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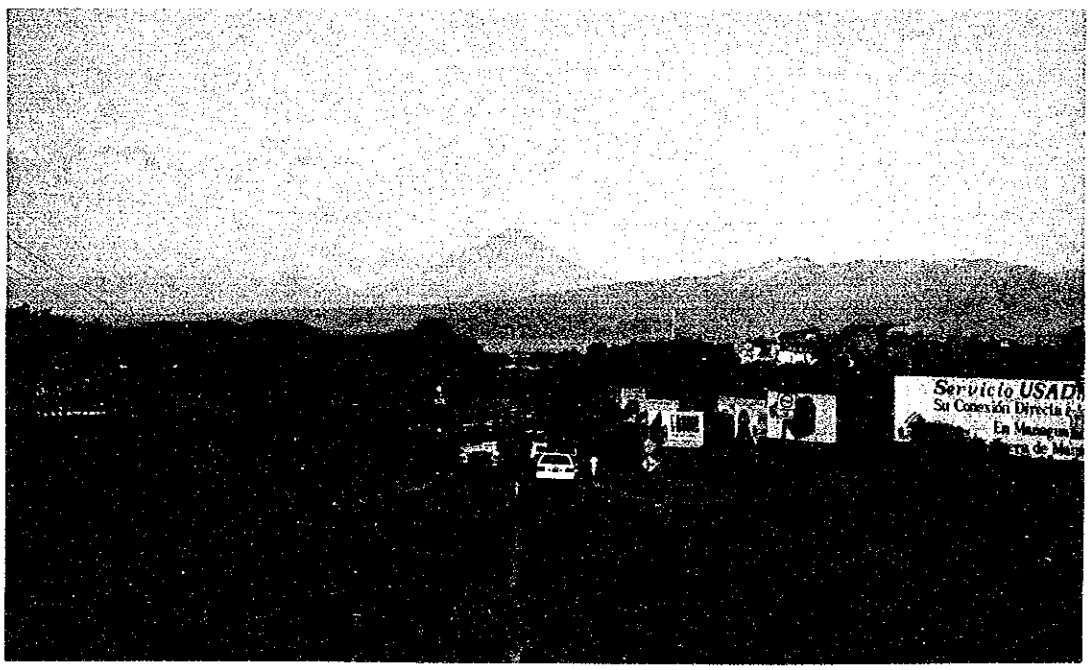
JAPAN INTERNATIONAL COOPERATION AGENCY

MINISTRY OF CONSTRUCTION AND TRANSPORTATION
THE REPUBLIC OF NICARAGUA

THE ROAD IMPROVEMENT AND REHABILITATION STUDY IN NICARAGUA

FINAL REPORT

SUMMARY



JULY 1994

CENTRAL CONSULTANT INC.
NIPPON KOEI CO., LTD.

Exchange Rate
US$ 1 = 6.15 Córdobas
July 1993

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PREFACE

In response to a request from the Government of Nicaragua, the Government of Japan decided to conduct The Road Improvement and Rehabilitation Study in Nicaragua, and entrusted the study to the Japan International Cooperation Agency (JICA).

JICA sent to Nicaragua a study team headed by Mr. Takashi Tachikawa of Central Consultant Inc. and composed of members from Central Consultant Inc. and Nippon Koei Co., Ltd., three times between February 1993 and February 1994.

The team held discussions with the officials concerned of the Government of Nicaragua, and conducted field surveys at the study area. After the team returned to Japan, further studies were made and the present report was prepared.

I hope that this report will contribute to the promotion of the project and to the enhancement of friendly relations between our two countries.

I wish to express my sincere appreciation to the officials concerned of the Government of Nicaragua for their close cooperation extended to the Study Team.

July, 1994

Kensuke Yanagiya

Kensuke Yanagiya
President
Japan International Cooperation Agency

LETTER OF TRANSMITTAL

July, 1994

Mr. Kensuke Yanagiya
President
Japan International Cooperation Agency
Tokyo, Japan.

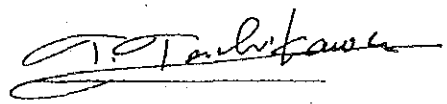
We are pleased to submit to you the final report on the Road Improvement and Rehabilitation Study in Nicaragua.

This study was conducted by the consortium of Central Consultant Inc. and Nippon Koei Co., Ltd., under a contract to JICA, during the period February 1993 to July 1994. In conducting the study, we have examined the various aspects related to the improvement and rehabilitation of the road network in order to formulate the Road Network Master Plan in Nicaragua. Then, we have also examined the feasibility of priority projects, which were selected during the course of the Master Plan Study stage.

We wish to take this opportunity to express our sincere gratitude to the officials concerned of JICA, the Ministry of Foreign Affairs, and Ministry of Construction. We would also like to express our gratitude to the officials concerned of the Ministry of Construction and Transportation and the Embassy of Japan in Nicaragua for their cooperation and assistance throughout our field survey.

Finally, we hope that this report will contribute to further promotion of the project.

Very truly yours,



Takashi Tachikawa
Project manager,
Study team on Road Improvement and
Rehabilitation Study in Nicaragua
Central Consultant Inc.

THE ROAD IMPROVEMENT AND REHABILITATION STUDY
IN NICARAGUA

OUTLINE

MASTER PLAN

1. Background

In order to realize improvement of the road network with the aim of stimulating the deteriorated economy by Managua earthquake, hurricanes, and civil war, the Nicaraguan government requested technical assistance from the Government of Japan. In response to this request, the Government of Japan decided to conducted a Road Improvement and Rehabilitation Study in Nicaragua.

2. Objective of the Study

The purpose of the Study is to formulate a Master Plan for improvement of the primary and secondary road network in the whole of Nicaragua (approximately 3,000 km) and to prioritize projects in the Master Plan, then to conduct a Feasibility Study on the selected projects (approximately 200 km).

3. Outline of the Plan

Since the establishment of the existing government in 1990, the deteriorated economy began to increase. Keeping pace with this economic growth, the traffic volume on major roads has been also increasing. Moreover, since the size of vehicle has become larger, the road surface has been getting deteriorated because of its poor maintenance. Therefore, based on the results of the road survey, future traffic volume, role of the roads, etc., the roads linked among cities with more than 10,000 population were set as the objective roads for this Study.

(1) Socio-economic Frame

GDP

The future GDP growth rate was set to be 2.5%, considering the economic growth rate since the establishment of the new government (1990), the projected growth rate by the government, and the results of interview with the staff of IDB and CABEI.

Population

The projected population of 6,676 thousands in 2010 by INEC was adopted as the future population.

Number of Vehicle Registered

The future number of vehicle registered was forecast by the regression model with the dependent variables of GDP, population, etc. The number of vehicle registered in 2010 was projected to increase to 208 thousands (1.5 times).

(2) Future Traffic Volume

The future traffic volume on the major roads was projected by the traffic assignment of the future O-D Table to the objective roads. The future O-D Table was forecast with the trip production model and trip generation and attraction model on the basis of the present O-D Table. The projected traffic volume on the main road sections is shown in Table-1.

Table-1 Traffic Volume on the Main Road Sections

(Unit : veh./day)

Road Section	1993	2010
Managua-Masaya	11,624	22,219
Managua-Tipitapa	4,708	9,531
Managua-León	2,605	5,123
Managua-Rivas	2,058	4,344
San Benito-Sébaco	2,588	4,469
León-Chinandega	4,292	9,295
Nandaime-San Benito	560	2,025
Telica-San Isidro	337	1,024

(3) Road Improvement Plan

In order to formulate the road improvement Master Plan, three factors; desired road classification (8 categories), ranking of road function (4 ranks) and service conditions (5 ranks) were introduced. Then, the road improvement level was determined for each road section in the road network and priority was established by means of weighting for the subnetwork and above three factors. Based on the examination of the priority value assigned to each road section, the road improvement Master Plan was formulated.

The following four projects, mainly included under the Short Term (Urgent) Plan in the Master Plan, were eventually recommended for the Feasibility Study by considering various aspects.

Table-2 Road Sections Selected for the Feasibility Study

Road Section	Distance
Masaya - Managua	29.0 km
Telica - San Isidro	96.8 km
Nandaime - San Benito	62.5 km
Tipitapa - Managua (two-lane section)	4.5 km
Total	192.8 km

(4) Existing Bridges on the Roads

Generally speaking, almost all existing bridges were constructed long ago, and some of them have been damaged considerably because the current traffic load and volume are much greater than what was expected when these bridges were designed. Moreover, recently many bridges have become the sites of traffic bottlenecks because they are too narrow and do not easy vehicle access. The bridges listed in Table-3 are in urgent need of major repair or total reconstruction.

Table-3 Bridges Requiring Urgent Repair or Reconstruction

Route No.	Bridge Name	Width(m)	Length(m)	Structure
Group I				
NIC-4	La Morita	7.0	9.0	RC-slab
NIC-4	El Arroyo	7.0	24.3	PCI
NIC-4	Mayaris	7.4	20.4	Simple Steel H Beam
NIC-4	El Arroyo No.1	7.0	20.0	PCI
NIC-26	Estero Real	7.0	58.0	RCT
NIC-26	El Guarumo	7.0	60.0	Two RC Slab +Two Girder
Group II				
NIC-2	Ochomogo	7.4	54.0	Truss
NIC-2	Gil Gonzales	7.4	37.0	Variable RCT
NIC-2	Las Lajas	7.4	47.0	Truss
NIC-7	Las Banderas	6.3	119.0	Truss+Five RCT
NIC-7	La Tonga	6.1	87.0	Truss+Two Plate Girder
NIC-12	Río Leona	7.4	18.5	Simple RC Two Girder
NIC-12	Telica	8.9	25.5	Simple RC Two Girder
NIC-12	Las Lanos	7.4	29.5	Three RC Slab
NIC-12	Cinco Cruces	7.5	26.7	Two RC Slab
NIC-24	La Pavona	7.4	16.2	Simple Two Girder
NIC-24	Río Negro 1	7.4	64.6	Four RCT Beam
NIC-24	Río Negro 2	7.4	60.0	Three RCT Beam
Group III				
NIC-1	Las Maderas	6.0	30.0	Truss
NIC-1	Sébaco	6.0	37.2	Tied Arch
NIC-1	El Venado	9.5	72.3	Simple Three PCT Beam

Note : RCT - Reinforced Concrete T Section
PCT - Prestressed Concrete T Section Beam
PCI - Prestressed Concrete I Section Beam

(5) Initial Environment Examination (IEE)

Environmental items for the IEE should be selected using the matrix method integrating the relationship between environmental items and environmental factors. The examination initially evaluated, the minor influences of air quality, water quality, noise and vibration, land subsidence, odor, land, soil, water, flora and fauna, waste, traffic, hazards, socio-economic conditions, safety, recreation facilities and water rights and rights of common.

Consequently, it was determined that environmental impact should be assessed at the Feasibility Study stage.

FEASIBILITY STUDY

1. Outline of the Plan

The project roads selected in the Master Plan stage were examined from the engineering, economic, and environmental aspects. The road class and the number of lanes were set as shown in Table-4.

Table-4 Road Class and Number of Lanes

Project Road	Road Class	Design Capacity (veh./hr/lane)	Directional Design Hourly Volume (veh./hr)	Number of Lanes
Managua-Masaya	TP-I (S)	1,400	2,600	4
Managua-Tipitapa	TP-I	800	900	2
Nandaime-San Benito	TP-I	700	800	2
Telica-San Isidro	TS-I	300	100	2

2. Design Criteria

Nicaraguan design criteria were used whenever available, however, if not available, recommendation by AASHTO, Japanese criteria, and recommendation in "Dianostico de la Infraestrucutura Vial del País" were examined.

A flexible pavement was recommended because it requires lower initial investment costs, and a shorter construction time while offering more comfortable riding conditions, considering the present economic situation of Nicaragua.

Among bridges on the project roads for the Feasibility Study, three bridges were judged to be necessary to be reconstructed. The bridge design condition was determined by "AASHTO Standard Specification for Highway Bridges:

3. Implementation Schedule

The implementation schedule of the project roads as shown in Figure-1.

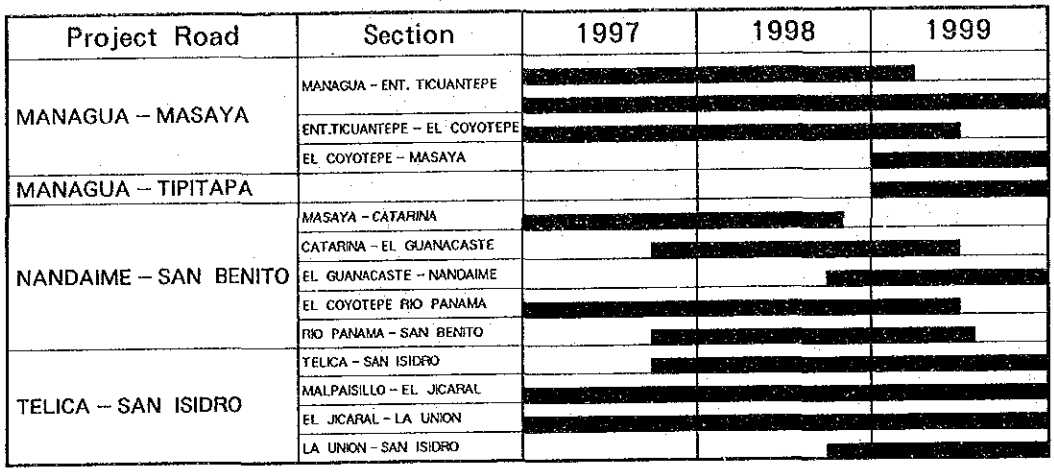


Figure-1 Implementation Schedule

4. Cost

The total project cost was estimated 780 million dollars as shown in Table-5, of which the foreign portion was 340 million dollars (44%). Considering the existing Nicaraguan financial situation, it is difficult for the Nicaraguan government to procure the fund in Nicaragua. Therefore, the government has a mind to borrow a low interest money from CABEI, IDB, etc. The government has a plan to receive a loan for the first section of Managua-Masaya road from CABEI with the results of this Study.

