## K.3 THE STUDY AREA

### K.3.1 EXISTING CONDITION

(1) General

The two major types of natural disaster problems in the Quindio are soil erosion and flooding damage.

Soil erosion is evident in the two types of soil erosion processes, namely normal erosion and accelerated erosion. The former, so-called natural erosion and/or geological erosion, is caused by the weathering of geological condition which maintain a balance between the soil resulting from the weathering of rock and its loss affected by the natural environment. The latter is a phenomenon in which soil moves at an increasing tempo due to destruction of the normal balance of weathering in process, for example: erosion caused by natural destruction -namely land sliding- the erosion caused by man such as land reclamation, and so on. In the Quindio, erosion problem is caused mainly by the accelerated erosion, and the following categories are observed:

- Sheet and rill erosion

When sheet and rill erosion occur and the land is cultivated for the next crop, these results of erosion are not readily visible. On moderate or gentle slopes with lower velocity of runoff, only the fine soil particles are removed. They remain in suspension and are finally carried out to the river or are deposited in the deltas of rivers. However, the soils which are the source of this eroded material, gradually lose their fertility and productive capacity. Only the coarse particles are left.

- Gully erosion

Gully erosion is the next and most destructive phase of water erosion (and this can easily be seen, particularly after heavy rain on cultivated land). It is caused by the concentration of runoff from extended areas into depressions. Whenever the volume and velocity of the runoff water becomes sufficiently high, it gradually removes the whole of the soil material and excavates a ditch. The gully always starts in the lower part of a slope. However, by removing the whole or part of the soil profile it creates a gully head with a sudden and steep fall.

Under such conditions even small quantities of runoff increase their erosive and carrying capacity. Furthermore, the splash

action of falling water undermines the lower part of the excavated earth wall at the gully head and causes the collapse of further parts of the soil material above the gully head. By this continuous process, gullies eat their way uphill to the very top of the sloping land, growing not only longer and deeper but also wider.

With continuous land degradation and reduction of the water holding capacity of the soil, the rate of gullying constantly increases. The excavated material is carried downhill. When gentler slopes are reached, the heavy particles -stones, gravel, sand- are deposited in river channels, lakes, behind dams and on the fertile lower lands. The fine particles are carried out to the river or partly deposited in the deltas of the rivers.

- Land slide

Landslides occur as a natural phenomenon in geologically unstable areas, but they may also be man-induced. They occur on steep slopes and on soils overlaying impervious subsoil or parent material, in most cases with a downhill slope. Landslides are always connected with a high moisture content of the unstable soils. The basic reason for such man-induced landslides is disruption of the ecological balance in the area. For example, deforestation may completely change the water balance in a soil profile and also remove the mechanical barriers of the roots anchoring the soil in place.

As for flooding damage which is another type of natural disaster problem, headwater flood including debris flow is observed. Headwater floods are typical flash floods of short duration that occur rather frequently, that is, two or three times a year.

(2) Soil Erosion

1) General Observations

The land of the Quindio is classified into the following three zones of altitude, from the viewpoint of topography and existing land use (See FIG.K.1):

| Zone | Altitude |
|---|---|
| Mountain Area | More than 2,000m |
| Middle area | 2,000 - 1,200m |
| Low area | Less than 1,200m |

The Mountain Area includes the steep slopes and the comparatively gentle slopes around the top of the steep slopes. The two main types of land use are for grass and forest.

The Middle Area consists of the undulated land, the alluvium fan of which has been eaten away due to water erosion over and extended period of time. This area has higher potential than any other for agricultural production in the Quindio.

The Low Area is the flat land along the la Vieja River formed by the soil from the erosion of the alluvium fan and from the sedimentation caused by the headwater flooding of that river.

The soil erosion of the Quindio is obviously relevant to the land use. In and around the boundary areas of each zone, one can namely observe well-developed areas of erosion which are almost always used as grass land due to the steep slope (16%-27% of slope as an average).

The rill erosion can be observed in and around the grass land at the boundary between the Middle and Low Area, where it extends around the junction of the Quindio and Barragan Rivers and around the la Vieja River connecting it. Downstream of the Espejo River, the Roble River and some other streams, the gully erosion cuts a valley towards the slope where the Middle and Low Areas separate. Locally, the landslides and/or the exposure of top soil can be observed on the slope area and/or in and around the valley.

On the other hand, the rill erosion can also be observed in the grass land on the steep slope where is extending to the Mountain Area, at an altitude of approximately 2,000m. However, a characteristic of the soil erosion of said area is that the land sliding sites and/or the danger spots of landslide can be observed. It is especially found at the watersheds along the Verde River around Cordoba, along the junction of the Lejos and Azul Rivers close to Pijao, along the junction of the Rojo River, the Gris and San Juan Rivers close to Genova.

FIG.K.2 shows the Locations Map of Natural Disaster, based on the field investigation.

2) Factors Affecting Soil Erosion

Generally, in soil erosion, many kinds of natural and/or man-made factors are related with each others. In the Quindio, the major factors affecting soil erosion are: rainfall, topography, soil, land use and farming management.

a. Rainfall

Rainfall is beyond man's power of control. However, from the viewpoint of soil conservation, it is important to clarify the characteristics of rainfall.

It is well-known that the interaction between rainfall and soil erosion are as follows:

- Soil erosion is affected by intensity of rainfall more than by the water amount, in spite of the difference of soil moisture in the field,and

- The rainfall that acts on the erosion generally occurs only a few times throughout the year.

Based on the field survey and/or comments made by the farmers, in the Quindio, the critical rainfall intensity for soil erosion and especially landslides is approximately 30 - 50 mm per hour. This occurs mainly between October and December. Moreover, according to probability analysis, it will occur at intervals of five years.

b. Topography, Soil and Geology

Topography, soil and geology, as well as rainfall, all affect soil erosion.

As mentioned above, one can observe many kinds of soil erosion on the topography of steep slopes, for example, the soil on the steep slope area along the La Vieja River tends to become shallow. This is relevant to the soil texture, namely, the texture of soil covering all the Quindio mostly consists of Volcanic Ash which is eroded easily by rain-drop.

On the other hand, soil erosion is obviously relevant to geological conditions: the areas of soil erosion, especially landslides are mostly located near the techtonic line, running from North to South, and below the steep slopes at an approximate altitude of 2,000m.

c. Land Use and Farming Management

Land use and farming management each have different effects on soil erosion.

In land use, soil erosion on grass land is mainly caused by

livestock. As the animals move, they produce rills on the grass land, and these become deeper and progress gradually because of the rainfall-runoff relation. Finally a landslide occurs owing to destruction of the normal balance of the slope in gravity.

On the other hand, farming management is also responsible for the serious problems of the Mountain and Middle Area. Said problems are shifting cultivation and deforestation, and each one of them occasions headwater flooding as well as the lack of water resources. Moreover, the main problem is that not enough attention is paid to land conservation of the watershed.

The Middle Area has the problem of the cassava cultivation. It is well-known that its cultivation produces soil loss even more so considering the insufficient farming management. Nevertheless, it increases because cassavs has a high marketing potential.

3) Soil Loss

As a counteracting measure in farm land conservation, the important thing is to evaluate the loss of fertile soil caused by soil erosion in quantity and/or quality.

Over the years, many efforts have been made to evaluate soil loss and/or rate of soil erosion. Experimental plots at research stations, the measuring of sediment, and artificial rainstorms with specially designed movable sprinkler systems, are used on various slopes and soils, and under different management conditions. More and more informations is being gathered but, in many cases, the knowledge acquired is still insufficient to be applied to the specific conditions of a selected watershed.

a. Universal Soil Loss Equation

In order to estimate the soil loss, a "Universal Soil Loss Equation" has been developed in the U.S.A for cropland in a specific area. It has been applied in other areas of the U.S.A and efforts are being made to find general solutions for the application of the formula to other parts of the world. The equation is:

$$A = R.K.L.S.C.P.$$

where: A = Computed soil loss per unit area.

R = Rainfall factor, the number of erosion index (EI) units during the period under consideration. The erosion index is a measure of the erosive force of specific rain.

K = soil erodibility factor, the erosion rate per EI unit for a specific soil, in a cultivated continuous fallow on a 9 percent slope, 22.1m (72.6ft) long.

L = Slope length factor, the ratio of soil loss from the field slope length to that from a 22.1m (72.6ft) length on the same soil type and gradient.

S = Slope gradient factor, the ratio of soil loss from the field gradient to that from a 9 percent slope, on the same soil type and slope length.

C = Cropping-management factor, the ratio of soil loss from a field with specific cropping and management to that from the fallow condition on which the factor K is evaluated.

P = Erosion-control practice factor, the ratio of soil loss with contouring, strip-cropping or terracing to that with straight-row cultivation, up-and-down the slope.

The equation is simple but in most developing countries, the available data is insufficient to evaluate most of the components of the equation to make its realistic application possible. Even in developed countries some of the basic requirements of these components have not been fully explored.

In Colombia, the estimation of erosion rates qualitatively and quantitatively has been tried in the Middle Cauca River Basin, (8,000Km2), using above equation: from the information of XII CONGRESO LATINOAMERICANO DE HIDRAULICO "TASAS DE EROSION DE CUENCAS EXTENSAS".

Summarizing the result of that study report, the methodology has made it possible to estimate the hydric erosion degree at 446 ton/ha-year for the middle basin of the Cauca River.

However, the report recommends comparing the result with different and independent methods, since the result shown does

not permit determining clearly, by themselves, the benefits of the methodology and of the Universal Equation for its application to widespread watershed.

b. Estimation of Soil Loss in the Quindio

If records of real measure in and around the field can be obtained as an information on sedimentation, they can use effectively in estimating of soil loss.

In the Quindio, it would be possible to estimate soil loss by using the data of sedimentation measured by the HIMAT, at the Alambrado station on the La Vieja River: at 1,624 km2 from the watershed.

According to the graph (See Fig.K.3) illustrating the daily record of the sedimentation together with the daily discharge over four years (1982-1985), it is understood that soil loss from the farm land is exceedingly relevant to flood water condition. Namely, the amount of soil loss tends to become extremely large in the flood period and conversely small in the dry season.

Moreover, Fig.K.4 illustrates the grading curve of the soil sample obtained from the water in the river. The graph shows the texture of the material carried downstream by the water consists of silt and fine sand.

Total volume for the year is estimated as follows:

in unit: x 103t/year

| Year | 1982 | 1983 | 1984 | 1985 | Mean |
|---|---|---|---|---|---|
| Sedimentation | 3,620 | 590 | 3,180 | 3,070 | 2,615 |
| Unit(t/km2) | 2,229 | 363 | 1,958 | 1,890 | 1,610 |

Moreover, a probability analysis of the above data suggests the following result with each return period, as an approximate soil loss per year from the watershed (See the graph of FIG.K.5):

in unit: x 10 3t/year

| Return Period | Year | | | | |
|---|---|---|---|---|---|
| | 2 | 5 | 10 | 15 | 20 |
| Sedimentation | 3,100 | 3,500 | 3,800 | 3,900 | 4,000 |
| Unit(t/km2) | 1,900 | 2,150 | 2,340 | 2,400 | 2,460 |

(3) Flooding Damage

1) General Observation

In the Quindio, there are some rivers which show a high potential for the development of water resources. These rivers are classified longitudinally into two categories, as shown by the solid and broken line in FIG.K.6.

In the Mountain Area, all the rivers have a characteristic point at which the gradient of the river bed changes from a steep slope of about 20%, to a mild slope of about 2%, at an approximate altitude of 1,500 - 2,000 m. this topographical condition directly affects the flooding damage. Namely, the headwater flowing rapidly at the steep part of a river is controlled at the typical point and simultaneously the rising of the water level causes damages in and around that typical point. The cities of Pijao and Genova, as a matter of fact, are located at such a point. These cities suffer damage every year owing to the rising of the water level.

Moreover, the flood water includes the debris flow from destruction of the watershed caused by shifting cultivation and deforestation and causes of stone, gravel and sand deposits at said typical point.

In the Middle Area, since the gradient of the river bed is almost constant (about a 2% slope, as shown in FIG.K.6) and also, since the river bed is deep compared with the farm land, because of the advanced gully erosion, the flooding damage is hardly noticeable.

On the other hand, near and at the junction of the Quindio and Barragan Rivers, the land is mostly flat. Here, flooding damage is not obvious either. From this, it is considered that the headwater flooding is controlled due to the topographical condition of the river course.

2) Headwater Flood Producing Flood Damage

In the Quindio, attention regarding flood damages has to be paid to urban area of southern area. Especially the Pijao and the Genova, located around both typical points of the Lejos River at an altitude of approximately 1,600m and the Gris River at an altitude of approximately 1,500m respectively, suffer damages by headwater flood including debris flow.

With these points as background, headwater flood - damage relation was studied in the Lejos and the Gris Rivers, concentrating on hydrologic analysis.

In the study, first, the hydraulic characteristic of the rivers, namely the water level (or depth) - discharge relation was calculated by using the Manning Equation (value of roughness coefficient assumed in calculation is 0.05), in each cross-section of the rivers measured at said typical point. Next, in each watershed producing said river discharge, amount of headwater flood discharge and its frequency were estimated by using the Rational Formular. The rainfall adopted is as follows:

in unit: mm/day

| Watershed | Station | Return Period | | | |
|---|---|---|---|---|---|
| | | 5 | 10 | 15 | 20 |
| Lejos River | Pijao | 105.3 | 117.3 | 122.8 | 128.1 |
| Gris River | Gibraltar | 76.4 | 89.6 | 101.3 | 102.1 |

Moreover, the hydrologic characteristic of each watershed are as follows:

| | | |
|---|---|---|
| The Lejos River: | Watershed | 87.7 km2 |
| | Concentration Time | 1.3 hours |
| | Runoff Coefficient | 0.56 |
| The Gris River: | Watershed | 47.8 km2 |
| | Concentration Time | 1.0 hour |
| | Runoff Coefficient | 0.61 |

The results regarding hydraulic characteristics for typical

points of the rivers together with cross-section maps and frequency curves of headwater flooding made from the hydorlogic analysis in each watershed are shown in FIG.K.7 and K.8, respectively.

From the results of analysis, the following are discussed:

- Critical discharge that never causes flood damage to urban areas is approximatly 120m3/s and 160m3/s of headwater flood for the Lejos and Gris Rivers respectively. This discharge probably occurs every year, according to the frequency curve.

- The amounts of headwater flood flow producing the flood damages to both cities of Pijao and Genover will be approximately 470m3/s and 330m3/s, respectively. This discharge occurs at intervals of five to ten years.

3) Flood damage

In both cities of Pijao and Genova, the extent of damage forecasted when the headwater flood mentioned above occurs, was investigated in cooperation with these cities.

According to the information obtained, the following was clarified:

-Pijao city :Urban area where flood damage is forecasted

| | |
|---|---|
| Area | 34 ha |
| Population | 603 persons |
| House | 136 houses |

(forecasted extent of damage:$68,000,000 pesos)

Bridge

(forecasted extent of damage:$50,000,000 pesos)

:Rural area where flood damage is forecasted

| | |
|---|---|
| Area | 83 ha |
| Plantation | Coffee 40 %, Pasto 60 % |

-Genova city:Urban Area where flood damage is forecasted

| | |
|---|---|
| Population | 805 persons (Gris River) |
| | 68 persons (San Juan River) |
| House | 197 houses |

(forecasted extent of damage:$98,500,000 pesos)

Based on this information, flood damage - headwater flood

relation can be estimated by using the following equation:

$$C = f.a.P$$

where: C=Annual average direct losses by means of flood damage in monetary values or annual average benefit in case of countermeasure of flood damage

f=Probability of exceedance

a=Rate of damage

P=Production cost from the area damaged by headwater flood

FIG.K.8(1) illustrates the flood damage - headwater flood relation curve, and suggests that:

-In the Lejos River, measures to prevent flood damage will work within an amount of headwater flood ranging from 300 m3/s to 400 m3/s.

-In the Gris River, this headwater flood will be equivalent to approximately 300 m3/s in amount.

## K.3.2 EXISTING CONSERVATION WORKS

### (1) General

In the Quindio, the three major kinds of land conservation countermeasures are investigation for water erosion prevention work, guidance of farming management for water erosion prevention and reforestation of range lands.

### (2) Investigation into Water Erosion Prevention Work

Investigation into erosion control has been carried out mainly at both basins of the Lejos and the Gris Rivers. It is aimed at safeguarding the urban area from natural disaster such as land sliding.

The Commission Reports resulting from the investigation make clear that the factor affecting natural disaster are: the steep land slope, the high rainfall intensity and the low infiltration of soil consisting mainly of volcanic ash. These reports also recommend the need for civil work such as river training using gabions and so on.

### (3) Guidance of Farming Management

The C.R.Q is promoting the guidance of farming management among farmers for the purpose of preventing water erosion of the farming land. It is especially well-known that cassava cultivation occasions soil loss considering, even more so, the inadequate farming management. Therefore, C.R.Q together with CENICAFE has investigated of soil erosion resulting from cassava cultivation, and has prepared a guideline for farming management of cassava.

### (4) Reforestation

The Mountain Area of the entire Quindio has problems, namely the shifting cultivation and deforestation.

Consequently, the C.R.Q has not only conducted the farming management of the slope lands for the purpose of preventing the disorderly development caused by that problem, but it has also carried out reforestation actively. The following table shows the existing conditions of reforestation:

| Category | Area (ha) | | Planted Species |
|---|---|---|---|
| | Total | Forest | |
| Private | 669 | 370 | walnut,pinus patula, cypres and others |
| Private Company | 5,851 | 2,349 | pinus,patula,pinus oocarpa and others |
| C.R.Q | 2,022 | 1,937 | pinus patula,cypress alder tree and others |
| Total | 8542 | 4656 | |

## K.3.3 LAND EVALUATION AND CLASSIFICATION

### (1) Meaning of Land Evaluation and Classification

In integrated agricultural development, if the strategy for land use and/or farming management is unsuitable or it is misused without measures for soil conservation and disaster prevention, soil erosion of farm land will be accelerated and land fertility will be reduced by topsoil loss, and finally the eco-system of the watershed also might be destroyed.

In order to ensure fertile land as a basic property for agriculture, enough attention must be paid to evaluating land use capability, taking into account various factors in relation to development. The evaluation of land capability from the viewpoint of countermeasures of land conservation and disaster prevention is especially important. This is because soil conservation practices are often the major components which make improved land possible.

### (2) Methodology

Presently there are a number of different systems for evaluating land capability and land classification based on said evaluation. In particular, the U.S. Soil Conservation Service System is applied in many developing countries, however, the conditions in these countries are very different from those prevailing in the U.S.A. Thus, their physical and socio-economic problems require a more flexible approach in their solution, through evaluation of land capability that can be adapted to local conditions and constraints.

With these points as background, land capability in the Quindio was studied concentrating on a topographical map of 1/50,000 scale and an existing land use map made from diagnosis of the study area by means of remote sensing technique, and the result of field servey as well.

Prior to the study of land capability, in order to grasp existing farm land condition including Mountain Area in a fixed quantity, the slope of the whole area was measured using a topographical map and then classification map was made, since the slope of land has major implications for land use. The study of land capability was done by categorizing for method of countermeasures of land conservation and disaster prevention.

### (3) Grouping Slope of Land

To ascertain the topographical characteristic of land in the Quindio, slopes of land can be divided into the following five major groups with range of each gradient, based on the criteria of FAO (by FAO Soil Bulletin No. 44):

| | |
|---|---|
| Flat to almost flat | 0 - 2 % |
| Undulating | 2 - 6 % |
| Undulating to rolling | 6 -25 % |
| Steep | 25 -55 % |
| Very steep | >55 % |

In addition to these groups, two major areas, namely urban and river areas are classified as independent factors. Of these, the urban area consists of city area and the river area mainly extends to the Middle Area.

Major slope groups, however, may often be too wide for decisions on soil conservation practices, leveling for surface irrigation, land reclamation, bench terracing or for the classification of land capability.

Considering the major impact of slope on land use, the result of field survey recommends that nine groups of slope including subgroups are established. The result measured using topographical map is summarized below:

| Description | | Area (km2) | Percentage (%) Area(km2) | Percentage(%) |
|---|---|---|---|---|
| Flat to almost flat | : 0- 2% | | 22.4 | 1.2 |
| Undulating | : 2- 4% | | 379.7 | 19.5 |
| | : 4- 6% | | 216.8 | 11.1 |
| Undulating to rolling | : 6-10% | | 103.7 | 5.3 |
| | :10-15% | | 143.5 | 7.3 |
| | :15-20% | | 36.1 | 1.9 |
| | :20-25% | | 320.4 | 16.5 |
| Steep | :25-55% | | 362.9 | 18.7 |
| Very steep | : >55% | | 262.8 | 13.5 |
| Others | Major river area | | 80.7 | 4.1 |
| | Urban area | | 17.7 | 0.9 |
| | Total | | 1,946.7 | 100.0 |

According to the above table showing a rate of each slope group, the 2 - 4% undulating groups, mostly in the Middle Area, occupy the largest proportion, at 19.5 %. Next, 18.7% is undulating to rolling slope of 25 - 55% in the Mountain Area and agricultural land of southern area. Moreover, the classification map in FIG.K.9 illustrates that both cities of the Pijao and the Genova, which are major urban areas in the southern area, together with the Salento in the northern area, belong to the same topographical condition.

(4) Classification of Land Capability

1) Categorizing

In the Quindio, land capability concentrating on land conservation and disaster prevention can be discussed for the following four categories, based on topography and the existing land use map.

Category - 1: Mountain Area

Category - 2: Middle Area

Category - 3: Low Area

Category - 4: Rain Area

a. Category - 1: Mountain Area

Two types of existing land use in the Mountain Area is for grass and forest.

Of these, the forest area should maintain and preserve the existing condition from the viewpoint of natural conservation. Besides, it is suggested that grass land also should carry out reforestation in the whole. Taking into account topography, disaster condition, development of livestock industry, and so on, however, The grass land will be classified into two kinds of land use in future. One should be used to promote reforestation including the development of livestock industry and the other needs improvement of the existing condition due to eroded land.

Therefore, the Mountain Area can be divided into the following three categories for the future land use:

Category-1.1: Existing forest land.

This area should maintain and preserve the existing condition from the viewpoint of natural conservation.

Category-1.2: Existing grass land which has a comparatively steep gradient.

This area needs reforestation, from the viewpoint of disaster prevention of the watershed.

Category-1.3: Existing grass land which consists of comparatively eroded land.

This area needs improvement of covering condition by using wood, grass and so on, and/or needs civil works at some typical points namely the land sliding sites and/or the danger spots of landslide, aiming at natural conservation.

b. Category - 2: Middle Area

In the Middle Area, attention should be paid to protection of soil erosion for land conservation and disaster prevenstion.

Taking into account topography, land use, soil and so on, the Middle Area will be classified as shown below:

Category-2.1: Existing grass land which extends around the boundary area between the Mountain and Middle Area and/or idotted with the Middle Area.

This area needs land reclamation such as terracing, when converting existing land use.

Category-2.2: Upland that extends mainly at the southern area of the Quindio.

This area needs a canal system to drain surface water run-off aiming at protection against gully erosion, a farm road system maintaining farm condition due to steep slope of up-land comparatively, and moreover needs contour farming.

Category-2.3: Upland that extends around the northern area of the Quindio and consists of undulated land.
This area needs a canal system draining surface water run-off aiming at protection of gully

erosion along river and moreover needs covering such as green-belt, since area occupied by this category consists of mostly comparatively gentle slope.

Category-2.4: Upland which extends western part from the Armenia city and has high potential for agricultural production.

This area is good condition for agricultural management, in the existing circumstances. When considering new development in the future, arrangement of the drainage system will be required for preventing soil erosion.

Category-2.5: Upland that extends around the boundary area between the Middle and Low Area.

This area needs improvement of farming management such as mulching and/or reforestation and moreover civil works at some typical points such as land sliding sides, aiming at protection of soil loss.

c. Category-3: Low Area

In the Low Area, attention needs to be paid to flat land along the Barragan and La Vieja River. Said area needs a drainage system due to flood run-off, when developing as new agricultural land.

d. Category-4: River Area

Major rivers in the Middle Area consist of mostly deep river bed such as V type valley. Said rivers need river conservation aiming at maintenance of river function and protection of erosion accelerated.

2) Classification Map

FIG.K.10 shows classification map made by using categories mentioned above, and area corresponding each category is tabulated below:

| Description | | Area (km2 ) | Percentage (%) |
|---|---|---|---|
| Category - 1: Mountain Area | 1. | 479.7 | 24.6 |
| | 2. | 179.2 | 9.2 |
| | 3. | 311.8 | 16.0 |
| Category - 2: Middle Area | 1. | 146.2 | 7.5 |
| | 2. | 215.6 | 11.1 |
| | 3. | 110.3 | 5.7 |
| | 4. | 298.6 | 15.3 |
| | 5. | 73.2 | 3.8 |
| Category - 3: Low Area | | 23.1 | 1.2 |
| Category - 4: River Area | | 91.3 | 4.7 |
| Urban Area | | 17.7 | 0.9 |
| Total | | 1,946.7 | 100.0 |

## K.4 DEVELOPMENT PLAN

### K.4.1 GENERAL

Throughout the field survey and analysis of some information obtained, it is inexplainable that existing entire farming land of the Quindio is in good condition from the viewpoint of land conservation and disaster prevention. Consequently, in the integrated agricultural development, the sector of land conservation and disaster prevention has to bear responsibility for execution of the project.

In discussing the existing condition toward improvement of land, two major subjects are summarized as shown below:

One is disaster problem affecting urban and rural area, caused by flood water flow including debris flow, which runs along steep slope of river in the Mountain Area. Said disaster mostly occurs around the middle course of rivers, at boundaries between the Mountain and Middle, because slope of river course changes around boundaries in topography, and probability occurrence is high. On the other hand, in the Low Area, man-made disaster caused by the collection of construction materials (namely sand and gravel) on the river bed, occurs around flat land.

Other is countermeasures of soil conservation. The land of the Quindio is covered with comparatively fertile soil and almost all is utilized for agricultural production. However, some erosion can be observed from place to place on the land, since soil texture consists of Volcanic Ash which is eroded easily by surface water runoff, and existing land use and/or farming management is not always suitable for agricultural production.

In formulating development plan regarding land conservation and disaster prevention, basic concept has essentially come up with concentrating on these subjects. And then, the projects are selected, based on the study for classification of land capability toward development plan.

### K.4.2 CONSTRAINTS

Prior to the presentation of basic concept for development plan, the constraints which may reduce the implementation of the project have to be clarified. In the Quindio, the following are discussed:

- The Mountain Area occupied around eastern part of the Quindio must bear responsibility for water resources regarding

agricultural development as the area cultivating rainfall water. Nevertheless, shifting cultivation and/or deforestation are/is still done. This is probably, farmers have only a superficial understanding of the conservation of natural resources. This matter makes origin of disaster to the urban and rural area of downstream.

- In the Mountain Area, grass land occupying approximatly 50% of whole area will need reforestation, with a viewpoint of having natural conservation of watershed. However, to promote intentional reforestation is difficult, since said area consists mainly of private land.

- In the farming land, the Yuca which has a serious problem of soil erosion is cultivated unsystematically, although enough guidance regarding farming management is given to the farmers.

- Human element is probably the most serious limiting factor in carrying out improvement on agricultural land. Pressure on the land by a rapidly increasing rural population with advance of agricultural development might bring man's destructive activities without countermeasure for land conservation and disaster prevention. In this aspect, the most important factor affecting the effectiveness of land conservation and disaster prevention practices is that farmers understand about these problems and/or have knowledge.

- Human resources efforts regarding engineering for land conservation and disaster prevention are not sufficient. In fact, all research and/or civil works have carried out other cooperation except for C.R.Q.

## K.4.3 BASIC CONCEPT FOR DEVELOPMENT

### (1) Targets

Agricultural sector of the Quindio has high potential as a key industry of the future, although its potential is low under the existing condition. However, if enough attention is not paid to conservation of natural environment destroyed by unplanned development of watershed, disaster problem will continue to increase and moreover potential of agricultural development will be limited considerably. On the other hand, possibility of agricultural development will depend on the increase of agricultural productivity together with improvement of land capability and/or reorganization of land use.

In due paying attention to the above circumstances, besides,

taking into account the integrated agricultural development policy as well as the constraints prevailing in the land as a whole, specific targets for development plan regarding land conservation and disaster prevention are summed up, as shown below:

- Recovery of natural environment, and
- Ensuring and maintaining stable land for agricultural production.

(2) Development Strategy

In carrying out improvement of existing farm land toward targets of development plan, three kinds of measures are civil works, reforestation and promotion including guidance regarding farming management to farmers.

In order to actualize effectively these measures, the basic strategies are formulated hereunder:

1) Civil Works

Strategy for civil works can be discussed corresponding to the categories shown in the classification of land capability, namely the Mountain, Middle and Low Areas, since erosion and disaster problem of land are relevant to topography as often pointed out. However, individual strategies are formulated in relation to each other.

a. Strategy for the Mountain Area

The Mountain Area must bear responsibility for establishment of stable land at downstream as well as water resources for agricultural development. On the premise of preserving natural resouces of watershed, strategy includes the following:

- To control flood water flow causing together with debris flow at the Mountain Area, aiming at the prevention of flood damage and establishment of stable land, at downstream.

Based on this strategy, the plan for the Mountain Area includes the following two factors:

- Debris flow control
- Flood water control

b. Strategy for the Middle Area

The Middle Area must bear responsibility for stability and elevation of agricultural production on the premise of taking measures for soil conservation. Strategy for soil conservation consists of the following two factors:

- To carry out river training and preserve natural function which river should originally keep, aiming at raising effectiveness of soil conservation, and

- To introduce positive method of soil erosion control with not only civil works but also crop and/or farming management, aiming at prevention of fertile soil loss.

Based on these strategies, the plan for the Middle Area consists of the following factors:

- River training

- Civil works for soil erosion control
  Land reclamation,
  Arrangement of the canal system for surface water drainage, and so on.

- Farming management for soil erosion control
  Contour farming,
  Mulching, and so on.

c. Strategy for the Low Area

In the Low Area, strategy includes flood water control on the premise of river training at flat land extending around junction of the Barragan and the Quindio Rivers.

2) Reforestation

The reforestation has two major impacts on the land of whole area. One brings effectiveness to recovery of natural environment throughout prevention of soil erosion and disaster, by carrying out in connection with civil works. And the other contributes to social and economic promotion of the local area, by itself.

In the Mountain and Middle Areas, the following strategies are formulated:

a. Strategy for the Mountain Area

The reforestation to the Mountain Area will produce the manufacturing and marketing of wood-made, as well as, contribute the recovery of natural environment. With these points as background, the strategy is shown as follows:

- To implement reforestation and prevent unplanned development, aiming at the improvement of capacity cultivating rainfall of watershed as water resources,

- To create new employment sources for giving a better social-economic promotion of the people within the area.

- To promote livestock production throughout implementation of reforestation, aiming at a combination of forestry and agriculture.

b. Strategy for the Middle Area

Subject for the reforestation in the Middle Area is to prevent soil loss of farm land, aiming at elevation of agricultural productivity. The strategy is:

- To promote reforestation for soil erosion control of farming land, at steep slope land.

3) Promotion Including Guidance

Strategy for the promotion is to plan organization aiming at the study of the technical part regarding land conservation and disaster prevention, training to civil works engineer, guidance to farmers, and so on.

## K.5 THE PROJECTS

### K.5.1 FUTURE ASPECT

Prior to formulation of the project along the development strategy in the definite, the future aspect has to be described. Here, the specific projects are selected with high priority.

As before, land capability was studied, based on evaluation of existing conditions from the viewpoint of topography, land use, farming management, and so on, and also the land of the whole area was classified, concentrating on measures for land conservation and disaster prevention toward improvement of land which aims at the increase of agricultural potential in the future. Then the classification map was made .

This classification map for land capability, in summary, suggests two important themes toward the integrated agricultural development: necessity of natural conservation of the watershed for the Mountain Area and soil erosion control for the farm land extending to the Middle and Low Area. The basic concept for the development plan has been formulated, based on the principle of this.

Said classification map, on the other hand, describes the future aspect toward implementation of the integrated agricultural development. Thus, two important themes as mentioned before suggest what should be carried out for increasing agricultural potential, extending over a long period of time.

### K.5.2 SELECTION OF THE PROJECTS

(1) Criteria for Selection

In selection of the specific projects carried out along the strategy within the development plan for the sector of land conservation and disaster prevention, two major principles are:

- To establish the projects up to the year 2005 A.D., and

- To designate the natural conservation area of watershed.

In the former, the goal of the master plan for the integrated agricultural development in the Quindio is 2005 A.D. on the premise of establishment in the year 2005 A.D. Therefore, the projects are selected from the future aspect mentioned above.

In the latter, designating natural conservation area of watershed aims at legally preventing of unplanned development of the watershed, and also conservation of eco-system. Said areas have to be set up, for bringing enough results in implementation of the projects.

