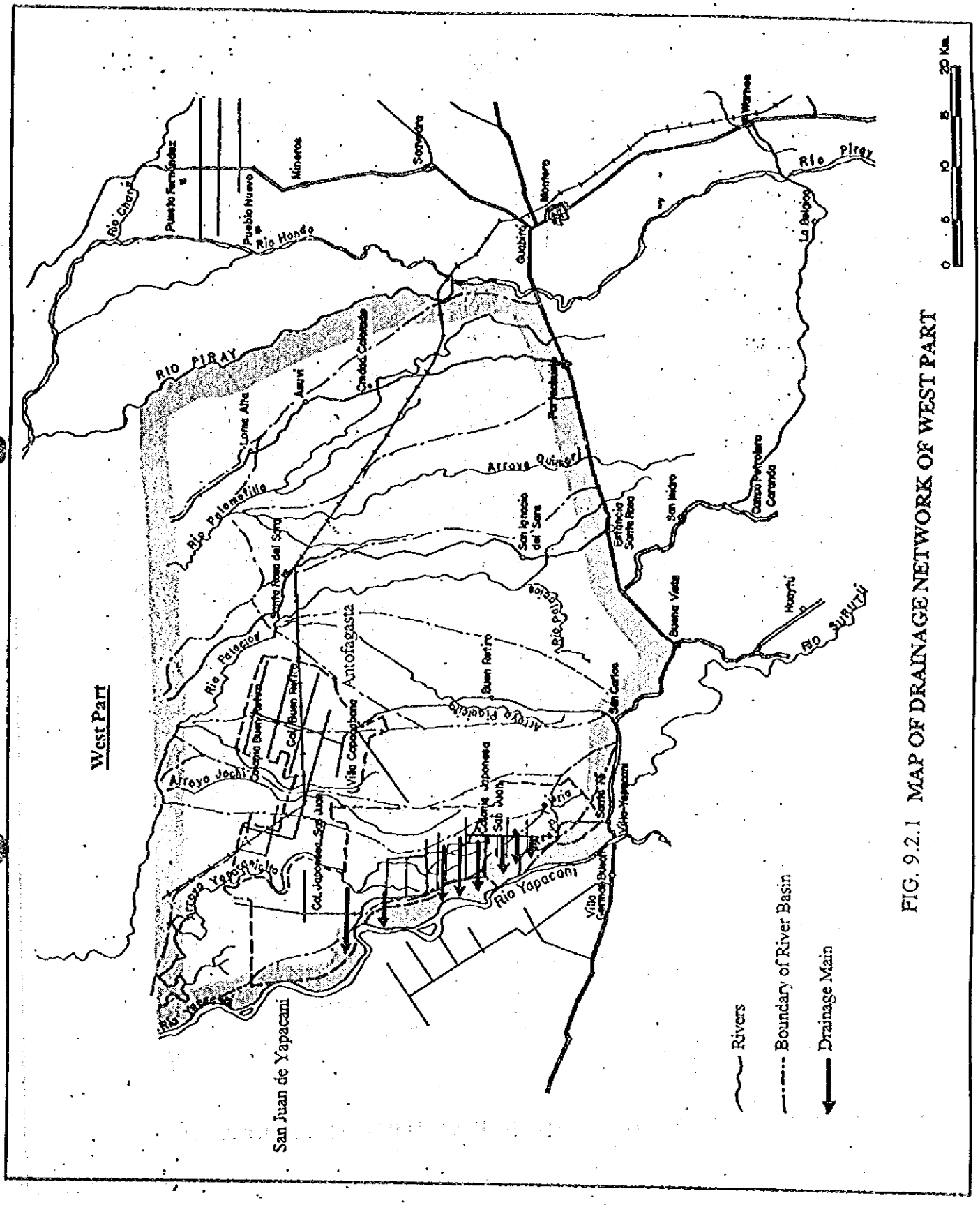


FIG. 9.2.1 MAP OF DRAINAGE NETWORK OF WEST PART

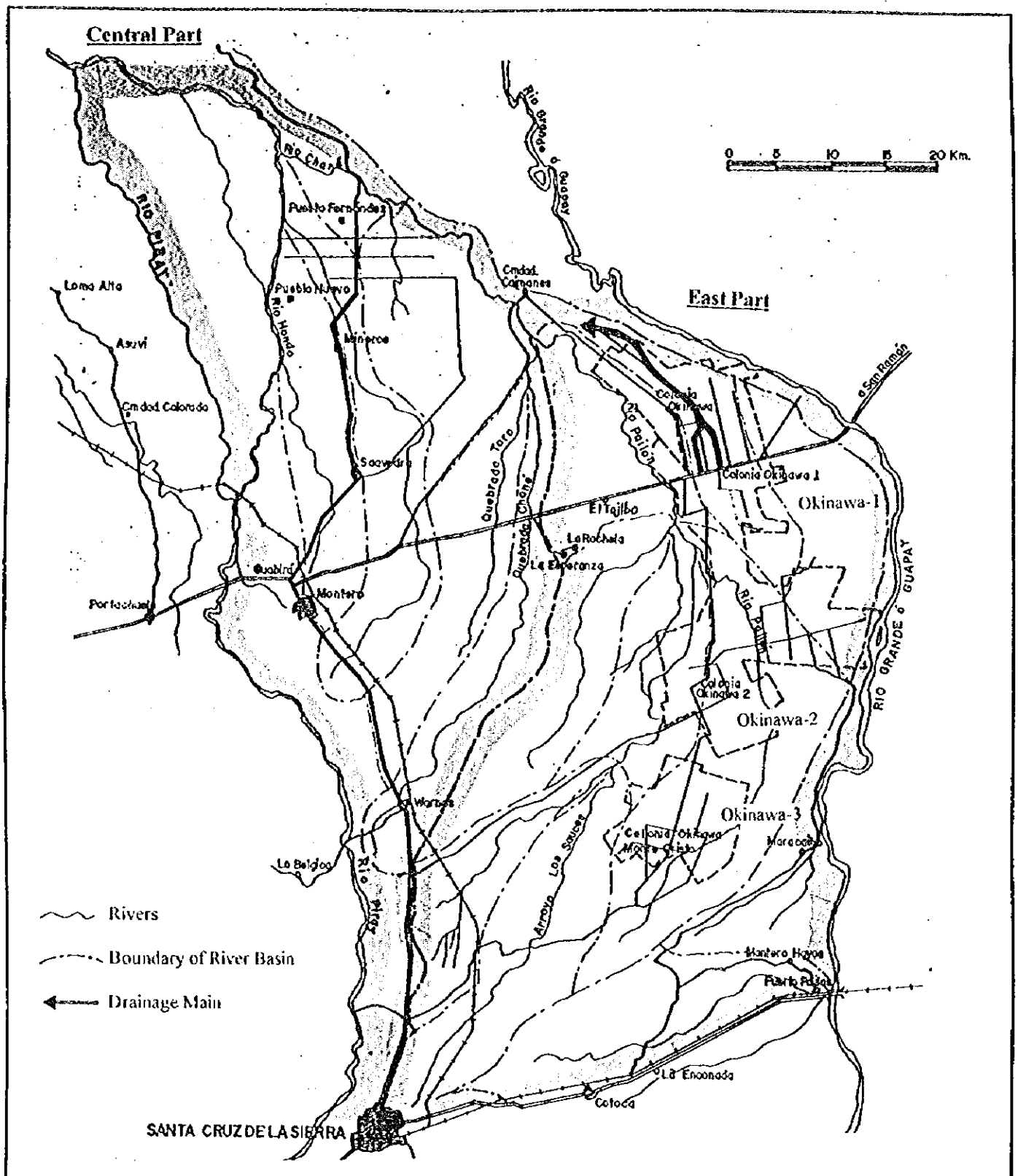


FIG. 9.2.2 MAP OF DRAINAGE NETWORK OF CENTRAL AND EAST PART

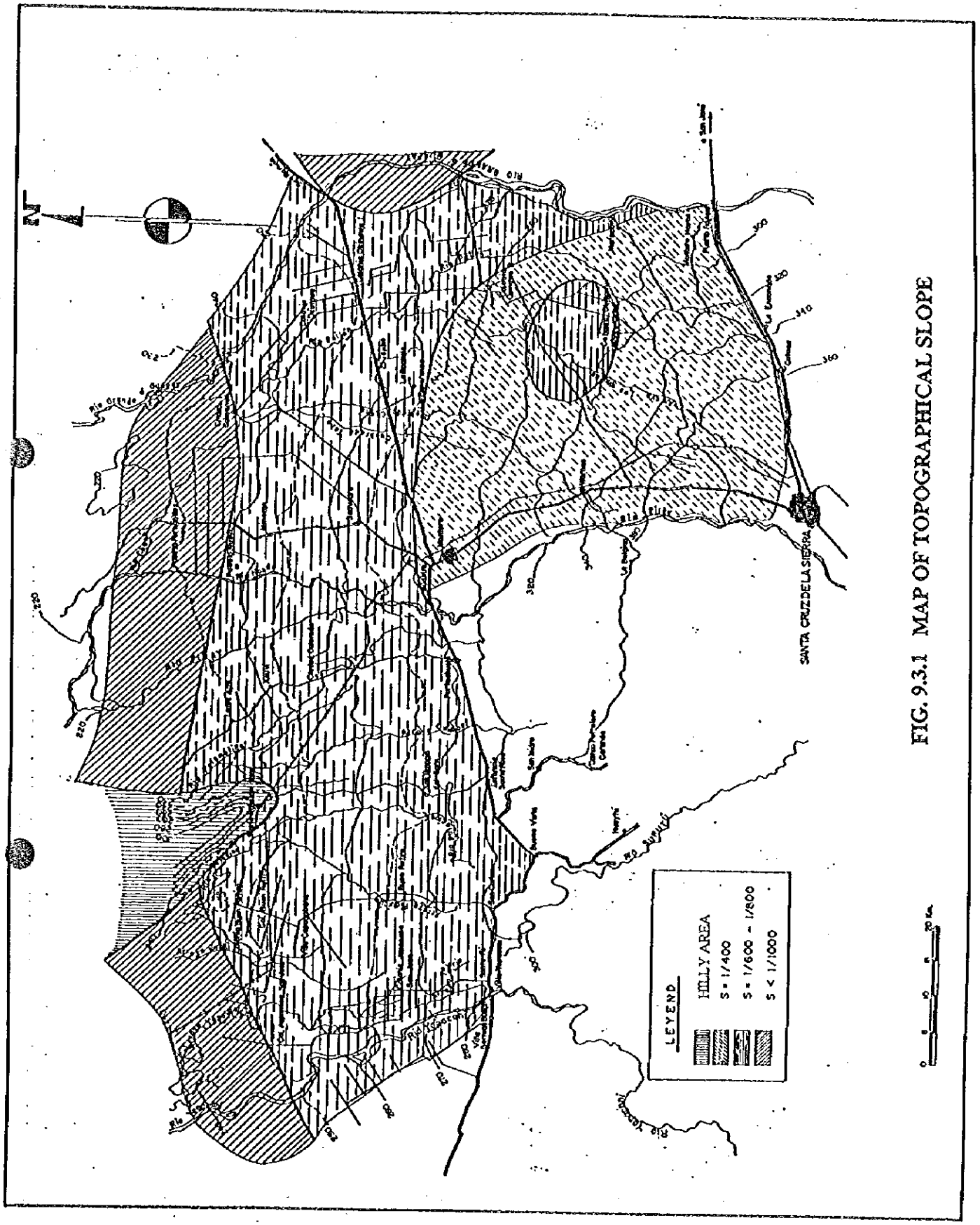


FIG. 9.3.1 MAP OF TOPOGRAPHICAL SLOPE

