SUPPORTING REPORT

I : RELATED PLANS AND PROJECTS

Supporting Report I: Related Plans and Projects

Table of Contents

List of Tables and Figures in Supporting Report I

I : RELATED PLANS AND PROJECTS

1. NATIONAL AND REGIONAL DEVELOPMENT PLAN

There are national development plans as follows;

- Economic and Social Development Plan, 1994-1999
- National Development Plan of Reppublic of El Salvador, 1994-1999

2. Urban Development Plan of San Miguel City

Presently, a study of urban development plan is on-going for San Miguel City.
It covers urban development plan including transportation, industry and water supply environment, etc..

3. FLOOD CONTROL AND WATER RESOURCES DEVELOPMENT

3.1 Olomega Project

In 1967, MAG made a irrigation and flood control project aiming the Olomega Valley to the north of Lake Olomega. The purposes of the project are as follows;

1) to protect the area of north of Lake Olomega from flood damage
2) to irrigate the area of north of Lake Olomega

After studying various alternatives including San Esteban Dam to attain the above mentioned purposes, following combination of facilities was selected.

1) for flood control purpose
- utilization of Lake Olomega for retarding basin together with embankments to the north of the lake and a floodway to divert flood discharge from the San Miguel River to the lake.
- drainage pipe from Lake San Juan Area to the San Miguel River.

2) for irrigation
- Tysihuat Dam and intake facilities for water source
- irrigation channels to convey and distribute water to the irrigation area

Overall configuration of the project is shown in Fig. I.3.1.
By implementing those projects, it is possible to irrigate and mitigate inundation on 9,000 ha of farmland.

3.2 Usulutan-San Miguel Irrigation Project

In 1975, MAG made an extensive irrigation project covering a large area of Usulutan and San Miguel.

The purpose of the project is to irrigate an area of 29,000 ha extending from Usulutan to Olomega Valley. The project area is divided into four sections and the section directly related to this study is San Miguel Sector in which San Esteban Dam is the main structure.

In Jocotal sector and San Denisio sector, the water sources are the San Miguel River, Lake Olomega and groundwater near Lake Jocotal. The intake structures for the above two sectors in the river are at El Derilio and Vado Marine respectively.

In Agua Aubterranea Sector, the source is groundwater.

The Fig. I.3.2 shows the concept of the whole project. Table H.3.1 and Table H.3.2 show the planned demand and supply scheme for each sector.

4. HYDRO-ELECTRIC POWER GENERATION

4.1 Hydro-power Generation Master Plan of the San Miguel River, CEL, 1982

CEL made a master plan of power development of the San Miguel River in 1982. It includes such projects as San Esteban Dam and Vertedero/San Antonio Dam. The generating capacity of the projects was estimated as sharing 20 MW for San Esteban Dam and 32MW for Vertedero/San Antonio Dam.

Fig. I.4.1 shows the all facilities included in the project.

4.2 Hydro-power Development Plan for the Lempa River and San Miguel River, CEL, 1995

In 1995, CEL made hydropower plan including Lempa River and San Miguel River. Fig. I.4.2 shows the damsite location map of the plan.

As the first stage of the project, they made preliminary study for all the project sites including San Esteban Dam site. As the result of the study, the unit generation rates of electricity were obtained as shown in Table H.4.1.

As shown in the table, the unit cost of electricity generated at San Esteban power plant is approximately six times of that of El Tiger Project.

5. WATER SUPPLY PLAN FOR SAN MIGUEL CITY

Presently, water supply plan for San Miguel City is on-going. According to its plan, expansion of the urban area toward south is expected where abundant water resources are available.

6. ENVIRONMENT

There are plans on environmental strategy as follows;

- National Environmental strategy and Action Plan, SEMA, 1994
- Environmental Program of El Salvador(PAES), MAG/SEMA, 1994-1996

7. WATERSHED MANAGEMENT

There are study and plan on watershed management and floodplain management as follows;

- Feasibility Study of Lempa River Basin Watershed Management, CEL, 1993
- Plan for Emergency Operation Center, COEN, 1995

Table I.3.1 OUTLINE OF USULUTAN-SAN MIGUEL IRRIGATION PROJECT

Sector	Irrigation Area	Required Water	Intake Site	Available Water	Cost (million US$), Price in 1990				
	(ha)	(million m^3)			Dam	Canal	Irrigation	Others	Total
San Dioniso	2,261	29.2	San Dionisio	San Miguel River (7-14.5 m^3/s), Lake Olomega (65 MCM/year)	0.20	2.56	0.34	1.12	4.22
Jocotal	3,954	49.5	El Delirio, Jocotal pump	San Miguel River (2.5-9.1 m^3/s), Lake Jocotal (1.2 m^3/s), Lake Olomega (65 MCM/year)	0.55	6.59	0.94	2.09	10.17
San Miguel	10,749	171.7	San Esteban	San Esteban Reservoir (Reservoir Voluem 105 MCM)	15.27	16.86	5.60	6.49	44.22
Aguas Subterraneas	11,952	125.6	(wells)	Groundwater (240 MCM/year)	0.00	3.98	2.09	17.99	24.06
Total	28,916	376.0							82.67

Table I.3.2 IRRIGATION REQUIREMENT (U/S IRRIGATION PROJECT)

	Irrigation Requirement														
Sector	San Dinonisio			Jocotal			Jocotal (pumped water)			San Miguel			Aguas Subterraneas		
	(m^3/s)	(m^3/day)	(m^3/month)	(m^3/s)	(m^3/day)	(m^3/month)	(m^3/s)	(m^3/day)	(m^3/month)	(m^3/s)	(m^3/day)	(m^3/month)	(m^3/s)	(m^3/day)	(m^3/month)
Jan	1.69	146,016	4,526,496	2.46	212,544	6,588,864	0.84	72,576	2,249,856	10.32	891,648	27,641,088	7.46	644,544	19,980,864
Feb	2.02	174,528	4,886,784	2.87	247,968	6,943,104	0.98	84,672	2,370,816	11.56	998,784	27,965,952	8.72	753,408	21,095,424
Mar	1.89	163,296	5,062,176	2.87	247,968	7,687,008	0.98	84,672	2,624,832	11.35	980,640	30,399,840	10.67	921,888	28,578,528
Apr	1.00	86,400	2,592,000	1.58	136,512	4,095,360	0.54	46,656	1,399,680	7.64	660,096	19,802,880	5.85	505,440	15,163,200
May	0.41	35,424	1,098,144	0.35	30,240	937,440	0.12	10,368	321,408	2.79	241,056	7,472,736	0.11	9,504	294,624
Jun	0.02	1,728	51,840	0.00	0	0	0.00	0	0	0.1	8,640	259,200	0.11	9,504	285,120
Jul	1.17	101,088	3,133,728	0.79	68,256	2,115,936	0.27	23,328	723,168	3.51	303,264	9,401,184	1.15	99,360	3,080,160
Aug	0.28	24,192	749,952	0.18	15,552	482,112	0.06	5,184	160,704	1.03	88,992	2,758,752	0.11	9,504	294,624
Sep	0.00	0	0	0.00	0	0	0.00	0	0	0	0	0	0	0	0
Oct	0.00	0	0	0.00	0	0	0.00	0	0	0	0	0	0	0	0
Nov	1.41	121,824	3,654,720	1.41	121,824	3,654,720	0.78	67,392	2,021,760	8.67	749,088	22,472,640	7.23	624,672	18,740,160
Dec	1.28	110,592	3,428,352	1.28	110,592	3,428,352	0.66	57,024	1,767,744	8.77	757,728	23,489,568	6.77	584,928	18,132,768
Total			29,184,192			35,932,896			13,639,968			171,663,840			125,645,472

Table I.4.1 ELECTRICITY DEMAND AND SUPPLY PLAN BY CEL

WATER DEMAND PROJECTION

DEMAND IN 2010	1,277 MW
DEMAND IN 1995	676 MW
DEMAND INCREASE	601 MW

HYDRO POWER PLAN

	CAPACITY	COST/POWER		NOTE
	(MW)	(US$/KWH)	RATIO (%)	
EL TIGER	351	0.047	100 %	
PASO DEL OSO ALTO	77	0.066	140 %	DD STAGE
ZAPOLITLO C	104	0.070	149 %	DD STAGE
SAN MARCOS	56	0.144	306 %	
SAN ESTEBAN	8	0.284	604 %	
TOTAL	596			

PRESENT SHARE OF SOURCE

	CAPACITY (MW)	RATIO
HYDROELECTRICITY	388	47 %
GEOTHERMAL	105	13 %
THERMAL	325	40 %
TOTAL	818	100 %

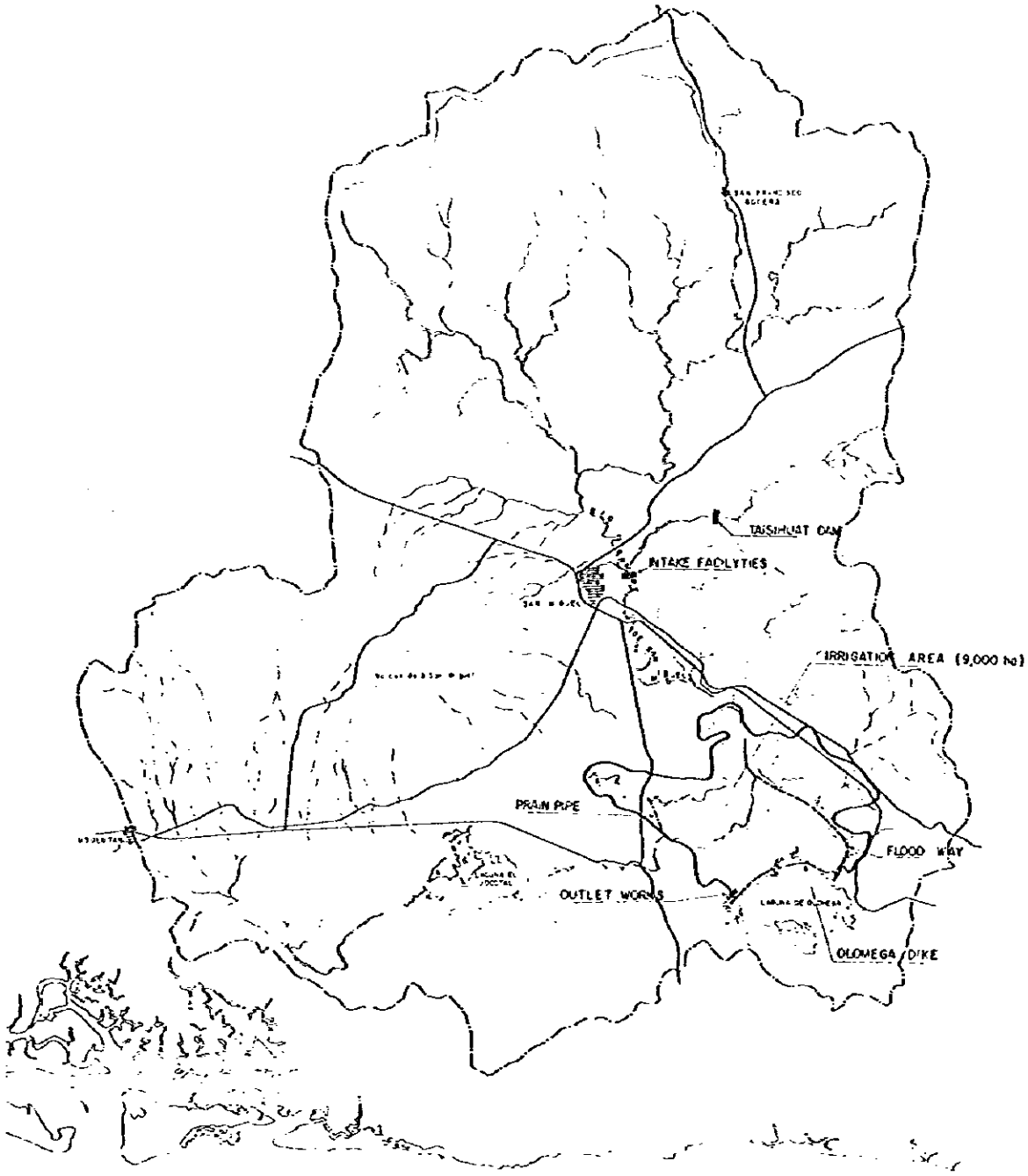


Figure I.3.1 CONCEPT OF OLOMEGA PROJECT (1967, MAG)

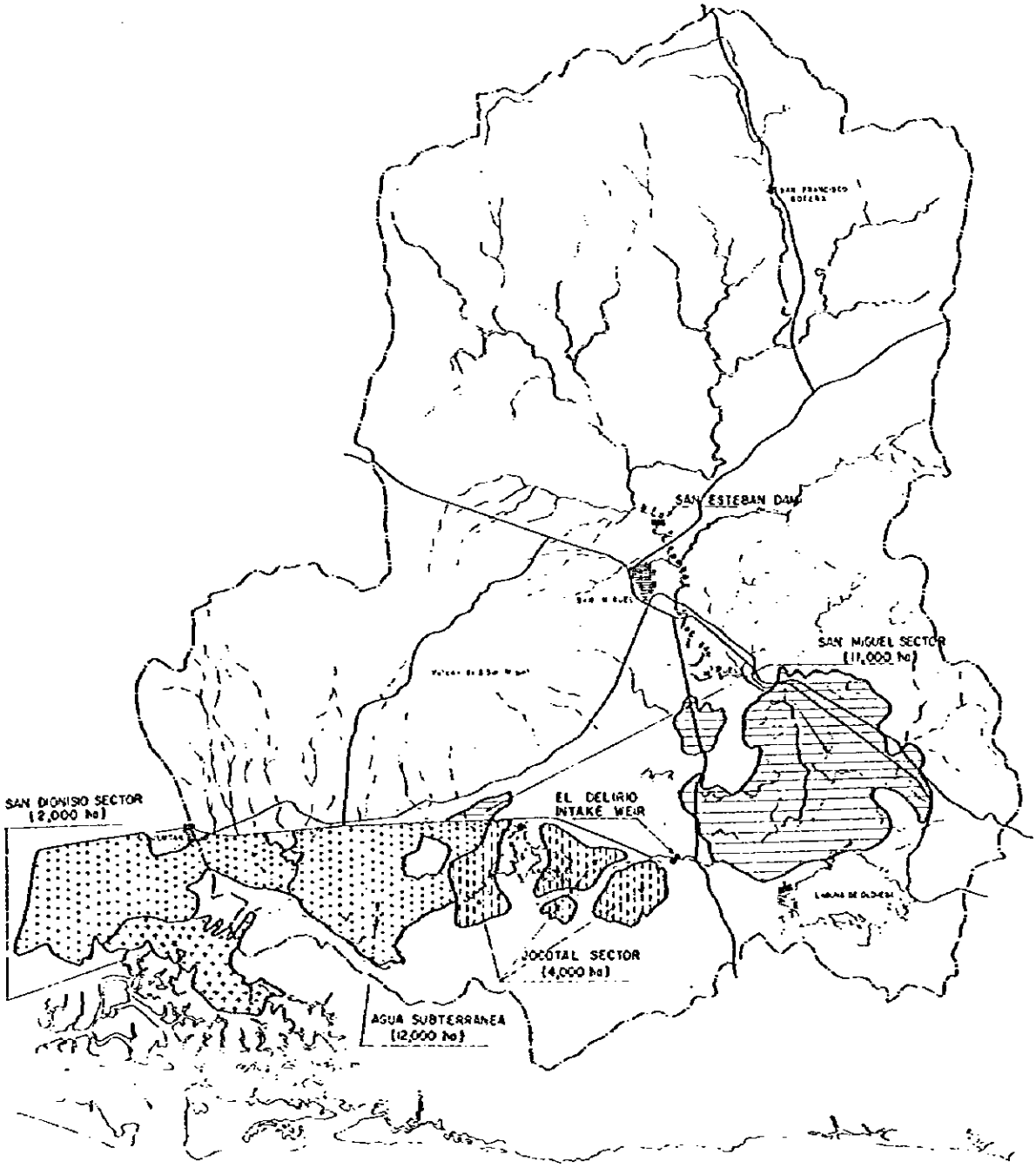


Figure I.3.2

CONCEPT OF USULTAN AND SAN MIGUEL IRRIGATION PROJECT (1975)

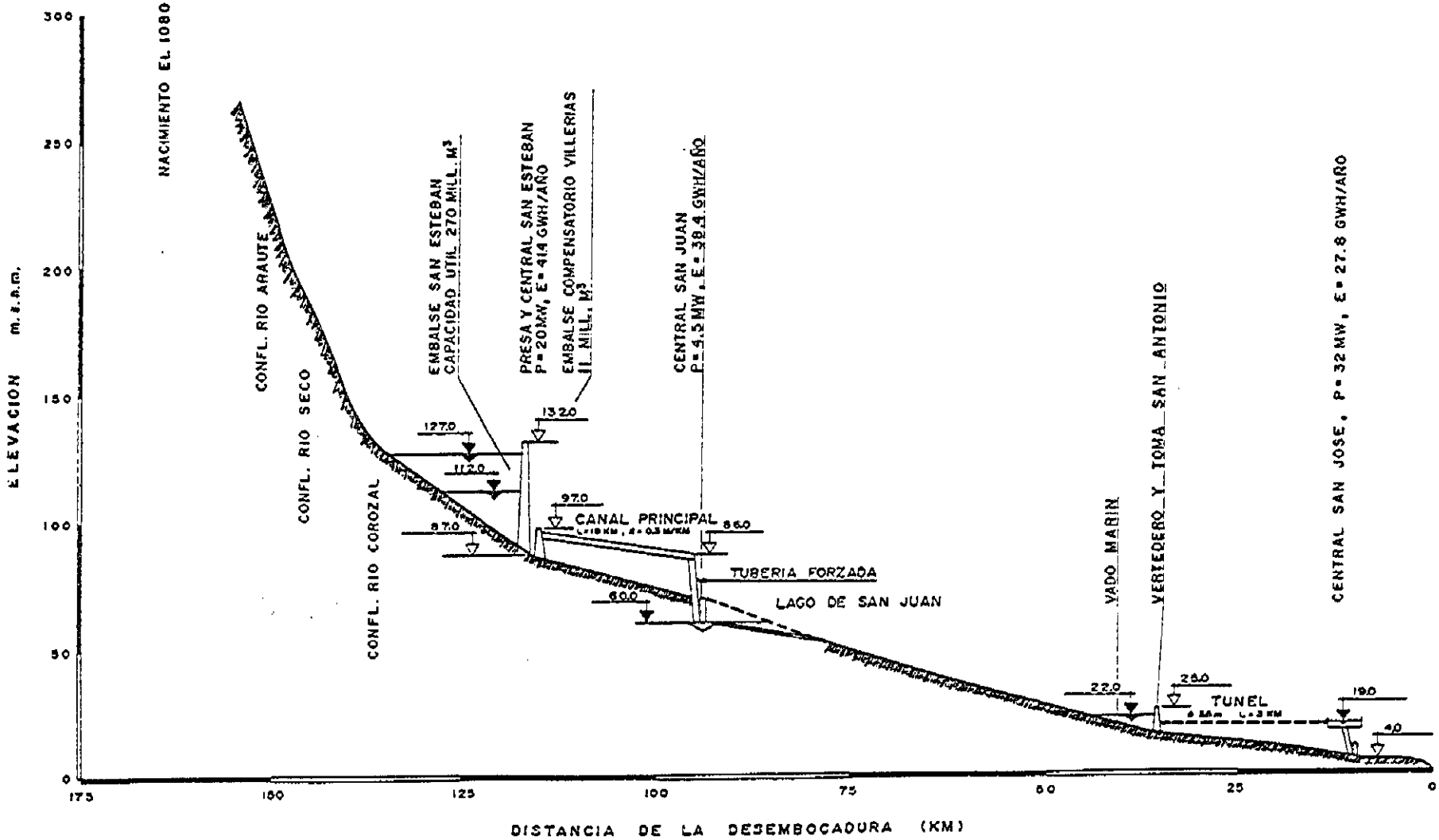


Figure I.4.1 HYDROELECTRIC MASTER PLAN OF SAN MIGUEL RIVER (1982, CEL)

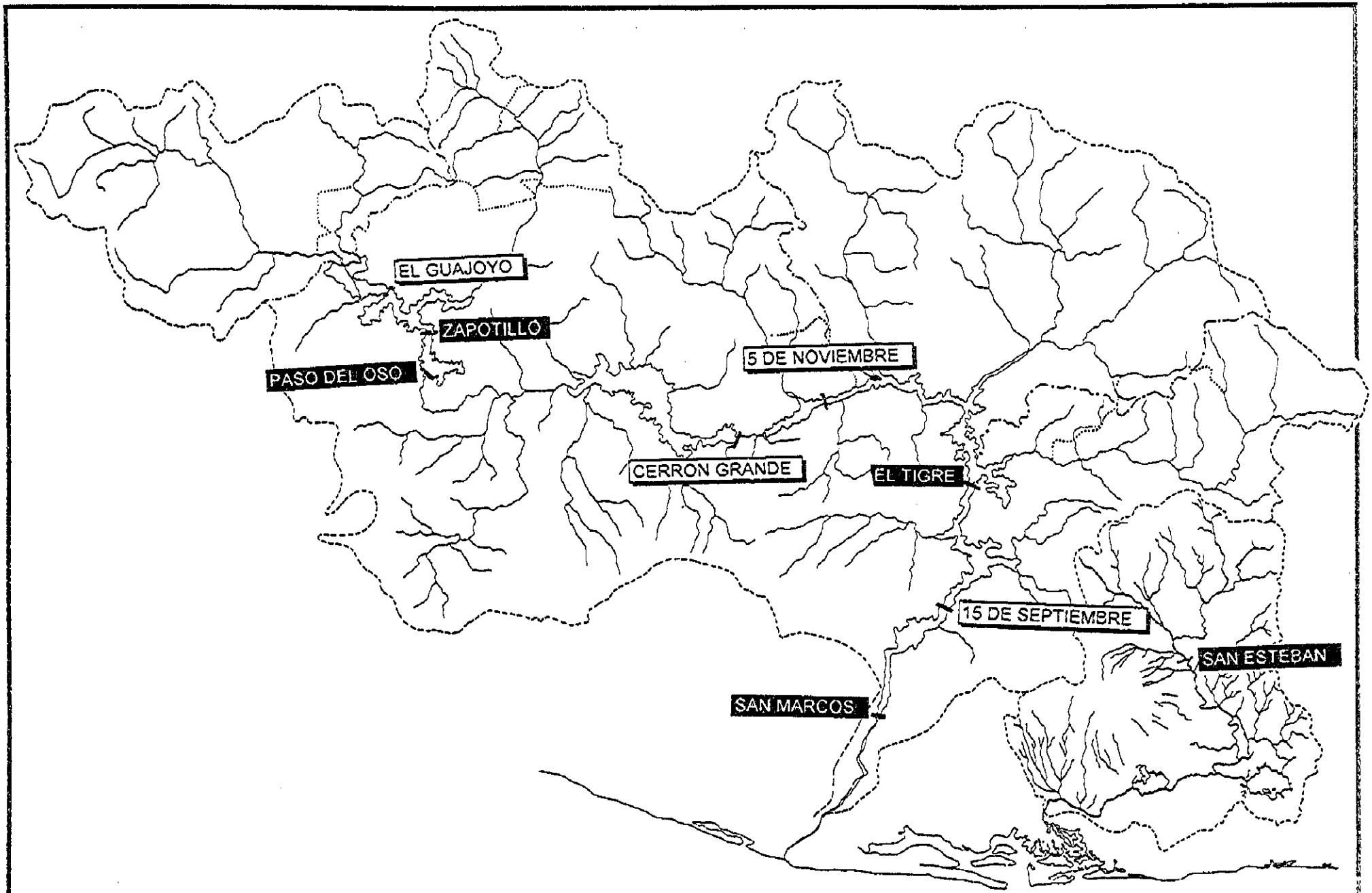


Figure I.4.2 HYDROELECTRIC PROJECTS IN LEMPA AND SAN MIGUEL RIVER (1995, CEL)

SUPPORTING REPORT

J: WATERSHED MANAGEMENT

Supporting Report J: Watershed Management

Table of Contents

List of Tables and Figures in Supporting Report J

J: WATERSHED MANAGEMENT

1. General

1.1 Background of the Study

The Study Area is covered with poor vegetation. Land use of the Study Area is composed of forest 14.7 %, pasture / grain 65.1 %, other agriculture 16.0 %. Permeability of the pasture land is low compared with that of the forest. In addition, the forest is able to retain stormwater, to increase the river discharge in the dry season, to reduce erosion, to hold the nourishment and to keep river-water clean better than other land uses. Therefore, it is desirable to cover the watershed with forest, from viewpoint of flood control and water resources development, considering the situation of flooding and water resources in the Study Area.

The forest is precious as a nature and also has an economic advantage by using it for production. Production of the pasture land is lower than that of forest, especially in the steep slope area. Forest area of the Study Area has been reduced by tree cutting for fire-wood, slash-and-burn farming, etc. and these methods are not sustainable because of high population density in the basin.