Table-5 Estimated Project Costs

(Unit : 1,000 Córdobas)

Item		Managua-Masaya		Managua-Tipitapa	Nandaime - San Benito	Telica - San Isidro
		1st Section	2nd Section			
Construction Cost	Local	41,524	52,247	7,734	118,685	131,435
	Foreign	35,624	44,785	5,322	91,258	99,014
	Total	77,148	97,032	13,056	209,943	230,449
Engineering Cost	Local	5,465	6,876	1,018	15,620	17,298
	Foreign	4,688	5,894	700	12,011	13,031
	Total	10,153	12,770	1,718	27,631	30,329
Subtotal	Local	46,989	59,123	8,752	134,305	148,733
	Foreign	40,312	50,679	6,022	103,269	112,045
	Total	87,301	109,802	14,774	237,574	260,778
Contingency	Local	4,699	5,912	875	13,431	14,873
	Foreign	4,031	5,068	602	10,327	11,205
	Total	8,730	10,980	1,477	23,758	26,078
Total	Local	51,688	65,035	9,627	147,736	163,606
	Foreign	44,343	55,747	6,624	113,596	123,250
	Total	96,031	120,782	16,251	261,332	286,856

Note : 1st Section - Managua-Entrada Ticuantepe
2nd Section - Entrada Ticuantepe-Masaya

5. Evaluation

The Study was judged to be sufficiently feasible from the engineering, economic and environmental aspects.

5.1 Economic Evaluation

The four project roads were economically evaluated. The following selected road cases were examined.

Table-6 Selected Road Projects

Project Road	Length (km)	Project No.
(1) Managua-Masaya		
* Managua-Entrada a Ticuantepe		
- At-grade intersection	8.52	Project-1
- Grade-separated intersection	8.52	Project-2
* Entrada a Ticuantepe-Masaya	17.38	Project-3
(2) Managua-Tipitapa	4.30	Project-4
(3) Nandaime-San Benito	62.13	Project-5
(4) Telica-San Isidro		
- Including improvement of alignment	95.76	Project-6
- Partial improvement	95.76	Project-7

The above projects were evaluated by comparing the cost with benefit. Travel time saving cost, vehicle operating cost saving and maintenance cost saving were accounted as the quantitative benefits. Internal Rate of Return (IRR), Net Present Value (NPV) and Benefit Cost Ratio (B/C) for each projects are shown in Table-7.

Table-7 Results of Economic Evaluation

	Project-1	Project-2	Project-3	Project-4	Project-5	Project-6	Project-7
IRR (%)	46.00	41.97	38.43	31.90	21.07	4.42	12.24
NPV (1000C$)	256,409	235,530	213,505	11,909	120,358	(73,239)	1,392
B/C	5.56	4.48	4.10	2.38	1.80	0.53	1.02

All projects except Project-6 show high values of the above three indicators, therefore, these projects can be judged feasible. As for the Managua-Masaya Road, "at-grade intersection system" was recommended to be installed at the Colonia Centro América intersection from the viewpoint of the economic evaluation. Regarding to the Telica-San Isidro Road, this project becomes feasible, if the improvement is limited to the improvement of the asphalt course for the whole section and partial improvement of base course, shoulder

and drainage for the certain stretch of this road. If implementing the road alignment, the Telica-San Isidro Road project is not feasible.

5.2 Environmental Impact Analysis (EIA)

The present condition of each environmental was investigated, and predictions and evaluations for 2000 and 2010 were provided. As a result of this examination, the minor influences of traffic conditions, air quality, water quality, noise and vibration, land, soil, flora, landscape and social conditions were identified.

The influences of environmental items including land, soil, flora, landscape and social condition are expected to be minimized by the environmental management plan. However, air quality, water quality, noise and vibration conditions will become worse than at present in some places, therefore, it will be necessary to set up air quality, water quality, and noise and vibration monitoring systems, and then control traffic conditions on the basis of monitoring results. It is recommended that the air quality, water quality, noise and vibration be closely monitored during the construction and use of roads.

6. Recommendations

(1) Feasibility of Projects

The results of the Study indicate that all Projects are technically and economically feasible, except for Telica-San Isidro Road. Taking into account the direct and enormous indirect benefits for regional development, besides the quantified savings in travel costs, the Projects should be implemented at the earliest opportunity.

(2) Establishment of a Monitoring System to Assess Environmental Impacts

Monitoring is considered necessary to preserve the environment during and after construction of the Project. Establishment of air pollution, water quality, and noise and vibration monitoring system for this purpose in the detailed design stage is strongly recommended.

(3) Relocation of Utilities

Detailed investigations, and negotiations with related offices for relocation of utilities will be necessary in the detailed design stage of the project.

(4) Need for Rehabilitation of the Managua-Masaya Road after the Year 2010

A preliminary engineering study and economic evaluation for this Project Road were conducted based on the predicted traffic volume after 2010. This study proposed that the Project Road be overlaid with pavement in 2014.

(5) Maintenance Program

Basically, maintenance work in Nicaragua is neither classified by implementation period nor scale. Hence, the maintenance program are required for the project roads, dividing the main maintenance activities into routine maintenance, periodic maintenance and incidental maintenance.

(6) Feasibility of the Telica-San Isidro Road Project

For the Telica-San Isidro Road, upgrading of the existing road section including improvement of road alignment was judged as unfeasible by the evaluation. On the other hand, improvement of the asphalt course, base course, shoulder and drainage, was judged as feasible with high indicators for the evaluation. Therefore, it is recommended to implement the improvement for a certain stretch of the Project Road by the year 2010. It is also recommended that the road classification of this Project Road will be upgraded to a level proposed in the Study in compliance with the increase of traffic volume in the future.

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1. MASTER PLAN

1. MASTER PLAN

1.1 BACKGROUND AND OBJECTIVES

(1) Background

The present government has pledged to reconstruct the Nicaraguan economy, which has been severely damaged by the Managua earthquake, hurricanes, and civil war. As a part of its efforts, the government has emphasized improvement of the road network with the aim of stimulating economic development. The following three policies related to road network improvement have been deemed essential.

- To promote improvement of the primary road network in line with the development of the Central American Highway network
- To improve the secondary road network in order to provide accessibility from agricultural areas to consumption areas and major ports
- To improve and/or construct access roads between the east coast and the west coast

Given the present difficult circumstances, the Nicaraguan Government has requested technical assistance from the Government of Japan to realize of the road network improvement. In response to this request, the Government of Japan decided to conduct a Road Improvement and Rehabilitation Study in Nicaragua (hereinafter refereed to as "the Study") and organize a Study Team (hereinafter refereed to as "the JICA Study Team").

(2) Objectives of the Study

In accordance with the above, the Study was carried out with the following objectives:

- To formulate a Master Plan for improvement of the primary and secondary road network in the whole of Nicaragua (approximately 3,000 km).
- To prioritize projects in the Master Plan, and conduct a Feasibility Study on the selected projects (approximately 200 km).
- To transfer technology to Nicaragua counterpart personnel in the course of the Study.

(3) Study Organization

The organization chart is shown in Figure 1-1.

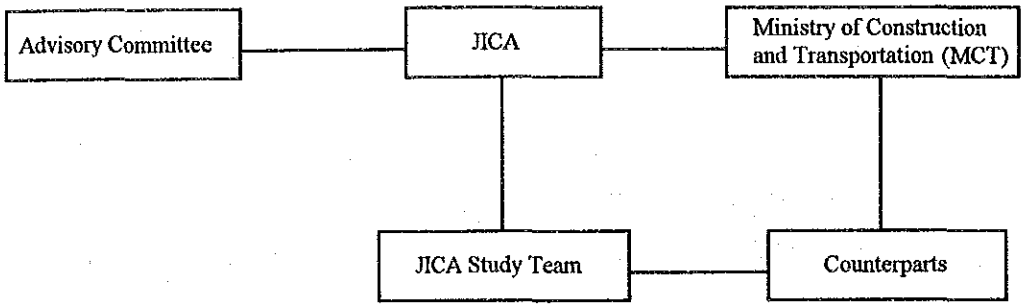


Figure 1-1 Organization Chart for the Study

(3) Basic Approach to the Study

The Study called for a Master Plan as its first phase and a Feasibility Study as its second phase. To accomplish the above objectives, the Study was carried out according to the work flowchart illustrated in Figure 1-2.

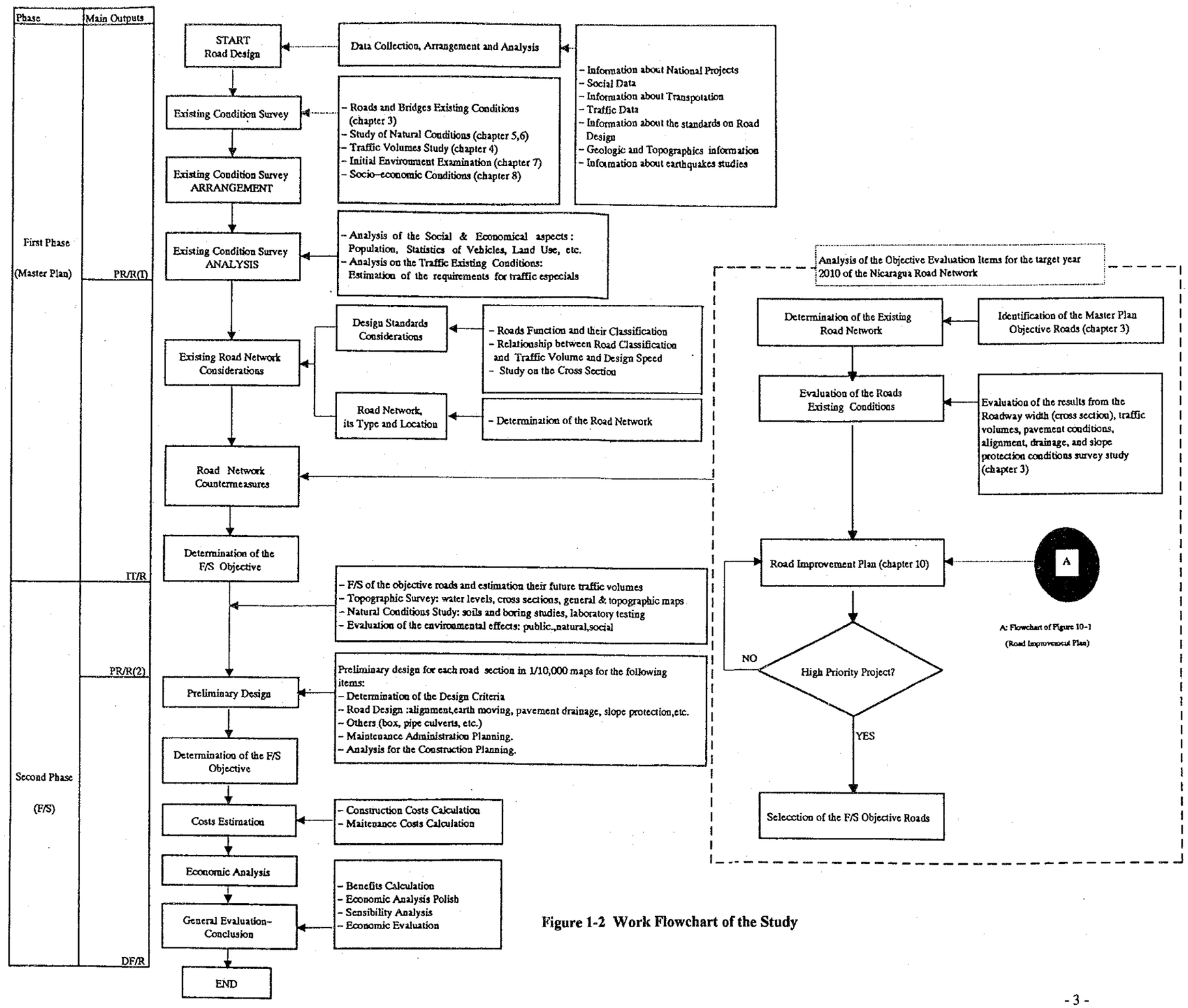


Figure 1-2 Work Flowchart of the Study

1.2 PRESENT CONDITIONS OF THE STUDY AREA

(1) Nicaraguan Economy

As of 1993, the current GDP was estimated of 10,520.8 million Córdobas, while consumption surpasses GDP by about 800 million Córdobas as shown in Table 1-1. As of 1992, per capita income in dollar terms was US$ 459. These facts suggest that the Nicaraguan economy is substantially supported by foreign assistance.

Table 1-1 GDP

(Unit: Million Córdobas)

Year	1990	1991	1992	1993*1
GDP	1,564.4	6,940.7	8,428.8	10,520.8
Consumption	1,551.6	7,648.6	9,971.0	11,335.4
Investment	301.3	1,452.5	1,707.8	2,395.6
Export	390.4	1,552.5	1,518.0	2,185.7
Import	678.9	3,713.0	4,768.0	5,396.0
Per Capita Income (1987 US$)*2	645	513	459	n.a.