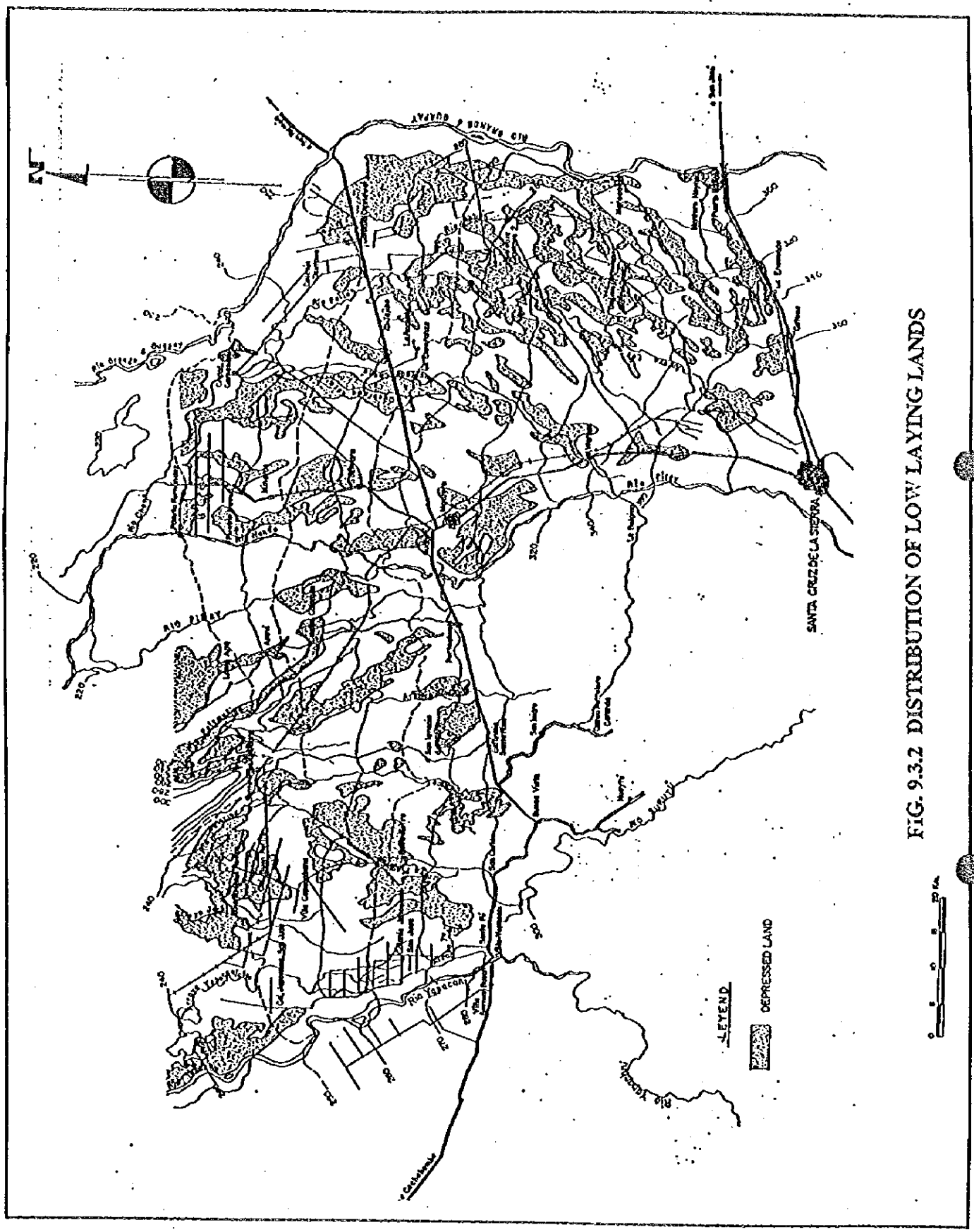


FIG. 9.3.2 DISTRIBUTION OF LOW LAYING LANDS

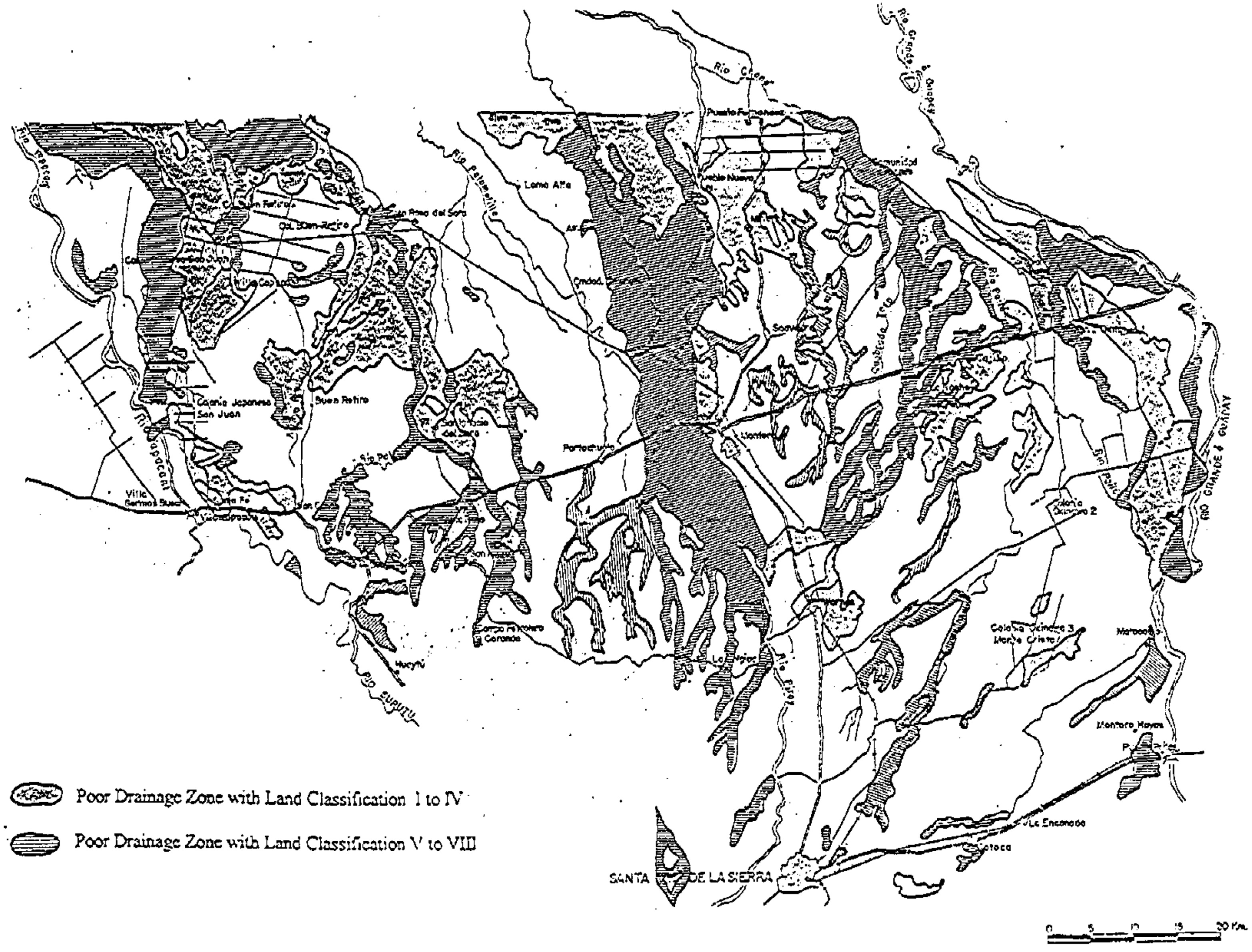


FIG. 9.3.3 MAP OF POOR DRAINAGE ZONE

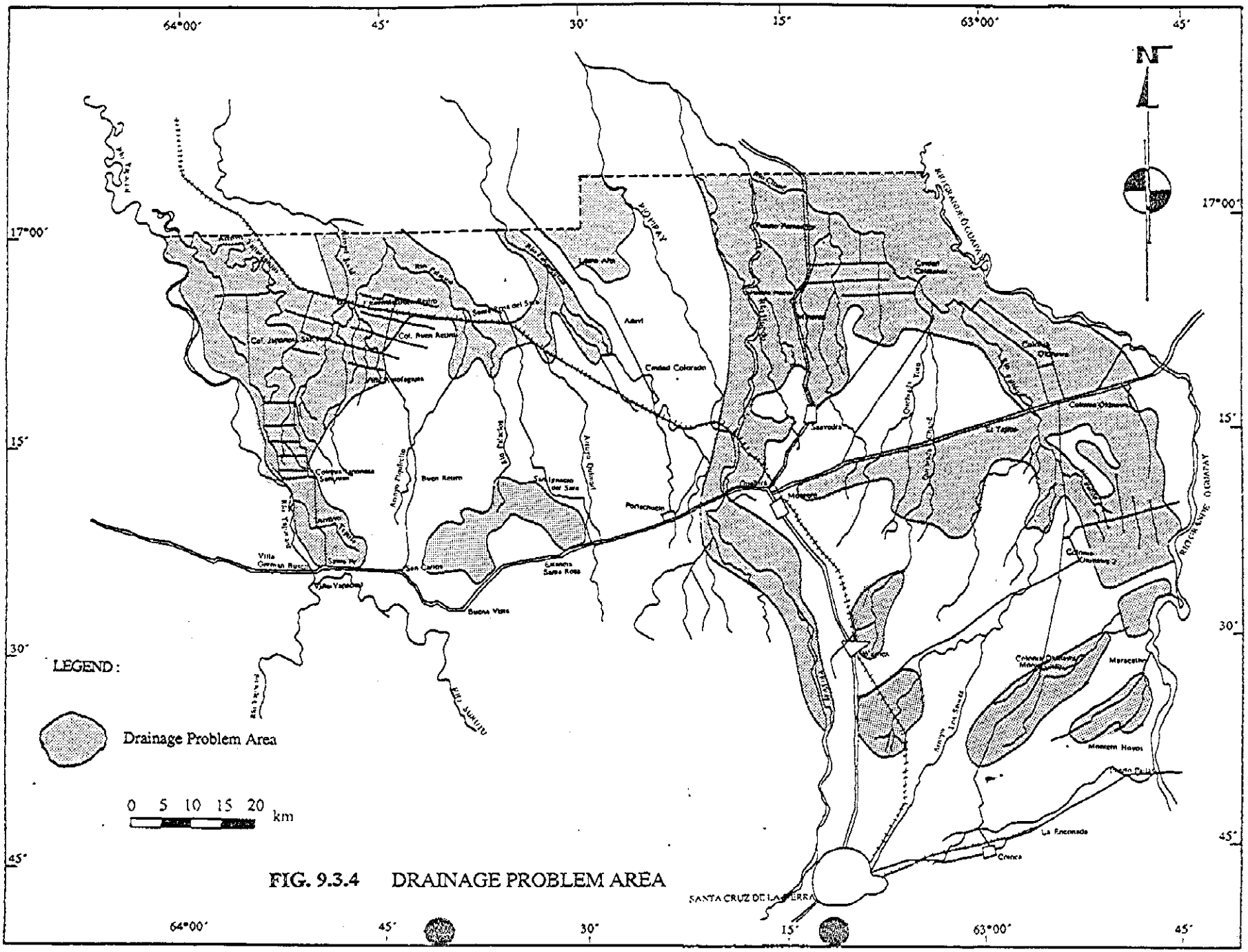


FIG. 9.3.4 DRAINAGE PROBLEM AREA

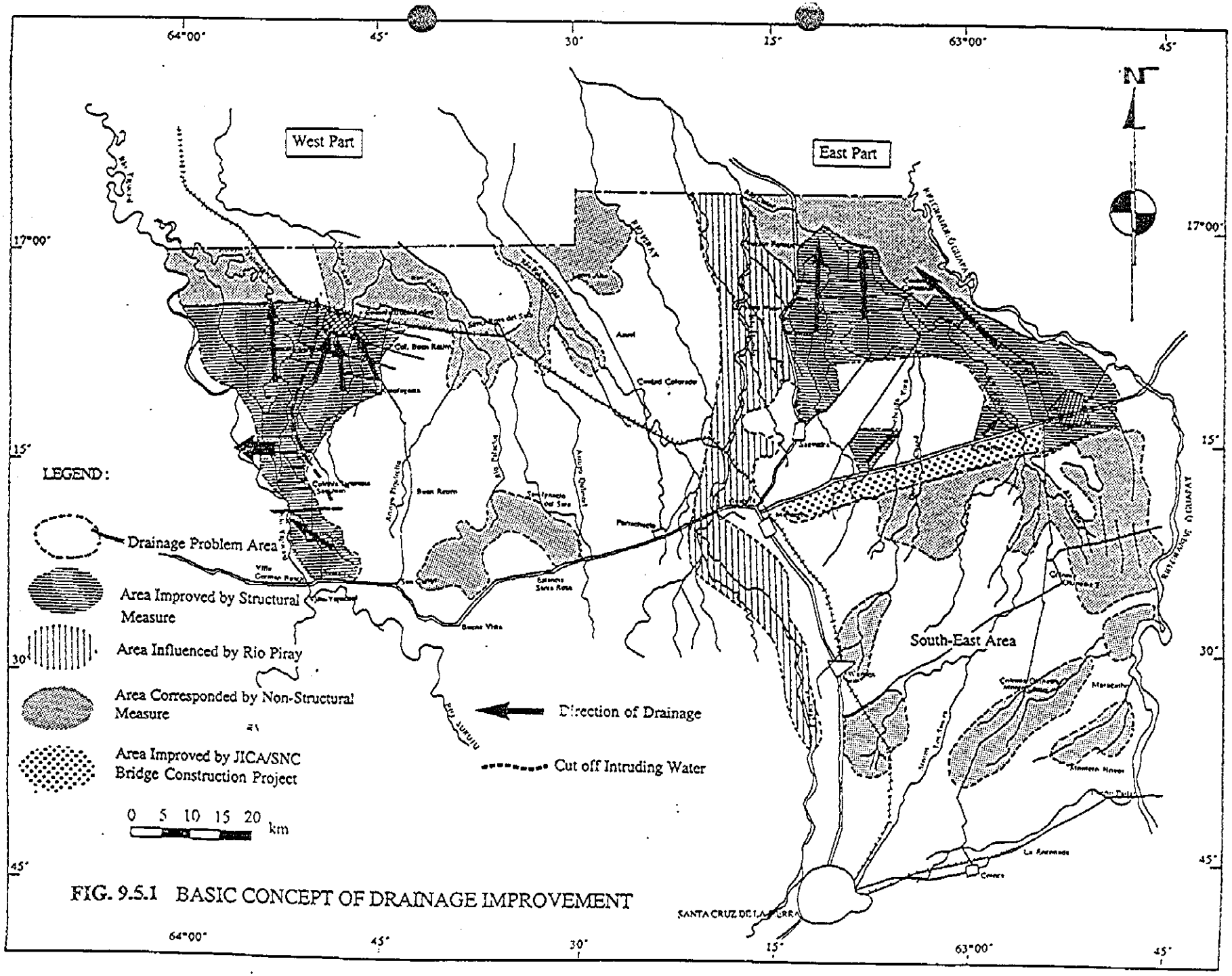