Based on the principle mentioned above, criterias for selecting the projects are as follows:

- High urgency and necessity

- Widely effective

- Realistic

(2) Selection of the Projects

Four kinds of the projects selected are for:

- Designating natural conservation area of watershed. This is to enact rules for land use of the Mountain Area for preventing unplanned development of watershed, for example deforestation, shifting cultivation and so on.

- Disaster prevention of watershed. This is applied at where, among designated natural conservation area mentioned above, natural condition is serious in particular.

- Improvement of river. This is expected to give a high effectiveness for soil conservation, by recovering natural function which river should contain, in and around the Middle and Low Area.

- Soil conservation of farm land. This is aimed at soil conservation mainly at the Middle Area, and also especially gives significance to enlightenment regarding the importance of soil conservation.

From the above mentioned point of view, the projects selected are summarized in TABLE 1, and FIG.K.11 illustrates location of the projects.

## K.5.3 PROJECT FORMULATION

### (1) Designating Natural Conservation Area Project

The natural conservation area is defined as special land where implementation of any development is controlled legally for establishing the following objectives:

- To cultivate rainfall water,
- To prevent debris flow,
- To prevent collapse of slope land, and
- To preserve eco-system of watershed

This idea was originally proposed for preventing unplanned development in the Mountain Area, namely shifting cultivation, deforestation and so on, and then maintaining reasonably natural environment. In the Mountain Area, as before, development strategy has recommended necessity of reforestation. However, it is difficult to promote intentional reforestation, because said area consists mostly of private land.

In order to control effectively unplanned development, natural conservation area is designated by law including the following terms:

- The management of designated area is unified by administration.
- Any development in said area is carried out, based on the request to administration.

In the integrated agricultural development of the Quindio, the natural conservation area should bear responsibility for elevation of agricultural potential of farm land. In setting up said area, however, the important matter is that local population has a proper understanding of the necessity of natural conservation. Because to control the development by law might produce a clash of interests between three local areas, up, middle and down areas of the watershed. If this idea is promoted by only administrative measure, balance for natural environment of comprehensive watershed might be destroyed preferably.

In the Quindio, the following watersheds are proposed as a natural conservation area, based on the study of evaluation and

classification for land capability:

| Rivers | Watershed (km2) | | | |
|---|---|---|---|---|
| | Total Area | Erosion/Torrent Control Area | Categories of Land Use | |
| | | | Wood-land | Meadow-land |
| Quindio | 140.4 | 3.2( 2) | 85.2(61) | 55.2(39) |
| Navarco | 63.3 | 3.2( 5) | 33.9(54) | 29.4(46) |
| Santo Domingo | 70.4 | 8.7(12) | 15.4(22) | 55.0(78) |
| Verde | 29.7 | 13.9(47) | 16.6(56) | 13.1(44) |
| Lejos | 87.7 | 30.7(35) | 60.7(69) | 27.0(31) |
| Azul | 72.3 | 3.4( 5) | 33.6(46) | 38.7(54) |
| Rojo | 114.5 | 11.5(10) | 62.4(54) | 52.1(46) |
| Gris | 47.8 | 4.5( 9) | 30.0(63) | 17.8(37) |
| San Juan | 51.5 | 5.6(11) | 36.7(71) | 14.8(29) |
| TOTAL | 677.6 | 84.7(13) | 374.5(55) | 303.1(45) |

* Parentheses show percentage against total area for each river.

(2) Disaster Prevention Project

1) General

As mentioned above, the development strategy has pointed out that the disaster prevention plan of the Mountain Area is formulated by combination of three planning factors: namely flood water and debris flow control plans, and forestation plan including woodland path plan.

The flood water control plan depends on the method of reducing flood flow from watershed by a flood control reservoir and riverwall, for preventing flood damage to urban and rural area of downstream. And also, for controlling debris flow produced from erosion of steep slope land such as land-slide, small scale dams are planned in upstream of watershed. The forestation is planned, aiming at conservation of watershed by means of vegetative cover.

2) Flood Water Control

The flood water control is applied to flood flow running along both rivers of the Lejos and the Gris respectively.

a. Location of Flood Control Reservoir

From the result of field survey, the flood control reservoir was proposed upstream, approximately 12 km from the Pijao city along the Lejos River, and upstream approximately 20 km from the Genova city along the Gris River. Both reservoirs on the Lejos and the Gris Rivers have watershed of approximately 87.7 km2 and 47.8 km2, respectively. The topographical maps of reservoir together with water level-volume relation graphs are shown in FIG.K.12 and K.13.

b. Estimation of Flood Water Flow

As for the flood water flow from the watershed, the amount of headwater flood and its frequency have already been studied: see (3)-2) Flooding Damage in K.3.1. The results are summarized as below:

| River | Watershed (km2) | Concentration Time (hr) | Frequency (Year) | | | |
|---|---|---|---|---|---|---|
| | | | 5 | 10 | 15 | 20 |
| Lejos | 87.7 | 1.3 | (31) 310 | (34) 350 | (36) 370 | (37) 380 |
| Gris | 47.8 | 1.0 | (26) 216 | (31) 253 | (35) 286 | (35) 288 |

* Parentheses show rainfall intensity per 1 hour.

c. Alternative Study for Flood Water Control

The reservoir capacity for flood water control can be analyzed by the water balance between runoff hydrograph from watershed and the reduced flow downstream.

-The runoff hydrograph can be described from water flow corresponding to return period of any years, assuming triangular hydrograph (by U.S.SCS: 1973).

-As for the reduced flow, two idea can be proposed by method

taking measures of riverwall at downstream. One can adopt critical flow which never damages to urban and rural areas at downstream, without taking measures of riverwall. As before, said flows of the Lejos and the Gris Rivers are equivalent to approximately 120m3/s and 160m3/s in water amount, respectively. The other can adopt the maximum possible flow, on premise of taking measures of riverwall. According to results estimated by the cross-section shown in FIG.K.12, said flows of the Lejos and the Gris Rivers are equivalent to approximately 300m3/s and 290m3/s in water amount, respectively.

-The reservoir capacity includes the sedimentation. Thus, as for design value of sedimentation, approximate 1500m3/km2/year for return period of ten years was taken from the analysis mentioned above, and then, using this value, the sedimentation during five years was assumed as total design volume, on premise of implementation of enough management.

The below shows the results of alternative study:

| River | Watershed (km2) | Headwater Reduced Flood Flow (m3/s) | (m3/s) | Reservoir Capacity (x103m3) Water Volume | Sedimentation | Total |
|---|---|---|---|---|---|---|
| Lejos | 87.7 | 350(10) | 120 | 1,050 | 650 | 1,700 |
| | | 370(15) | 120 | 1,120 | 650 | 1,770 |
| | | 380(20) | 120 | 1,260 | 650 | 1,910 |
| | | 350(10) | 300 | 70 | 650 | 720 |
| | | 370(15) | 300 | 175 | 650 | 825 |
| | | 380(20) | 300 | 280 | 650 | 930 |
| Gris | 47.8 | 253(10) | 160 | 300 | 350 | 650 |
| | | 286(15) | 160 | 400 | 350 | 750 |
| | | 288(20) | 160 | 450 | 350 | 800 |
| | | 253(10) | 290 | - | - | - |
| | | 286(15) | 290 | - | - | - |
| | | 288(20) | 290 | - | - | - |

* Parentheses show the year of the return period.

The above table shows that:

-As for the Lejos River, the reservoir capacity corresponding

the reduced flow of 120 m3/s can be reduced in half, by taking measures of riverwall around the urban area. Besides,difference of return period does not affect so much for reservoir capacity. As design return period, therefore, twenty years was selected, taking into account regional economic capacity for investments, and then reservoir capacity and the amount of headwater flood were determined.

-As for the Gris River, the riverwall work around the urban area does not need the flood control reservoir.

d. Dam Type and Riverwall Work

Dam heights can be estimated by using the water level-volume relation graphs shown in FIG.K.12. Besides, As for scope of riverwall works, 7 km and 10 km of length around the urban areas are proposed along both sides of the Lejos and the Gris Rivers, respectively.

| River | Watershed | Reservoir | | Riverwall | |
|---|---|---|---|---|---|
| | (km2) | Capacity (x103m3) | Height (m) | Length (km) | Height (m) |
| Lejos | 87.7 | 1,050 | 33 | 7 | 1.5 |
| Gris | 47.8 | - | - | 10 | 1.5 |

As for Dam type, concrete gravity Dam with orifice type spillway for flood control is adopted. Besides, the riverwall can be constructed by the gaviones.

3) Debris Flow Control

The debris flow control is applied to ones coursing along four rivers of the Santo Domingo, the Lejos, the Gris and the San Juan.

a. Location of Dam for Debris Flow Control

From the result of land capability classification study and field survey as well, the dams for debris flow control were proposed at the following dangerous points around the watershed:

| River | Watershed Area (km2) | Points | Disaster Prevention Area (km2) |
|---|---|---|---|
| Santo Domingo | 70.4 | 12 | 8.7 |
| Lejos | 87.7 | 6 | 30.7 |
| Gris/San Juan | 99.3 | 7 | 10.1 |
| Total | 257.4 | 25 | 49.5 |

b. Estimation of Debris Flow

The mechanism of debris flow is still un-known in detail. From the macro-mechanism, the following can be assumed in estimating debris flow:

- Sand/gravel produced at upstream of watershed will be classified into one running with flood water and the other accmulating in and around the mountain-side, in total volume.

From this matter, debris flow can be suggested by the following equation:

$$VA=VB+VC$$

$$VC=f.VA$$

where VA: Total volume of sand/gravel produced
VB: Total volume of sand/gravel accumulating in and around mountain-side
VC: Total volume of sand/gravel running with flood water
f : Ratio of VC to VA

In the above equation, VA, total volume of sand/gravel produced at upstream of watershed, can be estimated by relation of produced area of sand/gravel and depth. Produced area can be made clear by land capability map and/or field survey. As for depth causing land-slide and so on, besides, approximate 15m will be able to be forecasted from the viewpoint of topography and geology. The f, ratio of VC to VA, is shown below, since total volume of sand/gravel running from watershed to downstream is affected by extent, slope, and so on:

$$f=(H/L)0.4/A1/3$$

Where H/L: slope of river course
A : Area

From these matters, the amount of debris flow is estimated in total, as shown below:

| River | Total Produced Sand/Gravel | | Debris Flow (103m3) | | |
|---|---|---|---|---|---|
| | Produced Area(ha) | VA(x103m3) | Flow Rate | VC | Unit Volume |
| Santo Domingo | 1.74 | 261 | 0.24 | 63 | 5.3 |
| Lejos | 6.14 | 921 | 0.19 | 175 | 29.2 |
| Gris/San Juan | 2.02 | 303 | 0.45 | 135 | 19.3 |
| Total | 9.9 | 1,485 | | 373 | 53.8 |

c. Dam Type

In order to control the debris flow estimated, small scale concrete gravity dams with spillway for controlling flood water were proposed at some points of upstream.

The average dam height was estimated by the amount of debris flow forecasted and slope of river course in and around upstream of watershed, as shown below:

| River | Points | Amount of Debris Flow (m3) | Height (m) |
|---|---|---|---|
| Santo Domingo | 12 | 5,300 | 5 |
| Lejos | 6 | 29,200 | 20 |
| Gris/San Juan | 7 | 19,300 | 15 |

4) Reforestation Plan

The idea of reforestation is supported for the following area, based on the concept authorized by the C.R.Q. staff:

| River | Watershed (km2) | Proposed Reforestation Area (km2) |
|---|---|---|
| Santo Domingo | 70.4 | 32.2 |
| Lejos | 87.7 | 15.1 |
| Gris/San Juan | 99.3 | 22.2 |
| Total | 257.4 | 69.5 |

a. Planting Plan

In order to carry out the reforestation in the proposed area, the selected species are the PINUS PATULA and CUPRESSVS LUSITANICA, since previous experiences have shown a yield of 12-15m3/ha.

Planting density is as follows:

| Species | Planting Density | Tree per Ha |
|---|---|---|
| Cupressus Lusitanica (Triangle system for very steep areas) | 2.5mx2.5m | 1848 |
| Pinus Patula (Triangle system for very steep areas) | 2.5mx2.5m | 1848 |

b. Management of Plantation

After the land has been planted, a professional is necessary for executing a management plan, taking into account weed control, fertilization, pruning, and cutting selection for clearing up the forest.

Four stages are important for the forester in an artificial forest:

Reforestation : Planting trees

The setting up: Planting trees according to the place, density and species.

Management : The forester takes care of the forest for having good quality of trees and meeting

the objectives.

Forest produce: Soil is worked according to yield, purpose, and cutting turns.

c. Forest Produce Stage

Forest produce with the technical management cited before will allow foresters to get good quality of wood and provide employment opportunities. The industrial use of harvested wood is obtained after the eiththh year, when stems are 7cm D.A.P (22cm C.A.P) and less than 15cm.

They are generally used for fences, pulp, and combustible (coal); after the twelveth year another forest produce is made for industrial use.

Consequently as before, forests are the best vegetal coverage for protecting the quality of a watershed. For improving eroded uplands by means of reforestation, it is necessary to stop the cause; therefore the setting up of forests for avoiding overpasturing and negative upland exploitation, as well as, producing wood are important.

d. Woodland Path Plan

In the disaster prevention plan of watershed, woodland path for carrying out management of civil work facilities and forest, and preserving natural resources as well, is planned in and around the watershed.

(3) River Improvement Project

1) General

Two rivers selected for river improvement are the Espeio and the Verde. They have a different approach to each other to soil conservation in the Middle Area. Namely, improvement of the Espejo River is approached from the viewpoint of elevation of the existing drainage condition, and besides, flood protection work is proposed along the Verde River, as river improvement.

2) Improvement of the Espeio River

a. Countermeasures

The Espejo River is small scale river running along the lower part of the Middle Area, and long and narrow land with steep slope extends along right side of river.

In the existing circumstance, this river bears responsibility for drainage from local area. However said river capacity is not always enough to flood water amount, due to sedimentation of silt and/or sand caused by water erosion of slope land at right side. Therefore, river water frequently inundates farm land along river course.

With these points as background, river improvement for this river consists of the following two countermeasures:

- Improvement of cross-sectional area, and

- Soil erosion protection work of slope land of right side.

b. Improvement of Cross-sectional Area

FIG.K.14 illustrates typical cross-sections of river at the Pueblo Tapao, where water flow is restricted among whole river course.

According to hydraulic analysis by using the Manning formula, these cross-sections have the maximum capacity, ranging from 95m3/s to 140m3/s: in analysis, roughness coefficient and river slope are assumed as N=0.032 and S=1.9% respectively.

On the other hand, the following table shows the result of probability analysis for flood water at said point:

| Watershed (km2) | Time of Concentration (hr) | Return Period (years) | Rainfall Intensity (mm/hr) | Flood Water (m3/s) |
|---|---|---|---|---|
| 97 | 3.7 | 5 | 12.4 | 101 |
| | | 10 | 13.4 | 108 |
| | | 15 | 14.0 | 113 |
| | | 20 | 14.2 | 116 |

Throughout these analysis, return period of ten years was selected, as design return period regarding river improvement, and flood water amount of 108 m3/s was taken.

As for river improvement work, the section of 1.0km in length was selected at the Pueblo Tapao along the river course. The river improvement work includes rearrangement of river bed by means of removing sedimentation and riverwall of both river sides.

c. Soil Erosion Protection Work

The land extending along right side of the Espejo River consists of long and narrow land with slope ranging from 6% to 10% in average.

In this land, the slope is not always stable due to no drainage system. Soil erosion and/or top soil loss frequently occur from place to place and soil material with runoff water runs down to the Espejo River. Resulting from this matter, fertility of this land tended to become low, and moreover capacity of the Espejo River was reduced by sedimentation of soil material.

With these points as background, necessity of soil erosion protection work by means of bench terracing is discussed as follows:

- Bench terracing is probably the most effective soil erosion protection practice on sloping land.

- Improvement of drainage systems also is one of effective soil erosion protection practices. In the slope land, however, elevation of agricultural potential in the future is probably produced good results by making farming management easy as well as improving drainage system.

- Improvement of farming condition in the slope land would make comprehensive approach for agriculture production possible.

In designing terraces, natural features should be used, if possible, in siting waterways, paths, and etc. FIG.K.15 shows proposed cross-section of bench terracing.

3) Improvement of the Verde River

a. Countermeasure

The Verde River, one of the major rivers in the Quindio, runs toward the Baragan River after meeting to the Santo Domingo and Quindio Rivers, going across the Quindio from the Mountain Area,

in a straight line. Said topographical condition gives easily rise to damage at farm land around middle course of the river, affected directly by flood water running down from the Mountain Area.

As for the flood water control, method taking measure by the resurvoir was already studied at the Mountain Area. In the middle area, however, this method is not useful in topography.

From these matters, flood protection work by means of riverwall is proposed at the section of 4km from junction of the Santre Domingo toward downstream, as effective method of countermeasure for flood protection.

(4) Soil Conservation Project

1) General

The farm land extending along the rigth side of the La Vieja River consists of steep slope and undulated land, and some kinds of erosion can be observed from place to place.

This land probably brings serious influence for fertility of the Middle Area, from the following viewpoints:

-This land forms the boundary between the Middle and Low Area, in the topographicall condition,

-In the present, decreasing of the fertility is observed due to top soil loss, in this land, and

-In the future, if attention regarding soil conservation is not paid for this land, influence of soil loss probably extends toward the Middle Area from top of slope.

To carry out countermeasure for soil conservation in this land, therefore, shoud contribute establishment of fertale land of the Middle Area, and elevation of agricultural potential of said area as well.

2) Soil Conservation Work

As for the soil conservation work, method by means of bench terracing was already proposed at the steep slope land along right side of the Espejo River. In this area, however, the same method is not suitable, because surface soil is shallow in layer.

Two kinds of soil conservation work proposed in this land are the gully erosion protection work and improvement of covering condition.

In this land, many numbers of points eaten away by the gully can be observed. They bring damages in the farm land and give rise to fertale soil loss of the land.

In order to protect the gully erosion, therefore, construction by means of concrete wall is proposed.

On the other hand, unstable condition of this land is probably caused by the existing land use which is for grass and/or upland crops. Therefore, this land has to pay attention for improvement of covering condition as well as civil work mentioned above.

As improvement of covering condition, planting green belt by means of forest, with width of approximately 10m and intervals of approximately 20m is proposed.

## K.5.4 PROJECT EVALUATION AND IMPLEMENTATION

### (1) Project Cost

#### 1) Quantity

The quantities estimated for each project is as follows:

a. Designating Natural Conservation Area

In order to designate the natural conservation area, the following three kinds of investigation are required as a preparatory work:

Land use in watershed of 677.6km2

Covering condition in watershed of 677.6km2

Soil and geology in watershed of 677.6km2

b. Disaster Prevention Plan

As for disaster prevention plan, the preparatory works and civil works are summarized as shown in TABLE K.2.

c. River Improvement Plan

As for river improvement plan, the preparatory works and civil works are summarized as shown in TABLE K.3.

d. Soil Conservation Plan

In the right side of the La Vieja River, proposed for soil conservation plan, the following preparatory works and soil conservation works are required:

Preparatory Works

Land use survey in area of 54km2

Disaster condition survey in area of 54km Design

Soil conservation works

Gully protection works 52 points

| | |
|---|---|
| Green belt | |
| Width | 10 m |
| Intervals | 20 m |
| Plant | Forest |

2) Cost

The project costs were estimated, based on the following criterias:

-The project costs were estimated by total costs including foreign and local currency, in dollars.

-The following were used for unit cost of civil works:

| | |
|---|---|
| Flood control dam | = 230 dollars per unit volume of concrete work |
| Debris flow control dam | = 200 dollars per unit volume of concrete work |
| Woodland path | = 330 dollars per m |
| Riverwall work | = 470 dollars per m |
| Bench terracing | =3,300 dollars per ha |

-In working of riverwall for both rivers of the Lejos and the Gris, improvement of bridges are considered in the construction cost.

-Forestation cost was estimated by unit cost per 1ha, showing in TABLE K.4.

-The following items do not include:

Operation/Maintenance during construction

Project administration

Contingency including price escalation

The results estimated are summarized as shown below:

in unit:million Col$

| Project | (Area) | Direct Cost |
|---|---|---|
| 1. Designating natural conservation area | (677.6km2) | 110 |
| 2. Lejos River Disaster prevention | ( 87.7km2) | 7,760 |
| Gris and San Juan River 〃 | ( 99.3km2) | 4,020 |
| Santo Domingo River 〃 | ( 70.4km2) | 3,000 |
| 3. Espejo River improvement (Including Soil Conservation | ( 1km) 14.4km2) | 1,300 |
| Verde River improvement | ( 4km) | 50 |
| 4. La Vieja River right side area soil conservation | ( 54.0km2) | 1,050 |
| TOTAL | | 17,290 |

Note:Breakdowns of each plan are shown in TABLE K.5,6,7 and 8.

(2) Evaluation

In order to evaluate feasibility of the proposed projects, generally, method by means of economic evaluation is utilized. One simple criteria in the econonmic evaluation procedure is the net added income for primary beneficiaries (the farmers). This is the difference of the net income for farmers between the "without" and the "with" situation.

In the projects regarding land conservation and disaster prevention, however, to define the feasibility by only economic analysis probably is difficult, since damages caused by disaster include some kinds of loss. (The damages may be classified as: direct losses to property, crops and land, that can be determined in monetary values; indirect losses, such as

depreciated property, traffic delays, and loss of income; and intangible losses not subject to monetary evaluation, including community insecurity, health hazards, and loss of life). Economic analysis may have only a low internal econcomic rate of return (IERR).

When evaluating the projects, the important matter is to make clear the situation and/or the meaning of the projects toward the integrated agriculture development. In the Quindio, the implementation of the integrated agriculture development probably depends on the establishment of water and land resources, and special attention must be paid to conservation of natural environment for ensuring stable water resourse and to improvement of slope land such as bench terracing for ensuring stable land resourse. Especially, improvement of slope land would contribute the elevation of land potential by making farming work easy.

With these points as background, the projects proposed for land conservation and disaster prevention are exactly situated on the integrated agriculture development. The projects probably bear responsibility for implementation of the agriculture development, as a foundamental factors toward the development.

The projects bring not only good effectiveness to agricultural sector but also comprehensive effectiveness to local area.

(3) Implementation

Implementation of the projects should be coordinated by many government ministries, departments and semi-government agencies. Because investment for the projects may be beyond the local economic capacity.

In the implementation, to carry out all of the projects at the same time probably is not available. In order to produce optimum effectiveness within possible capacity of investment, the projects have to be promoted on schedule along a long-range plan.

Of the projects proposed, the subject which should give most high priority is designating the natural conservation area by law. Because this is situated in the integrated agricultural development as well as the sector of land conservation and disaster prevention, as a foundamental and comprehensive factor.

Next, the priority would be given to the disaster prevention projects which is proposed at southern area of the Quindio.

However, these projects are situated in the integrated agricultural development, as urgent subject which contributes for the solution of the social differential in the Quindio.

As before, the projects include three proposed areas. Among them, countermeasures for the Lejos and the Gris/Sun Fuan Rivers shoud take precedence of the other, since the flood water including debris flow at that rivers frequently gives rise to direct loss of damage to urban area. And it is desirable that they are carried out in phased stages, as shown below:

First Stage ------ Riverwall Works

Second Stage ----- Flood Control Reservoir Works

Third Stage ------ Debris Flow Protection Works including Woodland Path

Fourth Stage ----- Forestation

From this, the projects which are highest urgency and necessity within the master plan for the integrated agricultural development are summarized below:

in unit:million Col$

| Project | Civil Works | Direct Cost |
|---|---|---|
| Urgent measure of the Pijao | Riverwall and improvement of bridge | 910 |
| Urgent measure of the Genova | Riverwall and improvement of bridge | 1,280 |
| Total | | 2,190 |

The other projects can be promoted toward the integrated agricultural development, based on a long-range plan.

## K.6 RECOMMENDATION

Success of the plan for land conservation and disaster prevention would depend on some factors which should be considered in the implementation. Throughout the study of the master plan, the following are recommended:

-C.R.Q. needs to ensure the engineering staff for land conservation and disaster prevention, and to make the organization for promoting the projects.

-C.R.Q. needs to make immediately the program for implementing the plan, including the educating campaign program regarding natural resourse conservation, in cooperation with the other organization concerning.

-In order to ensure the design criteria for land conservation and disaster prevention, the hydrometeorological data needs to be rearranged.

-Since degree of disaster problem depends mainly on the rainfall-runoff relation including factor of soil texture of land, the method of runoff analysis needs to be established.

TABLE K.1 GENERAL DESCRIPTIONO OF THE PROJECTS

| The Project | Area (km2) | Countermeasures | | | | | Others |
|---|---|---|---|---|---|---|---|
| | | Civil Works | | | Forestation | | |
| | | Flood Water Control | Debris Flow Control | Soil Erosion Control | Woodland Path | Reforestation | |
| 1.For designating natural conservation area | | | | | | | |
| Quindio River | 140.4 | | | | | | Protection of Planless Development |
| Navarco River | 63.3 | | | | | | |
| Santo Domingo River | 70.4 | | | | | | |
| Verde River | 29.7 | | | | | | |
| Lejos River | 87.7 | | | | | | |
| Azul River | 72.3 | | | | | | |
| Rojo River | 114.5 | | | | | | |
| Gris River | 47.8 | | | | | | |
| San Juan River | 51.5 | | | | | | |
| 2.For disaster prevention of watershed | | | | | | | |
| Santo Domingo River | 70.4 | | Construction of Dam | | Net-Work Plan | Disater Prevention | |
| Lejos River | 87.7 | Construction of Dam | Construction of Dam | | Net-Work Plan | Disater Prevention | |
| Gris/San Juan River | 99.3 | Construction of Dam | Construction of Dam | | Net-Work Plan | Disater Prevention | |
| 3.For improvement of river | | | | | | | |
| Espejo River | 155. | Improvement of cross-section | | Soil Erosion Protection Works on the Slope Area | | | |
| Verde River | 82 | Improvement of River Bed and River Sides | | | | | |
| 4.For soil conservation of farm land | | | | | | | |
| Right Bank of the La Vieja River | 54 | | | Soil Erosion Protection Works on the Slope Area | | | |

Note: "Soil Erosion Control" includes reforestation

TABLE K.2 DISASTER PREVENTION PLAN

| Description | Lejos | Gris/Sun | Santo Domingo |
|---|---|---|---|
| Watershed (km2) | 87.7 | 99.3 | 70.4 |
| Preparatory Works | | | |
| Land use (ha) | 132 | 132 | 3.6 |
| Land measurement (ha) | 132 | 132 | 3.6 |
| Design of civil work | Flood control Dam<br>Debris flow control Dam | | |
| Civil Works | | | |
| Flood Control Dam | | | |
| Height (m) | 33 | - | - |
| Concrete Works (m3) | 64,000 | - | - |
| Riverwall | | | |
| Height (m) | 1.5 | 1.5 | - |
| Gaviones Works (km) | 7 | 10 | - |
| Debris Flow Control Dam | | | |
| Numbers | 6 | 7 | 12 |
| Height in average (m) | 20 | 15 | 5 |
| Concrete works (m3) | 17,400 | 15,400 | 18,000 |
| Woodland Path (km) | 19 | 15 | 13 |
| Forestation (km2) | 15.1 | 22.2 | 32.0 |

TABLE K.3 RIVER IMPROVEMENT PLAN

| Description | Espejo | Verde |
|---|---|---|
| Preparatory Works | | |
| Land use (km2) | 14.4 | - |
| Measurement (ha) | 2 | 12 |
| Design of civil work | Riverwall<br>Bench terracing | |
| Civil Works | | |
| Riverwall work (km) | 1.0 | 4.0 |
| Bench terracing (km2) | 14.4 | - |

TABLE K.4 COST AND INVESTMENTS FOR SETTING UP ONE Ha OF PROTECTING-PRODUCING FORESTS DURING THE FIRST THREE YEARS SINCE 1987

| MONTH | | WAGE | Año 1 | Año 2 | Año 3 |
|---|---|---|---|---|---|
| 0 | Land Purchase | _ | 150.000. | | |
| | Land Cleaning | 14 | 11.900. | | |
| | Debris Burning | 5 | 4.250. | | |
| | Plantation Tracing | 3 | 2.550. | | |
| | Debankment | 6 | 5.100. | | |
| | Digging | 6 | 5.100. | | |
| | Distribution and Planting | 8 | 6.800. | | |
| | Fertilization | 6 | 5.100. | | |
| | Trees Cost | _ | 11.088. | | |
| | Fertilization 50gs.(N.P.K) | _ | 4.000. | | |
| | Borax | _ | 2.700. | | |
| | Tools | _ | 5.500. | | |
| | | | 214.088. | | |
| 6 | 2nd Cleaning around stem | 6 | 5.100. | | |
| | Land Cleaning | 7 | 5.950. | | |
| | Re-planting 10% | _ | 2.500. | | |
| | Tools | _ | 2.750. | | |
| | | | 16.300. | | |
| 12 | 3rd Cleaning around stem | 6 | | 5.100. | |
| | Tools | _ | | 1.375. | |
| | | | | 6.475. | |
| 18 | 4th Cleaning around stem | 6 | | 5.100. | |
| | Land Cleaning | 7 | | 5.950. | |
| | Tools | _ | | 2.750. | |
| | | | | 13.800. | |
| 24 | 5th Cleaning around stem | 6 | | | 5.100. |
| | Tools | _ | | | 1.375. |
| | | | | | 6.475. |
| 30 | Land cleaning | 7 | | | 5.950. |
| | Pruning | 7 | | | 5.950. |
| | Tools | | | | 2.750. |
| | TOTAL POR AÑO | | 230.388. | 20.275. | 21.125. |

TABLE K.5(1) PROJECT COST (Direct cost)

in unit: million Col$

1. Investigation works
for designating natural conservation area

| Description | Cost |
|---|---|
| Land use survey | 26 |
| Covering condition survey | 26 |
| Soil/geology survey | 58 |
| Total | 110 |

2. Civil works for disaster prevention plan

| Description | Lejos | Gris/San Juan | Santo Domingo |
|---|---|---|---|
| Civil Works | | | |
| Flood control dam | 3,750 | - | - |
| Riverwall | 825 | 1,175 | - |
| Improvement of Bridge | 335 | 220 | - |
| Debris flow control dam | 875 | 775 | 900 |
| Woodland path | 1,575 | 1,250 | 1,150 |
| Sub-total | 7,360 | 3,420 | 2,050 |
| Forestation | 400 | 600 | 950 |
| Total | 7,760 | 4,020 | 3,000 |

TABLE K.5(2) PROJECT COST

in unit: million Col$

3. Civil works for river improvement plan

| Description | Espejo | Verde |
|---|---|---|
| Civil Works | | |
| Riverwall work | 100 | 50 |
| Bench terracing | 1,200 | - |
| Total | 1,300 | 50 |

4. Civil works for soil conservation plan in right side of the La Vieja River

| Description | Cost |
|---|---|
| Civil Works | |
| Gully protection works | 450 |
| Forestation(Green belt) | 600 |
| Total | 1,050 |

