SUPPORTING REPORT

M: RIVER IMPROVEMENT PLAN

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1. EXISTING CONDITIONS OF BASIN AND RIVER

1.1 Catchment Conditions

(1) Location and Basin Area

El Salvador is located in the Central America extending approximately from 13°10'N to 14°30'N in latitude and from 87°40'W to 90°10'W in longitude. The San Miguel River is located in the eastern part of the country.

There are ten (10) major river systems in El Salvador as shown in Fig.M.1.1. The San Miguel River Basin is the second largest basin in El Salvador having a total basin area of 2,247 km^2 following the Lempa River Basin. The Lempa River has a total basin area of 18,246 km^2, of which 10,255 km^2 (56%) is located in the territory of El Salvador and the rest in Honduras (30%) and Guatemala(14%).

River system of the San Miguel is shown in Fig.M.1.2. The Guayabal and Villerias rivers which originate in the mountainous areas near Cacaopera, Delicias de Concepcion and Ciudad Barrios are the principal tributaries in the upper San Miguel River Basin. After these two rivers joins near Agua Zarca, it changes the name to the San Miguel River and flows down south getting out of the mountainous area. The river, changing its course westward near Lake Olomega, passing by Lake Jocotal, changing again toward north at the confluence of the Ereguayquin River, finally flows into the Pacific Ocean. The total length of the San Miguel River is about 124 km from the confluence of the Guayabal and Villerias rivers to the sea.

Basin area of the San Miguel River is 2,247 km^2 in total. Basin areas at major sections of the San Miguel River and those of the major tributaries are as follows:

1) San Miguel R. at Guayabal/Villerias R. jct. : 825.0 km^2
   - Guayabal R. : 452.5 km^2
     - San Francisco R. : 112.6 km^2
     - Seco R. : 153.6 km^2
     - Yawabal/San Diego R. : 128.5 km^2
     - Other basins : 57.8 km^2

- Villerias R. : 372.5 km^2
  - Cana R. : 121.2 km^2
  - Chapellique R. : 227.1 km^2
  - Other basins : 24.2 km^2

2) San Miguel R. at Taisihuat R. jct. : 1,061.2 km^2
   - San Esteban R. : 85.0 km^2
   - Raisihuat R. : 97.2 km^2
   - Other basins : 54.0 km^2
3) San Miguel R. at El Delirio : 1,637.0 km^2
4) San Miguel R. at Vado Marin : 1,900.0 km^2
5) San Miguel R. at Las Conchas : 2,246.8

(2) Topography

The upstream basin from the Urbina bridge is mountainous and the channel slope is comparatively steep. Villerias stream gauge station is located just downstream of the confluence of the Guayabal and Villerias rivers. From the Urbina bridge in San Miguel City, flat lands extend up to the sea, except for the rapids sections at El Delirio and Vado Marin.

Lands located upstream of the rapids are flat and depressed. Lake Olomega is located at the upstream of the El Delirio rapids and Lake Jocotal at the upstream of the Vado Marin rapids. The river meanders in these flat lands. The lands along the river and the lakes have been suffering from frequent flooding. A stream gauge station is located at Vado Marin.

In the reaches from Vado Marin to confluence of the Ereguayquin River, the left river bank is hilly, while the right side bank is flat and relatively steep forming a part of mountain skirt of San Miguel Volcano. The river bed slope is very small or inverse. The Ereguayquin River basin is covered by mud flow deposit and the soil erosion is remarkable.

In the downstream reaches of the confluence of the Ereguayquin River, the San Miguel River flows between hills with relatively steep channel slope and it gets out of the hills near Las Conchas. From Las Conchas, the river flows into the alluvial plain and then into estuaries and mangrove terrain.

(3) Climate

The climate of El Salvador is dominated by monsoons. The country is subject to the tropical transient air circulation, such as depressions, tropical storms and hurricanes.

Monthly variation of temperature, humidity, wind and rainfall in the basin is shown in Fig. M.1.3, selecting two stations: one at El Papalon located in the middle basin and another at San Francisco Gotera in the upper basin. Their principal features are presented below.

- Changes in monthly mean temperature are slight throughout a year. Annual average temperature is about 27℃ at both stations.
- Rainy and dry seasons are distinctive. The rainy season takes place from May to October and the dry season for the rest of the year. About 95 % of annual rainfall concentrates in the rainy season at both stations.
- The mean annual rainfall is 1,431 mm at El Papalon and 2,048 mm at San Francisco Gotera. Rainfall has a nature to occur in the afternoon and night. Heavy rainfalls are caused by tropical depressions and hurricanes.
- The monthly mean relative humidity changes depending on the monthly rainfall from 58 % to 82 % at El Papalon and 53 % to 80 % at San Francisco Gotera.

(4) Flooding

According to the flood survey conducted by the Study Team, the maximum and frequently inundated areas and inundated area of 1995-food are shown in Fig.M.1.4. Inundated areas for respective cases are shown below:

- Inundated areas of 1995 flood : 133.7 km^2
- Maximum inundated areas where residents have more or less experienced inundation in the past (referred to as potential flood area) : 181.1 km^2
- Frequently inundated areas which suffer from inundation once in 2 years or more (referred to as frequent flood area): 75.5 km^2

The major inundated areas are located at San Miguel City, Olomega, Jocotal, San Antonio and Usulutan. These areas have been suffering from the following damages and inconvenience:

- Damage in houses and properties,
- Damage in agriculture and livestock productions,
- Obstruction to traffic and other socio-economic activities,
- Worsening in sanitary conditions, and
- Other disturbance to peopleís livelihood

1.2 River Conditions

(1) River Channel

The San Miguel River extends for 124 km from river mouth to confluence of the Guayabal and Villerias rivers where the river changes its name to the San Miguel River.

For the convenience of description, the San Miguel River was divided into the following reaches depending on the topographic features and confluence of tributaries:

1) Lower Reaches from river mouth (0.0 km) to El Delirio (75.1 km): The Lower Reaches are further divided into stretches L1 through L4 from the lower end, at El Limon (18.3 km), confluence of the Ereguayquin River (27.7 km), Vado Marin (42.9 km) and El Delirio (75.1 km).
2) Middle Reaches from El Delirio (75.1 km) to confluence of the Guayabal and Villerias rivers (123.9 km): The Middle Reaches are further divided into stretches M1 through M6 from downstream, at confluence of the Olomega Drainage (76.6 km), divergence of the Pelota River (85.6 km), Lake Aramuaca (96.7 km), Moscoso Bridge (108.8 km), confluence of the Taisihuat River (112.8 km) and confluence of the Guayabal and Villerias rivers (123.9 km).

River basins along the Lower Reaches and Middle Reaches are called as the Lower Basin and Middle Basin, respectively. The upstream basin of the Middle Basin is called as the Upper Basin.

Discharge capacities of the existing San Miguel River were calculated based on the latest river survey results conducted by the Study Team. The bankfull channel capacity was calculated by the uniform flow formula assuming Manningís coefficient of roughness n = 0.035 for the whole river reaches as follows:

(Channel Slope and Capacity)

Stretch			Average slope	Chan. Capacity (m^3/s)
Code	From	To		
Lower Reaches (From river mouth to El Delirio)				
L1	River mouth	El Limon	1/1,450	-
L2	El Limon	Ereguayquin R.	1/1,080	340
L3	Ereguayquin R.	Vado Marin	1/2,880	450
L4	Vado Marin	El Delirio Br.	1/2,260	70
Middle Reaches (From El Delirio to Guayabal/Villerias rivers)				
M1	El Delirio	Olomega Drainage	1/1,660	1,320
M2	Olomega Drainage	Pelota R.	1/1,660	265
M3	Pelota R.	L. Aramuaca	1/1,660	580
M4	L. Aramuaca	Moscoso Br.	1/1,500	450
M5	Moscoso Br.	Taisihuat R.	1/1,040	1,870
M6	Taisihuat R.	Villerias R.	1/1,040 to 1/800	1,180 to 920

Channel profiles are shown in Fig.M.1.5. Main features of the San Miguel River are as follows:

1) There is a significant drop of riverbed of about 30 m at El Delirio (El Delirio rapids) and a smaller drop of a few meters at Vado Marin (Vado Marin rapids).
2) In the downstream reaches from confluence of the Ereguayquin River (stretches L1 and L2), channel slope abruptly changes steeper. In the upstream reaches of the confluence (stretch L3), the river bed slope is level or inverted up to the Vado Marin.
3) Channel capacity is high in the upstream reaches of Moscoso Bridge (stretches M5 and M6) and in El Delirio rapids.
4) Channel capacity is markedly low in stretches L4 and M2. Especially in stretch L4 alongside Lake Jocotal, the channel width is narrow and its capacity is only 70 m^3/s.

According to the geological survey conducted by the Study Team, exposed rocks were found on the river bed and/or river banks at the following reaches:

1) San Miguel River downstream reaches of the confluence of the Ereguayquin River: From section No. SM24 to SM30

2) San Miguel River downstream reaches of the Vado Marin bridge: From section No. SM54 to SM58
3) San Miguel River near El Delirio bridge: From section No. SM96 to SM104
4) San Miguel River near San Miguel City: From section No. SM162 to SM170
5) Upper San Miguel River: From section No. SM180 to SM182
6) Olomega drainage: Around OL1

Locations of exposed rocks are shown in Fig.M.1.6 for Vado Marin and El Delirio-Olomega sites. Most of these are soft rocks except for hard rocks at the foot of Cerro El Chichipate (Chichipate hill) near El Delirio.

(2) River Flow and Lake Water Level

Monthly average discharges at major stations of the San Miguel River and water level of Lake Olomega are shown in Fig.M.1.7 together with monthly rainfalls at San Francisco Gotera and El Papalon stations. According to the figure the maximum runoff occurs in September in the upstream reaches of Lake Olomega and in October in the downstream reaches of Lake Olomega and Lake Jocotal. The minimum runoff takes place in March at every stations. The monthly average discharge increases toward downstream reaches.

According to the water level records of Lake Olomega from 1970 to 1978, peak water level occurs in September or October. In July and August, the water level of Lake Olomega does not fall unlike the monthly rainfall pattern.

Water level records of Lake Jocotal are not available. Judging from the monthly average discharges at Vado Marin and Las Conchas, the peak water level of Lake Jocotal is deemed to occur in October.

Flow duration of the San Miguel River was calculated using the recorded data available at Moscoso, El Delirio, Vado Marin and Las Conchas stations. The result is shown in Fig.M.1.8.

(3) Flood Flow

Flood flow features of the San Miguel River are presented below.

Peak Flood Discharge: Annual maximum discharges at respective stations along the San Miguel River are extracted and compared each other in Fig.M.1.9. Villerias and Moscoso stations are located upstream of Lake Olomega, El Delirio station between Lake Olomega and Lake Jocotal, and Vado Marin and Las Conchas stations downstream of Lake Jocotal. The Annual maximum discharges at Vado Marin and Las Conchas stations remain markedly lower than those of Villerias and Moscoso stations, though the monthly average discharge increases toward downstream reaches as shown in Fig.M.1.7. This is probably due to the runoff detention by the lakes and inundation in the upstream reaches.

Runoff Concentration Time: The concentration time of runoff was estimated to be 6 hours at Villerias Station, and 7 days at Las Conchas Station.

Ranking of Past Major Floods: Based on the annual maximum discharge and 7-day basin mean rainfall data, ranking of the past major floods since 1959 were made as shown below. No discharge data is available after 1980.

Ranking of the Past Floods

Rank	Year	Peak discharge at Vado Marin	Basin mean 7-day rainfall
1	1988	-	326.8 mm
2	1992	-	299.8 mm
3	1982	-	285.3 mm
4	1974	307.9 m^3/s	271.8 mm
5	1969	296.0 m^3/s	-
6	1966	289.8 m^3/s	-

(4) Tide Level

There is only one tide gauging station at Cutuco (La Union) in El Salvador. Predicted tide table for the ports of Cutuco, El Triunfo, La Libertad and Acajutla are published by IGN every year as "Almanaque de Mareas". Tide level at El Triunfo Port is assumed to be applicable to the mouth of the San Miguel River. The tide level at El Triunfo as well as La Libertad and Acajutla is predicted based on the tide at Cutuco Port adjusting the time and amplitude as follows:

justment Factors to Obtain Tide Level)

Name of port	Location	Time lag (min.)		Multiplier to amplitude of tide		MSL above LWL (m)
		High	Low	High	Low	
Cutuco (La Union)	N 13.20, W 87.49	0	0	1.00	1.00	1.53
La Libertad	N 13.29, W 89.19	-26	0	0.67	0.67	1.01
Acajutla	N 13.34, W 89.50	-25	-3	0.64	0.64	0.98
El Triunfo	N 13.16, W 88.33	-10	-10	0.85	0.85	1.28

In order to estimate the mean high water (MHW) and mean low water (MLW) springs at El Triunfo, the high and low water springs at La Union were extracted from the tide tables "Almanaque de Marea" from 1994 to 1996, and converted into levels at El Triunfo Port (Table M.1.1). The calculated MHW and MLW at El Triunfo Port are as follows, which are used as water level conditions at the mouth of the San Miguel River:

- MHW = 1.39 m,MSL (1.41 m,MSL for May to Oct.: rainy season)
- MLW = -1.43 m,MSL (-1.40 m,MSL for May to Oct.: rainy season)

(5) Sediment Yield

According to the site reconnaissance and interpretation of topographic maps and aerial photographs, large scale collapses of mountain slope were not found in the upper basin of the San Miguel River.

On the other hand, geological map of the Study Area shows deposit of volcanic mud flow distributing widely in the upper basins of the San Esteban River and the Ereguayquin River including the Zope, Mejicapa, Constancia, Batres and San Diego rivers.

It is deemed that main portion of sediment of the San Miguel River yields owing to small scale collapses of mountain slope and secondary side erosions of river channels in the volcanic mud flow areas such as the San Esteban and Ereguayquin river basins.

According to the present land use map, most of the upper basin of the San Miguel River is used as pasture and basic grain lands. The upper most basins of the Villerias and Ereguayquin rivers are used for coffee field. The coffee field seems to protect land erosion. The field, however, shares small portion of the basin at present.

Two kinds of data are available for the sediment yield, i.e., suspended solid data of the San Miguel River by MAG and reservoir sedimentation data of the Lempa River by CEL.

Suspended solid data by MAG covers the years from 1970 to 1980. Based on the MAG's data, average annual yield of suspended solid were calculated as follows (Table M.1.2):

- 358,000 m^3/yr = 393 m^3/yr/ km^2 at Villerias
- 393,000 m^3/yr = 366 m^3/yr/ km^2 at Moscoso

The total sediment yield would be larger than the above values, since the bed load is not included in the suspended solid and the measuring during the floods were not always covered.

Since there is no dam in the San Miguel River Basin, the reservoir sedimentation data of the Lempa River were collected from CEL for sediment yield study. Along the Lempa River, there are four dams, i.e., Guija, Cerron Grande, 5-de-Noviembre, and 15-de-Septiembre dams from the upper reaches. Average annual sediment yield was estimated at 948 m^3/yr/ km^2 as shown in Table M.1.2.

(6) River Bed Materials

River bed materials along the San Miguel River and its major tributaries were surveyed by the Study Team at 15 sites (Fig.M.1.10). At each site 3 samples were taken at river bed sand bar, and left and right river banks.

Grain sizes of the river bed materials are shown in the said Fig.M.1.10 and Fig.M.1.11. According to the survey results, the following features of river bed materials are seen:

1) River bed materials sampled from sand bar are coarse and uniform in grading in comparison with those from river banks. This is reasonable since the sand bar materials have been subject to sorting due to water flows. However, samples from upper tributaries (sites C1 and G1) and El Delirio (sites S4 and S5) show different nature probably affected by local topography.

2) Grading of sand bar materials:
   - Samples of the main San Miguel River (sites S1 through S9) except S4 and S5 show similar grading. Average of mean grain size (d50) is 1.28 mm ranging from 0.95 mm to 1.60 mm.

- Grain sizes at sites S4, S5, C1 and G1 are relatively small with similar grading and mean grain size (d50) ranging from 0.34 mm to 0.56 mm.
- Samples of the Ereguayquin River show different grading and mean grain size (d50) ranging from 0.66 mm to more than 2.00 mm.

3) Grading of river bank materials:
   - Sample of site S1 shows outstandingly smaller grain size probably due to the locality of sampling place.
   - Samples of S2, S3, S4 and S5 show different grading each other. These river bank materials would not be formed by the sediment flow of the San Miguel River.
   - Grading of sites S6 through S9 (except S6-RBL) are similar with mean grain size (d50) of 0.43 mm in average, ranging from 0.29 mm to 0.59 mm.
   - Grading of sites U1 through U5 are also similar with mean grain size (d50) of 0.42 mm in average, ranging from 0.23 mm to 0.63 mm.
   - It is noteworthy that the grading curves of the San Miguel River at sites S6 through S9 and those of the Ereguayquin River are similar.

(7) Water Quality

According to the data observed during dry season in 1981, the BOD-values at Moscoso and Villerias show as high concentration as 15.2 PPM and 6.6 PPM, respectively. The values of BOD during the wet season were less than 3.0 PPM. The river water is polluted due to the domestic and industrial wastewater effluent.

A water quality survey has been conducted by the Study Team. The water samples were taken once in May, 1996 (dry season) and once in July, 1996 (wet season). The results of water quality tests are given in Fig.M.1.12. BOD-values in May, 1996 at Moscoso and Urbina were 4.7 PPM and 9.3 PPM, respectively.

According to the survey result, water quality of the San Miguel River are summarized as follows:

1) The water quality of San Miguel River is poor in every location especially downstream of San Miguel City. The TP, TN and BOD values fall in the following ranges for the measurements in May (driest month):

- TP : 0.64 to 4.13 PPM
- TN : 7.9 to 15.3 PPM
- BOD : 1.75 to 20.2 PPM

2) The pollutant sources of the San Miguel River are considered as follows:
   - Urban sewage form San Miguel City
   - Cattle waste scattered all over the area
   - Wastewater from sugar cane and coffee processing

3) The water quality of Lake Olomega is also low in terms of TP, TN, BOD and COD. The possible pollutant sources of the lake are as follows:
   - Wastewater and other pollutants from its own catchment
   - Floodwater from the San Miguel River

1.3 Existing River Facilities

(1) River Structures

Existing river facilities of the San Miguel River are shown in Fig.M.1.13.