Flood control by the structural measures is effective in a short term, however, it is difficult to cope with a large flood due to the nature of the project, which is non-profit and high cost. The cost of maintenance would be high, if not combined with the non-structural measures, due to sedimentation, increase in flood discharge, etc.

Considering the above, the watershed management is advantageous in the long run and accord with the national policy.

2. Present Situation

2.1 River Flow

Flood discharge of the San Miguel River at Moscoso ranges from 1,000 to 2,000 cu. m / sec. from the catchment with an area of 1,074 sq. km. Specific discharge of 1.0 to 2.0 cu.m / sec. / sq. km is not so large, because the basin is covered with grass or bush, even if not with forest.

The peak discharge would be reduced slightly if the basin is reforested. The annual minimum discharge at Moscoso is 2.1 cu. m / sec. (0.2 cu.m / sec / 100 sq. km), seems to be small.

2.2 Sediments

Sediment run-off from the Upper Basin would be an order of hundreds of cu. m / sq. km / year. According to the measurement data in Japan, erosion depth of grass land is about 20 % larger than that of forest. Erosion in the Upper Basin is not so serious problem.

In the Lower and Middle basins, mud flow deposit areas are distributed. These are located in the skirt of San Miguel Volcano and the areas between San Miguel and Usulutan volcanoes and produce much erosion, maybe an order of thousands cu. m / sq. km / year. The Ereguayquin River and the San Esteban River have mud flow deposit areas in their catchments and much sediment is discharged into the San Miguel River.

2.3 Present Situation of the Watershed Management

Watershed management such as reforestation and erosion control are planed and executed by DGRNR of MAG in principle. CEL has conducted a reforestation project in the Lempa River Basin. CENTA (National Center of Agriculture and Forestry Technology) of MAG is a key agency for reforestation, erosion control, etc. CENTA is developing the technology for implementation of the projects including research, education, nursery, production, etc. In the Study Area, there is a C.D.T. (Technological Development Center) in Morazan Department, which has 21 offices with 93 technicians in total. Organization chart of CENTA and C.D.T. are shown in Fig. J.2.1 and Fig. J.2.2.

Major issues related to the watershed management of the San Miguel River Basin are reforestation and erosion control. Since the land owners and workers are related for the execution of the projects, necessary incentives, such as cash, credit, technical assistance have been studied by PAES (Environmental Program of El Salvador) since 92 / 93. Forest Incentive Low is now under study. As to the erosion control, a study was conducted for the area located north of San Miguel City.

3. Watershed Management Plan

3.1 Objectives

The objectives of the watershed management are, to

- reduce the soil erosion volume,
- increase the river discharge in the dry season,
- reduce the peak flood discharge, and
- maintain the river-water clean,

in addition to protection of the agricultural land and preservation of nature.

3.2 Basic Concept

The watershed management is proposed based on the following concepts:

1) Topography, geology, soil and water conditions are taken into account for sustainable development program. The soil classification map made by MAG is basically used for planning.

2) An ideal land use plan, as a long-term program, was proposed by the Study Team by using the map made by MAG (refer to Fig. J.3.1).

3) For the Master Plan, the areas of reforestation and erosion control are to be selected from the ideal land use plan considering the work volume possible to complete until the target year of 2020.

Major points of the watershed management plan for each sub-basin are as described below:

Upper Basin

The Upper Basin is an important area for water resources as well as for floodwater storage. The vast pasture areas are located even in the steep mountain slopes. Such areas should be changed into forest by reforestation. There are mud-flow deposit areas in the upper San Esteban River basin which produce much sediments. Reforestation for steep slope areas or erosion control for gentle slope areas will be needed.

Middle Basin

The reserve forest area in the slope of San Miguel Volcano should be kept as forest. The mountain slopes of Lake Olomega catchment should be reforested to reduce sediments and pollutants flow into the lake.

Lower Basin

The large mud-flow deposit area between San Miguel and Usulutan volcanoes produces much sediments and affects the river-bed stability. The steep sloped mud-flow deposit areas should be reforested, and erosion control be made in the gentle sloped areas. Lake Jocotal water is supplied by the springs originated from the catchment with high permeability, and such condition should be preserved.

3.3 Proposed Watershed Management

The watershed management proposed for the Master Plan composed of the reforestation of 300 sq. km and erosion control of 200 sq. km as described below.

(1) Reforestation : 300 sq. km

- Protection forest area of about 70 sq. km out of the total area of 207 sq. km, excluding existing forest and the areas where it is difficult to reforest

- Potential production forest area of 74 sq. km located in the mud-flow deposit area

- Upstream steep slope area of 156 sq. km, which is used for pasture

(2) Erosion Control : 200 sq. km

- Potential agricultural area of 200 sq. km located in the mud-flow deposit areas having relatively steep slopes. Drainage and stormwater retention are applied.

- Ground sills of 30 places in the rivers located in the mud-flow deposit areas

The proposed watershed management is shown in Fig. J.3.2.

4. Organization for Project Execution

Proposed organization for the execution of the project is as follows:

(1) Existing organizations of MAG are to be applied and strengthened.

- Central Office of MAG in charge of planning, designing, administration and necessary arrangement for financing, incentives, etc.
- CENTA is in charge of education, research, nursery, planting, etc. from technological viewpoint. C.D.T. in Morazan should be strengthened as an Office in the Study Area for the execution of tree planting and erosion control work.

(2) Since the project is to be executed by landowners, workers, local people and NGOs under the assistance of MAG, participation of these will be required.

Proposed organization is shown in Fig. J.4.1.

5. Project Cost

The cost of the project for watershed management is as follows:

Reforestation	: 30,000 ha. x C. 3,000	=	C. 90,000,000
Erosion Control	: 20,000 ha. x C. 5,000	=	C. 100,000,000
Ground Sill	: 30 places x C. 600,000	=	C. 18,000,000
Total			C. 208,000,000

6. Implementation Schedule

The projects of the watershed management are proposed to be implemented independently from the projects of the structural measures. The watershed management projects are desired to be implemented as soon as possible and to be started in early stage. Though the methodology has been studied and the system has going to be established for the project implementation, arrangement in relation to the land owners and other related personnel would take time. Therefore, it is proposed to start from the areas where the arrangements are easy and execute uniformly until the target year of 2020.

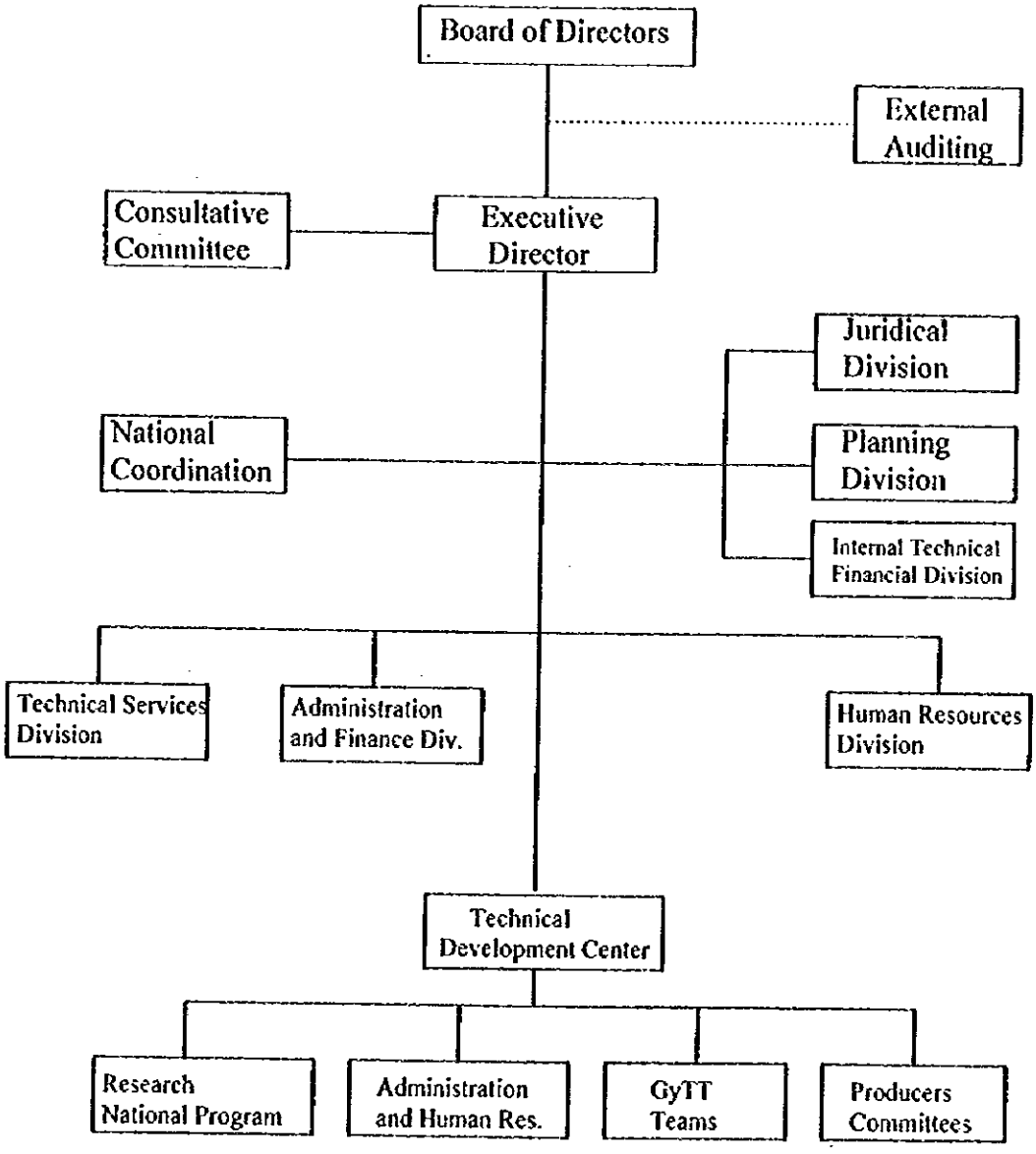
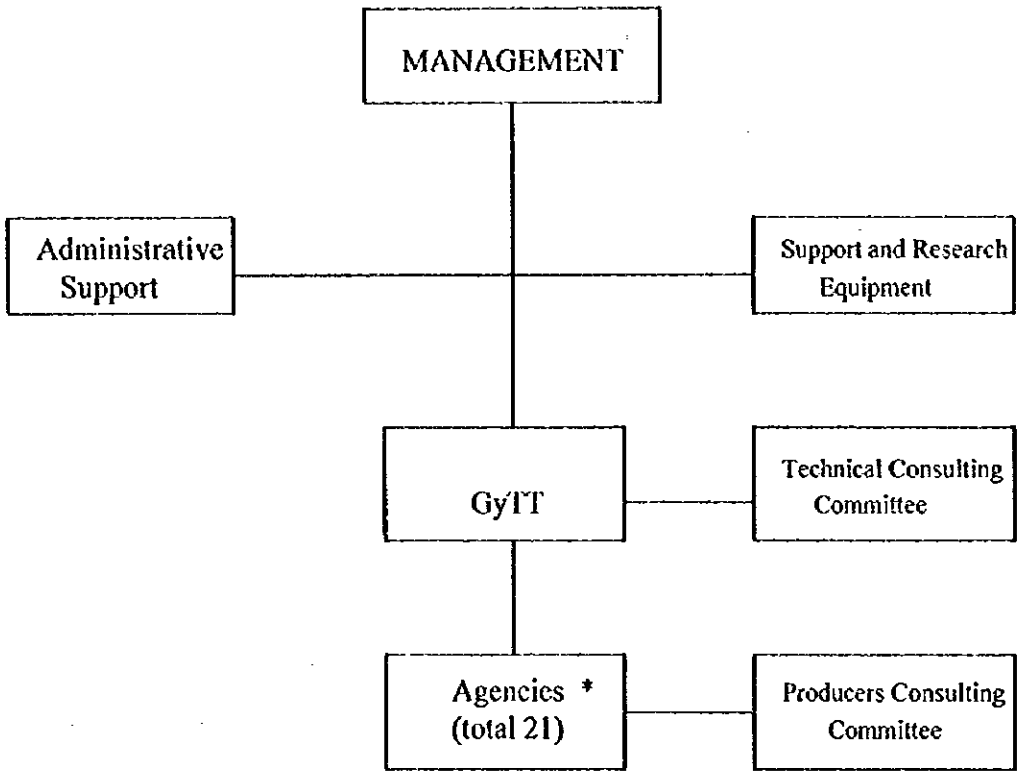


Figure J.2.1 ORGANIZATIONAL CHART OF CENTA



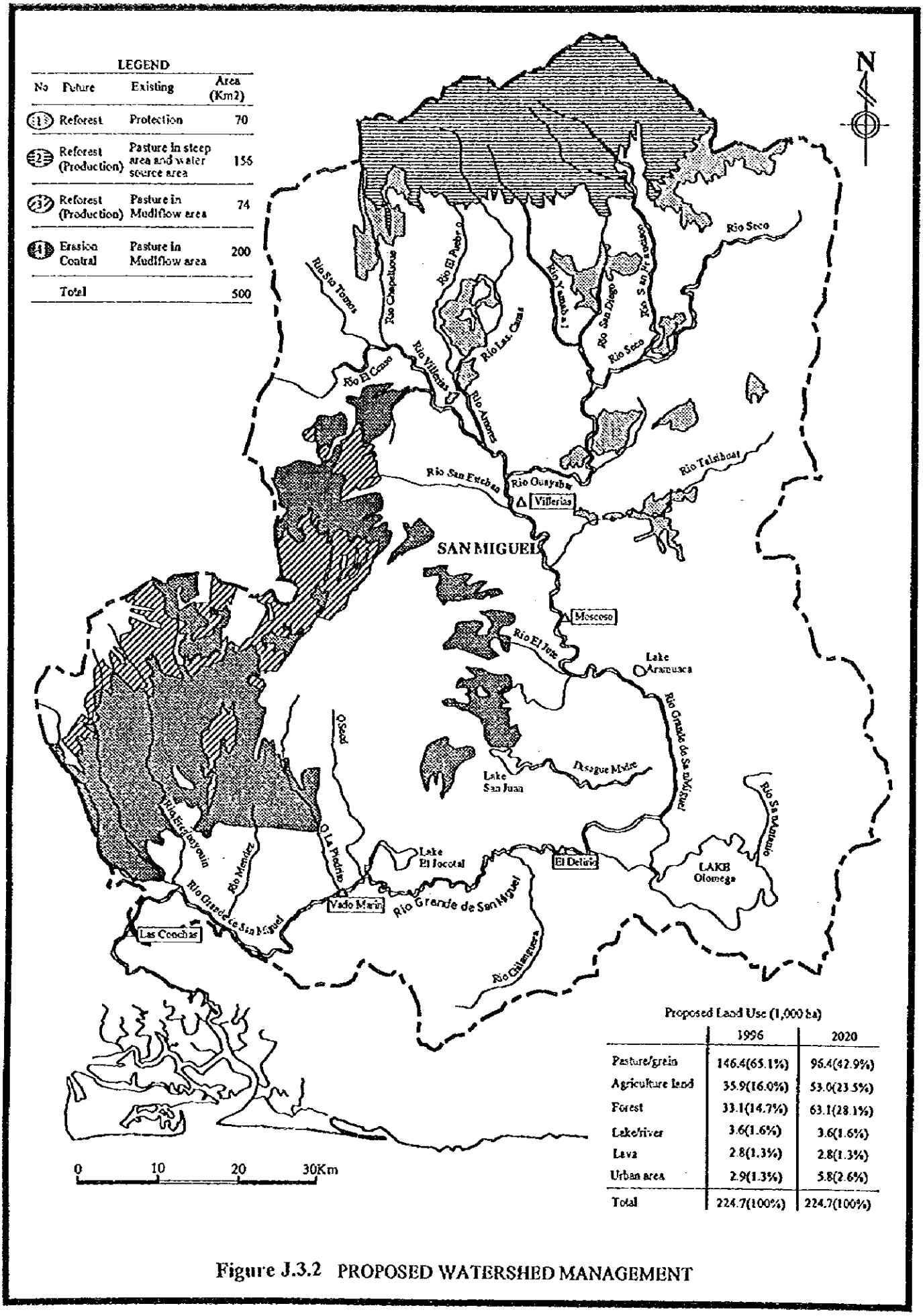
* See attached list

CDT = Technological Development Center

Figure J.2.2 **ORGANIZATION STRUCTURE C.D.T. IN MORAZAN (C.E.N.T.A.)**

Area	Recommended Action	Class	Area(ha)
Intensive Agriculture (1)	Annual crop cultivation, Improved pasture	[illegible]	41,9[illegible]
Intensive Agricultural (2)	Annual crop cultivation Improved pasture	[illegible]	6,3[illegible]
Intensive Agricultural with Erosion Control	Annual crop Improved pasture Permanent crop	[illegible]	36,53[illegible]
Water Tolerant Crop	Water tolerant crop such as rice	[illegible]	5,85[illegible]
Agroforestry	Tree Crop	[illegible]	20,[illegible]
Production or Protection Forest	Afforestation	[illegible]	56,22[illegible]
Protection Area	Protection	[illegible]	20,50[illegible]
River / Wet Area		[illegible]	1,65[illegible]
Urban			1,25[illegible]
Lake			2,4[illegible]
Total			224,35[illegible]

Figure J.3.1 PROPOSED FUTURE LAND USE



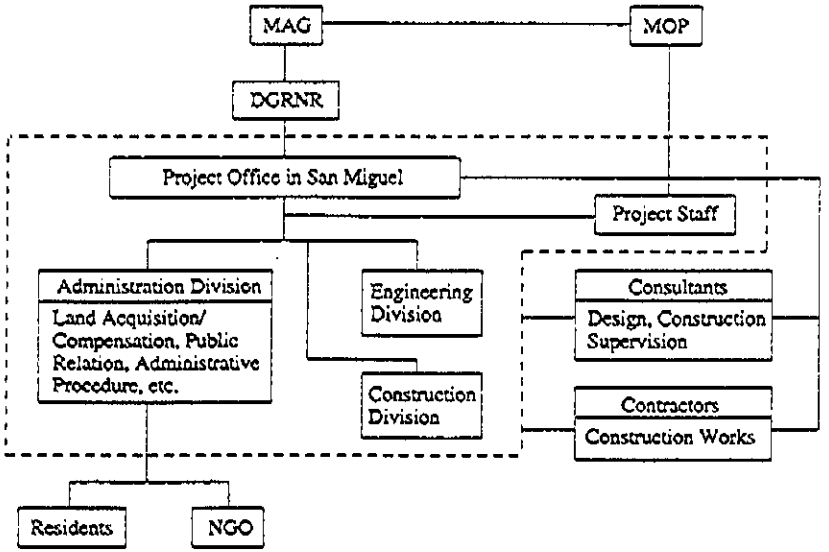
Proposed Land Use (1,000 ha)

	1996	2020
Pasture/grain	146.4(65.1%)	96.4(42.9%)
Agriculture land	35.9(16.0%)	53.0(23.5%)
Forest	33.1(14.7%)	63.1(28.1%)
Lake/river	3.6(1.6%)	3.6(1.6%)
Lava	2.8(1.3%)	2.8(1.3%)
Urban area	2.9(1.3%)	5.8(2.6%)
Total	224.7(100%)	224.7(100%)

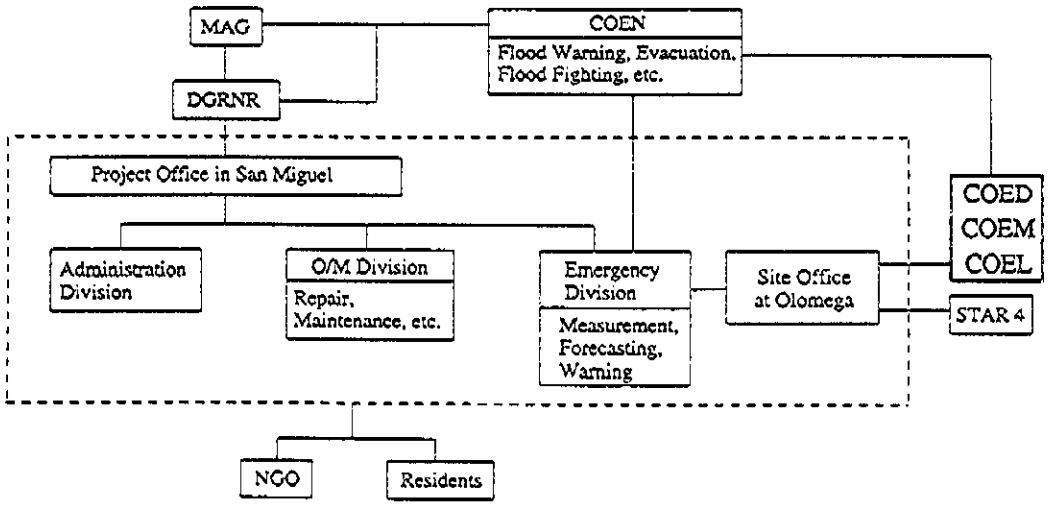
Figure J.3.2 PROPOSED WATERSHED MANAGEMENT

Proposed Organization for Structural Measures

(1) Design/Construction Stage



(2) Operation/Management Stage



Proposed Organization for Nonstructural Measures

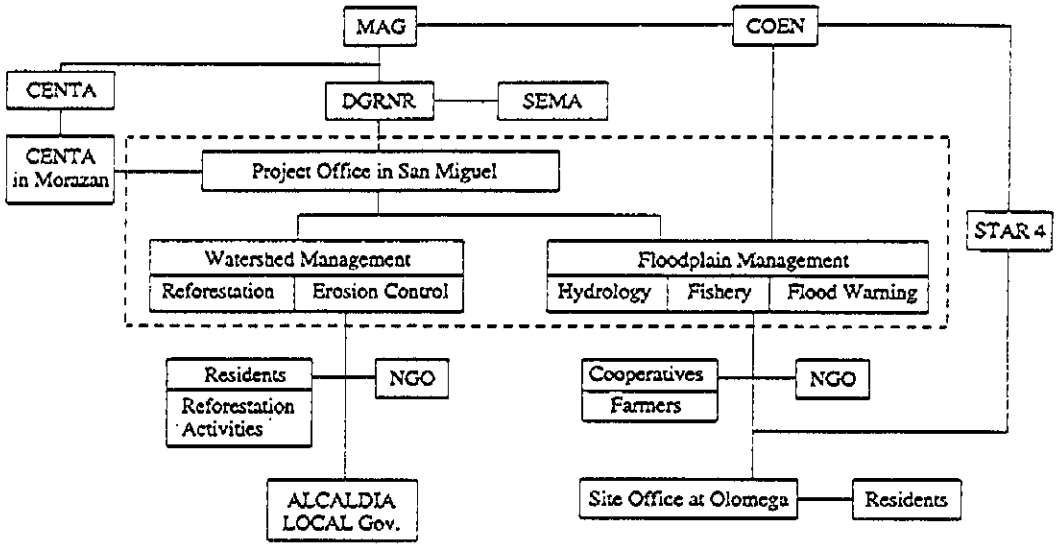


Figure J.4.1 PROPOSED ORGANIZATION

SUPPORTING REPORT

K: FLOODPLAIN MANAGEMENT

Supporting Report K: Floodplain Management

Table of Contents

List of Tables and Figures in Supporting Report K

K : FLOODPLAIN MANAGEMENT

1. General

Floodplain management is necessary, because the proposed flood control structural measures are not able to cope with a large flood due to its nature of non-profit and high cost. Therefore, it is required to reduce the damage, caused by a flood larger than the designed one, by non-structural measures. There are four major potential flood areas in the Study Area as follows:

- Flat area adjacent to Lake Olomega,
- Flat and depressed area around Lake Jocotal,
- Low and flat area in the river mouth delta, and
- The area along the San Miguel River near San Miguel City

As structural measures in the Master Plan, the river improvement and the floodwater retarding in Lake Olomega have been proposed. As the Priority Project, a partial flood control from these structural measures have been selected. The areas of the potential flood areas will be reduced by the projects, and flood to be considered in this floodplain management is divided into the following four stages :

Stage - 0 : Existing condition (without project),
Stage - 1 : After completion of the Priority Project, and
Stage - 2 : After completion of the Master Plan Project

2. Present Condition of the Potential Flood Area

2.1 Flood Conditions

Detailed information on flood condition is described in the Supporting Report "E". Flood conditions from viewpoint of floodplain management are summarized as follows:

The flooded area in the past (potential flood area) is 180 sq. km in total.

Usulutan Area (3,130 ha.)
This area is low and flat. Drainage of inner water is made directly to the Esteros and major flood problem is overflow from the San Miguel River. The lands of this area are used for agriculture / livestock such as annual crops, grazing, etc. This area is to be protected by the

proposed dikes. The flood depth and duration of the 1995 flood were less than 1 m and about one month respectively.

Jocotal Area (4,438 ha.)

The areas around Lake Jocotal and along the river are depressed, and flooded almost every year. The lands of these areas are mainly used for grazing, and other lands are for sugarcane. In the low areas along the San Miguel River, the lands are not used so much.

Olomega Area (9,840 ha.)

This area is the largest among the four areas, and used mainly for grazing (62 %), sugarcane (17 %) and annual crop (9 %). During the 1995 flood, flood depth was not large (mostly less than 0.2 m) and flood duration was about one week. During the largest flood, the depth was about 1 m and the duration was 3 to 4 weeks.