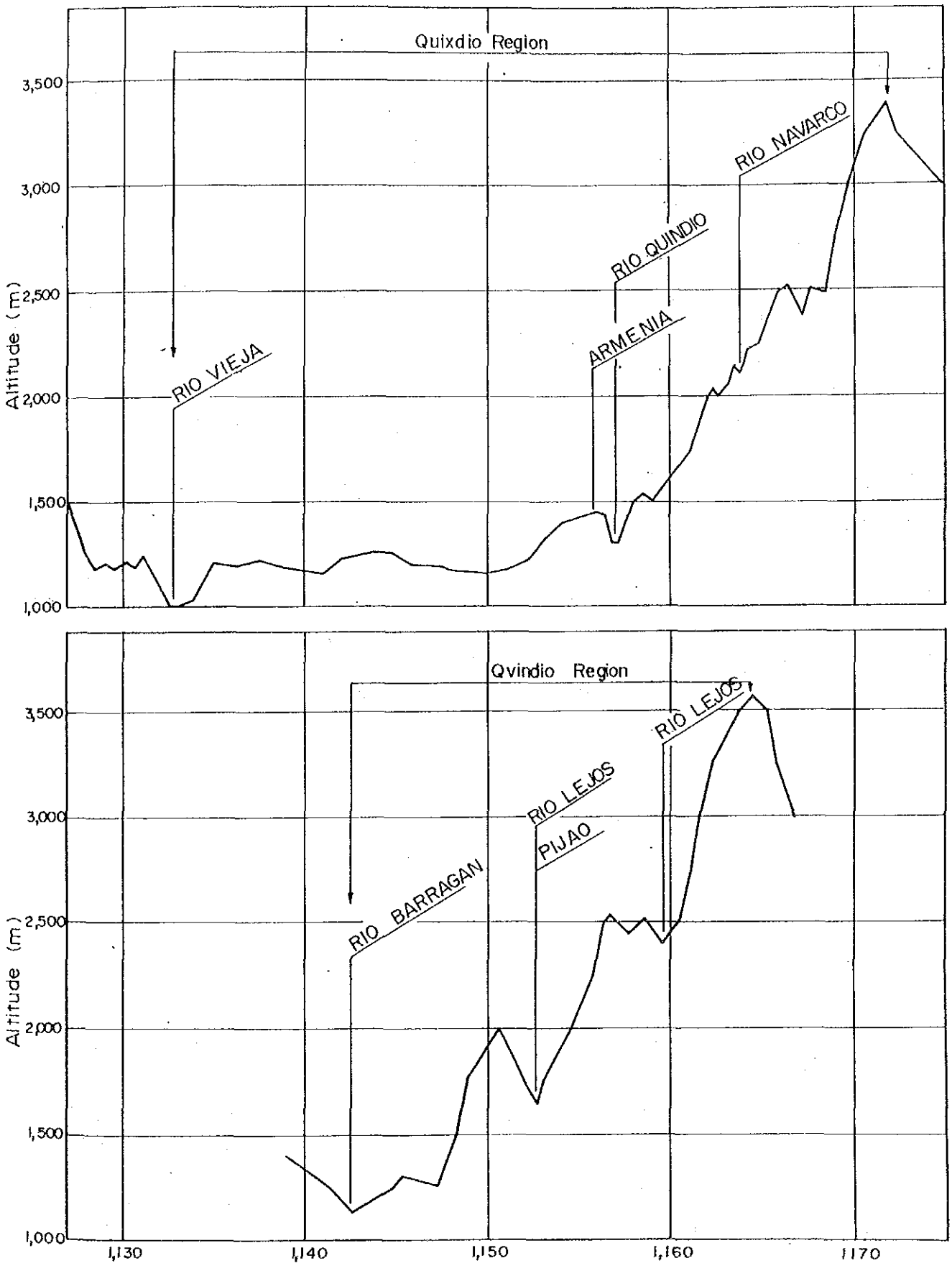



FIG. K.1 CROSS SECTION OF LAND IN QUINDIO

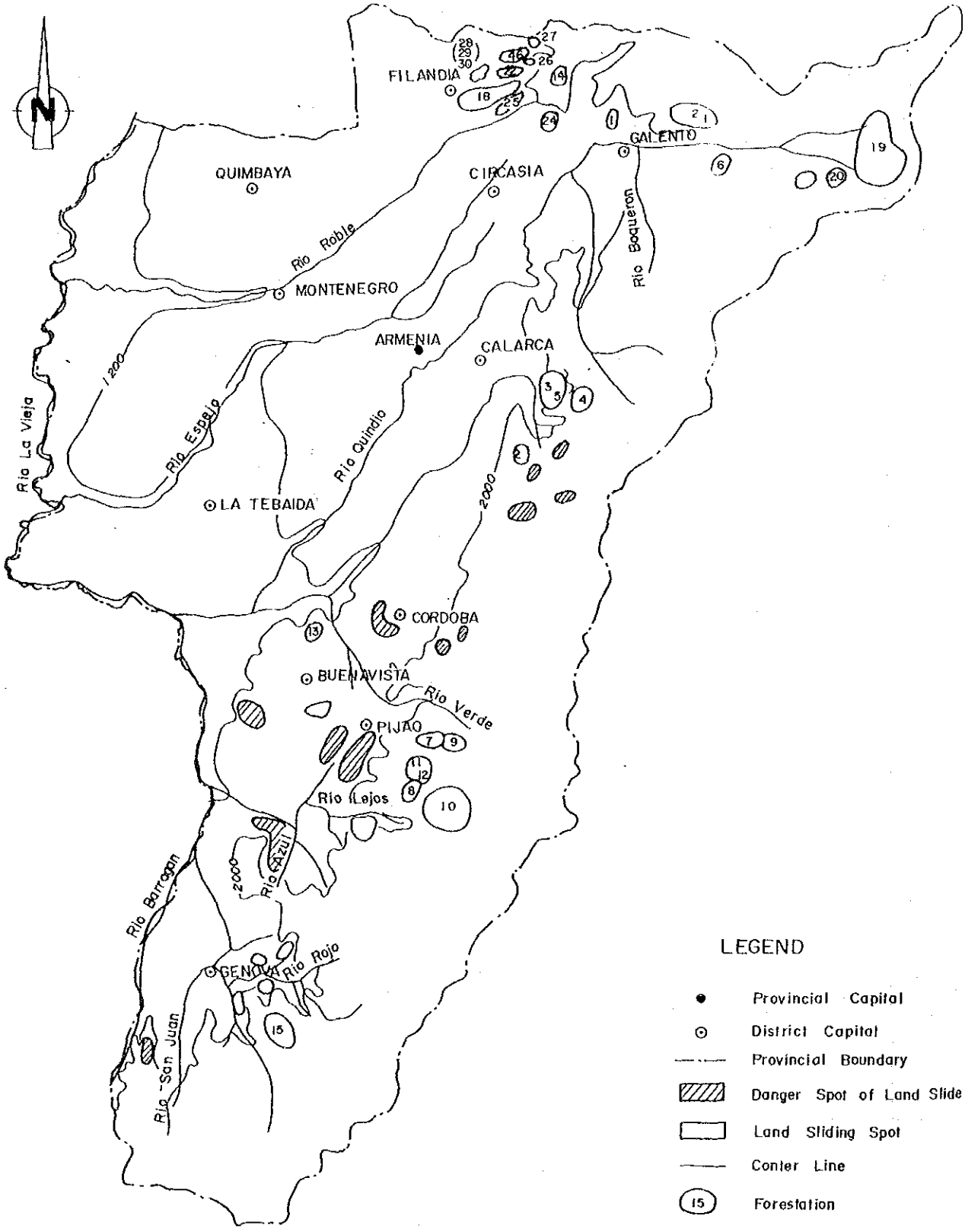



FIG. K2 LOCATION OF NATURAL DISASTER

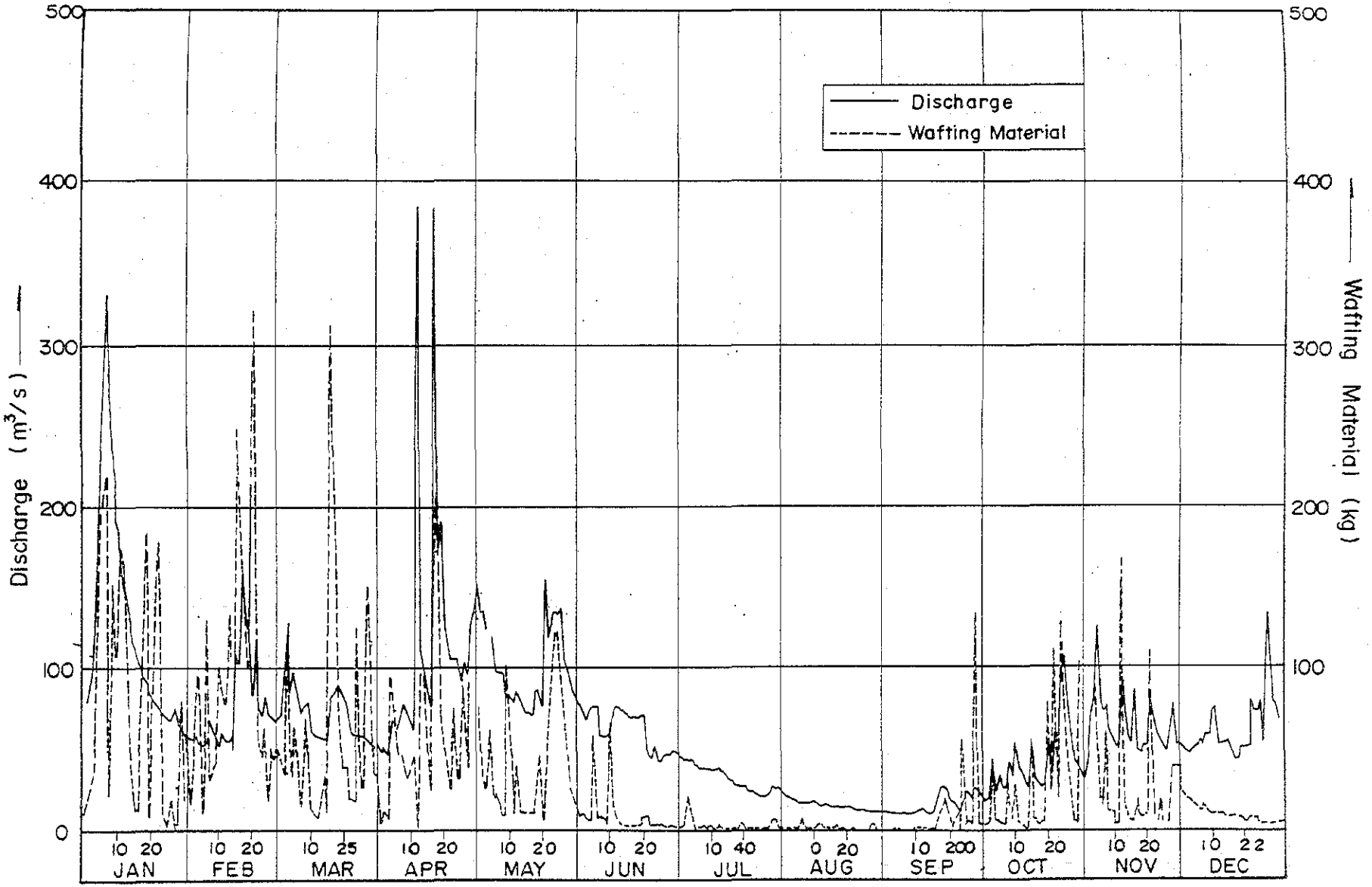



FIG. K. 3 (1) DAILY RECORD OF SEDIMENTAION IN 1982

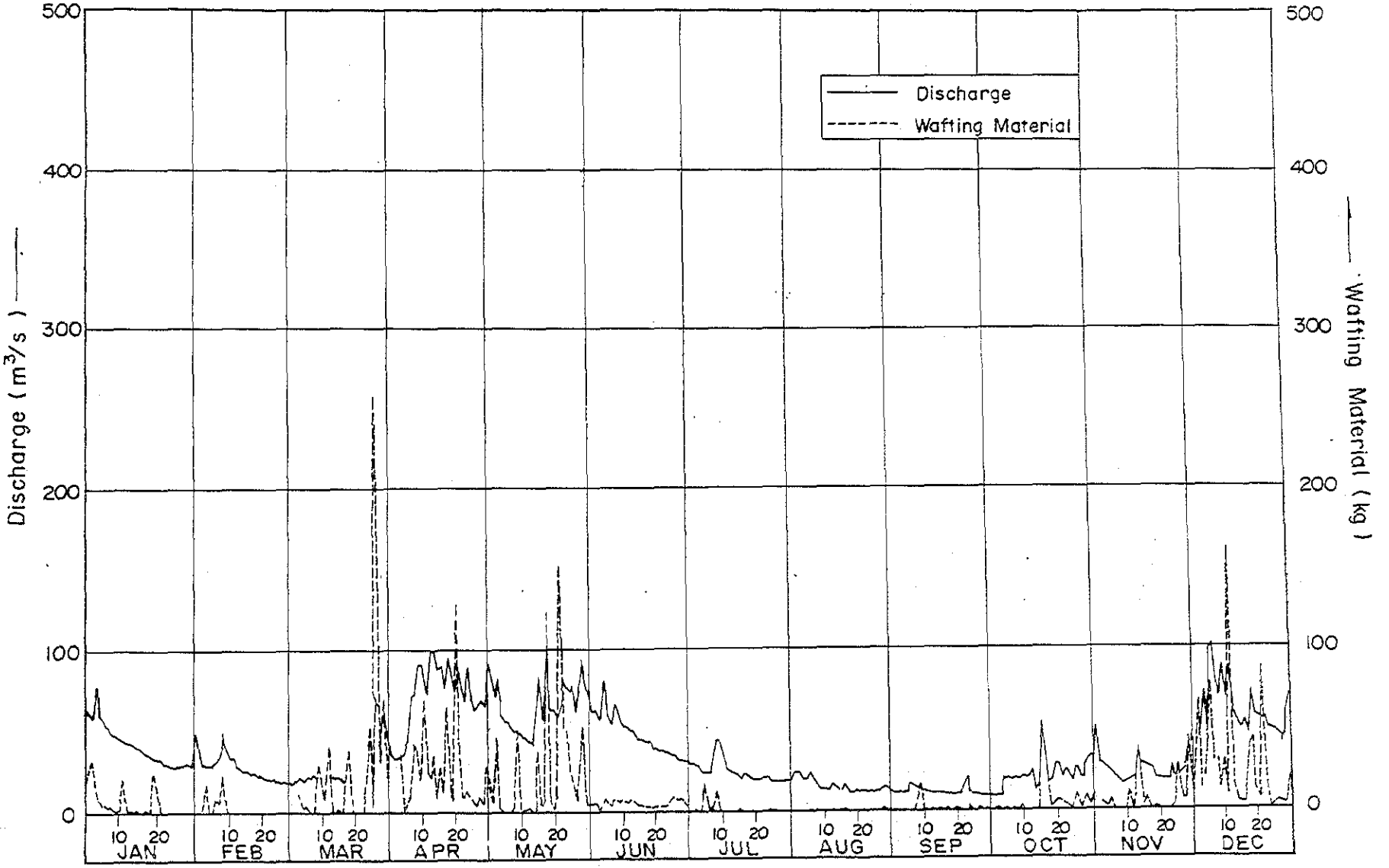



FIG. K.3(2) DAILY RECORD OF SEDIMENTATION IN 1983

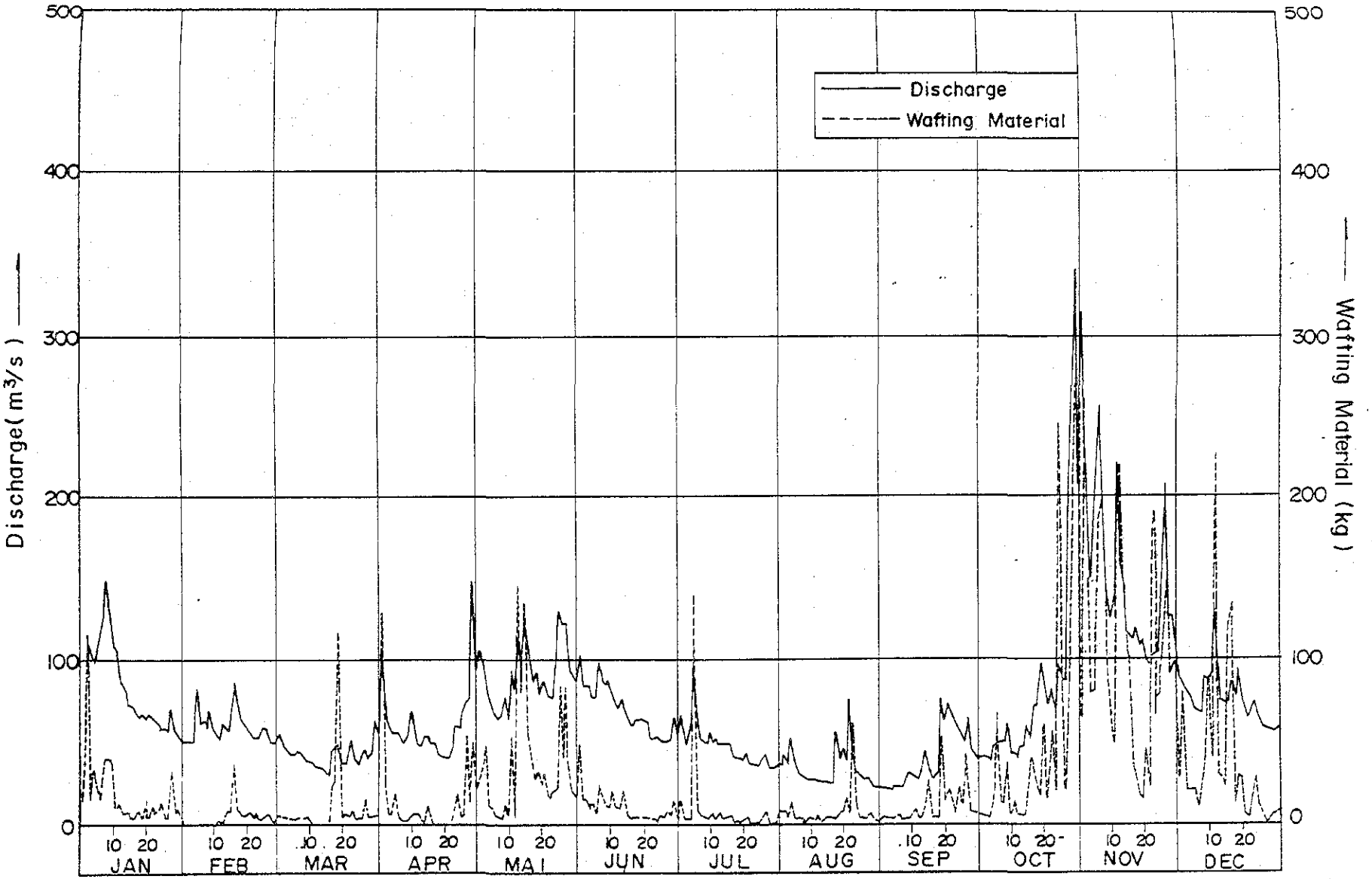



FIG. K.3(3) DAILY RECORD OF SEDIMENTATION IN 1984

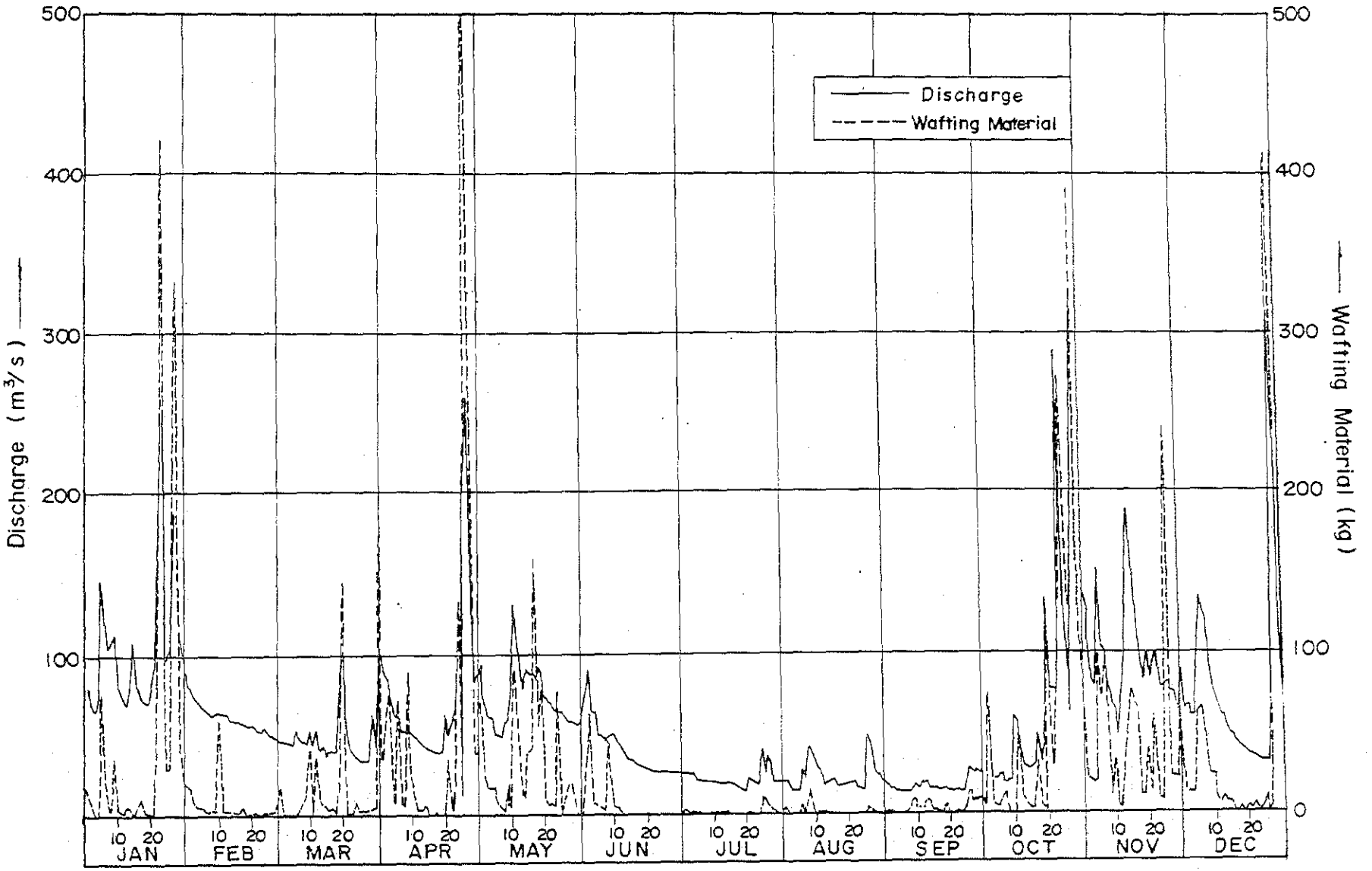



FIG. K.3(4) DAILY RECORD OF SEDIMENTATION 1985

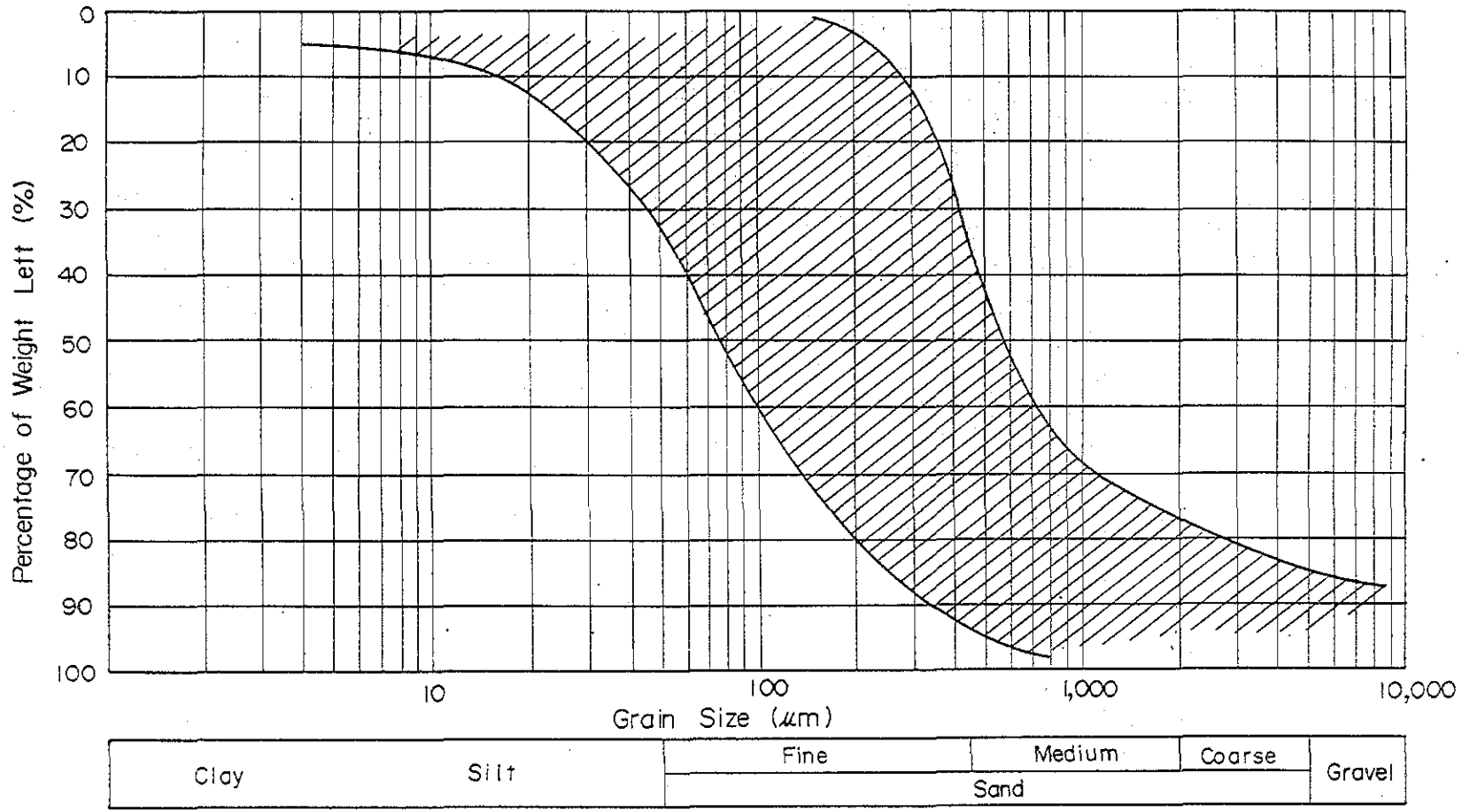



FIG. K.4 GRADING CURVE OF SOIL IN THE WATER OF RIVER

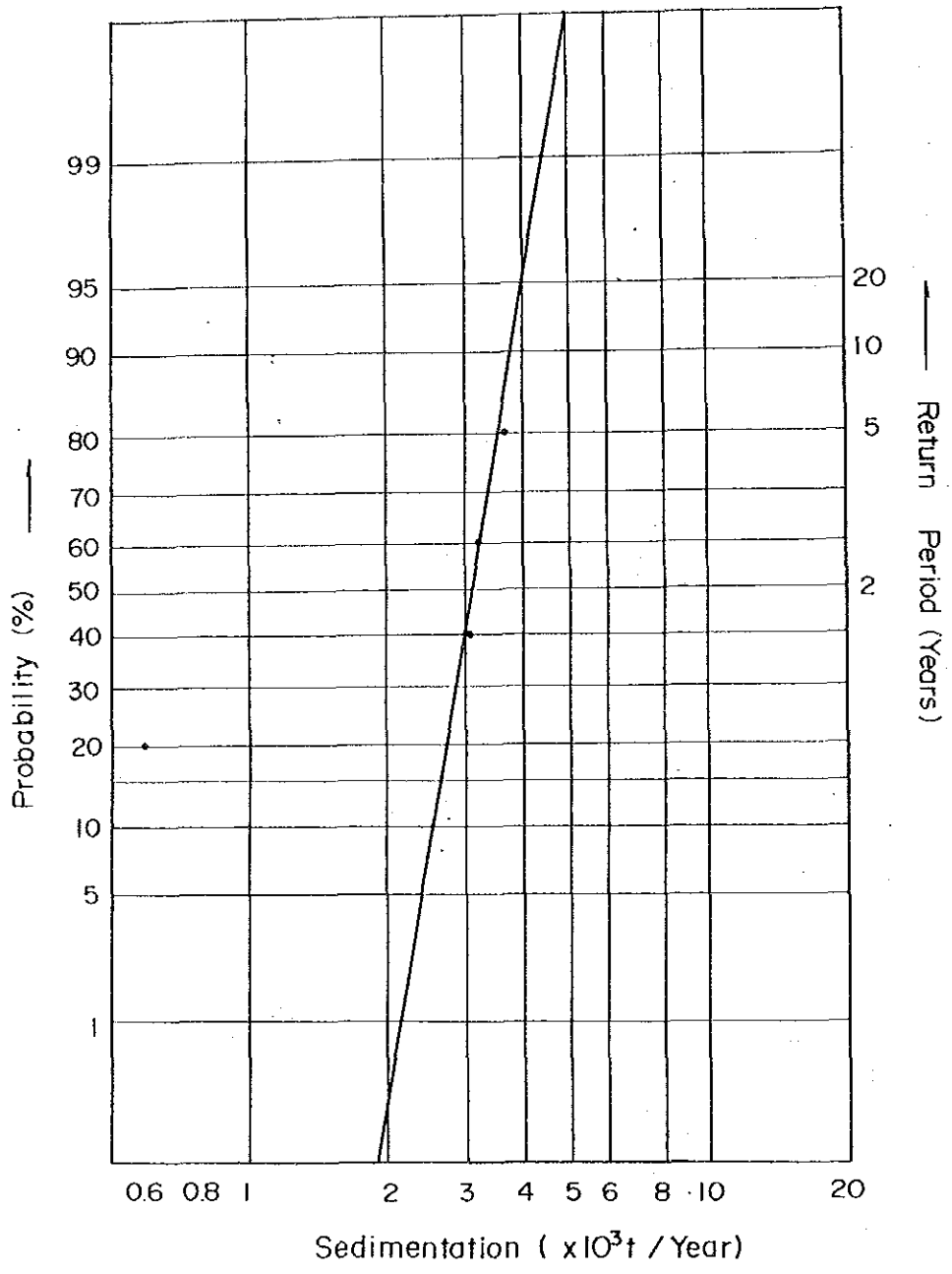
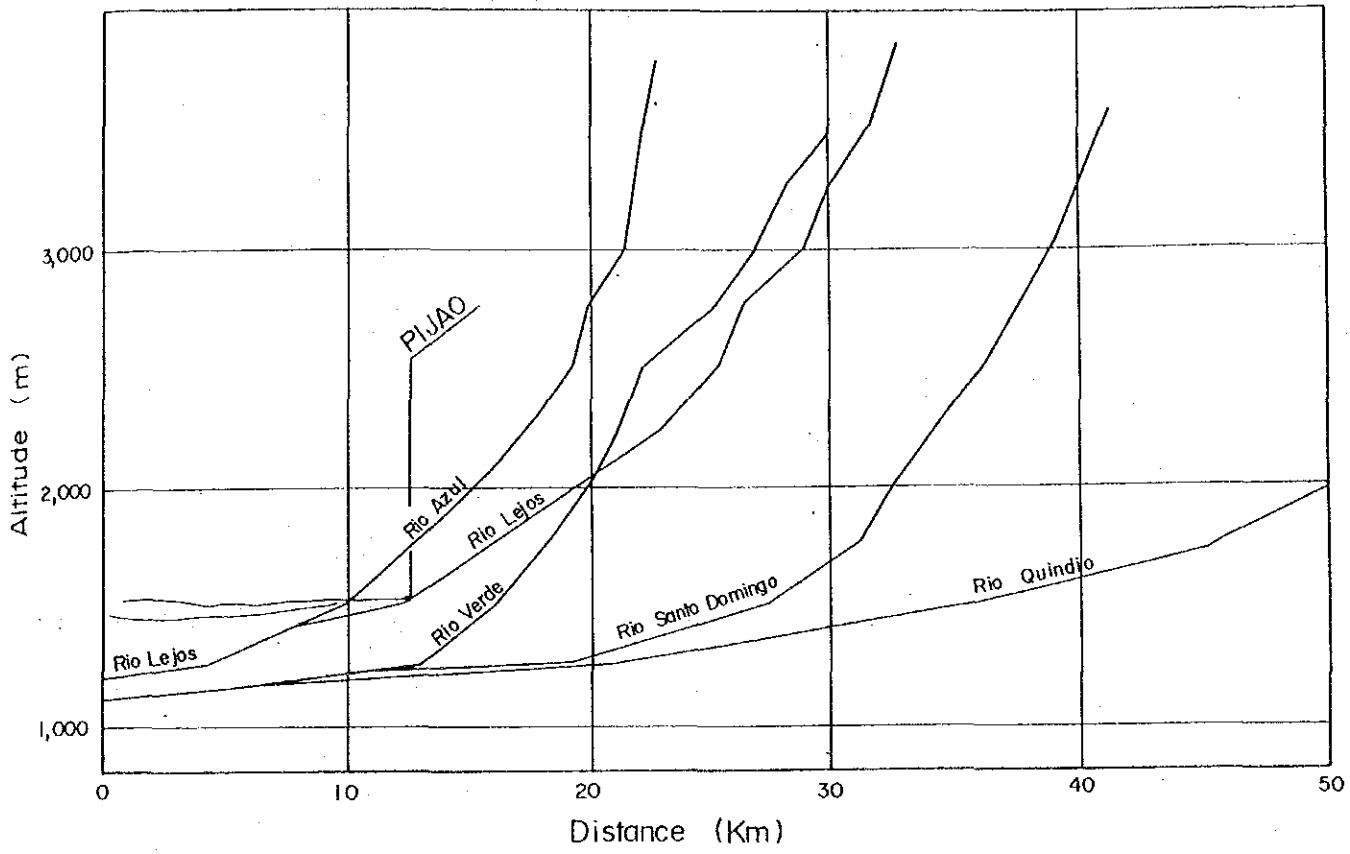