Dikes along the river course are the major flood control facilities of the San Miguel River. According to the result of river survey conducted by the Study Team, length of the existing dikes are shown in Table M.1.3. Dike is provided for about one tenth of total river length from Sect. SM0 (Santa Rita R.) to SM135 (Lake Aramuaca).

MAG has installed three intake pumps for irrigation purpose in the San Miguel River, among which two pumps have been abandoned and only one is operated now by a farmer's corporation. The capacity of the pump is estimated to be 0.17 m^3/s.

An intake weir for the San Esteban Hydropower plant exits in the upstream of San Esteban River. However, the power plant was abandoned in 1991.

There are 4 bridges across the San Miguel River in the downstream reaches from Moscoso bridge. They are Moropala, Vado Marin, El Delirio and Moscoso bridges. According to the additional river survey conducted by the Study Team, length and elevation of these bridges are as follows:

Bridge	Length (m)	Elevation* (m,MSL)
Moropala Br.	52	24.9
Vado Marin Br.	33	24.2
El Delirio Br.	32	50.3
Moscoso Br. (new)	140	96.0

* Elevation of lower limb of the bridge girder.

Vado Marin and Moscoso bridges are now under reconstruction. In the above table, dimensions of Vado Marin bridge are for the old one, and they will not change so much after the reconstruction.

(2) Lake Olomega

Lake Olomega play an important role for flood control of the San Miguel River, though it is a natural lake. The lake has also been used for fishery. At the outlet of Lake Olomega, a concrete weir has been equipped. The outlet structure of Lake Olomega has a conflicting history between fishermen and farmers as follows:

- Before 1940: The main course of the San Miguel River was located in the south of the present river (Fig.M.1.14).
- 1940's: A severe drought hit the area and the water area of Lake Olomega retreated. The farmers, taking advantage of the lake water retreat, placed their landmarks inside the present lake area.
- 1960-70: MAG and landowners shifted the course of the river northward to the present position in order to protect the lands from flooding.
- 1977-78: A severe drought hit again and the lake area shrank. The fishermen had to move to the artificial lakes along Lempa River for fishery.
- 1977-78: A dike was constructed to protect the northern areas of the lake from flooding.
- 1984-86: The fishermen group closed the outlet from Lake Olomega to Olomega Drainage in order to keep the lake water level high.
- 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. (Fig.M.1.14)
- 1995-1996: The side of the concrete weir was scored by flood flow.
- Present: The NGO has submitted an application to MAG for repairing the structure.

(3) Lake Jocotal

Lake Jocotal has also been serving for flood control and fishery. Jocotal drainage is the only channel connecting Lake Jocotal and the San Miguel River. At the head of the drainage, a weir made of gabion is installed. In the downstream reaches of the weir a culvert bridge crosses the Jocotal drainage near Hda. El Milagro. Although gate is not provided, the culvert controls the inflow and outflow from the Lake Jocotal. These structures are shown in Fig.M.1.15.

Lake Jocotal and its surrounding areas have been designated as a reserved area to protect natural fauna and flora.

2. BASIS OF PLANNING

2.1 Target Year

Flood control master plan is to be prepared to meet socio-economic conditions of the Study Area at a target year of planning. The target year was set at the year 2020 by the following reasons:

- National development plan of El Salvador has been prepared for the period up to 1999 and the population is projected up to 2020.
- Urban development plan of San Miguel City proposed in 1992 targeted the period of about 20 years.

2.2 Socio-economic Frame

Socio-economic frame of the Study Area is presented below for the present and perspective in the target year 2020.

• Population:	(1992)	(2020)
Study area	474 thousand	1,041 thousand
Whole country	5,119 thousand	8,534 thousand
• Economy:	(1994)	(2020)
GDP(whole country)	\$8,070 million	\$36,410 million
Average growth rate	6 %/year from 1994 to 2020	
• Land Use:	(1995 - 96)	(2020)
Urban area	29 km^2 (1.3%)	58 km^2 (2.6%)
Farm land	359 km^2 (16.0%)	530 km^2 (23.6%)
Pasture/crop land	1,464 km^2 (65.2%)	964 km^2 (42.9%)
Forest	331 km^2 (14.7%)	631 km^2 (28.1%)
Other	64 km^2 (2.8%)	64 km^2 (2.8%)
• Population Structure in 1992:	(Study Area)	(Whole Country)
Agriculture	46.8%	35.5%
Commerce	14.5%	15.0%
Manufacturing	10.2%	14.8%

2.3 Area to be Protected

Area to be protected by the flood control project is located within the potential flood area where residents have more or less experienced inundation in the past (181.1 km^2). The potential flood area covers:

- San Miguel City (Riverine areas)
- Olomega area
- Jocotal area
- Usulutan area

Some areas around Lake Jocotal, Lake Olomega, and Lake San Juan were excluded from the areas to be protected due to their depressed topography. The area to be protected is 162 km^2 in total.

2.4 Return Period of Design Flood

Return period of design flood was determined to be 10 years for the master plan taking the following into account :

- The area to be protected is still remain as a rural area except areas near San Miguel City, though the protected area is expected to be improved in the future. Therefore, flood damage potential is low compared with that of urban area.
- The size of river basin is medium.
- Therefore, large scale investment will not be economical.

3.BASIC STUDIES

3.1 Basic Flood Control Measures

(1) Conceivable Measures

In order to attain flood control, structural and non-structural measures are employed comprehensively. The measures are generally shown in Fig.M.3.1

For the flood control of the San Miguel River, the following measures are conceivable:

1) Structural Measures
    - River improvement
    - Floodway
    - Floodwater detention
2) Non-structural measures
    - Watershed management
    - Floodplain management

The conceivable flood control measures for the Study Area are shown in Fig.M.3.2.

In this report flood control by means of structural measures are discussed mainly. Discussions on non-structural measures are presented in SUPPORTING REPORT-J (Watershed Management Plan) and SUPPORTING REPORT-K (Flood Plain Management Plan).

(2) River Improvement

River improvement is a primary measure for flood control. River improvement by means of diking system, channel excavation, and cut-off channel were considered for the San Miguel River (Fig.M.3.2).

It is favorable to set the design high water level below the surrounding ground elevation as far as circumstances permit, so that the rain water in the surrounding areas could be drained by gravity.

The channel excavation is effective to lower the design high water level. Even for the floods exceeding the design scale, the excavated channel could alleviate the flooding in the riverine lands. However, the river improvement by channel excavation sometimes requires a large amount of earth works, and the excavated channel might bring about difficulties in water use and sedimentation problems.

In the meanwhile, river improvement by the diking system generally requires less earth works and could avoid the inconvenience of water use problem. The diking system, however, may cause the drainage problems in the areas protected by the dike and tributaries. The dike can not cope with the abnormal flood exceeding the design scale.

Improvement methods by the channel excavation and diking system were selected stretch by stretch considering the overall longitudinal profile of the river and topography of the surrounding basin.

The cut-off channel enables smooth passage of floodwater by shortening the channel length, steepening the slope, and smoothening the alignment. Since the cut-off channel brings about drastic changes in channel profile, careful studies and monitoring on water and sediment flows are necessary.

(3) Floodway Schemes

Two floodway schemes, Olomega and San Felipe floodways, have been studied previously in the Study Area. The Olomega and San Felipe floodways, however, were not incorporated in the alternative flood control schemes of the San Miguel River. The following paragraphs present the outline of schemes and the reason why they were not adopted.

Olomega floodway scheme: The scheme has been studied as a component of the Olomega Project proposed in 1967. The floodway aims to divert flood water of the San Miguel River to Lake Olomega and store it there to alleviate flooding in the Lower Basin. Principal features of the floodway scheme are as follows:

1) Most of floodwater of the San Miguel River is diverted at a section near Lake Aramuaca toward Lake Olomega by new floodway
2) Floodwater exceeding the design discharge of floodway is spilled into the existing San Miguel River.
3) The lake water level will be raised by the confining dike around the lake in order to detain the floodwater.

However, the Olomega floodway was not recommended mainly due to the following reasons:

1) Drainage of the areas located in the north of the lake becomes difficult due to high lake water level raised by confining dike.
2) Large amount of sediment will flow into the lake and may silt it up.
3) The lakeís ecology will be aggravated due to the sediment and polluted water flowing into the lake.
4) The scheme was planned about 30 years ago and social condition in the basin has changed.

San Felipe floodway scheme: The scheme has been studied in 1990 by MAG as an alternative scheme to alleviate flooding in the lower Usultan area. The floodway scheme aims to divert floodwater of the San Miguel River to the estuary area by cutting off the hill at Canton San Felipe. This floodway scheme was not recommended by the following reasons:

1) The scheme requires a large amount of excavation amounting to about 2 million m^3 or more, of which greater part are rock materials.
2) Cost of the work therefore is by far higher than the channel improvement cost of the existing river.
3) The floodway will change the conditions of water and sediment flows and may cause adverse effects on the downstream reaches.
4) The floodway section will have high river banks slope of about 35 m. Problems of water use and maintenance after completion of the floodway are anticipated.

(4) Floodwater Detention Schemes

Multi-purpose dam proposed at San Esteban (San Esteban dam) has a catchment area of 825 km^2 and is deemed to be effective for flood control as well as for hydroelectric power generation and irrigation. There are some other possible dam sites in the Upper Basin. These dams are not effective for flood control, since they are far away from the area to be protected and their catchment areas are small (less than 80 km^2)

Lake Olomega has been serving for floodwater storage in the Middle Basin. The storage would alleviate the flood burden in the downstream reaches. Lake Olomega has an area of about 20 km^2 and is possible to store the floodwater of 20 million m^3 for effective depth of 1.0 m. Use of the existing Lake Olomega enables to get rid of the problems such as site selection and land acquisition.

Lake Jocotal and surrounding areas have been reserved to protect ecological environment in the Lower Basin. There is an extensive depressed area along the San Miguel River near the lake and it would be difficult to make all the area free from flooding. In order to protect the ecology, it is not recommended to use the Lake Jocotal positively for flood detention. However, the lake has been serving for floodwater storage.

Therefore, San Esteban Dam and Lake Olomega were studied as alternative flood control measures of the San Miguel River. The floodwater storage function of the existing Lake Jocotal is reserved for flood control of the San Miguel River.

3.2 Study on Combination of Measures

(1) Alternative Schemes

According to the discussions in the previous subsection, component flood control measures for the San Miguel River are:

1) River improvement,
2) Flood retention by San Esteban Dam, and
3) Flood retention by Lake Olomega.

By combining the above structural measures, four cases of alternative schemes were established for selection of the optimal flood control master plan (Fig.M.3.3):

- Alternative-1: River improvement with no dam and no storage by Lake Olomega
- Alternative-2: River improvement with no dam and with storage by Lake Olomega
- Alternative-3: River improvement with dam and storage by Lake Olomega
- Alternative-4: River improvement with dam and no storage by Lake Olomega

The river improvement is a basic flood control measure and is considered necessary for every cases to attain flood control complementarily.

(2) Selection of Optimum Scheme

Design discharge distribution was first calculated for each alternative as shown in Fig.M.3.4 based on 10-year probable flood. Longitudinal profile and section of river channel, San Esteban dam, and other related structures were designed preliminarily based on the design discharge. The related structures include drainage sluices, ground sills, intake gate, side weir, outlet gate and bridges.

Quantities of works for respective alternatives were estimated for channel works, dam works and land acquisition and house compensation. The estimated work quantities and direct costs are summarized in Table M.3.1.

Finally, four alternative schemes were compared each other from economic, financial, social, technical and environmental view points as shown in Table M.3.2.

In conclusion, Alternative-2 was selected as the optimum scheme for flood control master plan by the following reasons:

1) The total cost is the lowest and economical.
2) Negative social impact is small.
3) Positive impacts on environment are large.
4) Technically, there is no remarkable difficulty.
5) Flood damages in the greater parts of the flood prone areas will be mitigated and the areas can be developed mainly for agricultural purpose.

3.3 Study on Lower End of Improvement in Estuary

(1) Alternative Schemes

The estuary reaches of the San Miguel River downstream from section SM13 were divided into four stretches depending on the channel conditions and land use of the riverine areas. The stretches and conditions of he riverine lands are as presented below.

1) Sta. Rita River from river mouth (sea) to SR21+0.20k: Existing river channel is wide enough and no improvement is necessary.
2) Stretch L1-1 from SR21+0.20k to SM1 (end of farm land): The river forms an anabranch surrounded by mangrove forest. The channel is shallow and narrow.
3) Stretch L1-2 from SM1 to SM7 (Cerro El Encantado): The river channel is shallow and narrow. This stretch is in the transition zone from sea water to fresh water affected by tide. The riverine areas are used as farm land of low productivity. No dike exists along the river.
4) Stretch L1-3 from SM7 to SM13 (El Limon R.): The riverine areas are used as farm land and the land is protected by earth dike.

River improvement should be extended in general to the sea so as to drain flood water from the upper basins into the sea without causing damages in the riverine areas. However, the channel improvement in the stretch L1-1 requires felling mangrove along river course. Felling mangrove should be discussed carefully. Lower end of channel improvement was studied from this viewpoint on the alternative schemes of different extents for improvement.

Considering the existing situation of the river and the riverine land, the following alternative schemes were established for the stretch downstream from SM13 in order to discuss the optimum lower end of river improvement (see Fig.M.3.5):

Scheme	Channel excavation	Dike
Alternative-1	Up to end of farm land(SM1)	Up to Cerro El Encantado(SM7)
Alternative-2	Up to end of farm land(SM1)	Up to end of farm land(SM1)Up
Alternative-3	Up to Sta.Rita R.(SR21+0.20k)	Up to end of farm land(SM1)Up

(2) Selection of Optimum Scheme

Surface profiles of the respective schemes were calculated and shown in Fig.M.3.6. Difference of the profiles is small between Alternatives 2 and 3. Therefore, the Alternative 3 has no advantages over the Alternative 2.

Table M.3.3 shows the cost estimated for each alternative. Merits and demerits of these alternatives were compared each other from various aspects in Table M.3.4.

The Alternative 1 has advantages over the Alternative 2 and accordingly Alternative 3 as well. The farm lands along the stretch L1-2 which are protected by the Alternative 2 are located in the blackish water zone and still remain low productivity.

In conclusion, the Alternative-1 which is the lowest in cost and has smallest impact on the environment was selected.

3.4 Study on River Course in Olomega Area

(1) Alternative Schemes

The Pelota River bifurcates near Hda. Potrero Verde and flow down for about 5.7 km to the outlet gate of Lake Olomega passing by the lake. Ordinary the Pelota River is dry. Flood water flows a few times a year during flood season. Olomega drainage of about 6.0 km long connects Lake Olomega and the San Miguel River.

In order to use Lake Olomega as a storage facility, a diversion channel (Olomega diversion channel) is necessary to connect the San Miguel River and the Lake.

With regard to the channel network consisting of the main San Miguel River, Pelota River, diversion channel and Olomega drainage, alternative study is required to determine the optimal routes of these rivers and channels.

Three alternative routes are conceivable for the main San Miguel River as follows:

Scheme	Route of main San Miguel R.
Alternative-1	Same route as existing river
Alternative-2	Same route as existing river with cut-off channel in the lower reaches
Alternative-3	On the existing routes of the Pelota River and Olomega Drainage. The existing San Miguel River will serve as a local drainage channel

The schemes are shown schematically in Fig.M.3.7. According to the result of runoff analysis, discharge distributions for these schemes are shown in Fig.M.3.8. Based on the preliminary facility design, quantities of works and project cost of these schemes were estimated for the stretch from SM103 to SM120-0.26k of the San Miguel River as shown in Table M.3.5.

(2) Selection of Optimum Scheme

Since the benefit of these schemes is the same, the optimum scheme was selected on the least cost basis and the scheme is checked from various aspects related to the project as shown in Table M.3.6.

The Alternative 2, in which the San Miguel River takes the same route as the existing channel with cut-off channel in the lower reaches from SM113, was finally selected.

3.5 Sediment Analysis

(1) Representative Grain Size of Bed Materials

Representative grain sizes of the San Miguel River such as d_{50}, d_{60} and d_{65} were estimated and shown in Table M.3.7 based on the data surveyed by the Study Team. The d_{50}, d_{60} and d_{65} denote the grain sizes below which smaller grains share 50, 60 and 65 % of total weight, respectively.

According to the samples taken from sand bar on river bed, grading curves are shown in Fig.M.3.9. The grading curves are similar in each stretch except for the samples from upper tributaries(C1,G1), El Delirio rapids(S4,S5), and site-U4 probably affected by the local conditions. Mean grain sizes of the respective river stretches are as follows:

Stretch	Samle	d_{50}(mm)	d_{60}(mm)	d_{65}(mm)
Lower Reaches	S1 through S3	1.21	1.53	1.69
Middle Reaches	S6 through S9	1.34	1.70	1.88
Ereguayquin R.	U1 through U3, U5	1.04	1.52	1.76

(2) Friction Velocity of Existing Channel

The friction velocity under bank-full flow conditions (bank-full friction velocity) is empirically known as a dominant factor to form the section of low water channel. The friction velocity is defined as follows:

$$U_* = (g\, R\, I)^{0.5}$$

Where

U_*: Friction velocity (m/s)

g: Acceleration of gravity (= 9.80 m/s^2)

R: Hydraulic mean depth (m)

I: Gradient of energy

The bank-full friction velocity of the existing channel was worked out and shown in Fig.M.3.10 together with other channel features such as channel slope, mean depth and channel width.

Based on the channel data over the country of Japan, Dr. Koichi YAMAMOTO has disclosed the relationship between the bank-full friction velocity and the grain size as shown in Fig.M.3.11. This relationship indicates that a given grain size corresponds to specific bank-full friction velocity. Average values of friction velocity of the San Miguel River are also shown in Fig.M.3.11.

