ANNEX M : WATER RESOURCES

Annex M : Water Resources

Table of Contents

List of Tables

List of Figures

Annex M : WATER RESOURCES

M.1 Introduction

M.1.1 General

For the establishment of water resources development plan, it is necessary to make a water use plan based on the existing conditions and future forecast of water supply and demand. Further more, the water use plan should be studied with the consideration to the purpose of water use classified into the two categories for urban area and rural area.

On the other hand, the water resources development is restricted by the meteorological and topographical conditions and a water use plan should consider these conditions. Therefore, from the viewpoint of effective water use, it is necessary to make a water use plan in consideration of the balance between water supply and demand.

From the viewpoint of water resources, the Department of Quindio may be divided into two(2) zones (eastern part with 1365.9km2 of catchment area and western part with 580.8km2) at the divide of the right bank of the Quindio River. Comparing with the eastern part where the water resources can be expected in mountain areas, water resources development may be more difficult in the western part because of small catchment area.

2,000mm of the annual rainfall can be expected in the Quindio, and approximately 50% of it flows out as surface water. Therefore, it can be said that there is a big potential of water resources in the Quindio. However, the same rainfall cannot always be expected and, in the dry seasons (January, February and July, August), a water shortage occurs sometimes at some areas, giving rise to a problem.

Water shortage is no serious social problem under the existing condition, and, there is no public recognition that water resources development should be one of the high priority subjects for the Quindio. However, considering increases in population and factories, improvement of agriculture using on irrigation system, etc, it is expected that water demand will increase. Therefore, water resources development should be one of the important subjects for the development of the Quindio.

M.1.2 Objective of the Study

The objective of this study is to infer the future water use based on the existing condition and to estimate the possible volume of water which can be obtained by new water resources development. The required dam volume concerning the proposed project is also studied in this section.

M.2 Potential of Water Resources

M.2.1 The Characteristic of The Water Resources in The Department of Quindio

All the rivers in the Department of Quindio belong to the La Vieja River System. From the viewpoint of water resources, the Quindio may be divided into 2 zones(eastern part with 1365.9km2 of catchment area and western part with 580.8km2) with the divide at the right bank of the Quindio River.

The characteristic of the eastern part is such that the source of all main rivers in the Central Range of the Andes, at over 2,000m of altitude, with 1,500-1,800mm of annual rainfall and approximately 800km2 of watershed which is 40% of the total area of the Quindio.

The characteristic of the western part is such that the source of the main river is in this area, at under 2,000m of altitude, with 2,600-2,900mm of annual rainfall and approximately 200km2 of watershed.

The gravitational diversion system is used mainly for the existing water supply system, but also the systems of pumping up water from rivers or wells used in the western part are compartively more in number than in the eastern part where water resources can be expected in mountain areas.

Otherwise 2,000 mm of annual rainfall is expectant in the Quindio, and 50% of it flows out as surface water. Therefore, there is a large potential of water resources in the Quindio.

M.2.2 Surface water

2,150 million m3/year (1.10 million m3/km2/year) of total annual runoff is estimated in the Quindio, and 1,490 million m3/year (1.09 million m3/km2/year) of the runoff is from the eastern part and 660 million m3/year (1.13 million m3/km2/year) from the western part. 0.90 million m3/km2/year of the average total annual runoff is estimated in the source area of the eastern part and 1.30 million m3/km2/year in the source area of the western part.

Considering the seasonal pattern of runoff, it quite low in the three months of July, August, September; 11% of total annual runoff is in the easter part and 15% in the western part. Due to this, there are limitations in the development of water resources by only using diversion system. However, if water reservoirs could be provided, it would be possible to supply much more water in the dry season. For example, to get 1 m3/s of new water supply at the point having 200km2 of watershed in the eastern part, it would be necessary to construct a water reservoir with 5 million m3 at any point at this watershed.

M.2.3 Groundwater

From the results of rough calculation, the groundwater is replenished with 5.0-10.0 million m3/100km2 (150-300 l/s/100km) of infiltrative water, however, it would be necessary to investigate in more detail, the groundwater so that it will be one of the water resources. The existing groundwater is used in the western part for rural water supply. The groundwater could be available for water supply in the case of small areas with small demand.

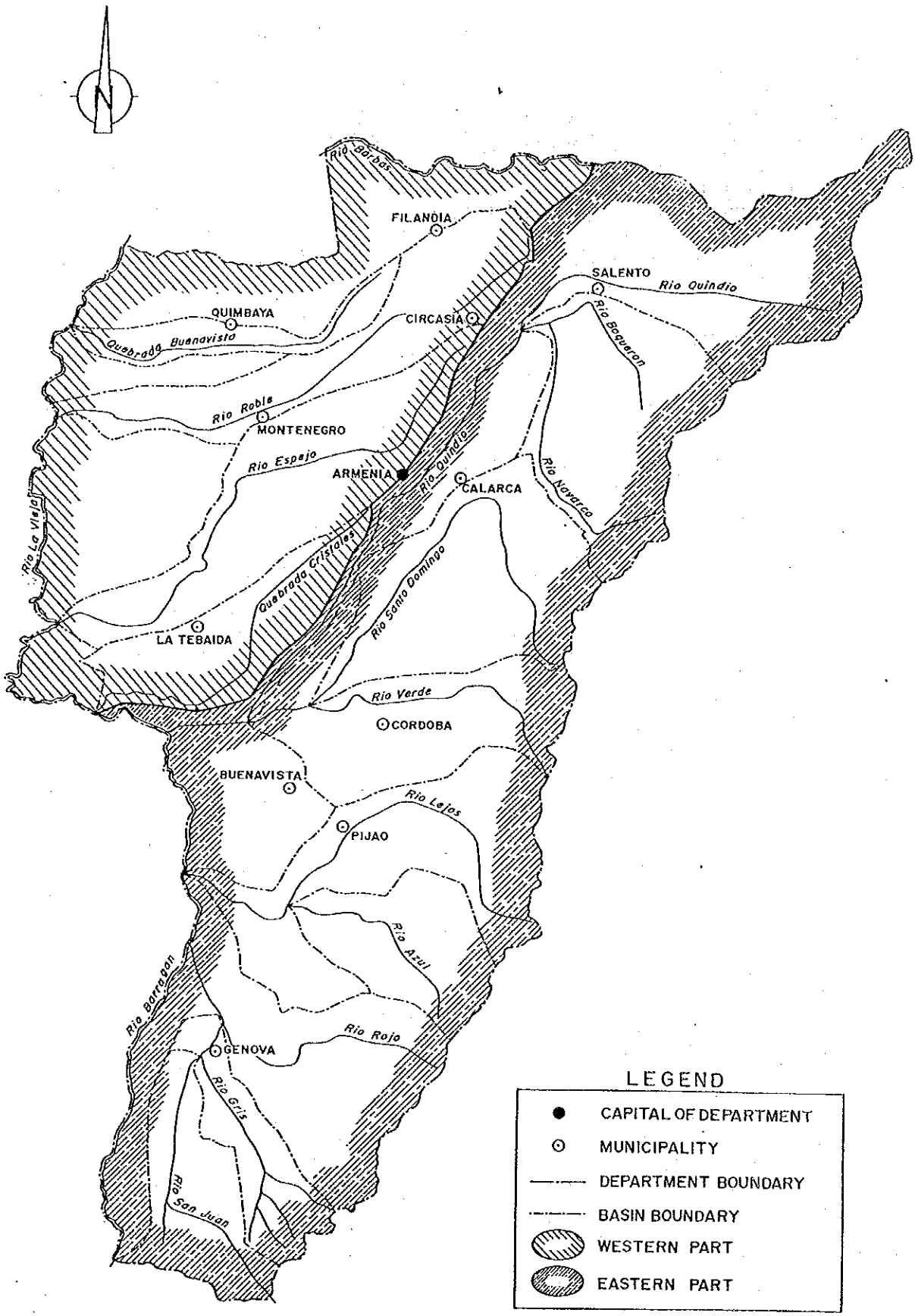


FIG.M.2.1 THE CATCHMENT BASIN OF THE QUINDIO

M.3 Water Use in The Department of Quindio

M.3.1 Existing Condition and Future Forecast of Water Use

Due to the lack of quantitative data on water use, the existing condition of water use is estimated only by using the information on the existing water supply facilities and the criteria of water supply plan in Colombia. (Information on the water supply facilities are described in Annex L)

(1) Urban Areas

There is no information available about the problem of water shortage in the urban area. However, considering the relation between the current population and the capacity of water supply system, it can be assumed that the existing water supply facilities in the urban areas of Calarca, Quimbaya and Montenegro have been used up to the their limitations (See Table M.3.1).

Considering the forecast of future population, it is estimated that the existing capacities of water supply system in the urban areas of Calarca and Quimbaya will come short for future water demand, and, in Montenegro, water shortage could be one of the serious problems during dry season. And, depending on the water quality in the Q.Cristales, the urban area in La Tebaida will suffer a similar problem (See Table M.3.2).

(2) Rural Areas

Currently, the existing small pumping systems have been used by farmers for getting water from the wells or rivers. However, the existing conditions of how water is used in the rural areas are not clearly known.

According to a hearing investigation, the south-western part of Circacia suffers a serious water shortage problem during dry season and the western part of Armenia is facing a water quality problem of the Espejo River. Social need for the solution of these problems is high.

(3) Hidroelectricity

One (1) electric power plants (La Union) has been in operation in the Quindio, and there is no problem of water shortage under the existing condition.

According to the rehabilitation plan of the El Bosque Plant, from 3.8 to 4.7 m3/s of the intake water from the Quindio River is expected, but these values are almost the same as the low water discharge at the existing diversion weir sight on the Quindio River in the dry period. From the viewpoint of effective use of these electric generation facilities, water resources development

would be required in the upper part of the Quindio River System.

(4) Irrigation Water

Currently, few farmers have irrigation system in the Quindio and their farms are irrigated in the dry season when they have no rainfall for one or two weeks. In fact, in the Quindio, no irrigation system is required all the year round under the existing agricultural management system. However, approximately twenty(20) continuous drought days on the average are observed and the farmers who have irrigation system have recognized the benefit of irrigation system.

Currently, almost no irrigation water is required. However, the intensive agriculture with irrigation system will prevail in the future.

M.3.2 River Water Intake System

Currently, based on the water volume permitted by CRQ, river water can be used by user. In the case of making the new application for the water use, the permission will be given by CRQ with the limitation which 50% of the river discharge.

There is no precedent for the case of using a Dam during the droughty season. Considering the examples of other Departments, 50% of the droughty discharge in the average year is applied as the river maintaining flow. Therefore, when the dam is used, the river water except the volume of water to maintain its stream is allowed to use.

Table M.3.1 Current Water Consumption in Urban Areas

Urban Area	Population in 1985 (man)	Unit Water Requirment (l/day /man)	Current Water Requirement (l/s)	Current Water Supply (l/s)	Difference (l/s)
Armenia	180,206	300	626	694	+68
Circacia	10,941	200	25	24	-1
Calarca	37,678	300	131	120	-11
Buenavista	1,133	150	2	8	6
Cordoba	2,300	150	4	12	8
Filandia	3,918	150	7	20	13
Genova	4,922	150	9	30	21
La Tebaida	15,913	200	37	45	8
Moneteregro	21,937	300	76	75	-1
Pijao	4,160	150	7	80	73
Quimbaya	20,262	300	70	70	—
Salento	2,507	150	4	8	4

Table M.3.2 Forecast of Future Water Demand in Urban Areas

Urban Area	Population in 2005 (man)	Unit Water Requirment (l/day /man)	Future Water Requirement (l/s)	Capacity of Facility (l/s)	Difference (l/s)
Armenia	251,857	300	874	1,398	521
Circacia	14,194	200	33	106	73
Calarca	50,398	300	175	170	-5
Buenavista	1,148	150	2	15	13
Cordoba	2,790	150	5	15	10
Filandia	3,226	150	6	25	19
Genova	5,491	200	13	40	27
La Tebaida	20,941	300	73	95	22
Moneteregro	29,091	300	101	110	9
Pijao	1,165	150	2	90	89
Quimbaya	27,817	300	97	90	-7
Salento	2,797	150	5	15	10

Note : Calculation is based on following criteria;

Population (man)	Unit Water Requirement
Under 5,000	150 l/day/man
5,000 ~ 20,000	200 l/day/man
Over 20,000	300 l/day/man

M.4 Development of Water Resources

M.4.1 Basic Concept

Based on water demand, water resources development should be considered for the areas having a water shortage problem. Considering the characteristics of the Quindio, the sufficient volume of water is available from rivers. Therefore, water resources development with the purpose of water supply during the dry period should be considered.

Depending on the existing topographic conditions and current water demand, the following alternatives could be considered:

a) Dam for several purpose
b) Small reservoir for small area
c) Pumping system

M.4.2 Preliminary Layout of Water Resources Development Plan

Based the basic concept, the preliminary layout of the water resources development plan for the new water demand of under the proposed project was studied and an optimum water sources plan is suggested as shown in Table M.4.1. For the example of the study, the plan of water resources for the Lower Quindio River Integrated Agricultural Development Project will be described in the subsequent section.

M.4.3 Water Source Plan for The Lower Quindio River Integrated Agricultural Development Project

(1) General

The water source plan was studied in the following manner;

a) Estimation of water demand
b) Alternative study of a main water supply system
c) Analysis of water balance
d) Study of facilities

The mean monthly data of the average pattern for the 2,5,10 and 20 year return period was used. Therefore, the study was not so accurate, however, it is sufficient for preliminary design and prefeasibility study.

(2) Estimation of Water Demand

The water demand for this project can be classified into three categories as follows;

- water for mini-hydroelectricity
- water for domestic and other use at La Tebaida

Table M.4.1 Water Source Plan for Project Area

Project Area			Water Source	Suggested System	Peak Water Requirement
Area A	Left Margin of The Lower Quindio River	1,500 ha	Baragan River	Pumping Station	0.71 m3/s
Area B	Right Margin of The Lower Quindio River	500 ha	Quindio River	Diversion (El Bosque)	0.26 m3/s
Area C	La Tebaida (I)	2,000 ha	Quindio River	Diversion (El Bosque)	1.06 m3/s
Area D	San Jose	3,400 ha	Espejo River	Pumping Station	1.78 m3/s
Area E	La Tebaida (II)	2,500 ha	Quindio River	Diversion (El Bosque)	1.24 m3/s
Area F	Circasia	1,600 ha	Small Stream	Pumping (Portable)	0.50 m3/s
Area G	Genova	200 ha	Small Stream	Pumping (Portable)	0.07 m3/s
Area H	Pijao	200 ha	Small Stream	Pumping (Portable)	0.07 m3/s
Area I	Cordoba Model Farm	30 ha	Small Stream	Pumping (Portable)	0.02 m3/s

- water for irrigation of Area A,B,C, and E

Based on the improvement plan of the mini-hydroelectric power station (El Bosque), the water requirement for mini-hydroelectricity can be estimated as 3.8m3/s which is constant (See Annex L).

Considering the forecast of future water use as shown in Table M.3.2, approximately 0.05m3/s of water requirement for the domestic use may be applied. And this water requirement is constant, and same as for the mini-hydroelectricity.

Irrigation water requirement was estimated for design droughty year of 2,5,10 and 20 year return period in Annex J. Considering the effective rainfall and the cropping pattern, the mean monthly irrigation water requirement for project area is applied.

These water requirements are shown in Table M.4.2.

(3) Alternative Study of Main Water Supply System

There is an old diversion weir at EL Bosque in the Quindio River and this facility can be used with the rehabilitation works for the main water supply system. The expected water head is at the altitude of approximately 1,380m and all water requirements can be supplied with a gravity system. However, considering the existing topographic condition, two alternatives as shown in Fig.M.4.1 should be studied.

The differences between these two systems is in the water source facility for the project area A; the pumping station in the Barragan River is proposed for System I and the aqueduct is proposed for System II. As other conditions can be expected almost same, only the construction and maintenance cost of the pumping station and the aqueduct is compared for the selection of the system.

The comparison of these cost estimations is shown in Table M.4.3, and System I should be selected with consideration to these results.

(4) Analysis of Water Balance

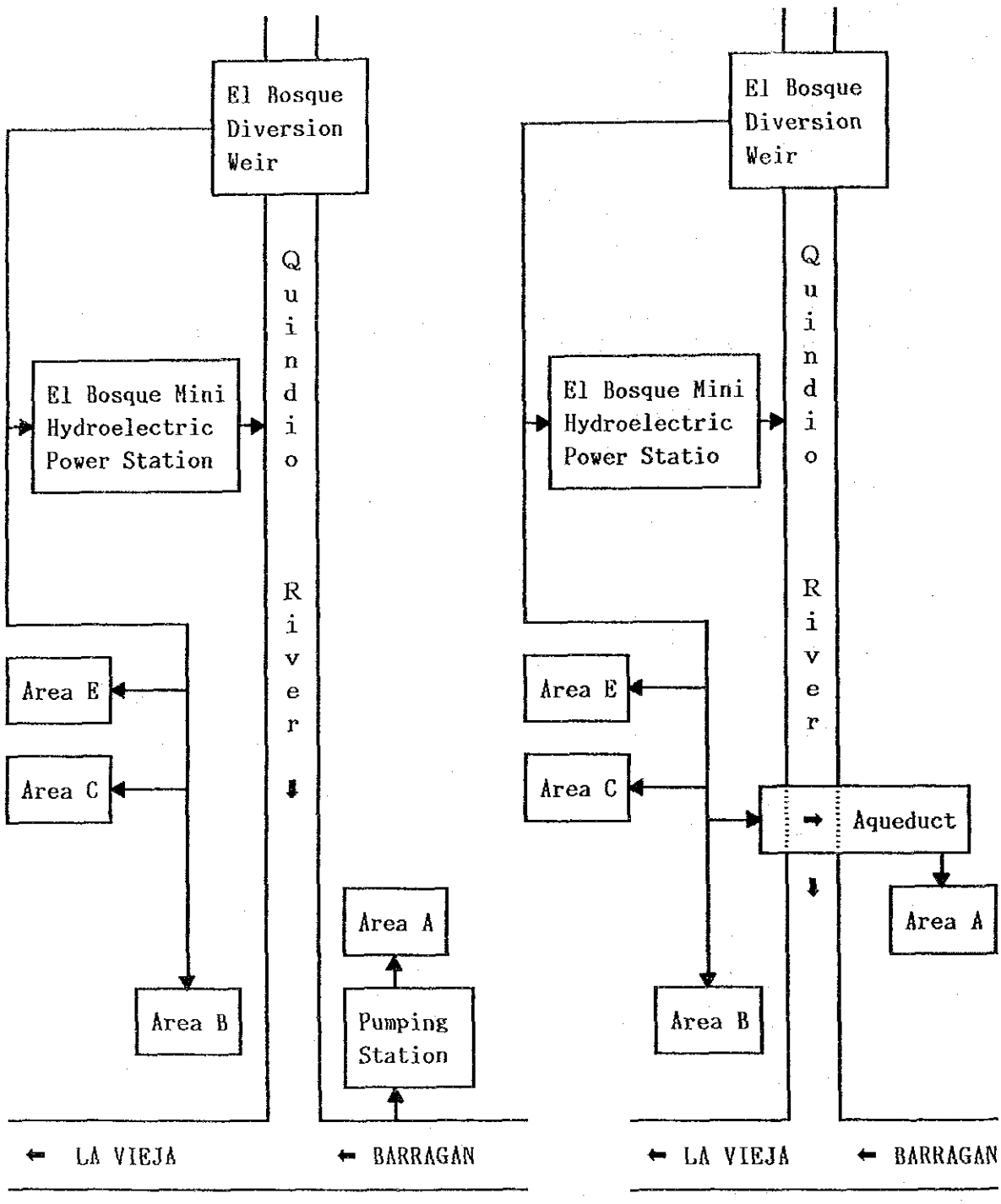
Considering the results of hydrological analysis, water balance was analyzed for following subjects.

- water balance at the diversion weir site (El Bosque)
- checking the water discharge at the pumping station site (for Area A)
- checking the annual runoff at the proposed dam site

Table M.4.2 Summary of Water Requirement (m3/s)

ITEM	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
MINI-HYDROELECTRICITY	4.222	4.222	4.222	4.222	4.222	4.222	4.222	4.222	4.222	4.222	4.222	4.222
DOMESTIC FOR LA TEBAIDA	.056	.056	.056	.056	.056	.056	.056	.056	.056	.056	.056	.056
RETURN PERIOD 1/2	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
IRRIGATION AREA A	.147	.064	.068	.011	.015	.150	.490	.353	.062	---	---	.030
IRRIGATION AREA B	.056	.001	---	---	---	.028	.170	.125	.019	---	---	.004
IRRIGATION AREA C	.080	.056	---	---	---	.015	.218	.046	.007	---	---	.004
IRRIGATION AREA E	.078	.074	---	---	---	---	.313	.040	---	---	---	---
RETURN PERIOD 1/5	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
IRRIGATION AREA A	.206	.111	.076	.013	.015	.235	.562	.432	.107	---	---	.045
IRRIGATION AREA B	.075	.024	---	---	---	.056	.194	.151	.040	---	---	.011
IRRIGATION AREA C	.178	.160	.022	---	---	.112	.323	.118	.019	---	---	.031
IRRIGATION AREA E	.214	.249	.041	---	---	.136	.467	.159	---	---	---	---
RETURN PERIOD 1/10	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
IRRIGATION AREA A	.242	.147	.082	.013	.023	.278	.596	.474	.132	---	---	.067
IRRIGATION AREA B	.087	.036	---	---	---	.070	.206	.165	.051	---	---	.022
IRRIGATION AREA C	.240	.213	.055	---	0.000	.177	.378	.156	.049	---	---	.051
IRRIGATION AREA E	.296	.336	.101	---	---	.221	.545	.223	.046	---	---	.001
RETURN PERIOD 1/20	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
IRRIGATION AREA A	.278	.182	.095	.014	.024	.313	.623	.507	.159	---	---	.087
IRRIGATION AREA B	.099	.048	---	---	---	.082	.215	.176	.060	---	---	.031
IRRIGATION AREA C	.291	.256	.083	---	.001	.231	.420	.195	.082	---	---	.097
IRRIGATION AREA E	.362	.409	.153	---	---	.288	.606	.288	.103	---	---	.055

NOTE : Conveyance Efficiency is applied as 90%
Irrigation Efficiency is applied as 57%
Effective Rainfall is considered for Irrigation Total



System I System II

Fig.M.4.1 Proposed Main Water Supply System

Table M.4.3 Comparison of Construction and Maintenance Cost

Item	System I	System II
Construction Cost	Pumping Station Capacity of pump (3 unit) Discharge Q=0.71 m3/s Pump Head H= 15 m Diameter D= 305 mm Cost of Pumping Station 50 Million Col$ (Including housing and other facilities)	Aqueduct Diameter D=700 mm Length L=400 m Driving Canal Length L=600 m Cost of Construction 70 Million Col$ (Including related structures)
Operation & Maintenance Cost	Project life 40 years Operation & Maintenance Cost 0.25 Col$/year (Including personnel expenses) x 40 years = 10 Million Col$ Replacement of Instruments 2 times for 40 years x 2 times = 30 Million Col$ Sub-Total 40 Million Col$	Project life 40 years Operation & Maintenance Cost 0.25 Col$/year (Including painting expenses) x 40 years = 10 Million Col$ Replacement of Instruments 2 times for 40 years x 2 times = 15 Million Col$ Sub-Total 25 Million Col$
Total Cost	90 Million Col$	95 Million Col$

a) Water Balance at Diversion Weir Site (El Bosque)

Considering the economical system, it would not be necessary to establish a perfect water supply system for all water demand. In the case of the costs of facilities being too high, the water supply plan should be changed. For the establishment of an optimum water supply system, the relation between water discharge and water demand should be understood.

The catchment area at the El Bosque site is Approximately 383km2 and 12.7m3/s of average water discharge can be expected. However, the mean water discharge in August is approximately 4.8m3/s and the droughty water discharge is estimated as 2.7m3/s. Depending on the return period of droughty year, these value of water discharge will decrease.

On the other hand, approximately 4.1m3/s of the mean total water requirement in August in the average year is estimated. The maintenance flow at downstream is not included in this value.

A calculation example of water balance is shown in Table M.4.4 and minus volume of difference in this table is required dam volume. The maintenance flow for downstream is not included in the other water requirement of this table. Therefore, considering the volume of the maintenance flow, the volume of dam may be required more. And, depending on the return period, required dam volume will vary.

The relations between peak water requirement and required dam volume for 2,5,10 and 20 year return period is shown in Fig.M.4.2. For example, in the 5 year return period, when the maintenance flow is assumed to be 50% of mean droughty discharge (1.2m3/s), the peak total water requirement will be approximately 6.2m3/s (including the maintenance flow) and 12 million m3 of dam volume may be required.

b) Checking Water Discharge at Pumping Station Site (for Area A)

Approximately 720km2 of catchment area can be estimated for the proposed pumping station site in the Barragan River and approximately 23.8m3/s of average water discharge can be expected. Considering the droughty year, 2.6m3/s of droughty discharge is estimated for 20 year return period.