FIG. K.5 LOG-PROBABILITY OF SEDIMENTATION



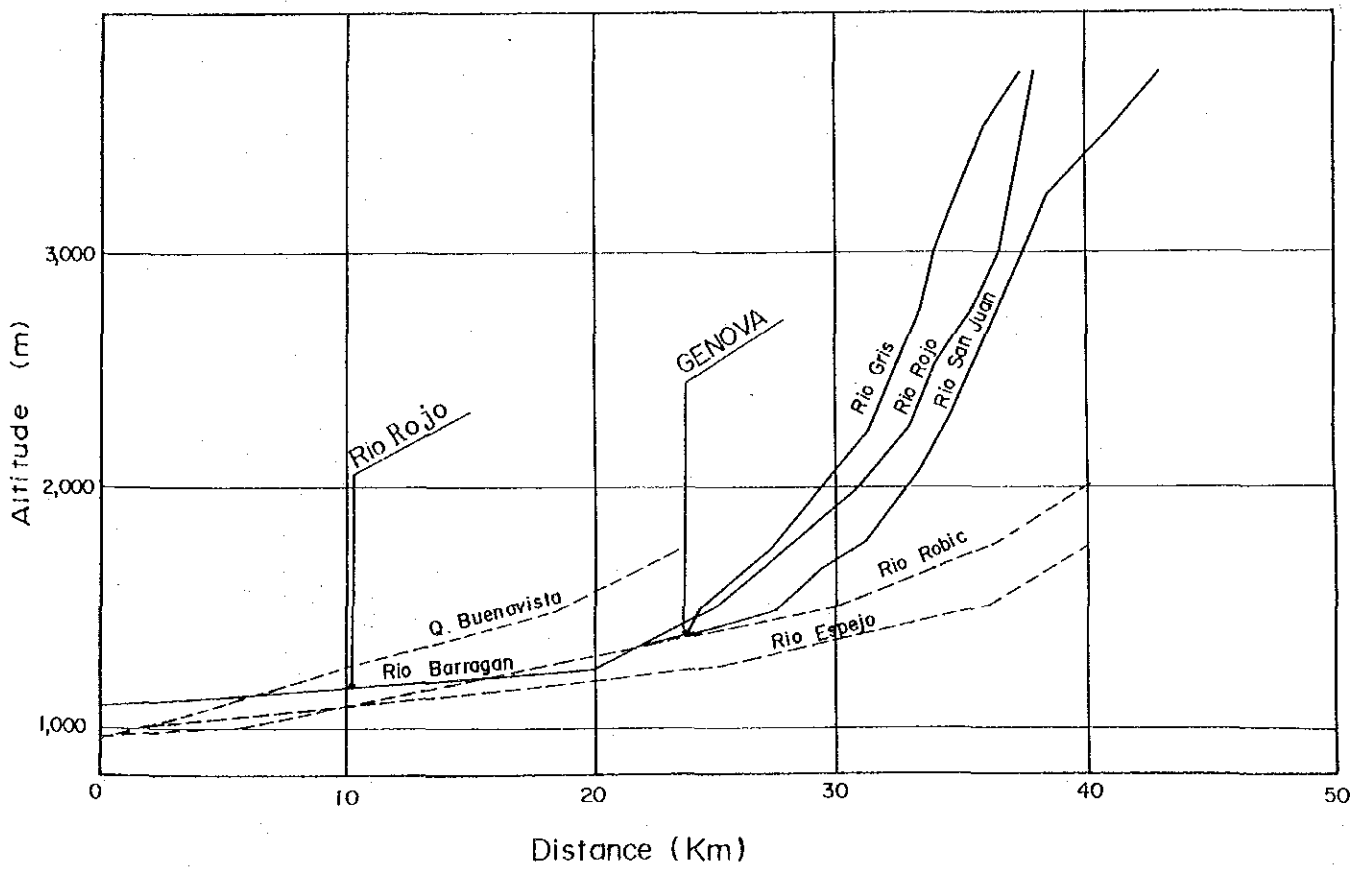
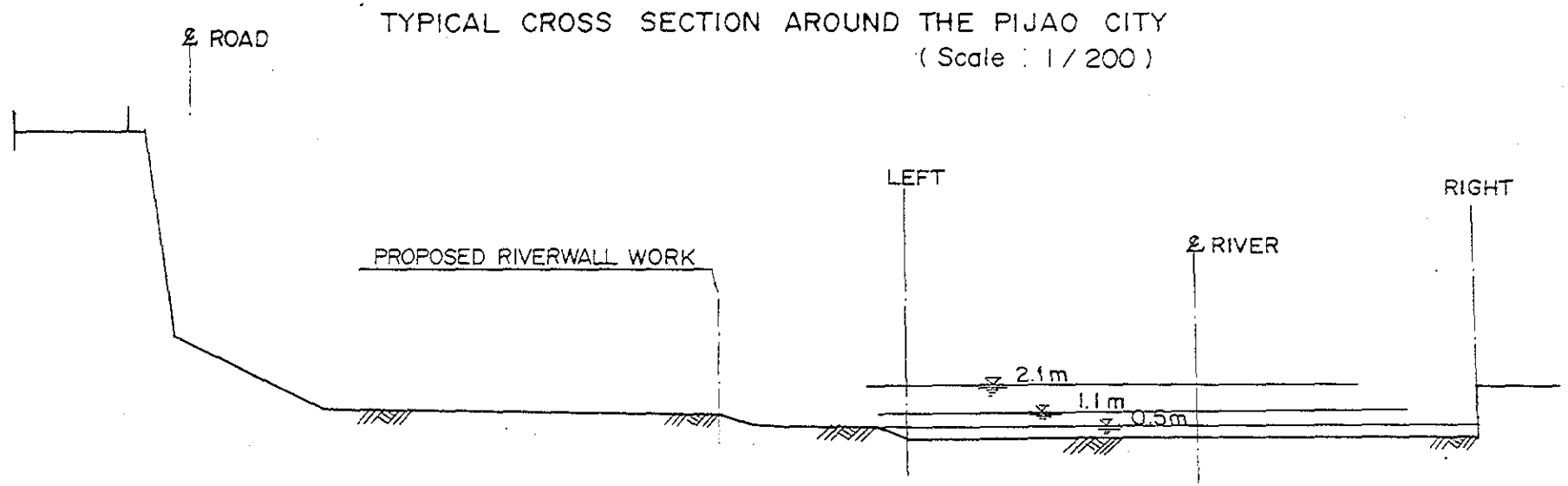




FIG. K. 6 LONGITUDINAL SECTION OF MAJOR RIVERS

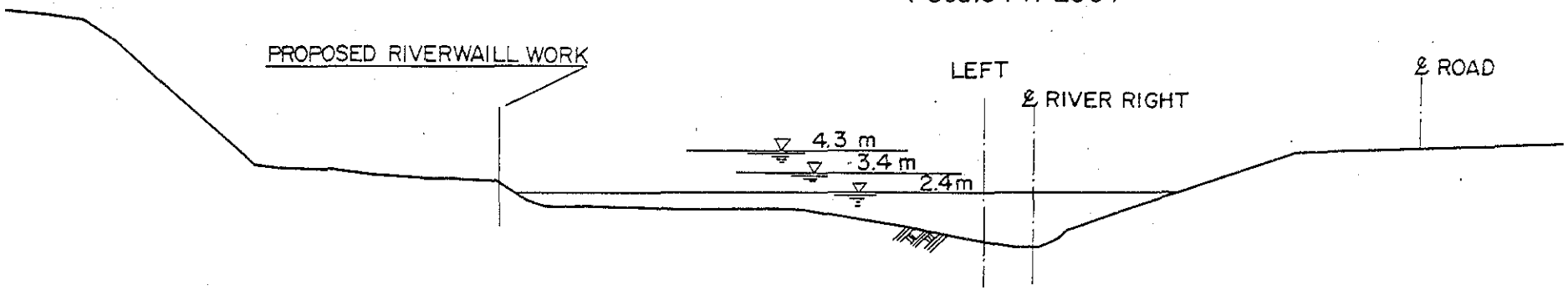



HYDAULIC CAPACITY OF THE LEJOS RIVER

| Water Depth (m) | Cross-Sectional Area ($m^2$) | Slope (%) | n | Velocity (m/s) | Discharge ($m^3/s$) |
|---|---|---|---|---|---|
| 0.5 | 9.6 | 6.6 | 0.05 | 2.85 | 27.4 |
| 1.1 | 26.0 | 6.6 | 0.05 | 4.73 | 122.9 |
| 2.1 | 70.4 | 6.6 | 0.05 | 6.68 | 470.2 |

FIG . K.7 ( 1 ) HYDRAULIC CHARACTERISTIC OF THE LEJOS RIVER

TYPICAL CROSS-SECTION AROUND THE GENOVA CITY
( Scale : 1/200 )




HYDRAULIC CAPACITY OF THE GRIS RIVER

| Water Depth (m) | Cross-Sectional Area ($m^2$) | Slope (%) | n | Velocity (m/s) | Discharge ($m^3/s$) |
|---|---|---|---|---|---|
| 2.4 | 34.0 | 8.4 | 0.05 | 1.98 | 67.4 |
| 3.3 | 64.4 | 8.4 | 0.05 | 2.49 | 160.5 |
| 4.3 | 107.2 | 8.4 | 0.05 | 3.08 | 330.7 |

FIG. K.7(2) HYDARULIC CHARACTERISTIC OF THE GRIS RIVER

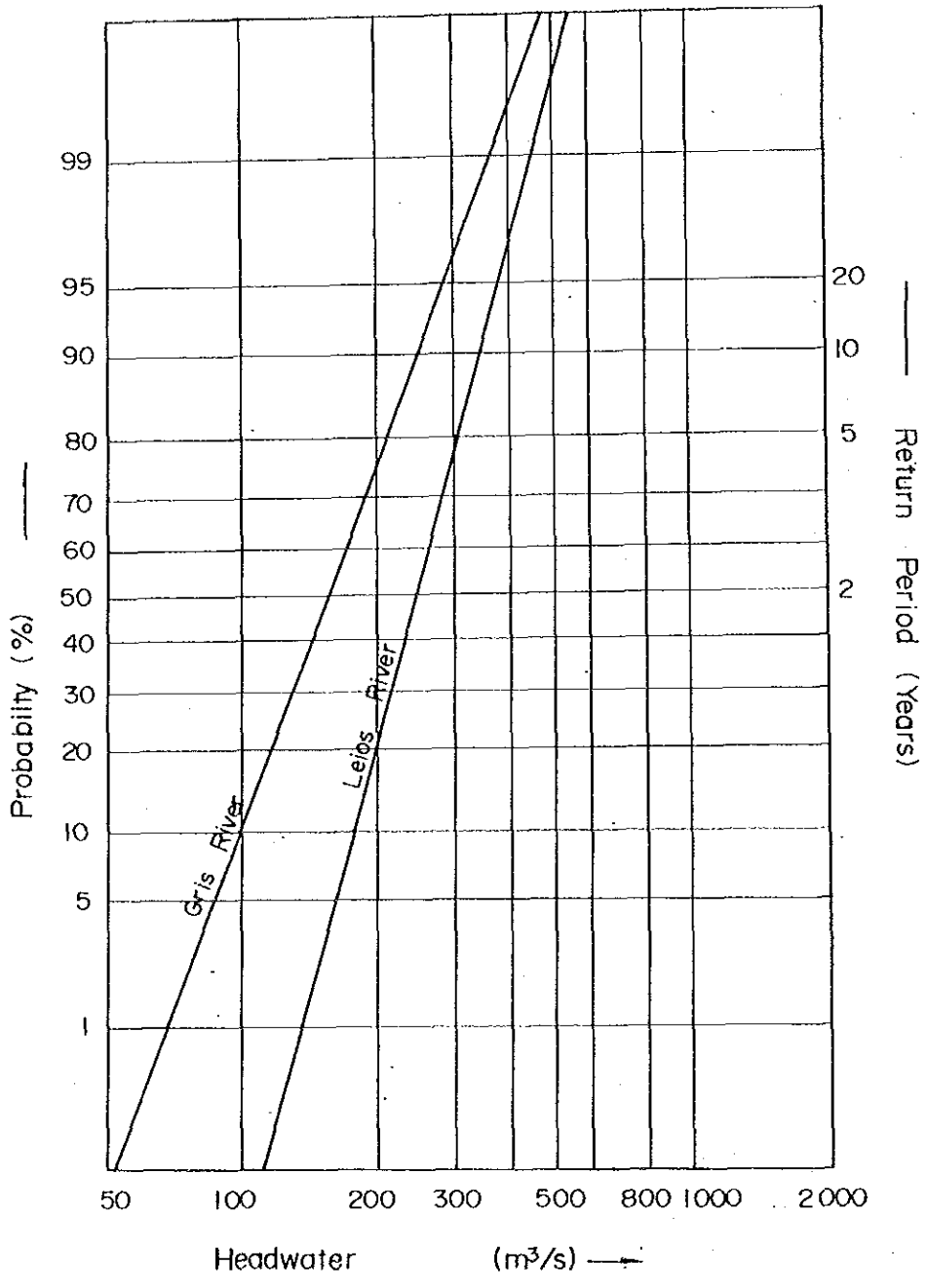



FIG. K.8 LOG-PROBABILITY OF HEADWATER FLOOD

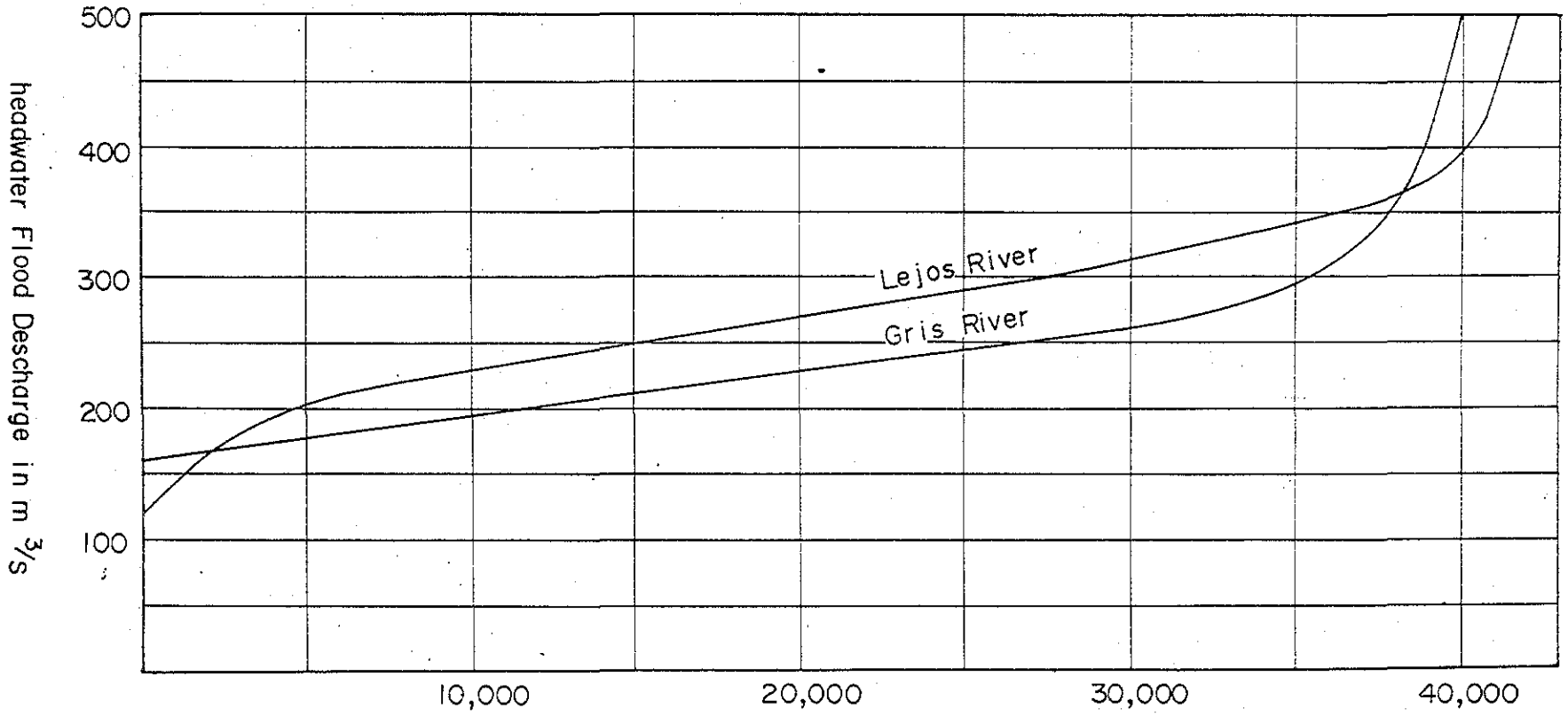



FIG.k.8(1) FIOOD DAMAGE– HEADWAIER FLOOD RELATION CURVE

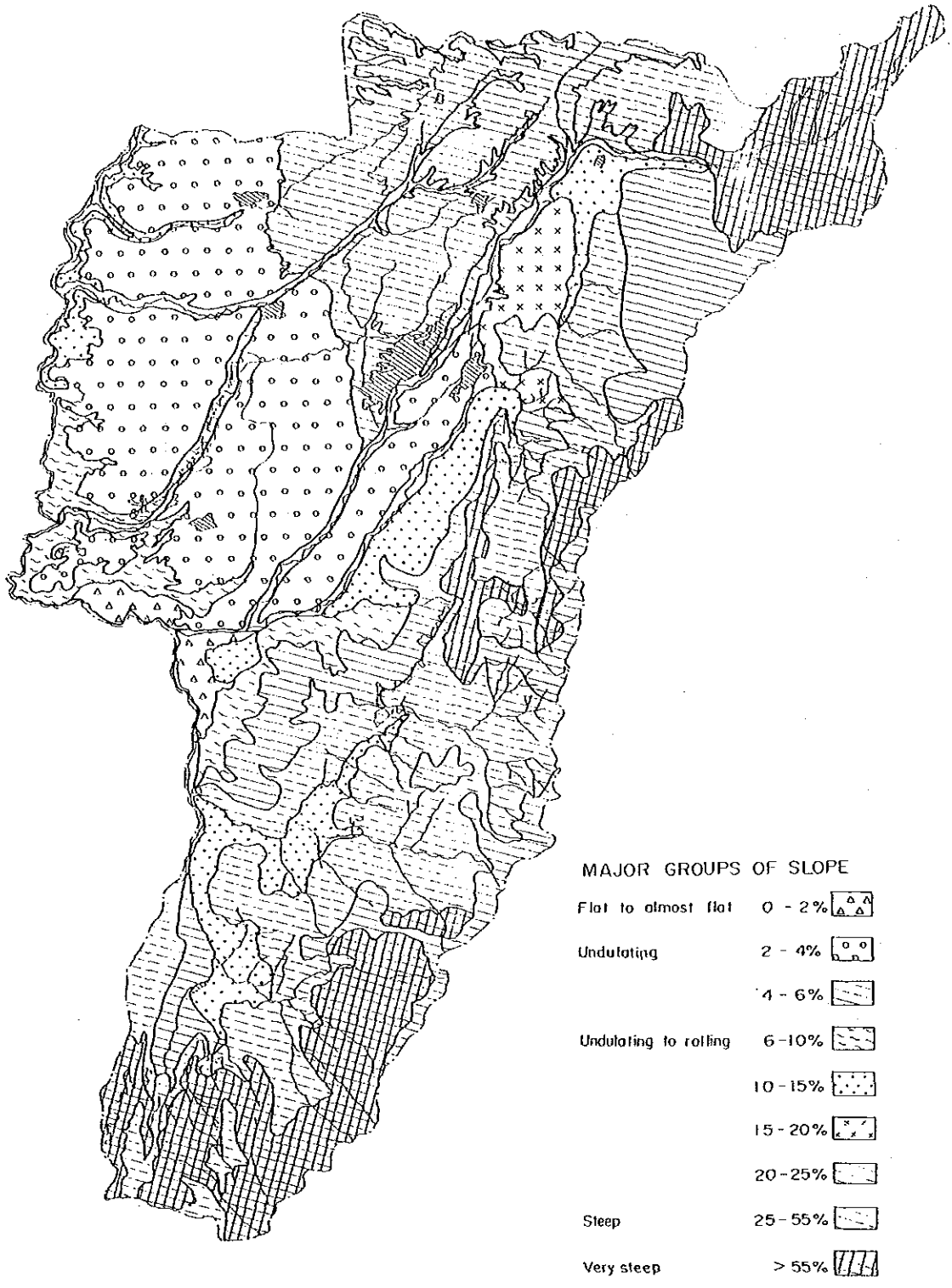



FIG. K.9 LAND CLASSIFICATION MAP BY SLOPE

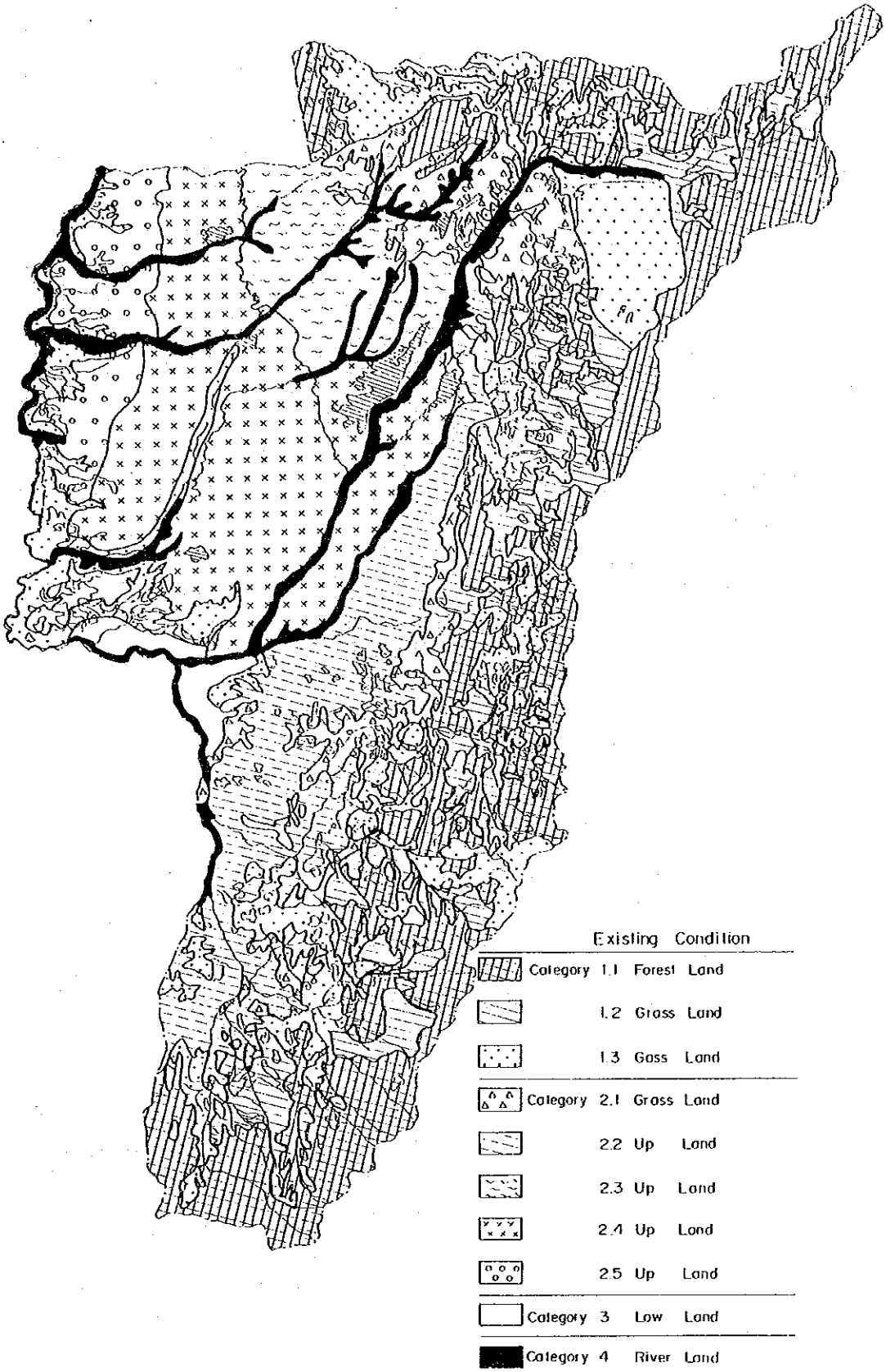



FIG. K.10 LAND CAPABILITY MAP

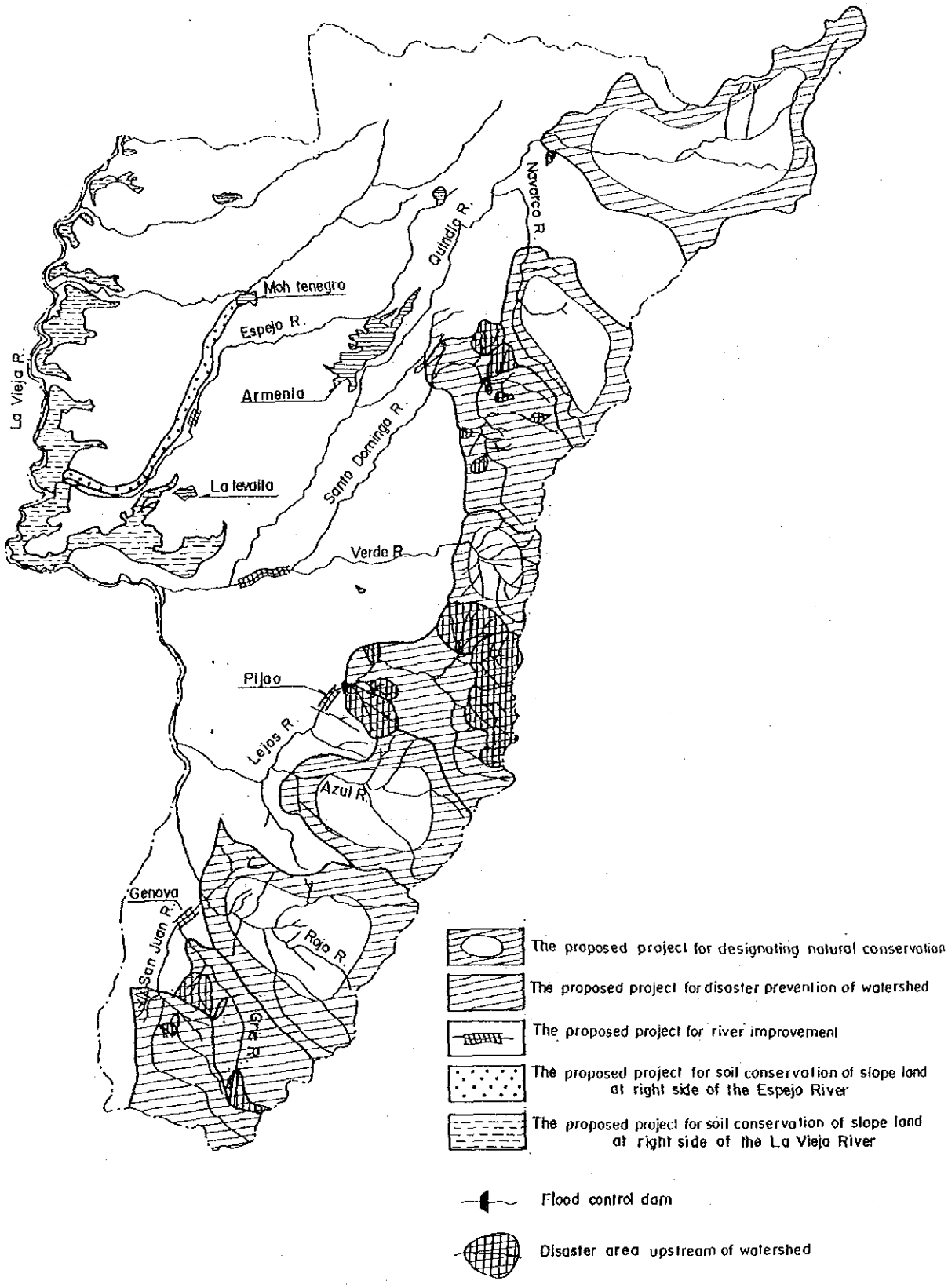
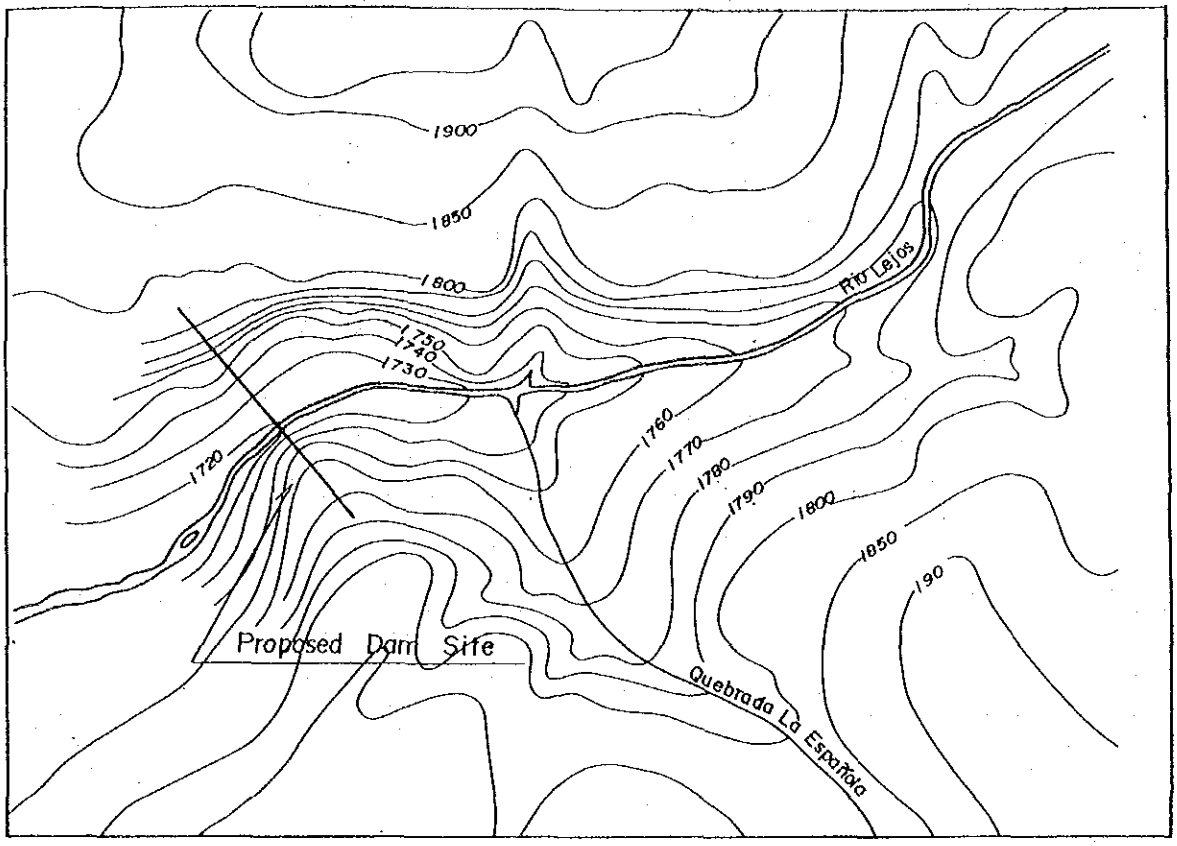
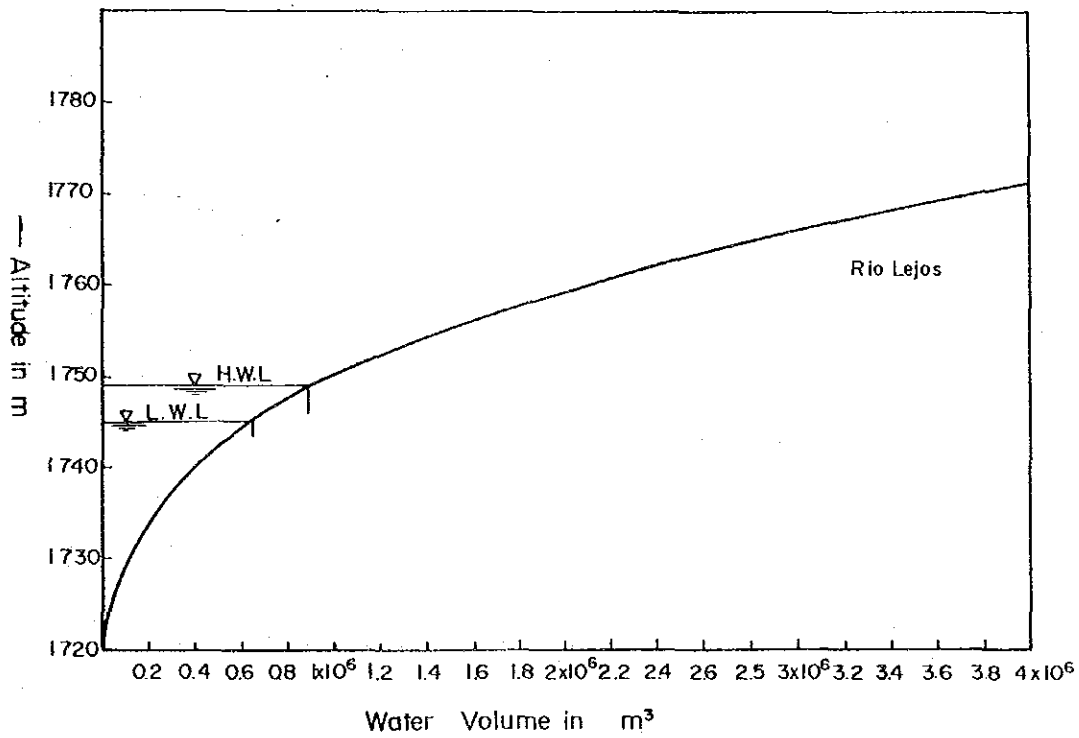