FIG. 9.5.1 BASIC CONCEPT OF DRAINAGE IMPROVEMENT

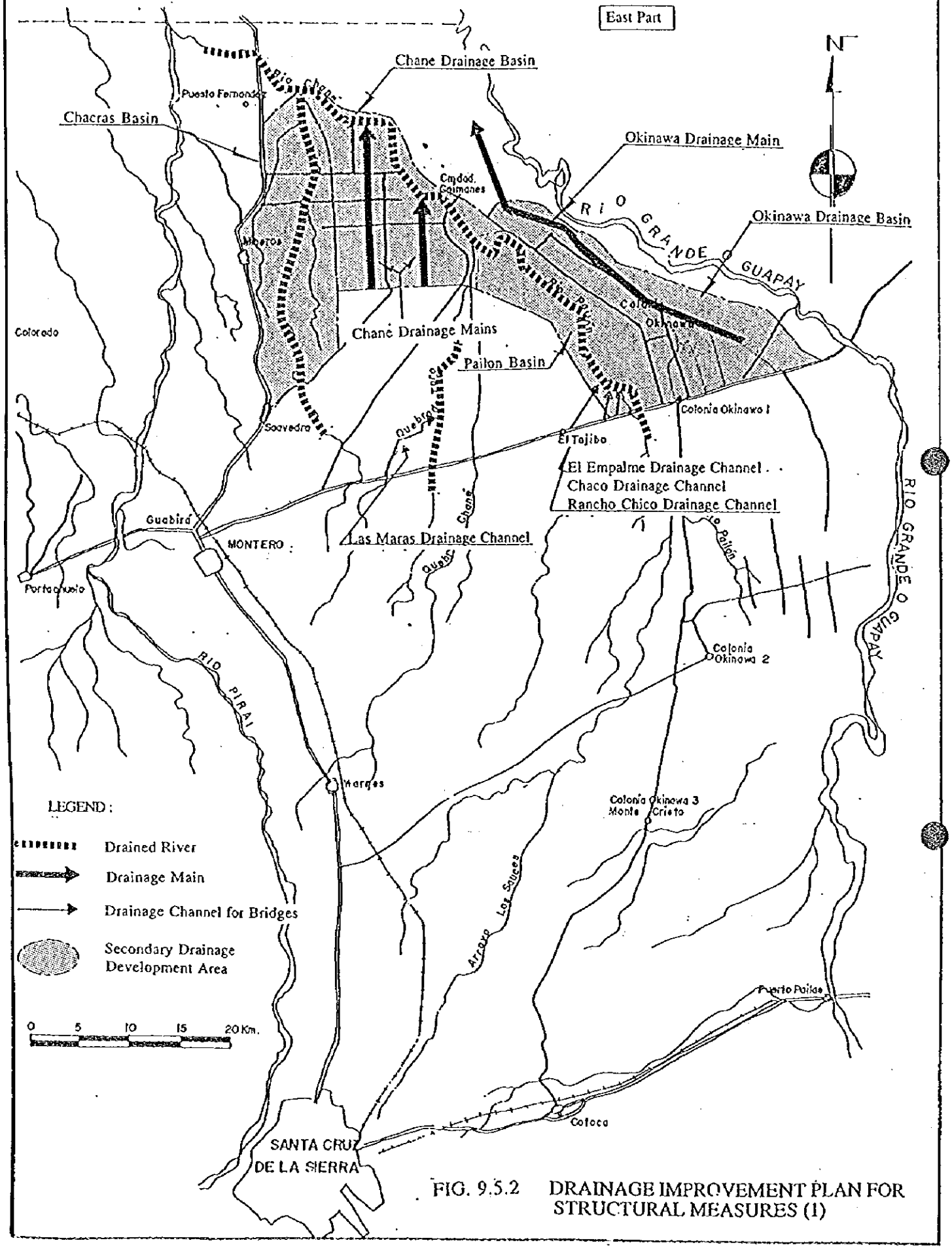


FIG. 9.5.2 DRAINAGE IMPROVEMENT PLAN FOR STRUCTURAL MEASURES (1)

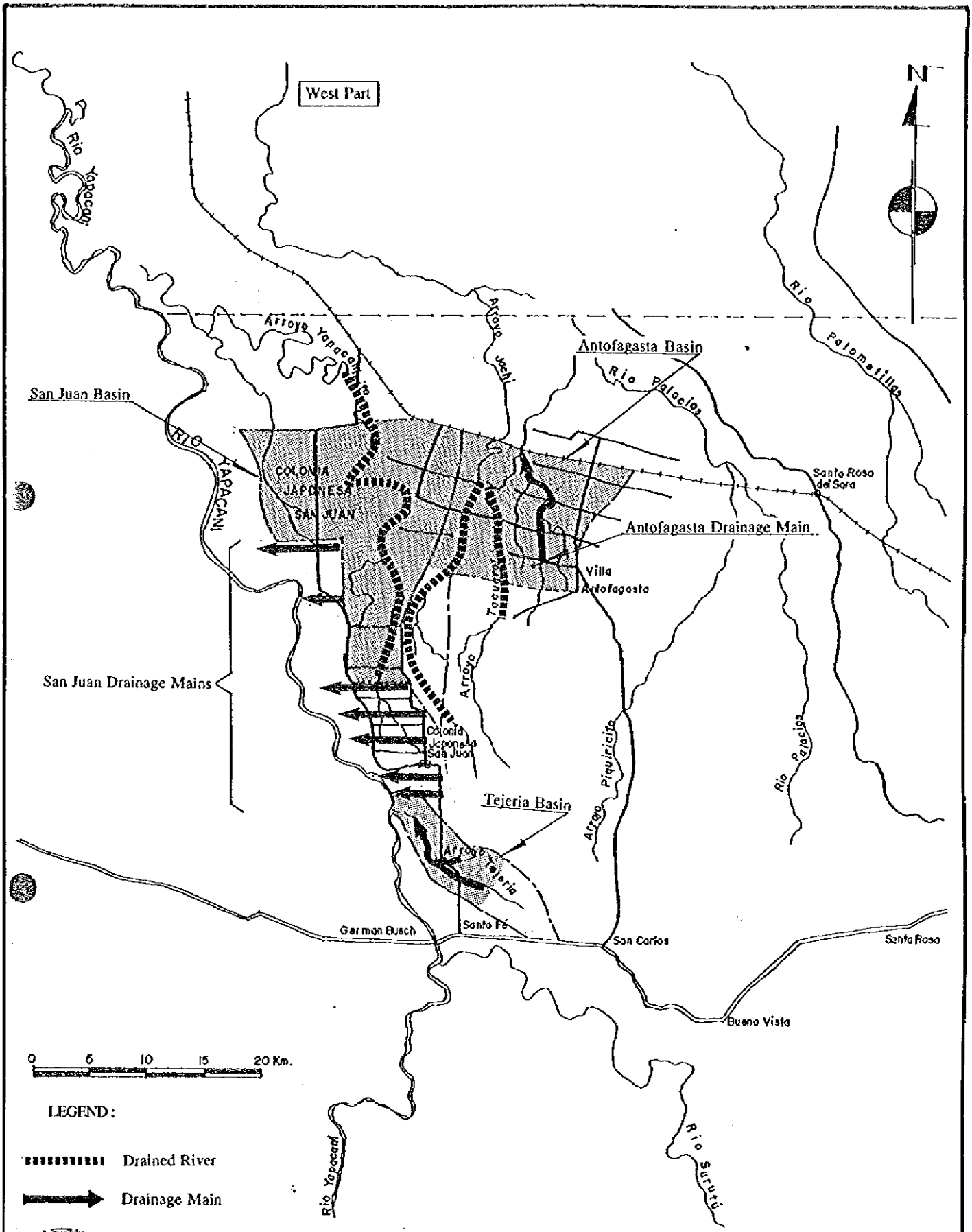


FIG. 9.5.2 DRAINAGE IMPROVEMENT PLAN FOR STRUCTURAL MEASURES (2)