On the other hand, approximately 0.7m3/s of the peak water requirement is expected, therefore there is no problem for the water source.

c) Checking Annual Runoff on Proposed Dam Site

From the viewpoint of the water resources, two dam site can be

Table M.4.4 Calculation of Water Balance at Sight El Bosque

RETURN PERIOD 1/2	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
(Q1) IRRIGATION (m3/s)	.214	.131	----	----	----	.043	.701	.211	.026	----	----	.007
(Q2) OTHERS (m3/s)	5.500	5.500	5.500	5.500	5.500	5.500	5.500	5.500	5.500	5.500	5.500	5.500
(Q3) SUB-TOTAL (m3/s)	5.714	5.631	5.500	5.500	5.500	5.543	6.201	5.711	5.526	5.500	5.500	5.507
(Q4) RIVER DISCHARGE(m3/s	13.572	11.689	11.179	14.670	14.788	9.924	6.355	4.158	4.413	10.258	17.299	13.984
(Q5) DIFERENCE Q4-Q3(M/S)	7.858	6.058	5.679	9.170	9.288	4.381	.154	-1.553	-1.113	4.758	11.799	8.477
VOLUME (1000m3)	21047.1	14656.1	15211.5	23769.7	24877.2	11355.8	411.3	-4159.8	-2885.2	12742.5	30581.8	22704.7
PEAK WATER REQUIREME 6.201 m3/s REQUIRED DAM VOLUME= 7044.9 1000m3												
RETURN PERIOD 1/5	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
(Q1) IRRIGATION (m3/s)	.214	.131	----	----	----	.043	.701	.211	.026	----	----	.007
(Q2) OTHERS (m3/s)	5.500	5.500	5.500	5.500	5.500	5.500	5.500	5.500	5.500	5.500	5.500	5.500
(Q3) SUB-TOTAL (m3/s)	5.714	5.631	5.500	5.500	5.500	5.543	6.201	5.711	5.526	5.500	5.500	5.507
(Q4) RIVER DISCHARGE(m3/s	11.939	10.283	9.834	12.905	13.009	8.730	5.590	3.658	3.882	9.023	15.217	12.301
(Q5) DIFERENCE Q4-Q3(M/S)	6.225	4.652	4.334	7.405	7.509	3.187	-.611	-2.053	-1.644	3.523	9.717	6.794
VOLUME (1000m3)	16672.7	11253.2	11608.3	19193.8	20110.9	8260.4	-1636.8	-5499.9	-4261.6	9436.4	25186.1	18197.5
PEAK WATER REQUIREME 6.201 m3/s REQUIRED DAM VOLUME= 11398.4 1000m3												
RETURN PERIOD 1/10	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
(Q1) IRRIGATION (m3/s)	.214	.131	----	----	----	.043	.701	.211	.026	----	----	.007
(Q2) OTHERS (m3/s)	5.500	5.500	5.500	5.500	5.500	5.500	5.500	5.500	5.500	5.500	5.500	5.500
(Q3) SUB-TOTAL (m3/s)	5.714	5.631	5.500	5.500	5.500	5.543	6.201	5.711	5.526	5.500	5.500	5.507
(Q4) RIVER DISCHARGE(m3/s	10.371	8.932	8.543	11.210	11.300	7.583	4.856	3.177	3.372	7.838	13.218	10.685
(Q5) DIFERENCE Q4-Q3(M/S)	4.657	3.301	3.043	5.710	5.800	2.040	-1.345	-2.534	-2.154	2.338	7.718	5.179
VOLUME (1000m3)	12473.2	7986.3	8149.2	14800.9	15535.2	5288.7	-3603.1	-6786.4	-5583.0	6262.6	20006.3	13870.6
PEAK WATER REQUIREME 6.201 m3/s REQUIRED DAM VOLUME= 15972.5 1000m3												
RETURN PERIOD 1/20	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
(Q1) IRRIGATION (m3/s)	.214	.131	----	----	----	.043	.701	.211	.026	----	----	.007
(Q2) OTHERS (m3/s)	5.500	5.500	5.500	5.500	5.500	5.500	5.500	5.500	5.500	5.500	5.500	5.500
(Q3) SUB-TOTAL (m3/s)	5.714	5.631	5.500	5.500	5.500	5.543	6.201	5.711	5.526	5.500	5.500	5.507
(Q4) RIVER DISCHARGE(m3/s	9.244	7.962	7.614	9.992	10.072	6.759	4.328	2.832	3.006	6.986	11.782	9.525
(Q5) DIFERENCE Q4-Q3(M/S)	3.530	2.331	2.114	4.492	4.572	1.216	-1.873	-2.879	-2.520	1.486	6.282	4.018
VOLUME (1000m3)	9454.9	5638.3	5663.0	11643.6	12246.4	3152.8	-5016.3	-7711.1	-6532.7	3981.4	16283.3	10760.7
PEAK WATER REQUIREME 6.201 m3/s REQUIRED DAM VOLUME= 19260.2 1000m3												

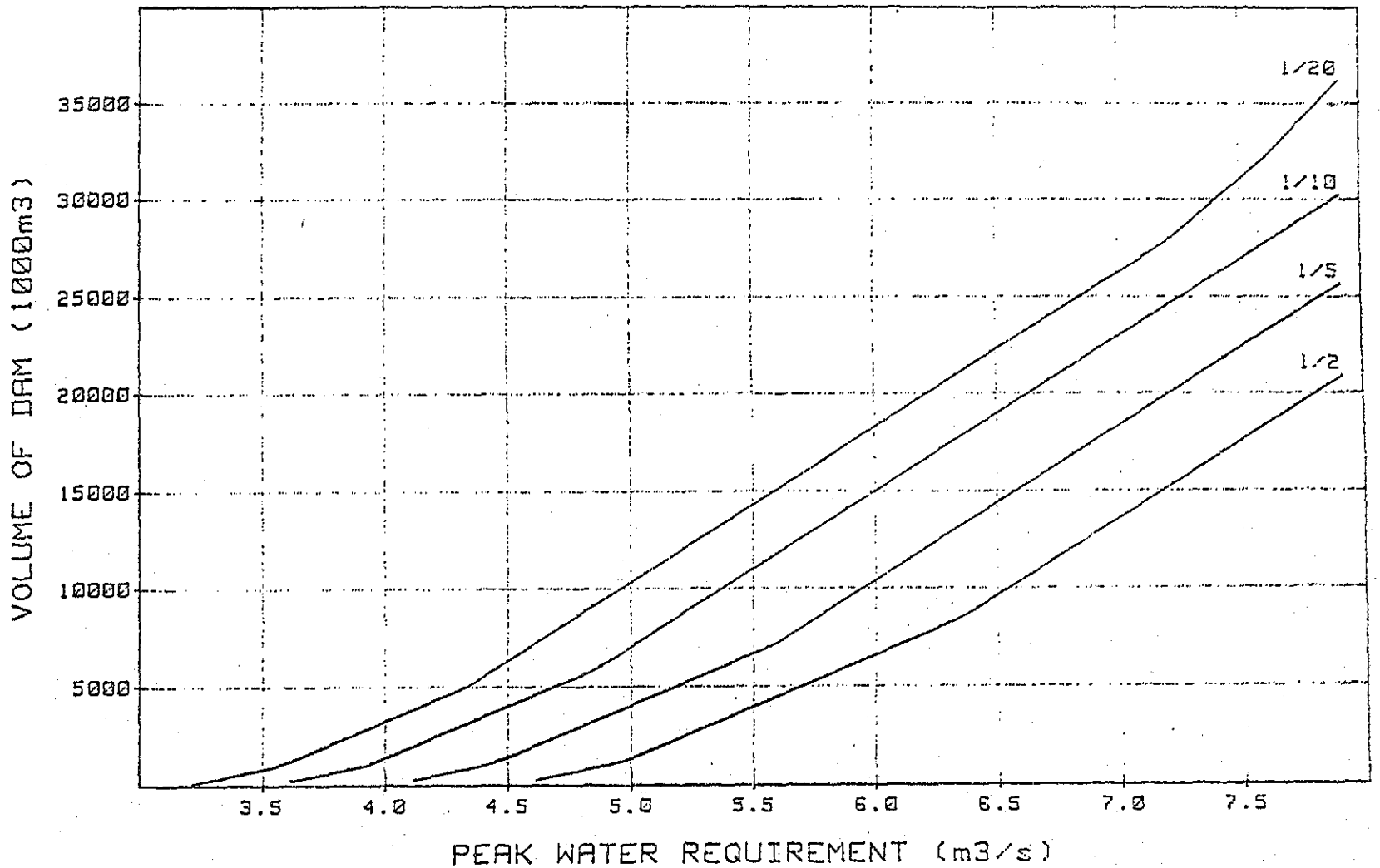


Fig.M.4.2 Required Dam Volume for BOQERON

proposed at the upper stream of the Quindio River System. One is in the Navarco River, which is located at the junction with the Boqueron River. The catchment area of this site is approximately 121 km2. The other is in the Quindio River, which is located approximately 5 km upperstream away from the junction with the Navarco River. The catchment area of this site is 148 km2.

Considering the sizes of the catchment areas, the site in the Quindio River should better be chosen. However, depending on the topographic condition, approximately 500m of dam length in the Quindio River is estimated to provide 15 million m3 of dam capacity and approximately 300m of dam length in the Navarco River for the same capacity. And, comparing the construction cost of the dam in the the Navarco River, more than 1.5 times the construction cost of a dam in the Quindio River is estimated. Therefore the Navarco River site should be selected for the water resources of the project.

Considering the annual rainfall at the catchment areas, approximately 120 million m3 of average annual runoff can be estimated and at least 83 million m3 of annual runoff can be estimated even for the 20 years return period. Therefore, in the case of the required dam capacity being possibly under 50 million m3, there is no water resources problem.

(5) Study of Facilities

Water supply system facilities including diversion works and pumping station are studied in Annex J. The preliminary design of a dam in the Navarco River is studied in this section.

a) Sedimentation Volume

Approximately 1,500 m3/km2/year of sedimentation volume was estimated under the existing condition. However, considering the natural conservation designation project in watershed, the condition of watershed may be improved. Therefore, in this study, 500 m3/km2/year of mean sedimentation volume is assumed for next 50 years and 3 million m3 of sedimentation volume is considered.

b) Preliminary Layout

The preliminary layout an Navarco Dam is shown in Fig.M.4.3. Considering 3 million m3 of sedimentation volume and 1.2m3/s of river maintenance flow at downstream of El Bosque Diversion Weir, the required dam capacity for the return period varies as shown in Fig.M.4.4. Therefore, considering the project benefit and cost, an economical dam capacity should be determined.

c) Study of Economical Dam Capacity

An economical dam capacity is determined with consideration of

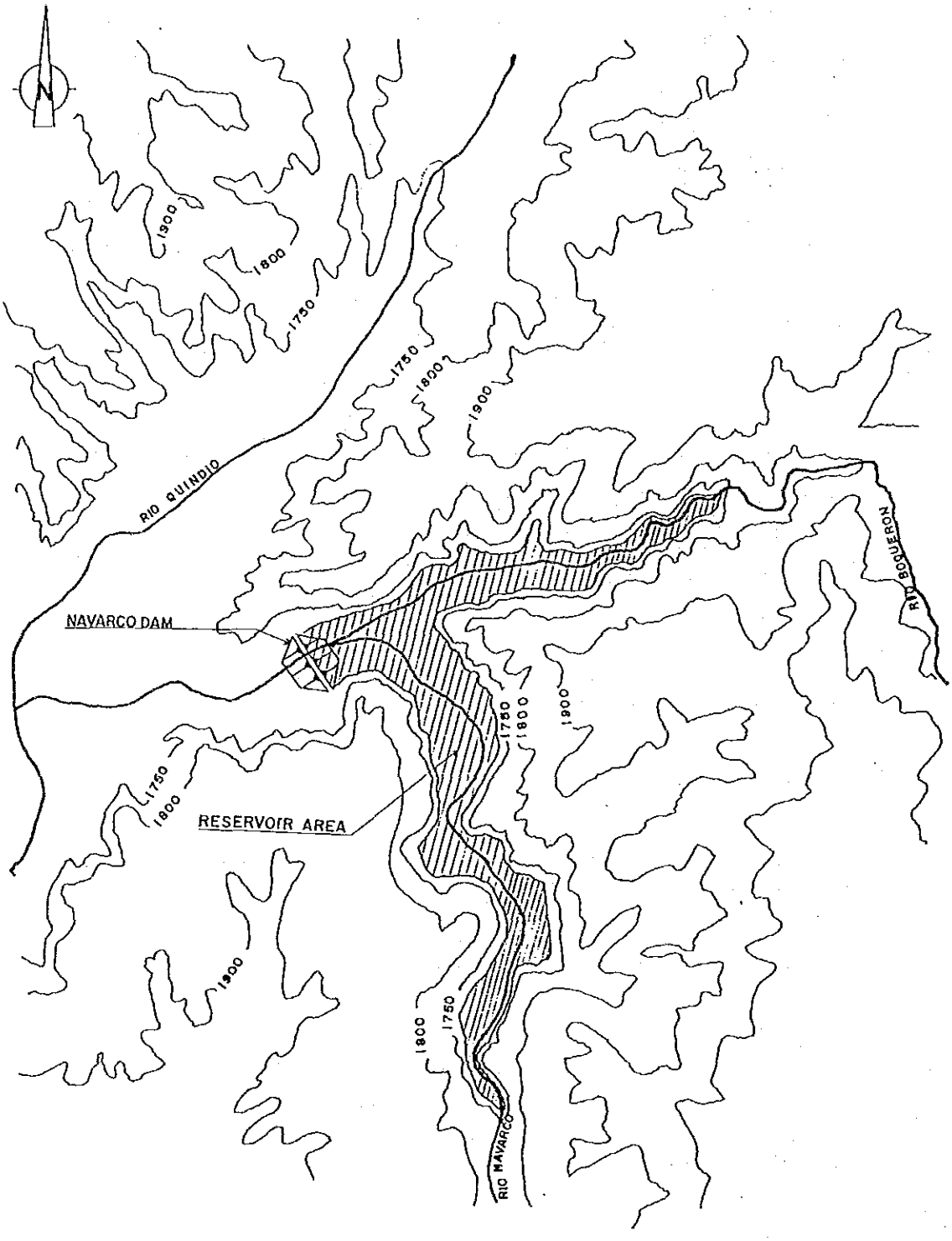
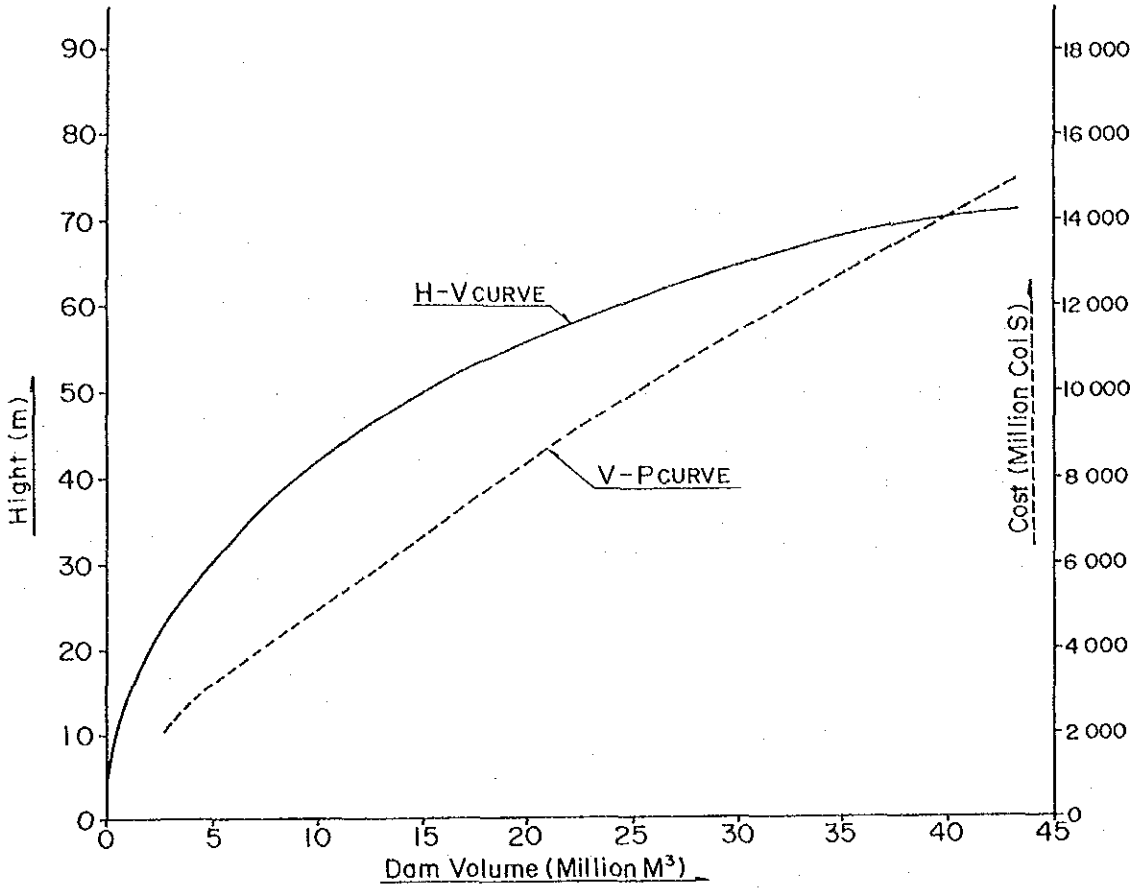
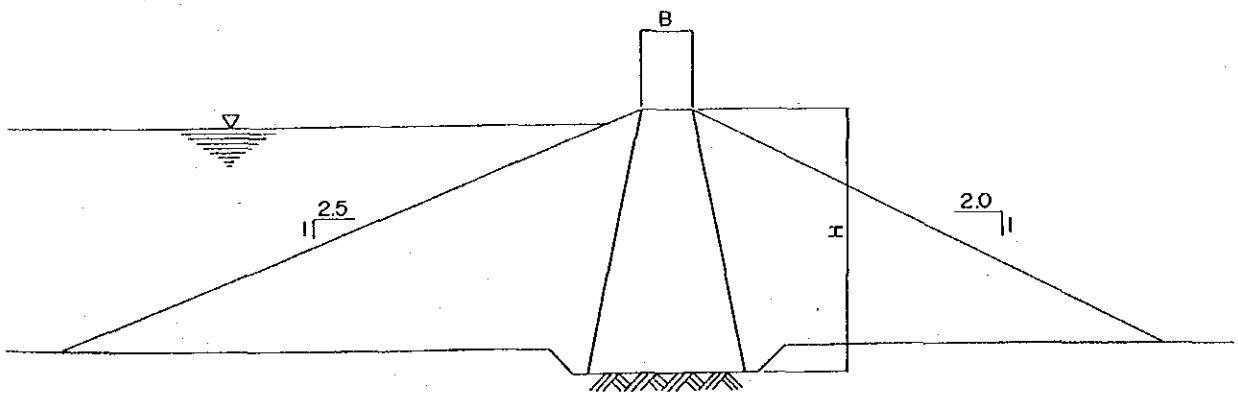


FIG. M.4.3 (1) PRELIMINARY LAYOUT OF DAM



RELATION BETWEEN VOLUME AND HIGHT OF DAM



STANDARD CROSS SECTION

FIG. M.4.3 (2) PRELIMINARY LAYOUT OF DAM

total project benefit and cost.

Based on the construction cost of the dam required for each return period, and adding total construction cost for all facilities of the project Area B,C and E and the operation and maintenance cost for 40 years of these project Areas, the total project cost is estimated. (See Fig.M.4.4)

Considering agricultural and electric product for 40 years, the project benefit is estimated. However, depending on the dam capacity for each return period, the difference in expectation for droughty damage should be considered.

Droughty damage is estimated by the expectation of rate of water shortage and water requirements (rate of insufficiency).

$$Pd=Ws/Wr$$

where Pd : Rate of insufficiency
Ws : Volume of water shortage
Wr : Volume of water requirement

Depending on the dam capacity for each return period, the rate of insufficiency varies as shown in Fig.M.4.5.

The probability(Pn), of which rate of insufficiency(Pd) for an N year return period, can be calculated as Pn=1/N and the expectation of rate of insufficiency can be calculated as follows;

$$Er=Pd*Pn$$

where Er : Expectation of rate of insufficiency

The expectation with the dam capacity meeting each return period is shown in Fig.M.4.6 and the total expectation with the dam volume meeting each return period can be driven from integral calculation of the curves in this figure. The total expectations of rate of insufficiency with the dam volume for each return period is shown in Fig.M.4.7.

The project benefit with dam capacity for each return period is calculated as follows;

$$Bi=B0*(1-Tei)$$

where Bi : Total project benefit with the dam volume for each return period
B0 : Project benefit without droughty damage
Tei: Total expectation of rate of insufficiency with dam capacity for each return period