FIG. K.11 LOCATION MAP OF THE PROPOSED PROJECT

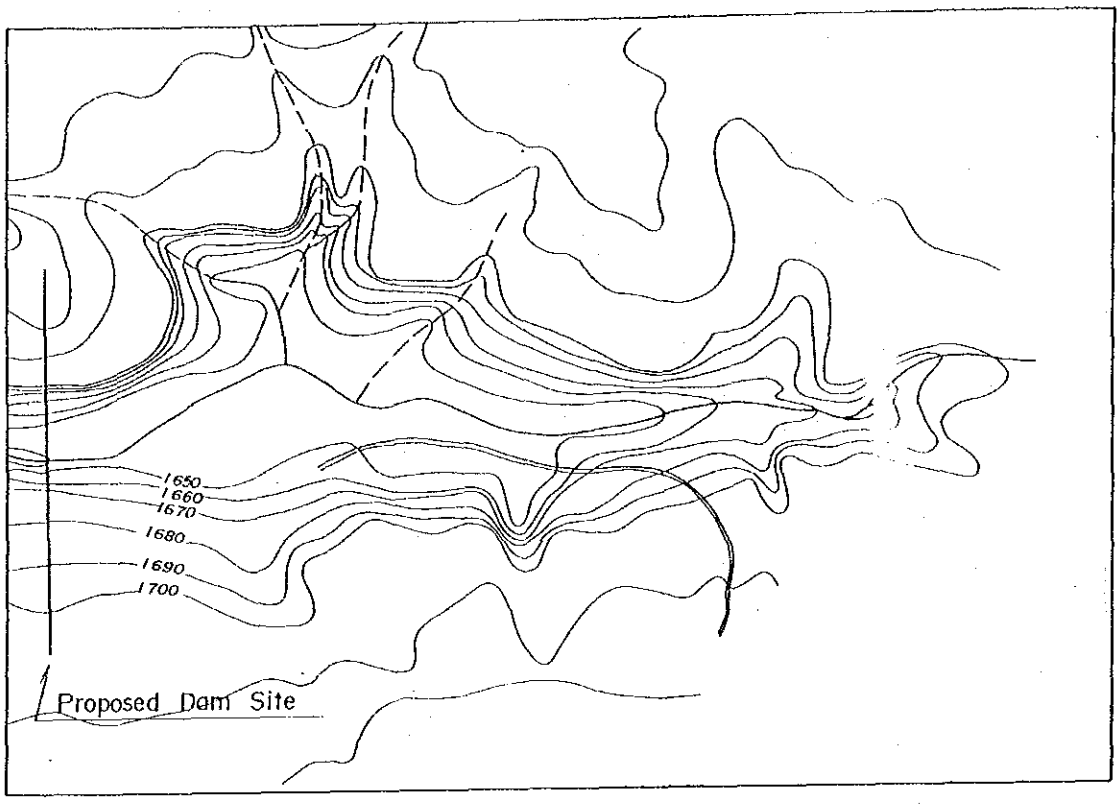



A. LOCATION MAP IN SCALE OF 1 : 50,000

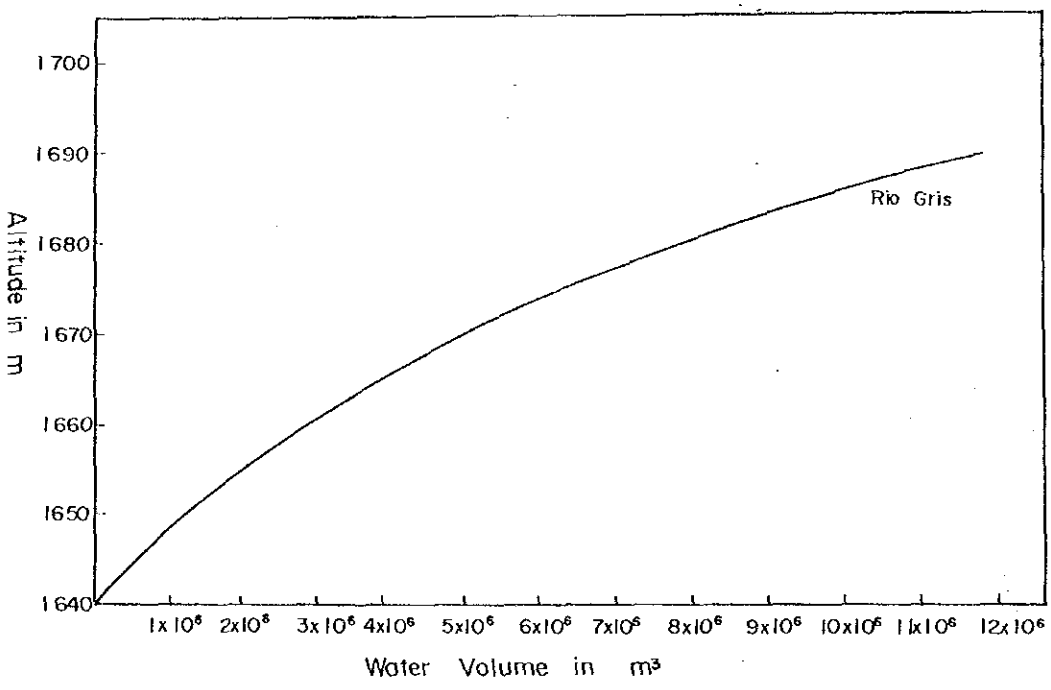



B. WATER LEVEL(H)-VOLUME(V) RELATION CURVE

FIG. K.12 LOCATION AND H-V CURVE OF FLOOD CONTROL RESERVOIR IN THE LETOS




A. LOCATION MAP IN SCALE OF 1:500




B. WATER LEVEL(H) - VOLUME(V) RELATION CURVE

FIG. K.13 LOCATION AND H-V CURVE OF FLOOD CONTROL RESERVOIR IN THE GRIS

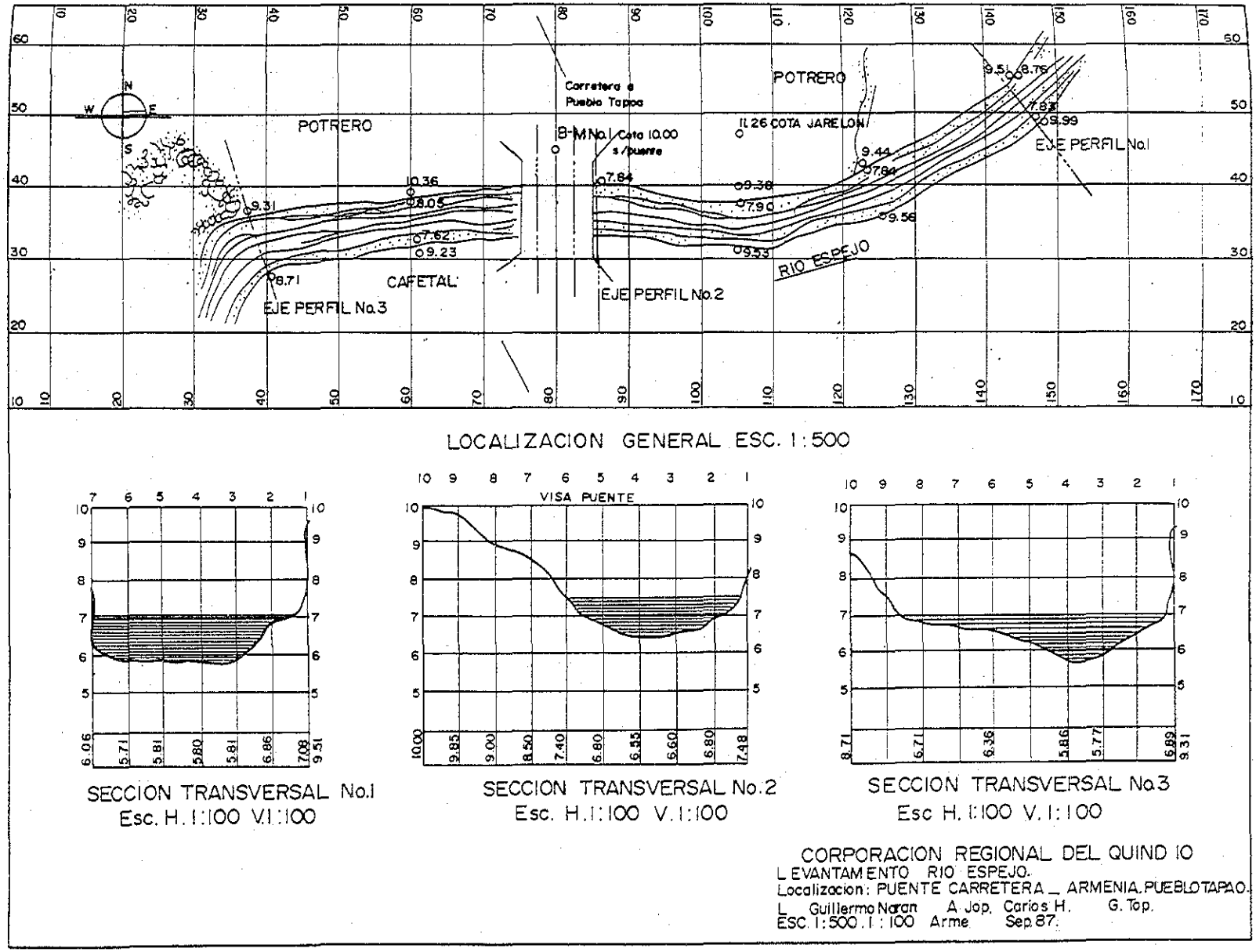
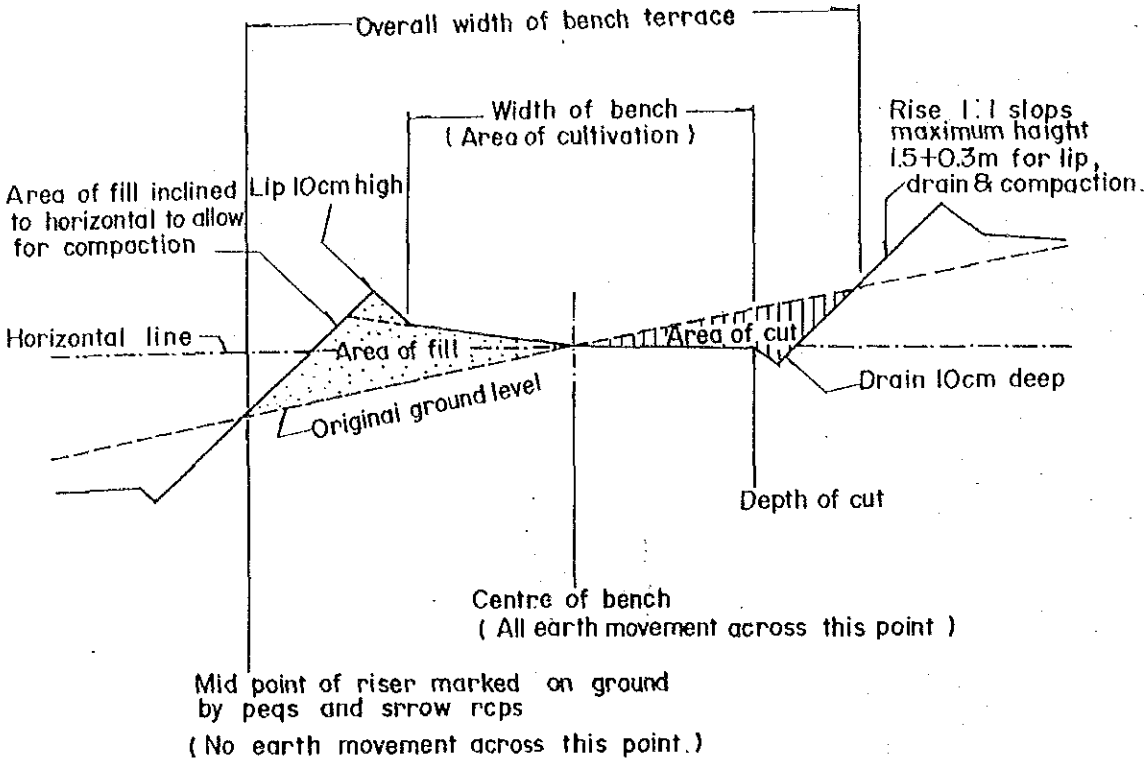



FIG.K.14 TOPOGRAPHICAL MAP OF THE ESPEJO RIVER




AREA AND VOLUME FOR BENCT TERRACIN DIFFERENT PERCENTAG SLOPES WITH BENCHES AT 1m VERTICAL INTERVAL

| Ground slope | | 5 | 10 | 15 | 20 | 25 | 30 | 35 |
|---|---|---|---|---|---|---|---|---|
| Width of benches 1/ | m | 18.50 | 8.50 | 5.17 | 3.50 | 2.50 | 1.83 | 1.36 |
| Width of bench terraces | m | 20.00 | 10.00 | 6.67 | 5.00 | 4.00 | 3.33 | 2.86 |
| No. of benches per 100 m of slope | – | 5 | 10 | 15 | 20 | 25 | 30 | 35 |
| Maximum depth of cut ( excluding drain) | m | 0.47 | 0.45 | 0.42 | 0.40 | 0.37 | 0.35 | 0.32 |
| Area of benches 1/per ha | | 0.925 | 0.850 | 0.775 | 0.700 | 0.625 | 0.550 | 0.475 |
| Slope area of riser per ha | $m^2$ | 919 | 1 838 | 2 758 | 3 667 | 4 596 | 5 515 | 6 434 |
| Volume of cut per ha of bench terraces | $m^3$ | 1 175 | 1 135 | 1 077 | 1 020 | 963 | 903 | 847 |
| Slope area of riser per ha of benches | $m^2$ | 994 | 2 162 | 3 559 | 5 283 | 7 354 | 10 027 | 13 545 |
| Volume of cut per ha of benches | $m^3$ | 1 270 | 1 335 | 1 390 | 1 457 | 1 540 | 1 642 | 1 783 |

1/ Area on which cultvation can take place.

FIG. K.15 CROSS SECTION OF BENCH TERRACES

# ANNEX L : RURAL INFRASTRUCTURE

# Annex L : RURAL INFRASTRUCTURE

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# Annex L : RURAL INFRASTRUCTURE

## L.1 General

The improvement of rural infrastructure is one of the important subjects for the agricultural integral development in the Department of Quindio. For the purpose of the development of Quindio, the rural infrastructure must be more improved. However, exactly there is a financial restriction and it is impossible to construct all required facilities at one time. Therefore, considering the most effective impact for the development of Quindio, required infrastructures and priority of projects must be studied.

The objective of this study is to understand the existing conditions of rural infrastructure and study the improvement plan with the consideration to development concepts of the agricultural integrated development for the Quindio.

## L.2 Existing Conditions

### L.2.1 Transportation

(1) Road Network

The existing major road network in Quindio radiates from the center of Armenia with the main road linking north to south and connecting Armenia with Pereira and Cali. On the other hand, local roads link the road network to the municipalities in the Quindio, and the roads branching off from the local roads make connections with the rural areas.

According to the Directorate of Planning of the Department of Quindio, the existing road network and conditions are as shown in Fig.L.2.1 and Table L.2.1. The conditions of pavements can be summarized as follows;

Existing Road Conditions

| Classification | Institution | Paved (km) | Unpaved (km) | Total (km) |
|---|---|---|---|---|
| National Road | Ministry of Construction | 154 | 60 | 214( 8.2%) |
| | National Fund for Road Plan | 0 | 317 | 317(12.1%) |
| Prefectural Road | Construction Division | 5 | 780 | 785(29.9%) |
| Personal Road | Individual | 0 | 1,305 | 1,305(49.8%) |
| Total | | 159 | 2,472 | 2,621 |

Table L.2.1 Existing Road Condition (1)

| No. | Route | Length (km) | Width (m) | Institution | Remark |
|---|---|---|---|---|---|
| 1 | Armenia - Rio Barbas | 24.0 | 12.0 | MOPT. | Paved |
| 2 | Armenia - Club Campestre | 10.0 | 12.3 | MOPT. | Paved |
| 3 | C.Campestre - El Alambrado | 16.0 | 12.3 | MOPT. | Paved |
| 4 | Armenia - Calarca | 6.0 | 10.0 | MOPT. | Paved |
| 5 | Calarca - La Linea | 24.0 | 12.3 | MOPT. | Paved |
| 6 | Variante - Calarca Norte | 2.0 | 12.0 | MOPT. | Paved |
| 7 | Armenia - Montenegro | 16.0 | 12.0 | MOPT. | Paved |
| 8 | Montenegro - Quimbaya | 10.0 | 12.0 | MOPT. | Paved |
| 9 | Armenia - La Espanola | 6.5 | 12.0 | MOPT. | Paved |
| 10 | Calarca - Rio Verde | 18.0 | 12.0 | MOPT. | Paved |
| 11 | Rio Verde - Barragan | 12.0 | 12.0 | MOPT. | Paved |
| 12 | Variante - Calarca Sur | 3.0 | 12.0 | MOPT. | Paved |
| 13 | Armenia - Pueblo Tapao | 10.4 | 9.0 | SOPD. | Paved |
| 14 | Libramiento - Circasia | 4.0 | 11.0 | MOPT. | Paved |
| 15 | Libramiento - La Tebaida | 5.0 | 12.0 | MOPT. | Paved |
| 16 | Cruces - Filandia | 8.0 | 8.0 | MOPT. | Paved |
| 17 | Rio Verde - Pijao | 2.0 | 10.0 | SOPD. | Paved |
| 18 | Rio Verde - Cordoba | 2.5 | 8.0 | SOPD. | Paved |
| 19 | Barragan - Genova | 1.5 | 8.0 | MOPT. | Paved |
| 20 | Genova - Rio Rojo | 2.3 | 5.0 | SOPD. | Paved |
| 21 | Arrayanal - Salento | 9.0 | 7.5 | MOPT. | Unpaved (A) |
| 22 | Filandia - Quimbaya | 17.0 | 6.0 | SOPD. | Unpaved (A) |
| 23 | Quimbaya - San Felipe | 6.0 | 12.0 | SOPD. | Unpaved (A) |
| 24 | Quimbaya - Pte.San Felipe | 13.0 | 6.0 | FNCV. | Unpaved (A) |
| 25 | Montenegro - Pueblo Tapao | 7.5 | 5.5 | Vias Dptales. | Unpaved (A) |
| 26 | Pueblo Tapao - El Prado | 5.7 | 7.0 | SOPD. | Unpaved (A) |
| 27 | El Prado - San Jose | 1.3 | 6.0 | SOPD. | Unpaved (A) |
| 28 | San Jose - La Tebaids | 4.1 | 7.0 | SOPD. | Unpaved (A) |
| 29 | San Jose - San Pablo | 7.0 | 6.0 | SOPD. | Unpaved (A) |
| 30 | Calarca - Quebradanegra | 12.8 | 6.5 | SOPD. | Unpaved (A) |
| 31 | Quebradanegra - La Frontera | 13.4 | 6.5 | SOPD. | Unpaved (B) |
| 32 | Rio Verde - Cordoba | 4.5 | 6.0 | SOPD. | Unpaved (A) |
| 33 | Rio Verde - Pijao | 12.0 | 10.0 | MOPT. | Unpaved (A) |
| 34 | Cordoba - La Quiebra | 7.6 | 5.0 | SOPD. | Unpaved (B) |

Table L.2.1 Existing Road Condition (2)

| No. | Route | Length (km) | Width (m) | Institution | Remark |
|---|---|---|---|---|---|
| 35 | La Cabana - Buenavista | 2.0 | 6.0 | SOPD. | Unpaved (A) |
| 36 | Pijao - Genova | 24.7 | 6.0 | FNCV. | Unpaved (B) |
| 37 | Barragan - Genova | 19.2 | 8.0 | MOPT. | Unpaved (A) |
| 38 | Filandia - La India | 9.5 | 5.5 | SOPD.FNCV. | Unpaved |
| 39 | Circasia - Montenegro | 15.2 | 7.0 | SOPD. | Unpaved |
| 40 | Pto.Samaria - Baraya | 13.0 | 5.5 | SOPD. | Unpaved |
| 41 | Pueblo Tapao - La Maria | 12.0 | 5.5 | Vias Dptales. | Unpaved |
| 42 | Calarca - Boquia | 23.0 | 7.0 | SOPD. | Unpaved |
| 43 | Salento - Cocora | 7.2 | 5.0 | FNCV. | Unpaved |
| 44 | Salento - La Siberia | 11.0 | 5.0 | FNCV. | Unpaved |
| 45 | Cordoba - Las Palmeras | 11.0 | 4.5 | FNCV. | Unpaved |
| 46 | Pijao - La Laguna | 10.0 | 4.5 | SOPD. | Unpaved |
| 47 | Genova - Pedregales | 12.0 | 5.0 | SOPD. | Unpaved |
| 48 | Genova - San Juan Alto | 9.0 | 5.0 | SOPD. | Unpaved |
| 49 | Salento - La Cabana | 19.0 | 5.0 | SOPD. | Unpaved (C) |
| 50 | La Nubia - Armenia | 6.9 | 5.0 | SOPD. | Unpaved (C) |
| 51 | Circasia El Vigilante | 7.0 | 5.0 | SOPD. | Unpaved (C) |
| 52 | Montenegro - El Vergel | 21.0 | 5.0 | SOPD. | Unpaved (C) |
| 53 | Puertorico - La Virginia | 4.0 | 5.0 | MOPT. | Unpaved (C) |

Note: (1) MOPT: Ministerio de Obras Publicas Transporte.
(2) SOPD: Secretaria de Obras Publicas Departamentales.
(3) F.N.C.V.: Fondo Nacional de Caminos Vecinales.
(4) Unpaved (A): Rehabilitation and Pavement has been planed
Unpaved (B): Rehabilitation has been planed
Unpaved (C): Secondary road

Total of paved roads = 183.2km

Total of unpaved roads = 357.7km Rehabilitation and Pavement plan: 121.1km
Rehabilitation plan : 45.7km
Without any improvement plan : 190.9km

Sourse: Plan vial Quindio 1983

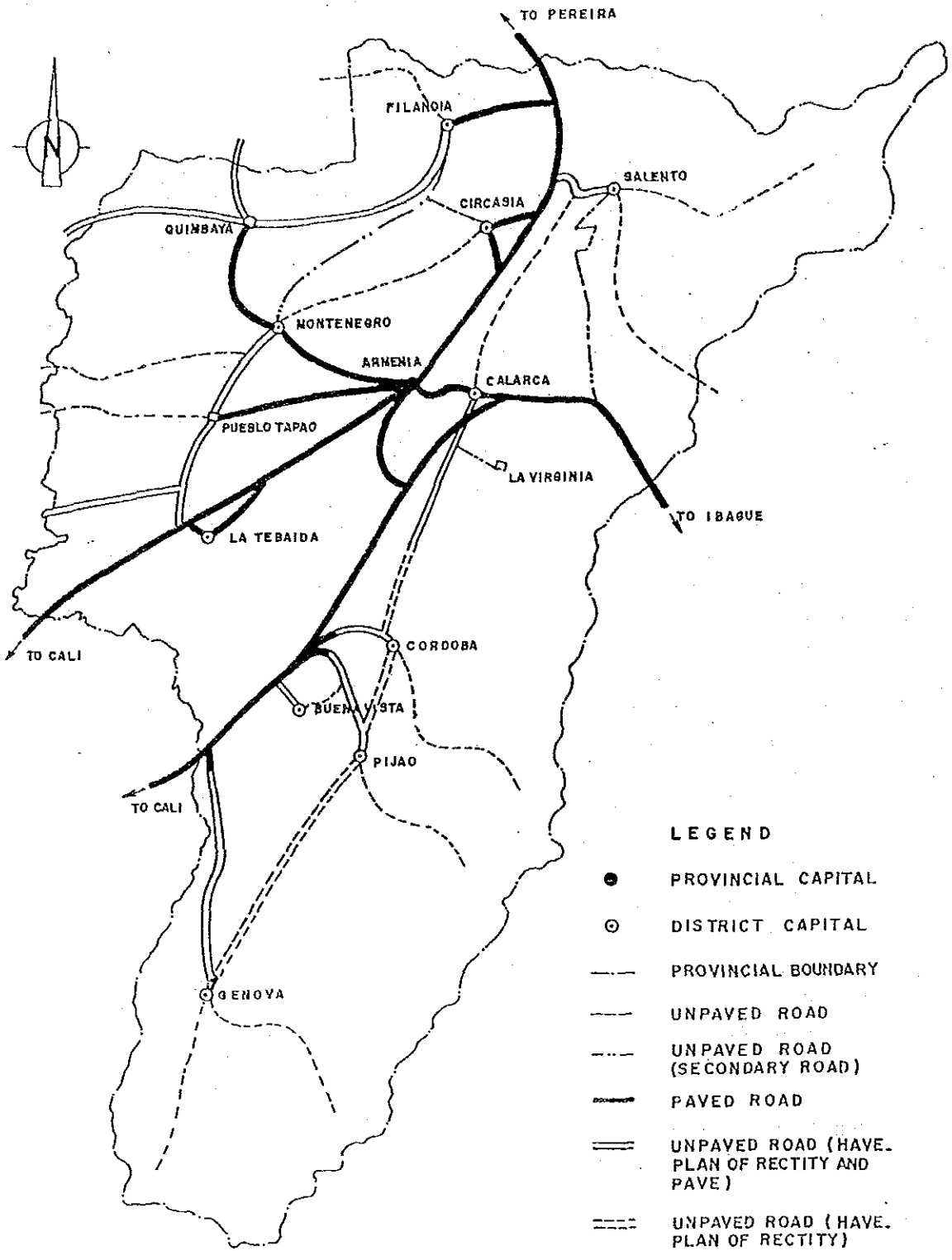


FIG L.2.1 ROAD NETWORK OF QUINDIO

Four main roads linking Armenia with other Departments and most major roads are paved, and their maintenance is good. However, concerning the local road network in the Quindio, few local roads connect major roads and paved area is quite small, making the major road network function insufficiently. The existing problems can be summarized as follows;

a) Transportation takes long time and the rate of bruised agro-production is high.
b) Transportation cost is high.
c) Marketing system improvement is obstructed.
d) Crop are damaged by the cloud of dust.

The condition of the existing main bridges on the above mentioned roads are shown in Fig.L.2.2 and Table L.2.2. These bridges are constructed of concrete or steel and there maintenance is good.

The traffic volume between Armenia and Calarca is approximately 8,000 vehicles per day, approximately 6,000 vehicles per day from Armenia to Circasia, and for the other main roads it is approximately from 1,500 to 3,000 vehicles per day. But the volume on the other roads is less than 1,000 vehicles per day.

(2) Traffic Services

There are eighteen(18) taxi companies and eight(8) bus companies in the Quindio, serving for the transportation between the center of Armenia and other towns as main public traffic means. Other public transportation services includes, only one service a day, that of the national railway (Ferro Carriles) between Armenia and Cali, and two jet plane services per day to Bogota from El Eden (La Tebaida) which is situated fifteen(15) km away from the center of Armenia.

## L.2.2 Electricity Services

(1) Existing Condition of Elctric Power Supply

The electric power supply and demand in the whole of Colombia is controlled by the Adjustment of Electric Corporation (ISA), and 63% of total electric power is supplied to Caldas, Risaralda, and Quindio, by ISA.