Note : *1 Projection
Source : Banco Central de Nicaragua
*2: Banco Central de Nicaragua world table(1992), Bank staff calculation

The average consumer price rate was 28.7% during 1981-1984, but since then the rate accelerated. In 1988 the rate of inflation reached 33,647.3% per annum, the highest in Nicaraguan history. However, inflation has been brought down by an austerity plan every year, bringing the monthly average down to 1.8%.

(2) Topography

Nicaragua is topographically divided into the following four regions:

- Nicaraguan Depression : Subsided area and successive low alluvial plains marked by large lakes and active volcanoes
- Pacific Central Plain : Raised region (800m) south of Managua to the sea level area along the Pacific coast.
- Interior Highlands : Mountainous area including the highest mountain in Nicaragua (200 m~2,000 m)
- Atlantic Coastal Plain : Plains less than 100 m in elevation and lagoon area

(3) Meteorology

The climate in Nicaragua can be mainly classified into four types in accordance with the W. Koppen method -- Tropical Savannah (Aw), Tropical Savannah in the Highlands (AwH), Tropical Monsoon (Am) and Tropical Forest (Af1),.

(4) Present Transportation System

a) Roads

The total length of the roads in 1992 was 15,011.2 km, with paved roads accounting for only 10.9% of all road, as shown in Table 1-3.

Table 1-2 Existing Roads by Surface Type in Each Region (1992)

(Unit : km)

Region	Asphalt	Surface Treatment	Gravel	Earth	Total
I	169.6	384.7	697.5	709.5	1,961.3
II	398.2	158.9	938.4	978.1	2,473.6
III	324.3	180.3	234.1	765.2	1,503.9
IV	312.2	118.0	724.7	1,363.7	2,518.6
V	258.6	568.5	648.4	796.4	2,271.9
VI	178.4	602.0	1,276.1	878.2	2,934.7
VII	0.0	686.7	307.0	130.0	1,123.7
VIII	0.0	0.0	0.0	0.0	0.0
IX	0.0	72.8	71.5	79.2	223.5
Total	1,641.3	2,771.9	4,897.7	5,700.3	15,011.2

Source : Inventario de la Red Vial 1993, MCT

b) Railways

In Nicaragua, a railway system consisting of 343.5 km of track was built in the Pacific coast regions, however, the whole railway system was abandoned at the end of 1993 due to the financial difficulties suffered by the Nicaraguan Railway.

c) Air transport

One international airport and twelve domestic airports are currently operating in Nicaragua. Of the twelve domestic airports, eight are located in Atlantic coast regions. Domestic air flights mainly serve to connect Managua to the Atlantic coastal regions. As shown in

Table 1-3, the number of domestic air passengers and the amount of cargo transport have been are decreasing.

Table 1-3 Transition of Air Transport

Year	Domestic			International		
	Passengers (person)	Cargo (lb.)	Post (kg)	Passengers (person)	Cargo (lb.)	Post (kg)
1988	45,683	4,112,360	3,606	233,628	10,873,713	205,105
1989	39,796	2,385,435	7,306	237,427	6,252,621	202,826
1990	48,004	1,703,585	4,997	290,208	6,769,354	112,236
1991	38,914	2,014,504	3,776	354,523	11,593,852	57,204
1992	24,426	374,658	546	353,637	15,465,771	105,442

Source: Diagnostico del Transporte Aereo, 1989 and latest data from MCT.

d) Seaports

The main seaports in Nicaragua are Corinto, Puerto Sandíno and San Juan del Sur on the Pacific coast, and El Bluff, Arlen Siu and Puerto Cabezas on the Atlantic coast. Almost half of all import/export in Nicaragua goes through Corinto and Puerto Sandíno. The share of the three ports located on the Atlantic coast is smaller due to this area's limited access to the other regions.

e) Inland waterways

The inland waterways of Nicaragua are clearly divided into two systems. In the Atlantic coast regions, in particular, inland waterways still play a major role in transport despite the recent development of the Matagalpa-Puerto Cabezas road.

1.3 ROAD NETWORK CONSIDERATIONS

(1) Present Road Network in Nicaragua

a) Growth of the Network

The road network in Nicaragua has been developed until 1980, however, the total length of this network was drastically decreased after 1980 due to the destruction of roads by natural disasters such as hurricanes. The road density in the Atlantic regions is extremely low compared with other regions because there is a lack of north-south links in those regions, which indicates that transportation still mainly depends on inland waterways.

b) Functional Classification of the Network

The functional classification of the road network was defined on the basis of the former National Transportation Study in 1976. The classifications are defined into the following five categories:

- Troncal Principal
- Troncal Secundaria
- Colectora Principal
- Colectora Secundaria
- Caminos Vecinales

According to the latest classification of 1988, the length of Troncal Principal, Troncal Secundaria and Colectora Principal are extremely limited, compared with the Colectora Secundaria on both a national and regional basis.

(2) Objective Road Network

The objective roads were defined as existing roads linking urban centers having populations of more than 10,000. The objective roads identified are shown in Table 1-4.

Table 1-4 Objective Road Network

Objective Road	Length (km)	NIC No.	No. in the Study	Remarks
Nandaime-El Espino	265.90	NIC 1/2/4/11	A-1~A-11	CA-1
Peñas Blancas-Nandaime-Guasaule	342.40	NIC 2/12/24	B-0~B-12	CA-1, CA-3
Granada-Masaya-Managua	47.00	NIC 4	C-1~C-2	
San Benito-El Rama	260.10	NIC 7	D-1~D-5	
Guanacaste-Granada	10.80	NIC 4	A-101	
Masatepe-Sm-Las Esquinas	19.60	NIC 18	A-102	
San Marcos-Jinotepe	6.20	NIC 20	A-103	
Granada-Int. Tipitapa	28.90	NIC 27	A-104	
Sébaco-Matagalpa	26.90	NIC 3	A-105	
Matagalpa-Yali	76.60	NIC 3	A-106	
Estelí-Yali	60.70	NIC 35	A-107	
Yalaguina-Ocotal	29.20	NIC 15	A-108	
Ocotal-Las Manos	24.00	NIC 15	A-109	
Managua-Tipitapa	21.00	NIC 1	A-104-1	
Ciudad Dario-Las Mulukuku	192.90	NIC 47-21	A-104-2	
San Dionisio-San Ramón	24.30	NIC 19	A-104-3	
Matagalpa-Siuna	115.70	NIC 5	A-105-1	
Puerto Cabezas-Waspan	137.50	NIC 21	A-105-3	
Estelí-El Sauce	44.60	NIC 49	A-107-1	
El Sauce-Ach-La Sirena	73.00	NIC 38	A-107-2	
Yali-Condega	42.40	NIC 3	A-107-3	
Condega-P. N1-Somoto	34.50	ND	A-107-4	
Palacaguina-Wiwilí	107.70	NIC 51	A-107-5	
La Reforma-Jalapa	55.10	NIC 29	A-107-6	
La Virgen-San Juan del Sur	18.30	NIC 16	B-102	
Rivas-Tola	13.10	NIC 62	B-103	
El Crucero-Masachapa	21.30	NIC 8	B-105	
Nejapa-Mateare-Izapa	60.10	NIC 28	B-106	
Izapa-Puerto Sandino	9.60	NIC 52	B-107	
Telica-La Cruz de la India	73.70	NIC 26	B-110	
La Cruz de la India-Int. San Isidro	23.10	NIC 26	B-111	
Chinandega-Corinto	20.00	NIC 24	B-114	
Chinandega-El Viejo-Potosi	76.20	NIC 12	B-115	
Somotillo-Cinco Pinos-San Juan de Limay	68.00	NIC 68	B-117	
Int. Telica-Larreynaga	6.40	ND	B-110-1	
Puerto Morazan-Rancherias	19.80	NIC 50	B-116-1	
Monte Grande-Boaco	14.00	NIC 9	D-101	
Acoyapa-Los Chiles	134.30	NIC 25	D-102	
Nueva Guinea-Cukra River-Bluefields	95.20	NIC 71	D-103	
San Francisco-Comoapa	21.00	NIC 17	D-101-1	
Las Lajitas-San Pedro	15.30	NIC 37	D-101-2	
Cukra River-Monkey Point	56.00	NIC 23	D-102-1	
Total Length	3,126.60			

(3) Existing Conditions of the Road Network

Taking into account the results of an evaluation of the present road network conditions, the following items were determined:

- Road (Pavement) Structure

- Drainage
- Slope Horizontal and Vertical alignment
- Cross-sectional composition

To establish a road network improvement plan, the following ranks and definitions were applied in evaluating existing conditions.

Table 1-5 Evaluation Ranks and Definitions

Rank	Definition
A	Critical
B	Progressive
C	Slightly progressive
D	Fair
E	Good

The evaluation revealed that 1,296.3 km (41% of a road network of 3,126.6 km) of roads are in critical condition, and 1,002.4 km (32% of the road network) of roads are in progressively deteriorating condition.

1.4 EXISTING TRAFFIC CONDITIONS

In order to obtain the basic traffic data for forecasting future traffic demand and formulating road standards such as road width, design speed, capacity, etc. for the objective roads of the Master Plan, an O-D survey, traffic volume counting survey, travel speed survey, and axle road survey were conducted.

The present O-D table was established based on the results of the above traffic survey. A total of 33 zones were established, including two foreign zones. Vehicle trips, excluding intra-zonal traffic, totaled 30,868. The modal split except motorcycle is shown in Table 1-6.

The largest traffic volume (11,624 vehicles/day) was observed on the Managua-Masaya road section, followed by the León-Chinandega road section (9,295 vehicles/day).

Table 1-6 Vehicle Trips by Vehicle Type

Vehicle Type	Vehicle Trips (veh./day)	Modal Share (%)
Passenger Cars	10,486	34.0
Microbuses	1,492	4.8
Large buses	2,176	7.0
Pick-ups	9,500	30.8
Trucks	4,732	15.3
Trailers	2,253	7.3
Tractors	229	0.7
Total	30,868	100.0

1.5 GEOLOGICAL CONSIDERATIONS

Nicaragua is generally divisible into four geographic provinces, such as the Pacific Coastal Plain, the Nicaragua Depression, the Interior Highlands and the Atlantic Coastal Plain, and these provinces well reflect each geological characteristics too.

Also the geology of the country is characterized by eight main active volcanoes running in a NW-SE direction, and by two large lakes, the Managua and the Nicaragua.

Many occurrences of large scale earthquakes originated from the contact plain between the major tectonic plates brought sometimes large disasters for inhabitants and structures.

There seems to be no marked disasters of landslides and by soft grounds, which have directly affected existing roads.

Necessary cautions have to be taken into account to prevent these disasters including earthquakes and the others in designing new roads.

1.6 METEOROLOGICAL AND HYDROLOGICAL CONSIDERATION

(1) Meteorological Information

a) Rainfall

The monthly rainfall pattern in Nicaragua shows an obvious distinction between the wet and dry season in a year. The wet season is between May and October, while the dry season is between November and April.

Zones with annual rainfall ranging from 800 mm to 2,000 mm are located in the Pacific and the Central regions. Annual rainfall on the Atlantic side exceeds 2,000 mm. The southeastern part of the territory is the most rainy area having annual rainfall of 4,000 mm to 6,000 mm.

b) Temperature

Annual mean temperature ranges from 20°C to 25°C in the Central region, from 25°C to 28°C in the Pacific region, and from 25°C to 26°C in the Atlantic region. The higher temperatures are observed at the end of the dry season (March/April), and the lower temperatures are observed at the beginning of the dry season (December/January).

c) Evaporation

In the Central and Pacific regions, annual evaporation exceeds annual rainfall. Annual evaporation varies from 1,800 mm to 2,500 mm by region, and higher values are generally observed north of the highlands (Ocotal) and along the lake shores (Managua and Nandaime).

(2) Hydrology

The territory of Nicaragua is generally divided into two hydrological regions, the Pacific Watershed, which has an area of 12,072 km^2, and the Atlantic Watershed, which has an

area of 116,882 km². In the Atlantic Watershed, the San Juan river basin includes two large lakes, Lake Managua and Lake Nicaragua.

The Pacific Watershed includes eight river systems. Most of these rivers have a relatively small drainage area and are less than 20 km in length, except the Estero Real River. This river has a narrow channel width and a discontinuous flow due to its small drainage area and the big difference between rainfall in the wet season and that in the dry season.

The Atlantic Watershed consists of 13 river systems with a relatively large drainage area. The rivers originate in the Interior Highlands running from the north to the south-east. Rivers with an abundant flow go down to the Atlantic Coastal Plain. The wetlands spread over the most downstream reaches, and are affected by tides, which occasionally cause inundation.

(3) Flooding on the Road Network

The roads and related structures have occasionally suffered from heavy rain and floods, particularly as a result of hurricanes passing through Nicaragua. Serious damage by such natural disasters causes a significant loss for the country, for example, by discouraging socio-economic activities, by stopping traffic, and by creating the need to spend a lot of money on reconstruction.