The relations between the total project benefit and cost with dam

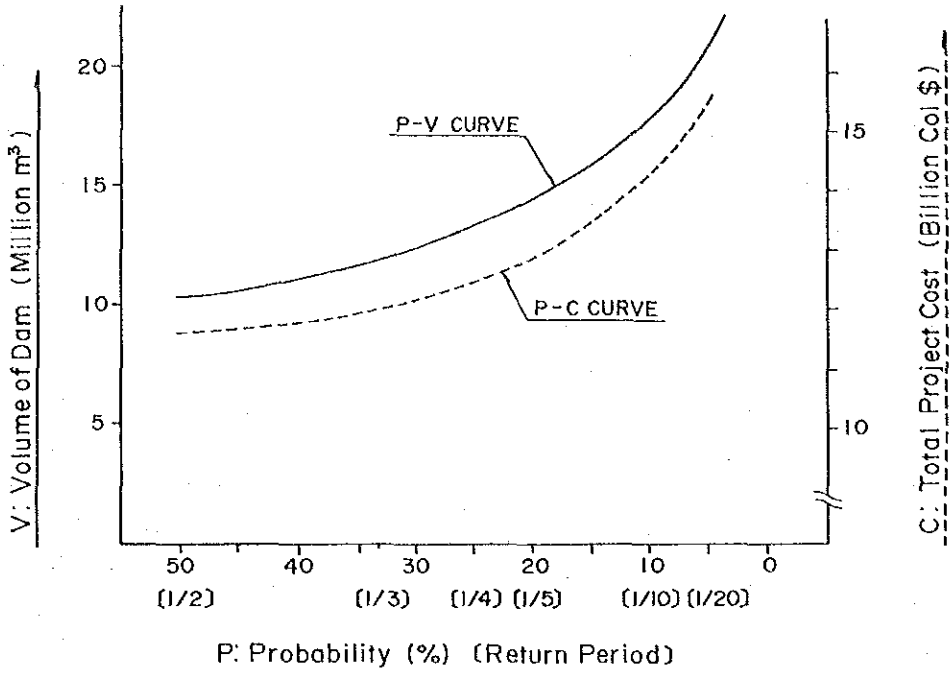


FIG. M.4.4 DAM VOLUME AND TOTAL PROJECT COST

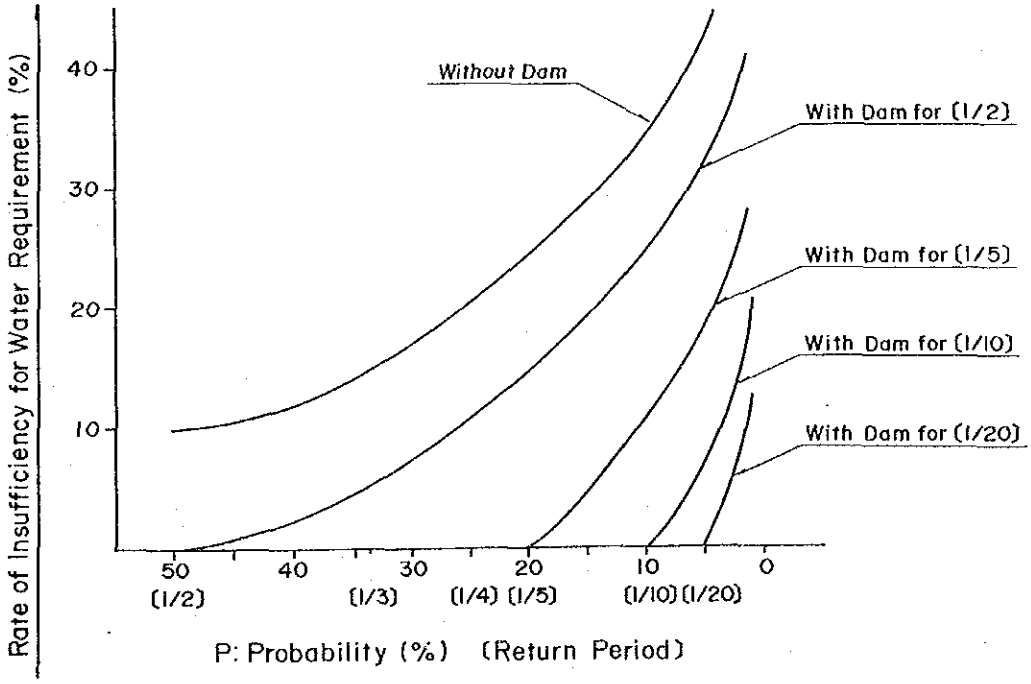


FIG. M.4.5 RATE OF INSUFFICIENCY FOR WATER REQUIREMENT

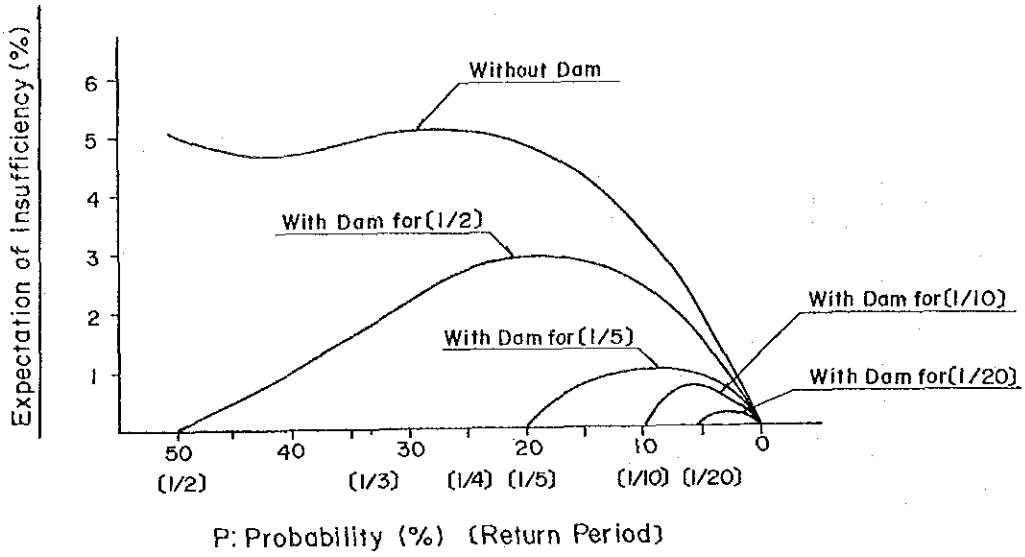


FIG. M.4.6 EXPECTACIONAL DISTRIBUTION OF INSUFFICIENCY

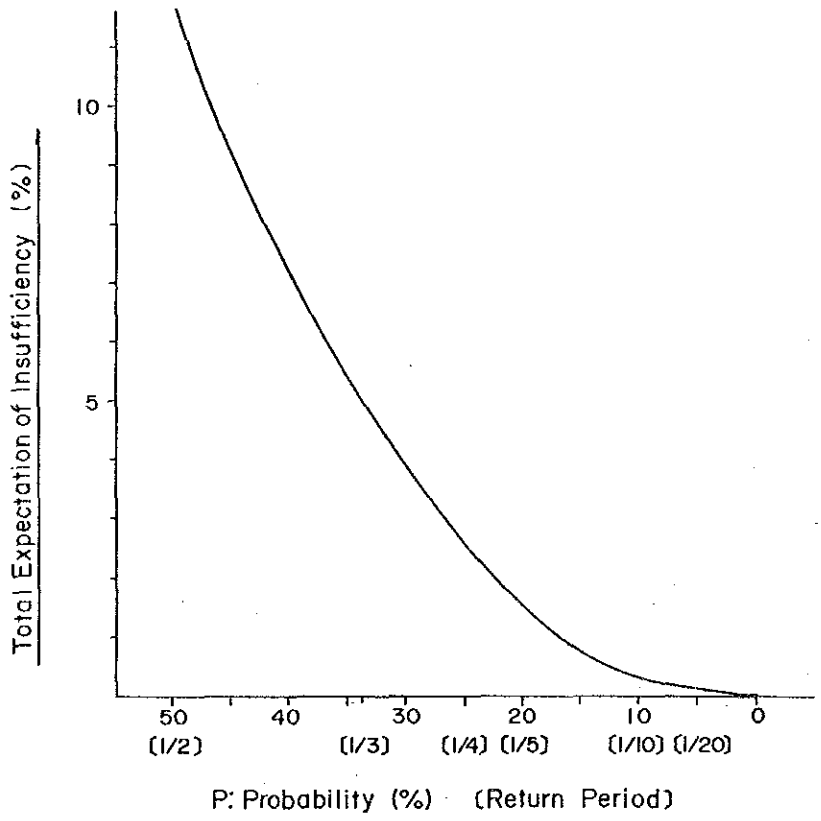


FIG. M.4.7 TOTAL EXPECTATION OF INSUFFICIENCY

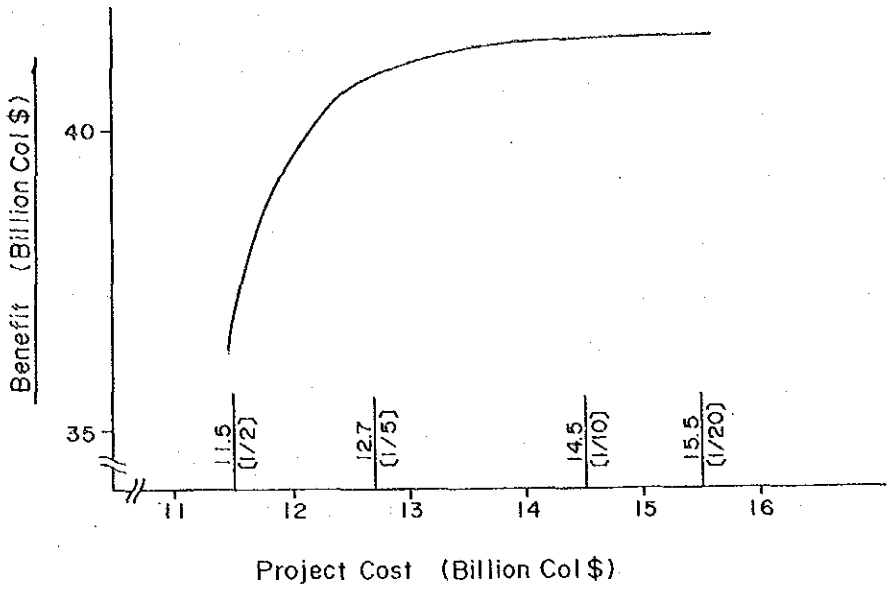


FIG. M.4.8 COST AND BENEFIT

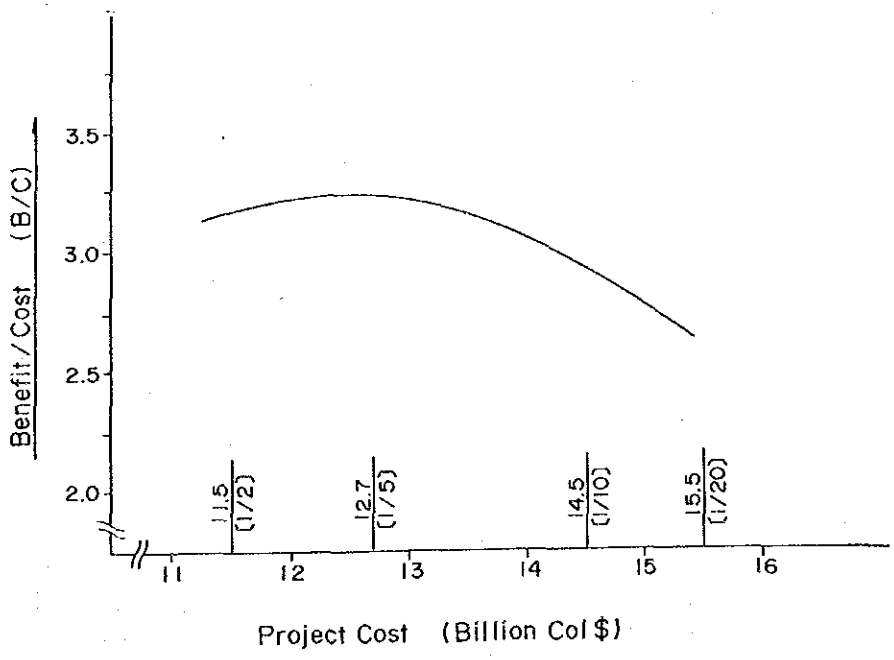


FIG. M.4.9 COST AND B/C

capacity for each return period are shown in Fig.M.4.8 and rate of B/C is shown in Fig.M.4.9. From these figures, it can be seen that the dam volume for 5 year return period could be the most economical dam volume.

d) Plan of Dam Operation

Considering the condition of the runoff discharge, the proposed dam operation for each return period is shown in Table M.4.5. Variations of water volume and depth are shown in Figs.M.4.10 and M.4.11.

e) Design Flood Discharge

The peak flood discharge at the Navarco Dam site was estimated as shown in Fig.M.4.12. In this study, considering the safety of the dam, 1.2 times the peak flood discharge for 200 year return period, which is 1,200 m3/s of the flood discharge, is applied for design flood discharge.

f) Summary of Dimensions of Navarco Dam (Plan A)

From the studies mentioned above, the dimensions of the Navarco Dam are summarized as follows;

Location : at the Navarco River where, downstream
at the junction with the Boqueron River

Length of Dam : 300 m

Hight of Dam : 48 m (high water level 45 m)

Embankment Volume : 950,000 m3

Reservoir Capacity :

For Irrigation	5 million m3
For Electricity	5 million m3
For Domestic	1 million m3
For Sedimentation	3 million m3
Total	14 million m3

Design Flood Discharge : 1,200 m3/s

Construction cost : 8,000 million Col$

M.4.4 Alternative of Dam

(1) General

The dam plan given in Section M.4.3 is to supply for all water demand at El Bosque Diversion Weir. In this section, the dam plan for the Water demand excluded the water for hydroelectricity is studied. Only water requirements of the irrigation and domestic

Table M.4.5 (1) Calculation of Water Balance on Navarco Dam

RETURN PERIOD 1/2	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
REQUIREMENT (m3/s)	5.692	5.609	5.478	5.478	5.478	5.521	6.179	5.689	5.504	5.478	5.478	5.485
FLOW FROM OTHER BASIN	10.218	8.499	6.977	8.739	10.432	7.553	4.909	2.696	3.761	6.807	11.181	9.930
DIFERENCE (m3/s)	4.527	2.891	1.499	3.262	4.955	2.032	-1.270	-2.993	-1.743	1.329	5.703	4.445
EXPECTED FLOW FROM DAM	----	----	----	----	----	----	1.270	2.993	1.743	----	----	----
MINI. DAM VOLUME (1000m3)	14300.0	14300.0	14300.0	14300.0	14300.0	14300.0	10899.7	6283.5	7703.2	14300.0	14300.0	14300.0
LOW WATER DEPTH (m)	43.5	43.5	43.5	43.5	43.5	43.5	41.3	31.4	33.0	43.5	43.5	43.5
FLOW FROM NAVARCO BASIN	3.354	3.190	4.202	5.931	4.356	2.371	1.445	2.217	2.934	5.535	6.118	4.054
MAX. DAM VOLUME (1000m3)	14300.0	14300.0	14300.0	14300.0	14300.0	14300.0	14300.0	12221.5	14300.0	14300.0	14300.0	14300.0
HIGH WATER DEPTH (m)	43.5	43.5	43.5	43.5	43.5	43.5	43.5	42.1	43.5	43.5	43.5	43.5
OVERFLOW FROM DAM (m3/s)	3.354	3.190	4.202	5.931	4.356	2.371	.176	----	.389	5.535	6.118	4.054
TOTALFLOW FROM DAM (m3/s)	3.354	3.190	4.202	5.931	4.356	2.371	1.445	2.993	2.132	5.535	6.118	4.054
MEAN DAM VOLUME (1000m3)	14300.0	14300.0	14300.0	14300.0	14300.0	14300.0	12835.3	9252.5	11506.1	14300.0	14300.0	14300.0
MEAN WATER DEPTH (m)	43.5	43.5	43.5	43.5	43.5	43.5	42.6	40.2	41.7	43.5	43.5	43.5

RETURN PERIOD 1/5	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
REQUIREMENT (m3/s)	5.692	5.609	5.478	5.478	5.478	5.521	6.179	5.689	5.504	5.478	5.478	5.485
FLOW FROM OTHER BASIN	9.320	7.790	6.556	8.270	9.611	6.883	4.460	2.157	3.009	5.447	10.446	9.143
DIFERENCE (m3/s)	3.628	2.181	1.078	2.792	4.133	1.362	-1.718	-3.532	-2.495	-.031	4.969	3.658
EXPECTED FLOW FROM DAM	----	----	----	----	----	----	1.718	3.532	2.495	.031	----	----
MINI. DAM VOLUME (1000m3)	14300.0	14300.0	14300.0	14300.0	14300.0	14300.0	9697.3	3263.6	1434.1	7294.0	14300.0	14300.0
LOW WATER DEPTH (m)	43.5	43.5	43.5	43.5	43.5	43.5	40.5	22.5	14.2	32.5	43.5	43.5
FLOW FROM NAVARCO BASIN	2.619	2.493	3.278	4.635	3.398	1.847	1.130	1.731	2.293	4.322	4.770	3.159
MAX. DAM VOLUME (1000m3)	14300.0	14300.0	14300.0	14300.0	14300.0	14300.0	12722.7	7899.9	7376.8	14300.0	14300.0	14300.0
HIGH WATER DEPTH (m)	43.5	43.5	43.5	43.5	43.5	43.5	42.5	33.2	32.6	43.5	43.5	43.5
OVERFLOW FROM DAM (m3/s)	2.619	2.493	3.278	4.635	3.398	1.847	----	----	----	1.706	4.770	3.159
TOTALFLOW FROM DAM (m3/s)	2.619	2.493	3.278	4.635	3.398	1.847	1.718	3.532	2.495	1.737	4.770	3.159
MEAN DAM VOLUME (1000m3)	14300.0	14300.0	14300.0	14300.0	14300.0	14300.0	11210.0	5581.8	4405.5	13082.0	14300.0	14300.0
MEAN WATER DEPTH (m)	43.5	43.5	43.5	43.5	43.5	43.5	41.5	30.6	24.8	42.7	43.5	43.5

Table M.4.5 (2) Calculation of Water Balance on Navarco Dam

RETURN PERIOD 1/10	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
REQUIREMENT (m3/s)	5.692	5.609	5.478	5.478	5.478	5.521	6.179	5.689	5.504	5.478	5.478	5.485
FLOW FROM OTHER BASIN	8.072	6.743	5.667	7.140	8.319	5.964	3.864	1.918	2.676	4.844	9.034	7.916
DIFERENCE (m3/s)	2.380	1.134	.189	1.662	2.841	.444	-2.315	-3.770	-2.828	-.634	3.556	2.432
EXPECTED FLOW FROM DAM	----	----	----	----	----	----	2.315	3.770	2.828	.634	----	----
MINI. DAM VOLUME (1000m3)	14300.0	14300.0	14300.0	14300.0	14300.0	14300.0	8099.6	657.9	0.0	919.1	11080.9	14300.0
LOW WATER DEPTH (m)	43.5	43.5	43.5	43.5	43.5	43.5	33.4	10.3	0.0	11.6	41.4	43.5
FLOW FROM NAVARCO BASIN	2.299	2.189	2.876	4.070	2.981	1.619	.992	1.519	2.013	3.794	4.184	2.769
MAX. DAM VOLUME (1000m3)	14300.0	14300.0	14300.0	14300.0	14300.0	14300.0	10756.5	4727.5	2616.6	11080.9	14300.0	14300.0
HIGH WATER DEPTH (m)	43.5	43.5	43.5	43.5	43.5	43.5	41.2	25.5	21.2	41.4	43.5	43.5
OVERFLOW FROM DAM (m3/s)	2.299	2.189	2.876	4.070	2.981	1.619	----	----	----	----	2.942	2.769
TOTALFLOW FROM DAM (m3/s)	2.299	2.189	2.876	4.070	2.981	1.619	2.315	3.770	2.828	.634	2.942	2.769
MEAN DAM VOLUME (1000m3)	14300.0	14300.0	14300.0	14300.0	14300.0	14300.0	9428.0	2692.7	7.5	6000.0	14300.0	14300.0
MEAN WATER DEPTH (m)	43.5	43.5	43.5	43.5	43.5	43.5	40.3	21.4	.1	31.1	43.5	43.5

RETURN PERIOD 1/20	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
REQUIREMENT (m3/s)	5.692	5.609	5.478	5.478	5.478	5.521	6.179	5.689	5.504	5.478	5.478	5.485
FLOW FROM OTHER BASIN	7.176	5.992	5.028	6.329	7.392	5.304	3.435	1.744	2.432	4.402	8.020	7.036
DIFERENCE (m3/s)	1.484	.383	-.450	.852	1.914	-.216	-2.743	-3.945	-3.072	-1.075	2.542	1.551
EXPECTED FLOW FROM DAM	----	----	.450	----	----	.216	2.743	3.945	3.072	1.075	----	----
MINI. DAM VOLUME (1000m3)	14300.0	14300.0	13095.5	14300.0	14300.0	13739.2	6952.2	0.0	0.0	0.0	5432.9	14300.0
LOW WATER DEPTH (m)	43.5	43.5	42.7	43.5	43.5	43.2	32.2	0.0	0.0	0.0	30.5	43.5
FLOW FROM NAVARCO BASIN	2.068	1.970	2.586	3.663	2.681	1.455	.893	1.367	1.812	3.413	3.762	2.489
MAX. DAM VOLUME (1000m3)	14300.0	14300.0	14300.0	14300.0	14300.0	14300.0	9343.2	2437.2	0.0	5432.9	14300.0	14300.0
HIGH WATER DEPTH (m)	43.5	43.5	43.5	43.5	43.5	43.5	40.2	20.9	0.0	30.5	43.5	43.5
OVERFLOW FROM DAM (m3/s)	2.068	1.970	2.137	3.663	2.681	1.239	----	----	----	----	.341	2.489
TOTALFLOW FROM DAM (m3/s)	2.068	1.970	2.586	3.663	2.681	1.455	2.743	3.945	3.072	1.075	.341	2.489
MEAN DAM VOLUME (1000m3)	14300.0	14300.0	14300.0	14300.0	14300.0	14300.0	8147.7	606.7	861.9	10308.7	14300.0	
MEAN WATER DEPTH (m)	43.5	43.5	43.5	43.5	43.5	43.5	33.5	10.0	0.0	11.3	40.9	43.5

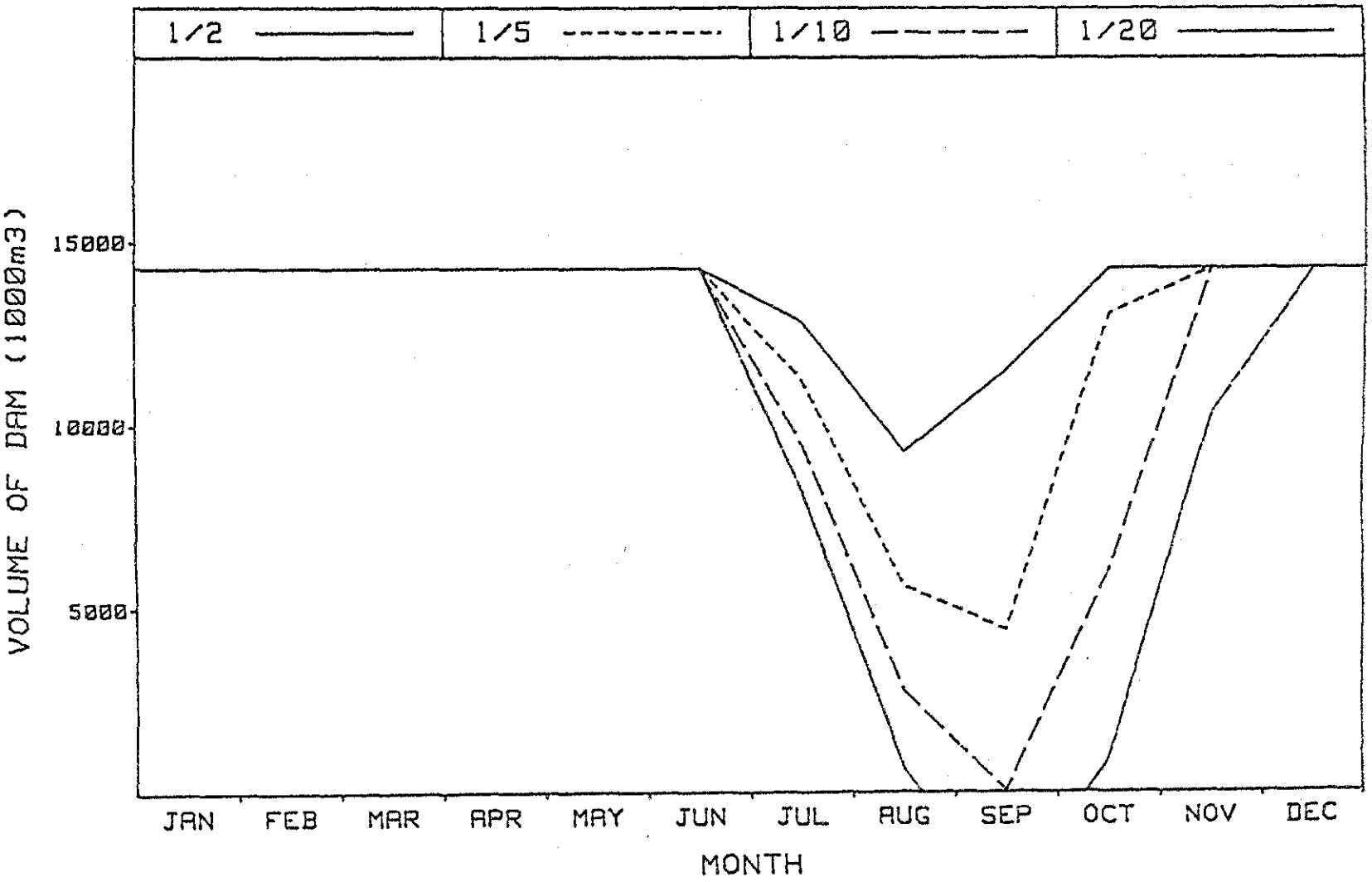


Fig.M.4.10 Variation of Dam Volume

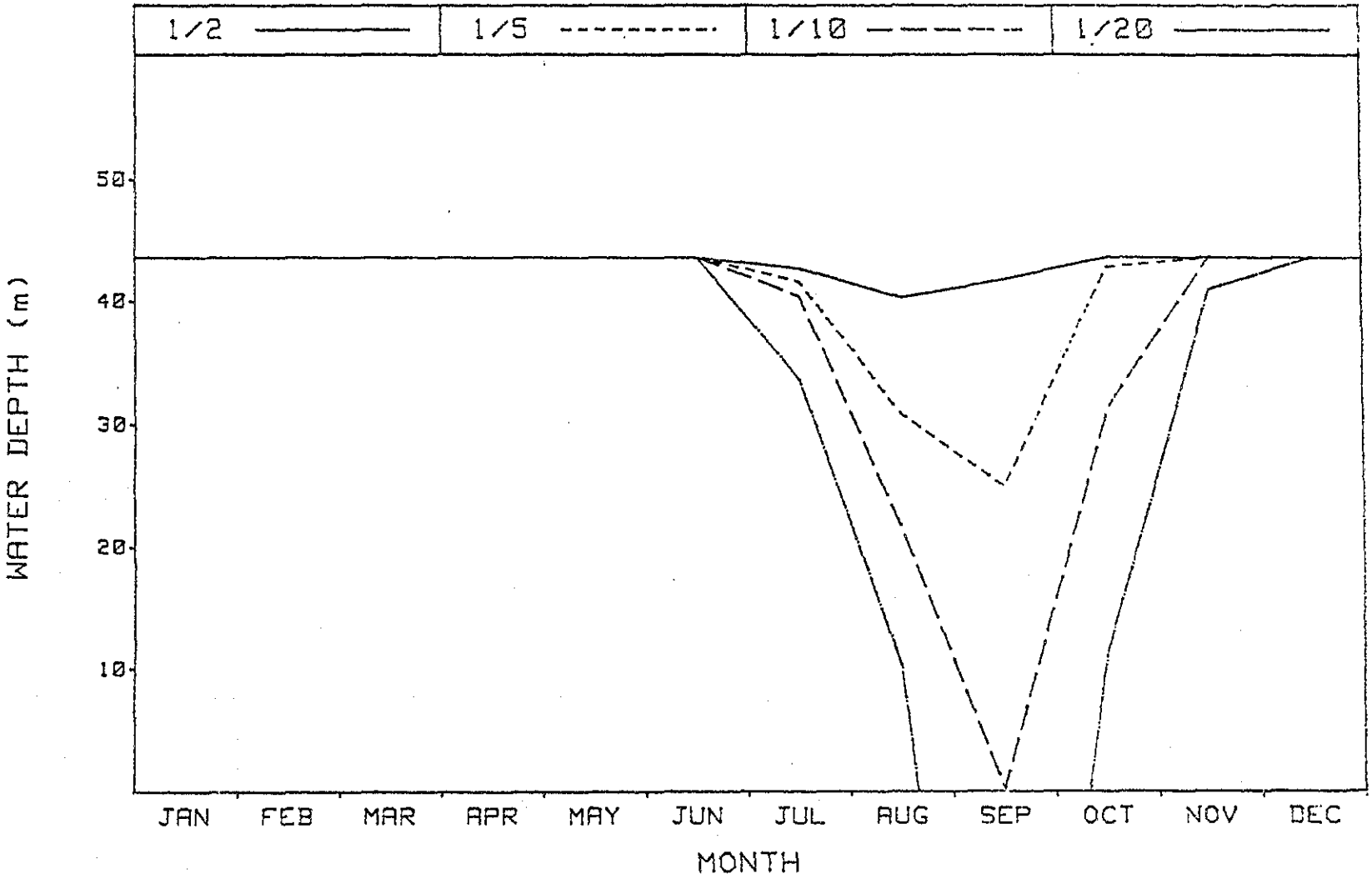


Fig.M.4.11 Variation of Water Depth

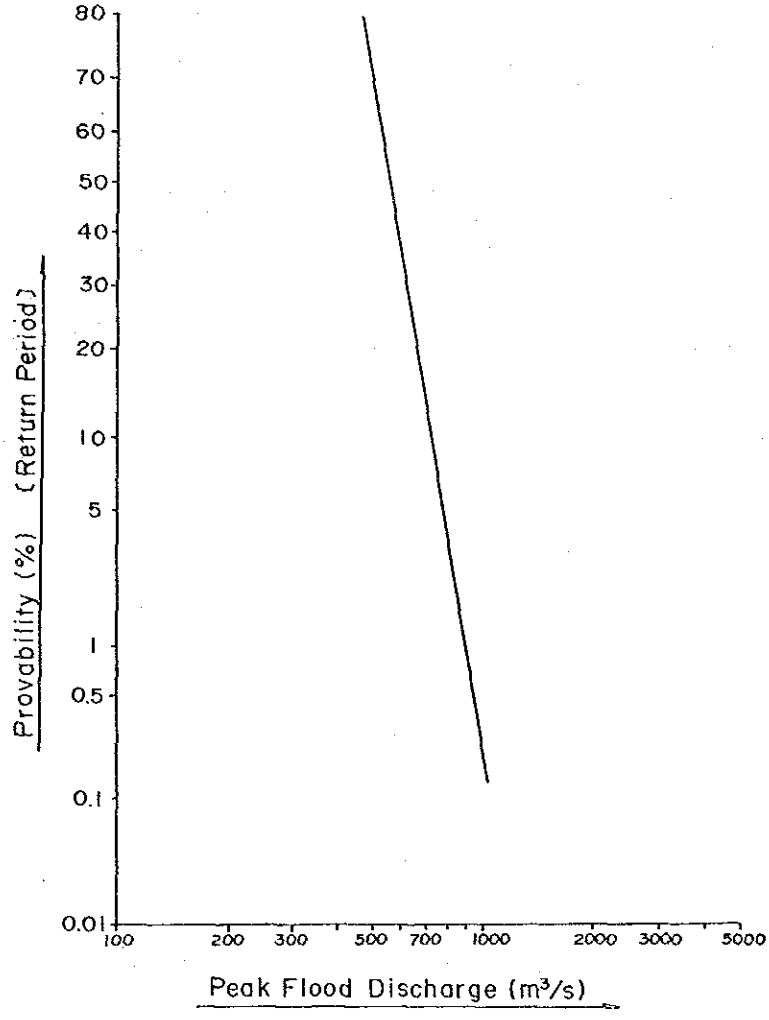


FIG. M.4.12 PEAK FLOOD DISCHARGE

water is Considered.