240,000 MWH/year of electric power is supplied by the Central Hydroelectric of Caldas (CHEC) and the management of the electric power supply is carried out by the Regional Autonomous Corporation of the Quindio (CRQ), the Coffee Committee of the Quindio (COMITE-CAFE), the Public Enterprises of Armenia (EPA), the Public Enterprises of Calarca (EPC), and the Municipalities of Montenegro and Quimbaya. The power transmission lines, power distribution stations and other related facilities are provided and electric power

Table L.2.2 Existing Major Bridges (1)

| No. | Bridge | River | Type | Scale(m) Width | Length | Height | Remarks |
|---|---|---|---|---|---|---|---|
| 1 | San Nicolas | Quindio | Suspension | 2.8 | 107.5 | 9.5 | |
| 2 | La Florida | Quindio | Concrete (metal) | 7.8 | 13.3 (138.0) | 57.0 | Con.1972 |
| 3 | La Maria | Quindio | Concrete | 9.1 | 30.0 | 10.0 | |
| 4 | Balboa | Quindio | Concrete | 9.0 | 75.5 | 9.0 | Curved bridge Con.1985 4 span |
| 5 | Pantanillo | Espejo | Concrete | 8.7 | 92.0 | 24.5 | 3 span |
| 6 | | Verde | Concrete | 8.5 | 44.0 | 6.7 | 3 span |
| 7 | | Barragan | Concrete | 8.0 | 66.0 | 7.3 | Con.1956 3 span |
| 8 | | Lejos | Metal | 4.0 | 45.0 | 8.3 | Con.1947 Flood |
| 9 | | Rojo | Concrete | 8.0 | 75.0 | 10.0 | Con.1981 |
| 10 | Tamborales | Stream | Concrete | 3.5 | 12.0 | 4.7 | |
| 11 | La Maizena | Stream | Concrete | 3.5 | 14.5 | 4.5 | Curved bridge |
| 12 | | Azul | Concrete | 3.5 | 15.0 | 2.5 | |
| 13 | Pte.Tabla | Lejos | Concrete | 4.0 | 13.0 | 4.0 | |
| 14 | Calle Larga | | Concrete | 4.0 | 15.0 | 5.0 | |
| 15 | | Lejos | Concrete | 7.9 | 46.3 | 3.3 | |

Table L.2.2 Existing Major Bridges (2)

| No. | Bridge | River | Type | Scale(m) Width | Length | Height | Remarks |
|---|---|---|---|---|---|---|---|
| 16 | Sardineros | Q.Sardineros | Concrete | 8.6 | 9.0 | 3.5 | |
| 17 | Pte El Alambrado | La Vieja | Metal | 8.6 | 100.0 | 16.0 | Con.1968 |
| 18 | Ratlroad Alambrado | La Vieja | Metal | 5.0 | 54.2 | 9.4 | Con.1926 by U.S.A |
| 19 | | Espejo | Concrete | 6.7 | 18.7 | 6.3 | |
| 20 | Pte La Maria | La Vieja | Suspension | 3.2 | 62.7 | 7.2 | Con.1982 from Genova |
| 21 | | Roble | Concrete | 10.5 | 36.8 | 12.5 | |
| 22 | | Stream | Concrete | 10.8 | 19.0 | 13.5 | |
| 23 | San Felipe | Stream | Concrete | 5.5 | 6.5 | 3.0 | Boundary of Valle |
| 24 | Bolillos | Stream | Concrete | 9.8 | 12.5 | 7.0 | |
| 25 | | Barhas | Concrete | 68.0 | 9.8 | 15.1 | 3 span Boundary of Risaralda |
| 26 | | Quindio | Metal | 5.5 | 21.0 | 5.0 | |
| 27 | La Nubia | Quindio | Metal | 3.1 | 28.0 | 7.0 | Constructed by Army |
| 28 | Pueblo Tapao | Espejo | Concrete | 15.8 | 7.8 | 2.4 | Constructed by Army |

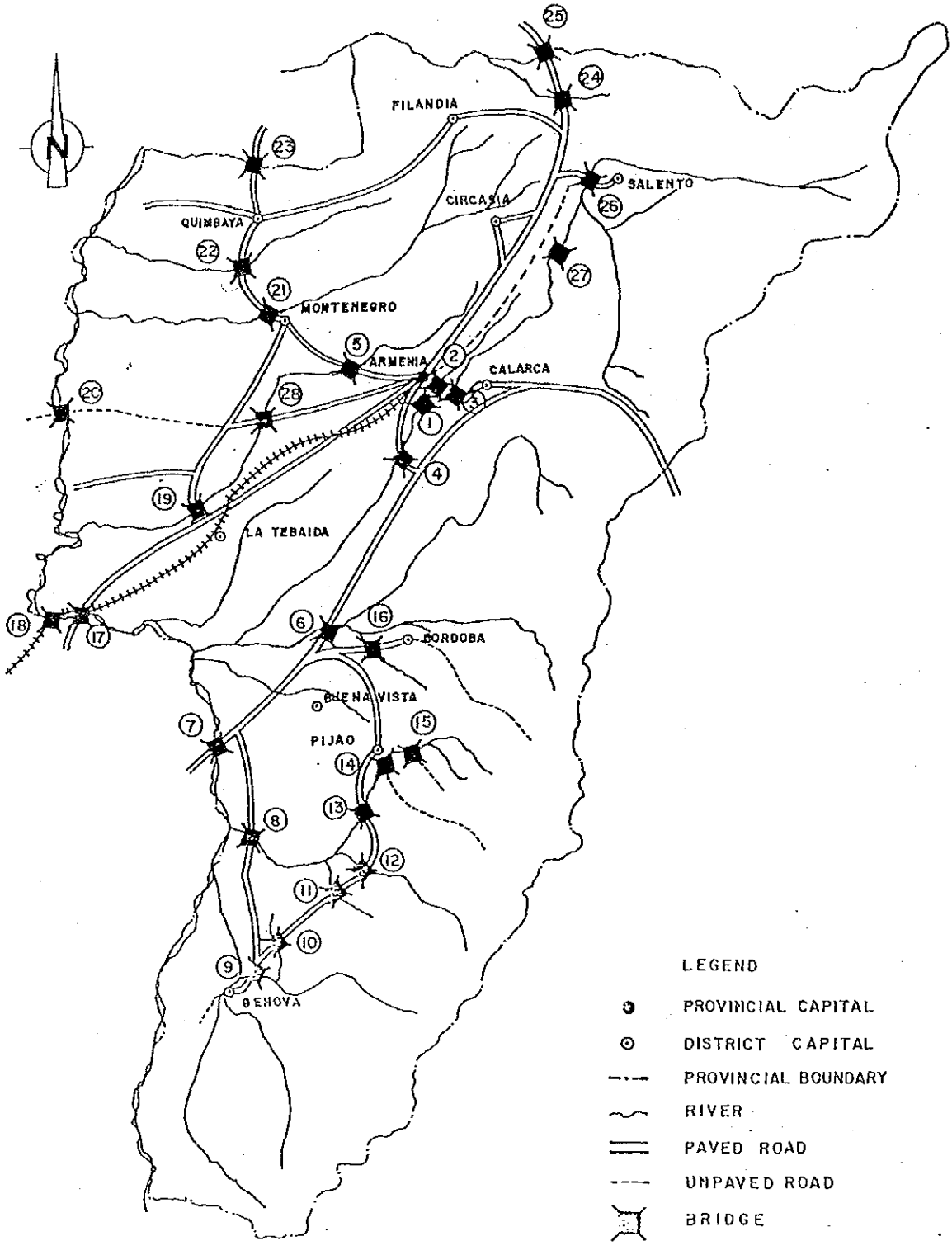


FIG L.2.2 LOCATION OF MAJOR BRIDGES

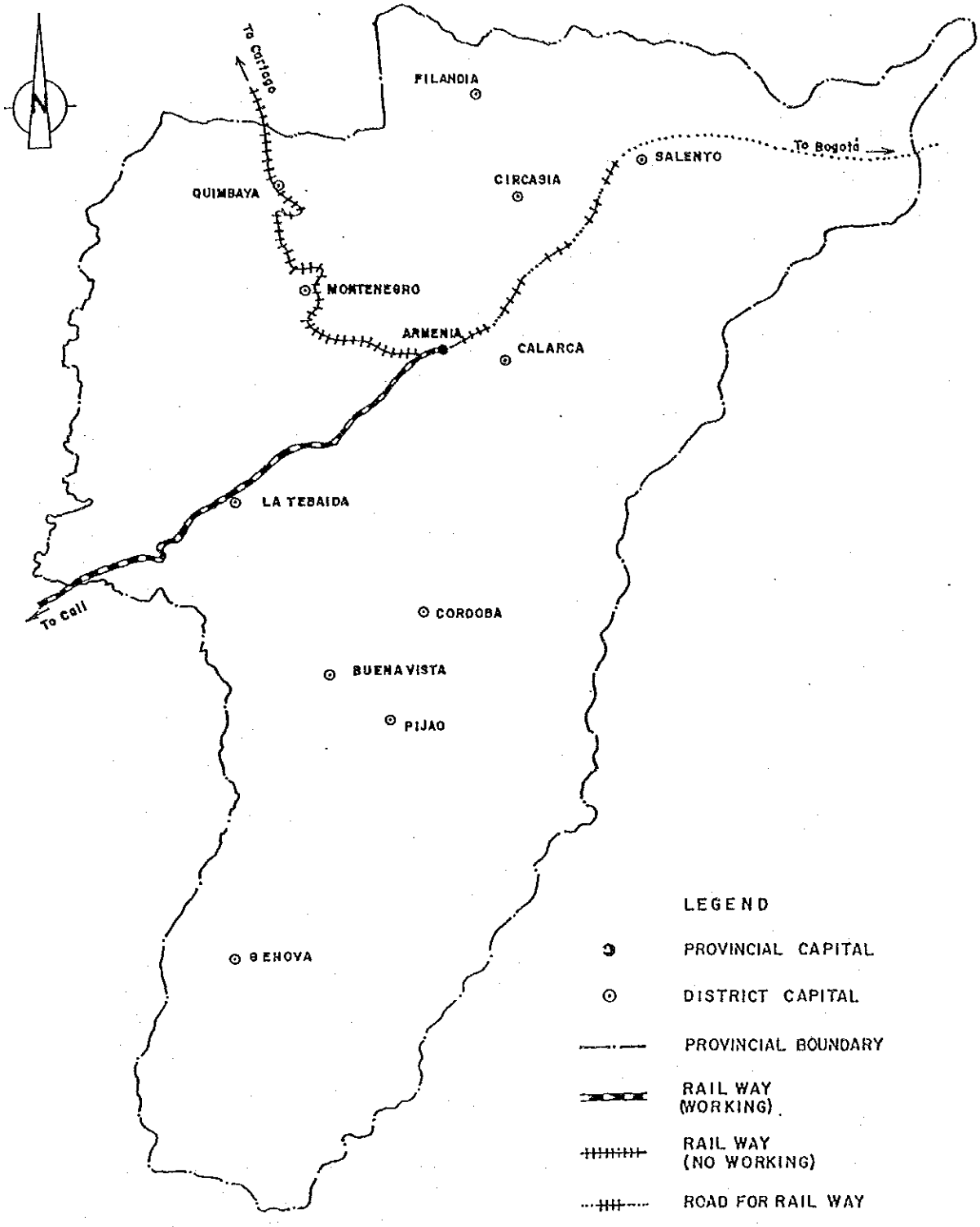


FIG L.2.3 RAIL WAY NETWORK OF QUINDIO

is supplied twenty four(24) hours a day in the Quindio.

The electric power network of the CHEC is as shown in Fig.L.2.4 and the sale of block electric power from the CHEC to the Quindio is as shown in Table L.2.3. The areas covered by public power service are shown in Fig.L.2.5. The system of the transmission lines and a diagram of the transmission lines are shown in Fig.L.2.6 and Fig.L.2.7. The distribution of consumers are shown in Table L.2.4.

(2) Existing Power Plants in the Quindio

There are six(6) electric power plants in the Quindio, four(4) of them(Canpestre, Bayona, La Union, El Bosque) are provided in the Quindio River, and others are in the Lejos River (Pijao) and the Roble River (Montenegro). However, they are extremely old and only one plant (La Union) is at work currently. The locations of these plants are shown in Fig.L.2.8 and summary of sthere facilities of them is given in Table L.2.5. Their rehabilitation has been considered, but only the first stage of the rehabilitation project of the El Bosque Plant is financed by EPA.

In view of stable electric power supply to the Quindio, the rehabilitation of the existing power plants would be required.

L.2.3 Water Supply and Sewage

(1) Water Supply

From the viewpoint of water resources, the Quindio may be divided into two(2) zones (eastern and western parts) at the divide of the right bank of the Quindio River (See Annex M). Gravitational system is used mainly at the existing water supply system in the Quindio, while pumping-up system with water from rivers orwells is used as well in the western part at rates comparatively more than in the eastern part where water resources are available in the mountain areas.

The water supply to the urban area is served by the Public Sanitary Works of the Quindio (EMPOQUINDIO), COMITECAFE, EPA, EPC, National Health Institute (INS) and the Municipality, and water treatment plants are provided in most urban areas. The coverage by aqueduct is shown in Fig.L.2.9 and the locations of water supply installations to urban aqueducts are shown in Fig.L.2.10. The summary of the existing conditions of urban aqueducts is shown in Table L.2.6.

There is no information on the problem of water shortage in any urban areas. However, considering the existing conditions of population and diversion facility, it is expected that the water shortage will be a more serious problem in the urban areas of Calarca, Quimbaya, and Montenegro. Depending on the water quality

Table L.2.3 (1) Sale of Block Electrical Power form CHEC to The Department of Quindio

Unit KWH

| Year | E.P.A. | E.P.C. | Montenegro | Quimbaya | C.R.Q. | Total |
|---|---|---|---|---|---|---|
| 1961 | 4,754,000 | -- | 953,900 | 814,000 | -- | 6,521,900 |
| 1962 | 7,510,000 | -- | 1,019,000 | 869,800 | -- | 9,398,800 |
| 1963 | 8,941,000 | -- | 781,300 | 997,475 | -- | 10,719,775 |
| 1964 | 8,523,000 | -- | 813,000 | 1,167,700 | -- | 10,503,700 |
| 1965 | 9,969,500 | 329,690 | 591,700 | 1,038,500 | -- | 11,929,390 |
| 1966 | 12,434,280 | 569,640 | 588,340 | 1,171,600 | -- | 14,763,560 |
| 1967 | 15,077,220 | 896,160 | 636,700 | 1,128,480 | -- | 17,668,560 |
| 1968 | 20,411,600 | 968,500 | 897,300 | 1,203,300 | -- | 23,470,700 |
| 1969 | 24,351,070 | 896,400 | 951,100 | 1,723,600 | -- | 27,922,170 |
| 1970 | 28,340,783 | 3,201,482 | 1,129,000 | 2,476,400 | 4,064,169 | 39,211,834 |
| 1971 | 34,561,740 | 3,244,090 | 1,611,700 | 2,576,000 | 7,660,460 | 49,635,990 |
| 1972 | 38,913,860 | 3,811,100 | 2,213,500 | 2,737,400 | 7,394,390 | 55,070,250 |
| 1973 | 43,910,725 | 3,907,315 | 2,291,180 | 3,335,500 | 8,380,613 | 61,753,333 |
| 1974 | 49,267,500 | 6,881,100 | 2,550,339 | 4,123,640 | 9,927,780 | 72,743,359 |
| 1975 | 60,132,400 | 6,139,200 | 3,517,585 | 4,505,500 | 12,177,860 | 86,472,545 |
| 1976 | 69,938,800 | 6,203,500 | 3,728,000 | 5,000,960 | 16,561,200 | 101,432,460 |
| 1977 | 70,466,330 | 7,958,986 | 3,903,000 | 6,475,188 | 19,120,434 | 107,723,938 |
| 1978 | 89,562,000 | 9,271,700 | 4,678,518 | 9,505,592 | 26,033,321 | 139,054,131 |
| 1979 | 106,829,953 | 9,318,400 | 4,971,220 | 10,743,803 | 33,928,102 | 165,791,483 |
| 1980 | 113,201,549 | 10,721,400 | 6,227,080 | 11,515,488 | 36,436,438 | 178,101,955 |
| 1981 | 105,007,529 | 14,210,254 | 6,098,040 | 10,882,336 | 41,010,960 | 177,209,129 |
| 1982 | 115,454,658 | 17,935,150 | 6,139,610 | 11,373,840 | 40,526,883 | 191,430,141 |
| 1983 | 120,181,047 | 11,936,400 | 6,318,873 | 13,747,022 | 50,625,608 | 202,808,950 |
| 1984 | 135,310,685 | 9,138,400 | 7,142,025 | 13,141,159 | 49,844,952 | 214,577,221 |
| 1985 | 144,898,809 | 9,885,250 | 7,199,772 | 13,494,138 | 51,172,820 | 226,650,798 |
| 1986 | 151,191,776 | 15,643,136 | 7,390,960 | 13,479,766 | 51,188,695 | 238,894,333 |

Sourse: CHEC

Table L.2.3 (2) Sale of Block Electrical Power from CHEC to Municipalities of Quindio

Unit KWH

| Year | Circasia | Filandia | Genova | Salento | La Tebaida | Total |
|---|---|---|---|---|---|---|
| 1963 | 617,787 | -- | 164,211 | -- | -- | 781,998 |
| 1964 | 762,389 | -- | 537,583 | -- | -- | 1,299,972 |
| 1965 | 754,649 | 55,030 | 533,954 | -- | 995,963 | 2,339,596 |
| 1966 | 954,680 | 388,560 | 551,634 | -- | 969,535 | 2,864,409 |
| 1967 | 941,684 | 455,647 | 643,629 | 11,542 | 1,123,026 | 3,175,528 |
| 1968 | 1,070,937 | 474,672 | 691,061 | 140,200 | 1,333,463 | 3,710,333 |
| 1969 | 1,135,073 | 516,446 | 685,487 | 253,869 | 1,381,755 | 4,658,117 |
| 1970 | 721,848 | 341,823 | 269,511 | 163,622 | 529,303 | 2,026,107 |

Note: Beginning 1970, the C.R.Q. started to administrate electric services to these Municipalities

Sourse: CHEC

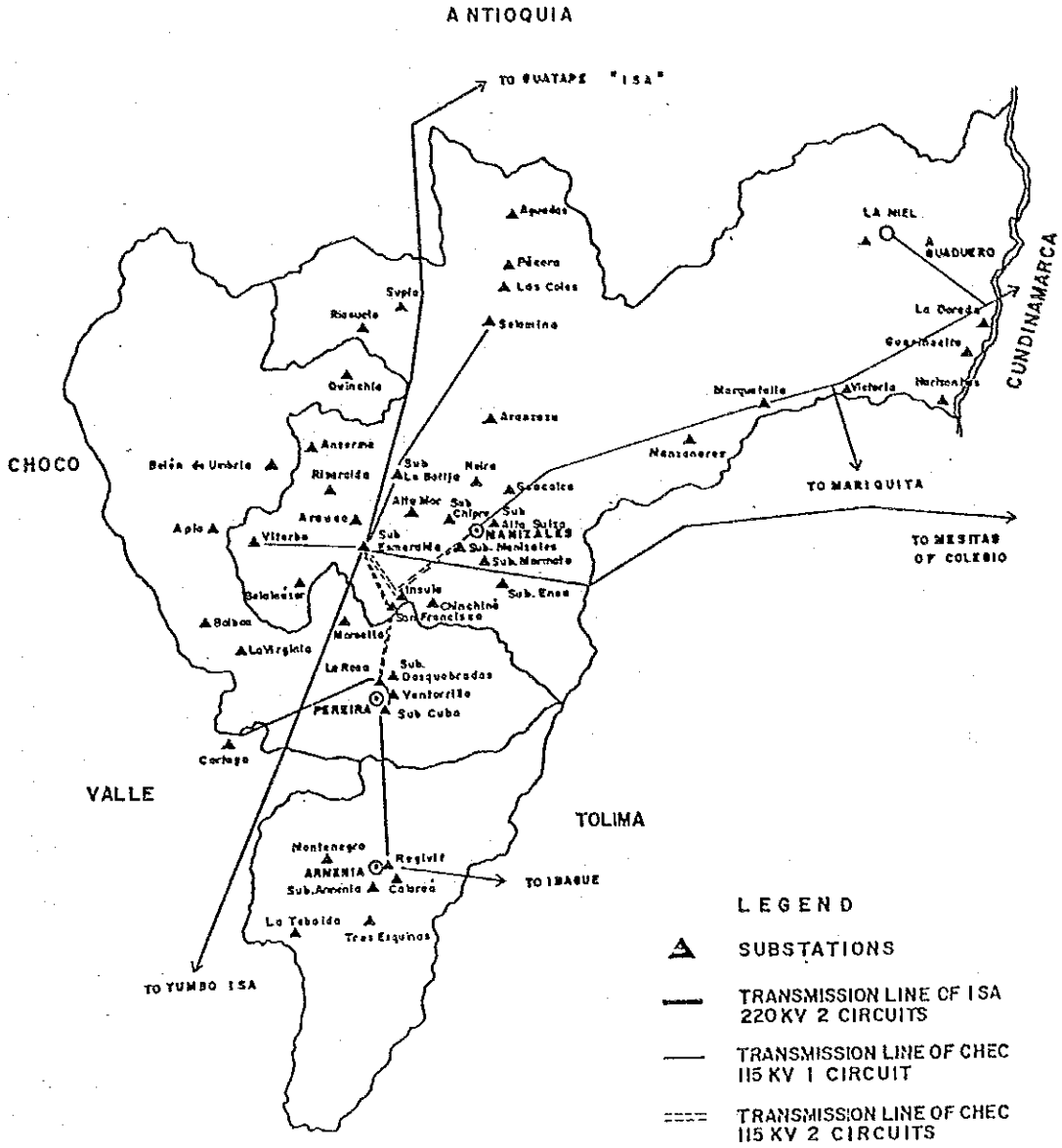


FIG L.2.4 ELECTRIC NETWORK OF CHEC IN GRAN CALDAS

Table L.2.4 (1) Distribution of Consumers by Type of Service
(1986 CRQ)

| | | |
|---|---|---|
| Total of Consumers | | 19,111 |
| Area | Urban Area | 10,163 |
| | Rural Area | 8,948 |
| Type to Service | Residentiary service tariff No.2 | 17,348 |
| | Official service tariff No.1 | 710 |
| | Industrial service tariff No.3 | 16 |
| | Commercial service tariff No.4 | 1,038 |

Source: C.R.Q.

Table L.2.4 (2) Distribution of Consumers by Municipality
(1986 C.R.Q.)

| Municipalities | Total | Consumers Rural | Urban |
|---|---|---|---|
| Genova | 1,702 | 622 | 1,080 |
| Buenavista | 482 | 224 | 258 |
| Cordoba | 706 | 257 | 449 |
| Pijao | 1,202 | 401 | 801 |
| Barcelona | 703 | | 703 |
| La Tebaida | 2,337 | | 2,337 |
| Circasia | 2,307 | | 2,307 |
| Salento | 651 | 140 | 511 |
| Filandia | 1,832 | 1,006 | 826 |
| Calarca | 866 | 851 | 15 |
| Quimbaya | 85 | 85 | |
| Montenegro | 840 | | 840 |
| Armenia | 5,398 | 5,362 | 36 |
| Total | 19,111 | 8,948 | 10,163 |

Sourse: C.R.Q.

Note: Consumers in Barcelona, Circasia, Tebaida and Montenegro are included in Armenia rural consumers.
In Armenia, Calarca, Quimbaya and Montenegro, there are another electric companies which also supply electric energy.

Table L.2.4 (3) Number of Consumers and Average Consumption
(1986 C.R.Q.)

| Type of Service | No. of Consumers | Average Consumptio | Average Tariff |
|---|---|---|---|
| Urban Area | | | |
| Residential | | Kw. | Col$ |
| 0 - 200 Kwh | 7,548 | 617,886 | 3.19 |
| 201 - 400 | 1,407 | 360,721 | 8.26 |
| 401 - 800 | 161 | 79,601 | 10.60 |
| 801 - 1600 | 10 | 10,601 | 12.94 |
| 1600 - | 2 | 4,503 | 16.35 |
| Official | 225 | 88,534 | 5.80 |
| Industrial | 2 | 55,784 | 6.62 |
| Commercial | 798 | 150,299 | 8.77 |
| Total | 10,153 | | |
| Urban Area | | | |
| Residential | | | |
| 0 - 200 Kwh | 5,020 | 496,604 | 3.19 |
| 201 - 400 | 1,702 | 484,121 | 8.26 |
| 401 - 800 | 972 | 532,709 | 10.60 |
| 801 - 1600 | 387 | 423,564 | 12.94 |
| 1600 - | 139 | 366,160 | 16.35 |
| Official | 485 | 517,757 | 5.80 |
| Industrial | 14 | 52,945 | 6.62 |
| Commercial | 239 | 172,489 | 8.77 |
| Total | 8,958 | | |

Sourse: C.R.Q.

Table L.2.4 (4) Electric Power Total Billings

| Type of Service | E.P.A. (1986) Consume (Kw) | % |
|---|---|---|
| Residential | 1,055,483 | 0.89 |
| 0 - 50 | 19,321,807 | 16.35 |
| 51 - 200 | 40,743,341 | 34.47 |
| 201 - 400 | 21,081,757 | 17.78 |
| 401 - 800 | 3,847,951 | 3.26 |
| 801 - 1600 | 1,332,604 | 1.13 |
| Fixed | 502,075 | 0.42 |
| Sub Total | 87,822,018 | 74.30 |
| Commercial | 16,468,806 | 13.93 |
| Industrial | 7,954,460 | 6.73 |
| Official | 4,122,585 | 3.49 |
| Public ligth | 1,835,400 | 1.55 |
| Total | 118,203,269 | 100.00 |

| Rank | M. Montenegro (1986) Consume (Kw) | % |
|---|---|---|
| 0 - 100 | 62,688 | 12.07 |
| 101 - 200 | 124,228 | 23.91 |
| 201 - 300 | 132,756 | 25.56 |
| 301 - 500 | 110,550 | 21.28 |
| 501 - 1000 | 45,658 | 8.79 |
| 1001 - | 43,578 | 8.39 |
| Total | 519,458 | 100.00 |

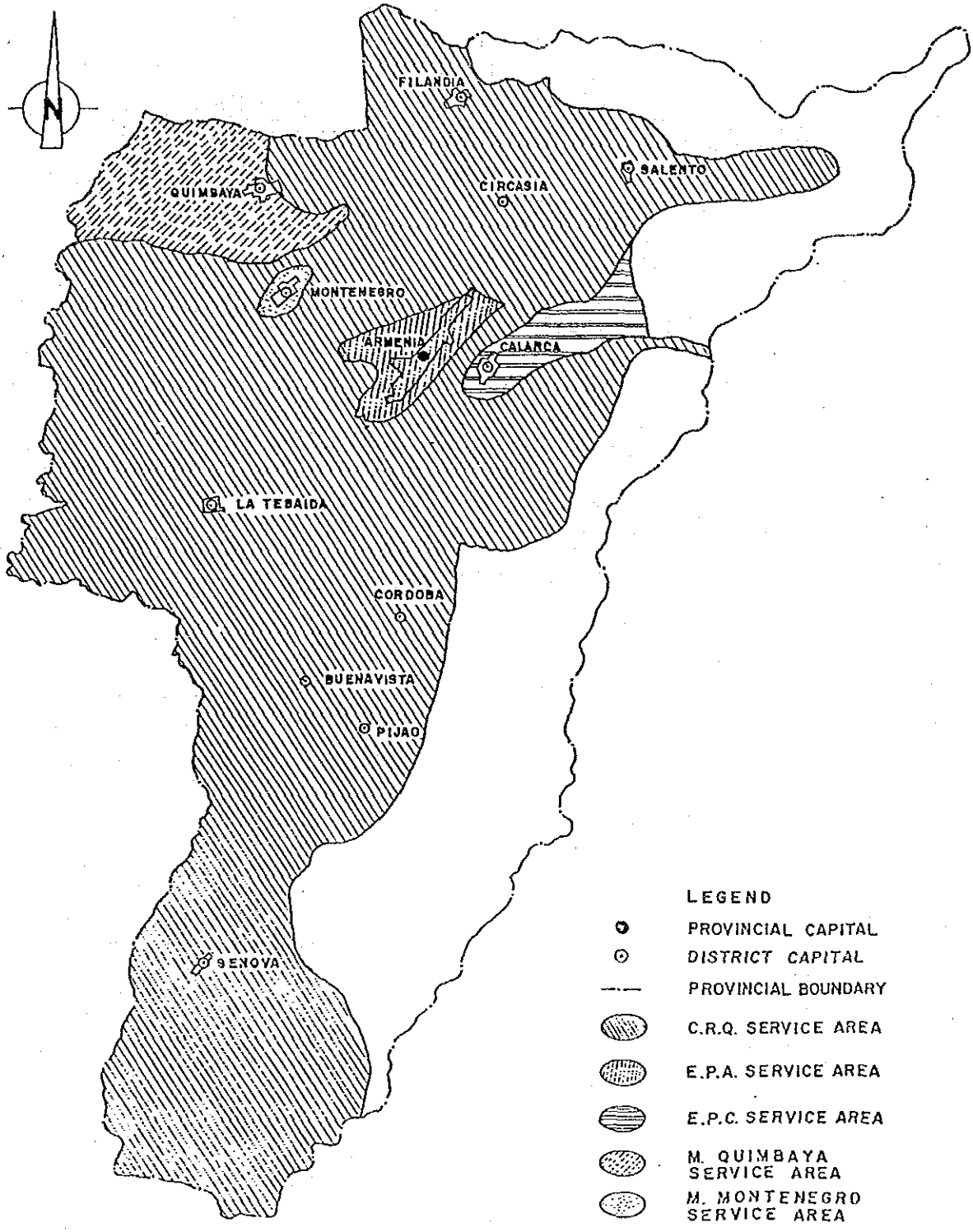


FIG L.2.5 SERVICE COVERAGE OF SUBSTATION

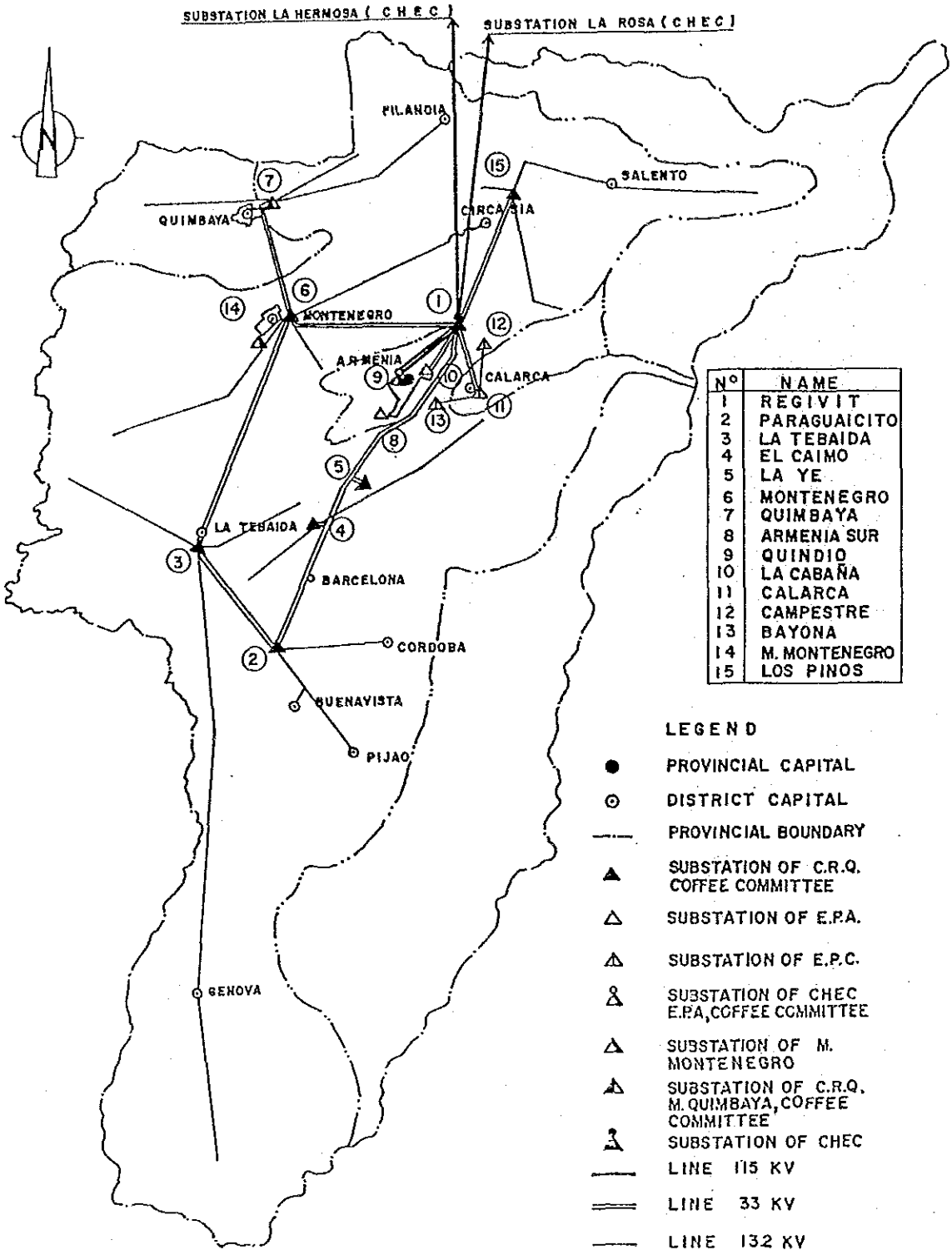


FIG L.2.6 TRANSMISSION LINE SYSTEM

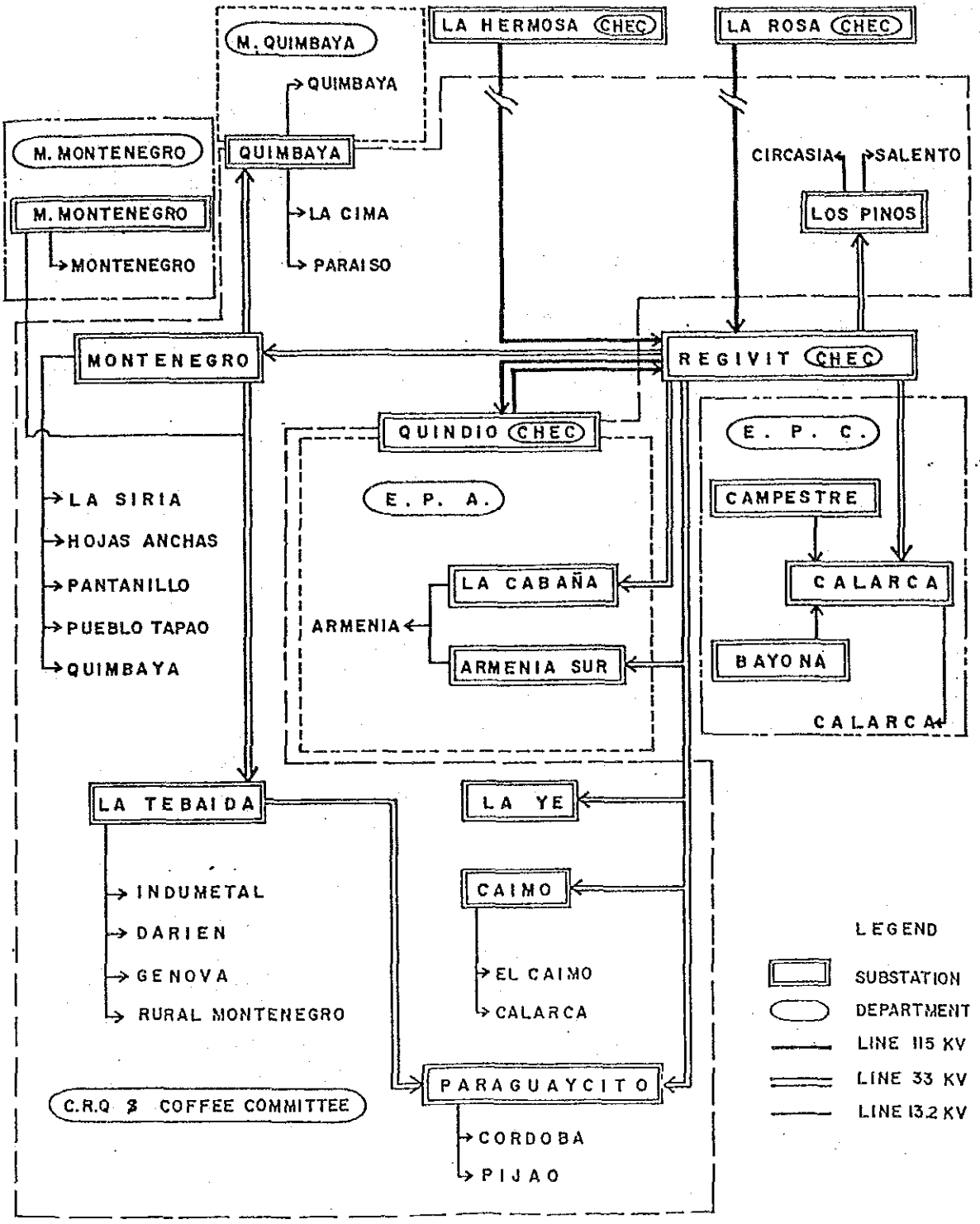


FIG L.2.7 DIAGRAM OF TRANSMISSION LINE

Table L.2.5 (1) Scale of The Facilities for Existing Power Plant

| No | Location | River | Volume of Water | A. Head | Volume of Electric Capacity | Institulion |
|---|---|---|---|---|---|---|
| | | | (m3/s) | (m) | (Kw) | |
| 1 | Campestre | Quindio | 1.7 | 60 | 1200 | EPC |
| 2 | Bayona | Quindio | 3.2 | 35 | 1200 | EPC |
| 3 | La Union | Quindio | 1.4 | 54 | 900 | EPC |
| 4 | El Bosque | Quindio | 2.6 | 80 | 2280 | EPA |
| 5 | Pijao | Lejos | 0.7 | 56 | 300 | CRQ<br>M. Pijao |
| 6 | Montenegro | Roble | 0.4 | 50 | 250 | M. Montenegro |