Through the studies above the following sediment flow characteristics of the San Miguel River were found:

1) The stretch from Olomega drainage to Moscoso bridge (stretch M2, M3 and M4) shows relatively stable channel conditions in the alluvial plain. The U_*-value in this stretch is 16 cm/s on an average.
2) The U_*-values in the stretches L1 and L4-1 through L4-4 are smaller due to small channel section and small flood discharge.
3) Plots of the U_*-d_{60} relationship of the San Miguel River are close to those of Japan, which indicates the sediment flow characteristics of the San Miguel River would be similar to those of Japan.

(3) Consideration for Design of Stable Channel

It is known that the bank-full discharge of the alluvial river corresponds to two to three-year probable runoff. The two-year probable discharge which would be worked out as an average of the annual maximum flood discharge is considered as a dominant discharge to discuss stable low water channel section of the San Miguel River.

In designing the channel excavation, the friction velocity of the excavated channel (U_*) should be within a permissible deviation from the representative U_*-value of the river under two-year probable discharge. If the U_*-value of the designed channel is too small, the excavated channel may silted up again.

For the present study, the representative U_*-value of the San Miguel River was taken to be 16 cm/s with permissible deviation of $\pm 20\%$. The representative U_*-value may vary if the river conditions such as two year discharge.

The channel section is first designed so as to convey design discharge below design high water level(DHWL) and then the section is examined from sediment-flow viewpoint by using the friction velocity.

4. RIVER IMPROVEMENT MASTER PLAN

4.1 Principles for Facility Design

(1) Extent of River Improvement

River improvement was planned for the stretch from the lower end of farm land (Sect.SM1) in estuary to Urbina bridge (sect. SM170-0.06k) in San Miguel City. The extent of river improvement in estuary has been decided based on the alternative study in Chapter 3. In the upper reaches of Urbina bridge (Military Route), river banks are high and no substantial flood damages occur.

(2) Design Discharge Distribution

Design discharge distribution was determined based on 10 year probable flood as shown in Fig.M.4.1.

(3) River Improvement

The San Miguel River was divided into a lot of stretches of different conditions and the channel improvement concept was discussed by stretches. Stretch codes in the Lower and Middle basins are denoted, respectively, by the initial L and M. The concept of channel improvement is shown in Table M.4.1. Layout plan of the channel improvement is shown in the Fig.M.4.1.

From Sta. Rita R. to Ereguayquin R. (stretches L1 through L2): The existing channel sections are markedly small especially in L1 due to bifurcation of the Limon and Cinco rivers. The channel is to be excavated up to L1-2 and dikes be constructed up to L1-3.

From Ereguayquin R. to Vado Marin (stretch L3): The existing river channel has relatively large section in this stretch. The channel is to be excavated and dikes be constructed locally.

From Vado Marin to La Canoa (stretches L4-1 through L4-4): Considering the drainage of surrounding areas, dikes are not to be constructed. The existing river meanders severely and channel section is small in these stretches. Channel excavation and normalization of alignment by cut-off channels are the principal measures. The DHWL was set lower than the ground except stretch L4-2. Ground elevation along the stretch L4-2 is too low to set DHWL lower than the ground. Inundation would remain in this stretch, though the flood conditions are improved much than ever.

From La Canoa to Sect. SM-103 (stretches L4-5): This stretch forms rapids being put between hilly lands. No work is necessary except upper portion of this stretch.

From Sect. SM-103 to Pelota R. (stretches M1, O1-1, COC and M2): Dike is not to be constructed in these stretches except for M2-3 setting the DHWL lower than the ground for the drainage of surrounding areas. Stretch M2-1 (sect. SM105 to SM113) of the existing San Miguel River will serves only for local drainage, because the floodwater of the San Miguel River is partly led to Lake Olomega by the proposed diversion channel and the remaining by new cut-off channel. No work is planned for the stretch M2-1, since the existing channel has enough capacity to convey runoff from its own basin.

Olomega drainage and Pelota R. (stretches O1, P1 and P2): Dike is not to be constructed for Olomega drainage (stretch O1) setting the DHWL lower than the ground to drain water in the surrounding areas. The Pelota River (stretches P1 and P2) is planned as a diversion channel to lead floodwater of the San Miguel River to Lake Olomega. The diversion channel provide with dikes.

From Pelota R. to Urubina bridge (stretches M3 through M6-1): The existing river channel has relatively large sections. The channel is to be excavated locally. Dikes are necessary only up to Lake Aramuaca (stretch M3).

(4) Lake Olomega

Lake Olomega is to be used for flood water storage as follows:

1) The lake water level should be kept above 64.0 m,MSL to ensure the fishery. And the lake water level should be kept below 65.5 m,MSL to mitigate the flood damages in the surrounding agricultural lands.
2) The lake water level is kept at 64.5 m,MSL preparing for the coming flood. Floodwater of the San Miguel River is led to the lake by a diversion channel and is stored in the lake up to the maximum water level of 65.5 m,MSL. The effective storage volume is about 20 million m^3 for the storage depth of 1.0 m.
3) The flood damage of the area around the lake and fish catch reduction would be alleviated by so controlling the lake water level within the limited range.

In order to divert floodwater of the San Miguel River to Lake Olomega, the Pelota River is planned to be improved as a diversion channel. At the bifurcation of the Pelota River from the San Miguel River, a diversion weir is planned. For the effective use of the storage volume of the lake, a control gate (Olomega control gate) is installed at the outlet of the lake. The existing Olomega drainage is also to be improved.

Studies of the structures and facilities related to the flood water storage by Lake Olomega are presented in SUPPORTING REPORT-L (Flood Water Storage Plan).

(5) Jocotal Area

The area around Lake Jocotal is depressed topographically. Some extremely low lands are difficult to make flood-free even after the completion of works.

Since the Lake Jocotal and its surrounding area have been designated as a reserved area to protect natural fauna and flora, no works are undertaken in these area except the improvement of river channel passing by.

The following positive effects are expected from the river improvement works:

- Reduction of flood damages in agricultural lands around Lake Jocotal
- Reduction of floodwater inflow into Lake Jocotal: This will diminish the ecological degradation and stabilize the fishery production.

4.2 Preliminary Facility Design

(1) River Channel

Channel of the San Miguel River was designed based on the concept presented in the previous section.

Channel Alignment: The channel alignment was designed, in principle, on the existing river course except for the following:

1) Local sharp bends of the existing river: Alignment was normalized.
2) Meandering river reaches in Jocotal area (stretches L4): Improved by cut-off channels.

3) Olomega diversion channel along the Pelota River (stretch P2): Channel was realigned so as to reduce the house compensation
4) New cut off downstream from SM113 (stretch COC)

In the Jocotal area, channel alignment was set so as to remain existing small ponds along the river as much as possible. Design alignment of the San Miguel River is shown in Fig.M.4.2.

Longitudinal Profile: Design high water level (DHWL) was set considering the past flood water level and ground elevation to be drained. The DHWL was set lower than the 1995-flood water level as a whole except for the stretches L1 through L2 and M3 where floodwater bifurcated or over-topped the dike during the 1995-flood.

Design river bed elevation was set principally at the existing lowest bed or higher. However, in the Jocotal area (stretches L4-2 through L4-4), the design river bed was set lower than the existing bed, since the existing channel section is too small to convey the design discharge.

Channel slopes were designed approximately same as those of the existing channel. Design profile of the San Miguel River is shown in Table M.4.2 and Fig.M.4.3.

Channel Section: The channel section was designed for 10-year design discharge based on the channel flow calculations. The channel flow was calculated under the assumed Manningįs coefficient of roughness presented below.

- $n = 0.035$ for existing channel
- $n = 0.030$ for improved low water channel
- $n = 0.045$ for improved high water channel

Side slope of the excavated channel is 1 on 2 and berms are provided on both side slope at 3 m above the design river bed.

Standard channel section of the San Miguel River is shown in the said Table M.4.2 and representative design sections are shown in Fig.M.4.4.

Dike and Revetment: Standard dike section is shown in Fig.M.4.5.

Revetment of low water channel was designed at the sharp bends where flood flows may attack directly. Concrete frame works filled with stones were assumed for the revetment works.

Standard drawing of the revetment works is shown in Fig.M.4.6.

(2) Structures

Drainage Sluice: Drainage sluice was designed crossing the dike for interior drainage where ground elevation of the protected area was lower than the DHWL.

Three types of drainage sluices were planned depending on the size of basin areas to be drained as follows:

- Type A : 1.25 m (width) x 1.25 m (height)
  for the drainage area(Da) up to 1.0 km^2
- Type B : 1.75 m (width) x 1.75 m (height)
  for the drainage area(Da) ranging from1.0 km^2 to 3.0 km^2
- Type C : 2.50 m (width) x 2.5 m (height)
  for the drainage area(Da) ranging from 3.0 km^2 to 4.5 km^2

Standard drawing of the drainage sluice is shown in Fig.M.4.7.

Ground Sill: Ground sill works are necessary at the drop of river bed in order to consolidate and stabilize the river bed. Standard drawing of the ground sill is shown in Fig.M.4.8.

(3) Appurtenant Facilities

Intake Gate: At the head of new cut off channel at SM113, the existing San Miguel River is closed for floodwater. However, the existing river downstream of SM113 needs to convey irrigation water during dry season. An intake gate was installed across the dike of the existing San Miguel River. Design discharge of the intake gate was assumed at 3.0 m^3/s based on the average channel flow during dry four months.

Structure of the intake gate is principally the same with drainage sluice (Type B), though the operation is different.

Bridge: The existing bridges at Moropala and Vado Marin need to be reconstructed, since Moropala Bridge is not enough in length and Vado Marin Bridge in length and elevation.

New bridges are necessary across the new cut-off channel (COC), Olomega diversion channel (P2) and Olomega drainage (O1). Prestressed concrete bridges of 8 m wide were assumed for these bridges. Standard drawing of new bridge is shown in Fig.M.4.9.

Rural Road: The existing rural roads need to be relocated in some places because of the river improvement works.

(4) Land Acquisition and House Compensation

The land within the designed river area is to be expropriated for the works, and houses located in the design river area should be compensated.

The river area covers the lands between proposed dikes including dike and other areas necessary for the administration of river facilities and structures.

The number of houses to be compensated was estimated based on the topographic maps (scale 1/10,000) prepared for the Study.

4.3 Quantity of Works

Quantities of works estimated based on the results of preliminary design are shown in Table M.4.3. Main features of the project works are presented below.

- Earth excavation: 14,353,000 m^3
- Rock excavation: 603,000 m^3
- Embankment: 1,843,000 m^3
- Revetment: 6,000 lin.m
- Drainage sluice: 15 places
- Ground sill: 4 places
- Diversion weir: 1 place
- Control gate: 1 place
- Bridge: 5 places

Among the works for river improvement, channel excavation shares major portion of works. The excavated materials in the Jocotal area were planned to be dumped in the lowlying lands along the river, while those in the other areas needed transportation to the final disposal sites.

The reaches near Vado Marin and El Delirio need rock excavation which is high in unit work cost. The quantities of rock excavation were estimated based on results of the additional river survey and site reconnaissance.

4.4 Selection of Priority Project

The project cost required for the implementation of Master Plan (excluding non-structural measures) was estimated at ¢ 1,097 million (or US$ 125.4 million) on the fixed prince basis as of December 1996 (Table M.4.4), according to the SUPPORTING REPORT-N: Construction Plan and Cost Estimate.

Master Plan will be carried out by the target year 2020. It is practical to implement the work by stages keeping pace with development of the basin, since the implementation of Master Plan requires a lot of construction cost extending for a long period.

Therefore, Priority Project for the immediate implementation was proposed selecting from the Master Plan.

(1) Criteria for Selection of Priority Project

Priority project is to be selected within the frame of Master Plan, considering the size of the cost and financial aspects, execution and management aspects, and the urgency, effects and efficiency, and sequence of execution of the project components, in line with the following criteria for the selection:

1) Economic target: EIRR is larger than that of whole Master Plan.
2) Financial target: The total project cost is less than ¢ 800 million and the construction period is less than 5 years.
3) Social target: The negative impact shall be small and acceptable, and positive impact (beneficial area) shall be as large as possible.
4) Environmental target: The negative environmental impact shall be small.

Since the project works of Master Plan are for the flood control purpose of one river system, it is difficult to select Priority Project by the component works of the Master Plan. Furthermore, it is also difficult to select a priority area for protection, since the respective areas of Olomega, Jocotal and Usulutan are waiting for the immediate implementation of flood control measures.

Therefore, the Priority Project is planned for the whole stretch of the Master Plan by reducing the safety degree of protection or, in other words, setting the return period of design discharge lower, in order to materialize the flood control effects as early as possible though it is limited.

(2) Return Period for Priority Project

River channel with dike should be designed based on 10 year probable discharge same as the Master Plan, since if the dike is over-topped the protected areas would suffer from more disastrous damages than ever. Reduction of channel excavation were considered instead for the reaches without dikes.

Figure M.4.10 shows inundated areas for different scales of channel excavation under various magnitudes of flood events. From this figure it is seen that the marked reduction in inundated area can be achieved by the channel excavation for 2 year probable discharge.

Economic viability of schemes of different return periods were examined in SUPPORING REPORT-O (Project Evaluation). Schemes of 10, 5 and 2year return periods were selected for the study. According to the result of study, it was confirmed that the 2-year scheme yields the highest EIRR as follows:

- 10-year scheme: EIRR = 15.2 %
- 5-year scheme: EIRR = 15.9 %
- 2-year scheme: EIRR = 18.1 %

Therefore, 2-year scheme was proposed for Priority Project which improve the river channel based on 10 year probable discharge for the reaches with dike, and 2 year probable discharge for the reaches without dike (channel excavation). Facility plan for the Priority Project are discussed in the succeeding chapter based on the principles discussed above.

5. RIVER IMPROVEMENT (PRIORITY PROJECT)

5.1 Basic Study for Priority Project

(1) Design Discharge for Priority Project

Since 10 year probable flood is applied to the reaches with dike and 2 year flood to the channel excavation without dike, the following three cases of design discharge were calculated by the runoff analysis:

1) Master Plan: Design discharge was calculated based on 10-year probable rainfall. Storage of Lake Olomega was taken into account
2) Priority Project for channel excavation: Design discharge was calculated based on 2-year probable rainfall. Storage of Lake Olomega was taken into account.
3) Priority Project for dike design: Design discharge was calculated based on 10-year probable rainfall. Runoff retardation due to storage of Lake Olomega and inundation along no-dike reaches were taken into account.

According to the result of runoff analysis design discharge distributions were determined as shown in Fig.M.5.1.

(2) Flow Calculations for Existing River Channel

Surface profiles of the existing river channel were examined by the non-uniform flow model for the following hilly reaches:

1) From river mouth to Vado Marin: Based on 10-year and 2-year probable discharges
2) Upstream reaches from Lake Aramuaca: Based on 10-year and 2-year probable discharges

As a result of the examination the followings were clarified:

1) The existing river channel from the confluence of the Ereguayquin River to Vado Marin has enough capacity to 2-year probable discharge except for small portions of sections at the confluence and just downstream of Vado Marin bridge.
2) The existing river channel upstream from Lake Aramuaca has also enough capacity to 2-year probable discharge.

5.2 Preliminary Facility Design for Priority Project

(1) Design of River Channel

Concept of channel improvement for the Priority Project is shown in Table M.5.1 in comparison with Master Plan. Layout plan of these projects are shown in Fig.M.5.2.

Extent of River Improvement: Same stretch with that of Master Plan were subject to the improvement except for the reaches upstream from Aramuaca (stretches M4 through M6) where the channel has enough capacity to 2 year probable discharge.

Channel Alignment: The dike alignments should be designed on the same alignments of those of Master Plan. Channel alignment is, therefore, the same with Master Plan (Fig.M.4.2) except the width of low water channel.

Channel Profile: The design high water level (DHWL) of the Priority Project was set at the same elevation with that of the Master Plan (Table M.5.2 and Fig.M.4.3).

Channel Section: For the Priority Project, the channel section with dike was designed based on 10-year design discharge and the channel section without dike on 2-year design discharge, while the channel section for the Master Plan was designed based on 10-year design discharge for the whole stretch. Design channel section for the Priority Project is shown in Table M.5.2 together with design profile. Representative channel sections are also shown in Fig.M.4.4.

Dike embankment: The same standard dike section was applied to both the Priority Project and the Master Plan (Fig.M.4.5).

Revetment: Revetment of low water channel was designed at the sharp bends where flood flows would attack directly (Fig.M.4.6).

(2) Structures

Drainage Sluice: Drainage sluice was designed crossing the dike for inland drainage where the land side ground elevation was lower than the DHWL for interior drainage (Fig.M.4.7).

Ground Sill: Ground sill works are necessary at the drop of river bed in order to consolidate and stabilize the river bed (Fig.M.4.8).

(3) Appurtenant Facilities

Intake Gate: The same structure with that of Master Plan.

Bridge: The existing bridges at Moropala and Vado Marin need to be reconstructed for Master Plan, since Moropala Bridge is not enough in length and Vado Marin Bridge in length and elevation. However, these bridges will not be reconstructed for the Priority Project.

New bridges are necessary across the New Cut Off (CF), Olomega diversion channel (P2) and Olomega drainage (O1). Prestressed concrete bridge, 8 m wide, was assumed (Fig.M.4.9).

Rural Road: The existing rural roads need to be relocated in some places because of the channel excavation and dike embankment works.

(4) Land Acquisition and House Compensation

The land within the design river area will be expropriated for the works, and the houses located in the design river area should be compensated.

5.3 Quantity of Works

Quantities of works estimated based on preliminary facility design are shown in Table M.5.2 for the Priority Project. Main features of the project works are presented below.

- Earth excavation: 7,883,000 m^3
- Rock excavation: 152,000 m^3
- Embankment: 1,173,000 m^3
- Revetment: 6,000 lin.m
- Drainage sluice: 1 place
- Ground sill: 4 places
- Diversion weir: 1 place
- Olomega Control Gate: 1 place
- Bridge reconstruction: 3 places

5.4 Study on Partial Schemes of Priority Project

According to the SUPPORTING REPORT-N (Construction Plan and Cost Estimate), project cost required for the implementation of the Priority Project (excluding non-structural measures) amounts to ¢ 598 million (or US$ 68.3 million) on the fixed prince basis as of December 1996 (Table M.5.4). The fund required for the project implementation were estimated at ¢ 775.9 million (or US$ 88.7 million) considering price contingency during the construction period.