1.7 INITIAL ENVIRONMENT EXAMINATION (IEE)

(1) Selection of Environmental Items for the IEE

The main purpose of the IEE is to preserve the natural and living environment and to assess the need for an environmental impact assessment in the next stage. Environmental items for the IEE should be selected using the matrix method integrating the relationship between environmental items and environmental factors. Consequently, the following environmental items were selected:

- Living environment (Pollution)

  Air quality, water quality, soil contamination, noise and vibration, land subsidence, and odor

- Natural environment

  Land (topography and geology), soil, water (rivers, lakes, water courses), underground water, sea and sea shore, flora and fauna, and landscape

- Social environment

  Waste, historical and cultural monuments, traffic, hazards, relocation, social conditions, cutting district, safety, recreation facilities, and water rights and rights of common

(2) Environmental Problems in Nicaragua

The environmental problems in Nicaragua are primarily air pollution, water pollution, flora and fauna, soil erosion and water. Air pollution by automobiles, underground water contamination, noise and vibration near by roads and factories, increase of waste, sewage, odors from factories and lakes, etc. are expected to increase in the near future as economic activities expand.

(3) Setting of Environmental Quality Standards

American standards are applied to air quality environmental standards. Water quality standards in Nicaragua are now under discussion, so Japanese standards have been tentatively applied as water quality standards. Japanese standards have also been tentatively applied as noise, vibration and soil contamination standards. The influence on other envi-

ronmental items such as land subsidence, odor, waste, land, water, flora and fauna, landscape, hazards, traffic safety and socio-economic problems in the project area should be minimized.

(4) Evaluation

The IEE environmental checklist, consisting of environmental items and their sub-divisions, was used to check present environmental conditions. The results of the evaluation are summarized in Table 1-7.

Table 1-7 Environmental Evaluation

Environmental Items	Evaluation Section				
	Section 1	Section 2	Section 3	Section 4	Overall Evaluation
1) Air quality	2	2	2-3	2-3	2
2) Water quality	2	2-3	2-3	2-3	2
3) Soil contamination	3	3	3	3	3
4) Noise and vibrations	1-2	3	2-3	2-3	1-3
5) Land subsidence	3	2-3	3	2-3	2-3
6) Foul odor	3	2-3	2-3	3	2-3
7) Land	1-2	3	2	2-3	1-3
8) Soil	2-3	2-3	2	2-3	2-3
9) Water	2	2-3	2	2-3	2
10) Underground water	3	3	3	3	3
11) Sea	3	3	3	3	3
12) Flora and fauna	2	4	2-3	2-3	2
13) Landscape	3	3	3	3	3
14) Waste	3	2-3	2-3	2-3	2-3
15) Historical and natural monuments	3	3	3	3	3
16) Traffic	3	2-3	2-3	2-3	2-3
17) Hazards	3	2-3	2-3	2-3	2-3
18) Relocation	3	3	3	3	3
19) Socio-economic conditions	3	4	4	4	4
20) Cutting district	3	3	3	3	3
21) Safety	2	2-3	2-3	2	2-3
22) Recreation facilities	3	2-3	2-3	2-3	2-3
23) Water rights and right of common	3	4	4	4	4
Synthetic Evaluation					2

Note : Evaluation results
1 = Major influence
2 = Minor influence
3 = No influence
4 = Unknown

Based on the above results, the main environmental problems in Nicaragua were determined to be the following.

① Air pollution by factories and automobiles.

② Water contamination of lakes and rivers by domestic and industrial wastewater, eutrophication.

③ Deforestation, desertification, extinction of valuable species of flora and fauna.

④ Soil erosion by deforestation.

⑤ Desertification, flooding, etc. concerning water.

⑥ Others.

- Noise and vibration by automobiles and industries.
- Underground water contamination.
- Waste increase.
- Sewage.
- Odors caused by waste and eutrophic lakes.

(5) Need for an Environmental Impact Analysis (EIA)

The main causes of environmental impact resulting from the projects are the construction and the use of roads. Air quality, water quality, soil contamination, noise and vibration, land subsidence odor, land, soil, underground water, sea, flora and fauna, landscape, waste, historical and cultural monuments, traffic hazards, relocation, socio-economic conditions, cutting, district, safety, recreation facilities, water rights and rights of common have been selected as environmental items.

The examination also initially evaluated, the minor influences of air quality, water quality, noise and vibration, land subsidence, odor, land, soil, water, flora and fauna, waste, traffic, hazards, socio-economic conditions, safety, recreation facilities and water rights and rights of common.

Consequently, it was determined that environmental impact should be assessed at the Feasibility Study stage.

1.8 FUTURE SOCIO-ECONOMIC FRAMEWORK

(1) GDP

The government has predicted a growth in GDP of 5% per annum for 1994 and 1995. Nevertheless, after considering the existing unstable economic and political situation, and following interviews with officers in the IDB, CABEI, MED, etc., the JICA Study Team assumed an annual growth rate of 2.5%.

(2) Population

Future population by zone was forecast on the basis of future population figures by region projected by INEC. The population of each zone in 2010 was projected to increase about 1.6 times on average over the 1993 figure.

(3) Vehicles Registered

The future number of registered vehicles by vehicle type was predicted using the linear regression model and factoring in dependent variables such as GDP, population, etc. The total number of registered vehicles in 2010 was projected at about 1.5 times the 1993 figure.

(4) Increase in Agricultural Production through Redevelopment

The quantities of major agricultural products such as cotton, coffee, sugar, banana, rice, maize, sorghum and beans were projected on the basis of the effect of the governmental redevelopment strategy on the agricultural development. This increment was then converted into the vehicle trip increment resulting from the above agricultural redevelopment strategy.

1.9 FUTURE TRAFFIC DEMAND

(1) Projection Method

Future traffic demand was projected by the procedure shown in Figure 1-3.

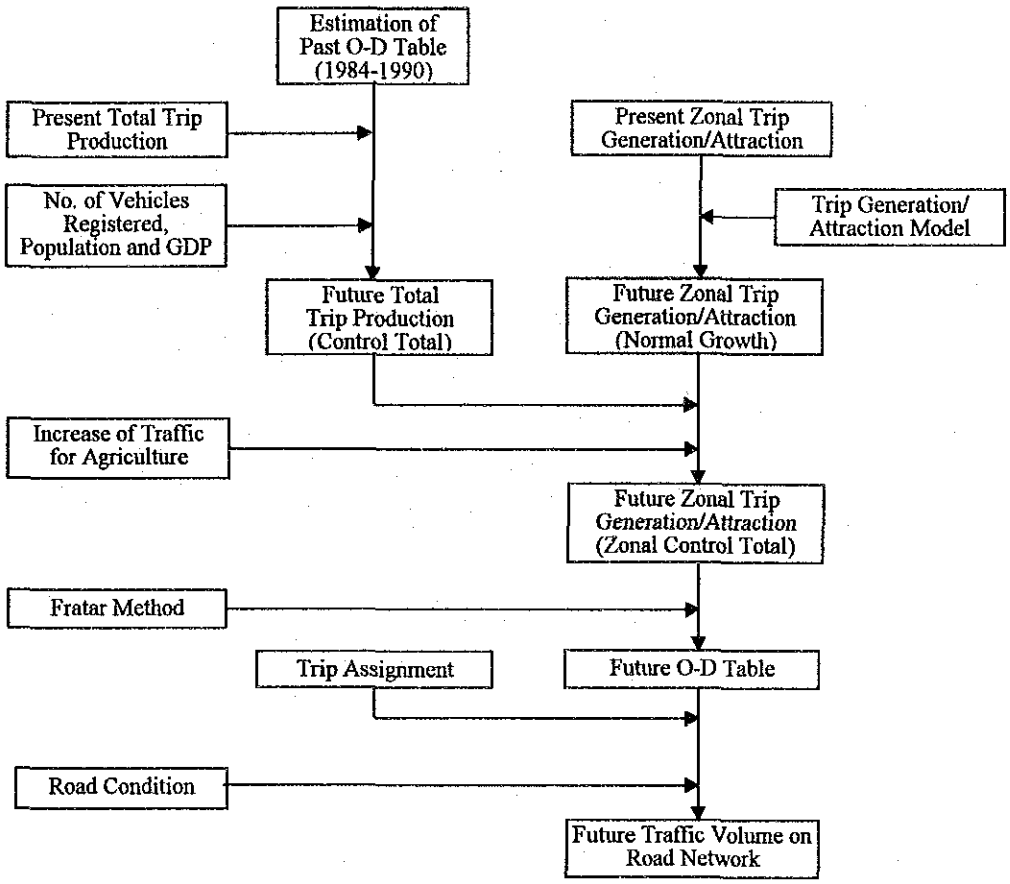


Figure 1-3 Future Traffic Demand Projection Procedure

(2) Future Traffic Volume on the Road Network

Total trip production and zonal trip production/attraction were projected using the applicable regression model. The total number of future vehicle trips was expected to increase to 65,164 in 2010 from 30,825 in 1993 (an expansion rate of 2.114). To this total, the vehicle trip increment resulting from the agricultural redevelopment strategy was added. Based on this future O-D table, the traffic volume was assigned to the objective roads using the QV method. Future traffic volume on the main objective road is shown in Figure 1-4.

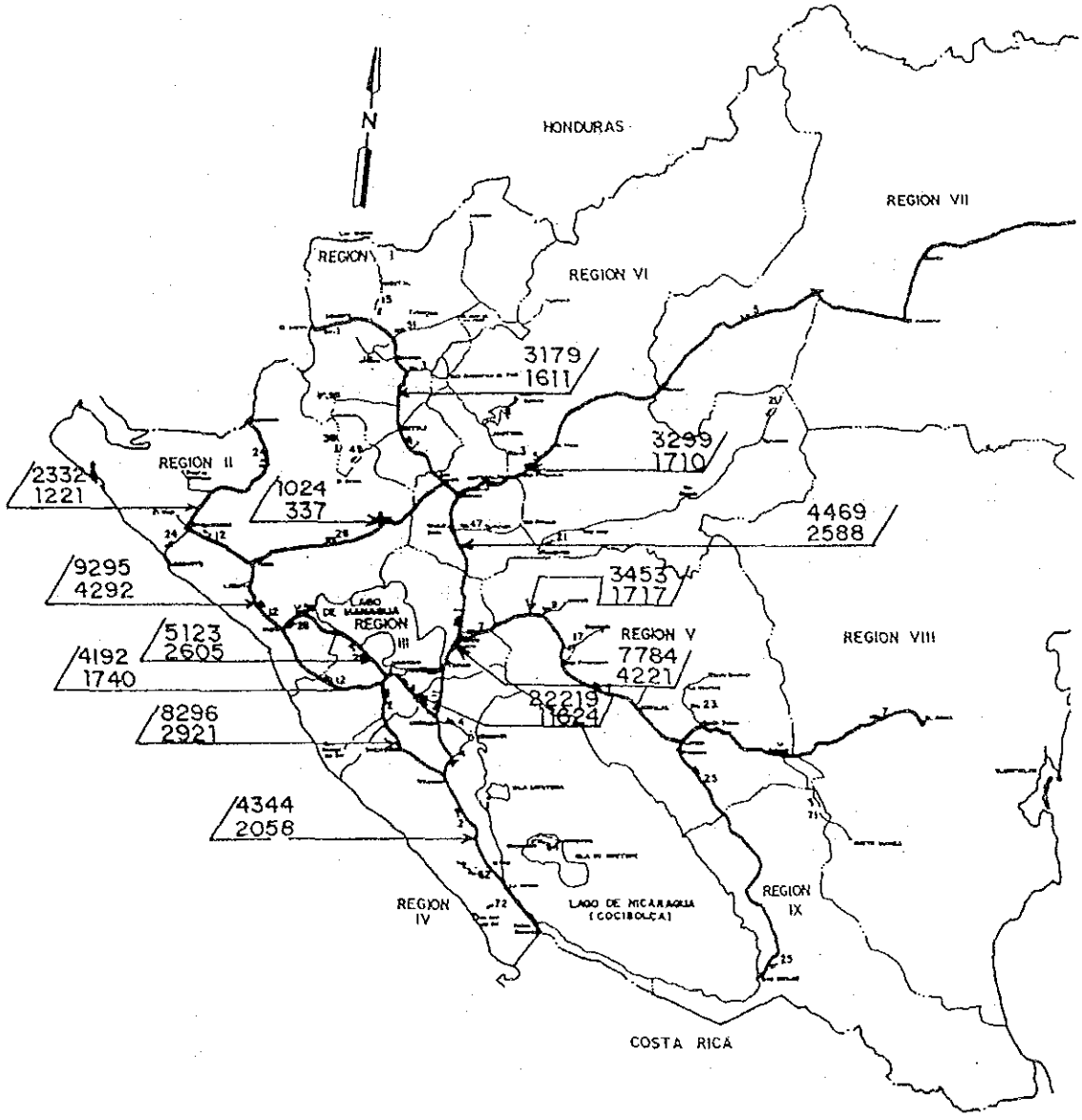


Figure 1-4 Future Traffic Volume on Road Network

1.10 ROAD NETWORK IMPROVEMENT PLAN

(1) Road Network Strategies

The process used to formulate the Master Plan is shown in Figure 1-5. To achieve the aims of the Study objectives, three factors; desired road classification, ranking of road function, and service conditions, were introduced.