Area Near San Miguel City (700 ha.)

This area is narrow and long and considered to be parts of the river area. The urban area of San Miguel City is expanding toward this area.

2.2 Present System of Floodplain Management

COEN (National Emergency Committee) is an agency related to floodplain management. There are three levels of Emergency Committee in addition to National level, namely, Department level (COED), Municipal level (COEM) and Local level (COEL). Each level of COE is characterized as follows:

COEN

COEN is headed by the President and consists of the Vice President, the Minister of Internal Affairs, the Executive Secretariat of COEN, Emergency Operation Center (COE), related agencies, and COED, COEM, COEL. The Minister of Internal Affair coordinates the related Ministries such as National Defense, MAG, MOP, Public Health, Foreign Affairs, etc. The related agencies are Green Cross, PNC, CEL, Municipal Office, ANDA, etc.

COED

COED headed by the Department Governor consists of Department Commander, Hospital Director, Road Engineer, MAG Representative, Sectors related to the activities and services in an emergency, and COEM. The Sectors are Defense/ Security, Public Services (water, electricity, water), Housing, Education, Communication, Damage Evaluation, Rescue, Food/

Clothing, Transport, etc.

COEM

COEM headed by the Mayor consists of PNC (National Civil Police), Director of Health Unit, School Director, COEL, and Sectors related to the emergency activities such as public services, agriculture, monetary aide, etc.

Organization charts of COEN, COED and COEM are shown in Figs. K.2.1 to 2.4.

As to floodplain management, MAG is an important part of COEN. STAR 4, in Ilopango, of MAG is in charge of weather forecasting by using the satellite image data and has close contact with COEN. The activities of STAR 4 for flood forecasting are, to forecast the location of hurricane, and to forecast the location and intensity of rainfall.

3. Proposed Floodplain Management

3.1 Objectives

The objectives of the floodplain management are as follows :

- Effective use of Lake Olomega for floodwater retarding,
- Well balanced operation of the lake water level for flood damage mitigation, fishery and ecology of the lakes of Olomega and Jocoatal,
- Prevention of increase in potential flood damage due to uncontrolled expansion of the San Miguel urban area,
- Avoidance of unfavorable effects of embankment construction on flooding, and
- Prevention of increase in potential flood damage in the river mouth delta area due to developments.

3.2 Floodplain Management Measures

3.2.1 Area Near San Miguel City

The urban areas of San Miguel City are expanding toward the flood prone areas along the San Miguel River. Existing urban areas along the river are not functioning well due to flooding. Since the flood prone areas are narrow and long, like a river area, it is not rational to make all area flood free. Therefore, the urban area should be located outside the area required for the

river improvement. A land use regulation to is to be proposed for decision of the required river area and recommendation on land use.

3.2.2 Lake Olomega and Its Surrounding Areas

For floodplain management of this area, it is necessary to consider the following:

(1) Lake Olomega Water Level Operation
- To keep the minimum water level of 64.5 m during the dry season for fishery,
- To keep the water level of less than 65.5 m during the flood season for floodwater storage,
- To monitor the river and lake water levels for minimizing the damage caused by flood including larger than the designed one.

(2) Reduction of Potential Flood Damage
- The areas to be protected by the proposed dikes should prepare against flood-flow caused by a large flood, say about 20-year flood, which may overtop the dike.
- Even after completion of the Priority Project, a part of the downstream area and the peripheral areas of the lake would be flooded. Land use regulation, flood proofing and flood warning will be applied.

3.2.3 Lake Jocotal and Its Surrounding Areas

This area is originally flood prone and ecology of the lake should be improved. The following should be considered.

- Reduction of floodwater flow into the lake
- Reduction of the potential flood damage
- Some areas around the lake would be flooded even after completion of the Project.

Land use regulation, flood proofing and flood warning will be applied.

3.2.4 Estuary Delta Area in Usulutan

The mangrove forest of this area has been decreased due to developments for agriculture, fishery, salt production, etc. This area is to be protected by the dikes.

Land use regulation and flood proofing will be applied.

3.3 Proposed Floodplain Management Master Plan

3.3.1 Land Use Regulation and Flood Proofing

Land use regulation and flood proofing to prevent the increase in potential flood damage are proposed as follows:

(1) Regulation of urbanization of the narrow flood prone area near San Miguel City
The areas can be used for low damage potential purposes such as agriculture, park, etc.

(2) Land use regulation and flood proofing for the low areas around Olomega and Jocotal lakes
These areas are allowed to be flooded, due to difficulty in making flood-free, even the proposed flood control projects are implemented.

(3) Flood proofing such as elevated floor building, partial embankment, etc. for the areas protected by the proposed dikes and allowed to be flooded,
Cooperation with the agencies related to the development and the residents will be required.
A flood risk map for each stage of flood control works will be used for education of the residents and coordination with the related agencies.

3.3.2 Flood Forecasting / Warning System

(1) Basic Concept

Basic concept of the proposed flood forecasting and warning system are as follows:

- For the execution of the project, existing system of COEN will basically be applied.
- STAR 4 will forecast the flooding.
- One New Site Office at the Control Gate site is proposed for collection of the water level data as well as for operation of the gates.
- One New Project Office in San Miguel, proposed for the execution of the structural measure project, will also in charge of coordination with the agencies related to flood forecasting / warning.
- Five automatic water level gauging stations with telemeters are to be used for flood warning in addition to the operation of Lake Olomega water level.
- Existing system of COEN is to be improved from viewpoint of flood control.

Forecasting by using rainfall data in the upper basin was not recommended because of the following reasons.

- Flood level does not rise so rapidly and not so dangerous,
- For forecasting, new rainfall stations with telemeters would be required. It is costly not only to provide but also to maintain. And time of forecasting can be shortened by only several hours, and
- It is possible to do it in the future when it becomes necessary due to unexpected urbanization, etc.

Proposed locations of the water level stations are as follows:

1) Olomega Area

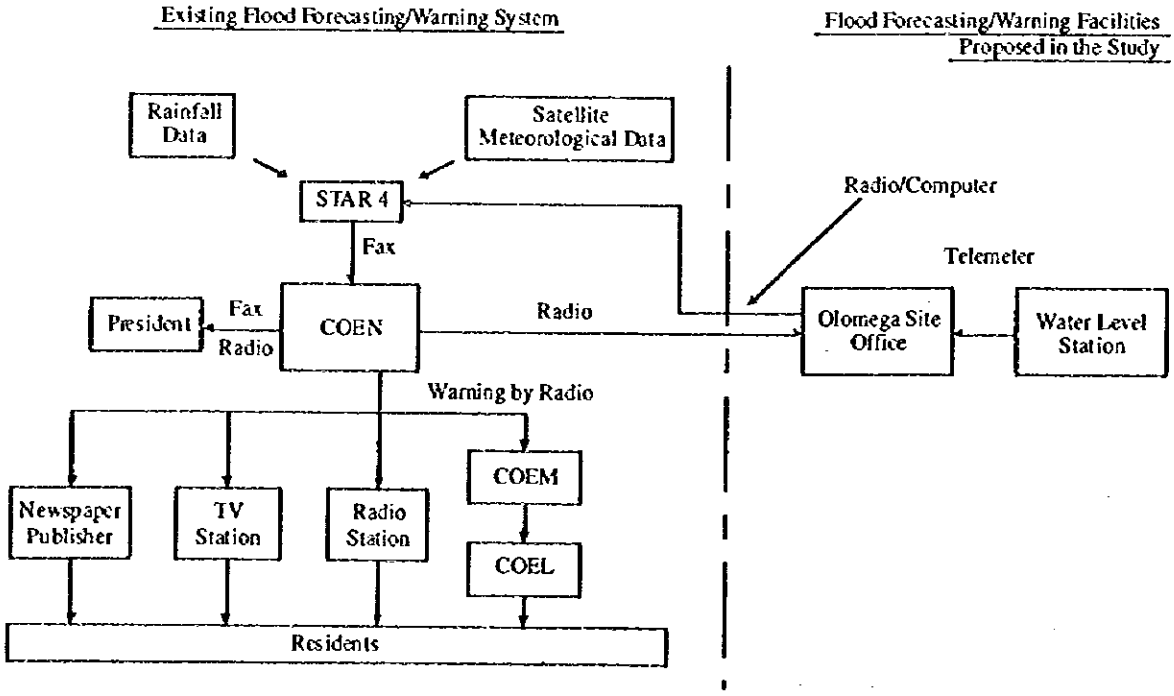
- Moscoso (San Miguel River) : inflow to flood prone area,
- Diversion point (San Miguel River) : discharge into Lake Olomega and flood level of the river ,
- Upstream of El Delirio (San Miguel River) : flood level of the low area,
- Lake Olomega : for lake water level operation, and

2) Jocotal Area

Vado Marin (San Miguel River) : flood level of Jocotal area and discharge its downstream

(2) Forecasting / Warning Method

Flood forecasting and warning is proposed to be made by the following method:



Proposed Floodplain Management Master Plan is shown in Fig. K.3.1.

3.3.3 Proposed Organization

Proposed Organization for the floodplain management is as follows:

- Existing system of COEN is to be applied for both of the land use regulation / flood proofing and the flood forecasting / warning,
- DGRNR and STAR 4 will be a key organizations for flood warning,
- STAR 4, Site Office in Olomega and central COEN will communicate with each other by radio and computer,
- Project Office of MAG in San Miguel will undertake the land use regulation by coordinating the related government authorities. The Office will also educate the residents about the floodplain management,
- Olomega Site Office will undertake the collection and analysis of the water level data, and gate operation, and
- COEL will be an organization to involve the residents in the Project. Hence the houses are scattered in a wide areas with an average density of 0.54 and 1.0 house / ha. in 1996 and 2020 respectively, local level organization for evacuation and flood fighting will be required.

Proposed Organization for the floodplain management is shown in Fig. K.3.2.

3.3.4 Implementation Schedule

The proposed project for the floodplain management is scheduled to implement as follows:

- Until completion of the Priority Project, floodplain management will be executed under the existing system of COEN. The flood risk map prepared in this Study can be used. The area for floodplain management will cover the whole potential flood area.
- After completion of the Priority Project, floodplain management will be executed under the proposed organization covering mainly the areas of Olomega and Jocotal.
- The project will be implemented until the target year 2020.

4. Detailed Floodplain Management Plan for Priority Project

4.1 General

A flood risk map covering the potential flood areas of Near San Miguel City, Olomega, Jocotal and Usulutan have been prepared for the following purposes:

(1) As a basic information for detailed planning of the land use regulation / flood proofing and flood warning,

(2) To inform the residents and authorities related to development about the floodplain management plan, and discuss, covering the following contents :

- Background and purposes of the whole flood control projects and implementation schedule,
- Contents of the flood risk areas depending on the implementation schedule,
- How to use the lands and methodology of flood proofing.

For the selected Priority Project, detailed floodplain management plan covering the areas of San Miguel, Olomega and Jocotal were prepared.

4.2 Flood Risk Map for Priority Project

The flood risk maps showing flood areas caused by several magnitudes of floods in each stage of the river improvement have been analyzed. The maps of the potential flood areas of Near San Miguel City, Around Lake Olomega and Around Lake Jocotal are characterized as follows:

Flood Areas (in sq. km), Near San Miguel City

Magnitude of Flood	Existing River	After 2-year Improvement (Priority Project)	After 10-year Improvement (Master Plan)
2-year Flood	1.6	1.6	0.0
5-year Flood	2.0	2.0	0.0
10-year Flood	2.5	2.5	0.0
20-year Flood	3.0	3.0	0.0
50-year Flood	3.5	3.5	0.0

Flood Areas (in sq. km), Around Lake Olomega

Magnitude of Flood	Existing River	After 2-year Improvement (Priority Project)	After 10-year Improvement (Master Plan)
2-year Flood	41.5	9.2	0
5-year Flood	54.5	14.0	4.6
10-year Flood	69.4	15.5	9.6
20-year Flood	78.0	17.5	10.0
50-year Flood	83.7	55.4	55.4

Flood Areas (in sq. km), Around Lake Jocotal

Magnitude of Flood	Existing River	After 2-year Improvement (Priority Project)	After 10-year Improvement (Master Plan)
2-year Flood	25.6	9.0	5.2
5-year Flood	29.7	26.0	5.9
10-year Flood	31.0	27.7	10.0
20-year Flood	32.0	29.0	15.4
50-year Flood	33.0	29.3	9.0

The flood risk maps are shown in Fig. K.4.1.

4.3 Flood Forecasting and Warning Plan

4.3.1 Proposed System

Proposed flood forecasting/warning system consists of the following five (5) automatic water level gauging stations with telemeters at,

- Moscoso (inflow to the flood risk area),
- Diversion point (San Miguel River flood level at Olomega Diversion Weir),
- El Delirio (downstream end of the flood area around Olomega),
- Vado Marin (San Miguel River flood level at flood area around Jocotal), and
- Lake Olomega (fishery and flood water retarding).

The Site Office at Olomega will collect and analyze the above water level data, operate the control gate at the outlet of Lake Olomega and prepare information for flood warning.

4.3.2 Flood Forecasting and Warning Method

(1) Target Areas

The flood forecasting/warning is proposed for the potential flood areas of Around Olomega and Jocotal. The flood forecasting/warning system is proposed to be completed by 2,005 when the river improvement against 2-year flood is completed. Therefore, the flood warning will be targeted to the areas anticipated to be flooded after completion of the river improvement.

(2) Flood Forecasting Method

Flood forecasting is proposed to be made by water level (or discharge) change at Moscoso. For the preparation of the flood warning, existing weather meteorological station, STAR 4 in Ilopango, will be used. STAR 4 has hourly base satellite image data and some rainfall data. The water level data sent from the Site Office will also be used for forecasting.

(3) Flood Warning Method

All water level data collected and analyzed in the Olomega Site Office shall be informed to the residents through COEN. The homes in the potential flood areas are scattered in wide areas having a density of about 0.5 families /ha. at present and 1.0 families / ha. in 2,020. Therefore, transmission of information to all residents by telephone, siren, transceiver, etc. will not be practical. These method will be applicable to the limited number of persons like community chiefs.

Usage of radio and computer is recommended for the data transmission method.

Existing system for flood warning and evacuation is basically applied in this plan.

4.4 Land Use Plan

4.4.1 Area near San Miguel City

Present land use of the potential flood area consists of grazing 31.5%, urban 23.5%, sugarcane 23.3%, annual crop 8.6%, etc. with a total area of 700 ha.. This narrow and long flood prone area is mostly formed by old river courses and even a large flood will not expand the area so much due to steep topography.

Land use of this area is recommended based on the following policies:

- Area required for the river improvement works to cope with 50-year flood shall be kept, considering the required width and future land use. The required width of the river is 100 m to 110 m.
- Outside of the river area should not be developed for commercial, industrial and residential purposes, unless embankment or other flood proofing method is applied. It can be used for the areas with low damage potential such as agriculture, park, etc.

4.4.2 Area around Lake Olomega

A guideline of the land use for this area is proposed, from viewpoint of flood control, as follows:

- The areas anticipated to be flooded by 2-year flood should not be developed for any purpose,
- The area not flooded by 10- year flood can be developed for any purposes,
- The areas flooded by 10-year flood but not flooded by 2- year flood can be used for low potential damage purposes,

Existing land use of the potential flood area consists of grazing (61.9%), sugarcane (17.1%), annual crop (9.1%), bush/forest (1.1%), etc. with a total area of 9,840 ha. According to the survey of farmer's desire, crop land would be expanded instead of grazing if the flood control project is executed.

4.4.3 Area around Lake Jocotal

Existing land of the potential flood area consists of grazing (55.1%), sugarcane (15.8%),

annual crop (10.8%), bush/forest (0.8%), etc. with a total area of 4,438 ha. Increase in crop land area, after the flood control, is anticipated.
There is a plan to improve the ecology of Lake Jocotal and should be taken into this plan.

The guideline proposed for the Olomega area is applied also to this area.

4.5 Flood Fighting and Education

Organization for flood fighting, including, forecasting, warning, evacuation, etc. is proposed as follows:

- MAG central office for general arrangement,
- MAG Project Office in San Miguel for public relation, education and coordination with the related agencies,
- Site Office at Olomega for collection and analysis of the water level data, O / M of Control Gate and the water level gauging stations,
- STAR 4 for weather (flood) forecasting,
- COEN for warning, evacuation and other necessary coordination in emergency period,
- PNC, local government, local authority, residents, and other related organizations

Proposed floodplain management for the three areas is shown in Fig. K.4.2.

Existing system of COEN will be applied for flood warning and flood fighting. COEN consists of COED (Department level), COEM (Municipal level) and COEL (Community level). COEL includes the residents in the flood prone areas and can be participate in the flood fighting activities.

Education to the residents will be made by MAG for smooth implementation of the floodplain management by using the flood risk maps covering the following contents:

- Concept and purposes of whole flood control project,
- Concept of floodplain management such as land use regulation, flood proofing and flood fighting,
- Implementation schedule of the structural measures, and
- Activities to be taken by the residents

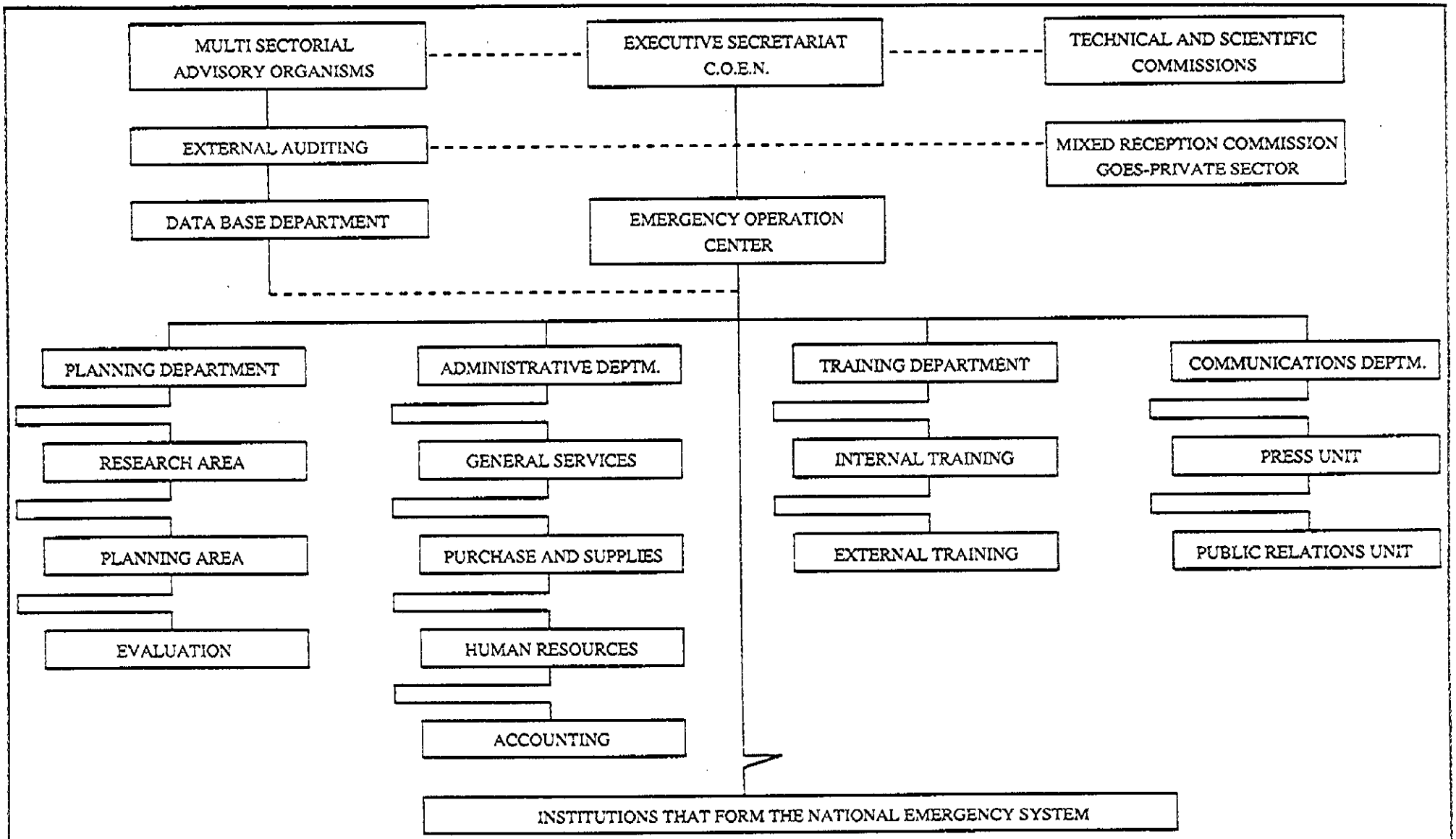


Figure K.2.1 ORGANIZATIONAL CHART OF THE EXECUTIVE SECRETARIAT OF C.O.E.N.

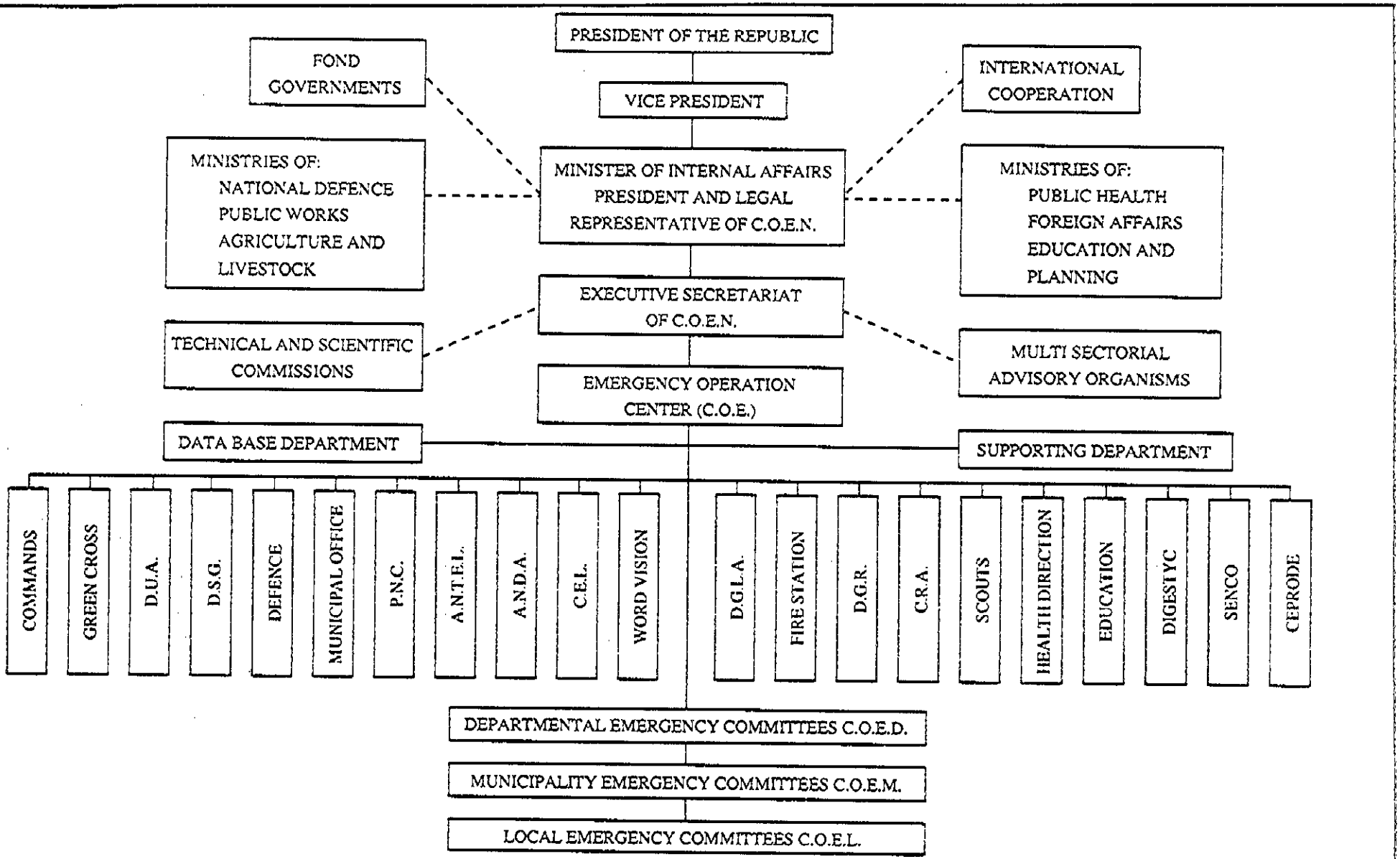


Figure K.2.2 GENERAL ORGANIZATIONAL CHART OF THE NATIONAL EMERGENCY COMMITTEE (C.O.E.N.)