The proposed Priority Project is judged to satisfy the criteria presented in Section 4.4.

Partial schemes of the Priority Project were studied here to examine their economic viability. The following partial improvement schemes were conceivable for the Priority Project of the San Miguel River:

1) Alternative 1: Improvement of whole reaches (Priority Project)
2) Alternative 2: Improvement from river mouth to El Delirio (stretches L1 through L4, i.e., Olomega area is not subject to the improvement).
3) Alternative 3: Improvement from river mouth to the Ereguayquin River junction (stretches L1 and L2 only, i.e., Jocotal and Olomega areas are not subject to the improvement).

Other than the above, schemes to improve Olomega and/or Jocotal area only are conceivable. These schemes, however, call for the improvement in the lower reaches up to the sea in order to avoid the adverse effects due to improvement in the upper reaches. Therefore, these schemes are economically disadvantageous to the above alternative 1 and 2, because of small reduction in cost and much reduction in area to be protected.

The project costs of lternatives 1 through 3 were estimated as shown below (Table M.5.5) on the fixed price basis as of December, 1996.

Alternative 1: ¢ 597.7 million
Alternative 2: ¢ 235.2 million
Alternative 3: ¢ 69.3 million

Economic viability of these schemes were evaluated in SUPPORTING REPORT-O (Project Evaluation) and the results are as follows:

EIRR = 18.1 % for Altemative 1

EIRR = 26.3 % for Altemative 2

EIRR = 17.5 % for Altemative 3

All of the partial improvement schemes of Alternative-1 through 3 yield high EIRR enough and are economically viable.

Table M.1.1 HIGH AND LOW TIDES AT EL TRIUNFO PORT

HIGH WATER SPRING TIDE(Period: 1994 - 1996)

High water spring tide(m,MSL)				
Year	Mon	Day	Time	Tide
1994	1	2	18	1.30
1994	1	12	3	1.30
1994	1	31	18	1.47
1994	2	12	16	1.22
1994	2	28	17	1.58
1994	3	13	16	1.19
1994	3	29	16	1.65
1994	4	12	16	1.19
1994	4	27	16	1.65
1994	5	12	16	1.19
1994	5	26	15	1.63
1994	6	10	15	1.22
1994	6	24	15	1.53
1994	7	11	16	1.30
1994	7	23	15	1.42
1994	8	11	5	1.42
1994	8	21	15	1.30
1994	9	9	5	1.55
1994	9	21	3	1.25
1994	10	7	4	1.63
1994	10	20	3	1.19
1994	11	5	3	1.65
1994	11	20	4	1.17
1994	11	29	23	1.17
1994	12	4	3	1.60
1994	12	20	4	1.17
1994	12	31	1	1.35
Average(Jan-Dec)				1.38
Average(May-Oct)				1.39

High water spring tide(m,MSL)				
Year	Mon	Day	Time	Tide
1995	1	3	4	1.53
1995	1	21	18	1.25
1995	2	2	17	1.40
1995	2	19	18	1.40
1995	3	3	16	1.35
1995	3	20	17	1.50
1995	3	31	15	1.27
1995	4	17	16	1.58
1995	4	30	15	1.22
1995	5	16	16	1.63
1995	5	30	15	1.19
1995	6	14	15	1.63
1995	6	29	16	1.19
1995	7	13	15	1.60
1995	7	29	16	1.22
1995	8	11	15	1.50
1995	8	30	5	1.35
1995	9	11	4	1.42
1995	9	27	4	1.45
1995	10	9	3	1.35
1995	10	27	4	1.55
1995	11	7	2	1.25
1995	11	24	3	1.58
1995	12	8	3	1.17
1995	12	24	4	1.58
Average(Jan-Dec)				1.40
Average(May-Oct)				1.42

High water spring tide(m,MSL)				
Year	Mon	Day	Time	Tide
1996	1	8	4	1.14
1996	1	22	4	1.55
1996	2	8	17	1.19
1996	2	20	16	1.53
1996	3	8	17	1.30
1996	3	20	16	1.47
1996	4	6	16	1.40
1996	4	18	15	1.40
1996	5	5	16	1.50
1996	5	17	15	1.30
1996	6	3	16	1.58
1996	6	16	15	1.22
1996	7	3	16	1.63
1996	7	17	16	1.19
1996	8	1	16	1.63
1996	8	16	16	1.19
1996	8	31	4	1.60
1996	9	16	5	1.27
1996	9	29	4	1.55
1996	10	15	4	1.35
1996	10	28	3	1.47
1996	11	13	4	1.42
1996	11	26	3	1.35
1996	12	13	4	1.50
1996	12	25	3	1.19
Average(Jan-Dec)				1.40
Average(May-Oct)				1.42
Average: 1994-1996 (Jan-Dec)				1.39
Average: 1994-1996 (May-Oct)				1.41

LOW WATER SPRING TIDE(Period: 1994 - 1996)

Low water spring tide(m,MSL)				
Year	Mon	Day	Time	Tide
1994	1	1	11	-1.42
1994	1	13	9	-1.40
1994	1	30	10	-1.55
1994	2	12	10	-1.32
1994	2	28	22	-1.66
1994	3	14	22	-1.27
1994	3	29	22	-1.74
1994	4	12	22	-1.25
1994	4	27	22	-1.71
1994	5	12	22	-1.19
1994	5	26	21	-1.61
1994	6	12	23	-1.22
1994	6	24	21	-1.47
1994	7	12	23	-1.30
1994	7	24	22	-1.37
1994	8	10	23	-1.42
1994	8	22	21	-1.27
1994	9	9	11	-1.53
1994	9	21	9	-1.25
1994	10	7	10	-1.66
1994	10	21	9	-1.22
1994	11	5	9	-1.69
1994	11	20	10	-1.19
1994	12	4	8	-1.66
1994	12	21	10	-1.22
Average(Jan-Dec)				-1.42
Average(May-Oct)				-1.38

Low water spring tide(m,MSL)				
Year	Mon	Day	Time	Tide
1995	1	3	10	-1.61
1995	1	20	11	-1.35
1995	2	1	9	-1.53
1995	2	19	11	-1.47
1995	3	3	10	-1.45
1995	3	19	22	-1.59
1995	4	1	22	-1.35
1995	4	17	22	-1.66
1995	5	1	22	-1.25
1995	5	16	22	-1.66
1995	5	31	22	-1.17
1995	6	15	22	-1.61
1995	6	30	22	-1.14
1995	7	13	21	-1.55
1995	7	31	23	-1.22
1995	8	12	22	-1.50
1995	8	29	23	-1.32
1995	9	11	10	-1.42
1995	9	27	10	-1.47
1995	10	10	9	-1.37
1995	10	26	10	-1.59
1995	11	8	9	-1.27
1995	11	25	10	-1.66
1995	12	9	10	-1.22
1995	12	24	10	-1.69
Average(Jan-Dec)				-1.45
Average(May-Oct)				-1.41

Low water spring tide(m,MSL)				
Year	Mon	Day	Time	Tide
1996	1	8	10	-1.22
1996	1	22	10	-1.71
1996	2	7	10	-1.27
1996	2	20	9	-1.66
1996	3	8	23	-1.37
1996	3	20	21	-1.55
1996	4	6	22	-1.47
1996	4	18	21	-1.42
1996	5	5	22	-1.55
1996	5	18	21	-1.30
1996	6	3	22	-1.59
1996	6	17	22	-1.17
1996	7	3	22	-1.61
1996	7	17	22	-1.12
1996	8	1	22	-1.64
1996	8	16	22	-1.14
1996	8	30	22	-1.61
1996	9	16	10	-1.25
1996	9	29	10	-1.59
1996	10	15	10	-1.37
1996	10	28	9	-1.50
1996	11	14	10	-1.50
1996	11	26	9	-1.37
1996	12	13	10	-1.59
1996	12	26	9	-1.27
Average(Jan-Dec)				-1.43
Average(May-Oct)				-1.42
Average: 1994-1996 (Jan-Dec)				-1.43
Average: 1994-1996 (May-Oct)				-1.40

Table M.1.2 DATA FOR SEDIMENT YIELD STUDY

Observed Suspended Solid

Year	Unit	Suspended solid(1000ton/year)	
		Villerias	Moscoso
1970/71	-	200	986
1971/72	-	171	511
1972/73	-	321	446
1973/74	-	207	463
1974/75	-	2504	1841
1975/76	-	-	455
1976/77	-	12	-
1977/78	-	-	115
1978/79	-	-	474
1979/80	-	-	331
Average	-	569	625
Volume(m^3/year)	m^3/year	358	393
Specific gravity	ton/m^3	2.65	2.65
Void ratio	-	0.4	0.4

Source: MAG

Sedimentation Volume in Existing Reservoirs of Lempa River

Item	Unit	Reservoir name				
		Guija	Cerron Grande	5 de Noviembre	15 de Septiembre	Weighted average
Catchment	km^2	2768	8584	9863	17524	
Residual catchment	km^2	2768	5816	1279	7661	
Initial year	year	1963	1976	1974	1983	
Initial volume	10^6m^3	560	2180	65	393	
Volume in 1994	10^6m^3	508.7	2026.2	40.7	335.5	
Annual sedimentation	10^6m^3/yr	1.65	8.54	1.22	5.23	
Specific sedimentation	m^3/yr/km^2	598	1469	950	682	950

Source: CEL

Table M.1.3 EXISTING DIKE LENGTH AND HEIGHT

LOWER SAN MIGUEL RIVER

Sect.No	Distance (m)	Left bank Height (m)	Left bank Length (m)	Right bank Height (m)	Right bank Length (m)
SM 0	630	-	-	-	-
SM 1	700	-	-	-	-
SM 2	500	-	-	-	-
SM 3	590	-	-	-	-
SM 4	420	-	-	-	-
SM 5	1000	0.7	800	-	-
SM 6	600	0.7	385	-	-
SM 7	170	1.2	355	2.4	355
SM 8	540	1.6	565	2.4	565
SM 9	590	-	-	2.4	625
SM 10	660	-	-	2.8	490
SM 11	320	-	-	2.4	615
SM 12	910	-	-	2.8	740
SM 13	570	-	-	3.0	645
SM 14	720	2.8	580	4.0	580
SM 15	440	2.4	480	3.6	480
SM 16	520	3.2	680	3.6	680
SM 17	840	1.6	685	3.2	685
SM 18	530	2.8	485	1.2	485
SM 19	440	-	-	2.8	505
SM 20	570	-	-	-	-
SM 21	410	-	-	-	-
SM 22	750	-	-	-	-
SM 23	560	-	-	-	-
SM 24	540	-	-	-	-
SM 25	920	-	-	-	-
SM 26	550	-	-	-	-
SM 27	430	-	-	-	-
SM 28	510	-	-	-	-
SM 29	470	-	-	-	-
SM 30	510	-	-	-	-
Total	17910		5015		7450
Average		1.9		2.8	
Ratio			0.28		0.42

MIDDLE SAN MIGUEL RIVER

Sect.No	Distance (m)	Left bank Height (m)	Left bank Length (m)	Right bank Height (m)	Right bank Length (m)
SM 103	520	-	-	-	-
SM 104	570	-	-	-	-
SM 105	460		-	-	-
SM 106	550	-	-	-	-
SM 107	480	-	-	3.2	535
SM 108	590	-	-	2.8	550
SM 109	510	-	-	-	-
SM 110	740	2.0	845	2.8	845
SM 111	950	2.4	770	-	-
SM 112	590	3.2	565	-	-
SM 113	540	1.6	540	-	-
SM 114	540	2.6	475	-	-
SM 115	410	-	-	-	-
SM 116	730	-	-	-	-
SM 117	710	-	-	-	-
SM 118	780	-	-	-	-
SM 119	870	-	-	1.2	720
SM 120	570	2.4	710	-	-
SM 121	850	2.4	705	-	-
SM 122	560	2.8	695	-	-
SM 123	830	-	-	-	-
SM 124	940	2.8	835	2.0	835
SM 125	730	2.8	675	1.2	675
SM 126	620	2.4	675	2.4	675
SM 127	730	2.8	845	1.2	845
SM 128	960	1.6	730	-	-
SM 129	500	1.2	500	-	-
SM 130	500	-	-	-	-
SM 131	540	-	-	-	-
SM 132	470	-	-	-	-
SM 133	620	-	-	-	-
SM 134	800	-	-	-	-
SM 135	560	-	-	-	-
Total	21320		9565		5680
Average		2.4		2.1	
Ratio			0.45		0.27

PELOTA RIVER

Sect.No	Distance (m)	Left bank Height (m)	Left bank Length (m)	Right bank Height (m)	Right bank Length (m)
Olomega L	-	-	-	-	-
PL 1	20	-	-	1.5	550
PL 2	1080	-	-	1.5	1400
PL 3	1720	0.8	1530	1.3	1530
PL 4	1340	2.0	1380	2.0	1380
PL 5	1420	4.0	760	3.0	760
S.Miguel R	100	4.0	50	3.0	50
Total	5680		3720		5670
Average		2.7		2.1	
Ratio			0.65		1.00

(NOTE)

1) Sect.SM30 - SM103 : No dike
2) Upper reaches of SM135 : No dike
3) Olomega drainage : No dike

SUMMARY

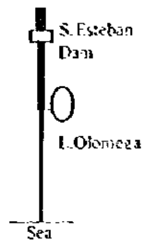
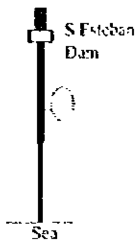
Total channel length.	99.39	km (up to Lake Aramuaca)		
Dike length				
Left bank:	18.3	km	18.4%	of total
Right bank:	18.8	km	18.9%	of total
Total :	37.10	km		

Table M.3.1 QUANTITIES AND COSTS FOR ALTERNATIVES (COMBINATION OF MEASURES)

Items	Unit		Alternative 1				Alternative 2				Alternative 3				Alternative 4			
	Unit	Cost(Col.)	Quantity	Amount (10^6 ¢)	L.C. (106 ¢)	F.C. (106 ¢)	Quantity	Amount (10^6 ¢)	L.C. (106 ¢)	F.C. (106 ¢)	Quantity	Amount (10^6 ¢)	L.C. (106 ¢)	F.C. (106 ¢)	Quantity	Amount (10^6 ¢)	L.C. (106 ¢)	F.C. (106 ¢)
1. Construction works																		
1.1 Channel works				1,191.8	131.2	1,060.6		820.2	100.9	719.3		435.8	58.4	377.4		506.3	58.6	447.8
Excavation	m^3	44	13,876,500	610.6	61.1	549.5	9,405,100	413.8	41.4	372.4	3,009,200	132.4	13.2	119.2	3,909,500	172.0	17.2	154.8
Excavation(Jocotal	m^3	27	15,754,800	425.4	42.5	382.9	7,501,400	202.5	20.3	182.3	4,436,300	119.8	12.0	107.8	7,364,500	198.8	19.9	178.9
Embankment	m^3	50	1,917,000	95.9	9.6	86.3	2,187,000	109.4	10.9	98.5	2,187,000	109.4	10.9	98.5	1,917,000	95.9	9.6	86.3
Revetment	m	4,500	6,600	29.7	8.9	20.8	8,400	37.8	11.3	26.5	8,400	37.8	11.3	26.5	6,600	29.7	8.9	20.8
Weir	l.s.			20.3	6.1	14.2		20.3	6.1	14.2		0.0	0.0	0.0		0.0	0.0	0.0
Sluice, etc.	l.s.			9.9	3.0	6.9		9.9	3.0	6.9		9.9	3.0	6.9		9.9	3.0	6.9
Bridge	nos.	13,240,000		0.0	0.0	0.0	2	26.5	8.0	18.6	2	26.5	8.0	18.6		0.0	0.0	0.0
1.2 Dam works				0.0				0.0				507.3	80.4	426.9		507.3	80.4	426.9
Dam body	l.s.											358.8	35.9	322.9		358.8	35.9	322.9
Spillway, etc.	l.s.											148.5	44.6	104.0		148.5	44.6	104.0
(Sub-total)				1,191.8	131.2	1,060.6		820.2	100.9	719.3		943.1	138.9	804.3		1,013.6	139.0	874.6
2. Land	l.s.			7.6	7.6			10.3	10.3			56.8	56.8			54.1	54.1	
3. Administration	l.s.			60.0	60.0			41.5	41.5			50.0	50.0			53.4	53.4	
4. Engineering	l.s.			119.9	13.2	106.7		83.1	10.2	72.9		100.0	14.7	85.3		106.8	14.6	92.2
5. Contingency	l.s.			137.9	21.2	116.7		95.5	16.3	79.2		115.0	26.0	89.0		122.8	26.1	96.7
Total				1,517.2	233.2	1,284.0		1,050.6	179.2	871.4		1,264.9	286.4	978.5		1,350.7	287.2	1,063.5

(NOTE) Above unit costs and work quantities are those estimated for alternative study in the first phase of study.