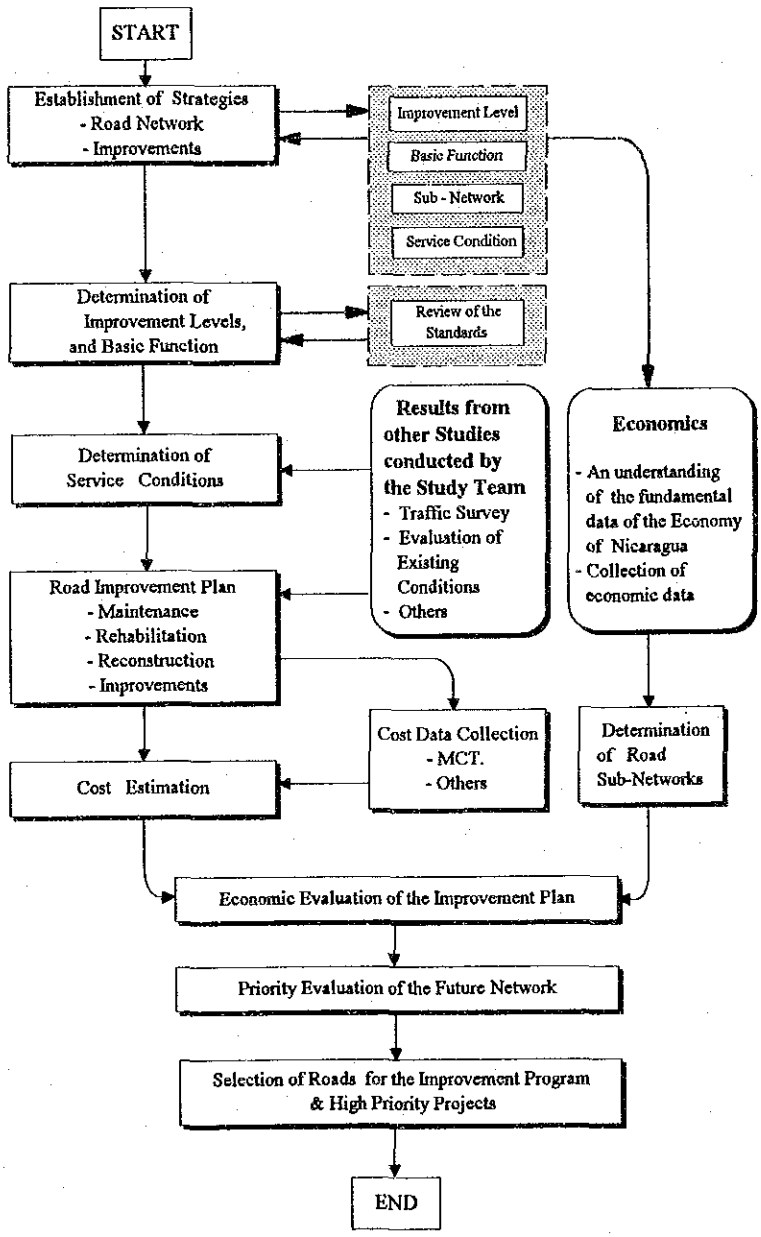


Figure 1-5 Formulation Process of the Road Network Master Plan

a) Desired Road Classification

Road classification was defined as shown in Table 1-8.

Table 1-8 Desired Road Classifications

Classification	Description	Urban Towns and Population	Traffic Flow ADT (veh./day)	Traveling Distance	Design Speed (km/h)			Remarks
					Flat	Hilly	Mountainous	
T.P.-I	Troncal	More than 100,000	More than 5,000	Long Distance	100	80	60	
T.P.-II	Principal	50,000-100,000	1,500-5,000		80	60	40	National 2a
T.S.-I	Troncal	25,000-50,000	500-1,500	Medium Distance	80	60	40	
T.S.-II	Secimdaroa	10,000-25,000			60	50	30	Departmental
C.P.-I	Colectora	5,000-10,000	250-500	Short Distance	50	40	30	Ia
C.P.-II	Principal				50	40	30	Departmental
C.S.	Colectora Secundaria	1,000-5000	100-250	Relatively Short Distance	50	40	30	2a
C.V.	Caminos Vecinales	Less than 1,000	Less than 100	Very Short Distance	40	30	20	

b) Ranking of Road Functions

The objective roads were ranked as follows:

- Rank a : North-South trunk road
- Rank b : East-West trunk road
- Rank c : Access roads to agglomeration areas and ports
- Rank d : Roads other than the above

c) Service Conditions

Service conditions were inspected and evaluated for each road section using five ranking (perfect road, good road, fair road, bad road and impossible road) based on modified AASHTO criteria.

On the basis of the above three factors, the road improvement level was determined for each road section in the road network.

(2) Road Network Evaluation Premise

The road network was evaluated by introducing the concept of "sub-network". The national road network is divided into the following seven sub-networks as shown in Table 1-9.

Table 1-9 List of Sub-Networks

Sub-network	Major Municipalities
Sub-network-1	Managua
Sub-network-2	Rivas
Sub-network-3	León, Chinandega
Sub-network-4	Estelí, Matagalpa, Jinotega
Sub-network-5	Telica, Sébaco
Sub-network-6	San Benito, El Rama
Sub-network-7	Matagalpa, Puerto Cabezas

(3) Cost Estimation

Costs were estimated on the basis of the established improvement plan. Cost by sub-network are summarized in Table 1-10.

Table 1-10 Cost Estimation of Projects by Sub-Network

(Unit : 1,000 Córdobas in July 1993)

Sub-network	Major Cities	Estimated Cost		
		Road Project	Bridge Project	Total
1	Managua/Masaya	354,979	10,500	365,479
2	Rivas	93,615	56,700	150,315
3	León/Chinandega	503,298	50,000	553,298
4	Estelí/Jinotega	481,280	118,000	599,280
5	Telica/Sébaco/Matagalpa	132,982	0	132,982
6	Boaco/El Rama	615,801	22,000	637,801
7	Matagalpa/Puerto Cabezas	507,496	0	507,496
Total		2,689,451	257,200	2,946,651*

Note - * : Equivalent to US$ 479,130 based on 6.15 Córdobas/US$

(4) Economic Evaluation of the Improvement Plan

The economic evaluation results by sub-network are shown in Table 1-11.

(5) Priority Evaluation of the Future Network

Priority was established by means of weighting for the sub-network and related factors as shown in Tables 1-12 and 1-13.

Table 1-11 Summary of IRR, NPV and B/C

Sub-network	IRR (%)	NPV (1,000 Córdobas)	B/C	Project Costs (Financial) (1,000 Córdobas)
Sub-network-1	28.1	507,596	3.03	365,479
Sub-network-2	25.7	106,192	2.61	150,315
Sub-network-3	19.1	300,371	1.76	553,298
Sub-network-4	2.5	-249,428	0.38	599,280
Sub-network-5	8.7	-23,150	0.74	132,982
Sub-network-6	-	-346,450	0.17	637,801
Sub-network-7	-	-317,808	0.04	507,496

Note : Discount rate = 12% for NPV, B/C

Table 1-12 Weights of the Sub-networks

Sub-network	Weight
Sub-network-1	30
Sub-network-2	15
Sub-network-3	15
Sub-network-4	15
Sub-network-5	15
Sub-network-6	5
Sub-network-7	5
Total	100

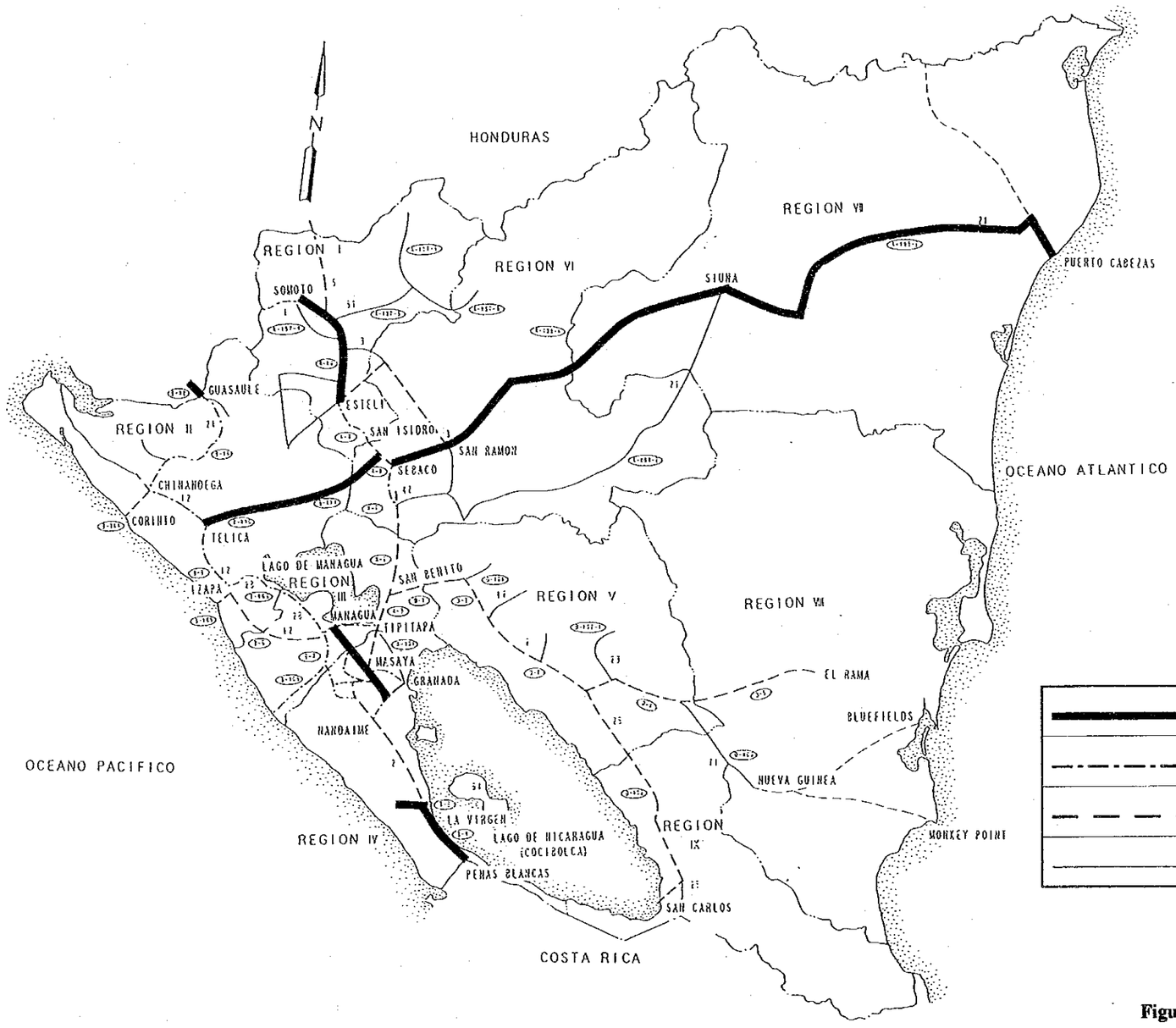
Table 1-13 Weights for Road Classification

Road Class (Weight 30)			Function (Weight 50)			Service Conditions (Weight 20)		
	%	Weight		%	Weight		%	Weight
TP-I(s)	100	30	a	100	50	V	100	20
TP-I	80	24	b	90	45	IV	75	15
TP-II	60	18	c	60	30	III	50	10
TS-I	60	18	d	20	10	II	25	5
TS-II	40	12				I	0	0
CP-II	0	0						

Each road section was prioritized in the order from the lowest priority value to the highest priority value, which is shown in Figure 1-6.

(6) Formulation of the Master Plan

Based on the examination of the priority value assigned to each road section, the road improvement Master Plan was formulated. In this case, any road section, which was assigned a priority level of "None", is deemed as not requiring urgent improvement. In this Master Plan Study, the following understanding of the relationship between the priority level and the implementation program was adopted.



━━━━	SHORT TERM PROJECTS
━·━·━	MIDDLE TERM PROJECTS (TO BE COMPLETED UP TO 2000)
━ ━ ━	LONG TERM PROJECTS (TO BE COMPLETED UP TO 2010)
———	PROJECTS (TO BE COMPLETED AFTER 2010)

Figure 1-6 Road Sections by Priority Level

a) Short Term (Urgent) Plan

Improvement and/or rehabilitation of road sections with a priority level higher than "Middle-High" must be implemented as soon as possible.

b) Medium Term Plan

Implementation of improvement and/or rehabilitation of sections with a priority level of "Middle" should be completed by the year 2000.

c) Long Term Plan

Adequate measures for sections with a priority level of "Low" must be taken by the year 2010.

The total length of the road sections and implementation costs required for the above program are as follows. Total cost was estimated at about 2,947 million Córdobas.

Table 1-14 Total Cost of the Road Improvement Master Plan

Program	Distance (km)	Cost (1000 Córdobas)	Cost/km (Córdobas)
Short Term	708.5	1,209,264	1,707
Medium Term	383.8	480.408	1,252
Long Term	858.3	1,256,979	1,464
Total	1,950.6	2,946,651	1,511

(7) Selection of Projects for the Feasibility Study

The JICA Study Team conducted a Feasibility Study on some of the projects mainly included under the Short Term (Urgent) Plan following this Master Plan Study in order to ensure satisfactory implementation of the Master Plan

The objective sections of the Feasibility Study were selected after considering the following aims:

① To exclude committed projects by international lending agencies and foreign countries

② To exclude projects in off-limit areas

③ To give priority to trunk roads

After considering ① and ② above, the following eight sections shown in Table 1-15 were selected.

Table 1-15 Projects Selected for the Feasibility Study

Road Section	Section No.
1) Nandaime - Guanacaste	A- 1
2) Guanacaste - Catarina	A- 2
3) Catarina - Masaya	A- 3
4) Masaya - Managua	C- 2
5) Rivas - Tola	B-103
6) Telica - La Cruz de la India	B-110
7) La Cruz de la India - San Isidro	B-111
8) Chinandega - El Viejo	B-115

After considering ③ above, road sections 5) and 8) were eliminated because they are apparently secondary roads. As a result, road sections 1), 2), 3), 4), 6) and 7) were recommended as Feasibility Study projects.