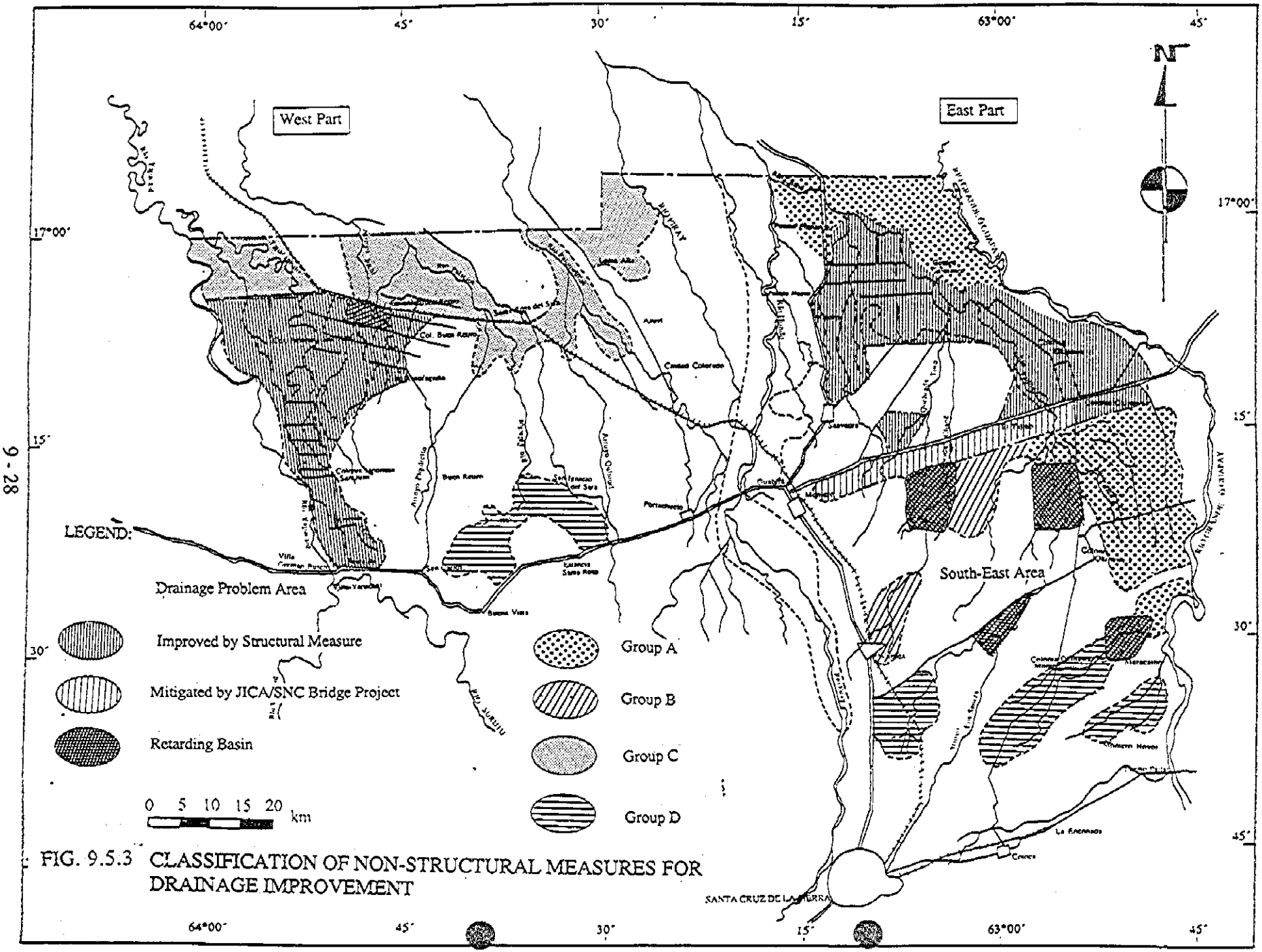


FIG. 9.5.3 CLASSIFICATION OF NON-STRUCTURAL MEASURES FOR DRAINAGE IMPROVEMENT

CHAPTER 10
ENVIRONMENT

CHAPTER 10 ENVIRONMENT

10.1 General

Every flood mitigation measure has some effects on the environment. Environmental law and regulation are briefly summarized and natural environmental conditions in the study area are investigated. Environmental impacts are assessed as the initial environmental examination (IEE).

Water quality was also analyzed at some selected points along the rivers in the study area to obtain information about the degree of water pollution.

10.2 Law and Regulations Related to Environment

10.2.1 Natural Environmental Law

The Natural Environmental Law (Modified by Law of Ministries of the Executive Power) No. 1,333 dated April 27, 1992, was the starting point to deal with environmental issues in a global and systematic manner. The objective of the law is the protection and conservation of the natural environment and natural resources. It regulates the action of man related to nature and promotes the sustainable development in order to raise the quality of life. Sustainable development means the process by which the necessities of the present generation are satisfied without risking the satisfaction of necessities for the future generations. The sustainable development is a global and permanent task. Natural environment and natural resources are the nation's patrimony, their protection and utilization are regulated by law. The law is public order, of social, economic and cultural interest.

The Natural Environmental Law establishes the principles for protection, conservation and restoration of both terrestrial and aquatic wild fauna and flora.

10.2.2 Environmental Impact Assessment

Environmental impact assessment (EIA) is applied as a set of management procedures to determine the effects of certain actions on the natural environment. It establishes the management process that should follow the tasks or activities in order to comply with the EIA.

SEMMA (Secretaria Nacional del Medio Ambiente) and SEDAMA (Secretarias Departmentl del Medio Ambiente) are in charge of controlling the compliance of EIA. Specific regulations are established to govern the administrative and legal aspects of EIA.

In May 1994 the Ministry of Sustainable Development and Environment approved a provisional rule of EIA to set up the environmental card (FA) as an instrument of categorization of EIA. At present other plans are being prepared such as regulation of prevention and control of the environmental quality, which defines the procedure for EIA, as well as control mechanisms for activities, works and projects.

10.3 Natural Environment in the Study Area

10.3.1 Ecological Areas

In the study area there are five ecological zones as follows:

- Tropical humid zone,
- Tropical highly humid zone to subtropical transition zone,
- Sub-tropical humid zone,
- Very humid subtropical zone,
- Mid humid zone.

10.3.2 Vegetation and Wild Fauna

In the northern part of the study area, different types of forests, medium, high and very high forests, still prevail along many rivers. In the central and southern areas secondary forests, savannas with low trees and pastures prevail, and in those areas impacts due to human intervention are evident.

The micro-region has areas with a high or very high ecological value. Rare flora and fauna and a variety of species are very important, as well as valuable characteristic biotopes, and require conservation.

There are regions with a very high ecological value:

- Protected area of Serrania Santa Rosa,
- Protected area of Bandos Rio Grande, Rio Pirai, and Laguna Bella,
- River protection areas of Rio Pirai, Rio Grande, Rio Surutu, and Rio Yapacani.

10.4 Initial Environmental Examination (IEE)

10.4.1 Role of IEE

The environmental impacts by the project proposed in the Master Plan, are assessed based on the available information.

The objective of IEE is to judge whether the project requires Environmental Impact Assessment (EIA) or not. If the project requires EIA, the contents for the further environmental study will be prepared based on the results of IEE.

10.4.2 Method of IEE

The IEE is conducted according to the guideline prepared by JICA for the project planning of socio economical infrastructure - river and sabo planning (published in September 1992). The regulation of evaluation of environmental impact and control of environmental quality prepared by MDS in 1994, is also used.

At first, the activity of the project is classified into several components and the impacts are evaluated on each environmental element as environmental matrix. The elements are listed in *Table 10.4.1*. They are classified into three main categories; social environment, natural environment and nuisance. In the matrix, the anticipated degree of impact on each element is grouped into four categories as follows:

A: Important impact,
B: Moderate impact,
C: Unknown,
D: No impact.

In Bolivia, the environmental impact should be examined for every project. As the first step, environmental card (FA) becomes an instrument of categorization of EIA. The contents of FA are:

- General information of the project,
- Project location and its description,
- Project description,
- Raw material, input and production of the project,
- Environmental aspects.

The project or activity is classified into the following levels:

- Require integrated EIA,
- Require specific EIA,
- Require no EIA but advisable for conceptual EIA,
- Require no EIA.

The idea of the FA is similar to the IEE. In this study, the IEE is modified according to the contents of the FA. In the IEE, negative impacts are mainly analyzed. On the other hand in the FA, positive impacts are also considered.

10.4.3 Environmental Impact

The environmental impacts and the environmental impact matrix are shown in *Tables 10.4.2* and *10.4.3*.

(1) Improvement of channels

The improvement works of river or drainage channels are to increase conveyance capacities of channels by widening, deepening and straightening of channels. An improved channel with increased flow capacity will likely alter the hydrological conditions.

During the wet season, at the upper reach, the flood water level will become lower and the duration will become shorter, but, at the lower reach, the flood water level will become higher with longer duration.

During the dry season, the water stage will likely become lower. This may cause the lowering of ground water table and contamination of the stream water.

Along the river, there are forest areas. The riverside forest may be an important shelter for wild animals and birds and rich in flora and fauna, compared with neighboring cultivated lands. The channel improvement may cause some impacts on the flora and fauna in the riverine environment.

The decrease in flood frequency will improve the living condition of the community and intensify the development. Sometimes this leads to increase in the risk to life and property due to the concentration of population and property.

(2) Construction of embankment

The construction of embankments is to confine the flood flow within a river channel. The construction of embankments will change the land form, forest and cultivated land along the river and may cause some impact.

(3) Control of land use

In the proposed flood retarding basins, the control of land use will be required as a part of the non-structural measures of flood mitigation. This may cause some social and economical impact on surrounding rural inhabitants, though the impact is unlikely significant.

(4) Change of land use

In the flood prone area the land use shall be restricted for the mitigation of flood damages. This may cause some social impact on the inhabitant, though the impact is not significant.

The evaluation of impact of each activity on the environmental element is summarized in *Table 10.4.2*, according to the impact evaluation criteria.

10.4.4 Further Investigation

The influence by the improvement of river channels that increase their flow capacities, should be studied. The flood flow, low flow discharge and ground water table along the channel would be altered. Accordingly not only fauna and flora in the riverine environment including retarding basins, but also socioeconomic or environmental conditions in the flood hazard area will be effected.

In conclusion, based on this IEE, EIA of the flood mitigation project is necessary because of the potential modification of hydrological conditions, effect on riverine forestation and the change of social condition of the inhabitants.

Based on the anticipated environmental impacts likely by the implementation of the flood mitigation and drainage improvement measures, the terms of reference (TOR) for the further environmental study should cover the following items:

- Land tenure and existing commons,
- Change of the flow conditions at downstream,
- Change of the ground water table level,
- Change of the water quality,
- Impacts on the flora and fauna along the riverine forestation.

10.5 Water Quality Survey

10.5.1 Survey Parameters

Water quality was surveyed in May and September in 1995 in the study area. The water quality parameters measured are as follows:

- Water temperature
- PH
- Dissolved oxygen (DO)
- Electric conductivity (EC)
- BOD
- Suspended solid (SS)
- Number of coliform groups

10.5.2 Location of Sampling

The samples were taken at the five locations shown in *Table 10.5.1* and *Fig. 10.5.1*. The locations of No. 2, No. 4 and No. 5 were selected to investigate the water quality at downstream of sources of wastewater. The sampling was done twice a day at locations No. 2, No. 4 and No. 5 and once a day at No. 1 and No. 3.

10.5.3 Method of Analysis

The samples were analyzed confonming the standard methods of the USA. That is the standard methods for the analysis of drinking water and sewage (metods normalizads para el analisis de aguas potbles y residuales) edited by Mary Ann H. Franon and the committee of American Public Association, American Water Works Association, Water

pollution Control Federation, 1992. The Spanish edition published in 1992 by Diaz de Santos S.A., is used.

10.5.4 Results

The results of water quality analysis are shown in *Table 10.5.2*. The water samples at the locations of No. 2 and No. 4 indicated heavy contamination by organic matter. The river seems to be affected by the discharge of untreated sewage from the urban area of Santa Cruz and the colonies located along the river. Elsewhere, the water quality deterioration is not significant.

At Puerto Pailas located along the Rio Grande, the suspended solids decreased from the rainy season to the dry season, but BOD and EC (CD) increased. Because of the decrease of discharge, the sediment load decreased and the concentration of dissolved material increased.