Table L.2.5 (2) Condition of The Facilities for Existing Power Plant

| | Diversion Work.s | Driving Channel | Head Tank | Pressure Conduit | Shed | Turbine | Generator |
|---|---|---|---|---|---|---|---|
| Campestro | Good | Need Repair | Good | Need Change | Good | Need Change | Need Change |
| Bayona | Good | Good | Good | Need Change | Good | Need Change | Need Change |
| La Union | Good | Good | Good | Good | Need Repair | Good | Good |
| El Bosque | Need Repair | Need Repair | Need Change | Need Change | Good | Need Change | Need Change |
| Pijao | Need Change | Need Repair | Need Change | Need Change | Need Change | Need Change | Need Change |
| Montenegro | Need Repair | Need Repair | Need Change | Need Change | Need Change | Need Change | Need Change |

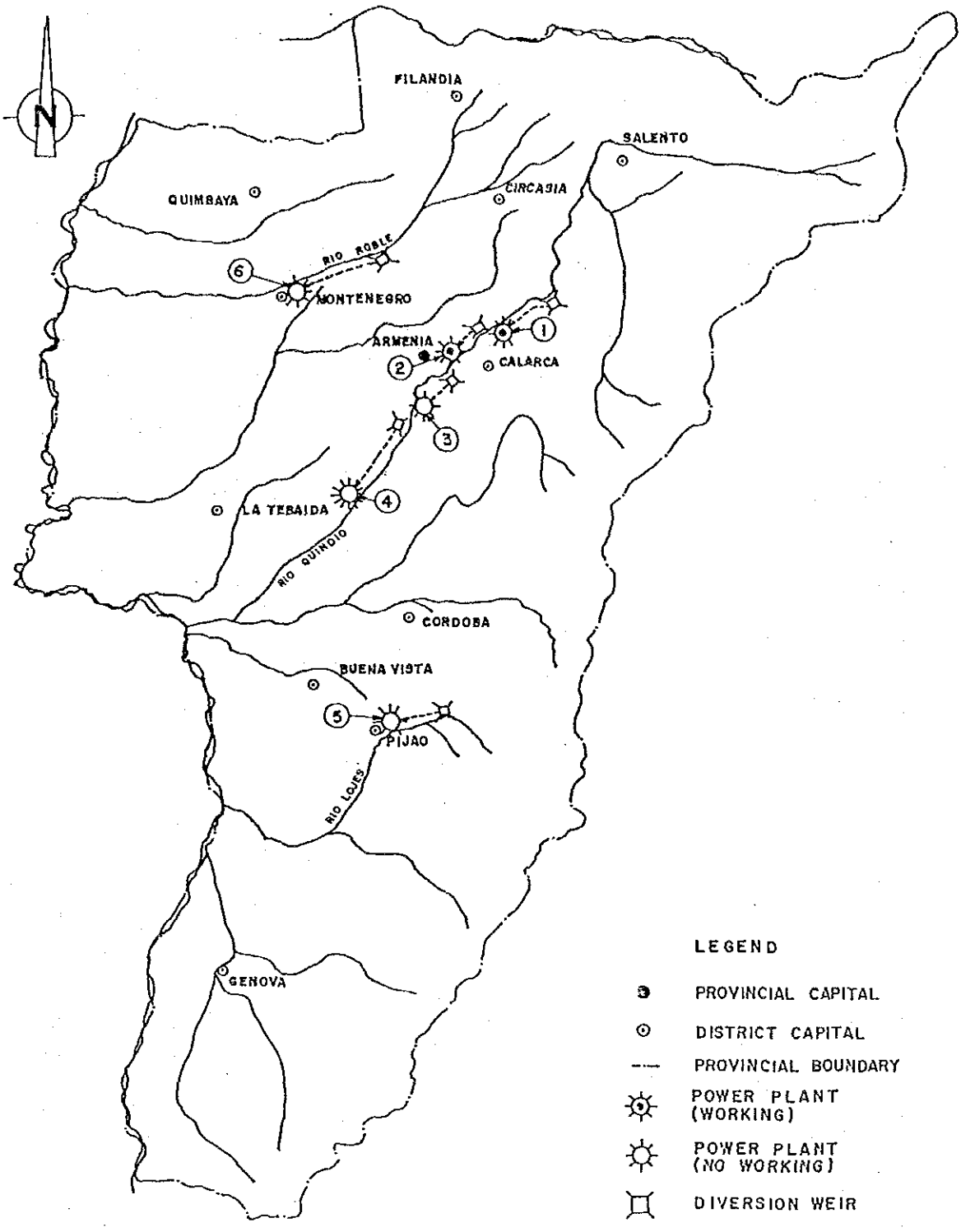


FIG L.2.8 LOCATION OF EXISTING POWER PLANT

TABLE L.2.6 URBAN AQUEDUCT (1)

| No. | Municipalities | Water Source | Supply Water L/S | Institution | Diversion Capacity 20 L/s | Weir Condition | Deficient Season | Supply Plan | Treatment plant |
|---|---|---|---|---|---|---|---|---|---|
| 1 | FILANDIA | Q.Bolillos | 20 | Empoquindio | 25 | good | 1,2,7,8 | 25 L/s(2008) | Conventional |
| 2 | SALENTO | Q.Cruz Gorda | 8 | " | 15 | good | None | 10 L/s(2008) | |
| | | Q.Corozal | | " | 20 | good | None | | France |
| 3 | CIRCASIA | Q.El Bosque | | " | 12 | good | 1,2,7,8 | | |
| | | Q.La Marina | | " | 12 | " | " | | |
| | | Q.Río Roble | 24 | " | 29 | " | " | 45 L/s(2008) | Conventional |
| | | Q.Villa Dora | | " | 29 | " | " | | |
| | | Las Aguilas | | Coffee Commitee | 106 | " | None | | |
| 4 | QUIMBAYA | Q.Buenavista | 70 | Empoquindío | 90 | " | None | | Conventional |
| 5 | MONTENEGRO | Q.La Soledad | | Empoquindío | 20 | " | " | | |
| | | Q.La Paloma | 75 | " | 20 | " | " | | Conventional |
| | | Río Roble | | " | 70 | " | " | | |
| 6 | ARMENIA | Rio Quindío | 1500 | E.P.A. | 3000 | good | None | | Conventional & American |
| 7 | CALARCA | Q.El Salado | 120 | E.P.C. | 170 | good | 1,2,7,8 | 270 L/S(2050) | Conventional & France |
| 8 | LA TEBAIDA | Q.Cristales | | Empoquindío | 50 | good | " | | |
| | | Well la Marina | 45 | | 45 | " | " | | Conventional no use |
| | | Well correccional | | " | 25 | | | | |
| 9 | CORDOBA | Q. El Roble | 12 | Municipal | 15 | " | 1,2,7,8 | | France |

Sourse: Informe del Estado Sanitario de los Acueductos del Departamento 1984

TABLE L.2.6 URBAN AQUEDUCT (2)

| No. | Municipalities | Water Source | Supply Water | Institution | Diversion Capacity | Weir Condition | Deficient Supply Season Plan | Treatment plant |
|---|---|---|---|---|---|---|---|---|
| 10 | BUENAVISTA | Q.La Picota | 8 | Municipal | 15 | good | 1,2,7,8 | France |
| 11 | PIJAO | Q.La Cascada | | Municipal Coffee Committee | 25 | " | " | |
| | | Q.La Cumbre | | I.N.S. | | " | " | No treatment plant |
| | | Río Lejos | 80 | Municipal | 90 | " | None | |
| | | Q.Calle Larga | | I.N.S. | | " | 1,2,7,8 | |
| | | Q.Las Pizarras | | Municipal Coffee Committee | | " | None | |
| 12 | GENOVA | Río Gris | 30 | Empoquindío | 40 | " | None | Conventional |

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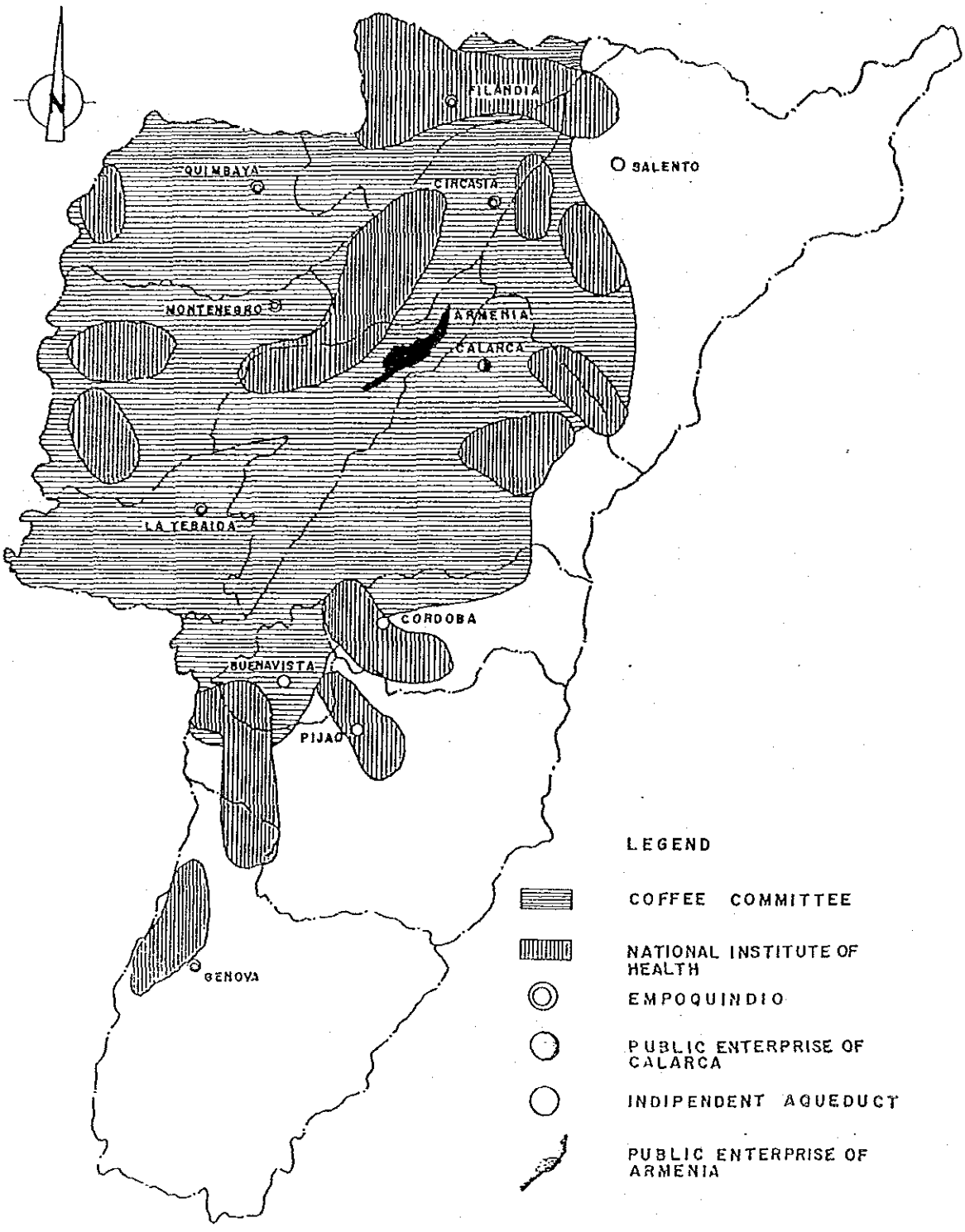


FIG L.2.9 COVERAGE OF AQUEDUCT

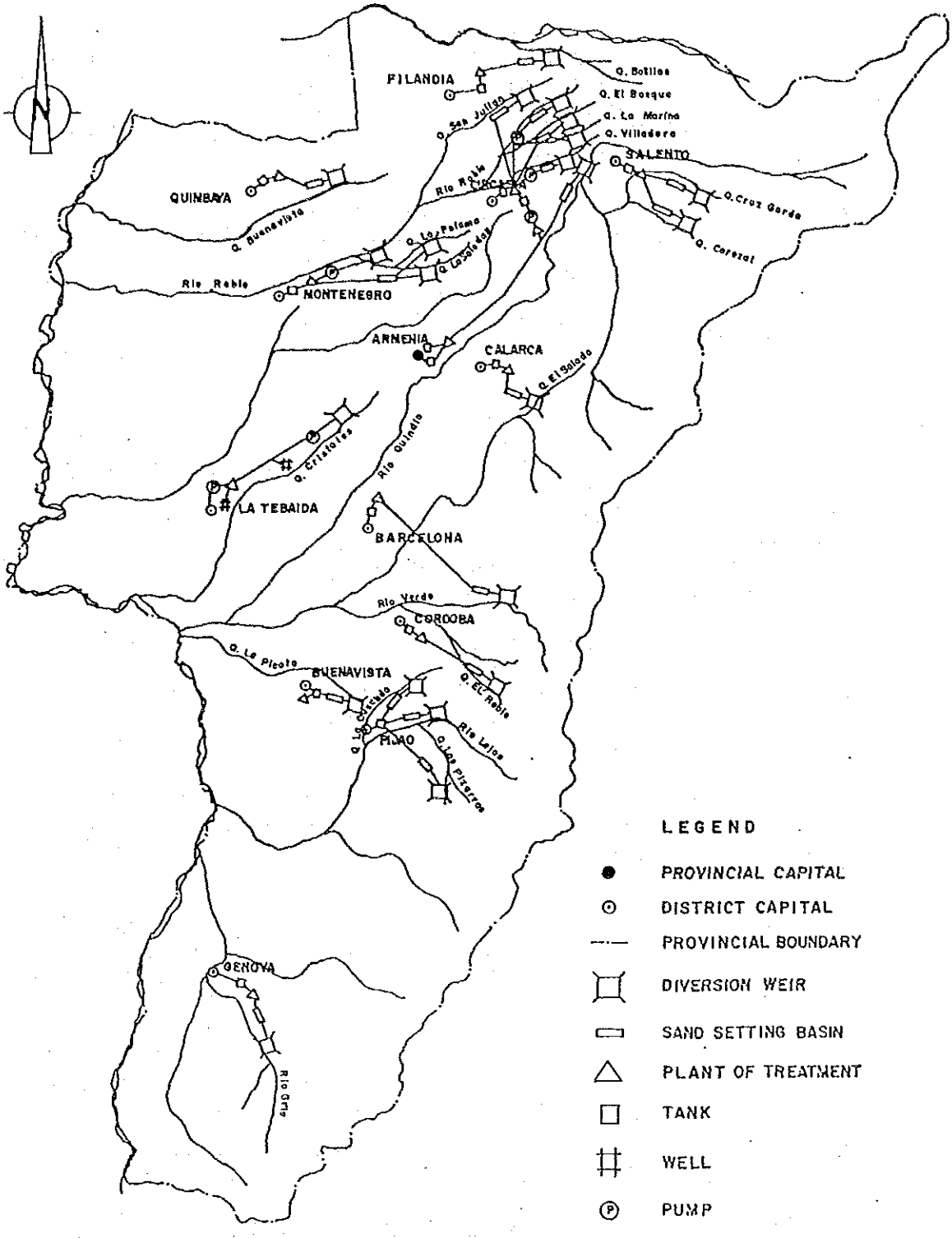


FIG L.2.10 LOCATION OF WATER SUPPLY INSTALLATIONS FOR URBAN AQUEDUCT

in the Q.Cristales, La Tebaida will face a similar problem.

While the water supply systems for rural areas are maintained by COMITECAFE, INS, and Municipality, there is no treatment plant in rural area. The location of diversion weir for rural aqueduct is shown in Fig.L.2.11 and the summary of existing condition of rural aqueduct is shown in Table L.2.7.

The construction of a few water treatment plants is under way and there are some other projects being planned by COMITECAFE. According to a hearing investigation, the southwestern part of Circasia is facing a serious water shortage problem, and the southwestern part of Armenia is facing a problem of the Espejo River's poor water quality.

(2) Sewage

Sewage pipeline system is provided in the urban area of the Quindio. However, there is no filter system and all sewage is discharged directly into the rivers. While some simple purification plants with infiltration system are provided in some parts of the rural areas of Armenia, Calarca, Quimbaya and Circasia, there is no purification plants in the majority of the rural areas, and sewage is discharged directly into the rivers.

L.2.4 Agro-Product Processing Facilities

The agro-product processing facilities in the Quindio may be classified into three(3) categories; coffee processing, livestock processing and other one.

There are two coffee processing factories managed by the cooperatives of coffee production in Montenegro and Calarca, some small factories having central processing, threshing machines and mills are existent in the Quindio.

Slaughterhouses are provided in every urban areas of the Quindio, and all are working without cutting instruments except one in Armenia. The information on the livestock processing facilities is given in Annex I.

There are factories of panderos, panela, feed, and other agro-processing facilities managed by private companies in the Quindio, but there production is small.

The conditions of the existing agro-product processing facilities are shown in Fig.L.2.13 and Table L.2.8.

70% of agro-processing goods consumed in the Quindio is imported from other Departments, hence it would be necessary to improve the agro-industry processing facilities for the development of the Quindio.

Table L.2.7 (1) Rural Aqueduct of Coffee Committee (i)

| No. | Aqueduct | Attended Municipallity | Water Source | Volume of Consumption L/S | Remarks |
|---|---|---|---|---|---|
| 1 | Portachuelo (Filandia) | Filandia | Portachuelo | 80.0 | |
| | | Montenegro | Pavas | 3.5 | |
| | | Quimbaya | La Armenia | 10.0 | |
| | | | Bambuco | 25.0 | |
| 2 | La Cauchera (Filandia) | Filandia | La Armenia | 1.5 | |
| 3 | La India (Filandia) | Filandia | Palmichal | 2.2 | |
| 4 | La Palmera (Filandia) | Filandia | La Carmelita la Gloria | 2.5 | |
| 5 | El Vergel (Filandia) | Filandia | La Arenosa | 1.5 | |
| 6 | La Montana (Quimbaya) | Quimbaya | Armenia | 11.1 | |
| 7 | Palestina (Salento) | Salento Circasia | Palestina | 0.6 | |
| 8 | Chaguala (Calarca) | Calarca Armenia | Pena Lisa Chaguala | 5.0 | |
| 9 | La Pradera (Calarca) | Calarca | El Pescador Zurrumbai | 4.4 | |
| 10 | Calabazo (Calarca) | Calarca | La Picota | 2.2 | |
| 11 | C.M.A. (Circasia) | Circasia Montenegro Armenia | San Julian El Roble | 14.0 | |
| 12 | La Bella (Calarca) | Calarca Armenia | La Sonadodra | 100.0 | |
| 13 | El Balso (Buenavista) | Buenavista | La Picota | 3.0 | |

Table L.2.7 (1) Rural Aqueduct of Coffee Committee (ii)

| No. | Aqueduct | Attended Municipality | Water Source | Volume of Consumption L/S | Remarks |
|---|---|---|---|---|---|
| 14 | Alto Del Oso (Cordoba) | Cordoba<br>Calarca<br>Armenia<br>Tebaida<br>Barcelona | Pavas<br>Rio Verde | 380.0 | |
| 15 | La Moravita (Cordoba) | Pijao | El Betel | 5.0 | |
| 16 | Murillo-Oro Sebastopol | Armenia<br>La Tebaida | Deep Well | 17.5 | Well (Parque recreacion) |
| 17 | Argentina-El Eden | La Tebaida | 2 Deep Wells | 5.0 | Well (Arco) |
| 18 | Prado-La Tebaida La Palmita | La Tebaida | 2 Deep Wells | 10.0 | Well (El Prado) |
| 19 | La Ceiba-Troncal | Montenegro | Deep Well | 25.0 | Well (Troncal) |
| 20 | Pueblo Tapao El Agrado Houses (11) | Montenegro | Deep Well | 25.0 | Well (Pueblo Tapao) |
| 21 | Mesa Alta (Portachuelo) | Quimbaya | Deep Well | 2.8 | Pavas well (En La Escuela) |
| 22 | La Montana | Quimbaya | Deep Well | 5.0 | Well (Gloria) |

Table L.2.7 (2) Rural Aqueduct of Institution of National Health

| No. | Aqueduct | Attended Municipality | Water Source | Volume of Consumption L/S | Remarks |
|---|---|---|---|---|---|
| 1 | Rio Verde | Buenavista | Casalarga | 0.66 | |
| 2 | Buenos Aires | Calarca | Q.La Gata | 1.38 | |
| 3 | Santo Domingo Alto | Calarca | Quebrada (3) | 0.07 | |
| 4 | Barcelona A. y B. | Circasia | Rio Roble | 1.79 | |
| 5 | R.Villarazo | Circasia | Q.Tenches | 3.05 | |
| 6 | R.Gilandia | Filandia | Q.Bolillo<br>Q.Barro Blanco | 4.10 | |
| 7 | La Castalia | Filandia | Q.Chisperos | 1.50 | |
| 8 | La Virgen | Montenegro | Orinoquito | 1.11 | Pump |
| 9 | Napoles | Montenegro | Q.La Clara | 0.94 | Pump |
| 10 | Barragan | Pijao | Q.Berlin | 0.58 | |
| 11 | P.Alejandria | Quimbaya | Quebrada (3) | 0.55 | |
| 12 | Canaan | Salento | Q.Lisboa | 0.69 | |
| 13 | Pinos | Salento | Q.San Antonio | 0.63 | |
| 14 | Roble | Salento<br>Filandia | Q.La Carolina<br>La Rivera | 0.56 | |
| 15 | Cascada | Genova | Bogotacito | 0.37 | |
| 16 | La Coca<br>Rio Lejos | Genova | La Coca | 3.00 | |
| 17 | La Virginia | Calarca | El Silencio<br>El Cofre | 2.20 | |
| 18 | Boquit | Salento | Q.El Rosario | 0.90 | |

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Table L.2.7 (3) Independent Rural Aqueduct

| No. | Aqueduct | Attended Municipality | Water Source | Volume of Consumption L/S | Remarks |
|---|---|---|---|---|---|
| 1 | Rio Verde | Buenavista | Q.La Picota | 0.31 | |
| 2 | La Divisa | Buenavista | | 0.25 | |
| 3 | Santo Domingo Bajo | Calarca | | 0.17 | |
| 4 | Castillo | Calarca | | 0.25 | |
| 5 | Pencil | Calarca | | 0.25 | |
| 6 | La Paloma | Calarca | | 0.43 | |
| 7 | Topacia B. | Genova | Q.La Topacia | 0.16 | |
| 8 | Topacia A. | Genova | Q.La Topacia | 0.21 | |
| 9 | La Granja | Genova | | 0.28 | |
| 10 | Rio Rojo | Genova | | 0.31 | |
| 11 | La Siberia | Cordoba | | 0.12 | |
| 12 | San Jose | Montenegro | | 0.23 | |
| 13 | La Maria | Pijao | | 0.41 | |
| 14 | Rio Lejos | Pijao | | 0.19 | |
| 15 | Berlin | Pijao | | 0.41 | |
| 16 | Puente Tabla | Pijao | | 0.33 | |
| 17 | Central De Beneficio | Montenegro | Q.San Pablo | 10.00 | By Gravity |
| | Cooperativa De Caficultores | | Q.La Risaralda | 50.00 | Pump |
| | De Armenia | | Deep Well | 1.50 | |
| 18 | La Mariela | Pijao | | 0.60 | |

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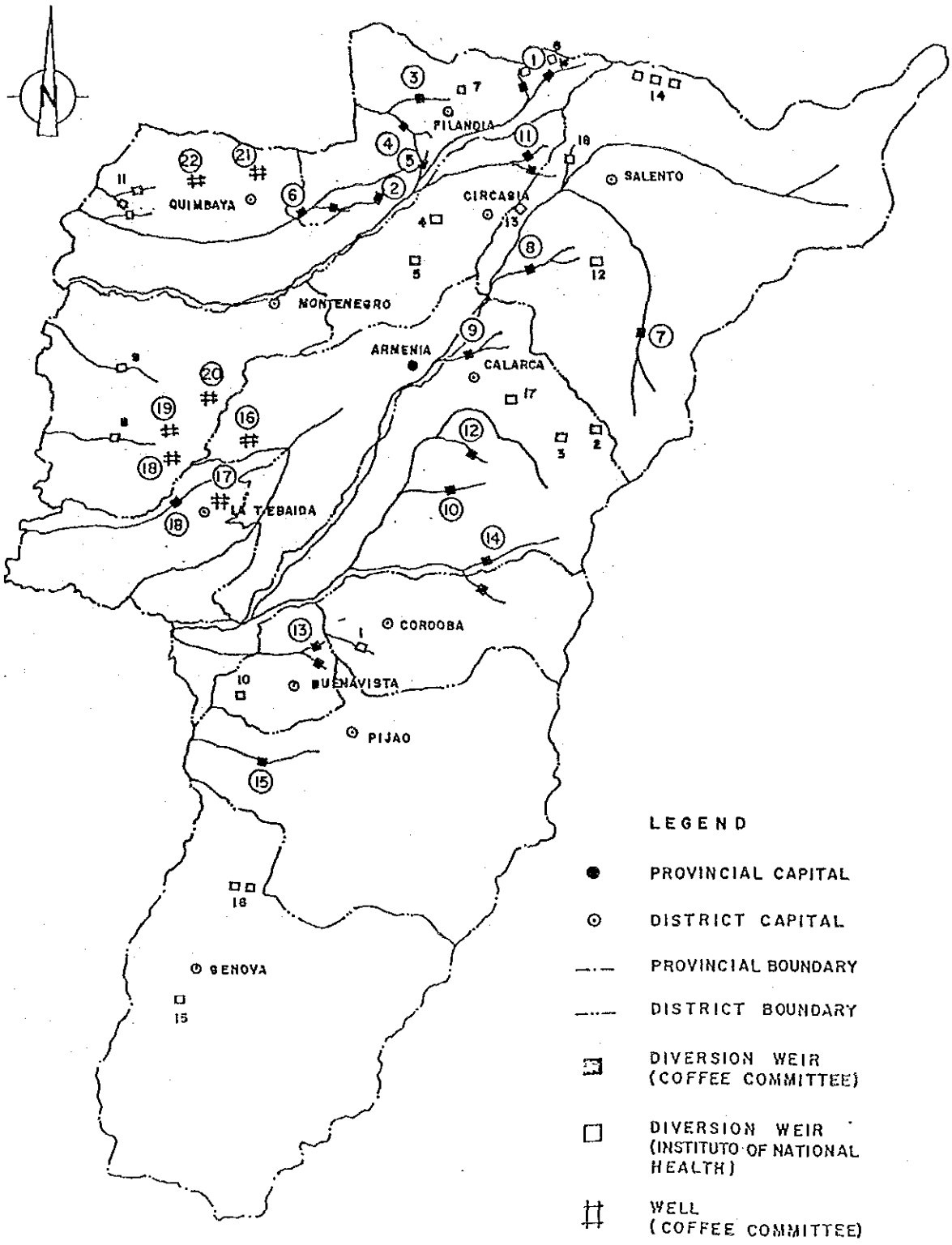



FIG L.2.11 LOCATION OF DIVERSION WEIR FOR RURAL AQUEDUCT

Table L.2.8 (1) Sewerage of Urban Area

| Municipality | Urban Population (1985) | Rivers to be | Discharge L/s Qmean | Qmax | Remarks |
|---|---|---|---|---|---|
| Armenia | 180,206 | Q.Hojas Anchas | 76.00 | 137.00 | Flow to Rio Espejo |
| | | Q.Armenia | 178.00 | 321.00 | Flow to Rio Espejo |
| | | Q.La Florida | 79.00 | 142.48 | Flow to Rio Quindio |
| | | Q.Los Naranjos | 25.00 | 45.09 | Flow to Rio Espejo |
| | | Q. Espejo | 102.00 | 183.95 | Flow to Rio Espejo |
| Calarca | 37,677 | Q.El Pescador | 33.50 | 79.76 | Flow to Rio Quindio |
| | | Rio Santo Domingo | 31.91 | 75.97 | |
| Barcelona (1) | 3,800 | Q.El Congal | 6.70 | 20.10 | Flow to Rio Verde |
| Montenegro | 21,936 | Rio Roble | 5.71 | 14.92 | |
| | | Q.Cajones | 32.37 | 84.56 | Flow to Rio Espejo |
| Quimbaya | 20,262 | Q.Buenavista | 31.66 | 83.80 | Flow to La Vieja |
| | | Q.Aguka Linda | 3.52 | 9.32 | Flow to La Vieja |
| La Tebaida | 15,912 | Q.La Jaramilla | 24.60 | 67.71 | Flow to Q.Cristales |
| | | Q.La Tulia | 3.20 | 8.80 | Flow to Q.Jaramilla |
| Circasia | 10,940 | Q.Las Yeguas | 14.24 | 41.52 | Flow to Q.HojasAnchas |
| | | Q.Cajones | 4.75 | 13.85 | Flow to Rio Roble |
| | | Q.Villadora | | | |
| Genova | 4,921 | Rio Gris | 1.28 | 3.84 | Flow to Rio San Juan |
| | | Rio San Juan | 7.26 | 21.78 | Flow to Rio Rojo |
| Pijal | 4,151 | Rio Lejos | 7.22 | 21.66 | |
| Cordoba | 2,300 | Q.La Espanola | 4.00 | 12.00 | Flow to Rio Verde |
| Salento | 2,507 | Rio Quindio | 3.25 | 9.75 | |
| | | Rio Boqueron | 1.10 | 3.30 | Flow to Rio Navarco |
| Buenavista | 1,133 | Q.La Picota | 1.18 | 3.54 | Flow to Rio Barragan |
| | | Q.Gallinetas | 0.79 | 2.37 | Flow to Rio La Picota |
| Filandia | 3,918 | Q.A.Rio Barbas | 3.80 | 11.40 | Flow to Rio Barbas |
| | | Q.Los Medios | 3.02 | 9.06 | Flow Rio Roble |

Note: (1) Urban District Belonging to Calarca.