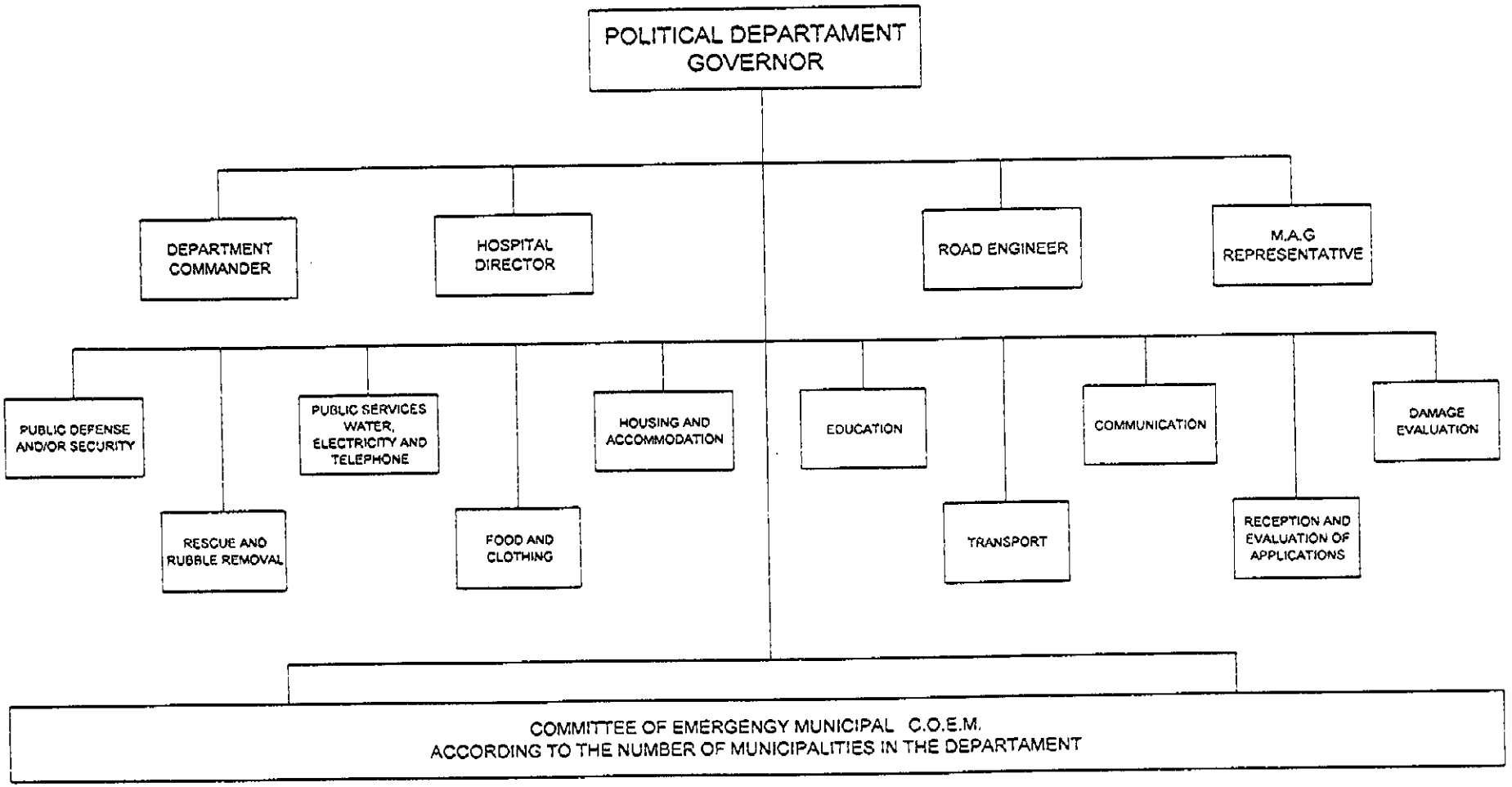


Figure K.2.3 ORGANIZATIONAL CHART OF THE DEPARTMENT EMERGENCY COMMITTEE, COED

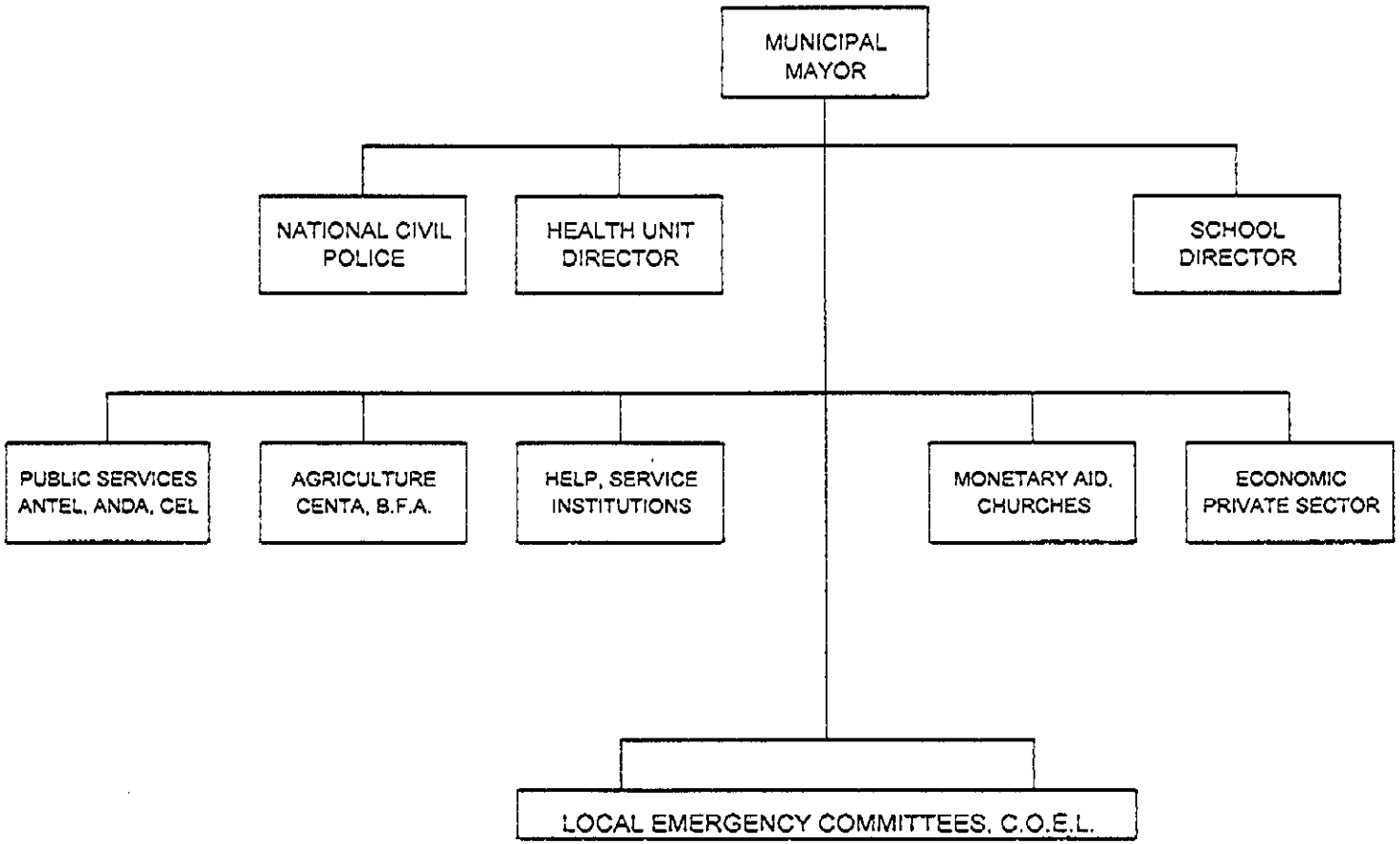


Figure K.2.4 ORGANIZATIONAL CHART OF THE MUNICIPALITY EMERGENCY COMMITTEE

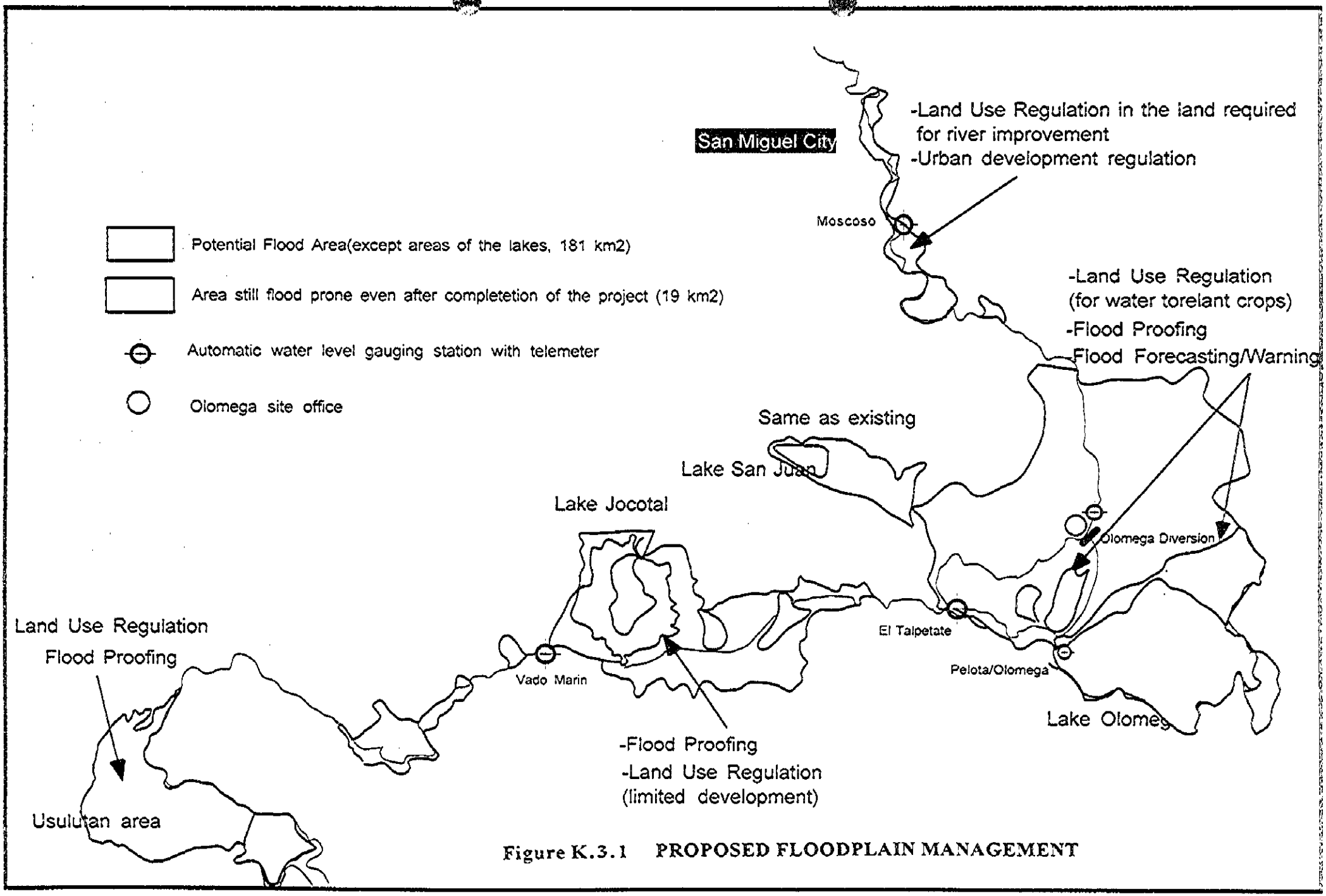
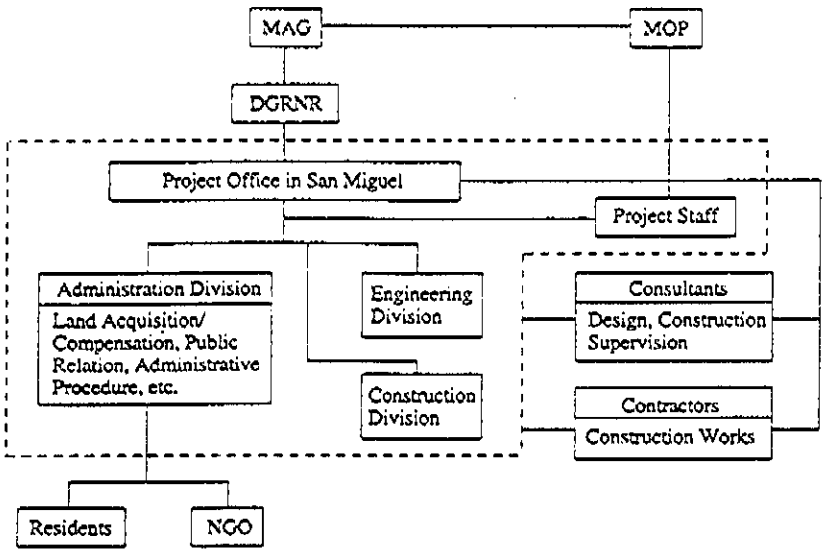


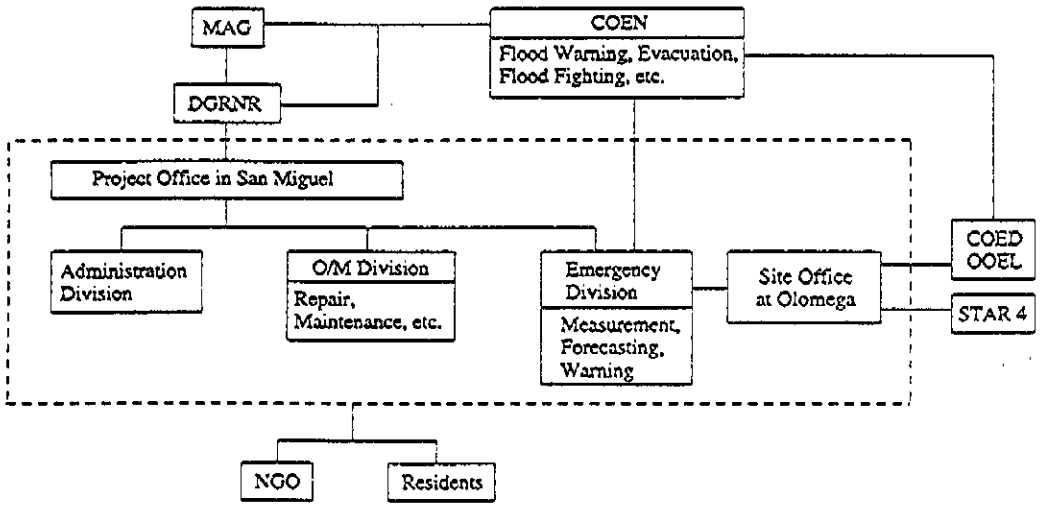
Figure K.3.1 PROPOSED FLOODPLAIN MANAGEMENT

Proposed Organization for Structural Measures

(1) Design/Construction Stage



(2) Operation/Management Stage



Proposed Organization for Nonstructural Measures

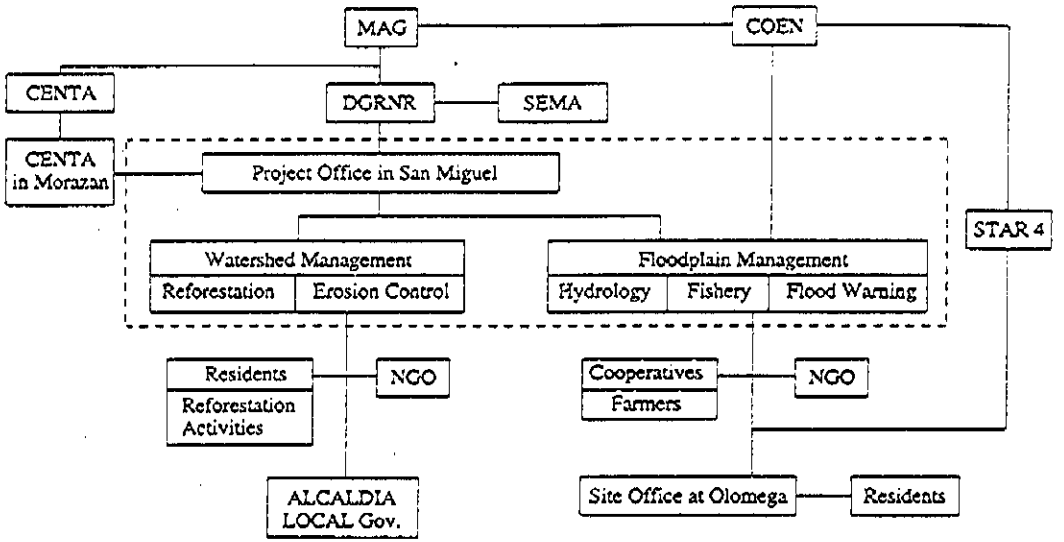
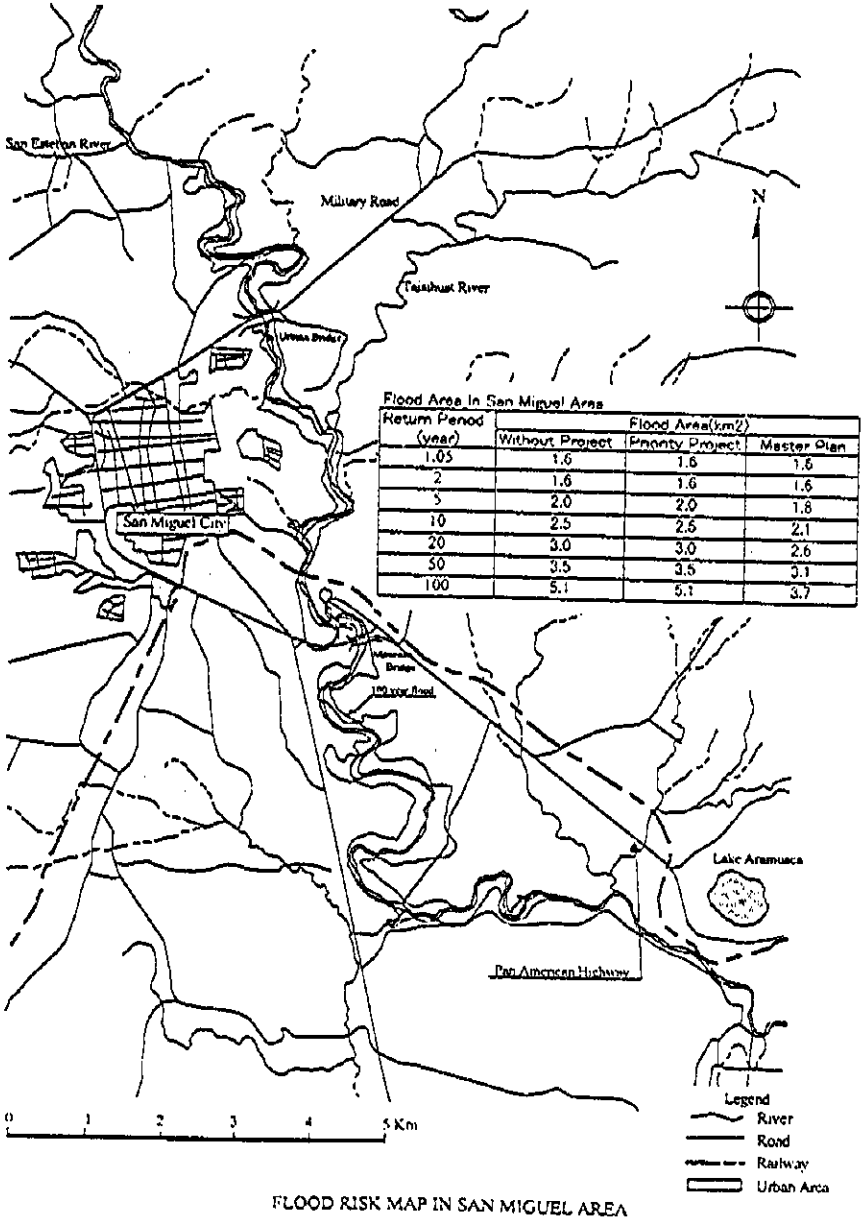


Figure K.3.2 PROPOSED ORGANIZATION



Flood Area in San Miguel Area

Return Period (year)	Flood Area(km2)		
	Without Project	Priority Project	Master Plan
1.05	1.6	1.6	1.6
2	1.6	1.6	1.6
5	2.0	2.0	1.8
10	2.5	2.5	2.1
20	3.0	3.0	2.6
50	3.5	3.5	3.1
100	5.1	5.1	3.7

FLOOD RISK MAP IN SAN MIGUEL AREA

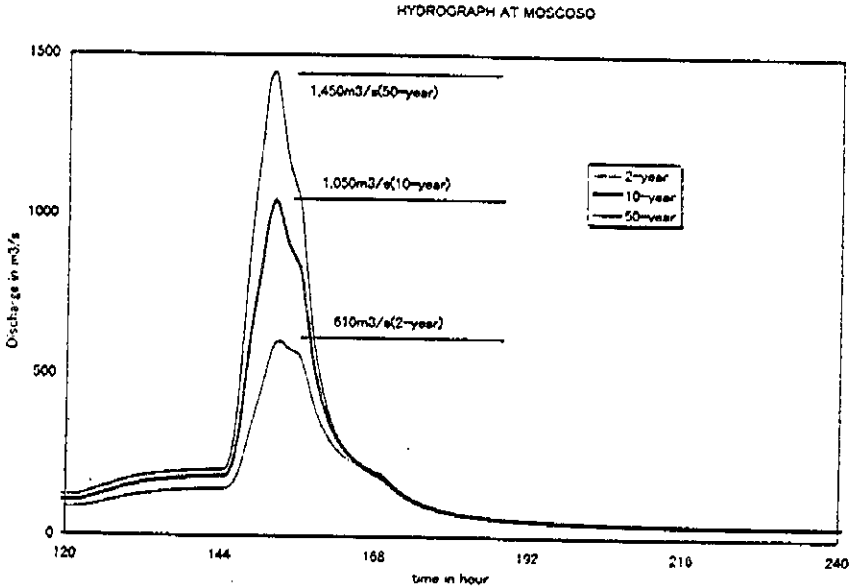
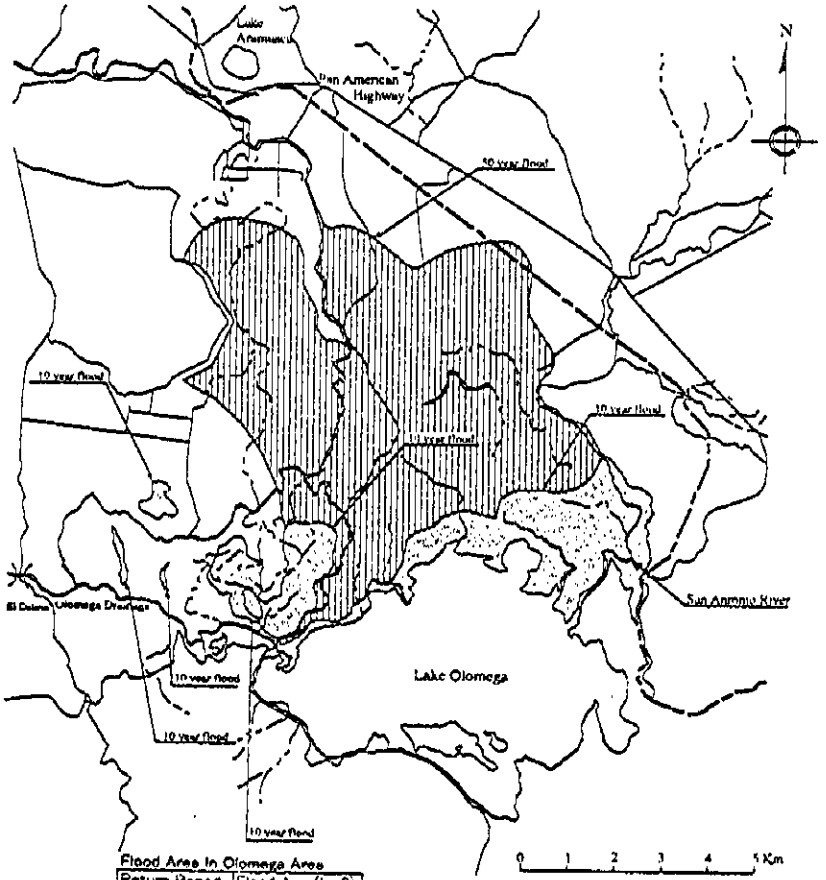