Nevertheless, in connection with the above selected road sections, the following road sections should also be improved at the same time given the need to ensure continuity of the trunk road (Central American Highway or NIC-1), although their priority level is lower than "*Middle-High*";

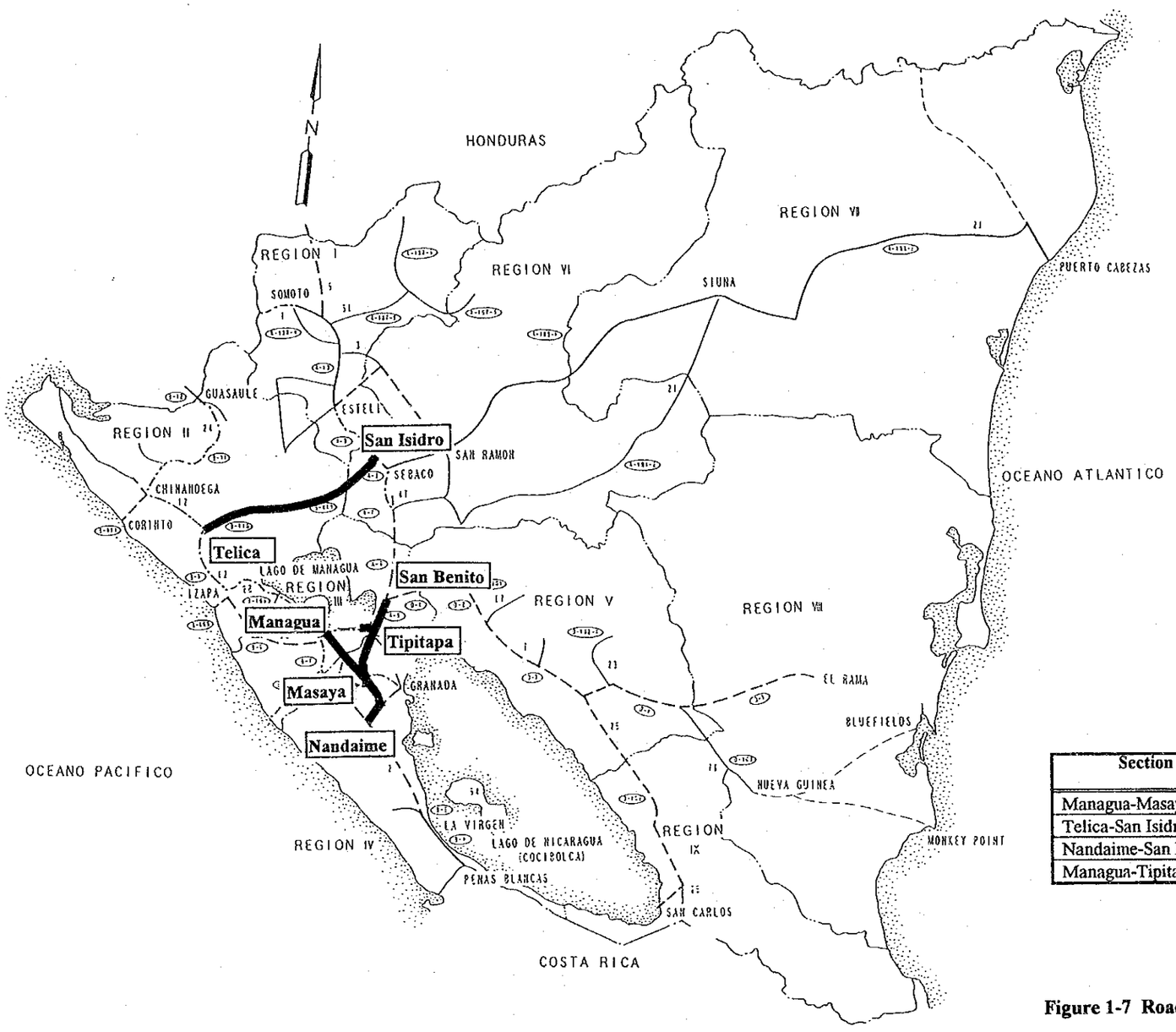
① Tipitapa-Int. San Cristóbal (Two-lane section from Tipitapa to Managua)
② Masaya - Tipitapa
③ Tipitapa - San Benito

In the case of the Tipitapa-Managua road section, the four-lane section (Managua-Int. San Cristóbal) is excluded, since its acts primarily as an intra-urban road, rather than as an inter-urban road.

The following four projects (Table 1-16) were eventually recommended for the Feasibility Study. Figure 1-7 shows the location of these four projects.

Table 1-16 Road Sections Selected for the Feasibility Study

Road Section	Distance
Masaya - Managua	29.0 km
Telica - San Isidro	96.8 km
Nandaime - San Benito	62.5 km
Tipitapa - Managua (two-lane section)	4.5 km
Total	192.8 km



Section	Road Length (km)	Description	
		Class	No. of Lanes
Managua-Masaya	29.0	TS-I (S)	4
Telica-San Isidro	96.8	TS-I	2
Nandaime-San Benito	62.5	TP-I	2
Managua-Tipitapa	4.5	TP-I	2

Figure 1-7 Road Sections Selected for the Feasibility Study

(8) Existing Bridges on the Roads

To reiterate, the road improvement and/or rehabilitation projects selected in the previous clause are urgent. Moreover, existing bridges on these roads must also be taken into account, as they represent an important part of the results of the Master Plan Study.

Generally speaking, almost all existing bridges were constructed long ago, and some of them have been damaged considerably because the current traffic load and volume are much greater than what was expected when these bridges were designed.

Moreover, recently many bridges have become the sites of traffic bottlenecks because they are too narrow and do not easy vehicle access.

The bridges listed in Table 1-17 below are in urgent need of major repair or total reconstruction.

Table 1-17 Bridges Requiring Urgent Repair or Reconstruction

Route No.	Bridge Name	Width(m)	Length(m)	Structure
Group I				
NIC-4	La Morita	7.0	9.0	RC-slab
NIC-4	El Arroyo	7.0	24.3	PCI
NIC-4	Mayaris	7.4	20.4	Simple Steel H Beam
NIC-4	El Arroyo No.1	7.0	20.0	PCI
NIC-26	Estero Real	7.0	58.0	RCT
NIC-26	El Guarumo	7.0	60.0	Two RC Slab +Two Girder
Group II				
NIC-2	Ochomogo	7.4	54.0	Truss
NIC-2	Gil Gonzales	7.4	37.0	Variable RCT
NIC-2	Las Lajas	7.4	47.0	Truss
NIC-7	Las Banderas	6.3	119.0	Truss+Five RCT
NIC-7	La Tonga	6.1	87.0	Truss+Two Plate Girder
NIC-12	Río Leona	7.4	18.5	Simple RC Two Girder
NIC-12	Telica	8.9	25.5	Simple RC Two Girder
NIC-12	Las Lanos	7.4	29.5	Three RC Slab
NIC-12	Cinco Cruces	7.5	26.7	Two RC Slab
NIC-24	La Pavona	7.4	16.2	Simple Two Girder
NIC-24	Río Negro 1	7.4	64.6	Four RCT Beam
NIC-24	Río Negro 2	7.4	60.0	Three RCT Beam
Group III				
NIC-1	Las Maderas	6.0	30.0	Truss
NIC-1	Sébaco	6.0	37.2	Tied Arch
NIC-1	El Venado	9.5	72.3	Simple Three PCT Beam

Note : RCT - Reinforced Concrete T Section
PCT - Prestressed Concrete T Section Beam
PCI - Prestressed Concrete I Section Beam

The Groups included in this table are defined as follows:

① Group I : Bridges included as part of the projects selected in the previous clause for the Feasibility Study carried out by the JICA Study Team. A preliminary engineering study of the measures required will be conducted during the Feasibility Study.

② Group II : Bridges located in road sections, which will be repaired with foreign funds.

③ Group III : Bridges located in the road network included in the Master Plan, not including those in Group I and II. More bridges will eventually be placed in this group when more detailed investigation is conducted. Only the bridges found at this stage of the Master Plan Study have been listed in Table 1-17. Not all bridges within the off-limit area were examined by the JICA Study Team.

Looking back on past road improvement or rehabilitation projects in Nicaragua financed by international agencies and foreign countries, it will be noted that work on bridges has often been excluded from projects because of limited funds.

When the projects related to the road sections that have bridges listed in Group II are formulated, the above-mentioned way would have a significantly real need for most fund suppliers since it will be possible to use limited funds more effectively.

2. FEASIBILITY STUDY

2. FEASIBILITY STUDY

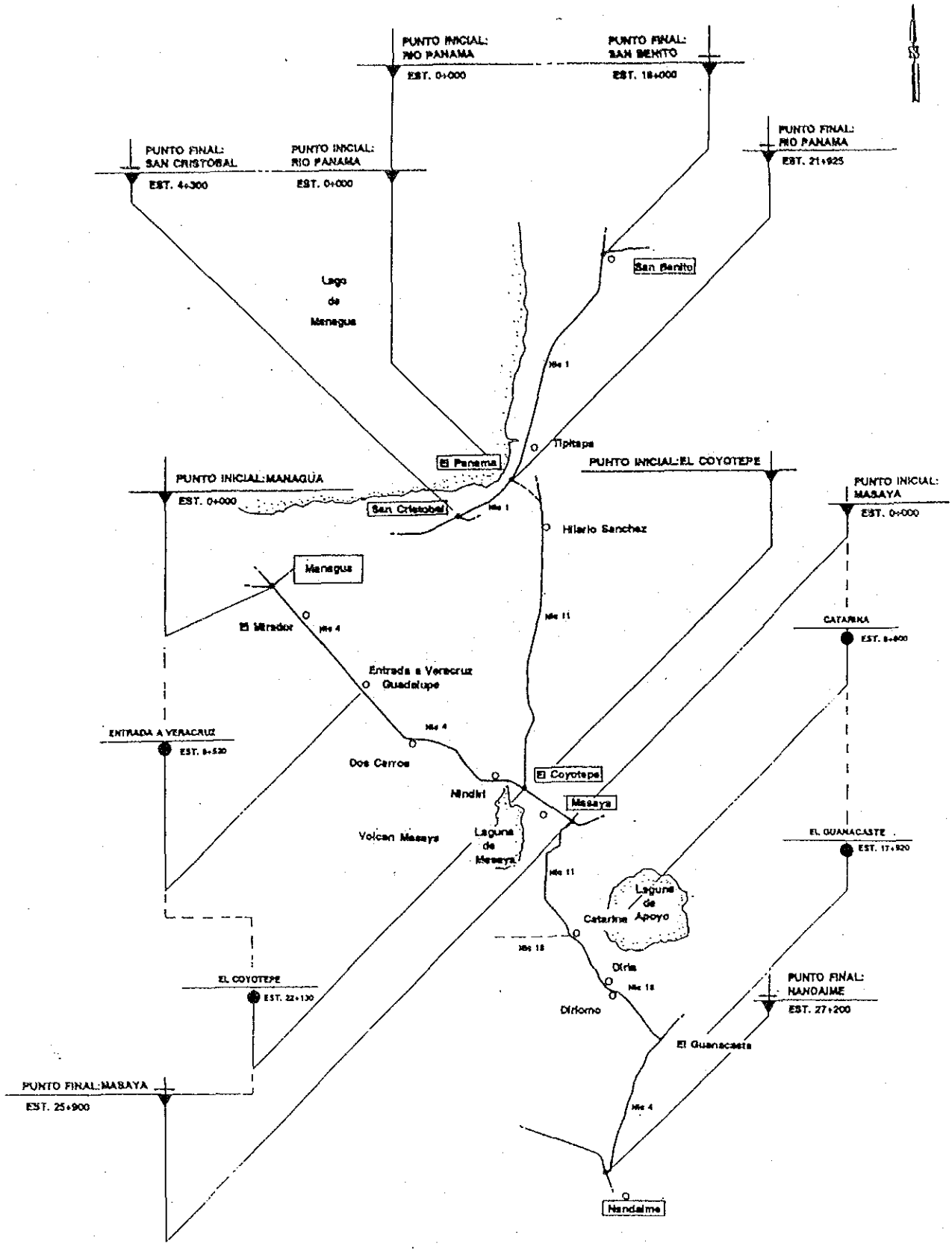
2.1 INTRODUCTION

(1) Objective of the Study

The objective of the Feasibility Study is to evaluate the technical and economic feasibility of the selected roads shown in Table 2-1 and Figure 2-1.