Table L.2.8 (2) Sewerage of Rural Area

| District | Municipality | River to be Discharged | Discharge Qmean | L/S Qmax | Remarks |
|---|---|---|---|---|---|
| La India | Filandia | Q.A.Rio Barbas | 0.40 | 1.24 | Flow Rio Barbas |
| Pueblo Tapao | Montenegro | Rio Espejo | 2.05 | 6.16 | Rio Espejo |
| El Triunfo Barcelona Alta | Circasia | | 0.28 | 0.83 | Treatment by infiltration |
| La Virginia | Calarca | Santo Domingo | 1.93 | 5.80 | Flow to rioSto Domingo |
| Barragan | Pijao | Rio Barragan | 0.20 | 0.60 | Flow to Rio Barragan |
| El Caimo | Armenia | | 0.47 | 1.41 | Treatment by infiltration |
| Puerto Rico | Quimbaya | | 0.27 | 0.89 | Treatment by infiltration |
| La Albania | Calarca | | 0.17 | 0.52 | Treatmen infiltration |

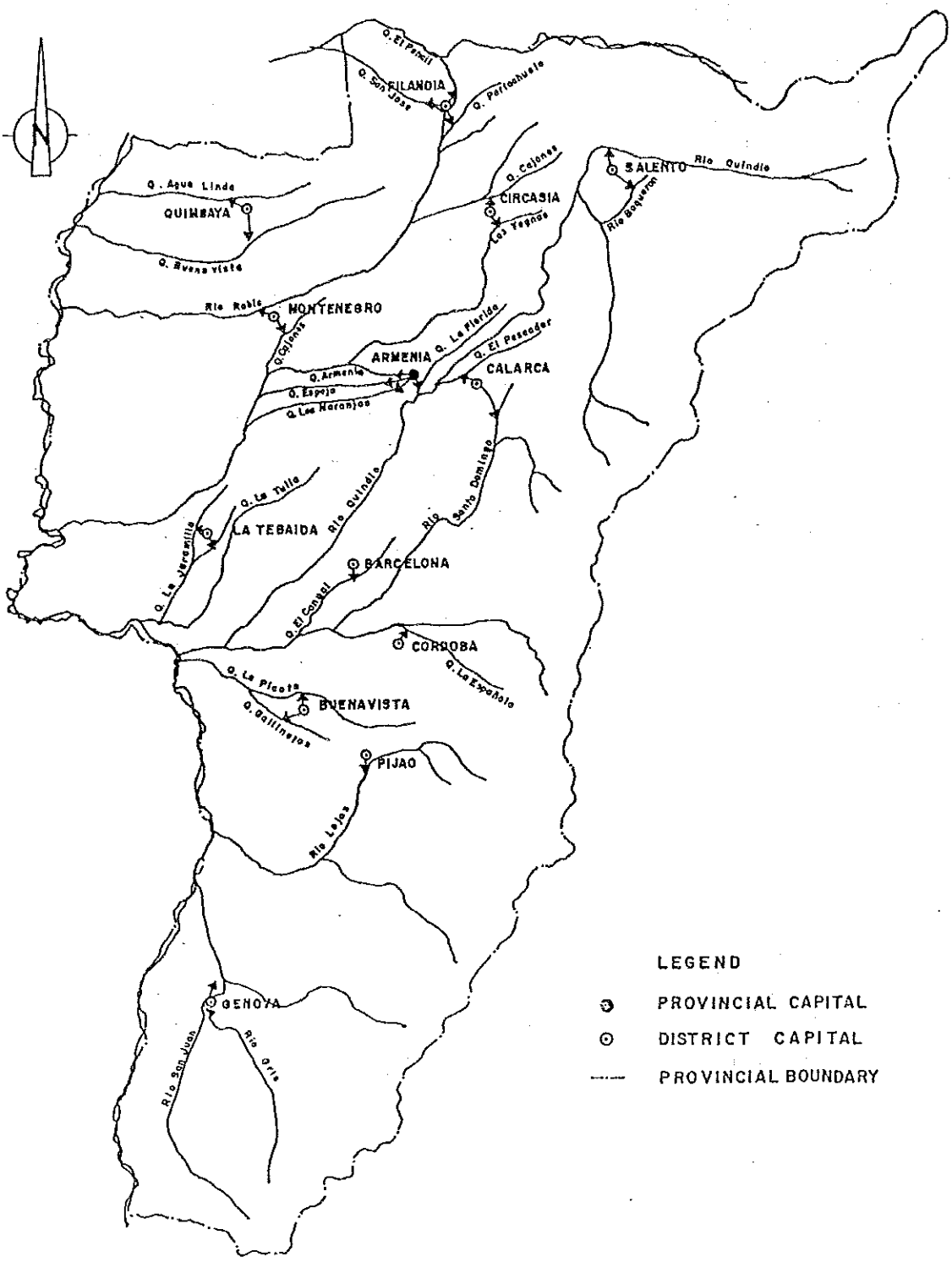



FIG L.2.12 SYSTEM OF SEWERAGE

Table L.2.9 Agro-Products Processing Facilities

| No. | Name | Location | Description |
|---|---|---|---|
| 1 | Slaughter-house of Armenia (E.P.A.) | Armenia | Number of sacrificed Cow 60-130/day<br>Pig 15-32/day |
| 2 | Curtimbres (Tannery) | Calarca | 2,000 M2 |
| 3 | Slauthter-house of Calarca | Calarca | Number of sacrificed Cow 68-75/week<br>Pig-90/week |
| 4 | Co-operative of the Coffee producers of Calarca (thrashing machine) | Calarca | |
| 5 | Co-operative of the Coffee producers of Armenia (Central Processing) | Montenegro | Pump-0 4"x2 50 L/s<br>San Pablo .. 1.0 L/s<br>Well .. 1.5 L/s |
| 6 | Slaughter-house of Genova | Genova | Nomber of sacrificed ordinally coffee harvest season<br>Cow 30/week 60/week<br>Pig 20/week 30-35/week |
| 7 | Slaughter-house of Pijao | Pijao | Nomber of sacrificed ordinally coffee harvest season<br>Cow 25/week 40/week<br>Pig 12-15/week 20/week |
| 8 | Citricos de Colombia (Fruits processing plant) | Armenia | 1 Year ago started<br>Orange, lemon, 8,000pounds/week<br>35,000 M2 |
| 9 | Fabrica de Panderitos el Paraiso (Factory of Pandero) | Circasia | 7 Years ago started<br>10,000 box/month |
| 10 | Panela Potosi (Factory of anela) | Montenegro | 19,200 kg/week<br>Sugarcane (2.5kg) panela (1 kg) |
| 11 | La Granja ltda. (Feed Factory) | Tebaida | (under repair)<br>Corn, rice, cassava |

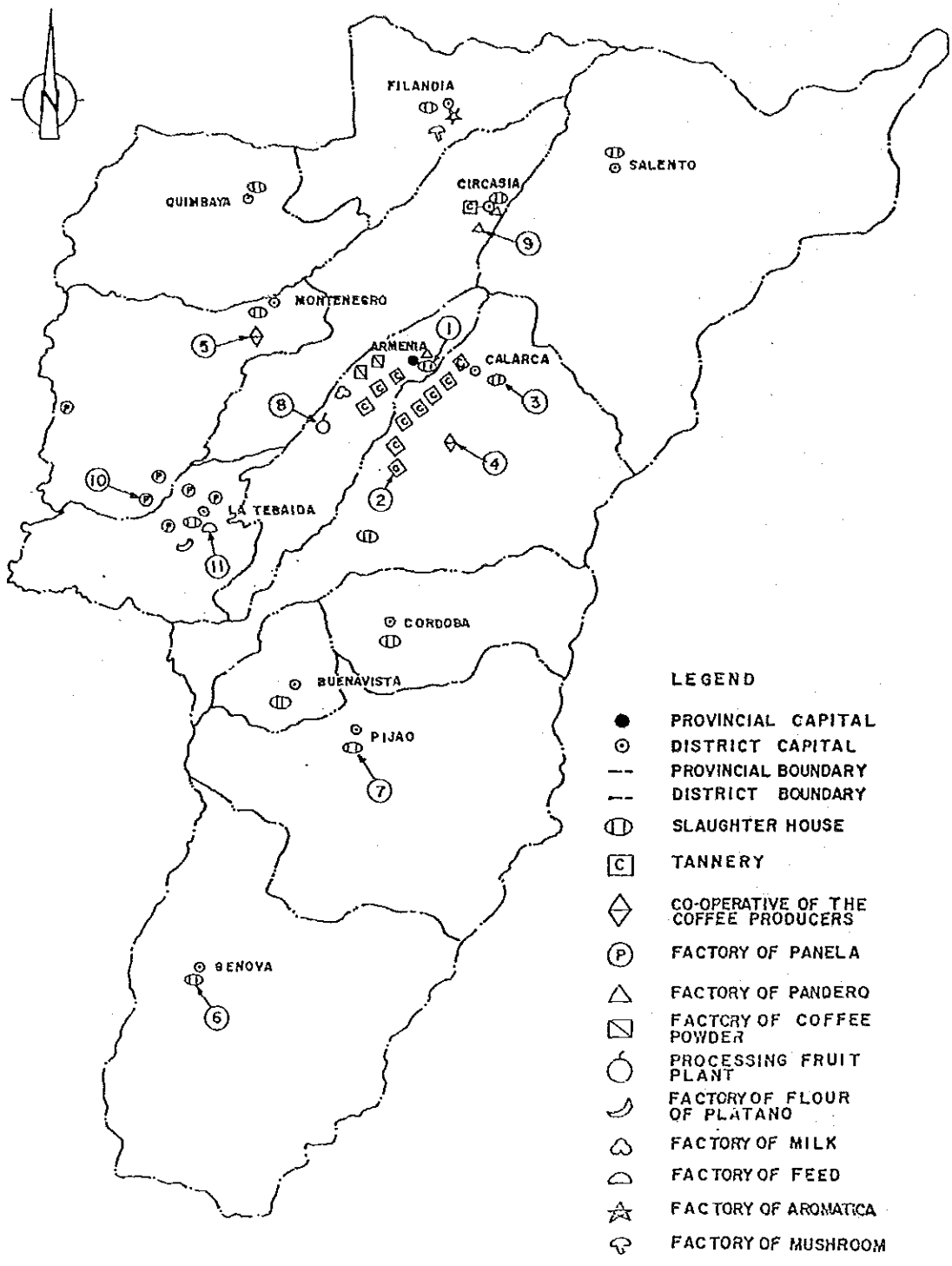



FIG L.2.13 LOCATION OF AGRO-PRODUCTS PROCESSING FACILITIES

## L.2.5 Telecommunications

Based on the improvement plan of the National Telecomunication Plan, the communication services of telegraph has been improved in the Quindio. Sixty(60) telephone circuits for long distance exist and circuits for short distance in the urban area can be summarized as follows;

Armenia 16,680 , Calarca 4,060 , Quimbaya 1,040
Montenegro 840 , Others 2,600

There are few circuits for rural areas, but the construction of telephone line is being carried out in some parts, in accordance to the telecomunication improvement plan in the Quindio.

## L.3 Rural Infrastructure Plan

### L.3.1 Rural Road Improvement Plan

(1) Basic Concept

From the viewpoint of effective transportation in the rural areas, not sufficient local road network is provided in the Quindio. Considering a capacity increase and a reduction in transportation cost, it would be necessary to improve the local road network. Improvement of the local road network would be one of the key point for the development of the rural areas and the improvement of marketing system. Therefore, a local road network should be projected with consideration to the effective impact on the development of the rural areas. Considering the existing conditions of local road networks, it will basically be necessary to first improve all the major roads connected with main roads, and then, improve local roads connecting the major roads.

(2) Development Strategy

- The improvement of the road network will be projected with due consideration given to three stages as follows;

  a) First Stage

  From the viewpoint of the Agricultural Integral Development Plan, the high priority road routes between rural areas will be improved.

  b) Second Stage

  According to the priority of the road plan for the Quindio, the major roads connected with the main roads and the urban areas will be improved.

  c) Third Stage

  From the viewpoint of the Regional Integral Development Plan, the road network in the Quindio will be developed.

- Considering the road improvement plan of the Quindio, the following routes, which have been already financed and are to be completed by 1990, hence are omitted from the Study.

  Montenegro - Puebro Tapao 7.2 km (Under Construction)
  Via Sardineros - Pijao 10.4 km (Under Construction)
  Via Sardineros - Cordoba 2.6 km

(3) Preliminary Layout of Road Network Improvement Plan

Based on the development strategy and existing road conditions, the preliminary layout of road network plan was drawn as shown in Fig.L.3.1. The expectant routes are summarized in Table L.3.1.

The widths of roads were designed based on the design criteria of Colombia.

(4) Selection of Project

Considering to the effective impact for the development of rural area, the following road improvement plan must be selected as the project.

a) First Stage

| Routes | | Distance (km) | Cost (Million Col$) |
|---|---|---|---|
| 1. Barragan | - Genova | 19.2 | 580 |
| 2. La Cabana | - Buenavista | 2.0 | 50 |
| 3. Arrayanal | - Salento | 9.0 | 210 |
| 4. Circasia | - La Pola | 9.5 | 200 |
| 5. Circasia | - Montenegro | 15.0 | 380 |
| 6. La Tebaida | - El Vergel | 13.5 | 360 |
| 7. El Vergel | - Calama | 3.0 | 150 |
| 8. Granada | - Portogal | 11.0 | 250 |
| 9. El Vergel | - Pescador | 11.5 | 450 |
| 10. Salento | - La Ceja | 10.0 | 30 |
| 11. Salento | - La Cocora | 10.0 | 20 |
| Total | | 113.7 | 2,680 |

b) Second Stage

| Routes | | Distance (km) | Cost (Million Col$) |
|---|---|---|---|
| 12. Genova | - Pijao | 27.0 | 810 |
| 13. Pijao | - Cordoab | 15.5 | 470 |
| 14. Cordoba | - Calarca | 27.0 | 810 |
| 15. Filandia | - Quimbaya | 17.0 | 390 |
| 16. Quimbaya | - Sanfelipe | 6.0 | 230 |
| 17. Puerto Tapao | - La Tebaida | 8.5 | 200 |
| 18. San Jose | - San Pablo | 4.0 | 90 |
| 19. La Suiza | - La Maria | 11.5 | 270 |
| 20. Baraja | - Puerto Samaria | 15.0 | 350 |
| 21. Quimbaya | - Puerto Alejandoria | 13.0 | 300 |
| Total | | 144.5 | 3,920 |

Table L.3.1 Summary of Preliminary Rayout of Road Network Plan

| Routes | | Distance (km) | Width (m) | Cost (Million Col$) | Traffic Volume in 2005 |
|---|---|---|---|---|---|
| FIRST STAGE | | | | | |
| 1.Barragan | -Genoba | 19.2 | 9.0 | 500 | 2,084 |
| 2. La Cabana | -Buenavista | 2.0 | 9.0 | 50 | 441 |
| 3. Arrayanal | -Salento | 9.0 | 9.0 | 210 | 786 |
| 4. Circasia | -La Pola | 9.5 | 9.0 | 200 | - |
| 5. Circasiac | -Montenegro | 15.0 | 9.0 | 380 | 797 |
| 6. La Tebaida | -El Vergel | 13.5 | 9.0 | 360 | - |
| 7. El Vergel | -Calama | 3.0 | 9.0 | 150 | - |
| 8. Granada | -Portogal | 11.0 | 9.0 | 250 | - |
| 9. El vergele | -Pescadorl | 11.5 | 9.0 | 450 | - |
| 10.Salento | -La Ceja | 10.0 | 5.0 | 30 | - |
| 11.Salento | -La Cocora | 10.0 | 5.0 | 20 | - |
| Total | | 113.7 | | 2,680 | |
| SECOND STAGE | | | | | |
| 12.Genova | -Pijao | 27.0 | 9.0 | 810 | 713 |
| 13.Pijao | -Cordoba | 15.5 | 9.0 | 470 | 497 |
| 14.Cordoba | -Calarca | 27.0 | 9.0 | 810 | 1,220 |
| 15.Filandia | -Quimbaya | 17.0 | 9.0 | 390 | 797 |
| 16.Quimbaya | -Sanfelipe | 6.0 | 12.0 | 230 | 2,266 |
| 17.Puerto Tapao | -La Tebaida | 8.5 | 9.0 | 200 | 1,944 |
| 18.San Jose | -San Pablo | 4.0 | 9.0 | 90 | 676 |
| 19.La Suiza | -La Maria | 11.5 | 9.0 | 270 | 242 |
| 20.Baraja | -Puerto Samaria | 15.0 | 9.0 | 350 | 242 |
| 21.Quimbaya | -Puerto Alejandoria | 13.0 | 9.0 | 300 | 242 |
| Total | | 144.5 | | 3,920 | |
| THIRD STAGE | | | | | |
| 22.Salento | -Sierra | 24.9 | 9.0 | 750 | 136 |
| 23.La Montana | -El Cuzco | 21.2 | 9.0 | 780 | - |
| 24.El Cuzco | -Urania | 5.5 | 9.0 | 170 | - |
| 25.Urania | -Pescador | 15.8 | 9.0 | 570 | - |
| 26.Pijao | -Las Maravillas | 26.0 | 5.0 | 65 | - |
| 27.Pijao | -El Diamante | 22.0 | 5.0 | 70 | - |
| 28.Genova | -Costa Rica | 24.0 | 5.0 | 91 | - |
| 29.Genova | -Pedegales | 24.0 | 5.0 | 108 | - |
| Total | | 163.4 | | 2,604 | |

Source : Plan Vial Quindio 1983(Gobernacion del Quindio)
Note : Traffic volume is vehicles/day

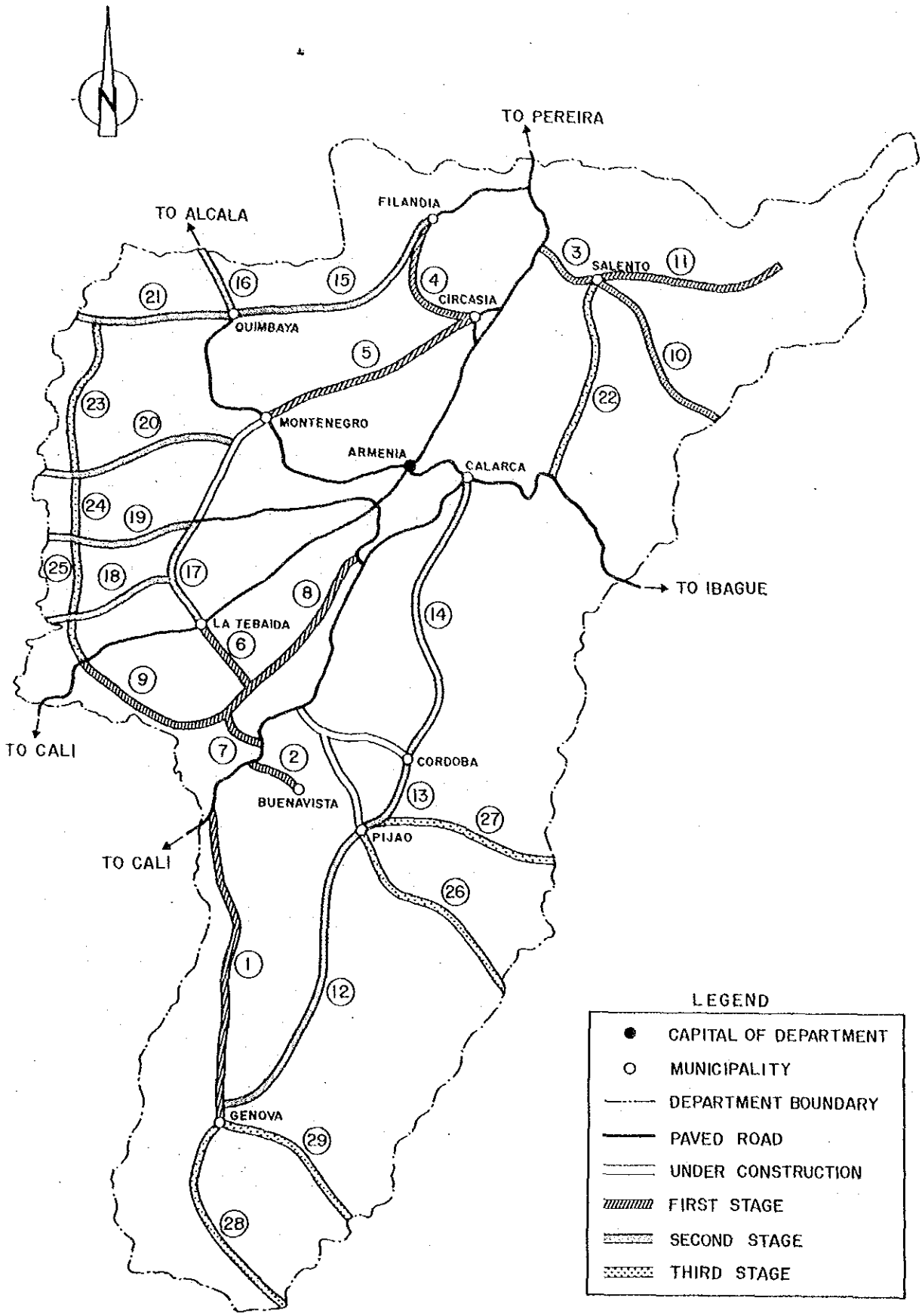
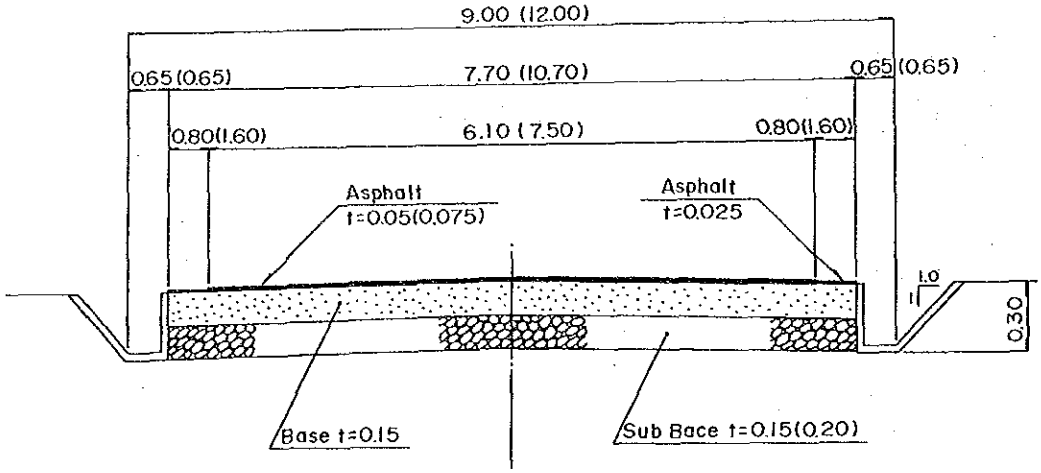



FIG.L.3.1 RURAL ROAD IMPROVEMENT PLAN




SECTION OF ROAD

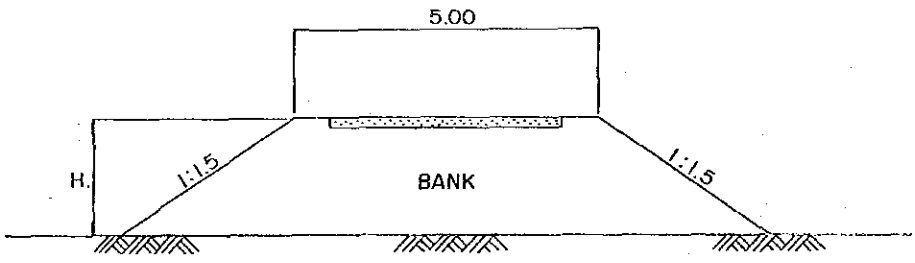



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FIG.L.3.2. SECTION OF ROAD

## L.3.2 Mini-Hydroelectric Power Station Plan

### (1) Basic Concept

Most electric power consumed in the Quindio is supplied from other Departments, and with consideration to stable electric power supply, it would be necessary to contemplate the rehabilitation of the existing old power stations as well as the construction of new power stations in the Quindio. Based on the analysis results of hydrology and with consideration to the current rehabilitation plan, the most effective development of electric power stations should be projected.

### (2) Development Strategy

The development of mini-hydroelectric power stations will be projected, based on the following considerations:

- According to the Scope of Work, new power stations, which are not covered by the regional development plan, are not included.
- Mainly, the rehabilitation of the existing old power stations will be projected except La Union Station which is currently in operation.
- The possibility of new power stations will be studied together with dam construction project for a irrigation plan or a the land conservation plan.
- A high priority will be given to the power stations having a head race which is part of the integrated water supply system.
- A priority will be given to the capacities of power stations.

### (3) Preliminary Layout of Improvement Plan

Based on the development strategy, The preliminary layout of the improvement plan was drawn as shown in Fig.L.3.2 and the summary of the layout is shown in Table L.3.2.

55 million kwh/year of electric power supply can be estimated by the improvement of the power stations.

### (4) Selection of Project

Considering the existing conditions of electric power supply in the Quindio, all projects proposed the Mini-Hydroelectric Power Program are required. However, when priority is given to these projects, the efficiencies of the stations should be considered. Therefore, based on the unit production cost of electric power, the following projects should be selected.

El Bosque Station : Replacement of the existing generator and turbine with new one.

Canpestre Station : Improvement of the headrace. Replacement of the existing penstock, turbine, generator and transformer with new one.

Bayona Station : Improvement of the headrace. Replacement of the existing penstock, turbine, generator and transformer With new one.

40 million kwh/year of electric power supply can be estimated by the rehabilitation of the power stations.

L.3.3 Rural Water Supply Plan

(1) Basic Concept

With consideration to the improvement of rural living environment, it would be necessary to improve the rural water supply system. However, it is impossible to provide a perfect supply system covering the whole area of the Quindio in a short time, as well as the cost of construction of facilities must be considered, therefore, considering the existing condition of the rural water supply in the Quindio, the improvement of the rural water supply system covering those areas which are facing serious problems at present should be projected first.

(2) Development Strategy

The improvement of the rural water supply system will be projected, based on the following considerations;

- The improvement of the rural water supply system covering the Southwestern part of Circasia suffering a water shortage will be contemplated.
- The improvement of the rural water supply system covering the Western part of Armenia suffering a poor water quality will be contemplated.
- The improvement of the rural water supply system will be projected not only for domestic water supply but also for providing irrigation water, coffee treatment water, livestock water, etc.
- Depending on the volume of total water demand, water source system facilities will be selected from among diversion system, pumping-up system, or well system.

(3) Selection of Project

Based on the development strategy, the improvement of the rural water supply project will be selected as follows;

- Southwestern Circasia : Construction of water source facilities and headrace. Establishment of water supply network system.
- Western Armenia : Improvement of water source facilities. Construction of water treatment facilities.

Considering to water demand of domestic and livestock use, following criteria is applied for the design water requirement.

Domestic use : 150 letter/day/parson

Livestock use : Cattle (dairy) 125 letter/day/head
Cattle (beef ) 42 letter/day/head
Swine 12 letter/day/head
Poultry 2 letter/day/head

The preliminary improvement plan of rural water supply are summarized as follows;

| | Southwestern Circasia | Western Armenia |
|---|---|---|
| Intake Discharge | 190 m3/day (2.2 l/s) | 230 m3/day (2.7 l/s) |
| Water Source Facilities | Roble River Diversion Works Driving Canal (5km) | Ground Water Well(Depth 100m) Driving Canal (5km) |
| Construction Cost | 20 million Col$ | 26 million Col$ |

Table L.3.2 Summary of Mini-Hydroelectric Power Station Plan (1)

| Station | Canpestre (Rehabilitation) | Bayona (Rihabilitation) | El Bosque (Rehabilitation) |
|---|---|---|---|
| Maximum Water Discharge | 2.4 m3/s | 4.6 m3/s | 3.8 m3/s |
| Effective Head | 60 m | 35 m | 80 m |
| Capacity KWH | 1,200 | 1,350 | 2,550 |
| Annual Electric Product | 10 million KWH | 11 million KWH | 21 million KWH |
| Construction Cost | 340 million Col$ (32.4 Col$/KWH) | 470 million Col$ (39.7 Col$/KWH) | 460 million Col$ (20.5 Col$/KWH) |
| Production Cost | 4.86 Col$/KWH | 5.96 Col$/KWH | 3.08 Col$/KWH |
| Summary of Project | Improvement of the headrace. Replacement of the existing penstock, turbine, generator and transformer with new one. | Improvement of the headrace. Replacement of the existing penstock, turbine, generator and transformer with new one. | Replacement of the existing generator and turbine with new one. |

Table L.3.2 Summary of Mini-Hydroelectric Power Station Plan (2)

| Station | Montenegro (Rehabilitation) | Pijao (Rehabilitation) |
|---|---|---|
| Maximum Water Discharge | 0.7 m3/s | 0.7 m3/s |
| Effective Head | 50 m | 56 m |
| Capacity KWH | 250 | 300 |
| Annual Electric Product | 2 million KWH | 3 million KWH |
| Construction Cost | 220 million Col$ (100.5 Col$/KWH) | 310 million Col$ (118.0 Col$/KWH) |
| Production Cost | 15.08 Col$/KWH | 17.70 Col$/KWH |
| Summary of Project | Improvement of the headrace and the diversion works. Construction of the headtunk and shed. Replacement of the existing penstock, turbine, generator and transformer with new one. | Improvement of the all facilities. Replacement of the all existing instrument. |

Table L.3.2 Summary of Mini-Hydroelectric Power Station Plan (3)

| Station | Navaruco (New Construction) | Genoba (New Construction) |
|---|---|---|
| Maximum Water Discharge | 3.5 m3/s | 0.4 m3/s |
| Effective Head | 40 m | 40 m |
| Capacity KWH | 1,000 | 120 |
| Annual Electric Product | 8 million KWH | 1 million KWH |
| Construction Cost | 480 million Col$ (60.0 Col$/KWH) | 400 million Col$ (380.5 Col$/KWH) |
| Production Cost | 9.00 Col$/KWH | 57.08 Col$/KWH |
| Summary of Project | Construction and installation of all facilities. | Construction and installation of all facilities. |

Table L.3.3 Summary of Rural Water Supply Plan

| Project Area | Southwestern Circasia | Western Armenia |
|---|---|---|
| Supply Area | 10 km2 | 10 km2 |
| Population | 730 parson | 720 parson |
| Cattle (daily) | 350 head | 180 head |
| Cattle (beef ) | 120 head | 130 head |
| Swine | 140 head | 140 head |
| Poultry | 5,700 head | 5,700 head |
| Daily Mean Water Requirement | 170 m3/day | 150 m3/day |
| Daily Maximum Water Requirement | 220 m3/day | 190 m3/day |
| Gross Water Requirement | 270 m3/day (3.1 l/s) | 230 m3/day (2.7 l/s) |
| Existing Condition of Water Supply | 0.9 l/s | --- |
| Insufficiency of Water Supply | 2.2 l/s | 2.7 l/s |
| Proposed Water Source | Roble River | Ground Water |
| Facilities | Diversion Work | Well (H=100m) |
| Driving Canal | Pipeline 5 km | Pipeline 5 km |
| Construction Cost | 20 million Col$ | 26 million Col$ |

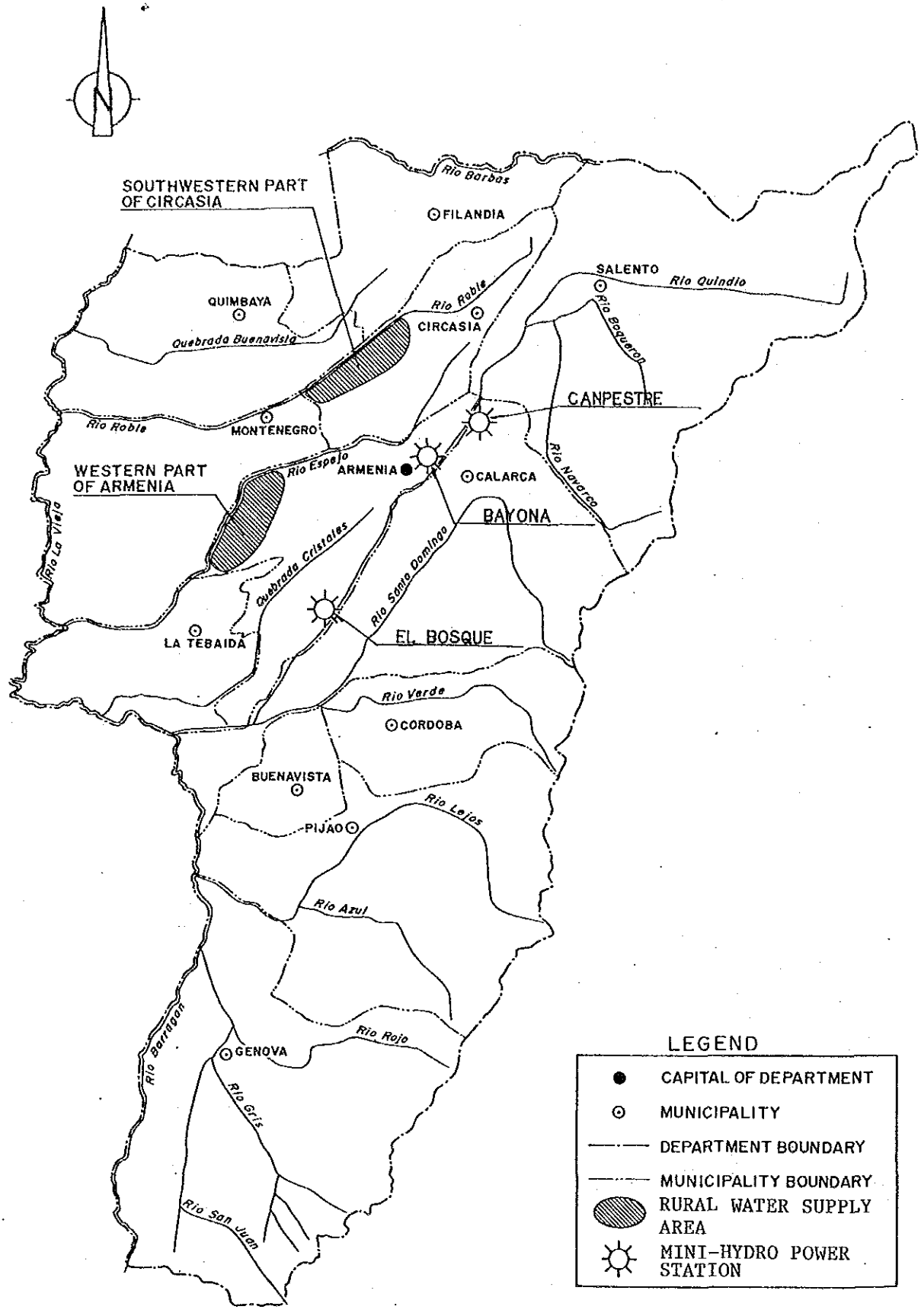


FIG.L.3.3. MINI-HYDROELACTRIC POWER STATION AND RURAL WATER SUPPLY PLAN