Table M.3.2 COMPARISON OF ALTERNATIVES (COMBINATION OF MEASURES)

Descriptions	Alt. 1	Alt. 2	Alt. 3	Alt. 4
SCHEMATIC DESCRIPTION OF ALTERNATIVE SCHEMES	 Channel improvement only	 Channel improvement + L.Olomega	 Channel improvement + L.Olomega + San Esteban dam	 Channel improvement + San Esteban dam
TECHNICAL ASPECTS				
. Difficulty	. Easier: Mainly channel improvement works	. Easier: Mainly channel improvement works	. More difficult: Dam construction and channel improvement works	. More difficult: Dam construction and channel improvement works
. Construction period	. Approx. 5 years	. Approx. 5 years	. Approx. 10 years	. Approx. 10 years
. Ranking (Wt=0.15)	. 1	. 1	. 3	. 3
FINANCIAL ASPECTS				
. Project cost(Ratio to Case-1)	. 1.00	. 0.69	. 0.83(multi-purpose)	. 0.89(multi-purpose)
. Ranking (Wt=0.40)	. 4	. 1	. 2	. 3
ECONOMIC ASPECTS				
. Benefit	. Reduction of flood damages . Enhancement of production	. Reduction of flood damages . Enhancement of production . Stable fishery in Lake Olomega	. Reduction of flood damages . Enhancement of production . Stable fishery in Lake Olomega	. Reduction of flood damages . Enhancement of production
. Ranking (Wt=0.15)	. 1	. 1	. 1	. 1
SOCIAL IMPACT				
. Land acquisition	. 3.7 km²	. 4.5 km²	. 35.5 km²	. 34.7 km²
. Re-settlememt	. 18 houses	. 20 houses	. 1,301 houses	. 1,299 houses
. Ranking (Wt=0.15)	. 1	. 1	. 3	. 3
ENVIRONMENTAL ASPECTS				
. Positive effects	. Stabilization of water level in Lake Jocotal	. Stabilization of water level in Lake Jocotal and Lake Olomega	. Stabilization of water level in Lake Jocotal and Lake Olomega	. Stabilization of water level in Lake Jocotal
. Negative effects			. Ecological changes in reservoir area	. Ecological changes in reservoir area
. Ranking (Wt=0.15)	. 2	. 1	. 3	. 4
OVERALL EVALUATION				
. Summary of ranking	. 1x0.15+4x0.4+1x0.15+1x0.15+2x0.15=2.35	. 1x0.15+1x0.4+1x0.15+1x0.15+1x0.15=1.00	. 3x0.15+2x0.4+1x0.15+3x0.15+3x0.15=2.30	. 3x0.15+3x0.4+1x0.15+3x0.15+4x0.15=2.85
. Overall ranking	. 3	. 1	. 2	. 4

REMARKS:

1) Quantities presented in this table are for the facility plan based on 10-year provable flood.
2) Wt: Weight for overall evaluation
3) F.C: Flood control

Table M.3.3 ESTIMATED COSTS FOR ALTERNATIVES (LOWER END OF IMPROVEMENT)

(Project Cost for Stretch from River Mouth to SM13)

Items	Unit	Cost(Col.)	ALT-1 Quantity	ALT-1 Total	ALT-1 L.C.	ALT-1 F.C.	ALT-2 Quantity	ALT-2 Total	ALT-2 L.C.	ALT-2 F.C.	ALT-3 Quantity	ALT-3 Total	ALT-3 L.C.	ALT-3 F.C.
				Amount(millon colons)				Amount(millon colons)				Amount(millon colons)		
1. Construction works				40.5	17.8	22.7		54.3	23.7	30.6		56.3	24.5	31.8
1.1 Channel works				39.4	17.0	22.4		52.0	22.2	29.8		54.0	23.0	31.0
Earth excavation(1	m^3	45	482,800	21.7	8.9	12.8	482,800	21.7	8.9	12.8	526,500	23.7	9.7	14.0
Earth excavation(2	m^3	20	0	0.0	0.0	0.0	0	0.0	0.0	0.0	0	0.0	0.0	0.0
Rock excavation	m^3	173	0	0.0	0.0	0.0	0	0.0	0.0	0.0	0	0.0	0.0	0.0
Embankment	m^3	42	381,900	16.0	6.6	9.4	680,300	28.6	11.7	16.9	680,300	28.6	11.7	16.9
Revetment	m	5,700	300	1.7	1.5	0.2	300	1.7	1.5	0.2	300	1.7	1.5	0.2
1.2 Structure works				0.8	0.5	0.3		2.0	1.2	0.8		2.0	1.2	0.8
Diversion weir	l.s.			0.0	0.0	0.0		0.0	0.0	0.0		0.0	0.0	0.0
Control gate	l.s.			0.0	0.0	0.0		0.0	0.0	0.0		0.0	0.0	0.0
Drainage sluice				0.8	0.5	0.3		2.0	1.2	0.8		2.0	1.2	0.8
Type-A	nos	426,000	0	0.0	0.0	0.0	0	0.0	0.0	0.0	0	0.0	0.0	0.0
Type-B	nos	586,000	0	0.0	0.0	0.0	2	1.2	0.7	0.5	2	1.2	0.7	0.5
Type-C	nos	754,000	1	0.8	0.5	0.3	1	0.8	0.5	0.3	1	0.8	0.5	0.3
Ground sill	m	18,269	0	0.0	0.0	0.0	0	0.0	0.0	0.0	0	0.0	0.0	0.0
1.3 Appurtenant works				0.3	0.3	0.0		0.3	0.3	0.0		0.3	0.3	0.0
Intake gate(Type-	nos	586,000	0	0.0	0.0	0.0	0	0.0	0.0	0.0	0	0.0	0.0	0.0
Bridge				0.0	0.0	0.0		0.0	0.0	0.0		0.0	0.0	0.0
Bridge(105m)	nos	13,400,000	0	0.0	0.0	0.0	0	0.0	0.0	0.0	0	0.0	0.0	0.0
Bridge(90m)	nos	12,600,000	0	0.0	0.0	0.0	0	0.0	0.0	0.0	0	0.0	0.0	0.0
Bridge(40m)	nos	7,000,000	0	0.0	0.0	0.0	0	0.0	0.0	0.0	0	0.0	0.0	0.0
Rural road	m	160	1,740	0.3	0.3	0.0	1,740	0.3	0.3	0.0	1,740	0.3	0.3	0.0
Telemetering syste	l.s.			0.0	0.0	0.0		0.0	0.0	0.0		0.0	0.0	0.0
2. Land and house				1.6	1.6	0.0		1.6	1.6	0.0		1.8	1.8	0.0
Land acquisit.(1)	$1000m^2$	2,150	728	1.6	1.6	0.0	728	1.6	1.6	0.0	834	1.8	1.8	0.0
Land acquisit.(2)	$1000m^2$	5,720	0	0.0	0.0	0.0	0	0.0	0.0	0.0	0	0.0	0.0	0.0
Land acquisit.(3)	$1000m^2$	2,570	0	0.0	0.0	0.0	0	0.0	0.0	0.0	0	0.0	0.0	0.0
Land acquisit.(4)	$1000m^2$	720	0	0.0	0.0	0.0	0	0.0	0.0	0.0	0	0.0	0.0	0.0
Land acquisit.(5)	$1000m^2$	3,580	0	0.0	0.0	0.0	0	0.0	0.0	0.0	0	0.0	0.0	0.0
Land acquisit.(6)	$1000m^2$	7,150	0	0.0	0.0	0.0	0	0.0	0.0	0.0	0	0.0	0.0	0.0
House compensat.	house	12,000	0	0.0	0.0	0.0	1	0.0	0.0	0.0	1	0.0	0.0	0.0
3. Administration	l.s.	-		2.1	2.1	0.0		2.8	2.8	0.0		2.9	2.9	0.0
4. Engineering	l.s.	-		6.3	2.3	4.0		8.4	3.1	5.3		8.7	3.2	5.5
5. Contingency	l.s.	-		5.1	2.4	2.7		6.7	3.1	3.6		7.0	3.2	3.7
Total				55.6	26.2	29.4		73.8	34.3	39.5		76.7	35.6	41.0

Table M.3.4 COMPARISON OF ALTERNATIVES (LOWER END OF IMPROVEMENT)

Descriptions	Alternative-1	Alternative-2	Alternative-3
Description of Alternative	Improvement works: Excavation: up to SM1 Embankment: up to SM7	Improvement works: Excavation: up to SM1 Embankment: up to SM1	Improvement works: Excavation: up to SR21+0.20k Embankment: up to SM1
Technical Aspects:			
Work quantity			
Earth excavation	482,800 m^3	482,800 m^3	526,500 m^3
Embankment	381,900 m^3	680,300 m^3	680,300 m^3
Revetment	300 m	300 m	300 m
Drainage sluice	1 place	3 place	3 place
Rural road	1,740 m	1,740 m	1,740 m
Water level in stretch L1-2	Low due to flooding	High confined by dike	Little difference from Alt.2
Financial Aspects: Project cost	55.6 million colons	73.8 million colons	76.7 million colons
Economic Aspects: Flood in areas along stretch L1-2	Flooding still remain	Protected from 10 year flood.	Protected from 10 year flood.
Social Aspects: Land / house	728,000 m^2 / 0 house	728,000 m^2 / 1 house	834,000 m^2 / 1 house
Environmental Aspects:	No significant impact	Flow concentrates to section SM1.	Flow concentrates to section SM1 and mangrove forest in stretch L1-1 to be cut 860 m long and 150 m wide.
Overall Evaluation:	**Selected:** Least cost and less social and environmental impact	Not selected:	Not selected: Little hydraulic effects and damage to mangrove forest.

(Note) Stretch of comparison: From river mouth to SM13

Stretch L1-1: From the upper end of mangrove forest(section SM1) to Cerro El Encantado(section SM7)

Table M.3.5 ESTIMATED COSTS FOR ALTERNATIVES (RIVER COURSE IN OLOMEGA AREA)

(Project Costs for Stretch from SM103 to SM120-0.26k)

Items	Unit		ALT-1				ALT-2				ALT-3			
	Unit	Cost(Col.)	Quantity	Amount(millon colons)			Quantity	Amount(millon colons)			Quantity	Amount(millon colons)		
				Total	L.C.	F.C.		Total	L.C.	F.C.		Total	L.C.	F.C.
1. Construction works				257.5	122.0	135.5		236.9	118.4	118.5		259.2	123.0	136.2
1.1 Channel works				207.4	89.0	118.4		171.9	77.0	94.9		208.3	89.4	118.9
Earth excavation(1	m^3	45	4,086,000	183.9	75.4	108.5	3,050,000	137.3	56.3	81.0	3,905,000	175.7	72.0	103.7
Earth excavation(2	m^3	20	0	0.0	0.0	0.0	0	0.0	0.0	0.0	0	0.0	0.0	0.0
Rock excavation	m^3	173	34,000	5.9	2.4	3.5	66,000	11.4	4.7	6.7	49,000	8.5	3.5	5.0
Embankment	m^3	42	227,900	9.6	3.9	5.7	239,600	10.1	4.1	6.0	384,300	16.1	6.6	9.5
Revetment	m	5,700	1,400	8.0	7.3	0.7	2,300	13.1	11.9	1.2	1,400	8.0	7.3	0.7
1.2 Structure works				21.4	16.1	5.3		23.1	17.6	5.5		21.6	16.3	5.3
Diversion weir	l.s.			10.9	9.4	1.5		10.9	9.4	1.5		10.9	9.4	1.5
Control gate	l.s.			9.4	5.8	3.6		9.4	5.8	3.6		9.4	5.8	3.6
Drainage sluice				0.0	0.0	0.0		0.0	0.0	0.0		0.0	0.0	0.0
Type-A	nos	426,000	0	0.0	0.0	0.0	0	0.0	0.0	0.0	0	0.0	0.0	0.0
Type-B	nos	586,000	0	0.0	0.0	0.0	0	0.0	0.0	0.0	0	0.0	0.0	0.0
Type-C	nos	754,000	0	0.0	0.0	0.0	0	0.0	0.0	0.0	0	0.0	0.0	0.0
Ground sill	m	18,269	59	1.1	0.9	0.2	151	2.8	2.4	0.4	73	1.3	1.1	0.2
1.3 Appurtenant works				28.7	16.9	11.8		41.9	23.8	18.1		29.3	17.2	12.1
Intake gate(Type-	nos	586,000	0	0.0	0.0	0.0	1	0.6	0.4	0.2	1	0.6	0.4	0.2
Bridge				20.4	10.6	9.8		33.0	17.2	15.8		20.4	10.6	9.8
Bridge(105m)	nos	13,400,000	1	13.4	7.0	6.4	1	13.4	7.0	6.4	1	13.4	7.0	6.4
Bridge(90m)	nos	12,600,000	0	0.0	0.0	0.0	1	12.6	6.6	6.0	0	0.0	0.0	0.0
Bridge(40m)	nos	7,000,000	1	7.0	3.6	3.4	1	7.0	3.6	3.4	1	7.0	3.6	3.4
Rural road	m	160	1,050	0.2	0.2	0.0	1,050	0.2	0.2	0.0	1,050	0.2	0.2	0.0
Telemetering syste	l.s.			8.1	6.1	2.0		8.1	6.1	2.0		8.1	6.1	2.0
2. Land and house				6.9	6.9	0.0		6.3	6.3	0.0		5.3	5.3	0.0
Land acquisit.(1)	$1000m^2$	2,150	0	0.0	0.0	0.0	0	0.0	0.0	0.0	0	0.0	0.0	0.0
Land acquisit.(2)	$1000m^2$	5,720	0	0.0	0.0	0.0	0	0.0	0.0	0.0	0	0.0	0.0	0.0
Land acquisit.(3)	$1000m^2$	2,570	0	0.0	0.0	0.0	0	0.0	0.0	0.0	0	0.0	0.0	0.0
Land acquisit.(4)	$1000m^2$	720	0	0.0	0.0	0.0	0	0.0	0.0	0.0	0	0.0	0.0	0.0
Land acquisit.(5)	$1000m^2$	3,580	1,925	6.9	6.9	0.0	1,771	6.3	6.3	0.0	1,473	5.3	5.3	0.0
Land acquisit.(6)	$1000m^2$	7,150	0	0.0	0.0	0.0	0	0.0	0.0	0.0	0	0.0	0.0	0.0
House compensat.	house	12,000	2	0.0	0.0	0.0	2	0.0	0.0	0.0	2	0.0	0.0	0.0
3. Administration	l.s.	-		13.2	13.2	0.0		12.2	12.2	0.0		13.2	13.2	0.0
4. Engineering	l.s.	-		39.7	14.7	25.0		36.5	13.5	23.0		39.7	14.7	25.0
5. Contingency	l.s.	-		31.7	15.7	16.0		29.2	15.0	14.1		31.7	15.6	16.1
Total				349.0	172.5	176.5		321.1	165.4	155.6		349.1	171.7	177.4

Table M.3.6 COMPARISON OF ALTERNATIVES (RIVER COURSE IN OLOMEGA AREA)

Descriptions	Alternative-1	Alternative-2	Alternative-3
Description of alternative	Route of San Miguel R: Existing channel route	Route of San Miguel R: Existing channel route with cut-off channel below section SM113	Route of San Miguel R: Existing route of Pelota River and Olomega drainage
Technical Aspects:			
Work quantity			
Earth excavation	4,086,000 m^3	3,050,000 m^3	3,905,000 m^3
Rock excavation	34,000 m^3	66,000m^3	49,000 m^3
Embankment	286,800 m^3	239,600 m^3	384,300 m^3
Revetment	1,400 m	2,300 m	1,400 m
Side weir and outlet gate	1 each	1 each	1 each
Ground sill	59 m	151 m	73 m
Intake gate	none	1 place	1 place
Bridge(new)	2 places	3 places	2 places
Rural road	1,050 m	1,050 m	1,050 m
Financial Aspects: Project cost	349.0 million colons	321.1 million colons	349.1 million colons
Economic Aspects:	Mitigation of flood damages	Same benefit as Alt.1	Same benefit as Alt.1
Social Aspects:			
Land / house	1,925,000 m^2 / 2 houses	1,771,000 m^2 / 2 houses	1,473,000 m^2 / 2 houses
Social impact	No significant impact	New cut-off channel	Route change of San Miguel R.
Environmental Aspects:	No significant impact Sediment inflow: less than ever	No significant problem Sediment inflow: less than ever	No significant problem Sediment inflow: less than ever
Overall Evaluation:	Not selected:	**Selected:** Least cost and less social/environmental impact.	Not selected:

(Note) Stretch of comparison: From SM103 to SM120-0.26K

Table M.3.7 MEAN GRAIN SIZE OF RIVER BED MATERIALS

Reaches	Site	Sample code	Cumulative percentage of passing materials (%)							Mean grain size(mm)									Remarks
			<0.045 (mm)	<0.106 (mm)	<0.181 (mm)	<0.355 (mm)	<0.710 (mm)	<2.0 (mm)	>2.0 (mm)	Average: d50			Average: d60			Average: d65			
			0.045	0.108	0.181	0.355	0.71	2		50 (%)	Sand bar	River bank	60 (%)	Sand bar	River bank	65 (%)	Sand bar	River bank	
Lower Reaches	S1	S1-RBL	10.80	58.31	71.60	76.71	83.88	97.24	100.00	0.10	1.39	0.12	0.11	1.67	0.14	0.11	1.81	0.15	1) Sample code: - RBL(or RBR) denotes the materials taken from left(or right) river bank. at about 0.3m below. - SB denotes the materials taken from sand bar on the river bed at about 0.3m below.
		S1-RBR	4.53	32.52	66.36	94.30	97.67	99.64	100.00	0.14			0.17			0.18			
		S1-SB	0.17	0.24	0.97	10.32	25.72	71.67	100.00	1.39			1.67			1.81			
	S2	S2-RBL	10.08	19.62	38.92	57.38	68.98	86.02	100.00	0.28	1.07	0.71	0.37	1.39	1.10	0.42	1.55	1.30	
		S2-RBR	5.35	12.23	21.06	33.71	43.72	62.41	100.00	1.14			1.83			2.18			
		S2-SB	2.48	5.54	9.36	19.37	38.63	79.35	100.00	1.07			1.39			1.55			
	S3	S3-RBL	3.49	8.16	12.44	22.38	36.57	73.03	100.00	1.19	1.17	0.76	1.54	1.54	1.00	1.72	1.72	1.12	
		S3-RBR	7.27	21.55	36.60	50.96	63.62	84.23	100.00	0.34			0.46			0.52			
		S3-SB	2.67	10.26	16.22	25.40	37.71	72.45	100.00	1.17			1.54			1.72			
El Delino (Rapids)	S4	S4-RBL	0.68	5.51	11.05	17.47	28.80	58.79	100.00	1.62	0.34	1.00	2.05	0.38	1.26	2.27	0.40	1.39	
		S4-RBR	1.51	8.58	20.95	46.07	85.59	94.20	100.00	0.39			0.48			0.52			
		S4-SB	0.60	3.23	9.41	52.37	77.13	85.59	100.00	0.34			0.38			0.40			
	S5	S5-RBL	2.68	12.50	16.45	25.64	38.97	63.41	100.00	1.29	0.40	0.87	1.82	0.55	1.24	2.08	0.63	1.43	
		S5-RBR	3.11	23.04	34.84	45.37	62.30	80.90	100.00	0.45			0.66			0.77			
		S5-SB	0.87	6.14	16.98	46.86	70.12	79.53	100.00	0.40			0.55			0.63			
Middle Reaches	S6	S6-RBL	0.34	6.18	10.73	17.42	27.14	54.68	100.00	1.78	0.95	1.05	2.25	1.24	1.33	2.48	1.38	1.47	
		S6-RBR	4.08	19.09	36.81	53.75	60.92	75.84	100.00	0.31			0.41			0.46			
		S6-SB	0.42	1.23	2.81	12.12	41.33	87.12	100.00	0.95			1.24			1.38			
	S7	S7-RBL	1.63	8.10	17.72	40.04	58.96	76.53	100.00	0.54	1.51	0.41	0.73	1.91	0.53	0.82	2.11	0.59	
		S7-RBR	3.71	17.69	30.07	62.28	71.73	84.43	100.00	0.29			0.34			0.36			
		S7-SB	0.51	3.41	6.69	15.50	29.73	62.27	100.00	1.51			1.91			2.11			
	S9	S9-RBL	1.44	11.34	21.39	40.20	54.92	75.09	100.00	0.59	1.60	0.51	0.83	1.96	0.69	0.96	2.14	0.78	
		S9-RBR	0.97	6.27	15.61	42.39	74.34	91.26	100.00	0.44			0.55			0.60			
		S9-SB	0.49	2.25	4.10	9.45	24.79	61.16	100.00	1.60			1.96			2.14			
Upper Tribu-taries	G1	G1-RBL	0.55	5.08	9.21	19.49	36.61	68.45	100.00	1.25	0.40	0.87	1.66	0.48	1.14	1.86	0.52	1.28	
		G1-RBR	6.06	10.18	17.07	40.62	65.55	83.57	100.00	0.49			0.63			0.70			
		G1-SB	0.61	2.49	8.67	44.31	89.38	92.94	100.00	0.40			0.48			0.52			
	C1	C1-RBL	0.89	6.94	12.36	18.66	27.26	48.73	100.00	>2.00	0.56	-	>2.00	0.67	-	>2.00	0.72	-	
		C1-RBR	1.43	6.77	16.10	30.05	47.35	75.19	100.00	0.83			1.30			1.53			
		C1-SB	0.63	2.75	8.25	29.46	63.87	76.59	100.00	0.56			0.67			0.72			
Ereguay quin River	U1	U1-RBL	5.03	12.42	34.43	51.28	67.39	86.03	100.00	0.34	0.75	0.34	0.44	1.57	0.43	0.49	1.98	0.47	
		U1-RBR	3.41	10.59	26.65	50.02	67.89	88.93	100.00	0.35			0.42			0.46			
		U1-SB	3.57	11.51	20.26	37.93	49.54	65.21	100.00	0.75			1.57			1.98			
	U2	U2-RBL	7.90	16.81	42.46	67.22	82.55	92.83	100.00	0.23	1.45	0.43	0.30	2.05	0.56	0.33	2.35	0.62	
		U2-RBR	3.82	9.84	17.28	35.37	54.52	80.80	100.00	0.63			0.81			0.91			
		U2-SB	0.56	2.45	6.50	21.64	37.53	59.18	100.00	1.45			2.05			2.35			
	U3	U3-RBL	2.11	10.06	42.04	55.71	68.52	85.32	100.00	0.28	0.66	0.42	0.40	0.81	0.58	0.46	0.88	0.66	
		U3-RBR	0.86	5.78	23.57	39.64	57.42	82.74	100.00	0.56			0.76			0.86			
		U3-SB	0.69	3.13	8.74	28.91	53.33	84.56	100.00	0.66			0.81			0.88			
	U4	U4-RBL	0.96	5.20	19.89	38.87	59.10	84.99	100.00	0.55	>2.00	0.55	0.73	>2.00	0.75	0.81	>2.00	0.85	
		U4-RBR	0.72	5.03	21.33	41.05	57.34	81.03	100.00	0.55			0.77			0.88			
		U4-SB	0.47	1.37	3.11	7.82	13.26	24.92	100.00	>2.00			>2.00			>2.00			
	U5	U5-RBL	3.23	11.94	34.49	50.51	65.49	87.79	100.00	0.34	1.29	0.34	0.45	1.64	0.43	0.50	1.82	0.47	
		U5-RBR	1.26	7.24	31.43	52.89	67.43	87.73	100.00	0.33			0.41			0.45			
		U5-SB	0.81	2.28	5.00	15.36	33.69	70.08	100.00	1.29			1.64			1.82			

Table M.4.1 CONCEPT OF CHANNEL IMPROVEMENT (MASTER PLAN)

Stretch			Concept of improvement for Master Plan
Code	From	To	
SAN MIGUEL RIVER			
L1-1	Santa Rita R. (SR21+0.20k)	End of farm land (SM1)	PL: Conservation of mangrove WK: None
L1-2	End of farm land (SM1)	Cerro El Encantado (SM7)	PL: Q10yr, DHWL>GH WK: Channel excavation, No dike.
L1-3	Cerro El Encantado (SM7)	Limon R. (SM13)	PL: Q10yr, DHWL>GH WK: Channel excavation, Dike
L2-1	Limon R. (SM13)	El Angel (SM24)	
L2-2	El Angel (SM24)	Ereguatquin R. (SM30-0.05k)	PL: Q10yr, DHWL>GH WK: Channel excavation, Dike(locally).
L3	Ereguatquin R. (SM30-0.05k)	Vado Marin Br. (SM58-0.02k)	
L4-1	Vado Marin Br. (SM58-0.02k)	Jocotal Drainage (SM64-0.03k)	PL: Q10yr, DHWL<GH, Realignment of river course WK: Channel excavation, Cut-off-channel, No dike,
L4-2	Jocotal Drainage (SM64-0.03k)	Brazo de S.M. (SM80-0.06k)	PL: Q10yr, DHWL>GH, Realignment of river course WK: Channel excavation, Cut-off-channel, No dike,
L4-3	Brazo de S.M. (SM80-0.06k)	Chilaguera R. (SM92-0.25k)	PL: Q10yr, DHWL<GH, Realignment of river course WK: Channel excavation, Cut-off-channel, No dike.
L4-4	Chilaguera R. (SM92-0.25k)	La Canoa (SM96)	
L4-5	La Canoa (SM96)	El Delirio (SM103)	PL: Existing capacity>Q10yr WK: None
M1	El Delirio (SM103)	Olomega Dr. (SM104+0.14k)	PL: Q10yr, DHWL<GH WK: Channel excavation, Cut-off-channel, No dike.
O1-1	Olomega D/SM (SM104+0.14k)	End of COC (OL1+0.80k)	
COC	End of COC (OL1+0.80k)	Start of COC/SM (SM113)	PL: Q10yr, DHWL<GH, Realignment of river course WK: Channel excavation, Cut-off-channel, No dike,
M2-2	Start of COC/SM (SM113)	Ground sill (SM117)	PL: Q10yr, DHWL<GH WK: Channel excavation, Cut-off-channel, No dike,
M2-3	Ground sill (SM117)	Pelota R. (SM119+0.09k)	PL: Q10yr, DHWL>GH WK: Channel excavation, Dike
M3	Pelota R. (SM119+0.09k)	L. Aramuaca (SM135)	
M4	L. Aramuaca (SM135)	Moscoso Br. (SM157)	PL: Q10yr, DHWL>GH WK: Channel excavation(locally), No dike
M5	Moscoso Br. (SM157)	Taisihuat R. (SM165+0.17k)	
M6-1	Taisihuat R. (SM165+0.17k)	Urbina Br. (SM170-0.06k)	
OLOMEGA DRANAGE			
O1-2	End of FW (OL1+0.80k)	Pelota R. (OL6+0.10k)	PL: Q10yr, DHWL<GH WK: Channel excavation, No dike
O2	Pelota R. (OL6+0.10k)	Olomega Outlet. (OL6+0.30k)	
Wo	Olomega Outlet. (OL6+0.30k)	Lake Olomega	
OLOMEGA DIVERSION CHANNEL			
Wi	Lake Olomega	Pelota R. (PL2+0.44k)	PL: Q10yr, DHWL>GH, Realignment of river course WK: Channel excavation, Dike
P2	Pelota R. (PL2+0.44k)	S.Miguel R. (SM120-0.26k)	

REMARKS:

1) PL: Concept of planning 2) WK: Concept of improvement works
3) Q10yr (or Q2yr): 10 year (or 2 year) probable discharge
4) Q'10yr: 10 year probable discharge with inundation upstream
5) Qex: Existing channel capacity
6) DHWL>GH (or DHWL<GH): Design high water level is higher than (or lower) than surrounding ground height.

Table M.4.2 DESIGN PROFILE AND SECTION (MASTER PLAN)

Location	Sta No	Stretch code	Distance(km) dX	Distance(km) X	Elevation(m,MSL) R Bed	Elevation(m,MSL) DHWL	Elevation(m,MSL) D.dike	Slope 1/I R bed	Slope 1/I DHWL	Width(m) b0	Width(m) b1	Width(m) b2	Width(m) B	Depth(m) H	Depth(m) h1	Qd (m^3/s)
LOWER REACHES																
River mouth	SR0	-	-	0.00	-	-	-	-	-	-	-	-	-	-	-	-
Santa Rita R	SR21+0.20k		10.00	10.00	-0.50	4.00	-	1,249	1,249	64	0	50	135	4.50	2.96	
End of farm land	SM1	L1-1	0.86	10.86	0.19	4.69		1,249	1,249	64	0	50	135	4.50	2.96	970
End of farm land	SM1		0.00	10.86	0.19	4.69	5.89	1,249	1,249	64	0	50	135	4.50	2.96	
Cerro El Encantado	SM7	L1-2	2.65	13.51	2.31	6.81	8.01	1,249	1,249	64	0	50	135	4.50	2.96	970
Cerro El Encantado	SM7		0.00	13.51	2.31	6.81	8.01	1,249	1,249	64	0	50	135	4.50	2.70	
Limon R	SM13	L1-3	3.36	16.87	5.00	9.50	10.70	1,249	1,249	64	0	50	135	4.50	2.70	970
Limon R	SM13		0.00	16.87	5.00	9.50	10.70	1,228	1,025	62	0	50	130	4.50	1.93	
Freguatquin R	SM30+0.05k	L2	9.33	26.20	12.60	18.60	19.80	1,228	1,025	62	6	44	140	6.00	3.00	970
Freguatquin R	SM30+0.05k		0.00	26.20	12.60	18.60	19.80	2,872	2,872	56	6	44	130	6.00	3.00	
Vado Marin Br (old	SM58	L3	15.51	41.71	18.00	24.00	25.20	2,872	2,872	56	6	44	130	6.00	3.00	830
Vado Marin Br (old	SM58		0.00	41.71	18.00	24.00	25.20	2,932	2,932	56	6	44	130	6.00	3.00	
Jocotal Drainage	SM63	L4-1	2.17	43.88	18.74	24.74		2,932	2,932	56	6	44	130	6.00	3.00	750
Jocotal Drainage	SM63		0.00	43.88	18.74	24.74	-	2,788	2,788	56	20	30	130	6.00	3.00	
Brazo de S M	SM79+0.15k	L4-2	6.30	50.18	21.00	27.00	-	2,788	2,788	56	20	30	130	6.00	3.00	890
Brazo de S M	SM79+0.15k		0.00	50.18	21.80	27.00	-	1,457	1,457	56	20	30	130	5.20	2.20	
Chilanguera R	SM91+0.32k	L4-3	4.37	54.55	24.80	30.00	-	1,457	1,457	56	20	30	130	5.20	2.20	890
Chilanguera R	SM91+0.32k		0.00	54.55	25.70	30.00	-	968	968	56	20	30	125	4.30	1.30	
La Canoa	SM95+0.38k	L4-4	2.42	56.97	28.20	32.50	-	968	968	56	20	30	125	4.30	1.30	770
La Canoa	SM95+0.38k		0.00	56.97				-	-		-	-		-	-	-
El Delirio	SM103	L4-5	6.74	61.29				-	-		-	-		-	-	-
MIDDLE REACHES																
El Delirio	SM103		0.00	61.29	56.07	61.07		1,637	1,637	53	20	30	125	5.00	2.00	
Olomega Dr./S M R	SM104+0.14k	M1	0.71	62.00	56.50	61.50		1,637	1,637	53	20	30	125	5.00	2.00	770
Olomega Dr./S M R	SM104+0.14k		0.00	62.00	56.50	61.50		1,637	1,637	52	20	30	125	5.00	2.00	
End of COC	OL1+0.80k	O1-1	0.85	62.85	57.02	62.02		1,637	1,637	52	20	30	125	5.00	2.00	760
End of COC	OL1+0.80k		0.00	62.85	57.02	62.02		1,637	1,637	52	20	30	125	5.00	2.00	
Start of COC/G sill	SM113	COC	2.10	64.95	58.30	63.30		1,637	1,637	52	20	30	125	5.00	2.00	760
Start of COC/G sill	SM113		0.00	64.95	59.30	65.30		1,637	1,637	29	6	44	105	6.00	3.00	
WL drop	SM117	M2-2	2.39	67.34	60.76	66.76		1,637	1,637	29	6	44	105	6.00	3.00	660
WL drop	SM117		0.00	67.34	61.75	68.75	69.95	1,637	1,637	16	6	44	95	7.00	4.00	
Pelota R	SM120-0.26k	M2-3	2.05	69.39	63.00	70.00	71.20	1,637	1,637	16	6	44	95	7.00	4.00	660
Pelota R	SM120-0.26k		0.00	69.39	63.00	70.00	71.20	1,637	1,637	40	6	44	120	7.00	4.00	
L. Aramuaca	SM135	M3	10.47	79.86	69.40	76.40	77.60	1,637	1,637	40	6	44	120	7.00	4.00	1,150
L. Aramuaca	SM135		0.00	79.86	69.40	76.40		1,637	1,637	40	6	44	120	7.00	4.00	
Moscoso Br.	SM157	M4	13.10	92.96	77.40	84.40		1,637	1,637	40	6	44	120	7.00	4.00	1,150
Moscoso Br.	SM157		0.00	92.96	77.40	84.40		1,440	1,440	32	6	44	110	7.00	4.00	
Taisihuat R.	SM165+0.17k	M5	4.25	97.21	80.35	87.35		1,440	1,440	32	6	44	110	7.00	4.00	1,050
Taisihuat R	SM165+0.17k		0.00	97.21	80.35	89.85		1,440	2,124	7	6	44	95	9.50	6.50	
Urbina Br.	SM170-0.06k	M6-1	2.23	99.44	81.90	90.90		1,440	2,124	12	6	44	100	9.00	6.00	960
OLOMEGA DRAINAGE CHANNEL																
End of Drainage	OL1+0.80k		0.00	0.00	59.02	62.02	-	1,657	1,657	29	0	50	95	3.00	0.01	
Olomega Outlet	OL6+0.10k	O1-2	4.11	4.11	61.50	64.50	-	1,657	1,657	29	0	50	95	3.00	0.01	150
Olomega Outlet	Wo+0k		0.00	4.11	63.50	65.50	-	0	0	200	0	0	210	2.00	0.00	
Wo+0.95k	Wo+0.95k	Wo	1.15	5.26	63.50	65.50	-	0	0	200	0	0	210	2.00	0.00	
DIVERSION CHANNEL																
Wi-1.10k	Wi-1.10k		0.00	-4.31	63.50	65.50	66.70	-	2,140	62	0	0	75	2.00	0.00	
Wi+0/PL2+0.44k	Wi-0.00k	Wi	1.10	-3.21	63.50	65.50	66.70	0	2,140	62	0	0	75	2.00	0.00	
Wi+0/PL2+0.44k	PL2+0.44k		0.00	-3.21	63.50	67.50	68.70	6,420	2,140	62	0	30	105	4.00	1.29	
San Miguel R	SM120-0.26k	P2	3.21	0.00	64.00	69.00	70.20	6,420	2,140	38	6	44	105	5.00	2.00	520

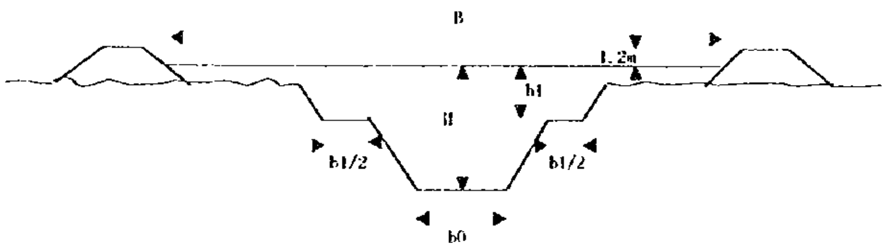


Table M.4.3 QUANTITY OF WORKS FOR MASTER PLAN(1/2)