In this case, the existing water discharge at El Bosque in the droughty season (July, August and September) is considered instead of river maintenance flow. Therefore, the calculation of water balance is different from that in Section M.4.3.

(2) Calculation of Water Balance

According to the preliminary layout of dam given in Section M.4.3, the dam volume may be summarized below in this case:

Volume of Dam :	For Irrigation	5 million m3
	For Domestic	1 million m3
	For Sedimentation	3 million m3
	Total	9 million m3

The calculation of water balance is shown in Table M.4.6 and Fig.M.4.13, M.4.14.

(3) Summary of Dimensions of The Navarco Dam (Plan B)

The dimensions of the Navarco Dam in this case is summarized below and these dimensions is available for the Master Plan.

Location : at the Navarco River where short distance down away from the junction with the Boqueron River

Length of Dam : 280 m

Hight of Dam : 40 m (High water level 37 m)

Embankment Volume : 650,000 m3

Reservior Capacity : 9 million m3

Design Flood Discharge : 1,200 m3/s

Construction Cost : 5,500 million Col$

Table M.4.5 (1) Calculation of Water Balance on Navarco Dam for the Master Plan

RETURN PERIOD 1/2	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
REQUIREMENT (m3/s)	.270	.187	.056	.056	.056	.099	.757	.267	.082	.056	.056	.063
FLOW FROM OTHER BASIN	10.218	8.499	6.977	8.739	10.432	7.553	4.909	2.696	3.761	6.807	11.181	9.930
FLOW WITHOUT DAM	13.572	11.689	11.179	14.670	14.788	9.924	6.355	4.158	4.413	10.258	17.299	13.984
FLOW FROM DAM FOR RIVER	0.000	0.000	0.000	0.000	0.000	0.000	1.445	1.462	.652	0.000	0.000	0.000
EXPECTED FLOW FROM DAM	----	----	----	----	----	----	2.202	1.729	.734	----	----	----
MINI. DAM VOLUME (1000m3)	9000.0	9000.0	9000.0	9000.0	9000.0	9000.0	3102.6	2343.5	6379.3	9000.0	9000.0	9000.0
LOW WATER DEPTH (m)	40.0	40.0	40.0	40.0	40.0	40.0	22.2	20.7	31.5	40.0	40.0	40.0
FLOW FROM NAVARCO BASIN	3.354	3.190	4.202	5.931	4.356	2.371	1.445	2.217	2.934	5.535	6.118	4.054
MAX. DAM VOLUME (1000m3)	9000.0	9000.0	9000.0	9000.0	9000.0	9000.0	6973.6	8281.5	9000.0	9000.0	9000.0	9000.0
HIGH WATER DEPTH (m)	40.0	40.0	40.0	40.0	40.0	40.0	32.2	33.6	40.0	40.0	40.0	40.0
OVERFLOW FROM DAM (m3/s)	3.354	3.190	4.202	5.931	4.356	2.371	----	----	1.923	5.535	6.118	4.054
TOTALFLOW FROM DAM (m3/s)	3.354	3.190	4.202	5.931	4.356	2.371	2.202	1.729	2.657	5.535	6.118	4.054
MEAN DAM VOLUME (1000m3)	9000.0	9000.0	9000.0	9000.0	9000.0	9000.0	5038.1	5312.5	9000.0	9000.0	9000.0	9000.0
MEAN WATER DEPTH (m)	40.0	40.0	40.0	40.0	40.0	40.0	30.0	30.3	40.0	40.0	40.0	40.0

RETURN PERIOD 1/5	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
REQUIREMENT (m3/s)	.437	.348	.078	.056	.056	.556	.972	.440	.174	.056	.056	.180
FLOW FROM OTHER BASIN	9.320	7.790	6.556	8.270	9.611	6.883	4.460	2.157	3.009	5.447	10.446	8.143
FLOW WITHOUT DAM	11.939	10.283	9.834	12.905	13.009	8.730	5.590	3.658	3.882	9.023	15.217	12.301
FLOW FROM DAM FOR RIVER	0.000	0.000	0.000	0.000	0.000	0.000	1.130	1.500	.873	0.000	0.000	0.000
EXPECTED FLOW FROM DAM	----	----	----	----	----	----	2.101	1.940	1.046	----	----	----
MINI. DAM VOLUME (1000m3)	9000.0	9000.0	9000.0	9000.0	9000.0	9000.0	3372.5	1201.8	3126.5	9000.0	9000.0	9000.0
LOW WATER DEPTH (m)	40.0	40.0	40.0	40.0	40.0	40.0	22.7	13.0	22.3	40.0	40.0	40.0
FLOW FROM NAVARCO BASIN	2.619	2.493	3.278	4.635	3.398	1.847	1.130	1.731	2.293	4.322	4.770	3.159
MAX. DAM VOLUME (1000m3)	9000.0	9000.0	9000.0	9000.0	9000.0	9000.0	6397.8	5838.1	9000.0	9000.0	9000.0	9000.0
HIGH WATER DEPTH (m)	40.0	40.0	40.0	40.0	40.0	40.0	31.6	30.9	40.0	40.0	40.0	40.0
OVERFLOW FROM DAM (m3/s)	2.619	2.493	3.278	4.635	3.398	1.847	----	----	.027	4.322	4.770	3.159
TOTALFLOW FROM DAM (m3/s)	2.619	2.493	3.278	4.635	3.398	1.847	2.101	1.940	1.073	4.322	4.770	3.159
MEAN DAM VOLUME (1000m3)	9000.0	9000.0	9000.0	9000.0	9000.0	9000.0	4885.1	3520.0	6097.8	9000.0	9000.0	9000.0
MEAN WATER DEPTH (m)	40.0	40.0	40.0	40.0	40.0	40.0	25.8	23.0	31.2	40.0	40.0	40.0

Table M.4.6 (2) Calculation of Water Balance on Navarco Dam for the Master Plan

RETURN PERIOD 1/10	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
REQUIREMENT (m3/s)	.539	.438	.111	.056	.059	.749	1.145	.511	.232	.056	.056	.281
FLOW FROM OTHER BASIN	8.072	6.743	5.667	7.140	8.319	5.964	3.864	1.918	2.676	4.844	9.034	7.916
FLOW WITHOUT DAM	10.371	8.932	8.543	11.210	11.300	7.583	4.856	3.177	3.372	7.838	13.218	10.686
FLOW FROM DAM FOR RIVER	0.000	0.000	0.000	0.000	0.000	0.000	.992	1.259	.696	0.000	0.000	0.000
EXPECTED FLOW FROM DAM	----	----	----	----	----	----	2.137	1.769	.927	----	----	----
MINI. DAM VOLUME (1000m3)	9000.0	9000.0	9000.0	9000.0	9000.0	9000.0	3277.5	1195.3	2861.0	8079.2	9000.0	9000.0
LOW WATER DEPTH (m)	40.0	40.0	40.0	40.0	40.0	40.0	22.6	13.0	21.7	33.4	40.0	40.0
FLOW FROM NAVARCO BASIN	2.299	2.189	2.876	4.070	2.981	1.619	.992	1.519	2.013	3.794	4.184	2.769
MAX. DAM VOLUME (1000m3)	9000.0	9000.0	9000.0	9000.0	9000.0	9000.0	5934.4	5264.9	8079.2	9000.0	9000.0	9000.0
HIGH WATER DEPTH (m)	40.0	40.0	40.0	40.0	40.0	40.0	31.0	30.3	33.4	40.0	40.0	40.0
OVERFLOW FROM DAM (m3/s)	2.299	2.189	2.876	4.070	2.981	1.619	----	----	----	3.450	4.184	2.769
TOTALFLOW FROM DAM (m3/s)	2.299	2.189	2.876	4.070	2.981	1.619	2.137	1.769	.927	3.450	4.184	2.769
MEAN DAM VOLUME (1000m3)	9000.0	9000.0	9000.0	9000.0	9000.0	9000.0	4506.0	3230.1	5470.1	9000.0	9000.0	9000.0
MEAN WATER DEPTH (m)	40.0	40.0	40.0	40.0	40.0	40.0	25.2	22.5	30.5	40.0	40.0	40.0

RETURN PERIOD 1/20	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
REQUIREMENT (m3/s)	.649	.516	.139	.056	.064	.905	1.278	.581	.291	.056	.056	.400
FLOW FROM OTHER BASIN	7.176	5.992	5.028	6.329	7.392	5.304	3.435	1.744	2.432	4.402	8.020	7.036
FLOW WITHOUT DAM	9.244	7.962	7.614	9.992	10.072	6.759	4.328	2.832	3.006	6.986	11.782	9.525
FLOW FROM DAM FOR RIVER	0.000	0.000	0.000	0.000	0.000	0.000	.893	1.068	.573	0.000	0.000	0.000
EXPECTED FLOW FROM DAM	----	----	----	----	----	----	2.170	1.669	.864	----	----	----
MINI. DAM VOLUME (1000m3)	9000.0	9000.0	9000.0	9000.0	9000.0	9000.0	3187.1	1107.8	2529.3	7224.9	9000.0	9000.0
LOW WATER DEPTH (m)	40.0	40.0	40.0	40.0	40.0	40.0	22.4	12.5	21.1	32.5	40.0	40.0
FLOW FROM NAVARCO BASIN	2.068	1.970	2.586	3.663	2.681	1.455	.893	1.367	1.812	3.413	3.762	2.489
MAX. DAM VOLUME (1000m3)	9000.0	9000.0	9000.0	9000.0	9000.0	9000.0	5578.2	4768.8	7224.9	9000.0	9000.0	9000.0
HIGH WATER DEPTH (m)	40.0	40.0	40.0	40.0	40.0	40.0	30.6	25.5	32.5	40.0	40.0	40.0
OVERFLOW FROM DAM (m3/s)	2.068	1.970	2.586	3.663	2.681	1.455	----	----	----	2.751	3.762	2.489
TOTALFLOW FROM DAM (m3/s)	2.068	1.970	2.586	3.663	2.681	1.455	2.170	1.669	.864	2.751	3.762	2.489
MEAN DAM VOLUME (1000m3)	9000.0	9000.0	9000.0	9000.0	9000.0	9000.0	4382.7	2938.3	4877.1	9000.0	9000.0	9000.0
MEAN WATER DEPTH (m)	40.0	40.0	40.0	40.0	40.0	40.0	24.8	21.9	25.8	40.0	40.0	40.0

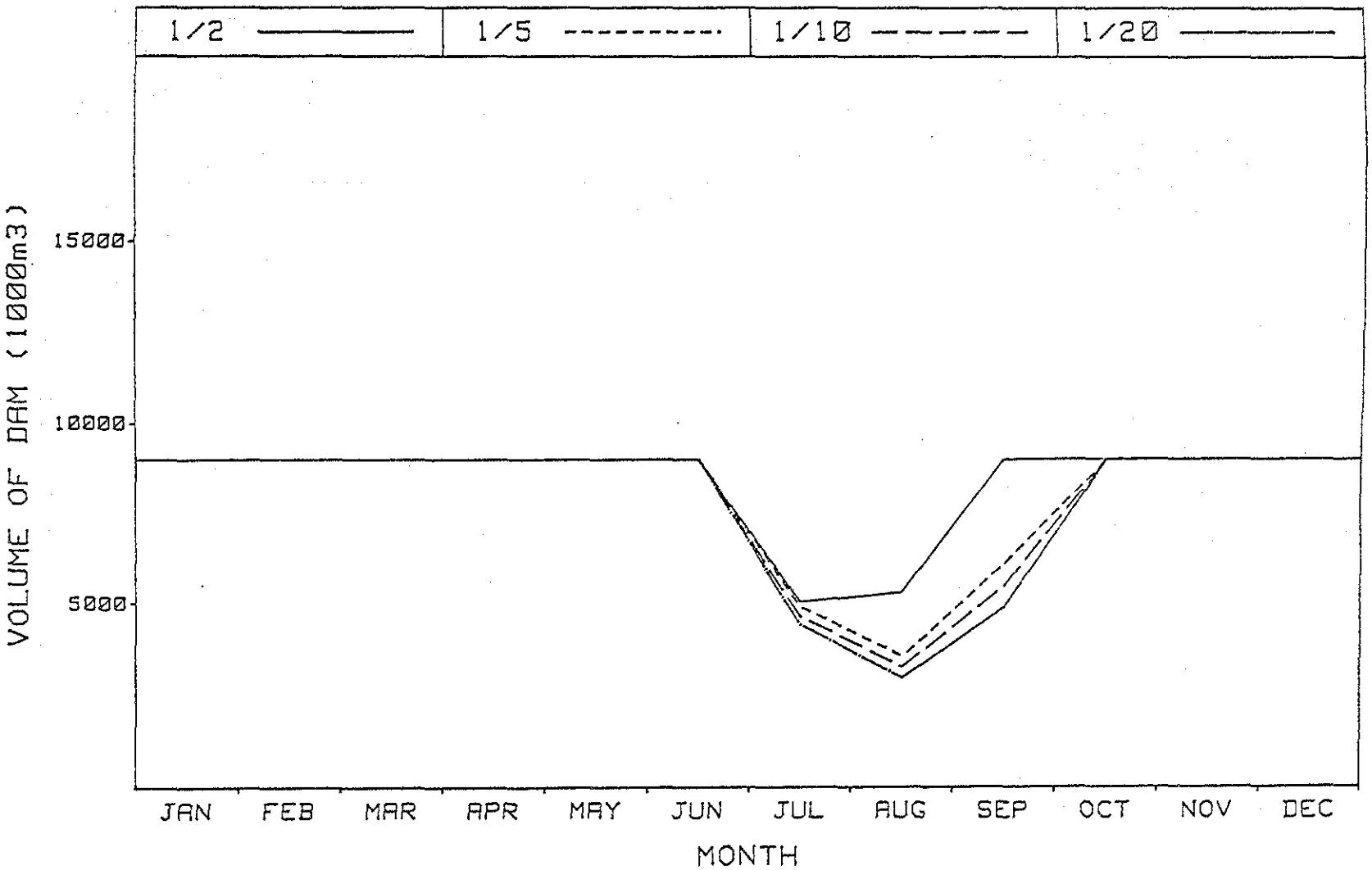


Fig.M.4.13 Variation of Dam Volume

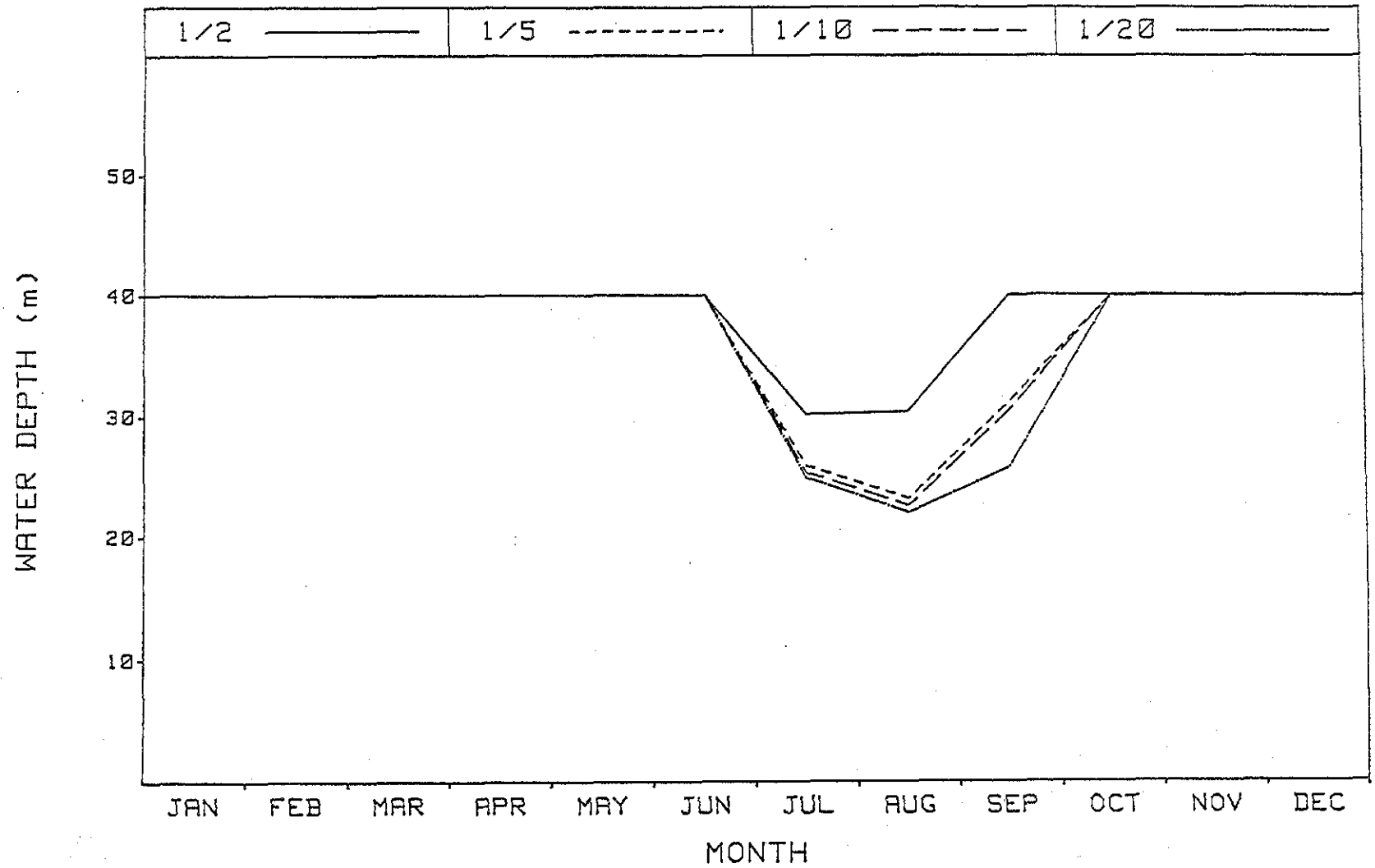


Fig.M.4.14 Variation of Water Depth

M.5 Water Balance for High Priority Project (I)

M.5.1 General

Water source plans for new water demand of high priority projects is basically depending on the river discharge and these water source plans is checked from the viewpoint of water resources in this section.

Mean monthly droughty discharge pattern was used for the calculation of water balance using the specific water discharge on Alambrado in the case of intake point with large watershed. In the case of intake point with small watershed, the mean monthly droughty discharge pattern were estimated using droughty rainfall pattern. The water balances were calculated for 2,5,10 and 20 year return period.

Considering the high priority projects, water balance on the following items were calculated.

- Irrigation
- Mini-hydroelectric power station

M.5.2 Irrigation

Considering to the high priority project, the water balances were calculated for following proposed project areas.

Area A : Quindio River Left Margin Area
Area C : Quindio River Right Margin Area (1)
Area E : Quindio River Right Margin Area (2)
Area F : Circasia Area

The water requirements were applied the monthly peak water requirements given in Annex J.2 and droughty monthly rainfall pattern were used with consideration to the scale of watershed. The conditions of calculation are summarized below:

	Area A	Area C	Area E	Area F
Irrigation area	140 ha	280 ha	200 ha	240 ha
Peak water requirement	0.11 m3/s	0.18 m3/s	0.14 m3/s	0.12 m3/s
Proposed Watershed	35 km2	25 km2	25 km2	30 km2
Rainfall Station	Praguaycito	La Tebaida	La Tebaida	Villadora

The result are as shown in Table M.5.1.

M.5.3 Mini-hydroelectric Power Station

Water balances were calculated on following three mini-hydroelectric power stations using the specific water discharge. Conditions of calculation is summarized below:

	Campestre	Bayona	El Bosque
Water requirement	2.4 m3/s	4.6 m3/s	3.8 m3/s
Watershed of intake point	333 km2	371 km2	382 km2

The result area as shown in Table.M.5.2.

Table M.5.1 (1) Calculation of Water Balance for AREA A

ITEM	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
WATER REQUIREMEN	.108	.111	.110	.103	.100	.104	.114	.115	.107	.096	.095	.100	.105
1/2 DISCHARGE	.829	.975	1.260	1.867	1.504	.678	.444	.591	1.010	1.819	1.920	1.132	1.169
INSUFFICIENCY	----	----	----	----	----	----	----	----	----	----	----	----	0(%)
1/5 DISCHARGE	.707	.831	1.074	1.592	1.283	.578	.378	.504	.861	1.551	1.637	.965	.997
INSUFFICIENCY	----	----	----	----	----	----	----	----	----	----	----	----	0(%)
1/10 DISCHARGE	.651	.765	.989	1.465	1.180	.532	.348	.464	.792	1.427	1.506	.888	.917
INSUFFICIENCY	----	----	----	----	----	----	----	----	----	----	----	----	0(%)
1/20 DISCHARGE	.608	.715	.923	1.368	1.102	.497	.325	.433	.740	1.333	1.407	.829	.857
INSUFFICIENCY	----	----	----	----	----	----	----	----	----	----	----	----	0(%)

Table M.5.1 (2) Calculation of Water Balance for AREA C

ITEM	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
WATER REQUIREMEN	.182	.124	.143	.167	.170	.154	.053	.054	.136	.170	.168	.176	.141
1/2 DISCHARGE	.536	.519	.737	1.006	1.067	.545	.420	.657	.725	1.081	.955	.715	.747
INSUFFICIENCY	----	----	----	----	----	----	----	----	----	----	----	----	0(%)
1/5 DISCHARGE	.444	.430	.610	.833	.883	.451	.347	.543	.600	.894	.791	.591	.618
INSUFFICIENCY	----	----	----	----	----	----	----	----	----	----	----	----	0(%)
1/10 DISCHARGE	.398	.386	.548	.747	.793	.405	.312	.488	.538	.803	.710	.531	.555
INSUFFICIENCY	----	----	----	----	----	----	----	----	----	----	----	----	0(%)
1/20 DISCHARGE	.364	.353	.501	.683	.725	.370	.285	.446	.492	.734	.649	.485	.507
INSUFFICIENCY	----	----	----	----	----	----	----	----	----	----	----	----	0(%)

Table M.5.1 (3) Calculation of Water Balance for AREA E

ITEM	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
WATER REQUIREMEN	.127	.130	.129	.120	.117	.121	.134	.135	.125	.113	.112	.117	.123
1/2 DISCHARGE	.536	.519	.737	1.006	1.067	.545	.420	.657	.725	1.081	.955	.715	.747
INSUFFICIENCY	----	----	----	----	----	----	----	----	----	----	----	----	0(%)
1/5 DISCHARGE	.444	.430	.610	.833	.883	.451	.347	.543	.600	.894	.791	.591	.618
INSUFFICIENCY	----	----	----	----	----	----	----	----	----	----	----	----	0(%)
1/10 DISCHARGE	.398	.386	.548	.747	.793	.405	.312	.488	.538	.803	.710	.531	.555
INSUFFICIENCY	----	----	----	----	----	----	----	----	----	----	----	----	0(%)
1/20 DISCHARGE	.364	.353	.501	.683	.725	.370	.285	.446	.492	.734	.649	.485	.507
INSUFFICIENCY	----	----	----	----	----	----	----	----	----	----	----	----	0(%)

Table M.5.1 (4) Calculation of Water Balance for AREA F

ITEM	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
WATER REQUIREMEN	.118	.084	.063	.094	.112	.110	.078	----	.017	.064	.087	.113	.078
1/2 DISCHARGE	1.149	1.327	1.455	1.753	1.215	.910	.547	.695	.882	1.658	1.951	1.434	1.248
INSUFFICIENCY	----	----	----	----	----	----	----	----	----	----	----	----	0(%)
1/5 DISCHARGE	.947	1.093	1.199	1.444	1.001	.750	.451	.573	.727	1.366	1.607	1.181	1.028
INSUFFICIENCY	----	----	----	----	----	----	----	----	----	----	----	----	0(%)
1/10 DISCHARGE	.856	.989	1.084	1.306	.905	.678	.408	.518	.657	1.235	1.453	1.068	.930
INSUFFICIENCY	----	----	----	----	----	----	----	----	----	----	----	----	0(%)
1/20 DISCHARGE	.788	.910	.998	1.202	.833	.624	.375	.477	.605	1.137	1.338	.983	.856
INSUFFICIENCY	----	----	----	----	----	----	----	----	----	----	----	----	0(%)

Table M.5.2 (1) Calculation of Water Balance at Point CAMPESTRE *** Water Requirement 2.4 m3/s ***

ITEM	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
1/2 DISCHARGE	13.582	11.698	11.187	14.681	14.799	9.931	6.359	4.161	4.416	10.265	17.311	13.994	11.032
INSUFFICIENCY	----	----	----	----	----	----	----	----	----	----	----	----	0(%)
1/5 DISCHARGE	10.374	8.935	8.545	11.214	11.304	7.586	4.857	3.178	3.373	7.841	13.223	10.689	8.427
INSUFFICIENCY	----	----	----	----	----	----	----	----	----	----	----	----	0(%)
1/10 DISCHARGE	9.012	7.762	7.423	9.741	9.819	6.590	4.220	2.761	2.930	6.811	11.486	9.286	7.320
INSUFFICIENCY	----	----	----	----	----	----	----	----	----	----	----	----	0(%)
1/20 DISCHARGE	8.033	6.918	6.617	8.683	8.752	5.874	3.761	2.461	2.612	6.071	10.238	8.277	6.525
INSUFFICIENCY	----	----	----	----	----	----	----	----	----	----	----	----	0(%)