At Arroyo Los Sauces to where the urban area of Santa Cruz drains partly, the values of EC, SS and BOD wrer high. Especially the values of BOD in dry season were twice times that of the rainy season, and the values of DO decreased corresponding to the increase of organic matter. At the Rio Pirai, the difference in water quality between the two seasons was insignificant.

At the Rio Chane, the water quality in the dry season was better than that in the rainy season. The contaminant was likely discharged from the local settlements and cattle fields, but likely discharged less in the dry season because of the reduced runoff.

At the Arroyo Yapacanicito, the water quality in dry season is worser than that in the rainy season.

During the study, simple water quality tests were carried out in May and September of 1995, to obtain overall information on the condition of rivers and streams of the study area. The test items are water temperature, turbidity, COD and nitrite. COD (chemical oxygen demand) is a measure of the amount of oxygen required to stabilize the waste chemically.

The results are shown in *Fig. 10.5.2*. The condition of water quality deterioration is approximately estimated as shown in *Table 10.5.3*. Along the Arroyo Los Sauce that is drained from the urban area of Santa Cruz and flows into the Rio Chane, the water is heavily polluted.

The Rio Grande is very clean from the view point of water quality though it contains heavy silt. All the other small rivers and the Rio Pirai located at upstream of the city of Santa Cruz are clean. One of the main sources of the water pollution is the city of Santa Cruz from where sewage flows into Rio Pirai and Arroyo Los Sauce.

In an overall sense, there is no significant difference between the results of water quality of May and September.

TABLES

TABLE 10.4.1 ENVIRONMENTAL ELEMENT

Social Environment

1. Resettlement
2. Economic activity
3. Traffic and public facilities
4. Community
5. Cultural property
6. Water right and right of common
7. Health and sanitation
8. Waste disposal
9. Safety

Natural Environment

10. Topography
11. Soil
12. Ground water
13. Hydrological condition
14. Coastal zone
15. Flora and fauna
16. Climate
17. Landscape

Nuisance

18. Air pollution
19. Water pollution
20. Soil contamination
21. Noise and vibration
22. Land subsidence
23. Odor

TABLE 10.4.2 ENVIRONMENTAL IMPACT MATRIX

Environmental Element	Activities (1)	(2)
1. Resettlement	C	C
2. Economic activity	C	C
3. Traffic and public facilities	C	
4. Community activity		
5. Cultural property		
6. Water right and right of common	B	C
7. Health and Sanitation		
8. Waste disposal		
9. Safety		
10. Topography	C	
11. Soil	C	
12. Ground water	B	
13. Hydrological condition	B	
14. Coastal zone		
15. Flora and fauna	B	C
16. Climate		
17. Landscape		
18. Air pollution		
19. Water pollution	C	
20. Soil contamination		
21. Noise and vibration		
22. Land subsidence		
23. Odor		
EIA requirement	Yes	No

Note: Criteria A: important impact
B: moderate impact
C: unknown
E: no impact

Activities (1) Improvement of channels
(2) Change of land use

TABLE 10.4.3 ENVIRONMENTAL IMPACT

Improvement of channels

Environmental Element	Impact	Causes of the Impact
1. Resettlement	C	Land acquisition
2. Economic activity	C	Decrease of flood damages
3. Traffic and public facilities	C	Improvement of bridges
6. Water right and right of common	B	Change of water course
10. Topography	C	Change of channel form
11. Soil	C	Salinization
12. Ground water level	B	Modification of surface water
13. Hydrological condition	B	Change of water course
10. Topography	C	Change of channel form
11. Soil	C	Salinization
12. Ground water	B	Modification of surface water level
13. Hydrological condition	B	Change of flow capacity
15. Flora and fauna	B	Change of river side forest
16. Water pollution	C	Decrease of low flow

Change of land use

Environmental Element	Impact	Causes of the Impact
1. Resettlement	C	Land acquisition
2. Economic activity	C	Decrease of flood damages
6. Water right and right of common	B	Land
15. Flora and fauna	B	Change of land use

TABLE 10.5.1 SAMPLING LOCATION OF WATER QUALITY SURVEY

	Name	River
No. 1:	Puerto Palias	Rio Grande
No. 2:	Estancia Clara Sauce	Arroyo Los Sauces
No. 3:	Puente Eisenhower	Rio Pirai
No. 4:	Comunidad Caimanes	Rio Chane
No. 5:	Estancia La Enconada	Arroya Ypacanicito

TABLE 10.5.2 RESULTS OF WATER QUALITY SURVEY

(1) May, 1995

Place	Temp degree C	PH	DO mg/l	CD umhos /cm	SS mg/l	SS mg/l	BOD mg/l	Colif nmp/100ml	Colif nmp/100ml
1	21.5	8.3	8.2	605	1459	1391	1.5	2.3E+3	4.6E+2
2	21.0	7.5	1.0	907	37	8	41.0	1.1E+6	9.9E+5
3	26.6	8.7	8.4	407	154	139	4.6	5.9E+3	1.2E+3
4	20.7	8.3	7.7	896	41	35	12.4	3.5E+3	1.3E+3
5	21.2	7.2	5.7	202	10	7	1.3	2.5E+3	1.3E+3

(2) September, 1995

Place	Temp degree C	PH	DO mg/l	CD umhos /cm	SS mg/l	SS mg/l	BOD mg/l	Colif nmp/100ml	Colif nmp/100ml
1	19.8	8.2	8.2	943	353	344	2.9	9.9E+2	9.2E+2
2	22.6	7.4	0.5	1127	45	14	93.0	1.0E+6	6.8E+5
3	27.4	8.5	7.2	430	149	135	4.7	8.6E+3	8.5E+3
4	22.6	8.3	6.3	1269	33	29	2.0	1.5E+3	5.0E+2
5	24.7	7.3	4.6	247	13	9	2.2	8.7E+3	2.1E+4

TABLE 10.5.3 RELATION BETWEEN COD AND WATER CONDITION

COD (mg/l)	Condition of Water
0	Clean
0 ~ 2	Possibly Contaminated
2 ~ 5	Slightly Contaminated
5 ~ 10	Contaminated
10 ~	Heavily Contaminated