From Location	From Station	To Location	To Station	Stretch code	Length dX(km)	Excavation (m^3)	Embank-ment(m^3)	Land ($1,000m^2$)	House (nos)
LOWER REACHES									
River mouth	SR0	Santa Rita R.	SR21+0.20k		10.00				
Santa Rita R.	SR21+0.20k	End of farm land	SM1	L1-1	0.86	0	0	0	0
End of farm land	SM1	Cerro El Encantado	SM7	L1-2	2.65	241,900	0	299	1
Cerro El Encantado	SM7	Limon R.	SM13	L1-3	3.36	240,900	381,900	429	0
Limon R.	SM13	Ereguatquin R.	SM30+0.05k	L2	9.33	743,000	469,300	845	3
Ereguatquin R.	SM30+0.05k	Vado Marin Br.(old)	SM58	L3	15.51	2,739,100	325,000	1,067	11
Vado Marin Br.(old)	SM58	Jocotal Drainage	SM63	L4-1	2.17	1,212,400	0	191	0
Jocotal Drainage	SM63	Brazo de S.M.	SM79+0.15k	L4-2	6.30	2,417,400	0	711	0
Brazo de S.M.	SM79+0.15k	Chilanguera R.	SM91+0.32k	L4-3	4.37	1,834,900	0	526	0
Chilanguera R.	SM91+0.32k	La Canoa	SM95+0.38k	L4-4	2.42	801,500	0	267	0
La Canoa	SM95+0.38k	El Delirio	SM103	L4-5	6.74	0	0	0	0
				Sub-total	63.71	10,231,100	1,176,200	4,335	15
MIDDLE REACHES									
El Delirio	SM103	Olomega D./S.M.R.	SM104+0.14k	M1	0.71	329,300	0	62	0
Olomega D./S.M.R.	SM104+0.14k	Start of COC/G.Sill	SM113	M2-1	5.36	0	0	0	0
Olomega D./S.M.R.	SM104+0.14k	End of COC	OL1+0.80k	O1-1	0.85	164,100	0	96	0
End of COC	OL1+0.80k	Start of COC/G.Sill	SM113	COC	2.10	722,400	0	289	0
Start of COC/G.Sill	SM113	WL drop	SM117	M2-2	2.39	315,400	0	184	0
WL drop	SM117	Pelota R.	SM120-0.26k	M2-3	2.05	216,700	103,400	171	0
Pelota R.	SM120-0.26k	L. Aramuaca	SM135	M3	10.47	775,000	427,400	654	3
L. Aramuaca	SM135	Moscoso Br.	SM157	M4	13.10	754,900	0	757	0
Moscoso Br.	SM157	Taisihuat R.	SM165+0.17k	M5	4.25	73,800	0	214	0
Taisihuat R.	SM165+0.17k	Urbina Br.	SM170-0.06k	M6-1	2.23	5,600	0	56	0
				Sub-total	43.51	3,357,200	530,800	2,483	3
OLOMEGA DRAINAGE									
End of Drainage	OL1+0.80k	Pelota R.	OL6+0.10k	O1-2	4.11	468,700	0	351	0
Pelota R.	OL6+0.10k	Olomega Outlet	OL6+0.30k	O2	0.20	91,700	0	18	0
Olomega Outlet	OL6+0.30k	Lake Olomega	Wo+0.95k	Wo	0.95	30,400	0	50	0
				Sub-total	5.26	590,800	0	419	0
OLOMEGA DIVERSION CHANNEL									
Olomega D.	OL6+0.10k	Diversion weir	PL2+0.44k	P1	1.53	0	0	0	0
Diversion weir	Wi+0/PL2+0.4	San Miguel R.	SM120-0.26k	P2	3.21	688,900	98,600	126	0
Lake Olomega	Wi-1.10k	Wi+0/PL2+0.44k	Wi-0.00k	Wi	1.10	88,000	37,600	423	2
				Sub-total	5.84	776,900	136,200	549	2
				Grand total	118.32	14,956,000	1,843,200	7,786	20

Table M.4.3 QUANTITY OF WORKS FOR MASTER PLAN(2/2)

Stretch	Revetment			Drainade sluice			Ground sill and gate			Road and bridge		
code	Code	L(m)	Remarks	Code	Da(km²)	Type	Code	Drop(m)	Wid (m)	Facility	Leng (m	Works
L1-1												
L1-2	Rs1	300	Left	S1	2.0	B				Left road	840	Relocation
				S2	2.5	B						
L1-3				S3	4.5	C				Left road	350	Relocation
										Right road	550	Relocation
L2	Rs2	300	Right	S4	0.5	A				Left road	2,150	Relocation
	Rs3	300	Right	S5	2.5	B				Right road	200	Relocation
				S6	0.5	A						
				S7	2.5	B						
				S8	1.0	A						
L3				S9	1.0	A				Moropara br.	86	Reconstruction
				S10	1.0	A						
				S11	1.5	B						
				S12	1.0	A						
				S13	3.0	C						
				S14	1.0	A						
L4-1	Rs4	200	Right							Vado Marin br	86	Reconstruction
L4-2	Rs5	200	Right				G1	0.8	100			
	Rs6	200	Left									
	Rs7	200	Right									
	Rs8	200	Left									
	Rs9	200	Left									
	Rs10	200	Right									
	Rs11	200	Right									
L4-3	Rs12	200	Left				G2	0.9	97			
	Rs13	200	Right									
L4-4	Rs14	200	Right									
	Rs15	200	Left									
	Rs16	200	Right									
	Rs17	200	Left									
L4-5												
M1												
O1-1												
COC	Rs18	300	Left				G3	1	92	COC bridge	90	New
	Rs19	300	Right									
	Rs20	300	Right									
M2-2	Rs21	200	Right				G4	0.99	59			
M2-3							Intake gate					
M3				S16	1.5	B						
M4												
M5												
M6-1												
O1-2	Ro1	200	Right							Drain ch. bridge	40	New
	Ro2	200	Left							Left road	200	Relocation
	Ro3	200	Right							Right road	450	Relocation
O2							Control gate					
P2	Rp1	200	Left				Diversion weir			Div.ch. bridge	105	New
	Rp2	200	Left							Right road	400	Relocation
	Rp3	200	Right									
Total		**6,000**	**m**		**15 places**		**Ground sill: 348 m**			**Bridge: 5 bridges**		
							Gate,weir: 3 places			**Rural road: 5,140 m**		

(Remarks)

1) L: Length of revetment works
3) Da: Approximate drainage area of sluice
4) Wid. of ground sill: Surface width of channel at DHWL

2) Type of sluice:
A: (width)1.25m x (height)1.25m
B: (width)1.75m x (height)1.75m
C: (width)2.50m x (height)2.50m

Table M.4.4 PROJECT COST FOR MASTER PLAN

Items	Unit		Quantity	Amount(million colons)		
	Unit	Cost(Col.)		Total	L.C.	F.C.
1. Construction works						
1.1 Channel works				705.1	306.2	398.9
Earth excavation(1)	m^3	45	8,087,000	363.9	149.2	214.7
Earth excavation(2)	m^3	20	6,266,000	125.3	51.4	73.9
Rock excavation	m^3	173	603,000	104.3	42.8	61.5
Embankment	m^3	42	1,843,000	77.4	31.7	45.7
Revetment	m	5,700	6,000	34.2	31.1	3.1
1.2 Structure works				34.7	25.6	9.1
Diversion weir	l.s.			10.9	9.4	1.5
Control gate	l.s.			9.4	5.8	3.6
Drainage sluice				8.0	5.0	3.0
Type-A	nos	426,000	7	3.0	1.9	1.1
Type-B	nos	586,000	6	3.5	2.2	1.3
Type-C	nos	754,000	2	1.5	0.9	0.6
Ground sill	m	18,300	348	6.4	5.4	1.0
1.3 Appurtenant works				67.7	37.5	30.2
Intake gate(Type-B)	nos	586,000	1	0.6	0.4	0.2
Bridge				58.2	30.3	27.9
Bridge(105m)	nos	13,400,000	1	13.4	7.0	6.4
Bridge(90m)	nos	12,600,000	3	37.8	19.7	18.1
Bridge(40m)	nos	7,000,000	1	7.0	3.6	3.4
Rural road	m	160	5,140	0.8	0.8	0.0
Telemetering system	l.s.			8.1	6.1	2.0
(Sub-total : 1.1+1.2+1.3)				807.5	369.3	438.2
2. Land and house				23.8	23.8	0.0
Land acquisit.(1)	10^3m^2	2,150	728	1.6	1.6	0.0
Land acquisit.(2)	10^3m^2	5,720	845	4.8	4.8	0.0
Land acquisit.(3)	10^3m^2	2,570	1,067	2.7	2.7	0.0
Land acquisit.(4)	10^3m^2	720	1,695	1.2	1.2	0.0
Land acquisit.(5)	10^3m^2	3,580	3,181	11.4	11.4	0.0
Land acquisit.(6)	10^3m^2	7,150	270	1.9	1.9	0.0
House compensat.	house	12,000	20	0.2	0.2	0.0
3. Administration	l.s.	-		41.6	41.6	0.0
4. Engineering service	l.s.	-		124.7	46.1	78.6
5. Physical contingency	l.s.	-		99.8	48.1	51.7
Total (1+2+3+4+5)				1,097.4	528.9	568.5

Note: The above costs are presented on the fixed price basis as of Dec.,1996 and price contingency is not included.

Table M.5.1 CONCEPT OF CHANNEL IMPROVEMENT

Stretch			Concept of improvement	
Code	From	To	Master Plan	Priority Project
SAN MIGUEL RIVER				
L1-1	Santa Rita R. (SR21+0.20k)	End of farm land (SM1)	PL: Conservation of mangrove WK: None	PL: Conservation of mangrove WK: None
L1-2	End of farm land (SM1)	Cerro El Encantado (SM7)	PL: Q10yr, DHWL>GH WK: Ch.ex, No dike,	PL: Q'10yr, DHWL>GH WK: Ch.ex. No dike,
L1-3	Cerro El Encantado (SM7)	Limon R. (SM13)	PL: Q10yr, DHWL>GH WK: Ch.ex. Dike	PL: Q'10yr, DHWL>GH WK: Ch.ex, Dike(Right only).
L2-1	Limon R. (SM13)	El Angel (SM24)		
L2-2	El Angel (SM24)	Freguatquin R. (SM30-0.05k)	PL: Q10yr, DHWL>GH WK: Ch.ex, Dike(locally),	PL: Qex>Q2yr WK: None
L3	Freguatquin R. (SM30-0.05k)	Vado Marin Br. (SM58-0.02k)		PL: Q2yr, DHWL>GH WK: Ch.ex(locally), No dike
L4-1	Vado Marin Br. (SM58-0.02k)	Jocotal Drainage (SM64-0.03k)	PL: Q10yr, DHWL<GH, Realign WK: Ch.ex, COC, No dike,	PL: Q2yr, DHWL<GH, Realign WK: Ch.ex, COC, No dike,
L4-2	Jocotal Drainage (SM64-0.03k)	Brazo de S.M. (SM80-0.06k)	PL: Q10yr, DHWL>GH, Realign WK: Ch.ex, COC, No dike,	PL: Q2yr, DHWL>GH, Realign WK: Ch.ex, COC, No dike,
L4-3	Brazo de S.M. (SM80-0.06k)	Chilaguera R. (SM92-0.25k)	PL: Q10yr, DHWL<GH, Realign WK: Ch.ex, COC, No dike,	PL: Q2yr, DHWL<GH, Realign WK: Ch.ex, COC, No dike,
L4-4	Chilaguera R. (SM92-0.25k)	La Canoa (SM96)		
L4-5	La Canoa (SM96)	El Delirio (SM103)	PL: Qex>Q10yr WK: None	PL: Qex>Q2yr WK: None
M1	El Delirio (SM103)	Olomega Dr. (SM104+0.14k)	PL: Q10yr, DHWL<GH WK: Ch.ex, COC, No dike,	PL: Q2yr, DHWL<GH WK: Ch.ex, COC, No dike,
O1-1	Olomega D/SM (SM104+0.14k)	End of COC (OL1+0.80k)		
COC	End of COC (OL1+0.80k)	Start of COC/SM (SM113)	PL: Q10yr, DHWL<GH, Realign WK: Ch.ex, COC, No dike,	PL: Q2yr, DHWL<GH, Realign WK: Ch.ex, COC, No dike,
M2-2	Start of COC/SM (SM113)	Ground sill (SM117)	PL: Q10yr, DHWL<GH WK: Ch.ex, COC, No dike,	PL: Q2yr, DHWL<GH WK: Ch.ex, COC, No dike,
M2-3	Ground sill (SM117)	Pelota R. (SM119+0.09k)	PL: Q10yr, DHWL>GH WK: Ch.ex, Dike	PL: Q'10yr, DHWL>GH WK: Ch.ex, Dike
M3	Pelota R. (SM119+0.09k)	L. Aramuaca (SM135)		
M4	L. Aramuaca (SM135)	Moscoso Br. (SM157)	PL: Q10yr, DHWL>GH WK: Ch.ex(locally), No dike	PL: Qex>Q2yr WK: None
M5	Moscoso Br. (SM157)	Taisihuat R. (SM165+0.17k)		
M6-1	Taisihuat R. (SM165+0.17k)	Urbina Br. (SM170-0.06k)		
OLOMEGA DRANAGE				
O1-2	End of FW (OL1+0.80k)	Pelota R. (OL6+0.10k)	PL: Q10yr, DHWL<GH WK: Ch.ex, No dike	PL: Q'10yr, DHWL<GH WK: Ch.ex, No dike
O2	Pelota R. (OL6+0.10k)	Olomega Outlet. (OL6+0.30k)		
Wo	Olomega Outlet. (OL6+0.30k)	Lake Olomega		
OLOMEGA DIVERSION CHANNEL				
Wi	Lake Olomega	Pelota R. (PL2+0.44k)	PL: Q10yr, DHWL>GH, Realign WK: Ch.ex, Dike	PL: Q'10yr, DHWL>GH, Realign WK: Ch.ex, Dike
P2	Pelota R. (PL2+0.44k)	S.Miguel R. (SM120-0.26k)		

REMARKS:

1) PL: Concept of planning
2) WK: Concept of improvement works
3) Q10yr (or Q2yr): 10 year (or 2 year) probable discharge
4) Q'10yr: 10 year probable discharge with inundation upstream
5) Qex: Existing channel capacity
6) DHWL>GH (or DHWL<GH): Design high water level is higher than (or lower) than surrounding ground height.
7) Ch.ex: Channel excavation
8) Realign: Realignment of river course
9) COC: Cut-off channel

Table M.5.2 DESIGN PROFILE AND SECTION (PRIORITY PROJECT)

Location	Sta No	Stretch	Distance(km)		Elevation(m,MSL)			Slope:1/I		Width(m)				Depth(m)		Qd
		code	dX	X	R Bed	DHWL	D.dike	R bed	DHWL	b0	b1	b2	B	H	h1	(m³/s)
LOWER REACHES																
River mouth	SR0	-	-	0.00	-	-	-	-	-	-	-	-	-	-	-	-
Santa Rita R	SR21+0.20k		10.00	10.00	-0.50	4.00	-	1,249	1,249	39	0	50	135	4.50	2.96	
End of farm land	SM1	L1-1	0.86	10.86	0.19	4.69		1,249	1,249	39	0	50	135	4.50	2.96	690
End of farm land	SM1		0.00	10.86	0.19	4.69	5.89	1,249	1,249	39	0	50	135	4.50	2.96	
Cerro El Encantado	SM7	L1-2	2.65	13.51	2.31	6.81	8.01	1,249	1,249	39	0	50	135	4.50	2.96	690
Cerro El Encantado	SM7		0.00	13.51	2.31	6.81	8.01	1,249	1,249	39	0	50	135	4.50	2.70	
Limon R	SM13	L1-3	3.36	16.87	5.00	9.50	10.70	1,249	1,249	39	0	50	135	4.50	2.70	690
Limon R	SM13		0.00	16.87	5.00	9.50	10.70	1,228	1,025	39	0	50	130	4.50	1.93	
Freguatquin R.	SM30+0.05k	L2	9.33	26.20	12.60	18.60	19.80	1,228	1,025	39	6	44	140	6.00	3.00	690
Freguatquin R	SM30+0.05k		0.00	26.20	12.60	18.60	19.80	2,872	2,872	29	6	44	130	6.00	3.00	
Vado Marin Br (old	SM58	L3	15.51	41.71	18.00	24.00	25.20	2,872	2,872	29	6	44	130	6.00	3.00	450
Vado Marin Br (old	SM58		0.00	41.71	18.00	24.00	25.20	2,932	2,932	29	6	44	130	6.00	3.00	
Jocotal Drainage	SM63	L4-1	2.17	43.88	18.74	24.74		2,932	2,932	29	6	44	130	6.00	3.00	390
Jocotal Drainage	SM63		0.00	43.88	18.74	24.74	-	2,788	2,788	29	6	44	130	6.00	3.00	
Brazo de S M	SM79+0.15k	L4-2	6.30	50.18	21.00	27.00	-	2,788	2,788	29	6	44	130	6.00	3.00	480
Brazo de S.M	SM79+0.15k		0.00	50.18	21.80	27.00	-	1,457	1,457	29	6	44	130	5.20	2.20	
Chilanguera R.	SM91+0.32k	L4-3	4.37	54.55	24.80	30.00	-	1,457	1,457	29	6	44	130	5.20	2.20	480
Chilanguera R.	SM91+0.32k		0.00	54.55	25.70	30.00	-	968	968	29	6	44	125	4.30	1.30	
La Canoa	SM95+0.38k	L4-4	2.42	56.97	28.20	32.50	-	968	968	29	6	44	125	4.30	1.30	422
La Canoa	SM95+0.38k		0.00	56.97				-	-		-	-		-	-	-
El Delirio	SM103	L4-5	6.74	61.29				-	-		-	-		-	-	-
MIDDLE REACHES																
El Delirio	SM103		0.00	61.29	56.07	61.07		1,637	1,637	27	6	44	125	5.00	2.00	
Olomega Dr./S.M.R	SM104+0.14k	M1	0.71	62.00	56.50	61.50		1,637	1,637	27	6	44	125	5.00	2.00	420
Olomega Dr./S M R	SM104+0.14k		0.00	62.00	56.50	61.50		1,637	1,637	27	6	44	125	5.00	2.00	
End of COC	OL1+0.80k	O1-1	0.85	62.85	57.02	62.02		1,637	1,637	27	6	44	125	5.00	2.00	420
End of COC	OL1+0.80k		0.00	62.85	57.02	62.02		1,637	1,637	27	6	44	125	5.00	2.00	
Start of COC/G sill	SM113	COC	2.10	64.95	58.30	63.30		1,637	1,637	27	6	44	125	5.00	2.00	420
Start of COC/G sill	SM113		0.00	64.95	59.30	65.30		1,637	1,637	16	6	44	105	6.00	3.00	
WL drop	SM117	M2-2	2.39	67.34	60.76	66.76		1,637	1,637	16	6	44	105	6.00	3.00	370
WL drop	SM117		0.00	67.34	61.75	68.75	69.95	1,637	1,637	16	6	44	95	7.00	4.00	
Pelota R	SM120-0.26k	M2-3	2.05	69.39	63.00	70.00	71.20	1,637	1,637	16	6	44	95	7.00	4.00	660
Pelota R	SM120-0.26k		0.00	69.39	63.00	70.00	71.20	1,637	1,637	40	6	44	120	7.00	4.00	
L. Aramuaca	SM135	M3	10.47	79.86	69.40	76.40	77.60	1,637	1,637	40	6	44	120	7.00	4.00	1,150
L. Aramuaca	SM135		0.00	79.86	69.40	76.40		1,637	1,637	40	6	44	120	7.00	4.00	
Moscoso Br.	SM157	M4	13.10	92.96	77.40	84.40		1,637	1,637	40	6	44	120	7.00	4.00	1,150
Moscoso Br.	SM157		0.00	92.96	77.40	84.40		1,440	1,440	32	6	44	110	7.00	4.00	
Taisihuat R.	SM165+0.17k	M5	4.25	97.21	80.35	87.35		1,440	1,440	32	6	44	110	7.00	4.00	1,050
Taisihuat R.	SM165+0.17k		0.00	97.21	80.35	89.85		1,440	2,124	7	6	44	95	9.50	6.50	
Urbina Br.	SM170-0.06k	M6-1	2.23	99.44	81.90	90.90		1,440	2,124	12	6	44	100	9.00	6.00	960
OLOMEGA DRAINAGE CHANNEL																
End of Drainage	OL1+0.80k		0.00	0.00	59.02	62.02	-	1,657	1,657	29	0	50	95	3.00	0.01	
Olomega Outlet	OL6+0.10k	O1-2	4.11	4.11	61.50	64.50	-	1,657	1,657	29	0	50	95	3.00	0.01	150
Olomega Outlet	Wo+0k		0.00	4.11	63.50	65.50	-	0	0	200	0	0	210	2.00	0.00	
Wo+0.95k	Wo+0.95k	Wo	0.95	5.06	63.50	65.50	-	0	0	200	0	0	210	2.00	0.00	
DIVERSION CHANNEL																
Wi-1.10k	Wi-1.10k		0.00	-4.31	63.50	65.50	66.70	-	2,140	62	0	0	75	2.00	0.00	
Wi+0/PL2+0.44k	Wi-0.00k	Wi	1.10	-3.21	63.50	65.50	66.70	0	2,140	62	0	0	75	2.00	0.00	
Wi+0/PL2+0.44k	PL2+0.44k		0.00	-3.21	63.50	67.50	68.70	6,420	2,140	62	0	30	105	4.00	1.29	
San Miguel R	SM120-0.26k	P2	3.21	0.00	64.00	69.00	70.20	6,420	2,140	38	6	44	105	5.00	2.00	520