Table M.5.2 (2) Calculation of Water Balance at Point BAYONA *** Water Requirement 4.6 m3/s ***

ITEM	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
1/2 DISCHARGE	14.398	12.400	11.859	15.563	15.687	10.528	6.741	4.411	4.681	10.881	18.351	14.834	11.695
INSUFFICIENCY	----	----	----	----	----	----	----	-.189	----	----	----	----	0(%)
1/5 DISCHARGE	10.997	9.472	9.059	11.887	11.983	8.042	5.149	3.369	3.576	8.312	14.017	11.331	8.933
INSUFFICIENCY	----	----	----	----	----	----	----	-1.231	-1.024	----	----	----	4(%)
1/10 DISCHARGE	9.553	8.228	7.869	10.326	10.409	6.985	4.473	2.927	3.106	7.220	12.176	9.843	7.760
INSUFFICIENCY	----	----	----	----	----	----	-.127	-1.673	-1.494	----	----	----	6(%)
1/20 DISCHARGE	8.515	7.334	7.014	9.204	9.278	6.226	3.987	2.609	2.769	6.436	10.853	8.774	6.917
INSUFFICIENCY	----	----	----	----	----	----	-.613	-1.991	-1.831	----	----	----	8(%)

Table M.5.2 (3) Calculation of Water Balance at Point EL BOSQUE *** Water Requirement 3.8 m3/s ***

ITEM	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
1/2 DISCHARGE	15.630	13.462	12.874	16.895	17.030	11.429	7.318	4.788	5.082	11.813	19.921	16.104	12.696
INSUFFICIENCY	----	----	----	----	----	----	----	----	----	----	----	----	0(%)
1/5 DISCHARGE	11.939	10.283	9.834	12.905	13.009	8.730	5.590	3.658	3.882	9.023	15.217	12.301	9.697
INSUFFICIENCY	----	----	----	----	----	----	----	-.142	----	----	----	----	0(%)
1/10 DISCHARGE	10.371	8.932	8.543	11.210	11.300	7.583	4.856	3.177	3.372	7.838	13.218	10.686	8.424
INSUFFICIENCY	----	----	----	----	----	----	----	-.623	-.428	----	----	----	2(%)
1/20 DISCHARGE	9.244	7.962	7.614	9.992	10.072	6.759	4.328	2.832	3.006	6.986	11.782	9.525	7.509
INSUFFICIENCY	----	----	----	----	----	----	----	-.958	-.794	----	----	----	4(%)

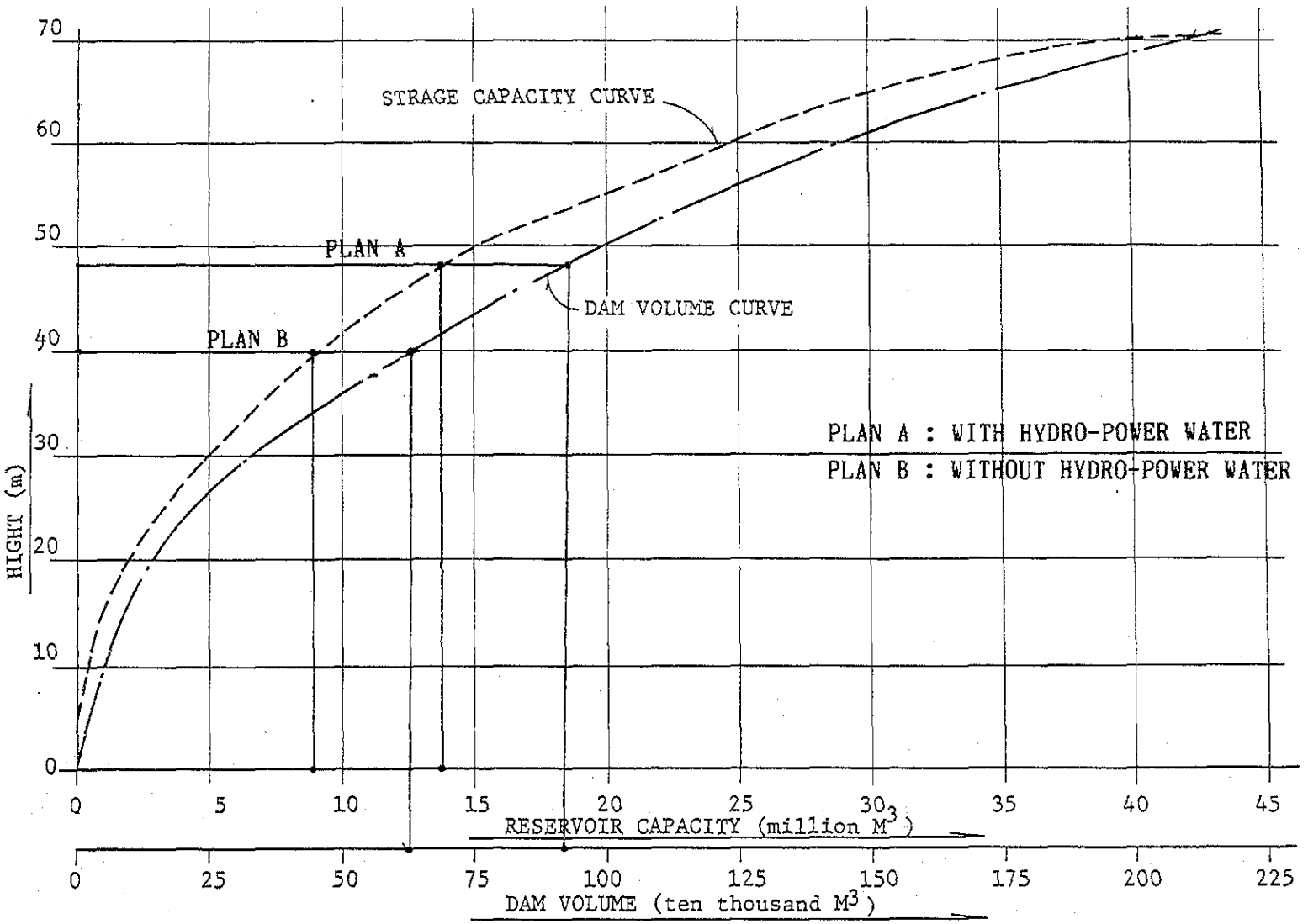


FIG M.4.15 RESERVOIR CAPACITY AND EMBANKMENT OF NAVARCO DAM

ANNEX N : PROJECT FORMULATION

Annex N: PROJECT FORMULATION

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

ANNEX N: PROJECT FORMULATION

N.1 INTRODUCTION

N.1.1 GENERAL

Bearing long-term development concepts in mind, development strategies have been pondered over seeking to implement and to complete integrated agricultural development plans by 2005 (hereinafter the Master Plan), and according to the development strategies, the Master Plan had been formulated.

Based on the Master Plan, sub-regional integrated agricultural development projects were formulated with consideration to the effective implementation of the projects.

Considering necessity, urgency, feasibility, etc., urgent projects have been selected and high priority projects were reformulated using these components.

N.1.2 SUMMARY OF PROJECTS

(1) Master Plan

According to the Future Land Use Plan and the development framework the Master Plan had been formulated. The Master Plan is classified into four (4) categories and summarized below:

Agricultural Development and Promotion Plan: seven (7) projects
Land Conservation and Disaster Prevention Plan: seven (7) projects
Water Quality Improvement Plan: seven (7) projects
Rural Infrastructure Plan: seven (7) projects

(2) Sub-regional Integrated Agricultural Development Projects

Based on the Master Plan, the following three (3) Sub-regional Integrated Agricultural Development Projects have been formulated.

a) The Lower Quindio River Integrated Agricultural Development Project
b) Southern Quindio Integrated Agricultural Development Project
c) Northern Quindio Integrated Agricultural Development Project

(3) High Priority Projects

The high priority projects are classified into two categories as shown below:

- High Priority Project (I) : Quindio River Basin Integrated Agricultural Development Project
- High Priority Project (II): Coffee Waste Water Treatment Project

Considering necessity, urgency, feasibility, etc., urgent projects have been selected from the components of sub-regional project and the High Priority Project (I) was reformulated. The High Priority Project (I) is summarized below:

1.	Agricultural Development Area:	4 areas = 5,810 ha
2.	Farmers' Cooperative Association:	2 cooperatives
3.	Livestock Development:	Cireasia Swine Breeding Center
4.	Freshwater Fish Culture:	400 fish ponds
5.	Experimental Farm:	2 forms
6.	Agro-Product Processing Facilities:	3 plants
7.	Urgent Flood Control:	Pijao and Genova
8.	Water Quality Improvement:	Cristales
9.	Rural Road Improvement:	113.7 km
10.	Mini-hydroelectric Power Plant Rehabilitation:	Campestre and Bayona

The high priority project (II) is described in ANNEX G.

N.2 QUESTIONNAIRE ON REGIONAL DEVELOPMENT IN THE DEPARTMENT OF QUINDIO

N.2.1 SUMMARY AND CONCLUSIONS

For the purpose of investigation into the awareness of leaders and engineers in the Department of Quindio, questionnaire on regional developments in the Quindio was conducted by Japanese Mission and about 50 leaders and engineers were requested to reply their opinions regarding the constrained factors of development and necessary projects, etc. The questionnaire results are summarized in Table N.2.1.

From the questionnaire results, coffee mono-culture ranked top in constrained factors of development. This suggests that inhabitants in the Quindio are afraid of coffee production in the future with consideration to international market prices and an expansion of marketing, and that industrialization in the Department of Quindio is being expected.

Both in regional development and agricultural development, promotion of agro-products processing sector ranked top. This also indicates that the inhabitants are expecting a revitalization of regional economy by agro-industry, i.e., industrialization.

However, in the promotion of agro-products processing sector, the introduction of private capital is inevitable, and it is necessary to improve infrastructure and to take into consideration finance and taxation.

On the other hand, coffee waste water treatment problems are perceived as serious problems, and the establishment of countermeasures acceptable from the socioeconomical viewpoint is considered difficult.

N.2.2 CONTENTS AND ANSWERS OF QUESTIONNAIRE

The contents and answers of the questionnaire which were conducted are as follows:

Q1. "What do you think about a level of economic culture in Quindio in comparison with national average?" (Answer-37 persons)

a) High level 20 (54.1%)
b) Same level 16 (43.2%)
c) Low level 1 (2.7%)

Q2. "What do you think about the direction of future development in Quindio?" (Answer-48 persons)

a) Agro-product processing facilities should be introduced 25 (52.1%)
b) Agriculture and livestock farming should be modernized and diversified 17 (35.4%)
c) Distribution mechanism should be improved 4 (8.3%)
d) Others 2 (4.2%)

Table N.2.1 Summary of Questionnaire Results

Rank	Constrained Factor of Development In Quindio	Necessary Project for Regional Development	Necessary Project for Agricultural Development	Concept on Coffee Waste Water Treatment
1	Coffee mono culture	Promotion of agro-products processing sector	Promotion of agro-products processing sector	Enlightenment for water quality improvement
2	Lack of long-term plan in administrative authorities	Water resources development	Consolidation of distribution and sales sectors	Study of economical treatment system
3	High loan interests and insufficient financing system	Development of areas other than suitable coffee culture areas	Diversification of agriculture	Utilization of fruit skin and flesh
4	Insufficiency of infrastructure	Road improvement	Improvement of agriculture cooperative	Introduction of concentrated treatment system
5	Insufficiency of farmers' education and support service system	Establishment of distribution mechanism	Introduction of irrigation system	Good measures not available at present

Q3. What factors are existing to prevent development in Quindio?" (Number of Answer - 109)

a) Conscious problems of provincial residents 35 (32.1%)

Mono-cultural tendency for coffee - 22
Lack of interest in the promotion of agriculture and livestock farming - 5
Egotism of enterprises - 5
Egotism of farmers - 3

b) Administrative problems 26 (23.9%)

Egotism of top classes - 10
Lack of aid and guidance from central government - 7
Poor planning capacity - 6
Heavy tax and expensive public service fee - 3

c) Problems of economy and distribution 22 (20.2%)

High interests and lack of loan institutions - 12
Unimproved distribution mechanism - 6
Weakness of provincial economic power - 2
Insufficient cooperative associations - 2

d) Lack of infrastructure 11 (10.1%)

Insufficient water resources development - 4
Lack of industrial sector - 3
Lack of electric power - 2
Lack of infrastructural facilities - 2

e) Problems of agricultural administration 10 (9.2%)

Inadequate education for farmers - 5
Lack of technical services - 3
Insufficient promotion of stock raising - 2

f) Social problems 5 (4.6%)

Lack of measures for good treatment of labor's employment - 2
Unbalanced land tenure - 2
Unemployment - 1

Q4. "Please give your opinions regarding the present situation and future of agriculture in Quindio."

1) Present situation (Answer - 21)

a) Too much centralization of coffee production 16
b) Insufficient funds for agricultural production 3
c) Mountain districts are not utilized effectively 1
d) Disruption of natural environment due to indiscriminate development 1

2) Future (Answer - 36)

a) Agro-product processing and distribution facilities should be provided 8
b) Crops should be multiplicated 7
c) Agriculture and livestock farming should be modernized 5
d) Integrated development plan should be established 4
e) Coffee productivity should be improved 4
f) Except coffee cultivation, productive areas should be strengthened 4
g) Natural environment should be recovered 2
h) Agricultural and livestock farming techniques in mountain districts should be improved 1
i) Agrarian reform should be implemented 1

Q5. "Please select any detailed projects in regional development." (Answer - 91)

a) Agro product processing facilities 17
b) Water resources development (including the generation of electricity) 10
c) Agricultural development in lands unsuitable for coffee cultivation, and highlands 7
d) Road improvement 7
e) Improvement of distribution mechanism 7
f) Improvement of water quality and environmental conservation 7
g) Rural water supply 6
h) Introduction of stock raising 6
i) Modernization of agriculture and livestock farming 6
j) Training of small and medium-sized enterprises 4
k) Forestation 3
l) Education for farmers 3
m) Inland fishery 2
n) Fruit trees, oleaginous crops, irrigation, agrarian reform, railway, international airport, and mineral resources development ..... 1 each

Q6. "Please select any detailed projects for agricultural development in Quindio." (Answer - 59)

a) Installation of agro-product processing facilities 14
b) Establishment of distribution mechanism such as collecting center for agricultural products 12
c) Diversification of agriculture 5
d) Establishment of agricultural cooperative association 4
e) Irrigation project (including dam) 4
f) Strengthening of technical services of agriculture 3
g) Agricultural development in mountain districts 3
h) Institution of subsidy or loan 2
i) Stabilization of coffee cultivation 2
j) Promotion of dairy farming 2

k) Agricultural mechanization, improvement of water quality, conservation of farmland, exported crops, smuggling control, prevention of damage due to blight and insects, supply of Colombia species, and education for farmers ..... 1 each

Q7. "Please give your ideas on countermeasures for coffee treatment waste water." (Answer - 41)

a)	Campaign for enlightening education for water environmental control and conservation	6
b)	Study for establishment of economical coffee treatment method	6
c)	Utilization of coffee skin and pulp	6
d)	Centralized treatment plant	6
e)	Installation of provisional pulp pit	4
f)	No effective countermeasures under present situation ..	4
g)	Obligation of individual treatment by each coffee farm	3
h)	Establishment of loan institution for treatment of coffee waste	3
i)	Supply of wash water	1
j)	Individual treatment plant by each coffee farm	1
k)	Exclusive canal for coffee waste water	1

N.3 MASTER PLAN

N.3.1 OUTLINE OF PROJECTS

According to the Future Land Use Plan and the development framework, the Master Plan had been formulated by following components:

- Agricultural Development and Promotion Project
- Land Conservation and Disaster Prevention Plan
- Water Quality Improvement Plan
- Rural Infrastructure Plan

(1) Agricultural Development and Promotion Plan

a) Quindio River Left Margin Agricultural Development Project

Objective of project:
- to redress unbalanced development level among sub-regions
- diversification of cropping

Project area: 1,500 ha (cropping area: 1,110 ha)

Proposed crop: vegetable, citrus, srgham, etc.

Peak water requirement: 0.71 m^3/s

Pumping station:
Barrgan pumping station D=350mm, H=15m, 3 units
Infarm pumping station D=350mm, H=60m, 1 unit

Irrigation canals: main canal: 9.0 km,
secondary canal: 14.0 km

Field irrigation systems: 37 sets

Drainage canal: 15 km

Land reclamation: 1,500 ha

b) Quindio River Right Margin Agricultural Development Project

Objective of project:
- to redress unbalanced development level among sub-regional
- diversification of cropping
- improvement of coffee productivity

Project areas:
- right margin of the Quindio River I 2,500 ha (cropping area 1,900 ha)
- right margin of the Quindio River II 2,500 ha (cropping area 1,720 ha)

Proposed crop: vegetable, citrus, srgham, cassava coffee plantain, etc.

Peak water requirement: 2.44 m^3/s

Navarco Dam: watershed: 126 km^2, effective capacity 6 million m^3
Height: 40 m, rockfill type

Head works (El Bosque): rehabilitation, total length: 181.5 m
height of crest: 1.0 m,
gate: 3.1x1.9 3 units

Irrigation canals: main canal: 54.0 km,
secondary canal: 42.0 km

Field irrigation systems: 131 sets

Drainage canal: 45 km

Land reclamation: 2,500 ha

c) San Jose Agricultural Development Project

Objective of Project:
- to redress unbalanced development level among sub-regions
- diversification of cropping

Project area: 3,400 ha (cropping area 2,460 ha)

Proposed crop: vegetable, citrus, srgham, coffee, cassava
cacao, etc.

Peak water requirement: 1.80 m^3/s

Pumping stations: Espejo pumping station D=450mm, H=60m, 4 units

Irrigation canals: main canal: 28.0 km,
secondary canal: 30.0 km

Field irrigation systems: 77 sets

Drainage canal: 23 km

Land reclamation: 2,000 ha

d) Circasia Agricultural Development Project

Objective of project:
- to redress unbalanced development level among farm classes
- diversification of cropping

Project area: 1,600 ha (cropping area: 1,080 ha)

Proposed crop: vegetable, tree crop, etc.

Peak water requirement: 0.50 m^3/s

Field irrigation systems: 36 sets

Drainage canal: 16 km

Land reclamation: 1,600 ha

Pork production development: feeding mill facility,
meat processing facility, etc.

e) Genova-Pijao Agricultural Development Project

Objective of project:
- to redress unbalanced development level among sub-regions

Project area: 400 ha (cropping area: 280 ha)

Proposed crop: vegetable, tree crop, etc.

Peak water requirement: 0.16 m^3/s

Field irrigation systems: 10 sets

Drainage canal: 4 km

Land reclamation: 400 ha

Pork production development: feeding mill facility, etc.

f) Quindio Agricultural Research Center Project

The installation of an agricultural extension and research center is hereby proposed so as to resolve a number of problems confronted by the agricultural sector in the Department and accelerate the coordination among related various projects and coordinated implementation. The organization of the center is proposed as follows:

Agricultural Technical Center: Agricultural Division
Livestock division
Environmental division
Social Education division

g) Salento Milk Cooling and Storage Plant Project

Organized commercial dairy farms produce and sell milk more efficiently. they own cooling and storage plants and are well organized to promote marketing to advertise and sell their products. Milk is then transferred to the processing plants for pasturization or further processing to better cheese or other milk products. Furthermore, modern lorries are equipped with coolers so that the processed milk be transported over a considerable distance without the milk becoming sour. Storage 10 k litters per week of capacity is proposed.

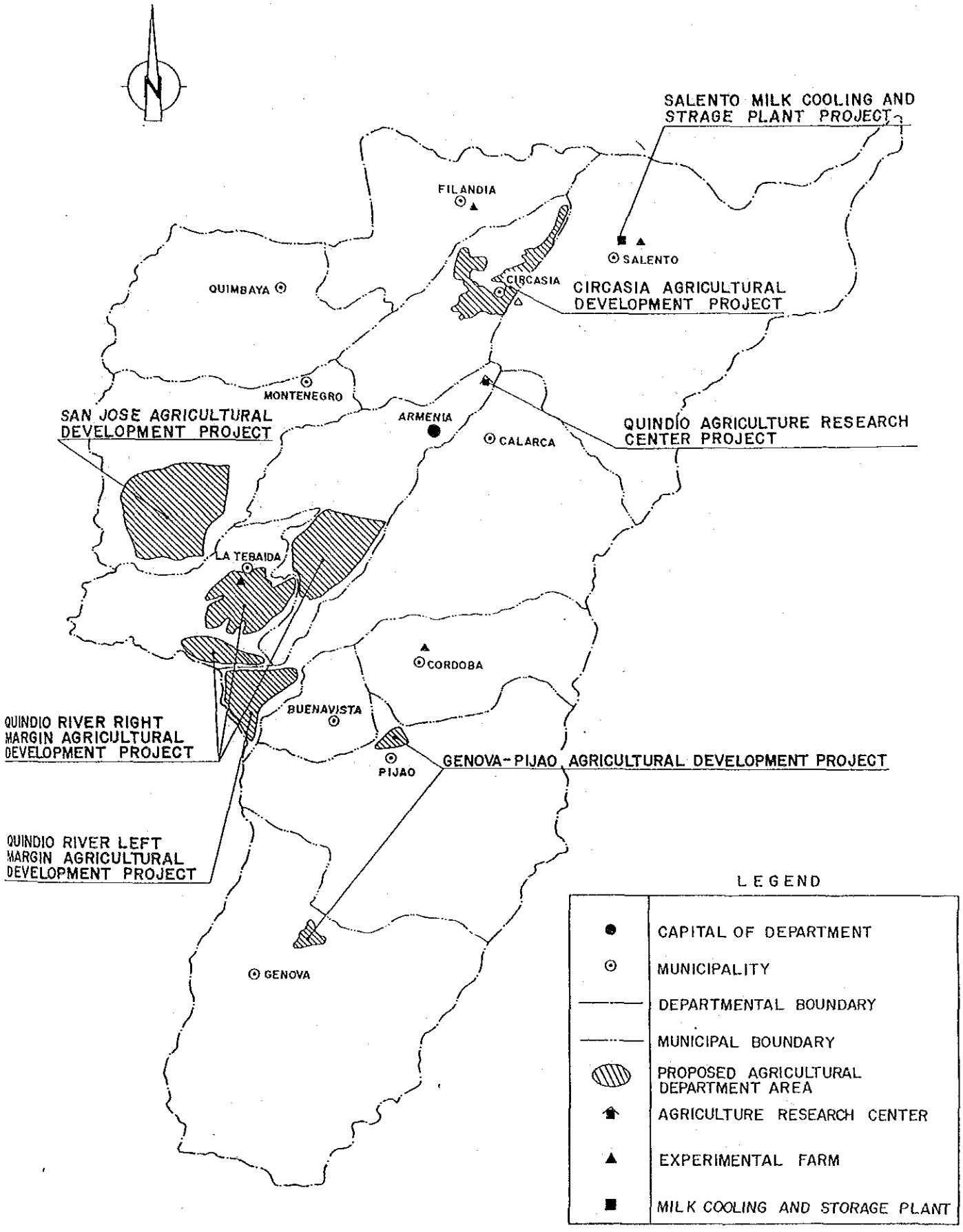


Fig. N.3.1 PROPOSED AGRICULTURAL DEVELOPMENT AND PROMOTION PROJECTS IN THE MASTER PLAN

(2) Land Conservation and Disaster Prevention Plan

a) Designating Natural Conservation Area Project

Objective of Project: Land conservation at watershed

Following areas should be designated as natural conservation areas at watershed:

River System	Watershed (km^2)
Quindio River	140.4
Navarco River	63.3
Santo Domingo River	70.4
Verde River	87.7
Azul River	72.3
Rojo River	114.5
Gris River	47.8
San Juan River	51.5
Total	677.6

b) Lejos River Disaster Prevention Project

Objective of project: flood control

Watershed: 87.7 km^2

Flood control dam: height 33 m, capacity 2.2 million m^3 concrete dam

Protection work on river side: river wall work: 7 km

Disaster prevention dam: height 5 m, 6 units

Reforestation: 15.1 km^2

Woodland path network: 19 km

c) Gris and San Juan River Disaster Prevention Project

Objective of project: flood control

Watershed: 99.3 km^2

Protection work on river side: river wall work: 10 km

Disaster prevention dam: height 5 m, 7 units

Reforestation: 22.2 km^2

Woodland path network: 15 km

d) Santo Domingo River Disaster Prevention Project

Objective of project: flood control

Watershed: 70.4 km^2

Disaster prevention dam: height 5 m, 12 units

Reforestation: 32.0 km^2

Woodland path network: 13 km

e) Espejo River Improvement Project

Objective of project: soil conservation and flood control

Watershed: 155.0 km^2

Improvement of cross section: 1 km

Protection work on slope land at right margin of the Espejo river:
- reforestation, drainage system, etc. on areas from junction with the La Vieja river to 10 km upstream

f) Verde River Improvement Project

Objective of project: soil conservation and flood control

Watershed: 82.0 km^2

Protection work on river side:
- areas from junction with the Santo Domingo river to 4 km downstream

g) La Vieja River Right Side Area Soil Conservation Project

Objective of Project: soil conservation

Erosion prevention weir: height 3 m, 15 units

Catch drain: 10 km

Improvement of drainage system: 2 km^2

Reforestation: 0.6 km^2

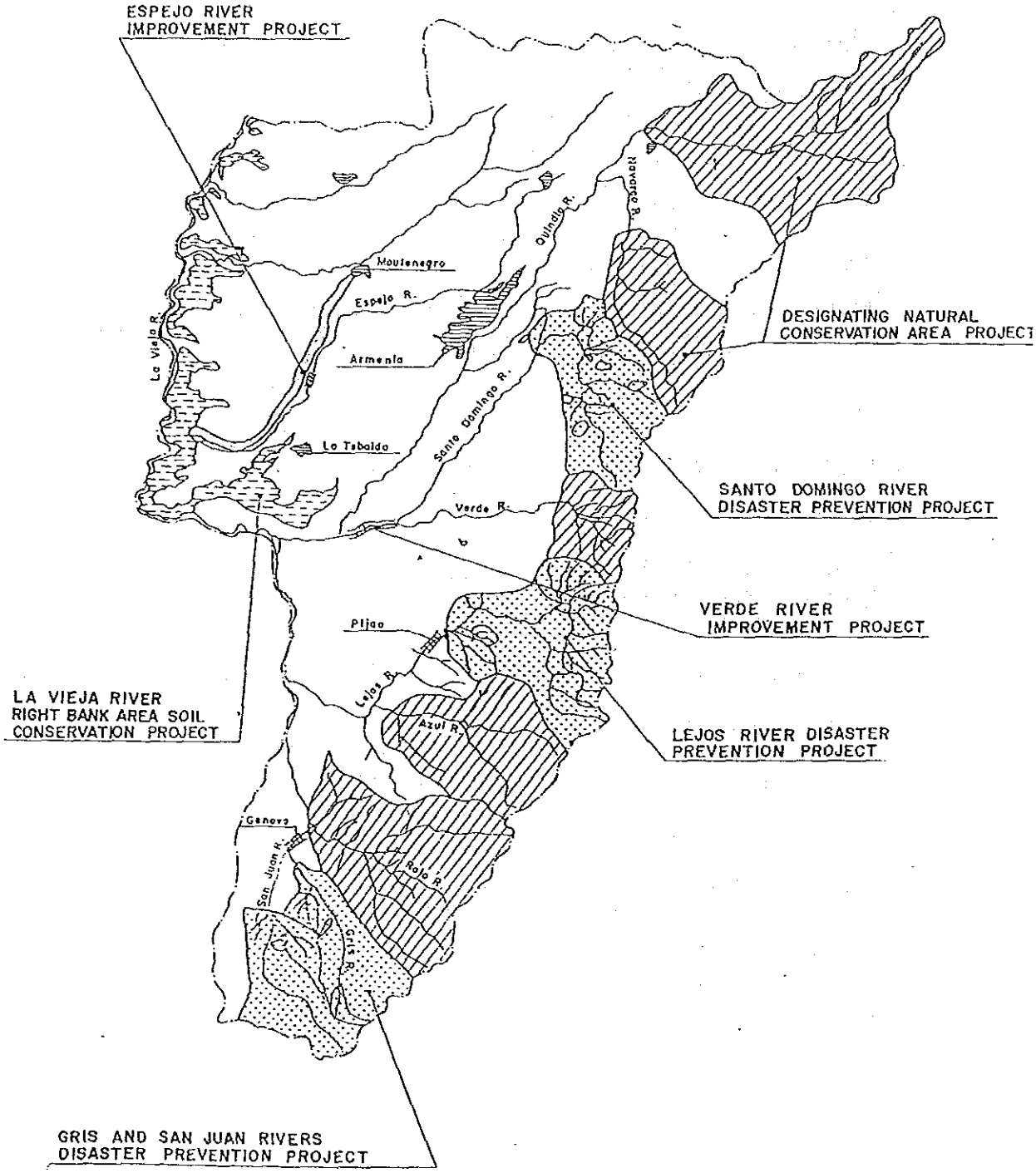


Fig. N.3.2 PROPOSED LAND CONSERVATION AND DISASTER PREVENTION PROJECTS IN THE MASTER PLAN

(3) Water Quality Improvement Plan

a) Cristales Coffee Waste Treatment Project
(670 coffee farms)
Treatment facilities:
- Centralized facility: 11
  (UASB method for 330 coffee farms from 5 ha to 30 ha)
- Individual facility (large): 55
  (UASB method for 55 coffee farms over 30 ha)
- Individual facility (small): 285
  (Oxidation ditch method for 285 coffee farms over 30 ha)
- Reservoir pit: 330
Vacuum car: 11

b) Roble Coffee Waste Treatment Project
(880 coffee farms)
Treatment facilities:
- Centralized facility: 11
  (UASB method for 330 coffee farms from 5 ha to 30 ha)
- Individual facility (large): 15
  (UASB method for 15 coffee farms over 30 ha)
- Individual facility (small): 535
  (Oxidation ditch method for 535 coffee farms over 30 ha)
- Reservoir pit: 330
Vacuum car: 11

c) Santo Domingo Coffee Waste Treatment Project
(900 coffee farms)
Treatment facilities:
- Centralized facility: 15
  (UASB method for 435 coffee farms from 5 ha to 30 ha)
- Individual facility (large): 55
  (UASB method for 55 coffee farms over 30 ha)
- Reservoir pit: 435
Vacuum car: 15

d) Espejo Coffee Waste Treatment Project
(840 coffee farms)
Treatment facilities:
- Centralized facility: 12
  (UASB method for 360 coffee farms from 5 ha to 30 ha)
- Individual facility (large): 35
  (UASB method for 35 coffee farms over 30 ha)
- Reservoir pit: 360
Vacuum car: 12

e) La Tebaida Rural Sewage Treatment Project

Intermittent Cycle Processing Facilities:
  Population: 21,000 (for Q. Cristales)
Oxidation ditch: 330 farms

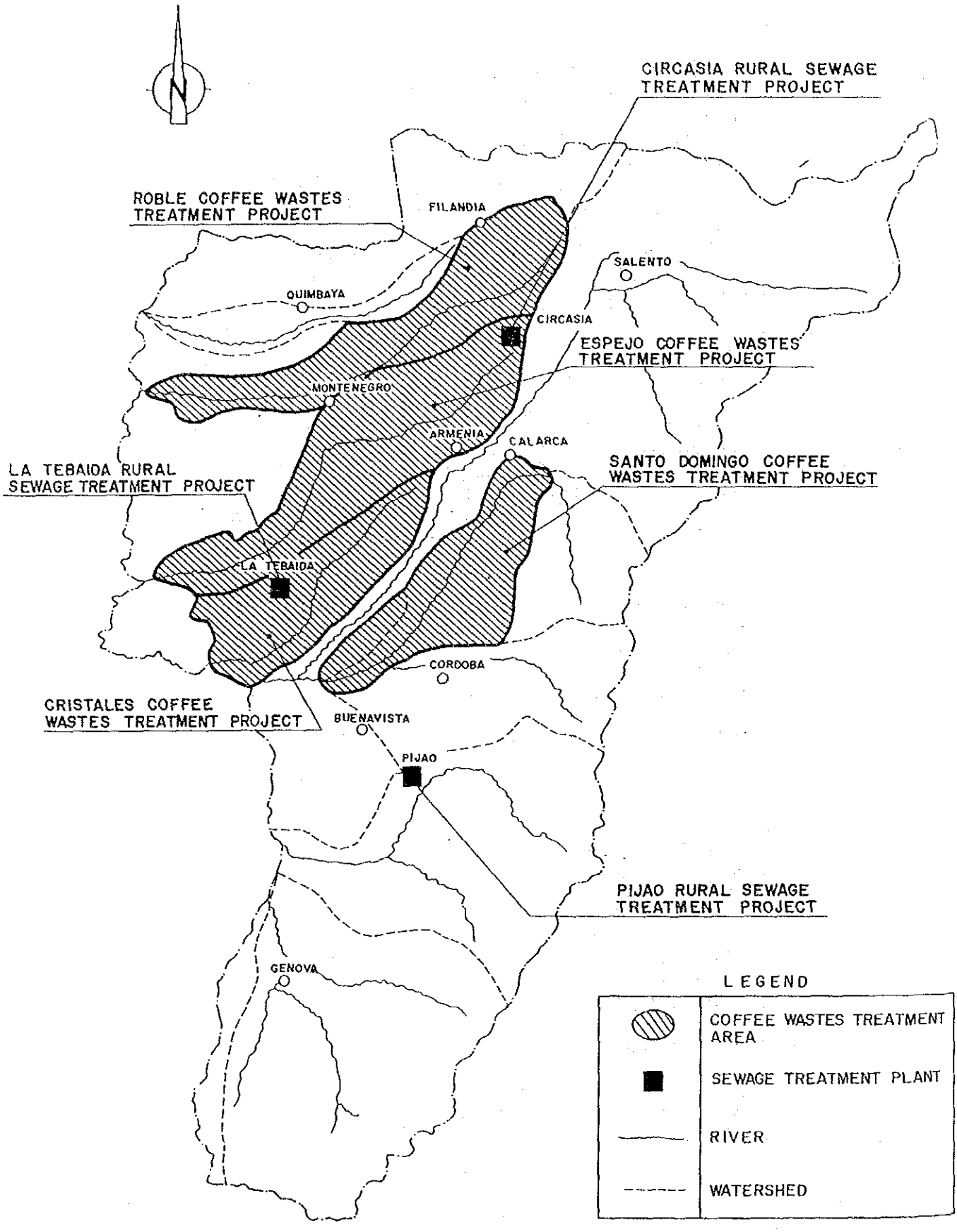


Fig. N.3.3 PROPOSED WATER QUALITY IMPROVEMENT PROJECTS IN THE MASTER PLAN

f) Circasia Rural Sewage Treatment Project

Intermittent Cycle Processing Facilities:
Population: 10,500 (for the Espejo river)
Population: 3,500 (for the Roble river)
Oxidation ditch: 500 farms

g) Pijao Rural Sewage Treatment Project

Intermittent Cycle Processing Facilities:
Population: 4,200 (for The Lejos river)
Oxidation ditch: 850 farms

(4) Rural Infrastructure Improvement Plan

a) Phase I of Rural Road Improvement Project

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

Routes		Distance	Width	Cost
Barragan	- Genova	19.2	9.0	580
La Cabana	- Buenavista	2.0	9.0	50
Arrayanal	- Salento	9.0	9.0	210
Circasia	- La Pola	9.5	9.0	200
Circasia	- Montenegro	15.0	9.0	380
La Tebaida	- El Vergel	13.5	9.0	360
El Vergel	- Calma	3.0	9.0	150
Granada	- Portogal	11.0	19.0	250
El Vergel	- Pescador	11.5	9.0	450
Salent	- La Ceja	10.0	5.0	30
Salent	- La Cocora	10.0	5.0	20
Sub-total		113.7		2,680

b) Phase II of Rural Road Improvement Project

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

Routes		Distance	Width	Cost
Genova	- Pijao	27.0	9.0	810
Pijao	- Cordoba	15.5	9.0	470
Cordoba	- Calarca	27.0	9.0	810
Filandia	- Quimbaya	17.0	9.0	390
Quimbaya	- Sanfelipe	6.0	12.0	390
Puerto Tapao	- La Tebaida	8.5	9.0	200
San Jose	- San Pablo	4.0	9.0	90
La Suiza	- La Maria	11.5	9.0	270
Baraja	- Puerto Samaria	15.0	9.0	350
Quimbaya	- Puerto Alejandoria	13.0	9.0	300
Sub-total		144.5		3,920

c) El Bosque Hydroelectric Power Station Rehabilitation Project

Outline of project: Replacement of the existing generator and turbine with new ones

Dimensions of facilities:		
	water discharge:	3.8 m^3/s
	effective head:	80 m
	capacity:	2,550 kW

Institution: EPA

d) Canpestre Hydroelectric Power Station Rehabilitation Project

Outline of project:
Improvement of the headrace.
Replacement of the existing penstock, turbine, generator and transformer with new ones.

Dimensions of facilities:		
	water discharge:	2.4 m^3/s
	effective head:	60 m
	capacity:	1,200 kW

Institution: EPC

e) Bayona Hydroelectric Power Station Rehabilitation Project

Outline of Project:
Improvement of the headrace.
Replacement of the existing penstock, turbine, generator and transformer with new ones.

Dimensions of facilities:		
	water discharge:	4.6 m^3/s
	effective head:	35 m
	capacity:	1,350 kW

Institution: EPC

f) Southwestern Circasia Rural Water Supply Project

Objective of Project:
Water supply to areas facing the problem of water shortage

Construction of water supply facilities and headrace:
- diversion works driving canal 5 km

Establishment of water supply network system:
supply area: 10 km^2

Intake discharge: 190 m^3/day (2.2 l/s)

Water source: Roble river

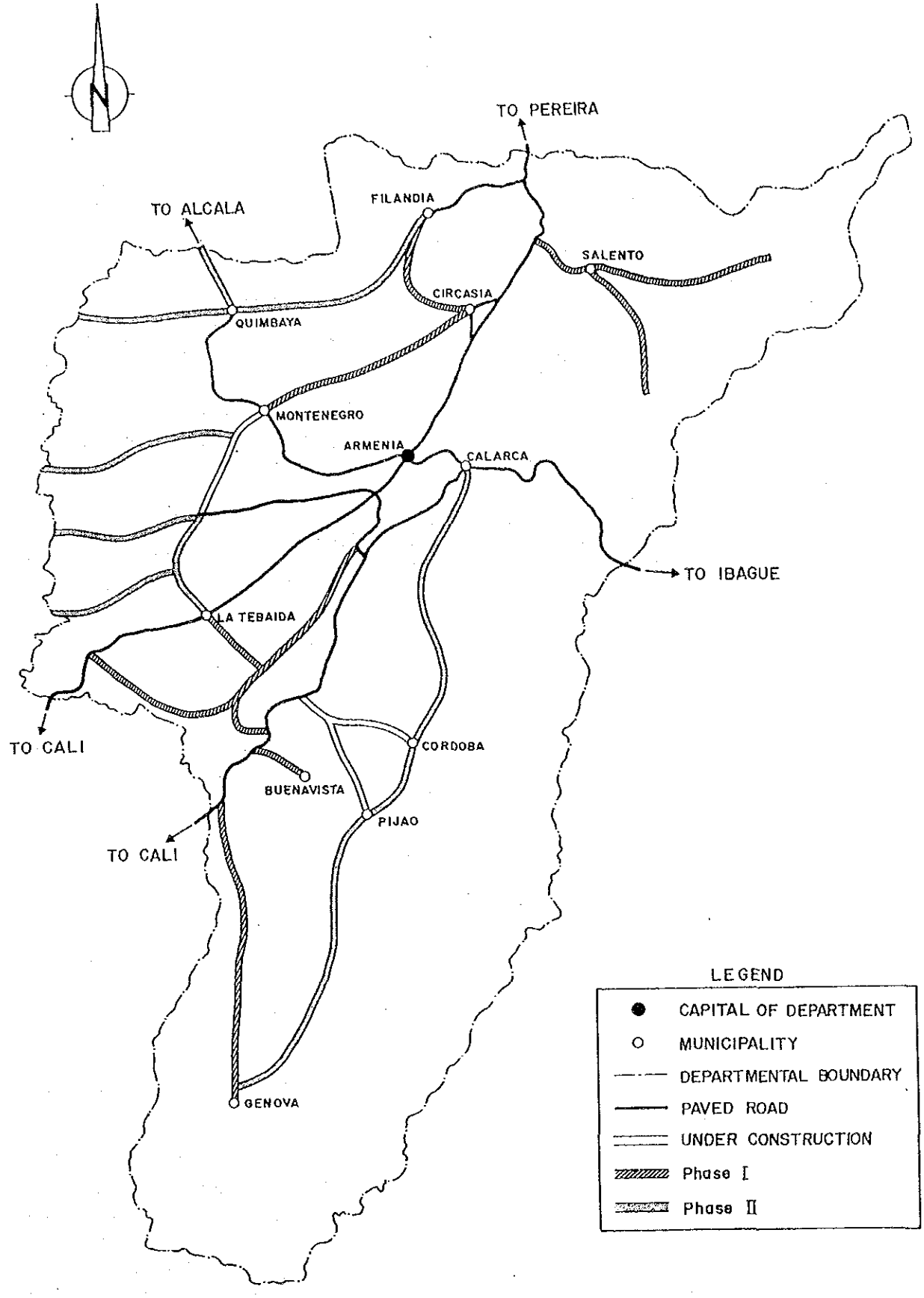


Fig. N.3.4 PROPOSED RURAL ROAD IMPROVEMENT PROJECTS IN THE MASTER PLAN.

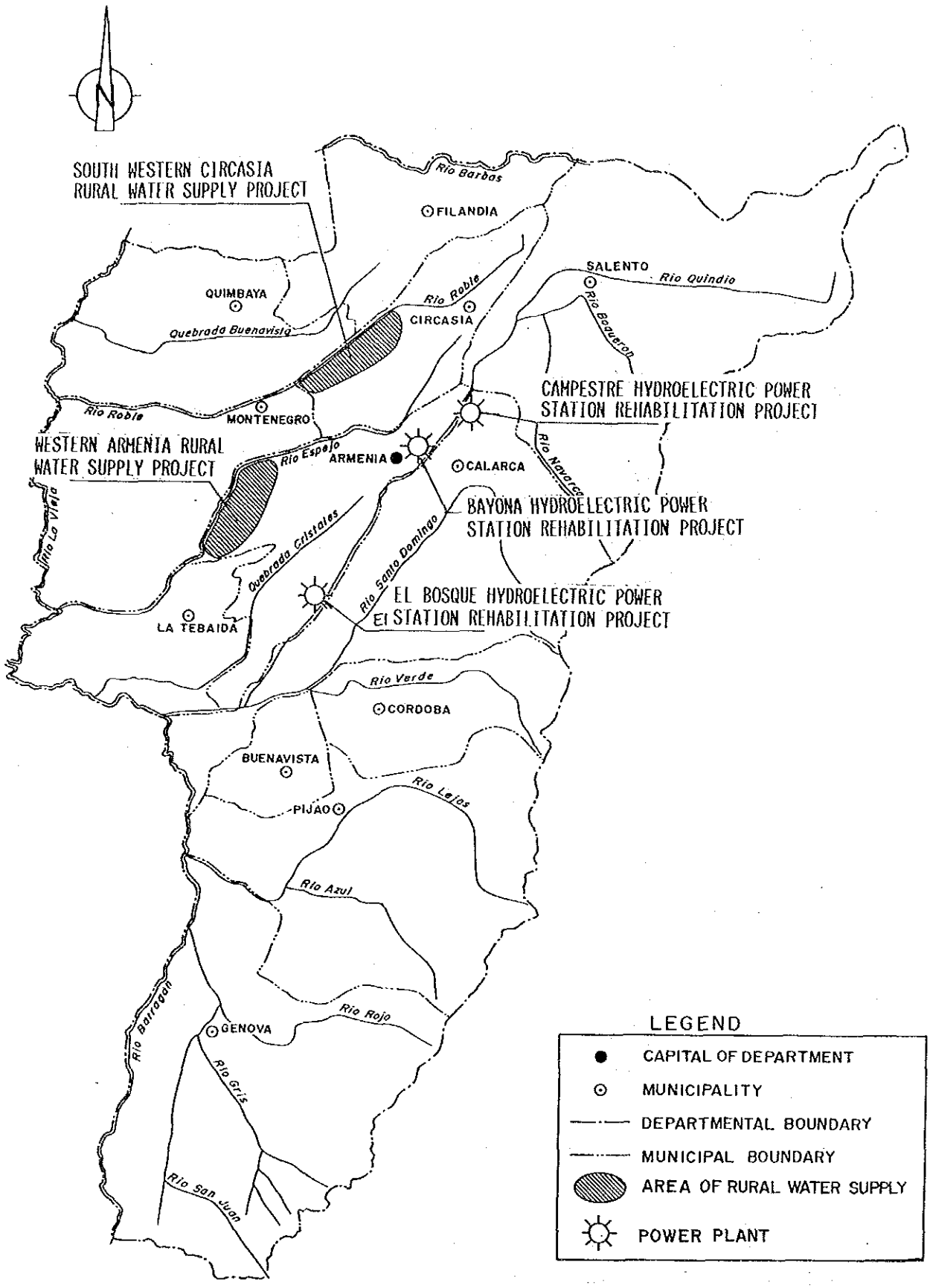


Fig. N.3.5 PROPOSED RURAL WATER SUPPLY AND POWER PLANT IMPROVEMENT PROGRAM

g) Western Armenia Rural Water Supply Project

Objective of Project:
water supply to areas facing the problem of water quality

Improvement of water supply facilities:
well (depth: 100 m), driving canal: 5 km

Construction of water treatment facilities

Establishment of water supply network system:
supply area: 10 km^2

Intake Discharge: 230 m^3/day (2.7 l/s)

Water Source: groundwater

N.3.2 Costs of Projects

Direct construction costs for the projects were roughly estimated based on the market prices in November 1987 and the exchange rate applied is fixed at:

US$1 = Col.$250 = ¥145

Indirect costs were estimated as 30% of the direct construction costs. Preparatory works, administration fee and engineering service fee are included in each indirect cost. Physical contingency was estimated as 20% of each direct construction cost.

List of projects and project cost is shown in Table N.3.1 Project cost are summarized below:

(Million Col.$)

Project	Direct Cost	Indirect Cost	Physical Contingency	Total
Agricultural Development Plan	14,655	4,400	4,235	22,290
Prevention Disaster & Land Conservation Plan	17,290	5,180	3,470	25,940
Water Quality Improvement Plan	9,720	2,945	2,035	14,700
Rural Infrastructure Improvement Plan	7,915	2,401	1,564	11,880
Total	49,580	14,926	10,304	74,810

Table N.3.1 Summary of Project Costs for The Master Plan (1)

Million Col.$

Projects	Direct Cost	Indirect Cost	Physical Contingency	Total
Quindio River Left Margin Agricultural Development Project	880	260	160	1,300
Quindio River Right Margin Agricultural Development Project	8,460	2,540	2,000	13,000
San Jose Agricultural Development Project	2,130	640	430	3,200
Circasia Agricultural Development Project	1,130	340	230	1,700
Genova-Pijas Agricultural Development Project	300	90	60	450
Quindio Agricultural Technical Center	1,730	520	350	2,600
Salento Milk Cooling and Storage Plant	25	10	5	40
Sub-total	14,655	4,400	3,235	22,290
Designating Natural Conservation Area Project	110	35	25	170
Lejos River Disaster Prevention Project	7,760	2,320	1,620	11,700
Gris and Sun Juan Rivers Disaster Prevention Project	4,020	1,200	780	6,000
Santo Domingo River Disaster Prevention Project	3,000	900	600	4,500
Espejo River Improvement Project	1,300	390	210	1,900
Verde River Improvement Project	50	15	5	70
La Vieja River Right Side Area Soil Conservation Project	1,050	320	230	1,600
Sub-total	17,290	5,180	3,470	25,940

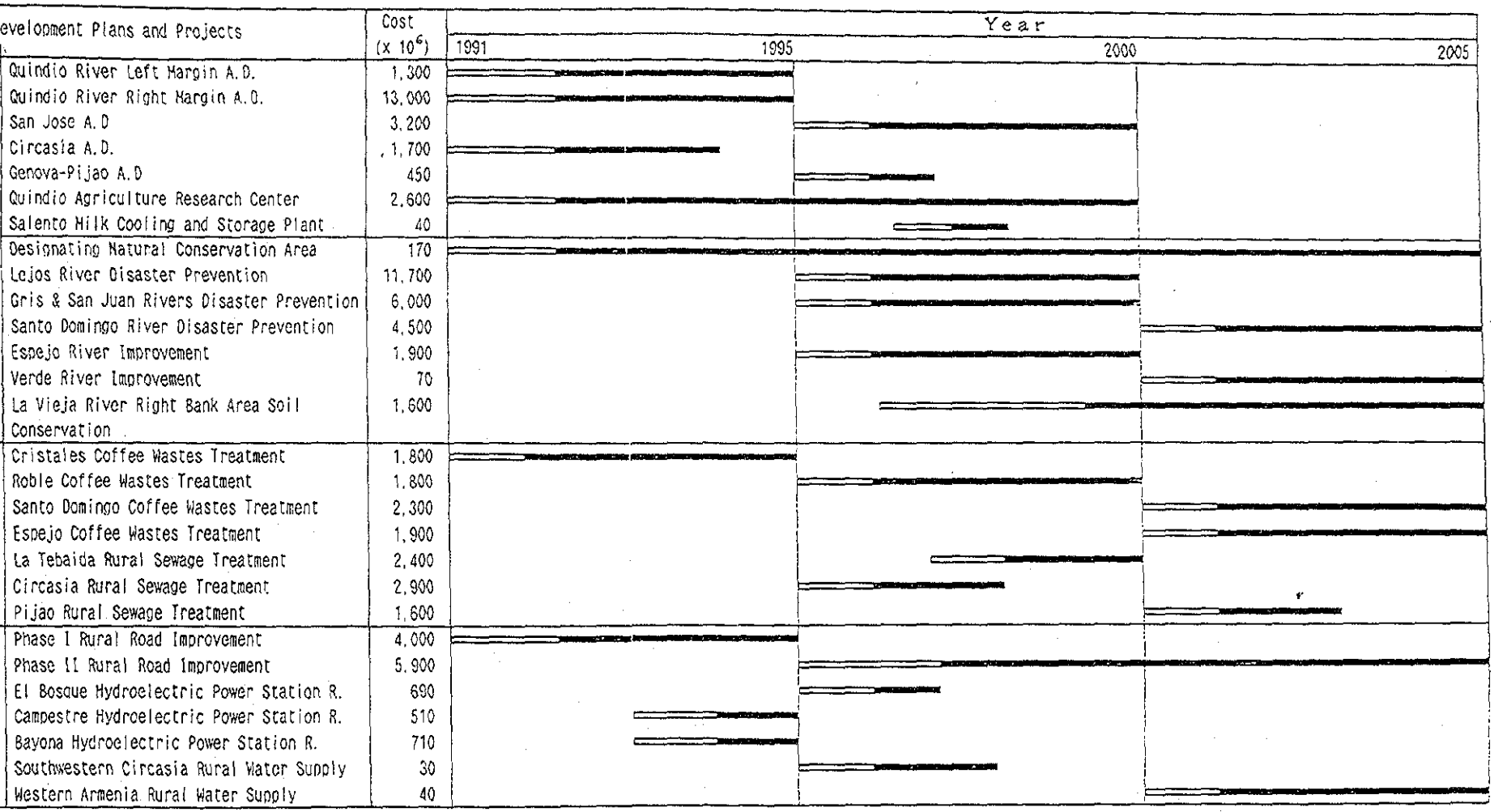
Table N.3.1 Summary of Project Costs for The Master Plan (2)

Million Col.$

Projects	Direct Cost	Indirect Cost	Physical Contingency	Total
Cristales Coffee Waste Treatment Project	1,170	395	235	1,800
Roble Coffee Waste Treatment Project	1,210	350	240	1,800
Santo Domingo Coffee Waste Treatment Project	1,510	450	340	2,300
Espejo Coffee Waste Treatment Project	1,280	380	240	1,900
La Tebaida Rural Sewage Treatment Project	1,600	480	320	2,400
Circasia Rural Sewage Treatment Project	1,900	570	430	2,900
Pijas Domestic Sewage Treatment Project	1,050	320	230	1,600
Sub-total	9,720	2,945	2,035	14,700
Phase I Rural Roads Improvement Project	2,680	800	520	4,000
Phase II Rural Roads Improvement Project	3,920	1,200	780	5,900
El Bosque Hydroelectric Power Station Rehabilitation Project	460	140	90	690
Campestre Hydroelectric Power Station Rehabilitation Project	340	100	70	510
Bayona Hydroelectric Power Station Rehabilitation Project	470	145	95	710
Southwestern Armenia Rural Water Supply Project	20	6	4	30
Western Armenia Rural Water Supply Project	25	10	5	40
Sub-total	7,915	2,401	1,564	11,880
Grand Total	49,580	14,926	10,304	74,810

Fig. N.3.6 THE MASTER PLAN IMPREMENTATION SCHEDULE

	Development Plans and Projects	Cost ($\times 10^6$)
AGRICULTURAL DEVELOPMENT AND PROMOTION PLAN	Quindio River Left Margin A.D.	1,300
	Quindio River Right Margin A.D.	13,000
	San Jose A.D	3,200
	Circasia A.D.	1,700
	Genova-Pijao A.D	450
	Quindio Agriculture Research Center	2,600
	Salento Milk Cooling and Storage Plant	40
LAND CONSERVATION AND DISASTER PREVENTION PLAN	Designating Natural Conservation Area	170
	Lejos River Disaster Prevention	11,700
	Gris & San Juan Rivers Disaster Prevention	6,000
	Santo Domingo River Disaster Prevention	4,500
	Espejo River Improvement	1,900
	Verde River Improvement	70
	La Vieja River Right Bank Area Soil Conservation	1,600
WATER QUALITY IMPROVEMENT PLAN	Cristales Coffee Wastes Treatment	1,800
	Roble Coffee Wastes Treatment	1,800
	Santo Domingo Coffee Wastes Treatment	2,300
	Espejo Coffee Wastes Treatment	1,900
	La Tebaida Rural Sewage Treatment	2,400
	Circasia Rural Sewage Treatment	2,900
	Pijao Rural Sewage Treatment	1,600
RURAL INFRA-STRUCTURE PLAN	Phase I Rural Road Improvement	4,000
	Phase II Rural Road Improvement	5,900
	El Bosque Hydroelectric Power Station R.	690
	Campestre Hydroelectric Power Station R.	510
	Bayona Hydroelectric Power Station R.	710
	Southwestern Circasia Rural Water Supply	30
	Western Armenia Rural Water Supply	40



Preparatory Stage Construction Stage A.D. = Agricultural Development R. = Rehabilitation

N.4 PRELIMINARY FORMULATION OF SUB-REGIONAL INTEGRATED AGRICULTURAL DEVELOPMENT PROJECT

N.4.1 SELECTION OF PROPOSED DEVELOPMENT PROJECTS

For the efficient implementation of agricultural development plans and programs in the Department of Quindio, it is advisable that these plans and programs be integrated into one or more projects which comprise different components required to give a large impact on the implementation of the projects. Furthermore, in view of expecting positive effects on other adjacent sub-regions, an earlier implementation of the projects is essential.