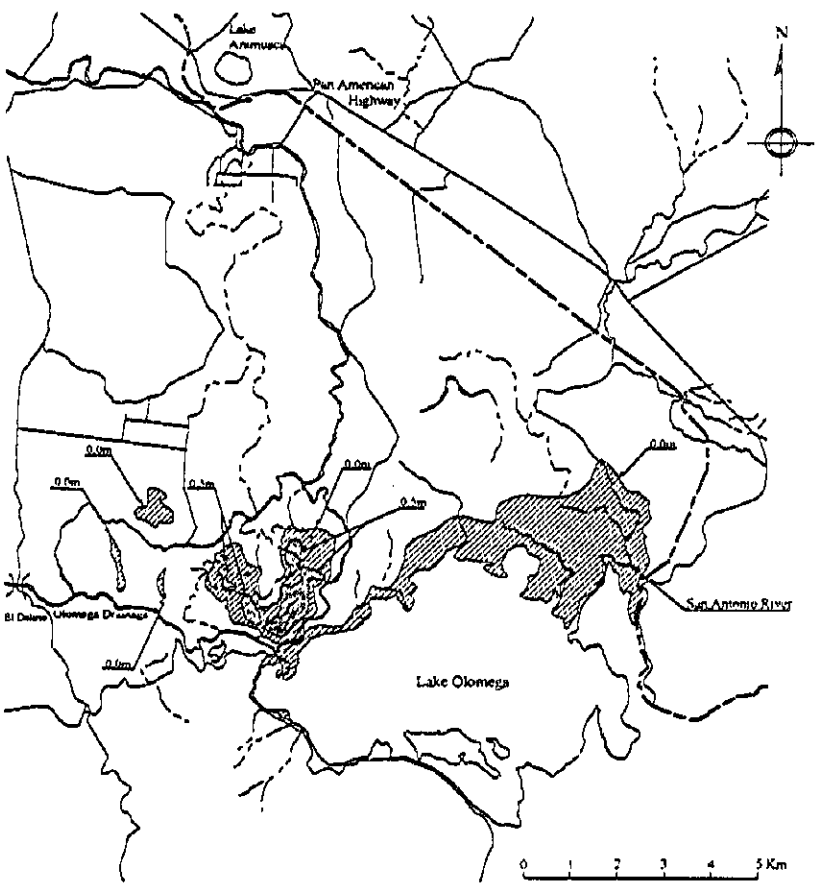
Figure K.4.1 (1/5) FLOOD RISK MAP IN SAN MIGUEL AREA



Flood Area in Olomega Area

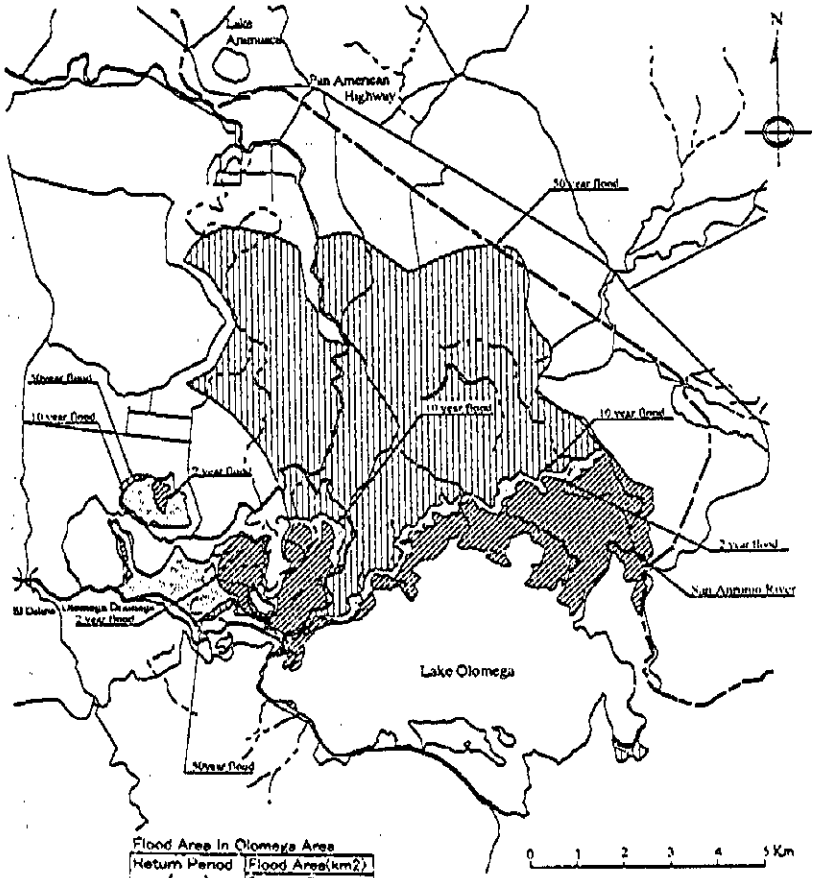
Return Period (year)	Flood Area(km2) Master Plan
1.05	0.0
2	0.0
5	4.6
10	9.6
20	10.0
50	55.4
100	59.1

FLOOD RISK MAP IN OLOMEGA AREA OF MASTER PLAN



CONTOUR LINES OF INUNDATION DEPTH FOR 10 YEAR FLOOD UNDER M/P

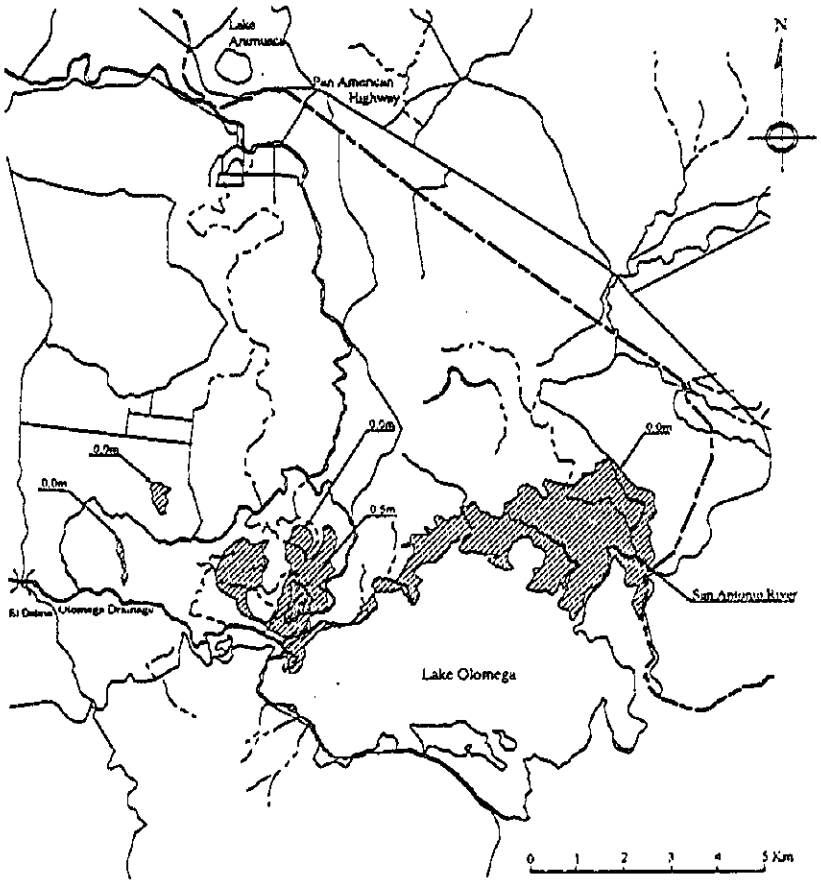
Figure K.4.1 (2/5) FLOOD RISK MAP IN OLOMEGA AREA OF MASTER PLAN



Flood Area in Olomega Area

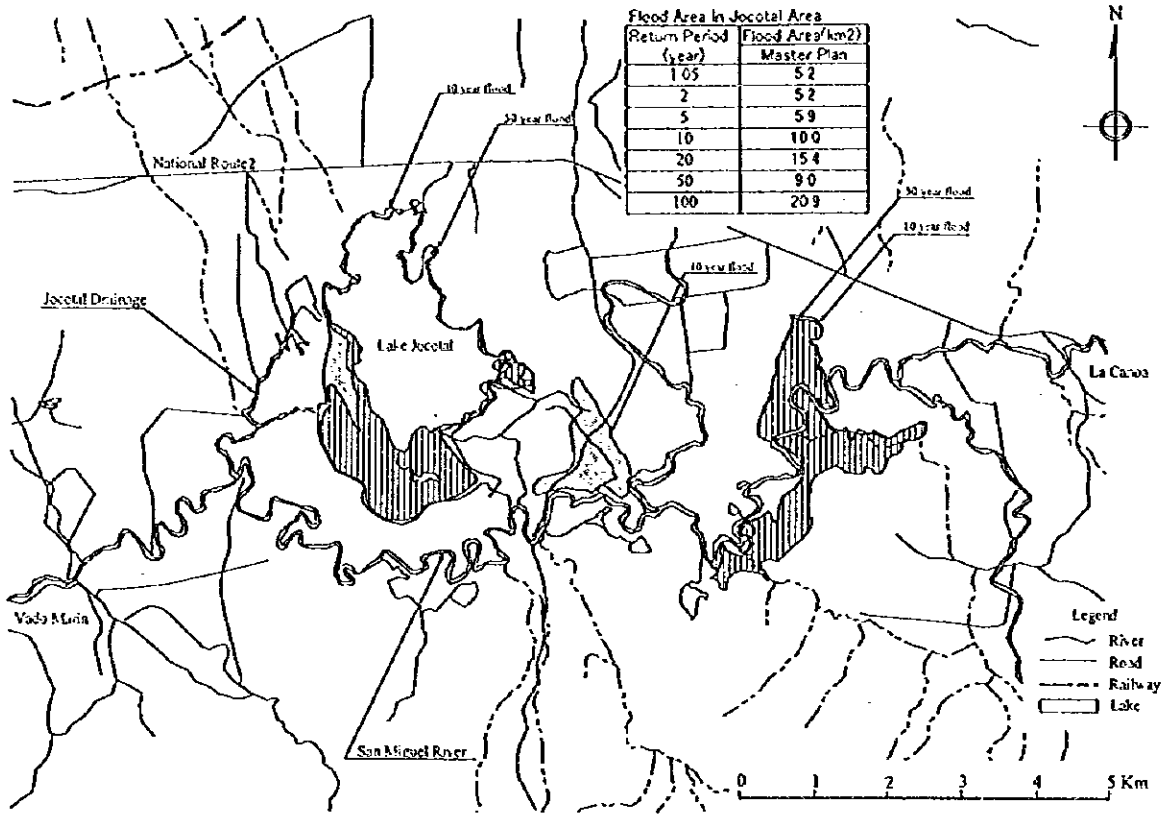
Return Period (year)	Flood Area(km2) Priority Project
1.05	0.0
2	9.2
5	14.0
10	15.5
20	17.5
50	55.4
100	59.1

FLOOD RISK MAP IN OLOMEGA AREA OF PRIORITY PROJECT

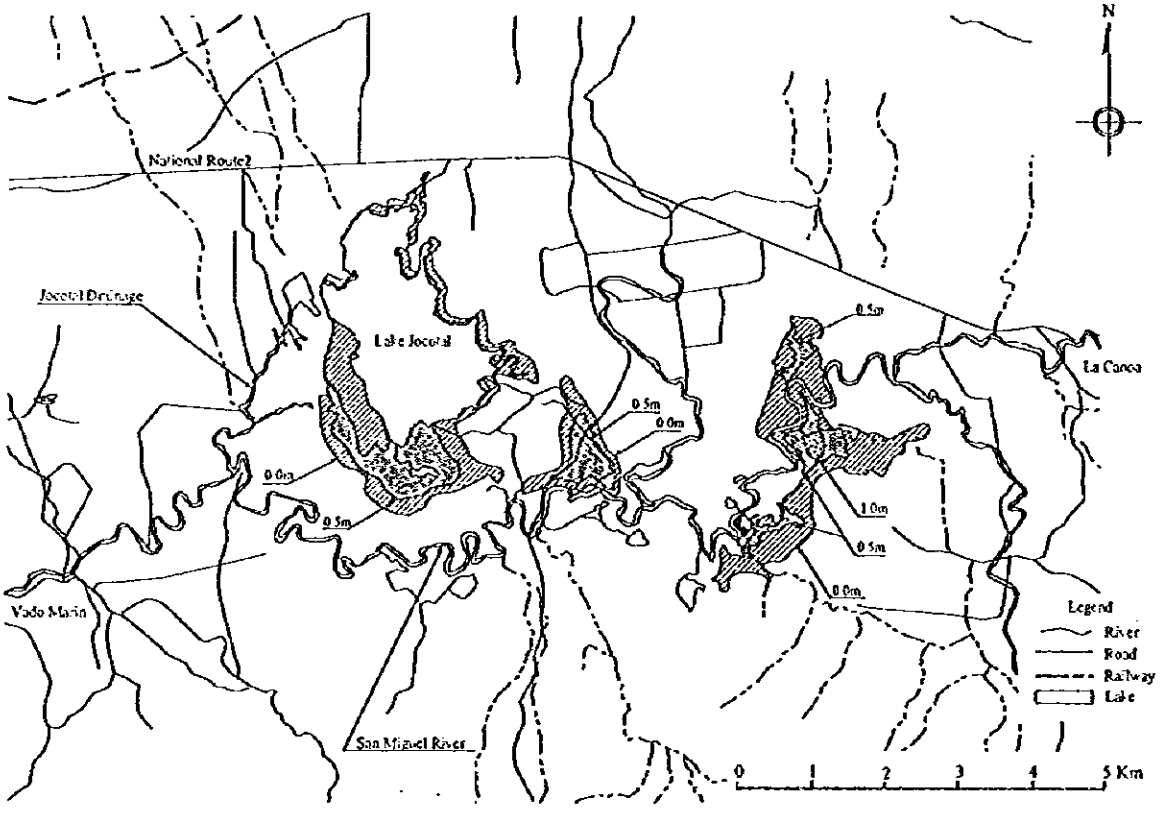


CONTOUR LINES OF INUN DATION DEPTH FOR 2 YEAR FLOOD UNDER P/P

Figure K.4.1 (3/5) FLOOD RISK MAP IN OLOMEGA AREA OF PRIORITY PROJECT

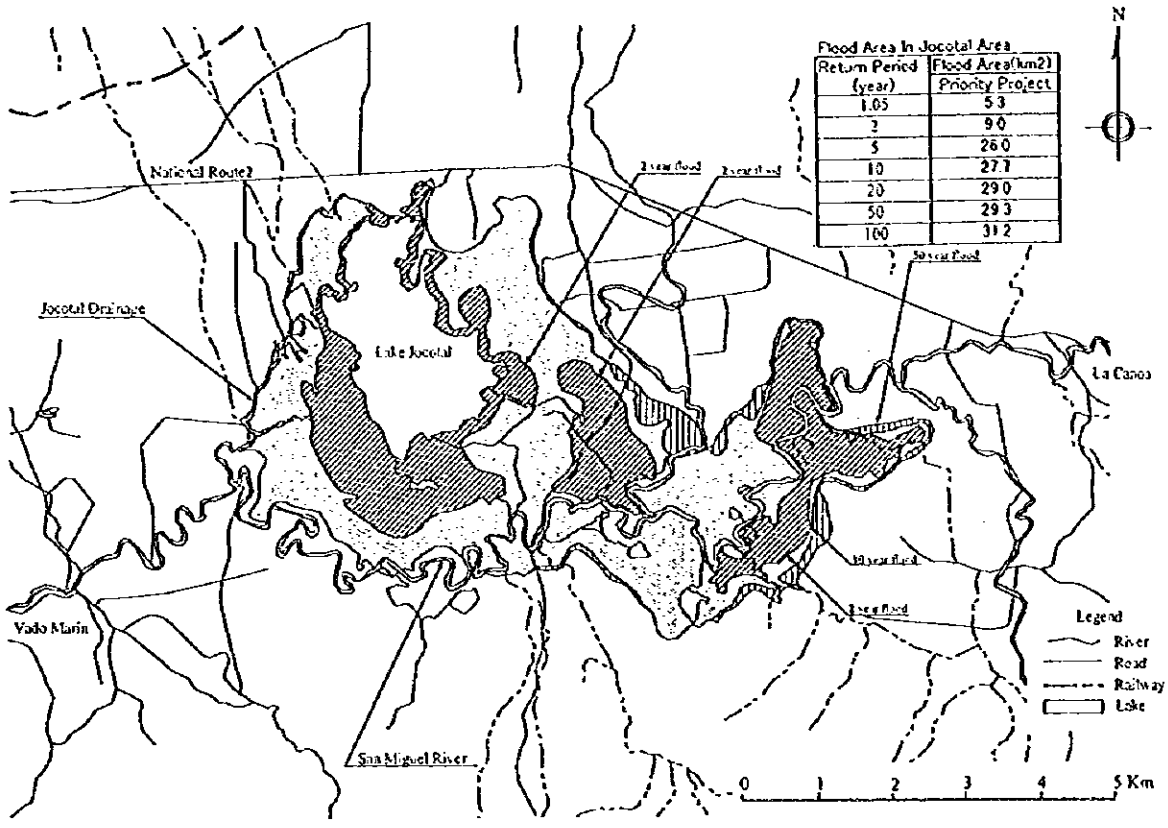


FLOOD RISK MAP IN JOCOTAL AREA OF MASTER PLAN

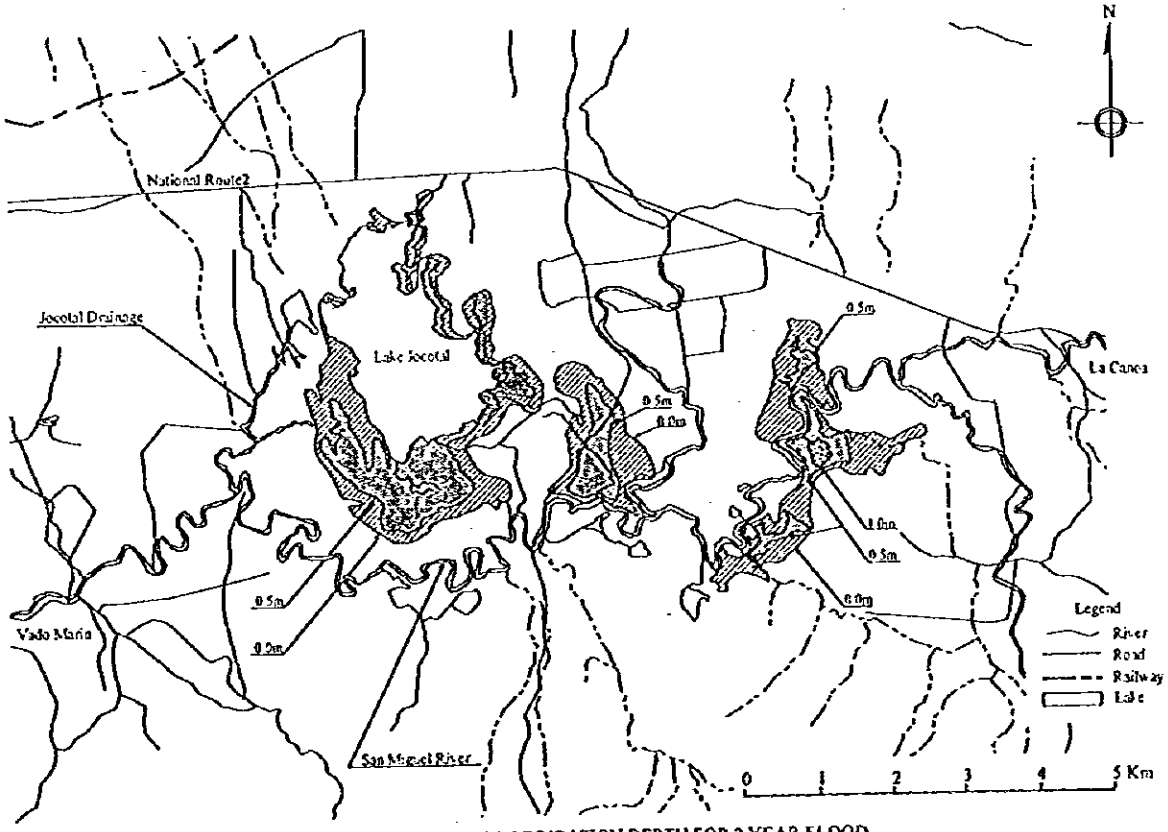


CONTOUR LINES OF INUNDATION DEPTH FOR 10 YEAR FLOOD
UNDER M/P IN JOCOTAL AREA

Figure K.4.1 (4/5) FLOOD RISK MAP IN JOCOTAL AREA OF MASTER PLAN



FLOOD RISK MAP IN JOCOTAL AREA OF PRIORITY PROJECT



CONTOUR LINES OF INUNDATION DEPTH FOR 2 YEAR FLOOD
UNDER P/P IN JOCOTAL AREA

Figure K.4.1 (5/5) FLOOD RISK MAP IN JOCOTAL AREA OF PRIORITY PROJECT

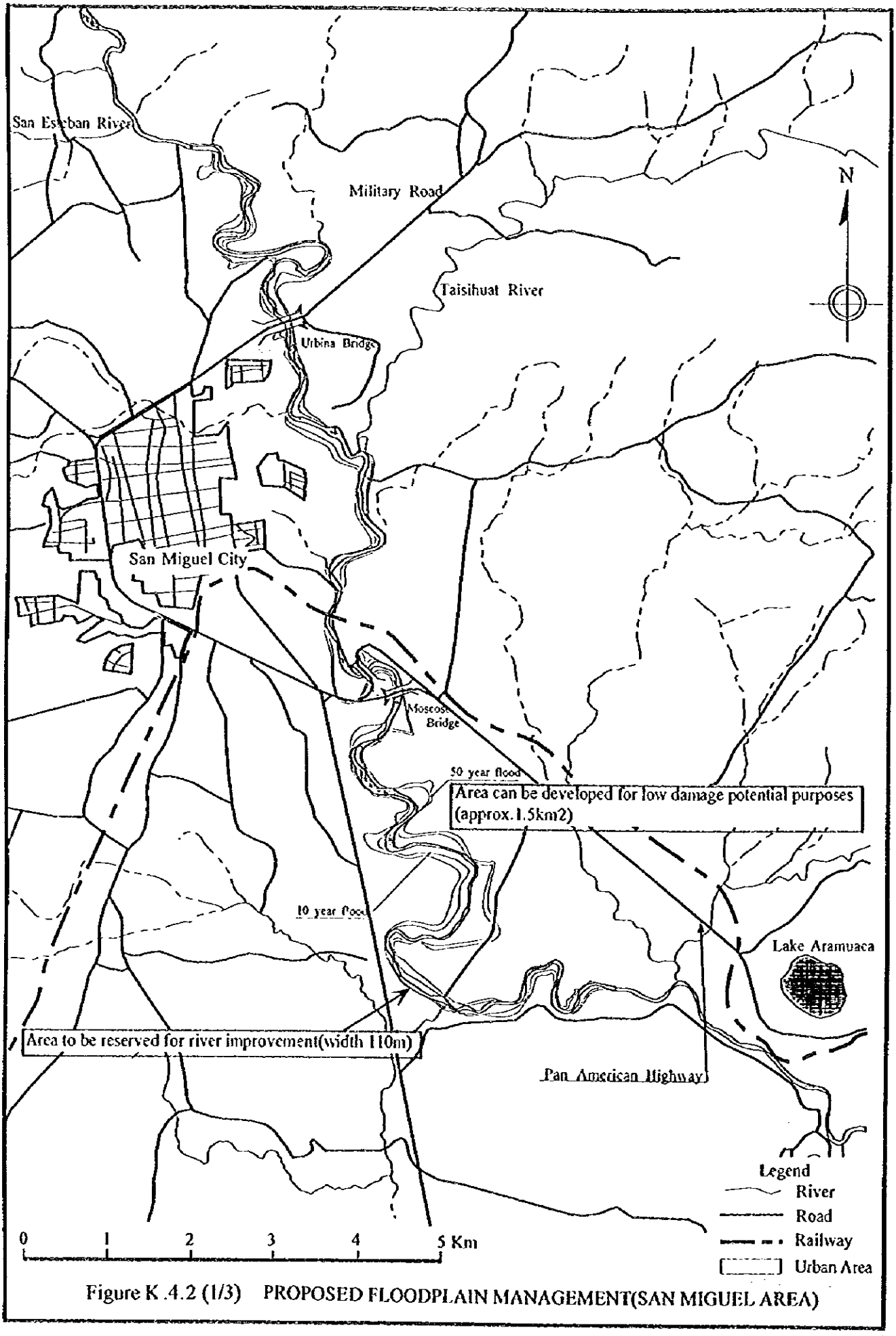


Figure K .4.2 (1/3) PROPOSED FLOODPLAIN MANAGEMENT(SAN MIGUEL AREA)