FIGURES

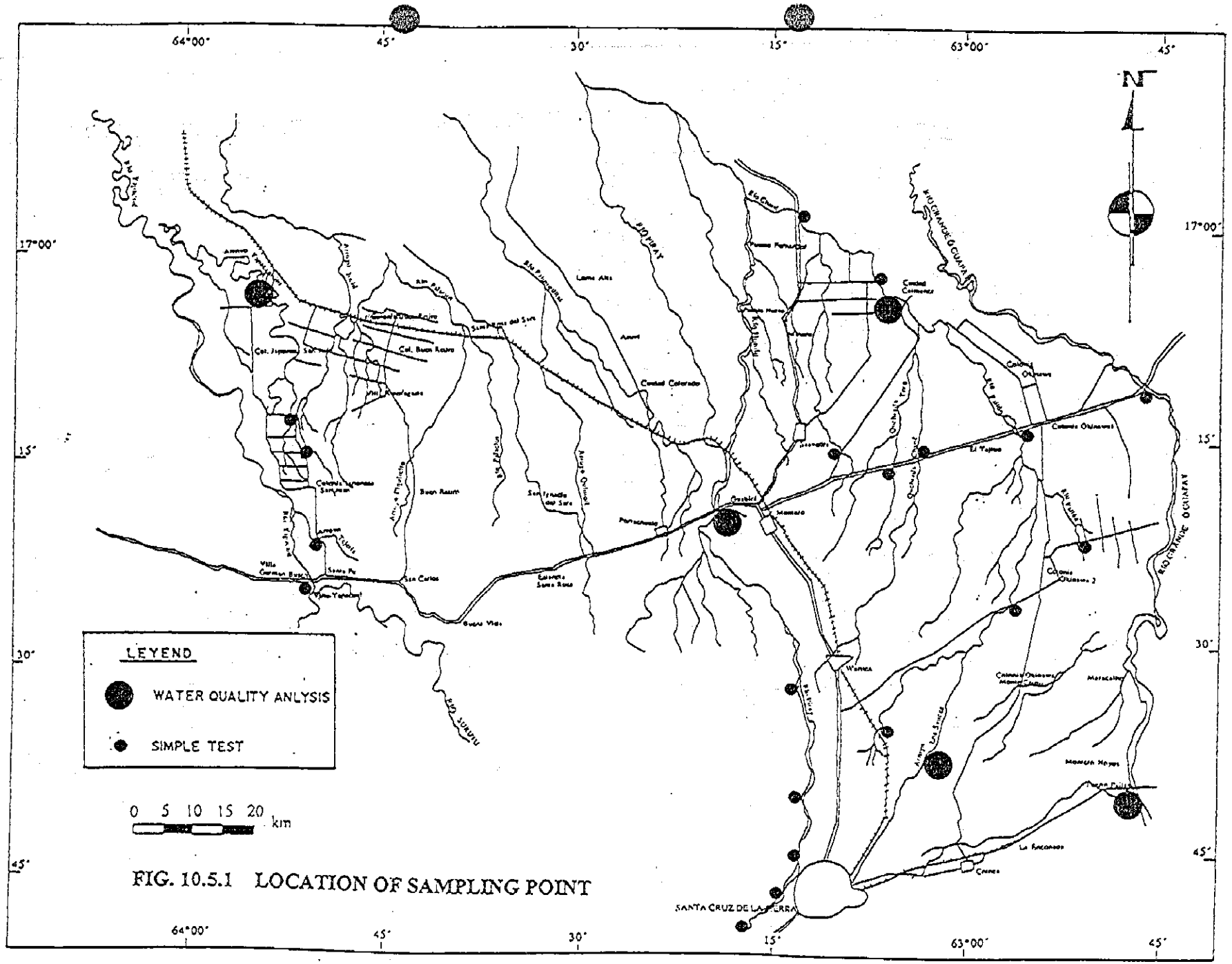


FIG. 10.5.1 LOCATION OF SAMPLING POINT

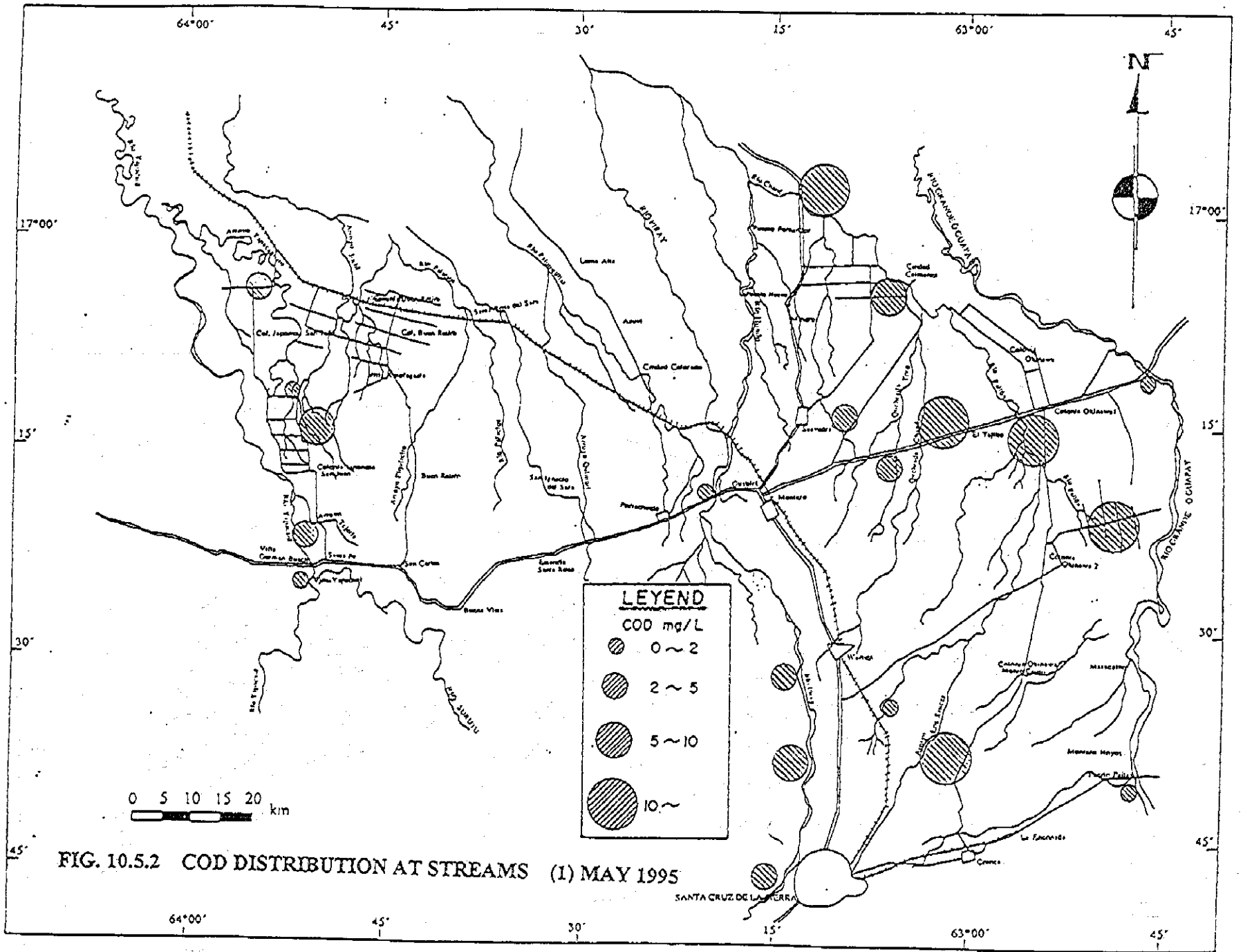


FIG. 10.5.2 COD DISTRIBUTION AT STREAMS (1) MAY 1995

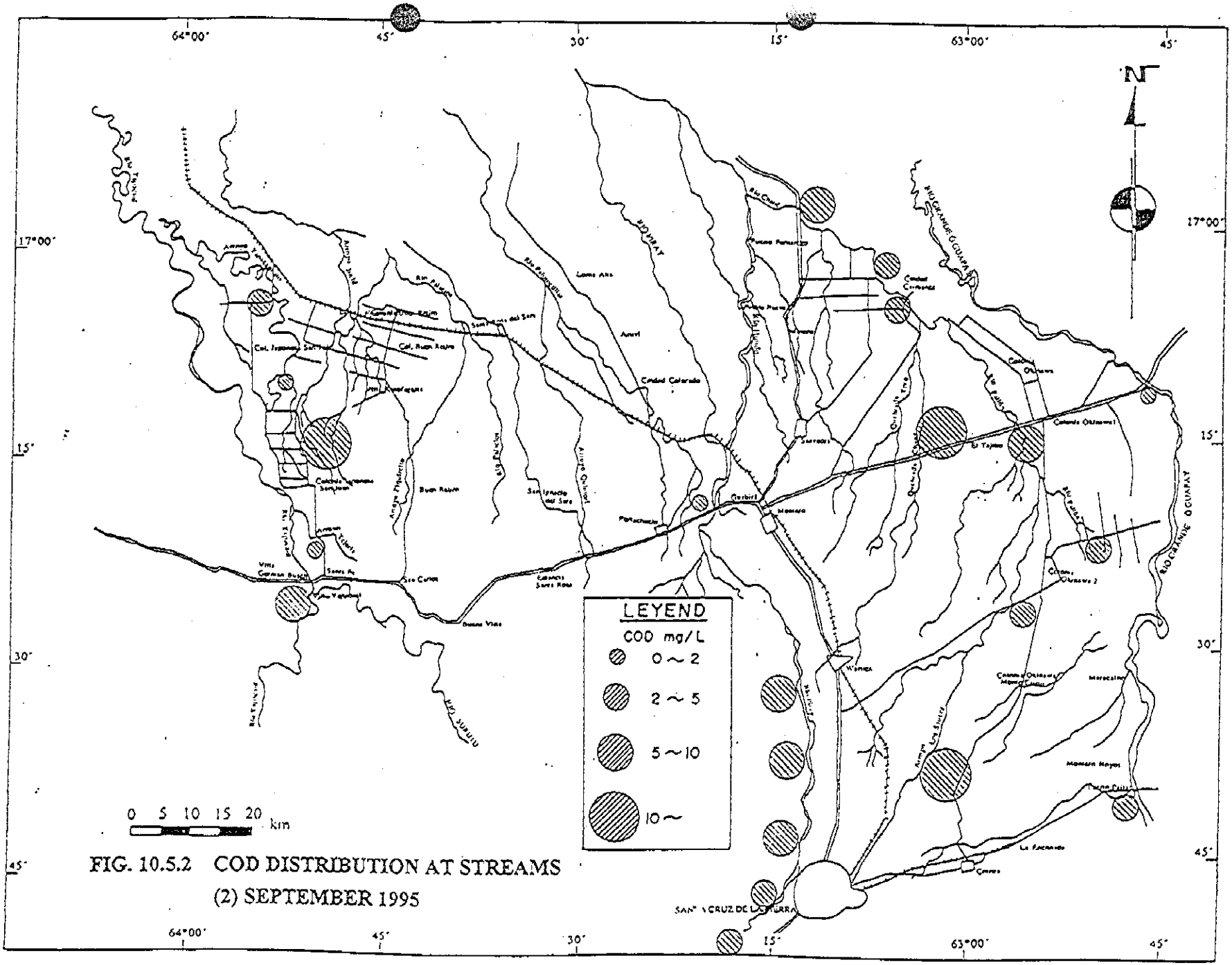


FIG. 10.5.2 COD DISTRIBUTION AT STREAMS
(2) SEPTEMBER 1995

CHAPTER 11
ORGANIZATION

CHAPTER 11 ORGANIZATION

11.1 General

In order to mitigate flood damages, several measures are taken according to the causes of flood and the related natural and socioeconomic conditions. Absolute flood control measures are rarely feasible either physically or economically. The commonly accepted measures for reducing flood damage are classified into two categories, i.e. structural measures and non-structural measures.

In order to implement the proposed flood mitigation and drainage improvement measures, necessary organizations and their functions are studied based on the exiting organizations.

11.2 Existing Organization for Flood Mitigation

The existing organizations related to flood mitigation are MDS, SENAMHI, SEARPI, CDF, CORDECRUZ, MDN and Municipalities. Those organizations are to be reorganized according to the popular participation law and the administrative decentralization law of January 1, 1996, but the new organization was not determined by the end of 1995.

In the administrative decentralization law, the executive power at the department level is exercised by the Prefecture that formed by the governor and the council. The governor has the power to initiate and execute programs and projects for public investment in the areas of:

- Road construction and maintenance,
- Rural electricity,
- Irrigation infrastructure and production support,
- Technical and scientific research and development,
- Conservation and preservation of the environment,
- Tourism promotion,
- Social assistance program,
- programs for municipal works,
- Other issues related to municipal government.

Flood mitigation measures will be one of these areas.

All regional development corporations in the country, including CORDECRUZ, were dissolved by the end of 1995. The property owned by these organizations is to be transferred to the control under the governor of the Department. Also all non profitable public institutions are to be dissolved and transferred to the administration of the governor.

11.3 Necessary Organization

(1) Meteorological and hydrological data collection and flood forecasting

Meteorological and hydrological data are the basic data and essential for the execution of flood mitigation measures. In the study area only rainfall data is available, but with various institutions.

One single information center is necessary to collect and compile meteorological and hydrological data with the coordination of various institutions. SENAMHI is most suited to fulfill this function with the reinforcement of staff and budget.

In a later stage, hydrological observation system enabling the collection of real time rainfall and water level data, will be required for flood forecasting as a part of the non-structural measures.

(2) Land use regulation

In order to mitigate flood damages in the study area, the land use in the flood hazard area should be regulated.

At the downstream of the Rio Chane, structural measures are unlikely feasible economically. The area should be preserved as forest cover or wetland in the sense of natural environmental preservation. Some parts of the areas should remain as nonresidential areas to mitigate heavy flood damages.

At the upstream, there are some forest areas that function as a retarding basin. Those forest areas need some kind of preservation from flood mitigation and environmental conservation aspects.

The local government and CDF have the overall jurisdiction over the land use. It is necessary to strengthen their functions as stipulated in the related law.

(3) Civil Defense

Civil Defense was established to deal with all type of damages by disasters including floods.

The activities of Civil Defense can be expanded, if it has adequate, staff and budget and the required data / information. As the basic information, it needs land use map, road map, flood hazard area maps and the available means and constraints of transportation including food and medicines. Canton Civil Defense can be mobilized for the flood fighting. Training of staff and development of an information network is also necessary.

(4) Implementation Organization

The organization for the implementation of flood mitigation and drainage improvement measures should be established. At present, there are many organizations in charge of flood mitigation. CORDECRUZ covers the regional planning that includes the land use planning of flood prone areas, and has a close relation with SENAMHI and SEARPI. SEARPI has responsibilities on the construction and maintenance of river improvement works in the Rio Pirai.

The organization in charge of flood mitigation and drainage improvement works should integrate and reinforce the flood mitigation related functions of CORDECRUZ, SEARPI and SENAMHI.

The implementation organization for the flood mitigation measures should have administrative functions of planning, managing and executing the related projects. The responsibilities of the organization are as follows:

- To organize necessary staff to conduct feasibility study detail design and implementation of the projects,
- To raise necessary funds for the project activities,
- To carry out preparatory works for implementation of the project, including non-structural measures,
- To conduct operation and maintenance activities after implementation of the projects.

The functions of the implementation organization shall be discussed more in details.

CHAPTER 12
CONSTRUCTION PLAN AND COST

CHAPTER 12 CONSTRUCTION PLAN AND COST

12.1 General

The structural measures required for flood mitigation and drainage improvement are mostly composed of river channel and drainage related works such as channel improvement, road-cum-embankment, drainage facilities and related structures. The construction costs were estimated based on the preliminary design of major facilities.

12.2 Construction Plan

(1) Major Construction Work

The major construction works are summarized as follows:

Construction Work

Sub-Project	River Improvement (km)		Main Drainage Improvement (km)		Secondary Drainage (km^2)		Road-cum-Embankment (km)	
	Alt.I	Alt.II	Alt.I	Alt.II	Alt.I	Alt.II	Alt.I	Alt.II
1. CHANE PAILON								
(1) Rio Chane	27.0	0	0	0	0	0	0	0
(2) Rio Pailon	32.0	32.0	6.5	6.5	50.0	50.0	0	0
(3) Chane Chacras	36.5	36.5	21.5	21.5	284.0	284.0	0	0
(4) Queb.Chane	34.0	34.0	8.0	8.0	0	0	0	0
(5) Okinawa Drainage	0	0	21.0	21.0	147.0	147.0	0	0
2. SAN JUAN ANTOFAGASTA								
(6) San Juan	14.1	14.1	41.3	41.3	115.0	115.0	0	0
(7) Antofagasta	20.3	20.3	10.0	10.0	97.0	97.0	9.0	9.0
Total	163.9	136.9	108.3	108.3	693.0	693.0	9.0	9.0

Note: Alt. I: Alternative-I
Alt. II: Alternative-II

The construction works include replacement of bridges and installation of culverts as well as rehabilitation works of existing facilities.

(2) Construction Plan

The construction schedule of major structural measures are prepared based on the followings:

- The proposed major construction works in the master plan are to be completed within ten (10) years from the year of 2001 to the target year of 2010,
- The supposed urgent works are to be executed within five (5) years from 2001,
- The major construction work is planned utilizing heavy equipment.