From the above-mentioned point of view, three sub-regions have been selected as the higher priority areas in which viable plans requiring earlier implementation on which those presented in Chapter 6 are concentrated. As a result, the following three integrated agricultural developments have been preliminarily formulated.

(1) The Lower Quindio River Integrated Agricultural Development Project.
(2) Southern Quindio Integrated Agricultural Development Project.
(3) Northern Quindio Integrated Agricultural Development Project.

N.4.2 THE LOWER QUINDIO RIVER INTEGRATED AGRICULTURAL DEVELOPMENT PROJECT

(1) Concept of Project Development

a) Project Background

The lower Quindio basin is situated within the Department of Quindio as an area of higher priority development in terms of agricultural activity. Nevertheless, development potential endowed to this area is evaluated to be higher than the actual level of development, suggesting that this project area offers a major development opportunity. In this connection, an intensified and integrated use of actual natural resources is required to promote further development of the area. It is expected that the implementation of the project with emphasis on agricultural development will serve to relax such constraints as water contamination, etc., and to show an example of future development for the rest of the Department.

b) Project Objective

The principal objective of the Project is to increase agricultural output by means of two basic ways: one is to intensify production per unit of lands where crops are produced depending on their natural conditions, and the other is to incorporate more lands into higher production with the introduction new crops species. The more efficient use of natural resources, the improvement of natural conditions, the adequate provision of social services and agricultural infrastructures are the supplemental objectives of the Project.

c) Development Targets

Development targets of the Project may be summarized as follows:

- To introduce multipurpose irrigation system to arable lands extended in the southern part of Armenia, the surrounding area of La Tebaida and the Lower basin of the Quindio river, and to attain stable farm management by elevating crop productivity per farmer and land, increasing production, and improving the quality of products.

- To introduce a treatment system of coffee related waste water in the farms located within the catchment area of the Cristales river, and to improve ecological condition of the area.

- To consolidate rural road networks and rural water system in the southern parts of America and La Tebaida, and to enhance the living conditions of the inhabitants.

- To establish a wholesale market and a processing installation of agro-products in La Tebaida, and to improve agricultural infrastructure.

- To construct dikes with roads along the lower basin of Quindio and Barragan rivers, and to alleviate flooding caused by these rivers.

- To prepare measures against eroding lands of the slope area on the right bank of the Q. Cristales, and to conserve farmlands.

- To rehabilitate the deteriorated mini-hydroelectric power plants in the Quindio river system, and to generate electric power for stable supply.

- To construct a multipurpose dam within the Quindio river system, and to attain a stable supply of water for irrigation, miscellaneous cropping and drinking, mini-hydroelectric power supplied to urban area, etc.

- To rehabilitate and expand the existing headworks and driving channel of the Caimo Power Station located in the middle basin of the Quindio river, and to incorporate a regional water supply system which includes water for irrigation, miscellaneous cropping and drinking, hydroelectric power generation, urban area, etc.

- To present some alternatives on the improvement of water quality to be taken from the Quindio river while treatment systems for the waste water in Armenia and Calarca should be provided.

(2) Project Outline

a) Land Use Plan

- Actual land use: Coffee, cassava, plantain, beans, grazing land, etc.
- Proposed land use: Citrus, feeding crops, vegetables, pineapples, coffee, plantain, etc.

b) Agricultural Development Plan

1) Cropping Pattern:
.Right Margin area of the Lower Quindio River I (2,500 ha)
- vegetables, feeding crops, beans, coffee, citrus, pineapples.
.Right Margin area of the Lower Quindio River II (2,500 ha)
- coffee, plantain, etc.
.Left Margin area of the Lower Quindio River (1,500 ha)
- citrus, pineapples, coffee.

2) Farm operation plan:
Optimum for area for coffee production (2,500 ha)
- to intensify actual land use of coffee and its intercrop production.
Other area (4,000 ha)
- to incorporate higher productive lands by introducing more profitable crops which are insufficiently produced in the Department.

3) Irrigation and drainage plan:
Rehabilitation of existing headworks and driving canal and construction of new driving canal and drainage canal.
Water Requirement: Left margin of Quindio: 0.71 m^3/s
Right margin of Quindio: 2.44 m^3/s
Irrigation canals: main canal: 61.0 km
secondary: 56.0 km
Drainage canal: 60 km
Pumping station: D=350mm, H=60m, 1 unit
Field irrigation system: 168 sets

4) Land reclamation plan:
Left margin of Quindio: 1,500 ha
Right margin of Quindio: 5,000 ha
Farm Road: 430 km

5) Water resources development plan:
Navarco dam aimed at irrigation, and rural water supply
- height: 45 m, effective water volume: 6 million m^3
El Bosque head works
- intake water discharge: 7.22 m3/s, total length: 181.5 m, height of crest: 1 m, gate: 3.1x1.9, 3 units

Driving canal: 70 km (rehabilitation)
Barragan pumping station aimed at irrigation
- D=350mm, H=15m, 3 units

6) Agro-industry development plan:
La Tebaida - agro-product processing plant.

7) Marketing system improvement plan:
La Tebaida - agro-products packing factory, wholesale market and formation of cooperatives.

8) Agricultural Technical Center:
La Tebaida (20 ha, vegetable, citrus, coffee)

c) Disaster Prevention and Land Conservation Plan

1) Disaster prevention plan:
Alignment of dikes with 10 km road
- La Vieja, Quindio and Barragan rivers.

2) Land conservation plan:
Slope protection works
- slope land at right margin of the Cristales river.

d) Water Improvement Plan

Coffee water waste treatment plan: Basin of Q. Cristales
Treatment facilities
- Centralized facility: 11
  (UASB method for 330 coffee farms from 5 ha to 30 ha)
- Individual facility (large): 55
  (UASB method for 55 coffee farms over 30 ha)
- Individual facility (small): 285
  (Oxidation ditch for 285 coffee farms under 5 ha)
- Reservoir pit: 330
Vacuum car: 11

e) Rural Infrastructure Development Plan

1) Road development plan: Rural roads: 39 km

2) Mini-hydroelectricity plan:
Rehabilitation of existing stations: Bayona and Canpestre.

3) Rural water supply plan: La Tebaida: 0.05 m^3/s

N.4.3 SOUTHERN QUINDIO INTEGRATED AGRICULTURAL DEVELOPMENT PROJECT

(1) Project Development Concept

a) Project Background

The southern sub-region of Quindio, which comprises a major part of Pijao and Genova is diagnosed as follows:

- The project area, far from the capital city of Armenia within the Department, is geographically unfavorable located. In addition, the complicated topography represented by steep slope has left is road network unconsolidated. The development level of social infrastructure in this area is also inferior to that of other sub-region of the Department.

- Crop production is not carried out in such an adequate manner as to facilitate the better use of land and other natural resources.

- The disordery development of river basins such as the practice of shifting cultivation and deforestation which are involved in the above-mentioned inappropriate land use has caused frequent mud flows and flooding.

- Though the quality of water in the Project area is relatively good at present, it may deteriorate in the future as the development of sub-region is accelerated. Especially, being located upstream of rivers, the pollution of water in this area will have greater influence on downstream areas.

The situation mentioned above regarding the Project area has prevented the area from being properly developed for agricultural purpose, which is turn has driven local population to emigrate to other places. Thus the imbalance between the area in question and developed sub-regions is accelerated.

Under the circumstances, the implementation of sub-regional development focused on the encouragement of agricultural sector in southern part of the Department will be essential so that the Department may have balanced development.

b) Project Objectives

The implementation of the southern Quindio integrated agricultural development project aims at achieving the following objectives.

1) Recovery of ecological conditions

Due to the disordery development of catchment area, the destruction of natural conditions is evident in the Project area. Therefore, the recovery of ecological conditions is an important component within the context of the formulation of the project.

2) Domiciliation of rural population

With an adequate provision of social infrastructure and enhancement of living standard, the rural-urban emigration will be alleviated.

3) Encouragement of small farmers

At present, small farmers are conducting unstable farm operations with inadequate land use and cropping systems, resulting in decreased land productivity together with larger imbalance among sub-regions. Taking this into account, the Project should be implemented with a view to encouraging small farmers.

4) Improvement of land communication system

Deficiency in road network is one of the factors that have left the Project area underdeveloped. The improvement of road network to connect the rest of the Department is necessary.

c) Development Targets

Targets for the implementation of the Project consist of:

1) Improvement of agricultural infrastructure to encourage small farmers.

2) Formation of producers' association as a supporting structure to encourage small farmers.

3) Improvement of land communication system.

4) Adequate provision of social infrastructure to promote the domiciliation of rural population and to redress imbalanced development level.

(2) Project Outline

a) Land Use Plan

Actual land use: Grass land
Projected land use: Vegetable, Fruits

b) Agricultural Development Plan

1) Cropping pattern: Pijao (200 ha) - Vegetables and fruits
Genova (200 ha) - Vegetables and fruits

2) Farm operation plan: Unit yield and output plan
Labor requirement

3) Irrigation and drainage plan:
Peak water requirement: 1.6 m^3/s
Field irrigation system: 10 sets
Drainage canal: 4 km

4) Land reclamation plan: 400 ha
Farm roads: 40 km

5) Agro-industry development plan:
Product packing plants (Pijao, Genova)

6) Marketing system improvement plan:
Formation of producers cooperative

7) Livestock development plan:
Swine raising promotion plan (Contract basis)
Breeding and feeding mills

c) Disaster Prevention and Land Conservation Plan

1) Disaster prevention plan:
Lejos and Gris and San Juan river: watershed: 187.0 km
Flood control dam in Lejos river:
height: 33 m, capacity: 2.3 million m^3, concrete dam
Disaster prevention dam: height 5 m, 13 units
Reforestation: 37.3 km^2
Woodland path network: 32.0 km

2) River protection plan:
River wall works in Gris and San Juan river: 10 km
River wall works in Lejos river: 7 km

d) Water Improvement Plan

1) Sewage treatment plan in Pijao:
Intermittent cycle facilities: population: 4,200
Land treatment facilities: 850 farms

e) Rural Infrastructure Improvement Plan

1) Roads improvement plan: Rural roads 61.7 km (width: 9 m)
96.0 km (width: 5 m)

N.4.4 NORTHERN QUINDIO INTEGRATED AGRICULTURAL DEVELOPMENT PROJECT

(1) Project Development Concept

a) Project Background

The project area, being developed in its greater portion for grazing and forestation lands, presents low land productivity in comparison with its potentials. The lack of road network and deficient provision of technical assistance to farmers are the major causes of under development of the area. Nevertheless, the endowments of less undulating topography and fertile soils intimate that the Project area has high potentials being developed for crop production. The development of this sub-region is expected to contribute an increase in agricultural production in the departmental level.

b) Project Objectives

The implementation of the Project has objectives to serve as elevating the land productivity of sub-region, correcting imbalanced level of development within the Department, and contributing to the increase of agricultural output of the Departmental in total.

The farmers in this project area are represented by small farmers who are cultivating crops out of coffee, so that encouragement of these small farmers is one supplemental objective of the Project.

c) Project Targets

The implementation of the Project includes the following targets:

- To carry out the reclamation of farmlands extending in and around Circasia, and to realize agrarian reform for recruiting settlers from among the farm workers within Quindio. This sub-project will provide an investigation and extension center for new crops.
- To incorporate demonstrative farm and extension office in to various areas within the project area.
- To associate farmers so as to facilitate extension service and the marketing of products.
- To improve trunk and secondary roads so that the transportation of products together with encouraging crop production.
- To provide an agro-products packing plant lest quality deterioration in transit should not take place.
- To construct a milk cleaning plant for facilitating the commercialization of dairy products.

- To incorporate a coffee related waste water treatment plant in the upstream of the Roble river, and to recover ecological conditions.

- To make better use of the existing pisciculture installation, extend fish raising technique, and elevate productivity.

(2) Project Outline

a) Land Use Plan

- Actual land use: Arable land, grazing land, forest, etc.

- Project land use: Vegetables, fruits, arable land, etc.

b) Agricultural Development Plan

1) Cropping pattern: Circasia 91,600 ha)
- vegetables, fruits, feed crops.

2) Farm operation plan:
- Diversification of farm operations by introducing vegetables
- Main activity, fruit and small and medium

3) Irrigation and drainage plan:
Peak water requirement: 0.50 m^3/s
Field irrigation system: 36 sets
Drainage canal: 16 km

4) Land reclamation plan: 1,600 ha
- Farm road: 160 km

5) Agro-industry development plan:
Circasia (breeding, feed mill and pork processing plant)
Salento (milk cleaning plant)

6) Agricultural technical center:
Circasia (8 ha, vegetable and citrus)

c) Water Improvement Plan

Coffee waste water treatment plan: Roble river basin
Treatment facilities:
- Centralized facility: 11
(UASB method for 330 coffee farms from 5 ha to 30 ha)
- Individual facility (large): 15
(UASB method for 15 coffee farms over 30 ha)
- Individual facility (small): 535
(Oxidation ditch method for 535 coffee farms under 5 ha)
- Reservoir pit: 330
Vacuum car: 11

d) Rural Infrastructure Improvement Plan

Road improvement plan: Rural roads: 33.5 km (width: 9 m)
20.0 km (width: 5 m)

N.4.5 ESTIMATED COST

Based on the cost estimation of the Master Plan, project costs of sub-regional integrated agricultural development projects were estimated as shown in Table N.4.1 and summarized below:

(Million Col.$)

Project	Direct Cost	Indirect Cost	Physical Contingency	Total
Integrated Agricultural Development project of the Lower Quindio Basin	13,010	3,943	2,897	19,850
Southern Quindio Integrated Agricultural Development Project	15,320	4,950	3,130	23,040
Northern Quindio Integrated Agricultural Development Project	3,895	1,160	785	5,840

Table N.4.1 Summary of Project Costs (Sub-Regions)

Million Col.$

Projects	Direct Cost	Indirect Cost	Physical Contingency	Total
The Lower Quindio River Integrated Agricultural Development Project				
Left Margin of the Lower Quindio River Agricultural Development Project	880	260	160	1,300
Right Margin of the Lower Quindio River Agricultural Development Project	8,460	2,540	2,000	13,000
Agro-product Processing Plant	240	70	50	360
Agricultural Technical Center	170	50	30	250
Slope Land Conservation Project at the Right Margin of Q. Cristales	50	15	10	75
Coffee Waste Treatment project on Q. Cristales Basin	1,170	395	235	1,800
Rural Roads Improvement Project	1,220	365	245	1,830
Canpestre Mini-Hydroelectric Power	340	100	70	510
Bayona Mini-hydroelectric Power Station Rehabilitation project	470	145	95	710
La Tebaida Rural Water Supply Project	10	3	2	15
Total	13,010	3,943	2,897	19,850
Southern Quindio Integrated Agricultural Development Project				
Genova, Pijao Agricultural Development Project	300	90	60	450
Disaster Prevention Project on the Lejos River Basin	7,760	2,320	1,620	11,700
Disaster Prevention project on the Gris and Sun Juan River Basin	4,020	1,200	780	6,000
Rural Sewage Treatment Project on Pijao	1,050	320	230	1,600
Rural Roads Improvement Project (Width: 9 m)	1,860	560	370	2,790
Rural Roads Improvement Project (Width: 5 m)	330	100	70	500
Total	15,320	4,590	3,130	23,040
Northern Quindio Integrated Agricultural Development Project				
Circasia Agricultural Development Project	1,130	340	230	1,700
Agricultural Technical Center	100	30	20	150
Swine Breeding, Feed Mill and Pork Processing Plant	600	180	120	900
Milk Cooling and Storage Plant	25	10	5	40
Coffee Waste Treatment Project on the Roble River Basin	1,210	350	240	1,800
Rural Roads Improvement Project (Width: 9 m)	780	235	160	1,175
Rural Roads Improvement Project (Width: 5 m)	50	15	10	75
Total	3,895	1,160	785	5,840

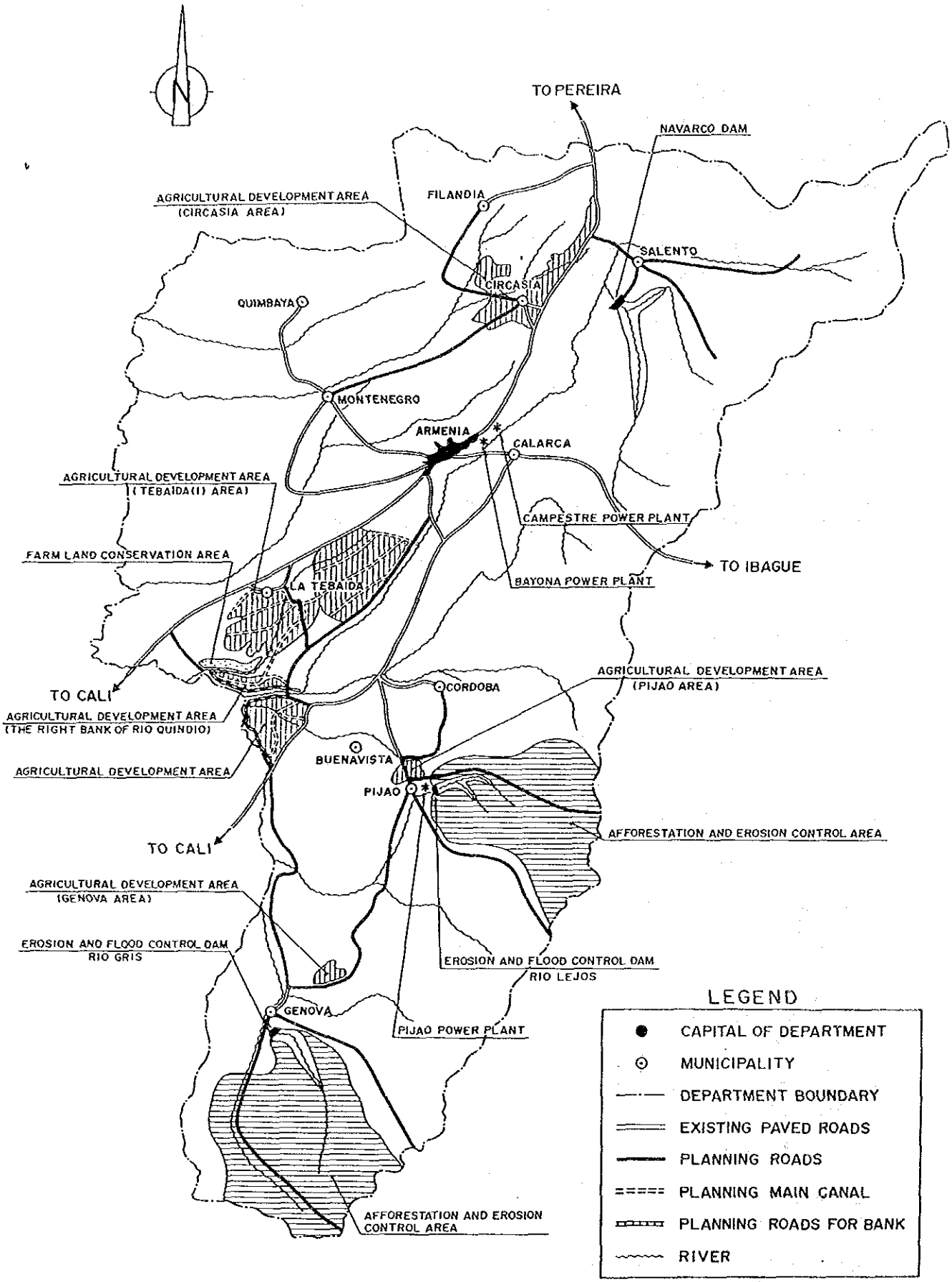


FIG.N.4.1. PROPOSED PROJECTS OF SUB-REGIONAL INTEGRATED AGRICULTURAL DEVELOPMENT PLAN

N.5 HIGH PRIORITY PROJECT (I)

N.5.1 OBJECTIVE OF HIGH PRIORITY PROJECT (I)

Objective of high priority project is summarized below:

- to redress unbalanced development level among sub-regions
- improvement of productivity for coffee production
- improvement of living condition
- diversification of agriculture
- effective use of water resources
- protection and conservation of natural resources

According to the objectives above, projects were selected from among sub-regional integrated agricultural development plans, and high priority project was reformulated with consideration to necessity, urgency and feasibility.

N.5.2 PROJECT FORMULATION

(1) Agricultural Development Project

a) Project Area

Following project areas were selected for the high priority project.

	Project Area	Cropping Area
Quindio River Left Margin Area	1,500 ha	1,110 ha
Quindio River Right Margin Area (1)	2,500 ha	1,900 ha
Quindio River Right Margin Area (2)	2,500 ha	1,720 ha
Circasia Area	1,600 ha	1,080 ha
Total	8,100 ha	5,810 ha

b) Irrigation Plan

Considering the existing conditions of agricultural management, time should be allowed for training the formers for the management of intensive agriculture using the irrigation system. Therefore, it is better to introduce irrigation system to a small area at an initial stage, and to expand irrigation area after the knowhow of using irrigation system has been attained step by step.

Considering the time schedule of the Master Plan, the areas for vegetable and an approximately 10% of coffee areas should be selected for irrigation area. Depending on the proposed cropping patterns in the project areas, following irrigation areas are recommended at an initial stage.

	Irrigation Area	
Quindio River Left Margin Area	Vegetable	140 ha
Quindio River Right Margin Area (1)	Vegetable	200 ha
	Coffee	80 ha
Quindio River Right Margin Area (2)	Coffee	240 ha
Circasia Area	Vegetable	240 ha
Total		860 ha

Peak water requirements are summarized below:

Quindio River Left Margin Area	0.11 m^3/s
Quindio River Right Margin Area (1)	0.18 m^3/s
Quindio River Right Margin Area (2)	0.14 m^3/s
Circasia Area	0.12 m^3/s
Total	0.55 m^3/s

Considering twenty-seven continuous drought days at a 5 year return period, following water reservoirs are required.

Quindio River Right Margin Area (1)
- farm pond type (effective water volume: 3,000 m^3) 10 units

Quindio River Right Margin Area (2)
- concrete weir type (effective water volume: 2,00 m^3) 3 units

Considering the irrigation areas, following field irrigation systems are required.