Table 2-1 Project Roads to Be Studied

Project Road	Section	Length (km)
Managua - Masaya	Managua(Est.0+0) - Entrada a Ticuantepe (Est.8+520)	8.520
	Entrada a Ticuantepe (Est.8+520) - El Coyotepe (Est.22+130)	13.610
	El Coyotepe (Est.22+130) - Masaya (Est.25+900)	3.770
	Total	25.900
Managua - Tipitapa	Río Panamá (Est.0+0) - San Cristobal (Est.4+300)	4.300
Nandaime - San Benito	Masaya (Est.0+0) - Catarina (Est.8+600)	8.600
	Catarina (Est.8+600) - El Guanacaste (Est.17+920)	9.320
	El Guanacaste (Est.17+920) - Nandaime (Est.27+200)	9.280
	El Coyotepe (Est.0+0) - Río Panamá (Est.21+295)	21.295
	Río Panamá (Est.0+0) - San Benito (Est.16+0)	16.000
	Total	65.125
Telica - San Isidro	Telica (Est.0+0) - Malpaisillo (Est.23+680)	23.680
	Malpaisillo (Est.23+680) - El Jicaral (Est.61+400)	37.720
	El Jicaral (Est.61+400) - La Unión (Est.79+830)	18.430
	La Unión (Est.79+830) - San Isidro (Est.95+760)	15.930
	Total	95.760
Total Length of the Project Roads		191.085



NANDAIME-SAN BENITO , MANAGUA-MASAYA

Figure 2-1 Location Map of the Project Roads (1)

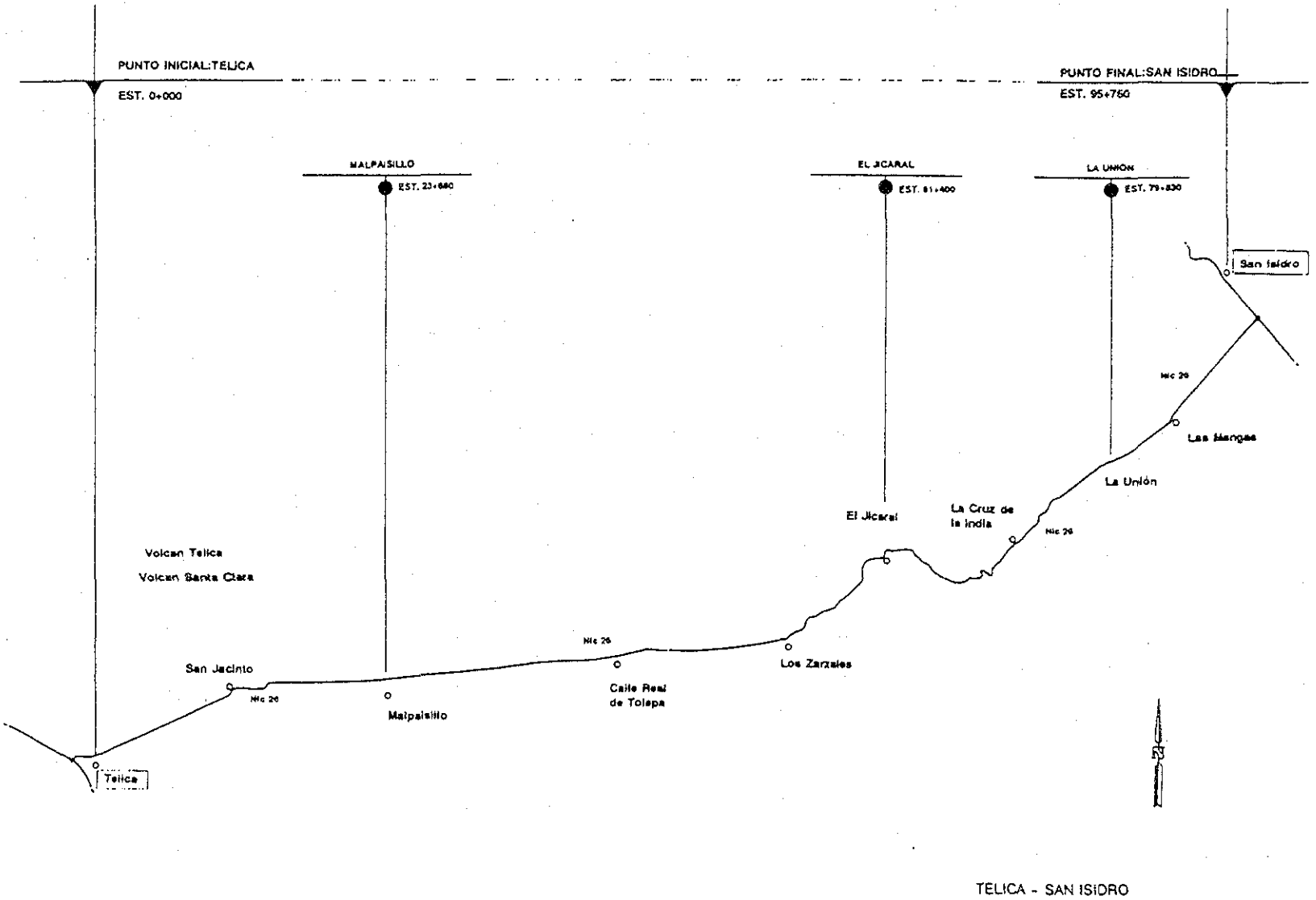


Figure 2-1 Location Map of the Project Roads (2)

2.2 EXISTING ROAD CONDITIONS

(1) Present Road Functions

The Project Roads are part of the national roads, and are classified as troncal principal or troncal secundaria. These Project Roads also function as north-south or east-west trunk roads in the national road network.

(2) Road Investigation

To clarify necessary improvement plans, investigations of road structure, drainage conditions, slope, cross section, horizontal and vertical alignment, bridges and drainage structures were carried out from several points of view, and results are summarized below.

Table 2-2 Road Structure Conditions

Project Road	Road Section	Existing Pavement	Existing Conditions
Managua-Masaya	Managua-Entrada a Ticuantepe	Asphalt Concrete Pavement	C
	Entrada a Ticuantepe-El Coyotepe	- do -	C
	El Coyotepe-Masaya	- do -	A
Managua-Tipitapa		Asphalt Concrete Pavement	B
Nandaime-San Benito	Masaya-Catarina	Asphalt Concrete Pavement	A
	Catarina-El Guanacaste	- do -	A
	El Guanacaste-Nandaime	Asphalt Double Treatment	B
	El Coyotepe-Río Panamá	Asphalt Treatment	D
	Río Panamá-San Benito	Asphalt Double Treatment	B
Telica-San Isidro	Telica-Malpaisillo	Asphalt Treatment	B
	Malpaisillo-El Jicaral	- do -	C
	El Jicaral-La Unión	- do -	D
	La Unión-San Isidro	- do -	C

Note : Existing conditions A - Critical, B - Progressive, C - Slightly Progressive, D - Fair

Table 2-3 Evaluation of Other Conditions

Project Road	Road Section	Drainage Conditions	Slope	Cross Section
Managua-Masaya		A	D	A
Managua-Tipitapa		B	C	C
Nandaime-San Benito	Masaya-Catarina	B	D	B
	Catarina-Guanacaste	B	C	C
	Guanacaste-Nandaime	B	B	B
	El Coyotepe-Río Panamá	C	B	B
	Río Panamá-San Benito	C	C	C
Telica-San Isidro	Telica-Malpaisillo	B	B	B
	Malpaisillo-El Jicaral	C	C	B
	El Jicaral-La Unión	C	B	C
	La Unión-San Isidro	B	B	B

Note : Conditions A - Poor, B - Poor-Fair, C - Fair, D - Fair-Good

Table 2-4 Substandard Sections on the Project Roads

Project Road	Road Section	Length of Substandard Section		Ratio of Substandard Section	
		Horizontal (km)	Vertical (km)	Horizontal (%)	Vertical (%)
Managua-Masaya		0.0	0.0	0.0	0.0
Managua-Tipitapa		0.0	0.0	0.0	0.0
Nandaime-San Benito	Masaya-Catarina	0.0	1.7	0.0	19.8
	Catarina-Guanacaste	0.0	1.4	0.0	15.0
	Guanacaste-Nandaime	0.0	0.0	0.0	0.0
	El Coyotepe-Río Panamá	0.0	0.4	0.0	1.8
	Río Panamá-San Benito	0.0	0.0	0.0	0.0
Telica-San Isidro	Telica-Malpaisillo	0.0	0.0	0.0	0.0
	Malpaisillo-El Jicaral	0.0	0.0	0.0	0.0
	El Jicaral-La Unión	1.5	1.1	8.4	6.2
	La Unión-San Isidro	0.0	0.0	0.0	0.0

(3) Geological and Soil Mechanical Investigation

Geological and soil mechanical investigation were carried out during the period from September 13 to October 31, 1993. The field work consisted of:

- Mechanical boring with penetration test
- Structure boring including a geological survey
- Study of rocks for a base course
- Study of soil materials for embankment by narrow pit
- Pit sampling and observation of existing road sections

A total of 156.54 long mechanical boring including standard penetration tests in 10 holes, was carried out at 3 locations along the Managua-Masaya Road, and that of 201.54 km long in 10 holes was conducted at 3 locations along the El Guanacaste-Nandaime section. The results were all fair for designing bridge foundation and river bank foundations for the Agua Agria River.

A total of 123.16 km long structure boring in 9 holes, including a surface geological survey, was carried out at 2 locations, where cutting and filling of the road on a large scale was programmed, along the Telica-San Ishidro section. Also a surface geological survey was conducted at the northern road cutting of the El Arroyo surface geological survey were satisfactory for designing cutting and filling of the programmed road.

Two samples, each of 50 kg, were collected from Proinco's gravel quarry in Veracruz and BOC's Cosmapa gravel quarry in southern Chinandega, and analyzed with unit weight.

Size distribution, water absorption and Los Angeles abrasion test. Basaltic gravel collected from both quarries was useful for pavement and base course.

Two borrow pit samples, each of 30 kg, were collected from the East Luis quarry along the Tipitapa-Masaya section and the San Jacinto quarry about 10 km east of Telica, and analyzed with Atterberg limits, size distribution and CBRs. Soil samples from the both locations show a minimum CBR values. Therefore, only selected materials might be able to supply as sub-soil materials.

A total of 20 samples were collected and investigated by each manual pit of 1 m long, 1 m wide and 1.5 m deep from all the road sections except the Managua-Masaya section, where a study was completed by the MCT before. Only three locations, i.e. one along the Tipitapa-Masaya section and two along the Telica-San Ishidro section, showed CBR values below 5%, and the others showed from 18-20 in Group Index.

(4) Hydrological Considerations

a) Design Rainfall Intensity

Design rainfall intensity was calculated so that discharge could be estimated for drainage design including roadway surface drainage and cross drainage. Rainfall intensity data obtained from at the rain gauge stations located near the Project Roads was applied in designing the drainage. The application of rainfall intensity for each project road is as follows:

- Managua-Masaya : Las Mercedes
- Managua-Tipitapa : Las Mercedes Nandaime-San Benito
  (Masaya-Nandaime) : Nandaime
  (El Coyotepe-Nandaime) :Las Mercedes
- Telica-San Isidro : León

b) Probable Flood Peak

The main reason for estimating the probable flood peak was to review the openings of existing bridges on the project roads, and to provide guidance for the rehabilitation of bridges

in view of existing hydraulics. The return period of the probable flood peak was estimated to be 50 years.

Table 2-5 Probable Flood Peak

(Unit: m^3/sec)

Project Road	Location	Drainage Area (km^2)	Probable 50-year Flood Peaks (m^3/sec)
Managua-Masaya	Sta. 8+170	86	406
Nandaime-San Benito (El Guanacaste-Nandaime)	Sta. 21+350	60	358
	Sta. 25+200	93	396
	Eroded Section	94	477
Telica-San Isidro	Sta. 23+200	8	76
	Sta. 45+970	38	246
	Sta. 54+480	10	100
	Sta. 61+430	424	1,592
	Sta. 66+810	7	65
	Sta. 68+180	52	328
	Sta. 94+205	47	269

2.3 TRAFFIC DEMAND

The present and future O-D Tables prepared in the Master Plan stage were dissolved for the purpose of predicting traffic volume on the selected roads more precisely for the Feasibility Study. Since the zones along the Project Roads were divided into between two and four zones, the total number of zones was expanded to from 33 to 54 zones

Using the above O-D tables, traffic volume on the Project Roads was forecast. Traffic volume on the road section between the intersection of Colonia Centro América and Est.02+410 was forecast at 43,492 vehicles/day by 2010. The projected traffic volumes on the Project Roads are shown in Figure 2-2.