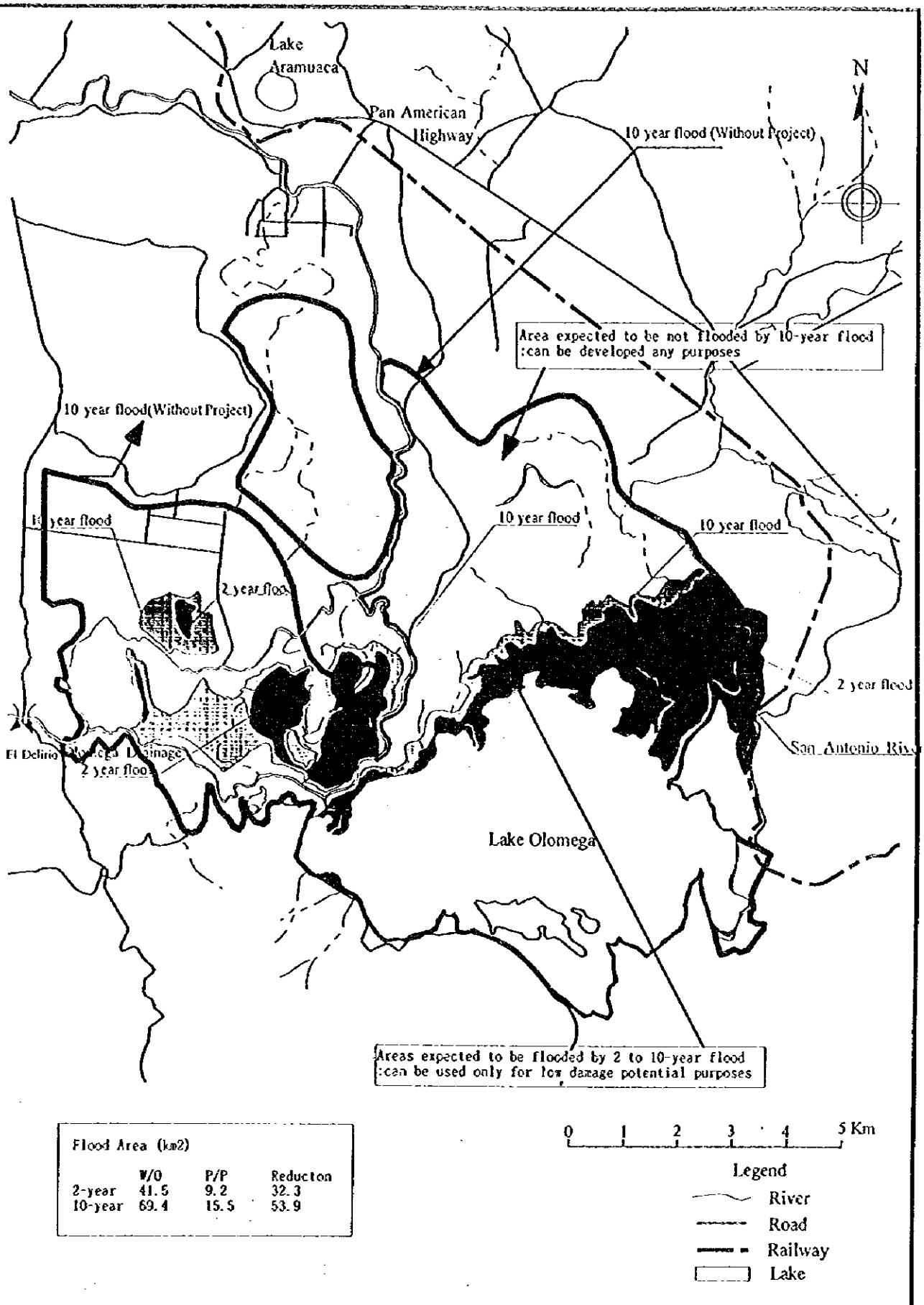


Figure K.4.2 (2/3) PROPOSED FLOODPLAIN MANAGEMENT(OLOMEGA AREA)

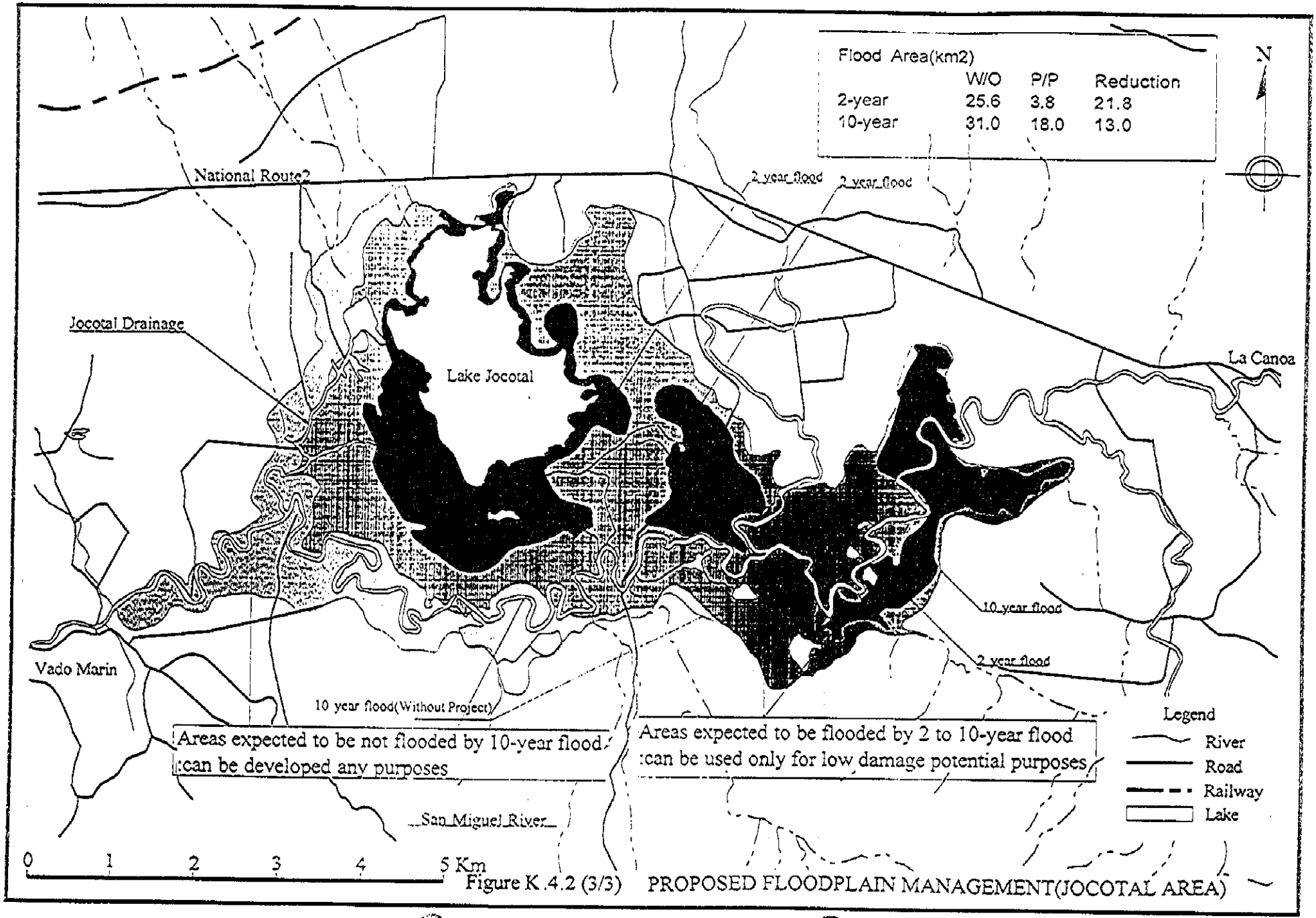


Figure K.4.2 (3/3) PROPOSED FLOODPLAIN MANAGEMENT(JOCOTAL AREA)

SUPPORTING REPORT

L: FLOODWATER STORAGE PLAN

Supporting Report L: Floodwater Storage Plan

Table of Contents

List of Tables and Figures in Supporting Report L

L: FLOODWATER STORAGE PLAN

1. DAMS

From the viewpoint of flood control, only those with large basins are effective. In this regard, San Esteban Dam site was selected for flood storage purpose and compared with other measures. As the results, the idea of multi-purpose San Esteban Dam was not included in the flood control master plan.

2. USAGE OF LAKES

2.1 Selection of Storage Site

For storage of floodwater a large catchment at facility site is required. The total volume of inundated water in 1995 is estimated as 100 million cubic meters. Therefore, for effective storage of flood, storage of tens of millions cubic meters is required.

If retarding basin is selected from a low area along the river, a large potential agricultural area is to be specified as a retarding basin. As the target area for flood protection is mainly farm land, it is not justified to sacrifice a part of farm land to protect another. Moreover, the target area for flood control is Olomega area and Jocotal area, the location should be in the middle or upper part of the river.

As a conclusion, retarding basin was selected on the existing lake of Olomega. Lake Olomega will serve a retarding basin to store floodwater and reduce peak flood discharge downstream reaches.

2.2 History of the Conflict on Lake Olomega

The outlet structure of the Lake Olomega has a conflicting history between the fishermen and the farmers as follows.

before 1940	The main course of the San Miguel River had been located in the south of the present river
1940's	A severe drought hit the area and the area of Lake Olomega retreated. The farmers taking advantage of the lake water retreat, placed their landmarks inside the present lake area.
1960-1970	MAG and landowners shifted the course of the river north-ward to the present position in order to protect the area from flooding.

1977,78	A severe drought hit again and the lake area shrank. The fishermen temporarily had to move to the artificial lakes along the Lempa River for fishery.
1977,78	A dike was constructed to protect the northern area of the lake from flooding
1984-86	The fishermen group closed the outlet from Lake Olomega to the Olomega Drainage in order to keep the lake water level.
1986-1992	The lake water rose and overflowed into the Olomega Drainage in uncontrolled way.
1992	The water flow started to form a single stream into the Olomega Drainage. However the outlet from the lake was still not a channel but a random overflowing.
1995.3	An NGO, which is representing the fishermen, constructed a concrete weir at the entrance of the Olomega Drainage.
1995-1996	The side of the concrete weir was scored by flood flow.
1996.6	The NGO submitted an application to MAG for construction of a weir.
1996-1997	The side of the concrete weir was scored further.

Presently, a concrete structure exists at the outlet of the channel and upstream channel has been buried leaving the lowest lake edge 65.2 m. Consequently, the lake surface is being maintained higher than that in 1970's. The minimum lake water level during the dry season in 1996 was 64.8 m.

Consequently, the fishermen want to maintain and repair the concrete structure to secure the maintenance of the present lake water level, while the farmers want to recover the once cultivated land on the north of the lake.

2.3 Lake Olomega Utilization

In the Master Plan, utilization of Lake Olomega as a retarding basin was planned. The reasons of this employment of Lake Olomega are described below.

(1) An alternative combination of projects without the employment of Lake Olomega costs 30% higher than the another alternative combination of projects including the Lake utilization.

(2) It is reasonably fair to distribute the burden of the flood control among the various areas along the river which get benefit from the project. In this sense, it is appropriate to store a part of the flood in the Lake Olomega and reduce the flood load downstream.

(3) Controlling the lake water level by properly operated gates will grant benefit to both the fishery and flood control in the area.

(4) The Lake Olomega usage has been in the midst of conflict between the fishermen and the farmers for a long period. In June 1996, the fishermen group submitted an application to MAG for construction of a control structure at the outlet of the lake and MAG is presently in a position to give the final answer to the conflict.

3. FLOODWATER RETARDING PLAN

3.1 Flood Discharge Allocation

3.1.1 Storage Volume of the Lake

The relationship between water level and volume of Lake Olomega is shown in Fig. L.3.1. It is derived from the results of the survey carried out by the Study Team in 1996.

3.1.2 Design Low Water Level of the Lake

(1) Reservoir Sedimentation

The sediment is transported into Lake Olomega from both the lake catchment and the San Miguel River.

The own drainage area of the lake is 200km² and the sediment yield can be calculated multiplying it by the sediment yield rate of the drainage area, which is estimated as 1,000m³/year/km², by referring the measured sediment yield from the existing reservoirs in the Lempa River. Thus the estimation of sedimentation for 100 years is 20 million m³.

The sediment transport from the San Miguel River is estimated from the flood sediment load and the average annual flood discharge which is expected to flow into the lake. The sediment load is estimated as 2,000ppm, considering the observed data in this study. The annual flood inflow expectation is estimated as 4 million m³/year after this project is implemented. Thus the hundred-year sediment yield from the San Miguel River is estimated as 8 thousand m³, less than one percent of the sediment yield from the lake catchment.

Thus the total design sedimentation volume in the lake is approximately 20 million m³, most of which comes from the lake catchment.

For a reference, the elevation-volume relationship established in 1967 in the study of "Olomega Project" is shown in Fig. L.3.2. The figure shows that the minimum elevation of the lake bottom is 62m and the total reservoir volume below 64m is 20 million m^3, which is almost identical with Fig. L.3.1. It means that the lake bottom configuration has yielded little change in these thirty years and the sedimentation effect has been in negligible scale. So the above mentioned 20 million m³ in 100 years may overestimate the real phenomenon.

By taking the conservative side, the sedimentation surface in 100 years is estimated as 64.0m, which is equivalent to the volume of 23 million m³.

(2) Fishery Activity

There is a tendency that the fish catch in Lake Olomega is small in years with flooding. Table L.3.1 shows relation between the annual runoff at the point of El Derilio and the annual fish product in Lake Olomega.

Within a year, fish catch is smaller during wet season than in dry season. Fig. L.3.3 shows the monthly fish catch and the lake water level during 1970's, only time when both the lake water level record and the fish catch data are available. From these data, the relation between the lake water level and the fish catch was drawn as Fig. L.3.4. They show that fish catch is limited when the lake water level is too low or too high. The reason of the small fish catch in low water level is apparent as it reduces the habitat of fish.

The reason why the high lake water level decreases the fish catch is not obvious. However, in the interview of the fishermen and MAG, following reasons were raised.

A. the common fishery method in the area is difficult for a deep water
B. a large depth decreases the density of fish in the lake
C. fish finds places to hide themselves when the water is deep
D. effect of the life cycle of fish

Whatever the reason may be, the fish production is low when the water level is too high. So, there seems to be most suitable depth for fishery operation. According to Fig. L.3.4 the favorable depth is between 64.0m and 65.5m.

By taking an allowance of 0.5m on the elevation 64.0m mentioned above, the minimum lake water level in this project was planned as 64.5m, corresponding storage volume being 34 million m³.

3.1.3 Design High Water Level of the Lake

The Design High Water Level of the lake was planned as 65.5m judging from the ground elevation around the lake.

Fig. L.3.5 shows contour lines around the lake. By setting the Design High Water Level as 65.5m, housing areas around the lake become free from inundation.

There is an area surrounded by dikes on the north of the lake where the ground elevation is lower than 65.5m. This area is presently a swamp and saving this particular place from flood is rather difficult and not practical to do so.

Therefore, this area has been excluded from the definition of the target area for flood mitigation and included in the target area for floodplain management. In order to get rid of inundation from this area, some other measures have to be taken apart from this plan. For example, one way is to reclaim the area or elevate it above 65.5m. Another way is to install drainage pumps to drain inner water.

3.1.4 Reservoir Allocation

The proposed reservoir allocation of Lake Olonega is as follows;

Dead Capacity	23,000 m³	(EL 62m~EL64.5m)
Flood Control Capacity	29,000 m³	(EL 64.5m~EL65.5m)

3.2 Flood Control Plan

3.2.1 Basic Concept

The baisc concept of flood control by Lake Olonega storage is as follows;

1) The design flood discharge at the Olonega Diversion Weir shall be cut by diversion of about the half of river peak discharge.
2) As the master plan is to cope with 10-year flood, the diversion weir is planned to cope with 10-year flood as the final structure.

3) As the priority project is planned to cope with 2-year flood, the diversion weir is planned as such in the priority stage.
4) The structure of diversion weir is planned so that it can be reconstructed easily from the priority stage to the final stage.
5) Olomega Control Gates are planned to cope with both the priority stage and the final stage.

3.2.2 Master Plan

According to the design discharge distribution of the whole river system in the Master Plan, the design inflow at the diversion weir is 1,150m³/s, while the diversion flow is 660 m³/s. The storage volume at this time is 19 MCM and the corresponding lake water level is 65.2m. The inflow and outflow hydrograph are shown in Fig. 6.4 in Data Book.

The calculated maximum lake water level of 65.2 m is lower than the Design High Water Level of65.5 m. The difference of 0.3 m, corresponding volume of 9 million m³, can be considered as a margin.

3.2.3 Prioriy Project

According to the design discharge distribution of the whole river system in the Priority Project, the design inflow at the diversion weir is 660m³/s, while the diversion flow is 365m³/s. The storage volume at this time is 14 million m³ and the corresponding lake water level is 65.1m. The inflow and outflow hydrograph are shown in Fig. 6.5 in Data Book.

3.3 Simulation

3.3.1 Flood Simulation

In order to see the behavior of the lake during a flood larger than the design flood, a mathematical simulation was performed.
The conditions for simulation are as follows;

River Improvement and retarding facilities;	Proposed ones for Priority Project
Return period of inflow flood;	10 years
Initial lake water level;	64.5m
Inflow from the own catchment;	considered
Outflow from the Olomega Control Gates;	0 m³/s

The result is shown in Fig. L.3.6. According to this simulation, when 10-year flood comes, the maximum water level of the lake reaches 65.6m, only 0.1m above the Design High Water Level and will not cause any serious problems.

3.3.2 Drought Simulation

The behavior of the lake during a extreme drought was simulated. The conditions for simulation are as follows.

Data used:	Between 1970 and 1979, only time when lake water level data is available.
Inflow:	As no data is available for the inflow into the lake, discharge data of Villerias and Moscoso were used and converted by specific discharge.
Evaporation :	Estimated by multiplying 0.7 to the pan evaporation values of El Papalon.

The operation rule of the gates are assumed as

- during wet season, the gates are operated to maintain the lake water level at 64.5m
- during dry season, the gates are operated to maintain the lake water level at 65.0m

The result of the simulation is shown in Fig. L.3.7 together with the recorded lake water level. Fig. L.3.7 shows that the lake water level is maintained above 65.0m even in 1978, thedriest year in ten years, by implementing of the project. Without project, lake water level actually went down to 63.4m and caused damage to the fishery.

3.4 Consent of the Parties Concerned

As there is a long history of conflict over operation of the lake, it is necessary to get the consent of the parties concerned in a careful way. It is recommended that let the all information open to the people and let them take part in the process of decision making.

Recommended procedure is as follows;

a. to explain the behavior of the lake in the past floods and droughts in a way that the people clearly understand the real picture of the problem
b. to explain the nature of the whole project, which is going to give benefit to all the people concerned
c. to show the position of the central government as a neutral party

d. to explain the basic concept of the lake operation, which is taking into account both flood control and fishery operation
e. to explain the result of mathematical simulations to show the improvement of the situation both in flood and drought by the implementation of the project
f. to explain the whole contents of the operation rule
g. to explain the operation and maintenance organization
h. if there is any good suggestion for the operation and maintenance of the facilities from the people, the opinion will be taken into account for formulating the O/M policies

It is also advisable to hold a periodical meeting after the actual operation of gates started and to show the result of the operation to the people.

4. FACILITIES PLAN

4.1 Structural Plan

4.1.1 General Layout

Two alternative river alignments were studied and the final alignment was decided as shown in Fig. L.4.1.

4.1.2 Site Investigation

The specific sites of the facilities were studied with respect to topography and geology. The area is rather flat and the geology around the area is composed of clay and silt. There is no hard soil or rock to be excavated by a ripper bulldozer.

The land use of the area is swamp or partly a pasture land. No houses are to be relocated for the construction of the facilities in this area.

4.1.3 Structural Plan

(A) Diversion Weir

As stated, before the diversion weir was planned through which half of the design peak discharge is diverted.

For the type of the structure, three different ideas were compared, namely a concrete monolith type, a concrete paved embankment type and a gabion type. The comparison is shown in Table L.4.1. Finally a concrete monolith type was selected mainly because of maintenance reason.

The diversion weir should be planned to cope with both stages of the two-year flood and the ten-year flood. Therefore, the structure was planned for two-year flood first as a part of the priority project and its modification in the final stage was planned.

(First Step; for the Priority Project)

- The crest elevation of the weir was determined to be 66.1 m as the normal water level of Lake Olomega during the wet season is 64.5m.
- The weir is located near the river side bank slope in order to let overflow as calculated. The proposed crest width is 62 m.
- The downstream bottom elevation of the weir was determined as 63.0m to get the cushion depth of 1 meter.
- The crest length of the weir was determined as 62m so that the discharge of 300 m^3/s isdiverted. Calculation of the overflow was done by unsteady flows analysis. For the reconfirmation of this analysis, it is recommended to conduct a hydraulic model test during the detailed design stage.
- The length of the cussion was planned in accordance with the final configuration of the structure to cope with 10-year flood.

(Second Step; for the Master Plan)

- The crest elevation of the weir = 67.3m.
- The crest length of the weir = 62 m (490 m^3/s diversion discharge).

(B) Olomega Control Gate

The control gate of Lake Olomega were planned so that the lake water level is operated for the purposes below.

- to store a part of the floodwater temporarily in order to mitigate the flood damage downstream during the wet season
- to maintain the lake water level during dry season so that appropriate water area and depth are maintained for fishery

The width and the depth of the outlet channel were proposed to same as these of the existing outlet channel. Fig. L.4.2 shows the relationship between the existing concrete weir and the control gates of this plan. Consequently, the width of the channel is 25 meters and the channel bed elevation is 63.0m.

As the gates are to be operated to cope with the small change of inflow and to maintain the lake water level during the wet season, the gate system should be composed of many number of small gates. The width of the gates is proposed to be one meter and two meters each.

The gates are planned to cope with the 10-year flood and the same structures are applied for 2-year flood, too.

4.1.4 Construction Plan

The general sequence of construction works is shown in Fig. L.4.3.

① Improvement of Pelota River
① Construc tion Oplomega Control Gages
② Improvement of Olomega Drainage
③ Diversion of Water from Lake Olomega through Olomega Drainage
④ Construction of Diversion Weir
⑤ Improvement of San Miguel River

4.2 Operation and Maintenance of Facilities

4.2.1 Operation

(1) Basic Concept

The basic concept of lake water level operation is as follows,

(during the wet season)

- to maintain the lake water level at 64.5m before a flood overflows the diversion weir
- when the flood overflows the diversion weir, the gates are controlled so that the flood stored in the lake effectively
- after the flood is over and the danger of inundation downstream eliminated, the stored water is released by controlling the gates, and the flood storage is recovered
- at the end of the wet season, the gates are operated so that the lake water level is raised up to 65.0m and maintained as it is

(during the dry season)

- the lake water level is maintained at 65.0m by closing the gates completely
- the total evaporation depth during the dry season is estimated as 80 to 90 cm, and as there is still inflow from the own catchment, the lake water level is maintained above 64.5 m

(2) Operation Rule of the Lake Olomega Control Gates (Draft)

Chapter 1 General

(Application)
The water level of Lake Olomega is to be operated according to this Operation Rule of Lake Olomega Control Gate.

(Purpose of Control Gate)
The purposes of the Control Gates are flood mitigation around the lake, maintenance of the lake water level and reduction of the flood in the downstream areas.

(Principle of Gate Operation)
The gates are to be exclusively operated by the head of the Olomega Site Office of MAG.

Chapter 2 Operation of Gates

(Wet Season and Dry Season)
Wet Season is defined as May 1 through October 31.
Dry Season is defined as November 1 through April 30 .

(Standard Lake Water Level) The Standard Lake Water Level is 64.5m

(Lake Water Level) The Lake Water Level is defined as the water level at the gauging station at Puerto Viejo.

(High Water Level) The High Water Level of the Lake is + 1.0m above the Standard Lake Water Level (65.5 m)

(Normal Water Level during Wet Season) The Normal Water Level during Wet Season of the Lake is the Standard Lake Water Level (64.5 m)

(Normal Water Level during Dry Season) The Normal Water Level during Dry Season of the Lake is +0.5m above the Standard Lake Water Level (65.0 m)

(Definition of Emergency Time)
1.When flood forecasting has been issued
2.When flood warning has been issued

3. When a warning of heavy rainfall has been issued and the head of the Office has judges it is necessary

(Required Operation during Emergency Time)

1. Communication with related agencies and data collection
2. Checking and maintenance of gates and testing of reserve power generator
3. Preparation of personnel for operation

(Flood Mitigation around the Lake)

When the lake water level is over the Normal Water Level during both wet and dry season, the gates are to be operated in order to maintain the lake water level as the Normal Water Level.

(Gate Operation during Dry Season)

During dry season, all the gates are to be operated or closed to maintain the Lake Water Level as +0.5m above the Standard Water Level.

(Calling off of Emergency)

The head of the office is to call off the emergency when it is not any longer necessary.

(Abrupt change of discharge)

Abrupt change of discharge in the upstream and the downstream of the gate should be avoided.

(Notice of Water Release)

The head of the office, when they start the operation of the gates, should notify the relevant organizations and the public beforehand.

(Observation, Inspection and Maintenance)

Periodical inspection and maintenance are necessary for diversion weir and control gates.

(Observation)

Observation of meteorological and hydrological phenomena should be achieved by the Site Office.

(Records)

Records of gate operation, meteorology and hydrology should be maintained by the Site Office.

4.2.2 Maintenance

The maintenance of the facilities will be done by MAG in the local office. The contents of operation and maintenance of the facilities are as follows;

Diversion Weir
- inspection of the concrete structures
- inspection and maiontenance of the channel and revetments

Control Gates
- inspection of the concrete weir
- inspection and maintenance of the gate leaves
- inspection and maintenance of the power unit
- inspection of the channel
- removal and treatment of water lily
- inspection and maintenance of stoplogs

5. ENVIRONMENTAL IMPACT

(1) Impact on the fishery activity

It is possible to maintain the water level of the lake during the dry season by the operating the gates and the project will give benefit to fishery activity.

(2) Impact of sedimentation

According to a flood simulation, the amount of flood flow into the lake after completion of the project is considerably smaller than that without the project.

So the impact of sedimentation on the lake will be eased by implementating the project.