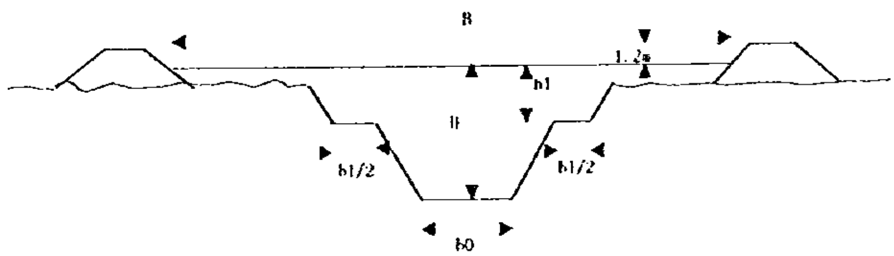


Table M.5.3 QUANTITY OF WORKS FOR PRIORITY PROJECT(1/2)

From		To		Stretch	Length	Excavation	Embank-	Land	House
Location	Station	Location	Station	code	dX(km)	(m^3)	ment(m^3)	($1,000m^2$)	(nos)
LOWER REACHES									
River mouth	SR0	Santa Rita R.	SR21+0.20k		10.00				
Santa Rita R.	SR21+0.20k	End of farm land	SM1	L1-1	0.86	0	0	0	0
End of farm land	SM1	Cerro El Encantado	SM7	L1-2	2.65	146,900	0	299	1
Cerro El Encantado	SM7	Limon R.	SM13	L1-3	3.36	77,600	239,300	429	0
Limon R.	SM13	Ereguatquin R.	SM30+0.05k	L2	9.33	207,300	266,200	845	3
Ereguatquin R.	SM30+0.05k	Vado Marin Br.(old)	SM58	L3	15.51	213,000	0	1,067	11
Vado Marin Br.(old)	SM58	Jocotal Drainage	SM63	L4-1	2.17	824,100	0	191	0
Jocotal Drainage	SM63	Brazo de S.M.	SM79+0.15k	L4-2	6.30	1,597,600	0	711	0
Brazo de S.M.	SM79+0.15k	Chilanguera R.	SM91+0.32k	L4-3	4.37	1,220,900	0	526	0
Chilanguera R.	SM91+0.32k	La Canoa	SM95+0.38k	L4-4	2.42	263,100	0	267	0
La Canoa	SM95+0.38k	El Delirio	SM103	L4-5	6.74	0	0	0	0
				Sub-total	63.71	4,550,500	505,500	4,335	15
MIDDLE REACHES									
El Delirio	SM103	Olomega D./S.M.R.	SM104+0.14k	M1	0.71	80,800	0	62	0
Olomega D./S.M.R.	SM104+0.14k	Start of COC/G.Sill	SM113	M2-1	5.36	0	0	0	0
Olomega D./S.M.R.	SM104+0.14k	End of COC	OL1+0.80k	O1-1	0.85	167,900	0	96	0
End of COC	OL1+0.80k	Start of COC/G.Sill	SM113	COC	2.10	556,500	0	289	0
Start of COC/G.Sill	SM113	WL drop	SM117	M2-2	2.39	320,100	0	184	0
WL drop	SM117	Pelota R.	SM120-0.26k	M2-3	2.05	216,700	103,400	171	0
Pelota R.	SM120-0.26k	L. Aramuaca	SM135	M3	10.47	775,000	427,400	654	3
L. Aramuaca	SM135	Moscoso Br.	SM157	M4	13.10	0	0	0	0
Moscoso Br.	SM157	Taisihuat R.	SM165+0.17k	M5	4.25	0	0	0	0
Taisihuat R.	SM165+0.17k	Urbina Br.	SM170-0.06k	M6-1	2.23	0	0	0	0
				Sub-total	43.51	2,117,000	530,800	1,456	3
OLOMEGA DRAINAGE									
End of Drainage	OL1+0.80k	Pelota R.	OL6+0.10k	O1-2	4.11	468,700	0	351	0
Pelota R.	OL6+0.10k	Olomega Outlet	OL6+0.30k	O2	0.20	91,700	0	18	0
Olomega Outlet	OL6+0.30k	Lake Olomega	Wo+0.95k	Wo	0.95	30,400	0	50	0
				Sub-total	5.26	590,800	0	419	0
OLOMEGA DIVERSION CHANNEL									
Olomega D.	OL6+0.10k	Diversion weir	PL2+0.44k	P1	1.53	0	0	0	0
Diversion weir	Wi+0/PL2+0.4	San Miguel R.	SM120-0.26k	P2	3.21	688,900	98,600	126	0
Lake Olomega	Wi-1.10k	Wi+0/PL2+0.44k	Wi-0.00k	Wi	1.10	88,000	37,600	423	2
				Sub-total	5.84	776,900	136,200	549	2
				Grand total	**118.32**	**8,035,200**	**1,172,500**	**6,759**	**20**

Table M.5.3 QUANTITY OF WORKS FOR PRIORITY PROJECT(2/2)

Stretch code	Revetment			Drainade sluice			Ground sill and gate			Road and bridge		
	Code	L(m)	Remarks	Code	Da(km²)	Type	Code	Drop(m)	Wid (m)	Facility	Leng (m)	Works
L1-1										Left road	840	Relocation
L1-2	Rs1	300	Left									
L1-3										Right road	550	Relocation
L2	Rs2	300	Right									
	Rs3	300	Right							Right road	200	Relocation
L3												
L4-1	Rs4	200	Right									
L4-2	Rs5	200	Right				G1	0.80	59			
	Rs6	200	Left									
	Rs7	200	Right									
	Rs8	200	Left									
	Rs9	200	Left									
	Rs10	200	Right									
	Rs11	200	Right									
L4-3	Rs12	200	Left				G2	0.90	56			
	Rs13	200	Right									
L4-4	Rs14	200	Right									
	Rs15	200	Left									
	Rs16	200	Right									
	Rs17	200	Left									
L4-5												
M1												
O1-1												
COC	Rs18	300	Left				G3	1.00	57	COC bridge	90	New
	Rs19	300	Right									
	Rs20	300	Right									
M2-2	Rs21	200	Right				G4	0.99	57			
M2-3							Intake gate					
M3				S16	1.5	B						
M4												
M5												
M6												
O1-2	Ro1	200	Right							Drain ch. bridge	40	New
	Ro2	200	Left							Left road	200	Relocation
	Ro3	200	Right							Right road	450	Relocation
O2							Control gate					
P2	Rp1	200	Left				Diversion weir			Div.ch bridge	105	New
	Rp2	200	Left							Right road	400	Relocation
	Rp3	200	Right									
Total		6,000 m			1 places		Ground sill: 229 m Gate,weir: 3 places			Bridge: 3 bridges Rural road: 2,640 m		

(Remarks)

1) L: Length of revetment works
2) Type of sluice:
   A: (width)1 25m x (height)1 25m
   B: (width)1 75m x (height)1.75m
   C: (width)2 50m x (height)2 50m
3) Da: Approximate drainage area of sluice
4) Wid of ground sill: Surface width of channel at DHWL

Table M.5.4 PROJECT COST

Items	Unit		Master Plan Project				Priority Project			
	Unit		Quantity	Amount(¢ 10^6)			Quantity	Amount(¢ 10^6)		
	Unit	Cost(Col.)		Total	L.C.	F.C.		Total	L.C.	F.C.
1. Construction works										
1.1 Channel works				705.1	306.2	398.9		366.9	167.5	199.4
Earth excavation(1)	m^3	45	8,087,000	363.9	149.2	214.7	3,977,000	179.0	73.4	105.6
Earth excavation(2)	m^3	20	6,266,000	125.3	51.4	73.9	3,906,000	78.1	32.0	46.1
Rock excavation	m^3	173	603,000	104.3	42.8	61.5	152,000	26.3	10.8	15.5
Embankment	m^3	42	1,843,000	77.4	31.7	45.7	1,173,000	49.3	20.2	29.1
Revetment	m	5,700	6,000	34.2	31.1	3.1	6,000	34.2	31.1	3.1
1.2 Structure works				34.7	25.6	9.1		24.7	18.8	5.9
Diversion weir	l.s.			10.9	9.4	1.5		10.5	9.0	1.5
Control gate	l.s.			9.4	5.8	3.6		9.4	5.8	3.6
Drainage sluice				8.0	5.0	3.0		0.6	0.4	0.2
Type-A	nos	426,000	7	3.0	1.9	1.1	0	0.0	0.0	0.0
Type-B	nos	586,000	6	3.5	2.2	1.3	1	0.6	0.4	0.2
Type-C	nos	754,000	2	1.5	0.9	0.6	0	0.0	0.0	0.0
Ground sill	m	18,269	348	6.4	5.4	1.0	229	4.2	3.6	0.6
1.3 Appurtenant works				67.7	37.5	30.2		42.1	24.0	18.1
Intake gate(Type-B)	nos	586,000	1	0.6	0.4	0.2	1	0.6	0.4	0.2
Bridge				58.2	30.3	27.9		33.0	17.2	15.8
Bridge(105m)	nos	13,400,000	1	13.4	7.0	6.4	1	13.4	7.0	6.4
Bridge(90m)	nos	12,600,000	3	37.8	19.7	18.1	1	12.6	6.6	6.0
Bridge(40m)	nos	7,000,000	1	7.0	3.6	3.4	1	7.0	3.6	3.4
Rural road	m	160	5,140	0.8	0.8	0.0	2,640	0.4	0.4	0.0
Telemetering syste	l.s.			8.1	6.1	2.0		8.1	6.1	2.0
(Sub-total : 1.1+1.2+1.3)				807.5	369.3	438.2		433.7	210.3	223.4
2. Land and house				23.8	23.8	0.0		19.2	19.2	0.0
Land acquisit (1)	10^3m^2	2,150	728	1.6	1.6	0.0	728	1.6	1.6	0.0
Land acquisit (2)	10^3m^2	5,720	845	4.8	4.8	0.0	845	4.8	4.8	0.0
Land acquisit (3)	10^3m^2	2,570	1,067	2.7	2.7	0.0	1,067	2.7	2.7	0.0
Land acquisit (4)	10^3m^2	720	1,695	1.2	1.2	0.0	1,695	1.2	1.2	0.0
Land acquisit (5)	10^3m^2	3,580	3,181	11.4	11.4	0.0	2,424	8.7	8.7	0.0
Land acquisit (6)	10^3m^2	7,150	270	1.9	1.9	0.0	0	0.0	0.0	0.0
House compensat.	house	12,000	20	0.2	0.2	0.0	20	0.2	0.2	0.0
3. Administration	l.s.	-		41.6	41.6	0.0		22.6	22.6	0.0
4. Engineering service	l.s.	-		124.7	46.1	78.6		67.9	25.1	42.8
5. Physical contingency	l.s.	-		99.8	48.1	51.7		54.3	27.7	26.6
(Sub-total : 1+2+3+4+5)				1,097.4	528.9	568.5		597.7	304.9	292.8
6. Price contingency	l.s.	-		480.2	321.3	158.9		178.2	123.4	54.8
Total				1,577.6	850.2	727.4		775.9	428.3	347.6

Figure M.5.5 COSTS FOR PARTIAL IMPROVEMENT OF PRIORITY PROJECT

Items	Unit		Alt. 1: Priority Project				Alt. 2: Usulutan/Jocotal				Alt. 3: Usulutan			
	Unit	Cost(Col.)	Quantity	Amount(¢ 10^6)			Quantity	Amount(¢ 10^6)			Quantity	Amount(¢ 10^6)		
				Total	L.C.	F.C.		Total	L.C.	F.C.		Total	L.C.	F.C.
1. Construction works														
1.1 Channel works				366.9	167.5	199.4		158.3	75.5	82.8		45.8	21.3	24.5
Earth excavation(1)	m^3	45	3,977,000	179.0	73.4	105.6	576,000	25.9	10.6	15.3	432,000	19.4	8.0	11.4
Earth excavation(2)	m^3	20	3,906,000	78.1	32.0	46.1	3,906,000	78.1	32.0	46.1	0	0.0	0.0	0.0
Rock excavation	m^3	173	152,000	26.3	10.8	15.5	69,000	11.9	4.9	7.0	0	0.0	0.0	0.0
Embankment	m^3	42	1,173,000	49.3	20.2	29.1	506,000	21.3	8.7	12.6	506,000	21.3	8.7	12.6
Revetment	m	5,700	6,000	34.2	31.1	3.1	3,700	21.1	19.2	1.9	900	5.1	4.6	0.5
1.2 Structure works				24.7	18.8	5.9		2.1	1.8	0.3		0.0	0.0	0.0
Diversion weir	l.s.			10.5	9.0	1.5		0.0	0.0	0.0		0.0	0.0	0.0
Control gate	l.s.			9.4	5.8	3.6		0.0	0.0	0.0		0.0	0.0	0.0
Drainage sluice				0.6	0.4	0.2		0.0	0.0	0.0		0.0	0.0	0.0
Type-A	nos	426,000	0	0.0	0.0	0.0	0	0.0	0.0	0.0	0	0.0	0.0	0.0
Type-B	nos	586,000	1	0.6	0.4	0.2	0	0.0	0.0	0.0	0	0.0	0.0	0.0
Type-C	nos	754,000	0	0.0	0.0	0.0	0	0.0	0.0	0.0	0	0.0	0.0	0.0
Ground sill	m	18,269	229	4.2	3.6	0.6	115	2.1	1.8	0.3	0	0.0	0.0	0.0
1.3 Appurtenant works				42.1	24.0	18.1		0.3	0.3	0.0		0.3	0.3	0.0
Intake gate(Type-B)	nos	586,000	1	0.6	0.4	0.2	0	0.0	0.0	0.0	0	0.0	0.0	0.0
Bridge				33.0	17.2	15.8		0.0	0.0	0.0		0.0	0.0	0.0
Bridge(105m)	nos	13,400,000	1	13.4	7.0	6.4	0	0.0	0.0	0.0	0	0.0	0.0	0.0
Bridge(90m)	nos	12,600,000	1	12.6	6.6	6.0	0	0.0	0.0	0.0	0	0.0	0.0	0.0
Bridge(40m)	nos	7,000,000	1	7.0	3.6	3.4	0	0.0	0.0	0.0	0	0.0	0.0	0.0
Rural road	m	160	2,640	0.4	0.4	0.0	1,590	0.3	0.3	0.0	1,590	0.3	0.3	0.0
Telemetering syste	l.s.			8.1	6.1	2.0		0.0	0.0	0.0		0.0	0.0	0.0
(Sub-total)				433.7	210.3	223.4		160.7	77.5	83.2		46.1	21.6	24.5
2. Land and house				19.2	19.2	0.0		10.5	10.5	0.0		6.4	6.4	0.0
Land acquisit.(1)	10^3m^2	2,150	728	1.6	1.6	0.0	728	1.6	1.6	0.0	728	1.6	1.6	0.0
Land acquisit.(2)	10^3m^2	5,720	845	4.8	4.8	0.0	845	4.8	4.8	0.0	845	4.8	4.8	0.0
Land acquisit.(3)	10^3m^2	2,570	1,067	2.7	2.7	0.0	1,067	2.7	2.7	0.0	0	0.0	0.0	0.0
Land acquisit.(4)	10^3m^2	720	1,695	1.2	1.2	0.0	1,695	1.2	1.2	0.0	0	0.0	0.0	0.0
Land acquisit.(5)	10^3m^2	3,580	2,424	8.7	8.7	0.0	0	0.0	0.0	0.0	0	0.0	0.0	0.0
Land acquisit.(6)	10^3m^2	7,150	0	0.0	0.0	0.0	0	0.0	0.0	0.0	0	0.0	0.0	0.0
House compensat.	house	12,000	20	0.2	0.2	0.0	15	0.2	0.2	0.0	4	0.0	0.0	0.0
3. Administration	l.s.	-		22.6	22.6	0.0		8.6	8.6	0.0		2.6	2.6	0.0
4. Engineering	l.s.	-		67.9	25.1	42.8		25.7	9.5	16.2		7.9	2.9	5.0
5. Contingency	l.s.	-		54.3	27.7	26.6		29.7	10.6	19.1		6.3	3.4	2.9
Total				597.7	304.9	292.8		235.2	116.7	118.5		69.3	36.9	32.4