Construction schedules are shown in *Tables 12.2.1* to *12.2.4*.

12.3 Cost Estimate

(1) Baisic Condition

The project cost is composed of the followings:

-	Direct cost:	Construction cost
-	Indirect cost:	Land acquisition and compensation cost, Administration cost, Engineering service cost, Operation and maintenance cost,
-	Contingency:	Physical contingency

The project cost is estimated in accordance with the followings:

- The cost is estimated based on the prevailing market price in Oct., 1995.
- The unit price such as materials, equipment and labor wages are incorporated as thirteen percent (13%) of IVA.
- The cost is estimated according to the method of CORDECRUZ.
- The cost is divided into foreign currency and local currency portion.
- The following exchange rate is adopted for currency conversion purpose.
  One (1) US $ = Bs 4.86 = Yen 100.0

The construction cost is composed of direct construction cost and indirect cost. The indirect construction cost is thirty percent (30%) of the direct construction cost, and is divided into the following three (3) items:

- Unforeseen : 5%
- Overhead : 10%
- Profit : 15%

(2) Unit Price

The unit price of labor, materials and equipment are estimated based on the prevailing market prices. The relevant data obtained from CORDECRUZ and other agencies are shown in *Tables 12.3.1* to *12.3.3*.

(3) Unit Cost

The compound unit cost is estimated by totaling the labor cost, equipment cost and material cost. The compound unit cost are summarized in *Tables 12. 3.4 (1)* and *(2)*. Their breakdown are shown in Supporting Report J.

(4) Currency Portion

Foreign currency and local currency portions are estimated as follows:

Foreign currency portion:

- Imported equipment, materials and supplies.
- Domestic materials for which the country is a net importer.
- Wages of expatriate personnel.
- Overhead and profit of foreign firms.

Local currency portion:

- Domestic materials and supplies for which the country is a net exporter
- Wages of local personnel.
- Overhead and profit of local personnel.
- Overhead and profit of local firms.

The unit prices of each components are as follows:

PARTICULAR	F.C (%)	L C (%)
(a) Labor Price	0	100
(b) Equipment Price	100	0
(c) Material Price		
Fuel	0	100
Cement	0	100
Structure Steel	100	0
Gabion Mat Net	100	0
Gravel, Sand	0	100
PVC-Pipe	100	0

(5) Land Acquisition Cost

This cost is estimated based on the unit cost obtained from CORDECRUZ and survey in the study area as follows, and incorporated as a local currency component.

- Clear Farm-land 60,000 US$/50ha
- Waste Land 15,000 US$/50ha

(6) Administration Cost

The cost for the project's administration, management and supervision is estimated in proportion to the construction cost. An allowance of five percent (5%) of the construction cost is provided for the cost and incorporated as a local currency component.

(7) Engineering Service Cost

The cost is estimated in proportion to the construction cost to cover the detailed design and construction supervision by consultants, and the proportion of detailed design to construction supervision has a ratio of sixty percent (60 %) to forty percent (40 %).

The engineering service cost is estimated to be ten percent (10%) of the construction cost and it's eighty percent (80%) is incorporated into the foreign currency component and twenty percent (20%) into the local currency component.

(8) Contingency

1) Physical Contingency

The physical contingency, amounting to fifteen percent (15%) of the construction cost, is provided to cope with any unforeseen circumstances during the implementation of this project.

2) Price Contingency

The price contingency is provided for the reflection of the inflation effect until the implementation of the projects. The price contingency is estimated assuming the inflation rate to be four percent (4%) per annum for foreign currency and seven percent (7%) for local currency.

(9) Operation and Maintenance Cost

OM cost consists of routine OM cost and civil works. Annual cost is estimated to be one percent (1%) of the base construction cost.

(10) Project Cost

The project costs in 1995 price are summarized as follows:

1) Project Costs of Alternative-I

(Unit: 1,000 Bs.)

Sub-Project	L/C	F/C	Total
1. CHANE-PAILON	449,234	453,041	902,275
(1) Rio Chane	82,582	93,166	175,748
(2) Rio Pailon	144,415	145,967	290,382
(3) Chane Chacras	110,375	107,675	218,050
(4) Queb. Chane	66,771	59,508	126,279
(5) Okinawa Drainage	45,091	46,725	91,816
2. SAN JUAN-ANTOFAGASTA	92,613	94,727	187,340
(6) San Juan	42,042	44,796	86,838
(7) Antofagasta	50,571	49,931	100,502
	541,847	547,768	1,089,615

Note: 1.0 US$ = Bs. 4.86 = Yen 100.0

2) Project costs of Alternative-II

(Unit: 1,000 Bs.)

Project	L/C	F/C	Total
1. CHANE-PAILON	366,652	359,875	726,527
(1) Rio Chane	-	-	-
(2) Rio Pailon	144,415	145,967	290,382
(3) Chane Chacras	110,375	107,675	218,050
(4) Queb. Chane	66,771	59,508	126,279
(5) Okinawa Drainage	45,091	46,725	91,816
2. SAN JUAN-ANTOFAGASTA	98,204	100,663	198,867
(6) San Juan	47,633	50,732	98,365
(7) Antofagasta	50,571	49,931	100,502
Total	464,856	460,538	925,394

Note: 1.0 US$ = Bs. 4.86 = Yen 100.0

TABLES

TABLE 12.2.1 CONSTRUCTION SCHEDULE OF CHANE-PAILON

ALTERNATIVE I

Sub-Project	Const. Volume	Year 0	1	2	3	4	5	6	7	8	9	10
1.RIO CHANE BASIN												
Rio Chane	27.0km											
2. RIO PAILON BASIN												
Rio Pailon	32.0km											
Main Drainage	6.5km											
Secondary Drainage	50.0km2											
3. CHANE CHACRAS BASIN												
Queb. Las Chacras	36.5 km											
Main Drainage	21.5 km											
Secondary Drainage	284.0km2											
4. QUEBRADA CHANE BASIN												
Queb. Chane	18.0km											
Queb. El Toro	16.0km											
Main Drainage	8.0km											
5. OKINAWA DRAINAGE BASIN												
Main Drainage	21.0km											
Secondary Drainage	147.0km2											

TABLE 12.2.2 CONSTRUCTION SCHEDULE OF SAN JUAN-ANTOFAGASTA

ALTERNATIVE I

Sub-Project	Const. Volume	Year										
		0	1	2	3	4	5	6	7	8	9	10
1.SAN JUAN BASIN												
Arroyo Yapacanicito	14.1km											
Main Drainage	41.3km											
Secondary Drainage	115.0km2											
2. ANTOFAGASTA BASIN												
Arroyo Tacuaral	7.7km											
Arroyo Jochi	12.6km											
Road	9.0km											
Main Drainage	10.0km											
Secondary Drainage	121.0km											

TABLE 12.2.3 CONSTRUCTION SCHEDULE OF CHANE-PAILON

ALTERNATIVE II

Sub-Project	Const. Volume	Year 0	1	2	3	4	5	6	7	8	9	10
2. RIO PAILON BASIN												
Rio Pailon	32.0km											
Main Drainage	6.5km											
Secondary Drainage	50.0km2											
3. CHANE CHACRAS BASIN												
Queb. Las Chacras	36.5 km											
Main Drainage	21.5 km											
Secondary Drainage	284.0km2											
4. QUEBRADA CHANE BASIN												
Queb. Chane	18.0km											
Queb. El Toro	16.0km											
Main Drainage	8.0km											
5. OKINAWA DRAINAGE BASIN												
Main Drainage	21.0km											
Secondary Drainage	147.0km2											

TABLE 12.2.4 CONSTRUCTION SCHEDULE OF SAN JUAN-ANTOFAGASTA

ALTERNATIVE II

Sub-Project	Const. Volume	Year										
		0	1	2	3	4	5	6	7	8	9	10
1.SAN JUAN BASIN												
Arroyo Yapacanicito	14.1km											
Main Drainage	41.3km											
Secondary Drainage	115.0km2											
2. ANTOFAGASTA BASIN												
Arroyo Tacuaral	7.7km											
Arroyo Jochi	12.6km											
Road	9.0km											
Main Drainage	10.0km											
Secondary Drainage	121.0km											

TABLE 12.3.1 LABOR WAGES

UNIT : Bs / Hour

Labor	Study Price		Summary
	Hour	Day	
Operator Class A	18.62	149.00	
Operator Class B	17.31	138.00	
Operator Class C	15.37	123.00	
Operator Class D	13.53	108.00	
Driver Class A	12.46	100.00	
Driver Class B	10.85	87.00	
Foreman	10.62	85.00	
Helper Class A	9.56	76.00	
Helper Class B	4.90	39.00	
Steel Bending Worker	4.90	39.00	
Bulding Worker	9.70	78.00	
Plant Operator	15.37	123.00	
Prompter	12.9	103.00	

TABLE 12.3.2 UNIT PRICE OF TYPICAL MATERIAL

UNIT : Bs

Item	Specification	Unit	Study Price	Summary
Kerosenne		Liter	1.13	
Diesel		Liter	1.54	
Gasoline		Liter	1.85	
Asphalt Concrete		Ton	326.00	67$US
Asphalt Emulsion		Liter	1.41	
Aggregate		M3	35.00	
Cement		Kg	0.58	
Sand		M3	25.00	
Crushed Gravel		M3	35.00	
Crushed Stone		M3	33.00	
Forming Wood		M2	2.20	
Steel Bar		Ton	2,916.00	
Nail		Kg	5.80	
Wire		Kg	5.00	
Corrugated S.P D=36"		M	572.00	
Corrugated S.P D=42"		M	683.00	
Corrugated S.P D=48"		M	834.00	
Gabion Mat	t=30cm	M2	7.00	
Transportation	Sand ,Gravel, Aggregates	M3	121.50	L=100km
Transportation	Sand ,Gravel, Aggregates	M3	36.00	L=30km
Transportation	Steel bar	Ton	50.00	L=100km
Transportation	Asphalt Concrete	Ton	83.00	0.17$US/km,L=100km

TABLE 12.3.3 CONSTRUCTION EQUIPMENT PRICE

UNIT : Bs / Day

Specification	H.P	Study Price	Summary
1.Bulldozer			
Bulldozer Cat D18 32T	289	204.00	
Bulldozer Cat D7 21T	200	186.00	
Bulldozer Cat D6 15T	165	112.00	
Bulldozer Cat D6 11T	100	94.00	
2.Shovel			
Shovel Cat 930 1.4m3	105	94.00	
Shovel Cat 966E 1.8m3	170	147.0	
3.Motor Grader			
Motor Grader Cat 120G 3.1m	125	77.00	
Motor Grader Komatzu 3.7m	166	107.00	
Motor Grader JD 770B 3.7m		107.00	
4.Macadam Roller			
Macadam Roller	75	39.00	
M.R.Dynapac CA-15T	79	42.00	
M.R.Dynapac CA-15T	115	58.00	
5.Water Truck			
Water Truck 10.0m3	290	31.00	
Water Truck 30.0m3m3		75.00	
6.Buck Hoe			
Buck Hoe 0.35m3	80	63.00	
Buck Hoe 0.60m3	99	90.00	
7.Dump Truck			
Dump Truck 5m3		30.00	
Dump Truck 8m3		37.00	
Dump Truck 10m3		40.00	
Dump Truck 12m3		67.00	
Dump Truck 25m3		72.00	
8.Rubber Tire Roller			
R.T.R.Dynapac CP-30T	100	60.00	
R.T.R.Dynapac CP-27T	100	52.00	
9.Asphalt Finisher 2.4-5.0m		160.00	
10.Asphalt Truck Sprayer			

TABLE 12.3.4(1) SUMMARY OF UNIT COST - (1)