(3) Impact on water quality

There is a fear of water quality deterioration of the lake by the introduction of the flood water into the lake. However, according to the study, most of the pollutant transported in the lake comes from the catchment of the lake and only small amount of water from the San Miguel River.

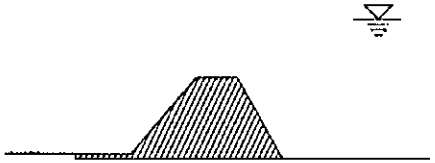
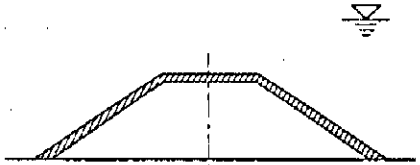
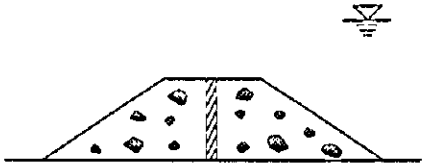
Consequently, the amount of pollutant brought into the lake will be reduced by the project. So the project will not give negative effect on water quality of the lake.

The water quality data collected in this study is limited and it is difficult to discuss a eutrophication problem. However, seeing the fact that the lake water quality is low in terms of COD, BOD and T-N, T-P both in May and July, the main source of pollutant may be the lake catchment. The methods to be studied are waste water treatment in the town and the residential area, cattle waste treatment, restriction of cattle feeding in the area erosion control.

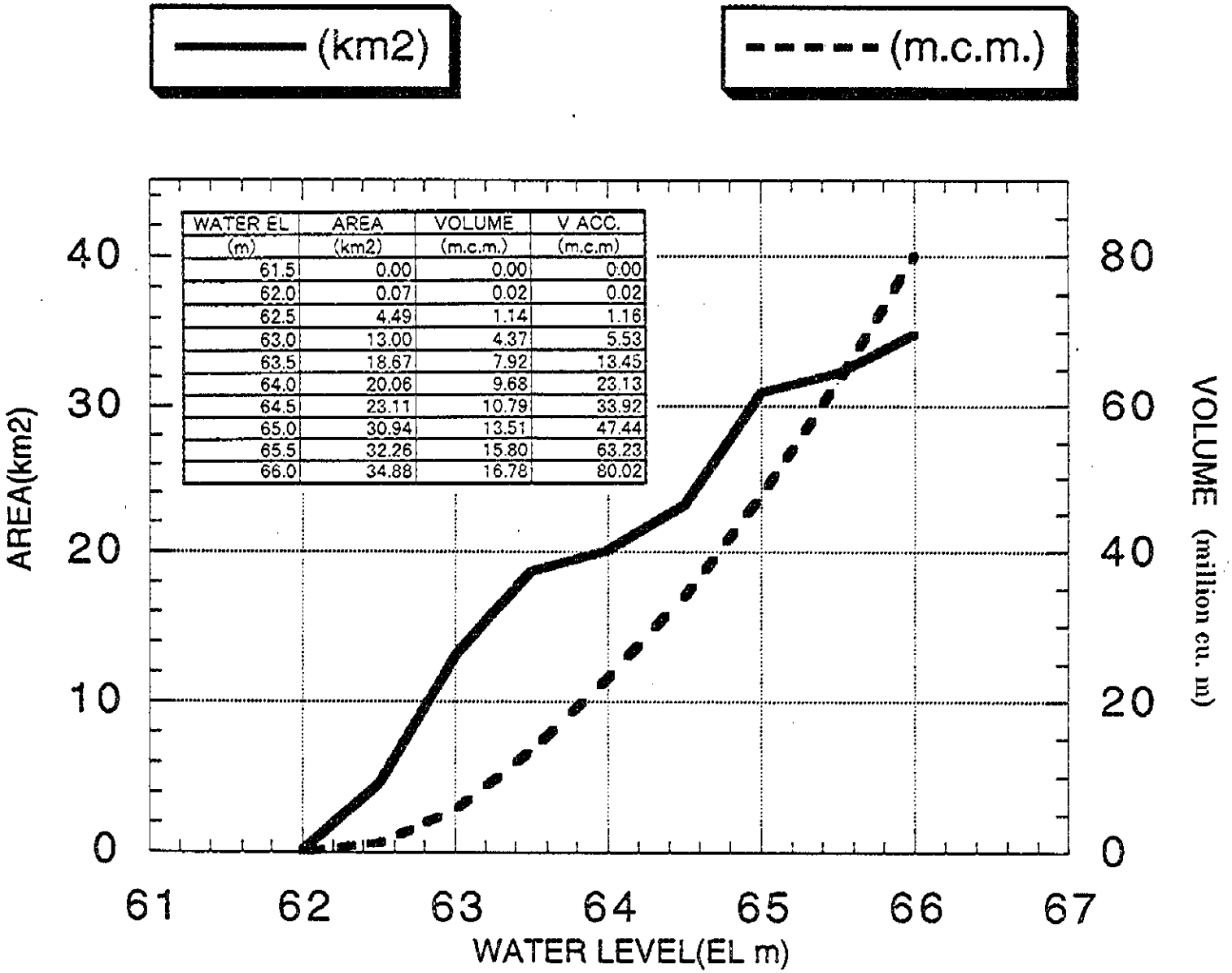
Table L.3.1 RELATIONSHIP BETWEEN ANUAL DISCHARGE AND FISH CATCH

YEAR	ANUAL DISCHARGE	FISH CATCH	
	(El Delirio)	Olomega	Jocotal
	($1000.000m^3$)	(1000 b)	(1000 b)
1976	366	1,671	217
1977	337	1,488	147
1978	923	297	136
1979	932	669	240
1980	-	757	316
1981	-	925	223
1982	-		99
1983	-	1,165	152

Table L.4.1. COMPARISON OF ALTERNATIVES OF DIVERSION WEIR

	a	b	c
	Concrete Monolith	Concrete Faced Fill	Rock Fill with Core
Structure			
Description	Concrete Monolith Structure	Embankment Paved by Concrete	Gabion or Rock Fill with Impermeable Core
Simplicity	○	×	×
Resitance Against Flow	○	△	△
Easy Maintenance	○	×	×
Easy Reconstruction	○	×	○
Natural Appearance	△	△	○
Cost	×	△	○
Total Evaluation	A	C	B

L.T.2



WATER EL (m)	AREA (km2)	VOLUME (m.c.m.)	V ACC. (m.c.m)
61.5	0.00	0.00	0.00
62.0	0.07	0.02	0.02
62.5	4.49	1.14	1.16
63.0	13.00	4.37	5.53
63.5	18.67	7.92	13.45
64.0	20.06	9.68	23.13
64.5	23.11	10.79	33.92
65.0	30.94	13.51	47.44
65.5	32.26	15.80	63.23
66.0	34.88	16.78	80.02

Figure L.3.1 AREA AND VOLUME OF LAKE OLOMEGA (SURVEY IN THIS STUDY)

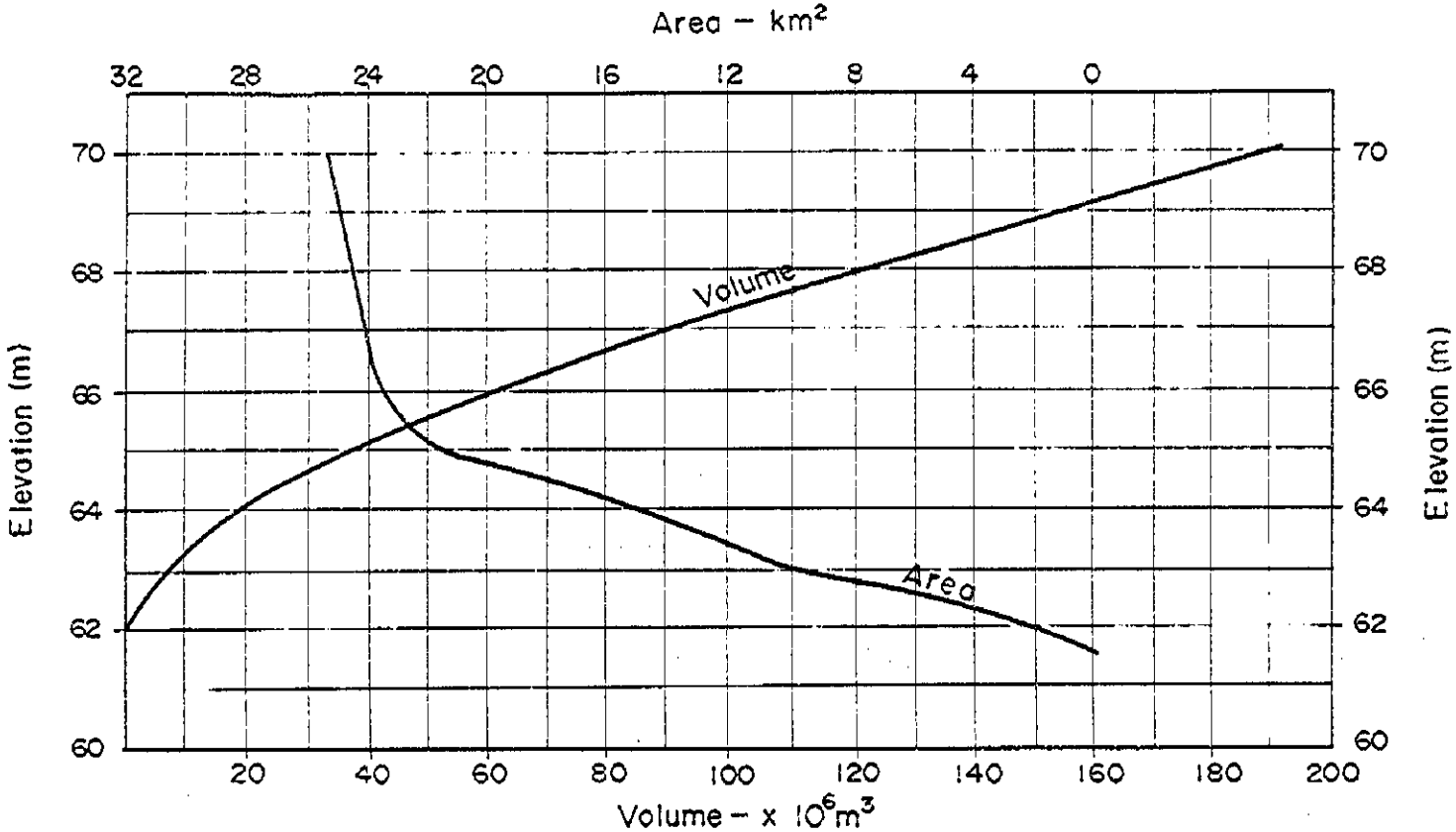


Figure L.3.2 AREA AND VOLUME OF LAKE OLOMEGA (OLOMEGA PROJECT, 1967, MAG)

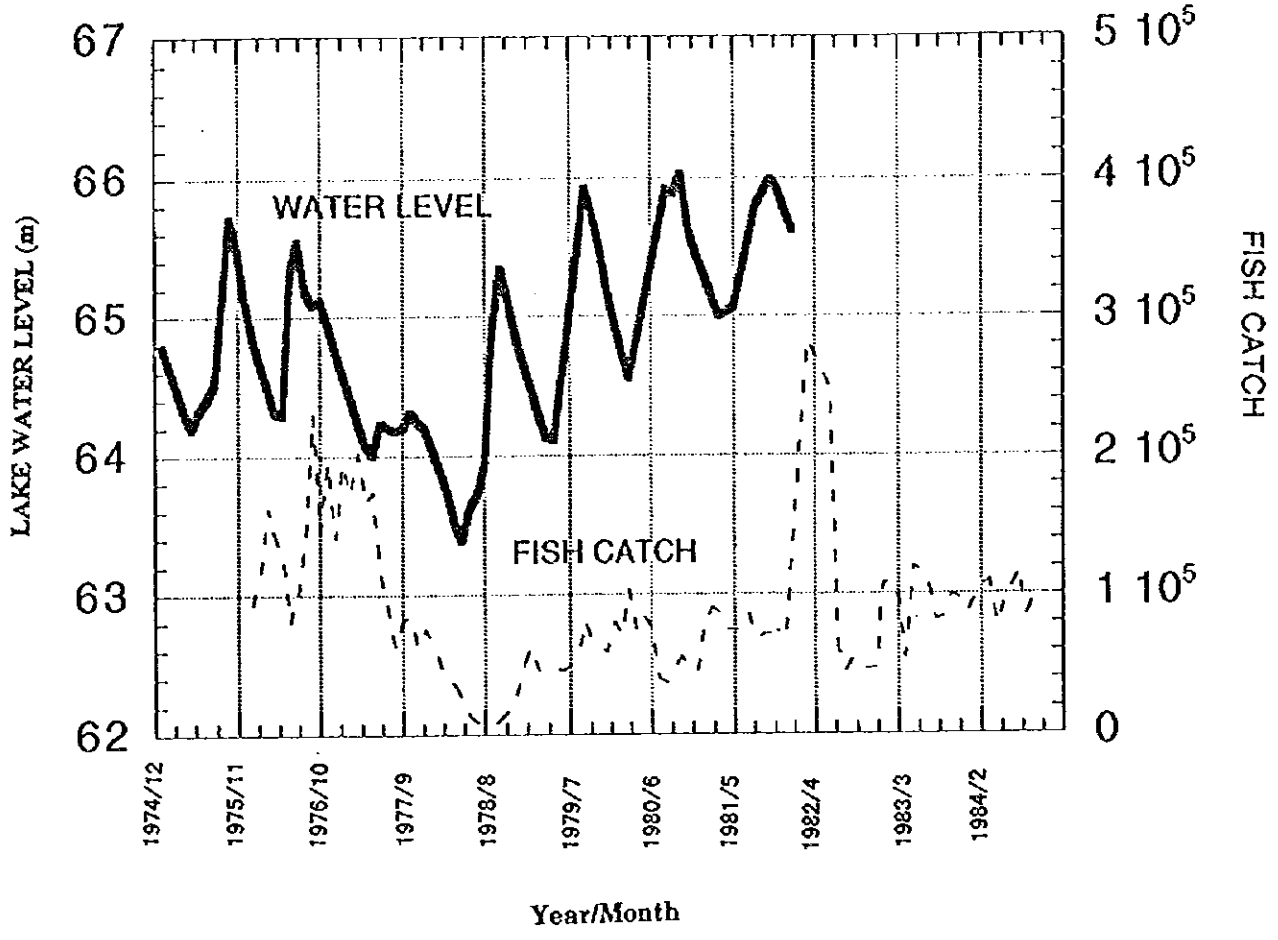


Figure L.3.3 LAKE WATER LEVEL AND FISH CATCH (TIME SERIES)

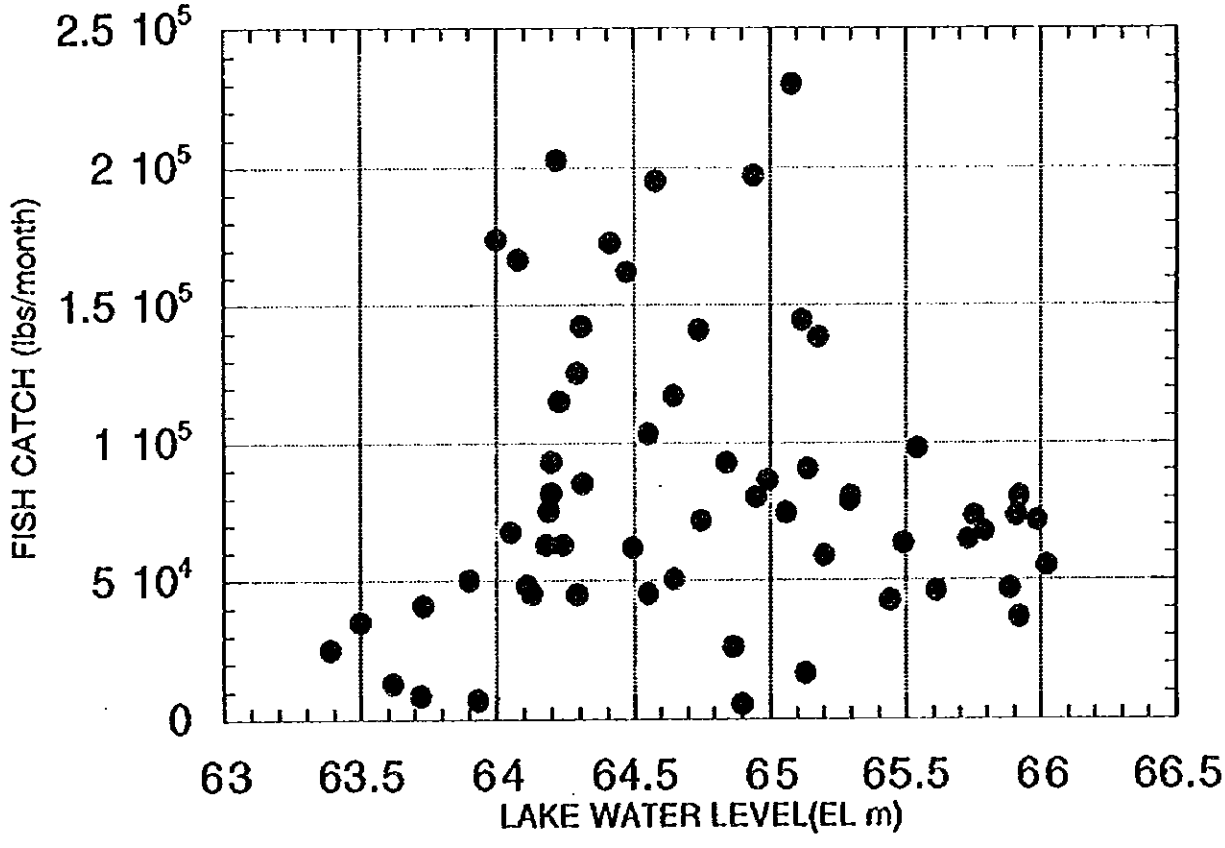


Figure L.3.4 LAKE WATER LEVEL AND FISH CATCH (CORRELATION)