Quindio River Left Margin Area	5 sets
Quindio River Right Margin Area (1)	10 sets
Quindio River Right Margin Area (2)	7 sets
Circasia Area	8 sets
Total	30 sets

c) Drainage Improvement and Land Reclamation Plan

Drainage improvement in poor drainage areas in flatlands at the both margins of the lower Quindio river were planned as follows:

Quindio River Left Margin Area	1,000 ha, 15.0 km
Quindio River Right Margin Area (1)	500 ha, 7.5 km

Depending on the land slope in project areas, land reclamation plans were projected as follows:

Land Classification	Under 3%	3% to 5%	Over 5%
Quindio River Left Margin Area	1,200 ha	500 ha	-
Quindio River Right Margin Area (1)	1,200 ha	1,300 ha	-
Quindio River Right Margin Area (2)	-	-	-
Circasia Area	-	300 ha	1,300 ha
Total	2,200 ha	2,100 ha	1,300 ha

d) Livestock Development and Freshwater Fish Culture Plan

A breeding center for the distribution of pigs to contract farmers with the provision of extension services was planned in Circasia. Institution of the breeding center may be done by livestock farmers cooperative and outline of the project is as below:

Institution: livestock farmers cooperative (400 farmers)
Breeding pigs: 400 heads
Swine production: 6,400 heads/year
(approximately 16 heads/farmer)

In addition, freshwater fish culture such as Tirapia, etc. should be promoted in parallel with swine production in Circasia Area. In planning of freshwater fish culture, adjustment with other freshwater fish culture which is being promoted by DRI-CRQ should be required.

Culture pond: 400 places (200 sqr.m/place)
Number of fish: 600 heads/pond

e) Farmers' Cooperation Association

Motivation and encouragement to organize a farmers cooperative in La Tebaida (520 farmers) and Circasia (400 farmers) for coffee production should be promoted. At the same time, the improvement of a marketing system to facilitate the sale of products supplied by cooperatives should be strengthened.

f) Experimental Form

The provision of an agricultural technical center is hereby proposed so as to resolve a number of problems confronted by the agricultural sector of the Department and to accelerate the coordination among related various projects and coordinated implementation. Therefore, following components are selected at an initial stage for the high priority project.

La Tebaida Slop Land Experimental Farm
- 20 ha, vegetable, citrus, coffee
Circasia Slop Land Experimental Branche Form
- 8 ha, vegetable, citrus

g) Agro-products Processing Facilities

Considering the proposed cropping pattern for the high priority project, following agro-products processing facilities were planned.

1. Circasia feed mill plant: 500 tons of swine/month
2. Circasia pork processing plant: 1 ton/day (ham, etc.)
3. La Tebaida agro-products processing plant:
   30 tons/day (pineapple, tomato)

(2) Rural Infrastructure Plan

a) Rural Road Improvement

Considering the redressing of unbalanced development level and agricultural project areas, following routes were selected for the high priority project.

Routes		Distance (km)	Width (m)
Barragan	- Genova	19.2	9.0
Arrayanal	- Salento	9.0	9.0
La Cabana	- Buenavista	2.0	9.0
Circasia	- Montenegro	15.0	9.0
Circasia	- La Pola	9.5	9.0
Pescador	- El Velgel	11.5	9.0
Poltogal	- Granada	11.0	9.0
La Tebaida	- El Velgel	13.5	9.0
El Velgel	- Calama	3.0	9.0
Salento	- Cocora	10.0	5.0
Salento	- Siberia	10.0	5.0
Total		113.7	

b) Mini-hydroelectric Power Station Development

Rehabilitation of mini-hydroelectric power stations in Campestre and Bayona were planned for the high priority project. Outline of projects are below:

Rehabilitation plan: Improvement of the existing driving canal
Replacement of the existing penstock, turbine, generator and transformer with new ones.

Dimensions of facilities:

	Campestre	Bayona
- water discharge	2.4 m^3/s	4.6 m^3/s
- effective head	60 m	35 m
- capacity	1,200 kW	1,350 kW
- institution	EPC	EPC

(3) Land Conservation and Disaster Prevention Plan

Considering the current damage due to flood disaster to Pijao and Genova, urgent flood control projects in the Lejos river and the Gris, San Juan river were planned. Outline of projects are summarized below:

	Pijao	Genova
River:	Lejos	Gris
Design flood discharge:	300 m^3/s	290 m^3/s
River wall works:	7 km	10 km
Improvement of bridge:	1	2

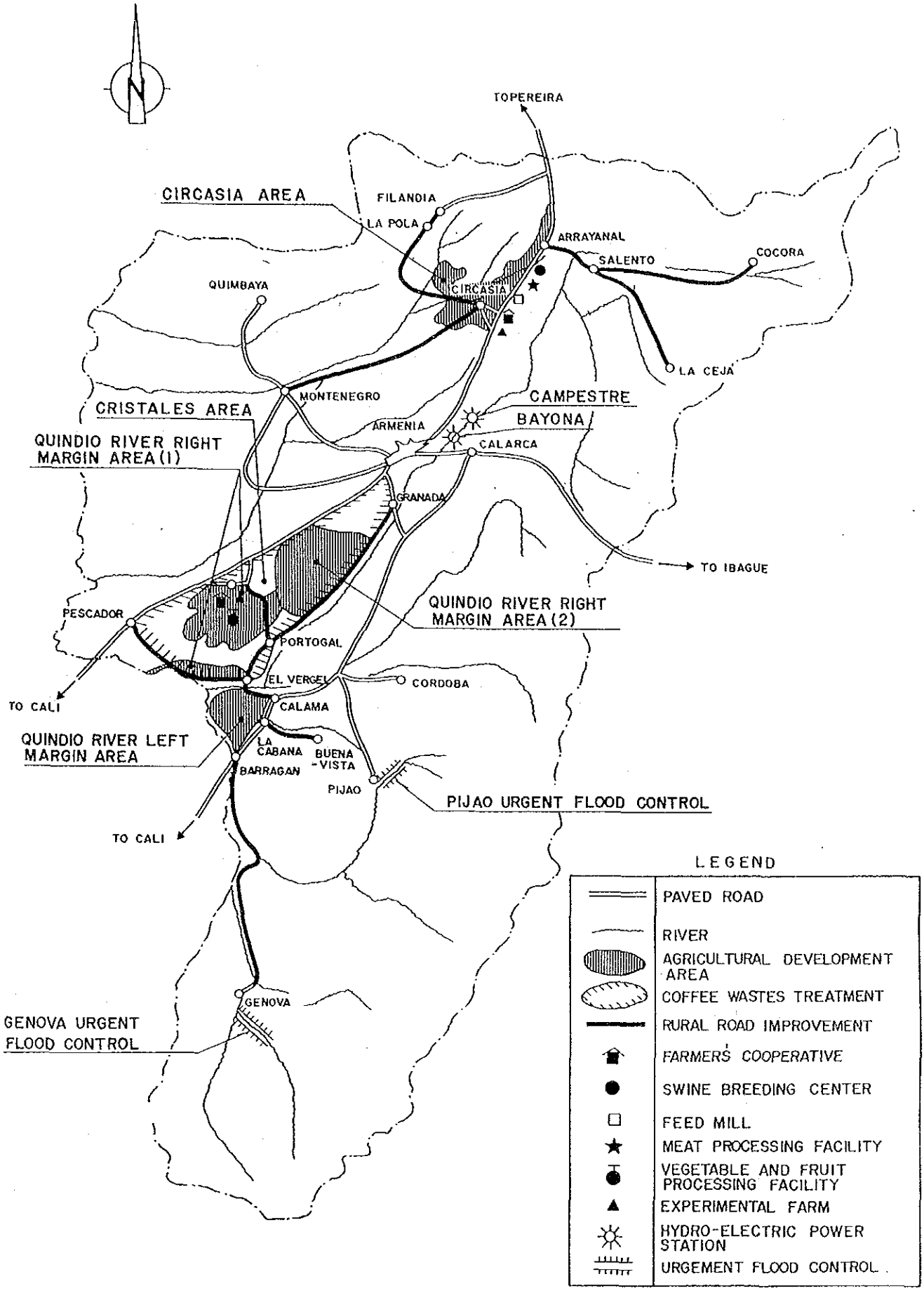


Fig. N.5.1 COMPONENT OF THE HIGH PRIORITY PROJECT I

(4) Water Quality Improvement Plan

Considering the existing condition of water quality, the basin of Q. Cristales is selected for the high priority project as a coffee waste water treatment model project. Outline of one project is summarized below:

Treatment facilities:
- Centralized facility: 11
  (UASB method for coffee farms from 5 ha to 30 ha)
- Individual facility (large): 55
  (UASB method for coffee farms over 30 ha)
- Individual facility (small): 285
  (Land treatment for coffee farms under 5 ha)
- Reservoir pit: 330

Vacuum car: 11

N.5.3 ESTIMATED COST

(1) Project Cost

Based on the market prices as of September 1987, direct construction costs were estimated. Exchange rate is fixed as follows:

US$1 = Col.$250 = ¥145

Indirect costs were estimated as 30% of the direct construction cost. Preparatory works, administration fee and engineering service fee are included in each indirect cost. Physical contingency was estimated as 20% of each direct construction cost. According to the implementation schedule of the high priority project, annual disbursement schedule was made as shown in Table N.5.1. 5% (in foreign currency) and 15% (in local currency) of cost escalation rate are applied and price escalation was calculated based on the disbursement schedule.

Project cost of the high priority project is shown in Table N.5.2 and summarized below:

(Million Col.$)

	Foreign Currency	Local Currency	Total
Direct Cost	7,878	1,722	9,600
Indirect Cost	1,300	1,580	2,880
Physical Contingency	1,580	340	1,920
Sub-total	10,758	3,642	14,400
Price Escalation	3,616	4,607	8,223
Grand Total	14,374	8,249	22,623

(2) Operation and Maintenance Cost

The annual operation and maintenance cost is estimated as 1.5% of the direct cost, indirect cost and physical contingency considering similar projects in Colombia and summarized below:

220 million Col.$/annual

Replacement cost has been estimated as shown below:

Pipes and sprinklers of field irrigation system	230 million Col.$	20 years
Pumps and electric facilities	130 million Col.$	30 years
Instruments of mini-hydroelectric power plant	420 million Col.$	35 years

Fig.N.5.2 Implementation Schedule of High priority project

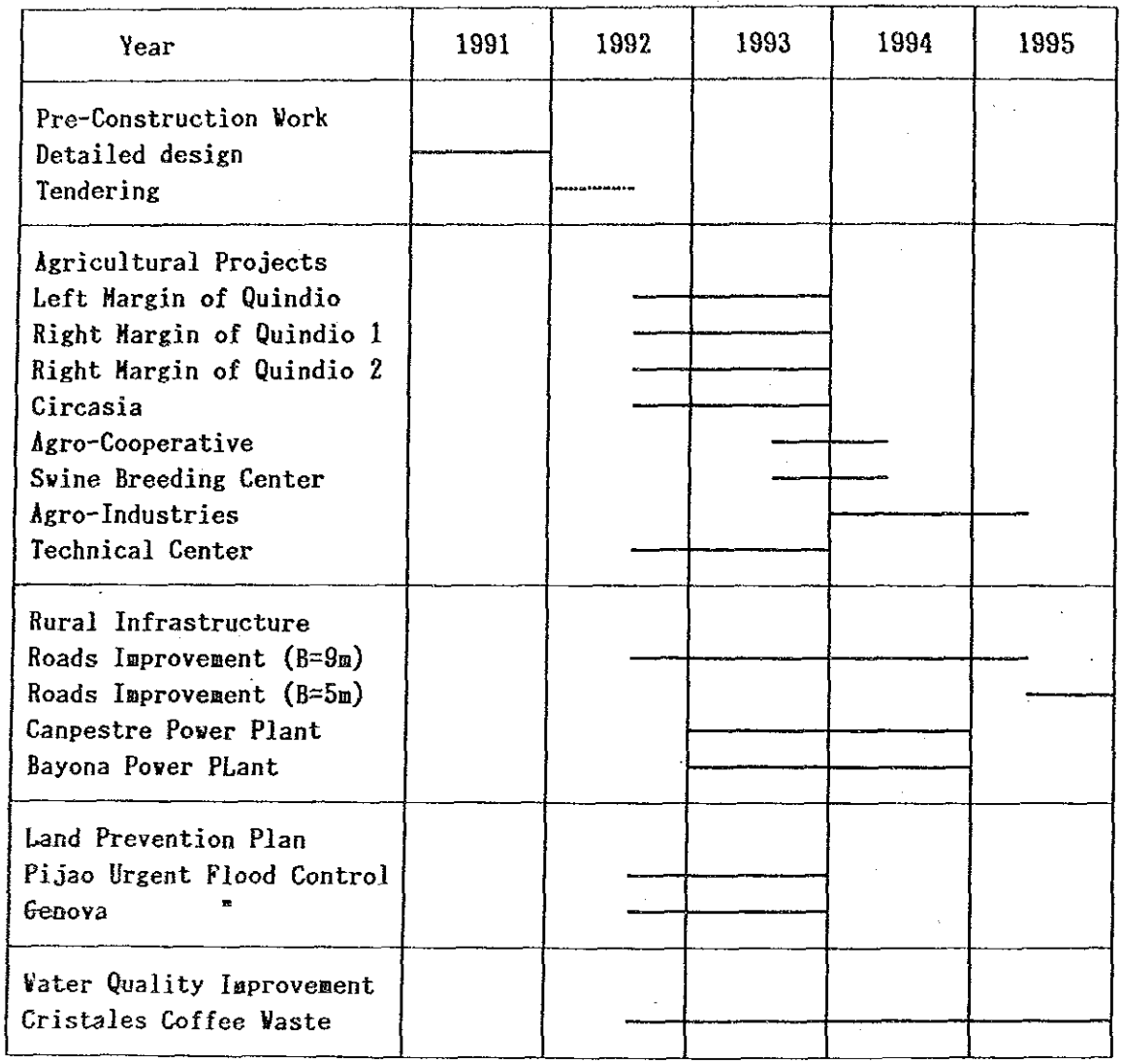


Table N.5.1 Summary of Annual Disbursment Schedule

Base Year : 1987 Cost Unit Million Col$

Item	1991		1992		1993		1994		1995		Grand Total		
	Foreign	Local	Foreign	Local	Foreign	Local	Foreign	Local	Foreign	Local	Foreign	Local	Total
Left margin of Quindio	—	—	146	34	219	51	—	—	—	—	365	85	450
Right margin of Quindio (1)	—	—	262	58	393	87	—	—	—	—	655	145	800
Right margin of Quindio (2)	—	—	31	5	47	7	—	—	—	—	78	12	90
Circasia	—	—	256	56	384	84	—	—	—	—	640	140	780
Agricultural Cooperative	—	—	—	—	5	3	7	5	—	—	12	8	20
Swine Breeding Center	—	—	—	—	6	4	6	4	—	—	12	8	20
Feeding Mill Plant	—	—	—	—	—	—	22	10	6	2	28	12	40
Pork Processing Plant	—	—	—	—	—	—	22	10	6	2	28	12	40
Agro-Product Processing Plant	—	—	—	—	—	—	136	56	34	14	170	70	240
Agricultural Technical Center	—	—	110	25	110	25	—	—	—	—	220	50	270
Rural Road Improvement (1)	—	—	460	66	690	99	920	132	230	33	2300	330	2630
Rural Road Improvement (2)	—	—	—	—	—	—	—	—	40	10	40	10	50
Canpestre Mini-Hydro Power	—	—	—	—	150	20	150	20	—	—	300	40	340
Bayona Mini-Hydro Power	—	—	—	—	210	25	210	25	—	—	420	50	470
Pijao Emergency Flood Control	—	—	296	68	444	102	—	—	—	—	740	170	910
Genova Emergency Flood Control	—	—	408	104	612	156	—	—	—	—	1020	260	1280
Q.Cristales Water Quality	—	—	85	32	255	96	255	96	255	96	850	320	1170
Preparatory Works	—	—	—	480	—	—	—	—	—	—	—	480	480
Administration	—	384	—	144	—	144	—	144	—	144	—	960	960
Engineering Service	1040	112	65	7	65	7	65	7	65	7	1300	140	1440
Physical Contingency	237	51	237	51	474	102	395	85	237	51	1580	340	1920
Subtotal	1277	547	2356	1130	4064	1012	2189	593	872	360	10758	3642	14400
(Foreign + Local)	(1824)		(3486)		(5076)		(2782)		(1232)				
Price Escalation	275	410	651	1143	1382	1329	891	984	416	741	3616	4607	8223
(Foreign + Local)	(685)		(1794)		(2711)		(1876)		(1157)				
Grand Total	1552	957	3007	2272	5446	2342	3080	1577	1289	1101	14374	8249	22623
(Foreign + Local)	(2509)		(5280)		(7787)		(4658)		(2389)				

Table N.5.2 Summary of Estimated Costs High Priority Project)

(Cost Unit : Million Col$)

Description	Foreign Currency	Local Currency	Total
1. Agricultural Development Plan			
(1) Left Margin of the Lower Quindio River	365.0	85.0	450.0
(2) Left Margin of the Lower Quindio River (1)	655.0	145.0	800.0
(3) Left Margin of the Lower Quindio River (2)	78.0	12.0	90.0
(4) Circasia	640.0	140.0	780.0
(5) Agricultural Producers' Cooperative	12.0	8.0	20.0
(6) Swine Breeding Center	12.0	8.0	20.0
(7) Feed Mill Plant	28.0	12.0	40.0
(8) Pork Processing Plant	28.0	12.0	40.0
(9) Agro-Product Processing Plant	170.0	70.0	240.0
(10) Agricultural Technical Center	220.0	50.0	270.0
Sub-Total [1.]	2208.0	542.0	2750.0
2. Rural Infrastructure Improvement Plan			
(1) Rural Roads Improvement (Width : 9m)	2300.0	330.0	2630.0
(2) Rural Roads Imorovement (Width : 5m)	40.0	10.0	50.0
(3) Canoestre Mini-Hydroelectric Power Plant	300.0	40.0	340.0
(4) Bayona Mini-Hydroelectric Power Plant	420.0	50.0	470.0
Sub-Total [2.]	3060.0	430.0	3490.0
3. Land Prevention Plan			
(1) Pijao Emergency Flood Control	740.0	170.0	910.0
(2) Genova Emergency Flood Control	1020.0	260.0	1280.0
Sub-Total [3.]	1760.0	430.0	2190.0
4. Water Quality Improvement Plan			
(1) Q.Cristales Coffee Waste Water Treatment	850.0	320.0	1170.0
Sub-total [1.-4.]	7878.0	1722.0	9600.0
5. Preparatory Works	0.0	480.0	480.0
6. Administration	0.0	960.0	960.0
7. Engineering Service	1300.0	140.0	1440.0
Sub-total [5.-7.]	1300.0	1580.0	2880.0
8. Physical Contingency	1580.0	340.0	1920.0
Sub-total [1.-8.]	10758.0	3642.0	14400.0
9. Price Escalation	3616.0	4607.0	8223.0
Total	14374.0	8249.0	22623.0

ANNEX O : PROJECT EVALUATION

Annex 0 : PROJECT EVALUATION

TABLE OF CONTENTS

LIST OF TABLES

Annex 0 : PROJECT EVALUATION

0.1 MASTER PLAN TO PRE-FEASIBILITY STUDY

The principle of this agro-sectoral master plan bases on the relationship between the landuse, land form, soil and climate of the area. The studies identify and delineate seven land zones for planning purposes, though they are not pure in terms of their individual components. This will further form the basis of the land evaluation.

The characteristics of a zone affect its potential landuse. Thus, a suitable landuse system for each zone is assessed and formulated so that its capacity would be effectively utilized.

Zone 2 and zone 4 have been selected for immediate implementation of agricultural development schemes in order to increase the productivity of land. In the first zone, a part of the land would be irrigated, and in the latter, the capability of smallholders would be exploited. In zone 3, the center of coffee production, a plan for the alleviation of water pollution would be incorporated into the processing of coffee beans with the intention of maintaining the quality of the produce. Finally, in zone 5, some protective means of stabilizing water-course are proposed.

A pre-feasibility study was then carried out on the four schemes which were mentioned above, on road improvement plans and on rehabilitation plans of two mini-hydroelectric power stations. The proposed projects for the lower reaches of the Quindio (zone 2) is relatively capital intensive. For the ones in the north Quindio (zone 4), on the other hand, more attention have been given to the social and institutional aspects of the area in order to create an integrated farming program so that it would vitalize the farm households in the area. Proposed projects in zone 5 would alleviate the damages which the inhabitants there have been incurred.

0.2 BENEFITS AND COSTS

0.2.1 BENEFITS

Expecting benefits of the proposed project would be calculated from the difference between those which would be derived from the "with project" situation and those which would be realized from the "without project" situation. Tangible and calculable benefits are explained here; the rest is assessed in 0.5.

At present, annual and perennial crops are grown on 90 percent of the flat land of the proposed project area in the lower reaches of the Quindio, the rest is mostly grassland. 60 percent of the marginal coffee production zone in the same area is covered by coffee, the rest is mostly grown with annual crops. The proposed project area in the north is mainly used for extensive cattle

grazing. In the proposed project area in the southern hilly zone, a torrent of water swept down the valleys every year.

The proposed project consists of different components. They are (i) construction of irrigation facilities, (ii) introduction of intensive farming with diversification of crops, (iii) construction of new feeder roads and road improvement, (iv) rehabilitation of mini-hydroelectric power stations, and (v) installation of filler plants for effluent from the coffee processing facilities. Each produces different type of benefits. They are as follows.

- The first two components are expected to produce a higher unit net income from the land.

- Road improvement, in general, would generate calculable benefits in the forms of running cost reduction and time saving. With reference to agriculture, the third project would reduce the degree of deterioration of agro-product, especially, vegetable and fruits during their transport; besides, the new access roads to the interior parts of the plane and the hill tops would provide some of the plots along the roads with housing development schemes.

- Generation of electricity has market ready to buy it in adjacent area in Quindio itself with existing distribution net-work.

The detailed tabulation of the benefits for each project was carried out and they are shown from table 0.1 to 0.9. Prices are as of September 1987.

0.2.2 COST

Indirect cost, physical contingency and land acquisition cost are all distributed to the individual projects in Table 0.10 Disbursement Schedule.

Production costs of the each crops in the farming activities are tabulated in the table 0.1, 0.4, 0.7.

The explanation of the costs are made along with those of benefits mentioned in 0.2 (2).

Prices are as of September 1987.

0.3 ECONOMIC EVALUATION

0.3.1 Factors used for calculation

The length of project life is set to 35 years after the completion of construction of the facilities which would be realized by the proposed Quindio Basin Integrated Agriculture Development Project i.e., 1995. The flow of benefits starts as soon as individual

component part of the project has been completed. Some of the facilities which have shorter useful lives would be replaced during the project life period according to their length of life.

The colombian currency has been directly connected to the US currency by a crawling peg system, and the japanese yen to the US currency by a flexible exchange rate system. So the economic exchange rate would be as equal as the financial exchange rates, which were Col$250 and Jap¥145 to the US dollar as of Sep. 1987.

The economic factor of the un-skilled labour cost is conveniently set to 0.5 using the LM method.

The economic price of the land is set to zero.

0.3.2 ECONOMIC PRICE OF COSTS AND BENEFITS

Economic farm-gate prices for such export/import agro-produces as coffee, orange, maize, sorghum and soy bean, and for an input, area are calculated.

The estimates are given in Table 0.13. The economic prices of farm sale are calculated in Tables 0.14, 0.16, 0.18, and its cash flows throughout the project life are given in Tables 0.15, 0.17, 0.19. The economic prices of the costs and benefits are also given explanation in Tables 0.3, 0.6, 0.9.

Disbursement schedule expressed in the economic price is given in Table 0.20, in which land acquisition cost is excluded and labour cost is halved from the financial one.

0.3.3 EIRR AND SENSITIVITY ANALYSIS

Cash flows of individual component projects are given in Table 0.21, and the summed-up cash flows with corresponding EIRRs are shown in Table 0.22.

The cash flows of three selected cases used in the sensitivity analysis are given in Table 0.23.

0.4 FINANCIAL EVALUATION

0.4.1 FIRR

Cash flows of individual component projects are given in Table 0.11, and the summed-up cash flows with corresponding FIRRs are shown in Table 0.12.

0.4.2 INVESTMENT AND ITS REPAYMENT

The investment in five years totaled 14,400 million Col$ expressed in 1987 price, 74.8% of which is from abroad, i.e., 2.15 billion

Col$ per year in average for five years. This is 3.72% of average net external debt planned in the four year development program (1987-1990).

Average local portion of yearly investment will come to 707 million Col$.

An example of debt service schedule for the foreign portion is given in Table 0.24. The long-term interest rate is set to 10%, and repayment term is set to 35 years with a grace period of 10 years.

Debt service will be at its peak in 2004; the amount will reach 1.38 billion Col$, about twice the size of CRQ's 1987 budget.

0.4.3 FARM ECONOMY

Within the proposed projects, cash flow of the individual farm in the Circasia agriculture development project is to be scrutinized, as the success of the cooperative depends on the stable household economy of member farms.

P/L statement of a farm with 3.0 ha plot: (Col$1,000)
(vegetable 1ha, orchard 1.7ha and piggery in kitchen garden)

	Sale	Expenditure	(family labour)	Net Income
Year 1	750	261	(199)	489
Year 2	1043	322	(254)	721
Year 3	1490	369	(317)	1121
Year 4	1864	556	(373)	1308
Year 5	1979	449	(395)	1530
Year 6	1837	481	(403)	1356
Year 7	1875	465	(392)	1410
Year 8	1864	556	(373)	1308
Year 9	1979	449	(395)	1530
Year 10	1875	481	(403)	1356
Year 11	1875	465	(392)	1410

In addition to this, each family will get Col$68,000 (including Col$20,000 equivalent to family labour cost) for the fattening of 16 pigs. This operation requires about 700 man-days in the busiest year (year 6).

Even in the first year, the operation can sustain a household, while preparing their orchard. And in a fully-fledged vegetable grower, the income can be compared with that of better-off coffee growers, without relying on the income source other than agriculture. This would give fairly food incentive to the families who want to work on the farm.