UNIT : Bs

N.O	Item	Specification	Unit	Unit Cost			Summary
				L/P	F/P	Total	
UC-1	Truck Operation	10T	hour	35.10	34.00	368.53	L.L 17.85(0.51)
UC-2	Concrete Mixing	180kg/cm2	m3	317.66	15.77	333.43	L.L 7.35(0.02)
UC-3	Concrete Mixing	240kg/cm2	m3	388.36	29.37	417.37	L.L 7.35(0.02)
UC-4	Concrete Mixing	350kg/cm2	m3	447.15	54.87	502.02	L.L 7.35(0.02)
UC-5	Concrete Pump Truck	90-110m3/H	hour	47.63	345.42	393.07	L.L 21.00(0.44)
UC-6	Concrete Plant Operation	30M3	m3	9.13	15.77	24.90	L.L 7.35(0.81)
UC-7	Tractor Shovel	1.8m3	hour	31.29	147.00	178.29	L.L 28.98(0.93)
UC-8	Water Truck	10.0m3	hour	31.22	31.00	62.22	L.L 18.27(0.59)
UC-9	Macadam Roller	10.0T	hour	44.84	39.00	83.84	L.L 28.98(0.65)
UC-10	Motor Grader	3.1M	hour	43.30	77.00	120.30	L.L 28.97(0.67)
UC-11	Concrete Curing		m3	4.29	0.00	4.29	L.L 3.90(0.91)
UC-12	Buck Hoe	0.6m3	hour	57.12	90.00	147.12	L.L 28.98(0.51)
UC-13	Dump Truck	11T	hour	36.67	37.00	73.67	L.L 15.00(0.41)
UC-14	Rubber Tire Roller	8-20T	hour	37.47	48.00	85.47	L.L 25.83(0.69)
UC-15	Tamper Operation	60kg	day	40.52	25.00	65.52	L.L 39.00(0.96)
UC-16	Bulldozer	15T	hour	62.82	87.00	149.82	L.L 31.29(0.50)
UC-17	Clamshell	0.60m3	hour	54.64	184.00	238.64	L.L 28.98(0.53)
UC-18	Truck Crane	15T	hour	34.74	87.00	121.74	L.L 21.00(0.60)
UC-19	Filling	Tamper	m3	12.71	6.78	19.49	L.L 10.98(0.86)
UC-20	Buck Hoe Loading	0.6m3	m3	1.50	2.36	3.85	L.L 0.76(0.51)
UC-21	Excavation	Bulldozer 15T	m3	0.82	1.14	1.96	L.L 0.46(0.50)
UC-22	Road Subbase Course	t=20cm	m2	39.19	0.52	39.71	Okinawa L.L 0.52(0.01)
UC-22	Road Subbase Course	t=20cm	m2	17.66	0.52	18.18	San Juan L.L 0.52(0.03)
UC-23	Road Base Course	t=15cm	m2	35.53	0.87	36.40	Okinawa L.L 0.37(0.01)
UC-23	Road Base Course	t=15cm	m2	17.29	0.87	18.16	San Juan L.L 0.37(0.02)

* L.L.: Total Labor Cost of Local Portion

TABLE 12.3.4(2) SUMMARY OF UNIT COST - (2)

UNIT : Bs

N.O	Item	Specification	Unit	Unit Cost			Summary
				L/P	F/P	Total	
UC-24	Asphalt Pavement	Surface t=5cm	m2	54.14	0.98	55.12	L.L 0.31(0.01)
UC-25	Asphalt Pavement	Binder t=5cm	m2	55.27	0.98	56.25	L.L 0.31(0.01)
UC-26	Asphalt Finisher	2.4-5.0M	hour	47.11	160.00	207.11	L.L 48.84(0.85)
UC-27	Concrete Placing	180kg/cm2	m3	358.16	48.66	406.82	L.L 9.58(0.03)
UC-28	Concrete Placing	240kg/cm2	m3	414.08	45.26	459.34	L.L 20.20(0.05)
UC-29	Concrete Placing	350kg/cm2	m3	474.64	71.53	546.17	L.L 20.20(0.04)
UC-30	Slope Forming		m2	3.39	2.88	6.27	L.L 2.49(0.73)
UC-31	Roadbed Compaction	Bulldozer 15T	m3	2.28	1.81	4.10	L.L 1.63(0.71)
UC-32	Soil Transportation	L=1km	m3	2.32	2.34	4.65	L.L 0.84(0.36)
UC-32	Soil Transportation	L=2km	m3	2.85	2.87	5.72	L.L 0.95(0.33)
UC-32	Soil Transportation	L=3km	m3	3.38	3.41	6.80	L.L 1.17(0.35)
UC-32	Soil Transportation	L=4km	m3	3.92	3.95	7.87	L.L 1.38(0.35)
UC-32	Soil Transportation	L=5km	m3	4.45	4.49	8.94	L.L 1.60(0.36)
UC-32	Soil Transportation	L=0.5km	m3	2.05	2.07	4.12	L.L 1.82(0.89)
UC-33	Excavation-Transportation	L=1km	m3	4.64	5.84	10.48	L.L 1.77(0.38)
UC-34	Base-Layer Placing		m2	0.44	0.43	0.87	L.L 0.36(0.81)
UC-35	Steelbar Bend&Placing		kg	0.65	3.14	3.79	L.L 0.64(0.98)
UC-36	Forming		m2	47.74	0.00	47.74	L.L 43.79(0.92)
UC-37	Gabion Mat	t=30cm	m2	52.6	11.05	63.65	L.L 27.00(0.51)
UC-38	Foundation Bed Stone	Crushed	m3	207.11	0.00	207.11	L.L 24.57(0.12)
UC-39	Excavation	Buck Hoe 0.6m3	m3	1.57	2.47	4.04	L.L 0.80(0.51)
UC-40	Clearing & Grubbing	Dozer&Buckhoe	m2	0.92	0.94	1.87	L.L 0.59(0.63)
UC-41	Embankment	dozer 15T t=20	m3	1.89	1.98	3.87	L.L 1.17(0.62)

TABLE 12.3.5 SUMMARY OF CONSTRUCTION COST (ALTERNATIVE I)

CHANE - PAILON — UNIT : 1000Bs

Sub Project / Works	Width (m)	Depth (m)	Length (km)	Construction Cost L/p	F/P	Total	Land Acquisition
1. Rio Chane							
Rio Chane Improvement	100~45	6.00~4.50	27.00	62,111	71,549	133,660	324
Sub total				62,111	71,549	133,660	324
2. Rrio Pailon							
Rio Pilon Improvement	70~65	5.00	32.00	99,955	99,477	199,432	433
MainDrainage	30~18	3.50~3.00	6.50	4,092	5,933	10,025	79
Secondary Drainage	12	3.00	16.00	5,508	5,882	11,390	23
Sub Total				109,555	111,292	220,847	535
3. Chane Chacras							
Queb. Las Chacras Improvement	45~37	3.00	36.50	35,440	30,183	65,623	365
Main Drainage	35~25	3.50~3.00	21.50	18,538	20,111	38,649	284
Secondary Drainage	12	3.00	42.00	29,605	31,618	61,223	125
Sub total				83,583	81,912	165,495	774
4. Quebrada Chane							
Queb. Chane Improvement	45~33	4.50~3.50	18.00	13,518	8,159	21,677	165
Queb. El Tolo Improvement	55	4.00	16.00	35,404	34,601	70,005	128
Main Drainage	25	3.00	8.00	2,068	2,193	4,261	47
Sub Total				50,990	44,953	95,943	340
5. Okinawa Drainage							
Main Drainage	35~16	4.00~3.00	21.00	18,174	18,783	36,957	239
Secondary Drainage	12	3.00	46.00	15,835	16,912	32,747	67
Sub Total				34,009	35,695	69,704	306
Total				340,248	345,401	685,649	2,279

SAN JUAN - ANTOFAGASTA — UNIT : 1000Bs

Sub Project / Works	Width (m)	Depth (m)	Length (km)	Construction Cost L/p	F/P	Total	Land Acquisition
6. San Juan							
Arro. Yapacanicito Improvement	35~30	3.00	14.10	7,561	6,895	14,456	118
Main Drainage(S.Juan Q. Tejeria)	21~14	4.00~3.00	41.30	10,160	12,360	22,520	76
Secondary Drainage	14	3.00	34.00	13,953	15,029	28,982	60
Sub Total				31,674	34,284	65,958	254
7. Antofagasta							
Arro. Tacuaral Improvement	26	4.00	7.70	6,010	6,356	12,366	51
Arro. Jochi Improvement	30~22	3.50	12.60	7,261	6,787	14,048	120
Road (San Juan-Antofagasta)	9.1	-	9.00	4,945	2,177	7,122	198
Main Drainage(Antofagasta)	28~25	4.00	10.00	5,768	7,179	12,947	98
Secondary Drainage	14	3.00	38.00	14,102	15,530	29,632	67
Sub Total				38,086	38,029	76,115	534
Total				69,760	72,313	142,073	788
(Alternative I) Total				410,008	417,714	827,722	3,067

TABLE 12.3.6 SUMMARY OF CONSTRUCTION COST (ALTERNATIVE II)

CHANE - PAILON — UNIT : 1000Bs

Sub Project / Works	Width (m)	Depth (m)	Length (km)	Construction Cost L/p	Construction Cost F/P	Construction Cost Total	Land Acquisition
1. Rio Chane							
Rio Chane Improvement	100~45	6.00~4.50	27.00	0	0	0	0
Sub total				0	0	0	0
2. Rrio Pailon							
Rio Pilon Improvement	70~65	5.00	32.00	99,955	99,477	199,432	433
MainDrainage	30~18	3.50~3.00	6.50	4,092	5,933	10,025	79
Secondary Drainage	12	3.00	16.00	5,508	5,882	11,390	23
Sub Total				109,555	111,292	220,847	535
3. Chane Chacras							
Queb. Las Chacras Improvement	45~37	3.00	36.50	35,440	30,183	65,623	365
Main Drainage	35~25	3.50~3.00	21.50	18,538	20,111	38,649	284
Secondary Drainage	12	3.00	42.00	29,605	31,618	61,223	125
Sub total				83,583	81,912	165,495	774
4. Quebrada Chane							
Queb. Chane Improvement	45~33	4.50~3.50	18.00	13,518	8,159	21,677	165
Queb. El Tolo Improvement	55	4.00	16.00	35,404	34,601	70,005	128
Main Drainage	25	3.00	8.00	2,068	2,193	4,261	47
Sub Total				50,990	44,953	95,943	340
5. Okinawa Drainage							
Main Drainage	35~16	4.00~3.00	21.00	18,174	18,783	36,957	239
Secondary Drainage	12	3.00	46.00	15,835	16,912	32,747	67
Sub Total				34,009	35,695	69,704	306
Total				278,137	273,852	551,989	1,955

SAN JUAN - ANTOFAGASTA — UNIT : 1000Bs

Sub Project / Works	Width (m)	Depth (m)	Length (km)	Construction Cost L/p	Construction Cost F/P	Construction Cost Total	Land Acquisition
6. San Juan							
Arro. Yapacanicito Improvement	35~30	3.00	14.10	7,130	6,418	13,548	118
Main Drainage(S.Juan Q. Tejeria)	21~14	4.00~3.00	41.30	14,838	17,377	32,215	76
Secondary Drainage	14	3.00	34.00	13,953	15,029	28,982	60
Sub Total				35,921	38,824	74,745	254
7. Antofagasta							
Arro. Tacuaral Improvement	26	4.00	7.70	6,010	6,356	12,366	51
Arro. Jochi Improvement	30~22	3.50	12.60	7,261	6,787	14,048	120
Road (San Juan-Antofagasta)	9.1	-	9.00	4,945	2,177	7,122	198
Main Drainage(Antofagasta)	28~25	4.00	10.00	5,768	7,179	12,947	98
Secondary Drainage	14	3.00	38.00	14,102	15,530	29,632	67
Sub Total				38,086	38,029	76,115	534
Total				74,007	76,853	150,860	788
(Alternative II) Total				352,144	350,705	702,849	2,743