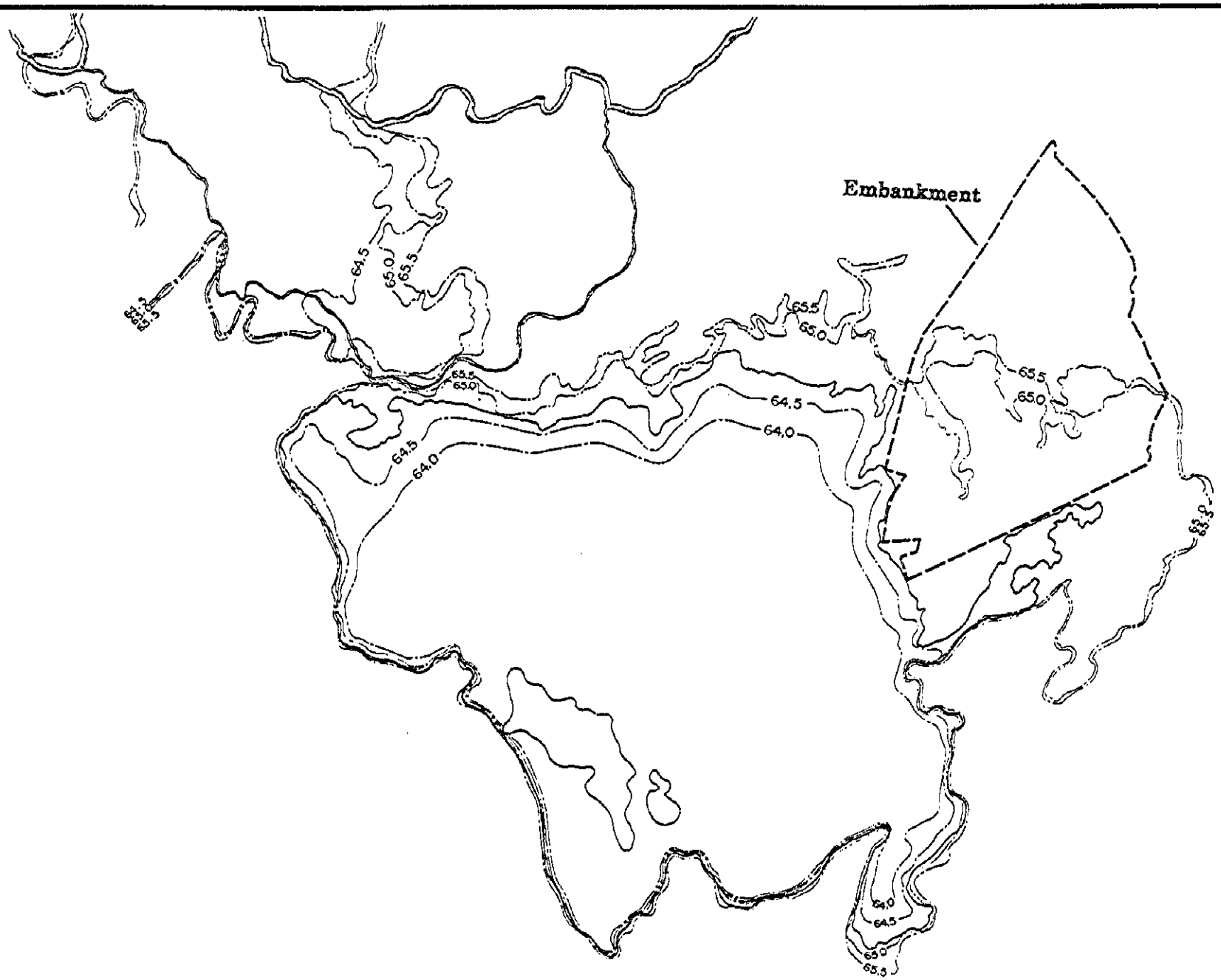


Figure L.3.5 CONTOUR MAP AROUND LAKE OLOMEGA

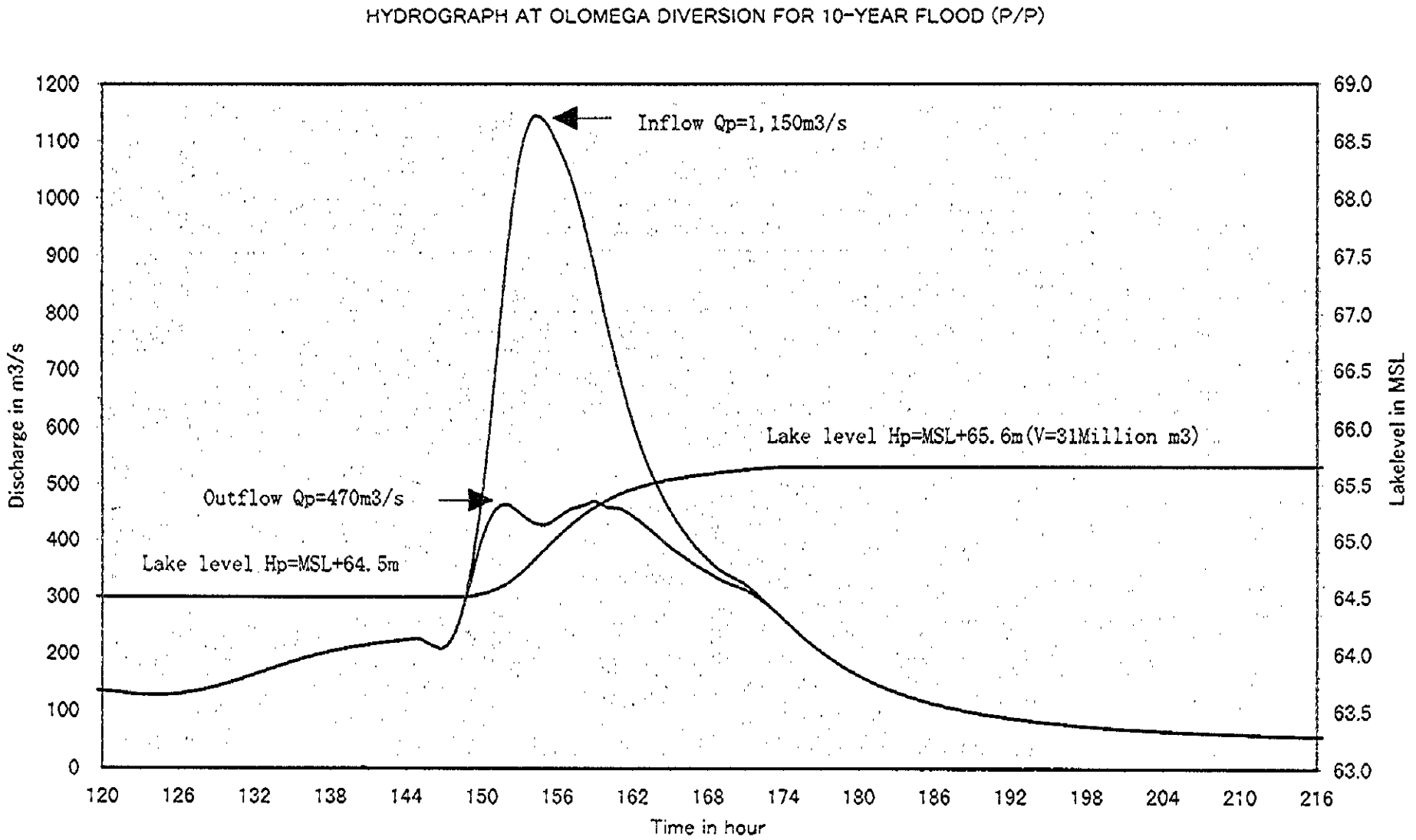


Figure L.3.6 FLOOD SIMULATION FOR LAKE OLOMEGA OF P/P 10-YEAR FLOOD

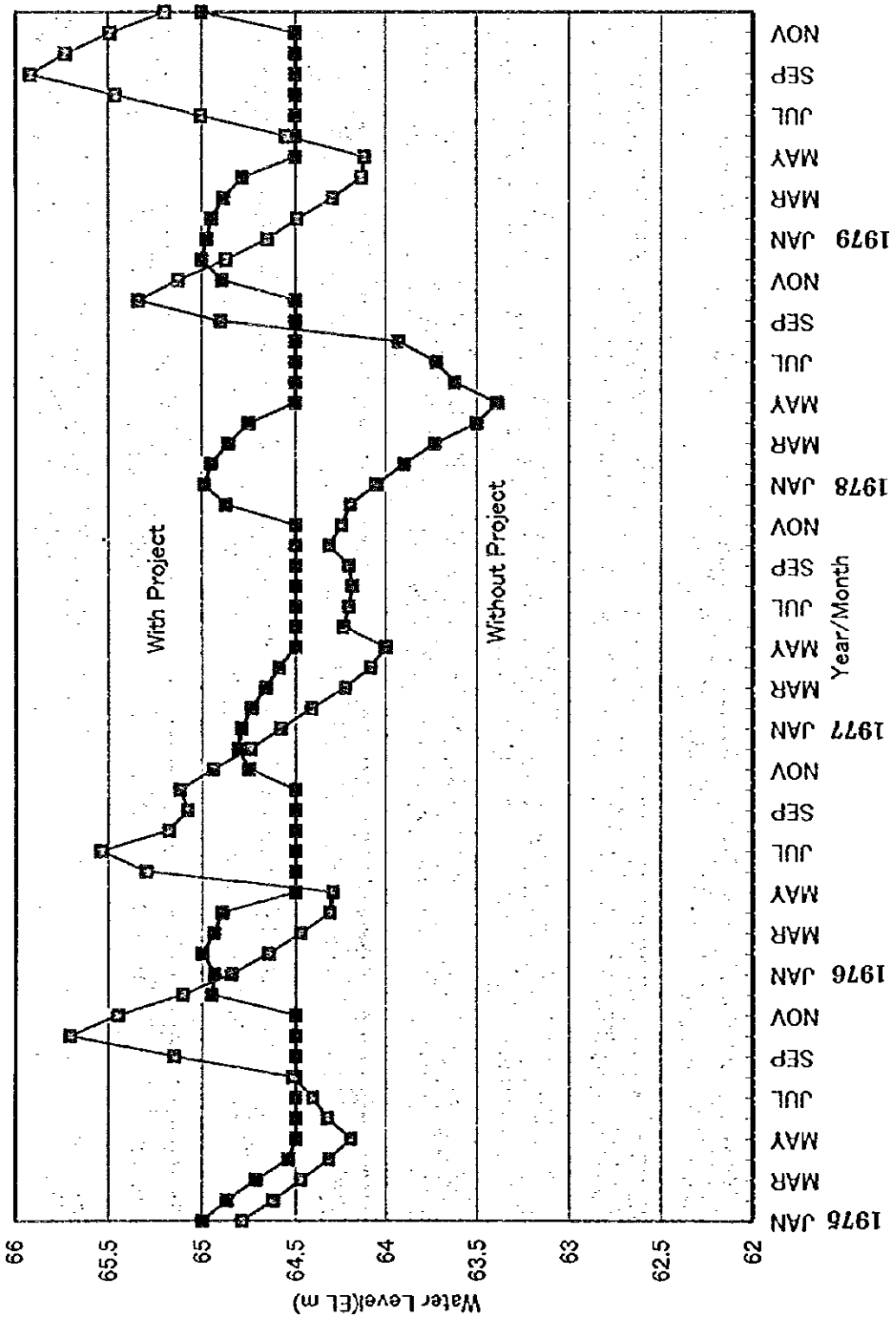


Figure L.3.7 DROUGHT SIMULATION OF LAKE OLOMEGA (1975 - 1979)

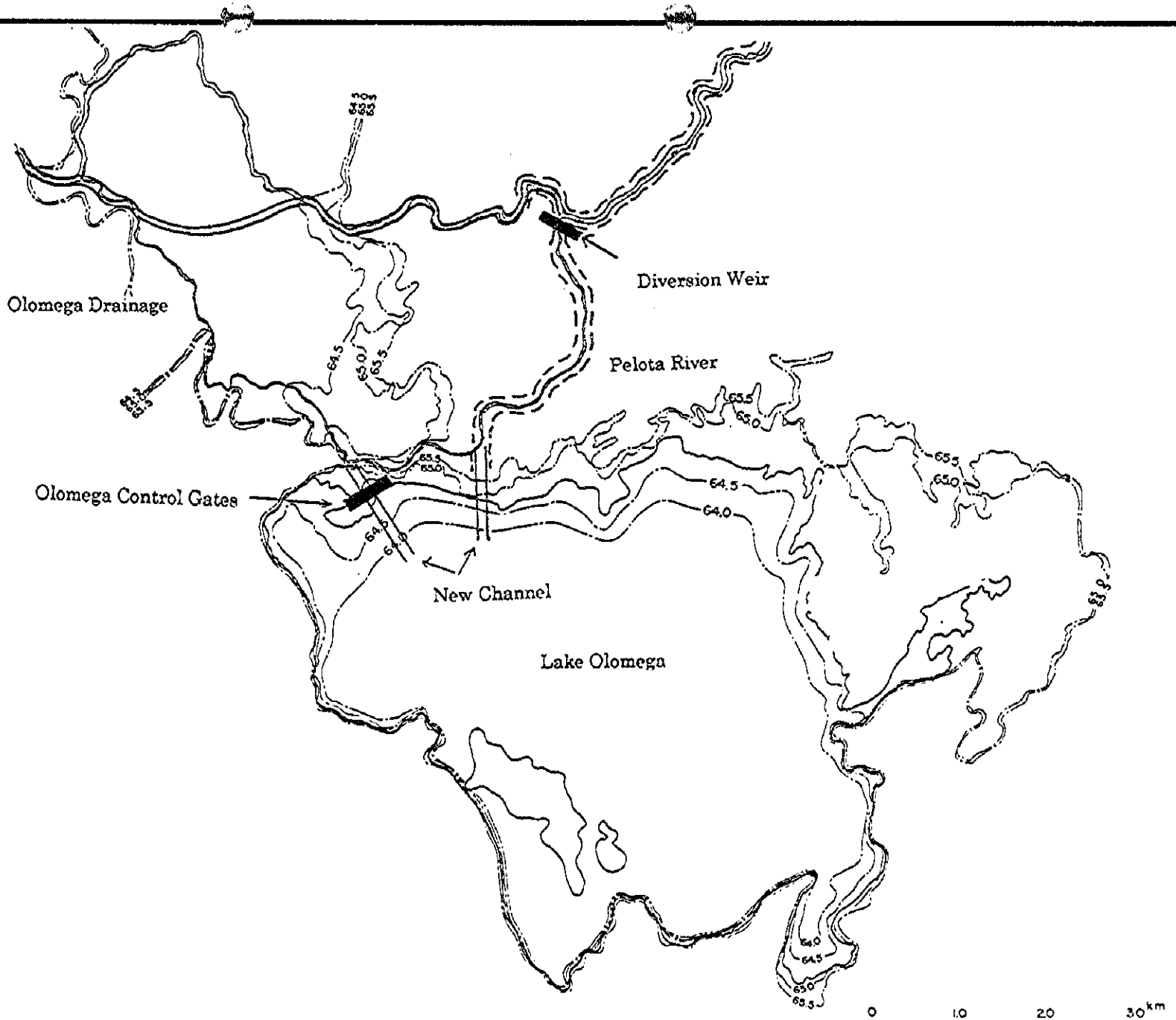


Figure L.4.1(1/3) GENERAL LAYOUT OF FACILITIES FOR USAGE OF LAKE OLOMEGA

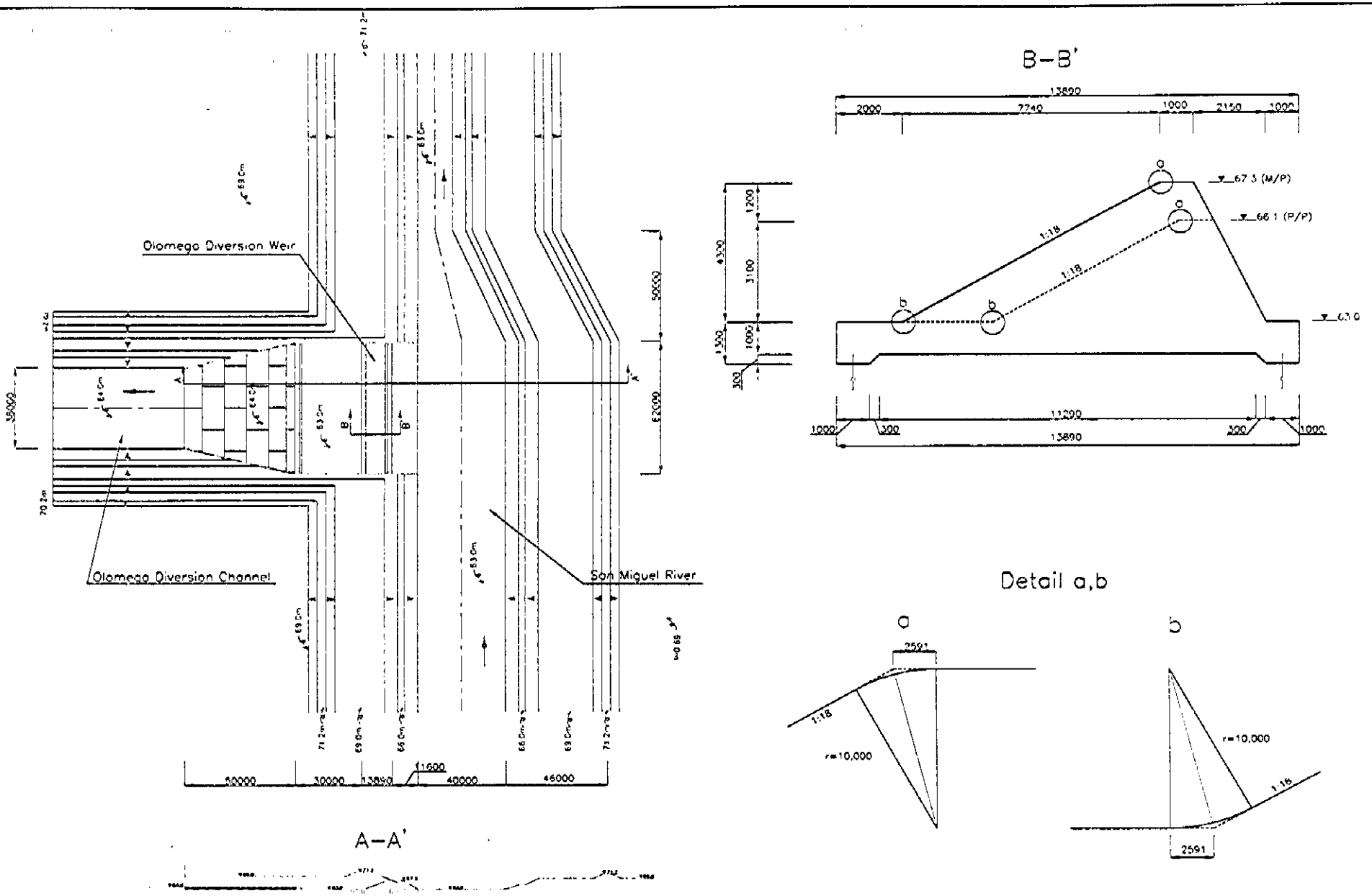
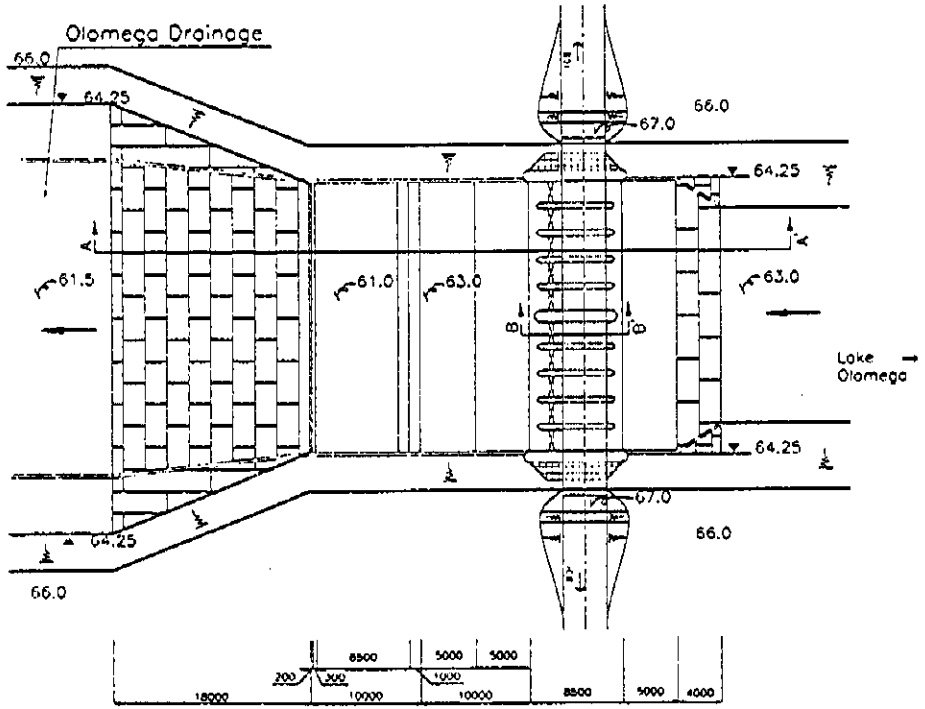
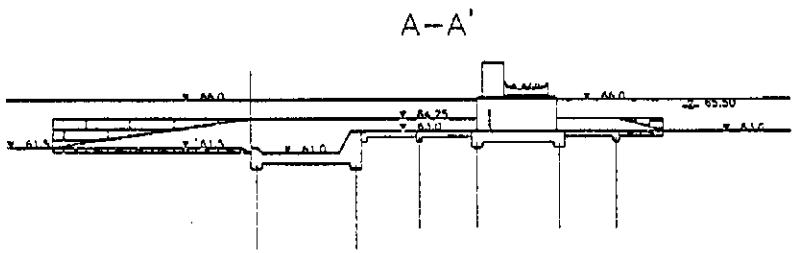
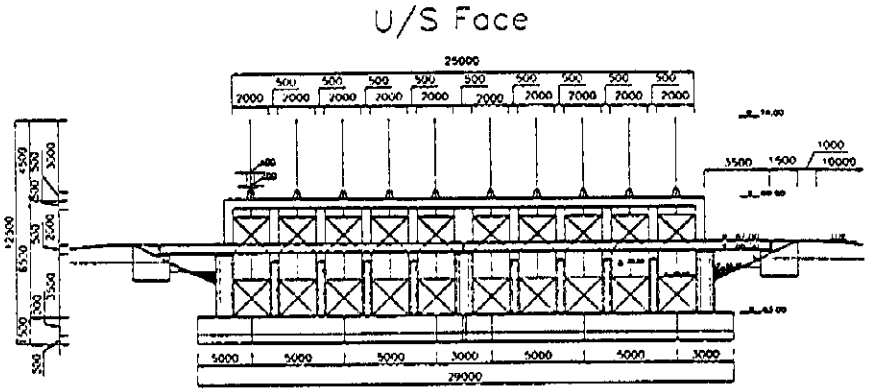


Figure L.4.1(2/3) **GENERAL LAYOUT OF FACILITIES FOR USAGE OF LAKE OLOMEGA (OLOMEGA DIVERSION WEIR)**







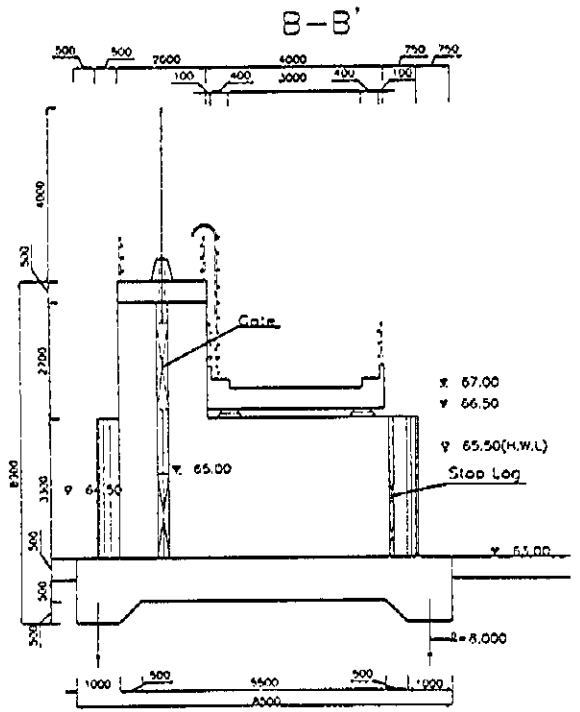


Figure L.4.1 (3/3) GENERAL LAYOUT OF FACILITIES FOR USAGE OF LAKE OLOMEGA (OLOMEGA CONTROL GATE)

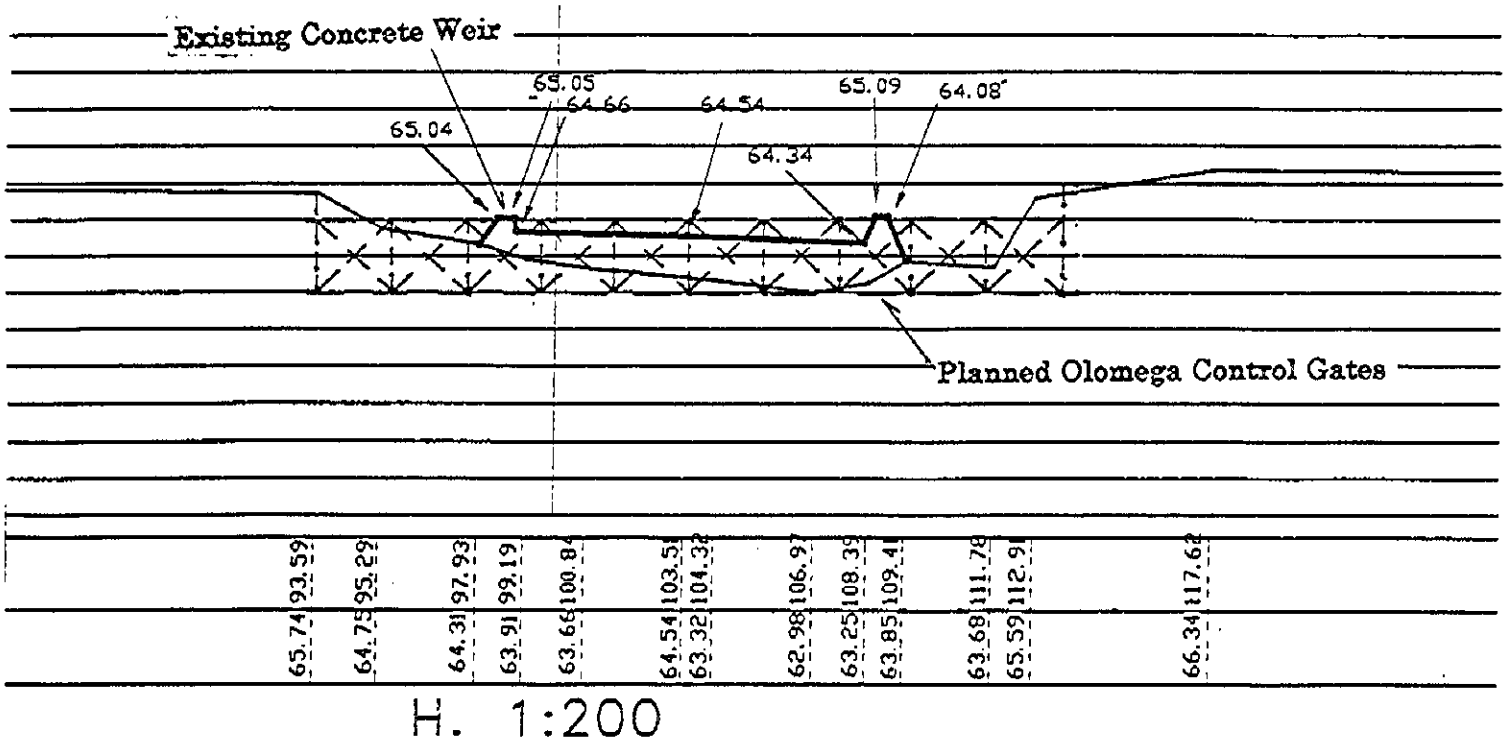


Figure L.4.2 EXISTING CONCRETE WEIR AND PLANNED OLOMEGA CONTROL GATE

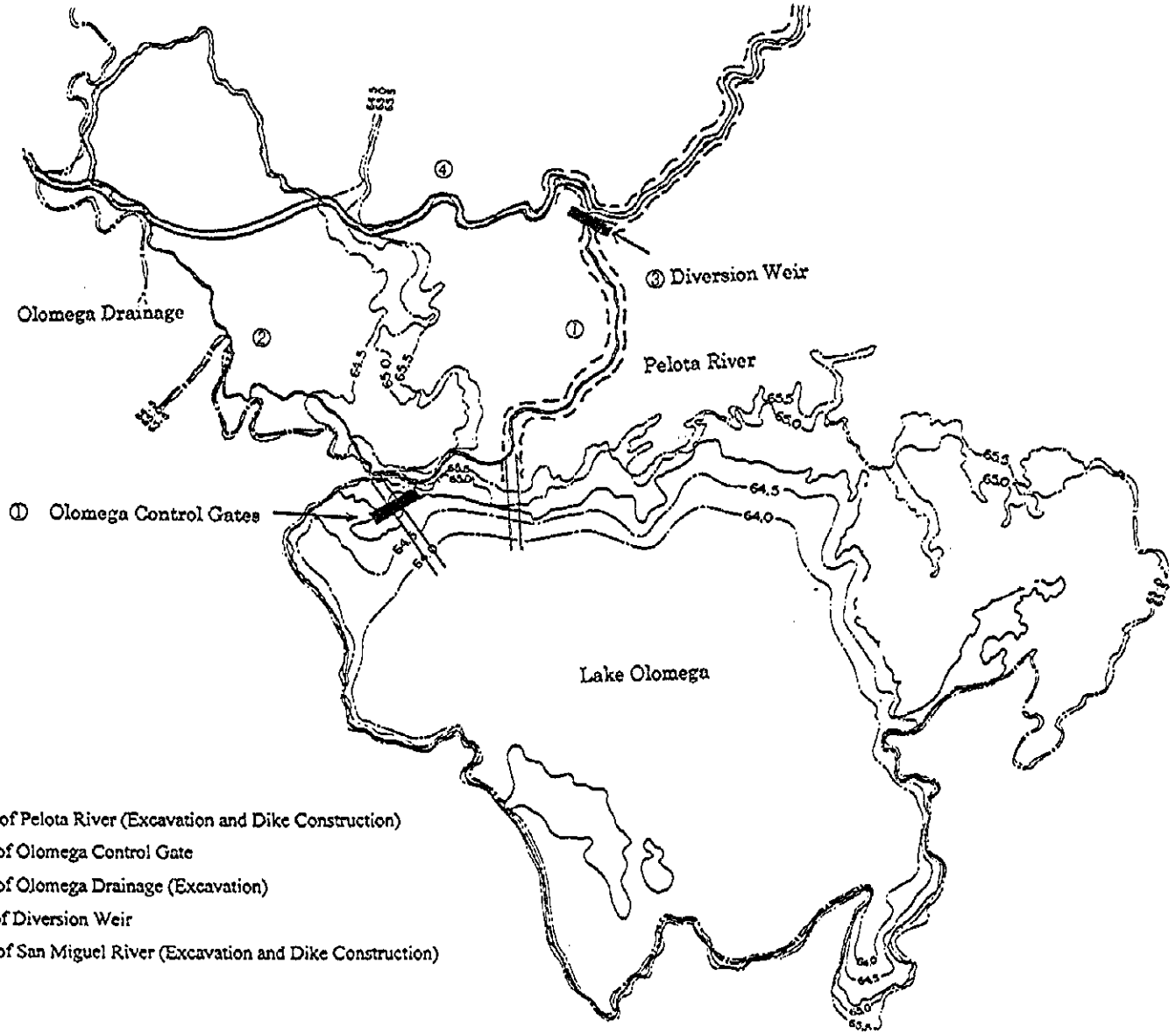


Figure L.4.3 SEQUENCE OF CONSTRUCTION WORKS