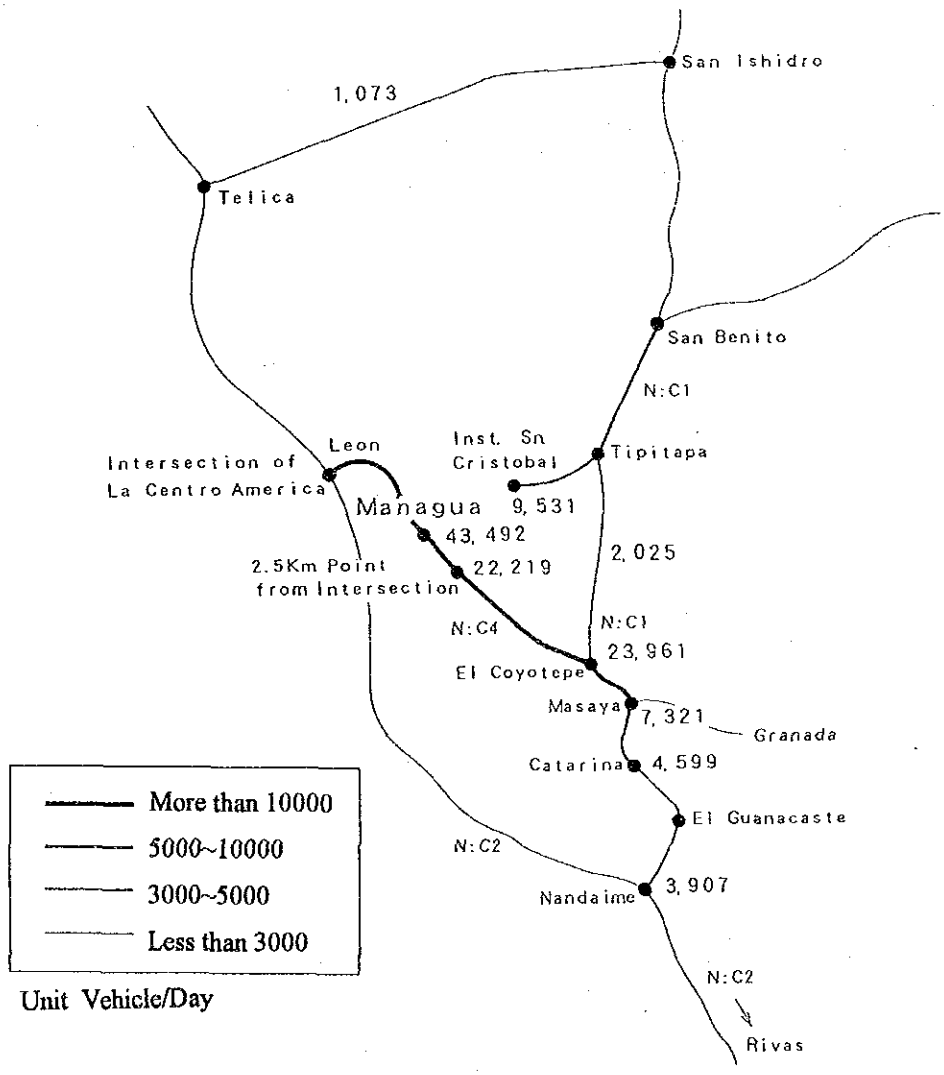


Figure 2-2 Traffic Volume on the Project Roads in 2010

2.4 ENVIRONMENTAL IMPACT ANALYSIS (EIA)

Ten environmental items, namely, traffic conditions, air quality, water quality, noise and vibration, land, soil, water, flora, landscape and social conditions were selected for the EIA.

The present condition of each environmental was investigated, and predictions and evaluations for 2000 and 2010 were provided. As a result of this examination, the minor influences of traffic conditions, air quality, water quality, noise and vibration, land, soil, flora, landscape and social conditions were identified to be as shown in Table 2-6.

Table 2-6 Integrated Environmental Evaluation

Environmental Item	Evaluation of the Whole Area	Integrated Evaluation
1) Air quality	2-3	3
2) Water quality	2-3	3
3) Soil contamination	3	-
4) Noise and vibration	2-3	3
5) Land subsidence	3	-
6) Odor	3	-
7) Land	2-3	3
8) Soil	2-3	3
9) Water	2-3	3
10) Underground water	3	-
11) Sea and seashore	3	-
12) Meteorology	3	-
13) Flora and fauna	2-3	3
14) Landscape	3	3
15) Waste	2-3	3
16) Historical and natural monuments	3	-
17) Traffic	3	3
18) Sanitation	3	-
19) Hazards	2-3	3
20) Relocation	2-3	3
21) Socio-economic conditions	3	-
22) Cutting district	3	-
23) Safety	2-3	3
24) Community	3	-
25) Recreation facilities	3	-
26) Water rights and rights of common	3	-

Note - Evaluation results : 1 : Major influence
2 : Minor influence
3 : Very minor or no influence
"-" in the integrated evaluation results means no environmental plan.

The influences of environmental items including land, soil, flora, landscape and social condition are expected to be minimized by the environmental management plan. However, air quality, water quality, noise and vibration conditions will become worse than at present in some places, therefore, it will be necessary to set up air quality, water quality, and noise

and vibration monitoring systems, and then control traffic conditions on the basis of monitoring results.

It is recommended that the environment be closely monitored during the construction and use of roads. The environmental items that require monitoring are air quality, water quality, noise and vibration. The monitoring contents are shown in Table 2-7.

Table 2-7 Contents of Monitoring

Environmental Item	Components	Location	Remarks
Air quality	NOx, CO, SPM, SOx, HC, O_3	Managua-Masaya Road	Air pollution monitoring
Noise and Vibration	dB(A), dB(B)	Managua-Masaya Road	Noise and vibration monitoring
Water quality	SS	Construction field	SS measurement

2.5 PRELIMINARY ENGINEERING STUDY

(1) Road Improvement Plan

a) Basic Policies

The objectives of the priority projects are as follows:

- To strengthen the north-south and east-west road links in the trunk road network
- To realize of a trunk road network that can accommodate high-capacity transport

Taking into account the above objectives, the following factors were considered during the development of the road improvement plan.

① Functions of the project road
② Considerations in establishing design criteria
③ Determination of appropriate geometric designs
④ Improvement of road surfaces
⑤ Rehabilitation / improvement of drainage system
⑥ Consideration of sidewalk and busbays
⑦ Project year
⑧ Widening of the existing road (only for Managua-Masaya Road)
⑨ Improvement of the existing intersection (only for Managua-Masaya Road)

b) Road Class and Number of Lanes

The road class (improvement level) for each project road was determined on the basis of determinations made during the Master Plan Stage. The number of lanes were determined by applying of highway capacity analysis method described in the Highway Capacity Manual.

c) Design Criteria

Nicaraguan design criteria were used whenever available. The recommended geometric design criteria for the project roads are shown in Table 2-9

Table 2-8 Road Class and Number of Lanes

Project Road	Road Class	Design Capacity (veh./hr/lane)	Directional Design Hourly Volume (veh./hr)	Number of Lanes
Managua-Masaya	TP-I (S)	1,400	2,600	4
Managua-Tipitapa	TP-I	800	900	2
Nandaime-San Benito	TP-I	700	800	2
Telica-San Isidro	TS-I	300	100	2

Table 2-9 Geometric Design Criteria for the Project Roads

Item		Unit	Application							Remarks
					Nandaime-San Benito		Telica-San Isidro			
			Managua-Masaya	Managua-Tipitapa	Masaya-Nandaime	El Coyotepe-San Benito	Telica-El Jicaral	El Jicaral-La Unión	La Unión-San Isidro	
Minimum Right-of-way Width		m	40	40	40	40	40	40	40	
Design Speed		km/hr	80	100	80	100	80	60	80	Discussed above
Lane Width		m	3.5	3.5	3.5	3.5	3.5	3.5	3.5	- ditto -
Median	Raised Width	m	3.0	-	-	-	-	-	-	- ditto -
	Inner Shoulder Width		0.5×2 sides	-	-	-	-	-	-	- ditto -
	Median Width		4.0	-	-	-	-	-	-	- ditto -
Outer Shoulder Width		m	2.5	2.5	2.5	2.5	1.5	1.5	1.5	- ditto -
Sidewalk Width		m	5.0		3.0	3.0	3.0	3.0	3.0	- ditto -
Minimum Stopping Sight Distance		m	120	160	120	160	120	80	120	Referred to sight distance for wet pavement on AASHTO recommendation
Minimum Radius Curvatures		m	255	415	255	415	255	135	255	Referred to AASHTO recommendation
Maximum Vertical Gradient		%	4 (7)	3 (5)	4 (7)	3 (5)	4 (7)	6 (8)	4 (7)	The value of the existing design criteria in Nicaragua was referred from the practical view points, and the parenthesized figure referred to the recommendation on the 1989 Study
Rate of Vertical Curvature (K-Value)	Crest	-	48 (33)	94 (57)	48 (33)	94 (57)	48 (33)	24 (18)	48 (33)	Referred to AASHTO recommendation
	Sag		33 (27)	48 (36)	33 (27)	48 (36)	33 (27)	21 (18)	33 (27)	
Crossfall		%	2.0	2.0	2.0	2.0	2.0	2.0	2.0	
Maximum Superelevation		%	6.0 (10.0)	6.0 (10.0)	6.0 (10.0)	6.0 (10.0)	6.0 (10.0)	6.0 (10.0)	6.0 (10.0)	

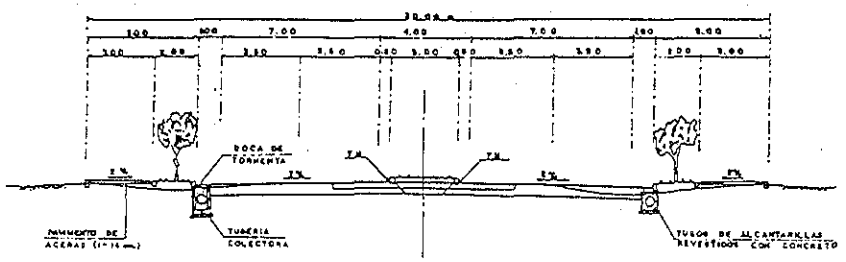
Note : ( ) shows absolute minimum values

(2) Preliminary Design

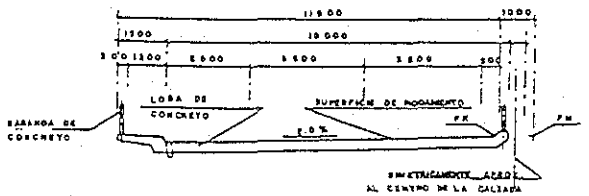
a) Geometric Design

The typical cross sections shown in Figure 2-3 were recommended for each project road. It is recommended that sidewalks and busbays be installed at several locations along each Project Road. In determining the horizontal and vertical alignment of each project road, the following factors were considered.

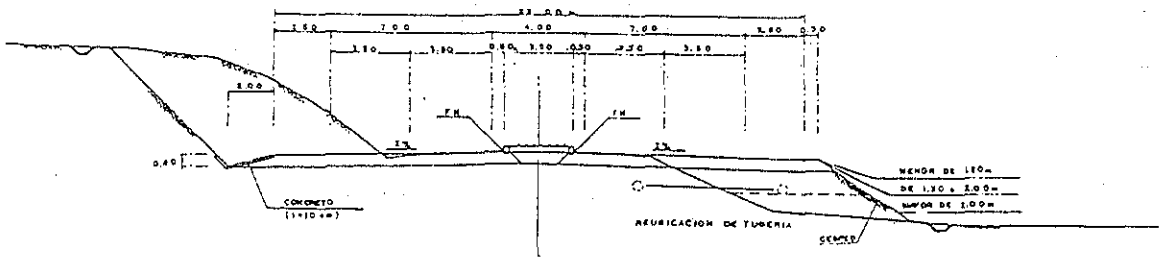
MANAGUA — MASAYA



SECCION TIPICA CON ACERA
ESCALA 1:100



SECCION DE PUENTE
ESCALA 1:100



SECCION TIPICA SIN ACERA
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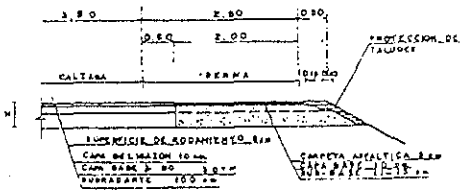
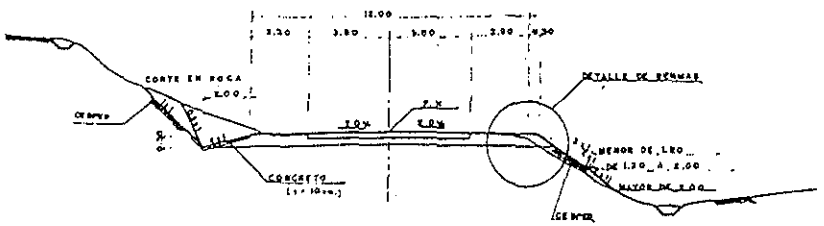


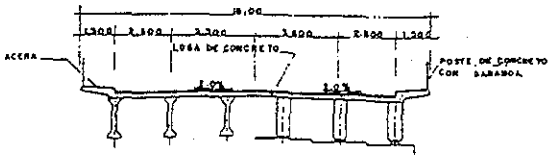
DETALLE DE BERMAS
SIN ESCALA

Figure 2-3 Typical Cross Section (1)

NANDAIME - MASAYA-TIPITAPA - SAN BENITO, TIPITAPA - SAN CRISTOBAL



SECCION TIPICA



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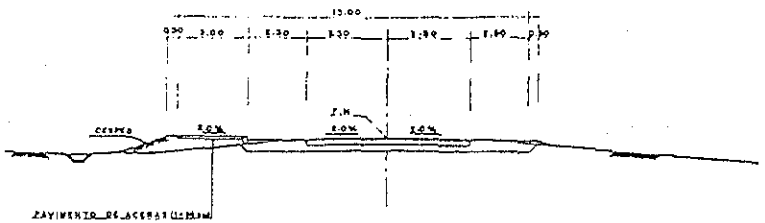
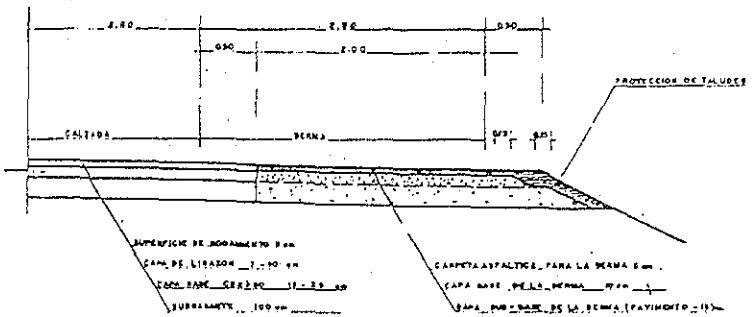


SECCION CON UNA ACERA



DETALLE DE BERMAS

Figure 2-3 Typical Cross Section (2)

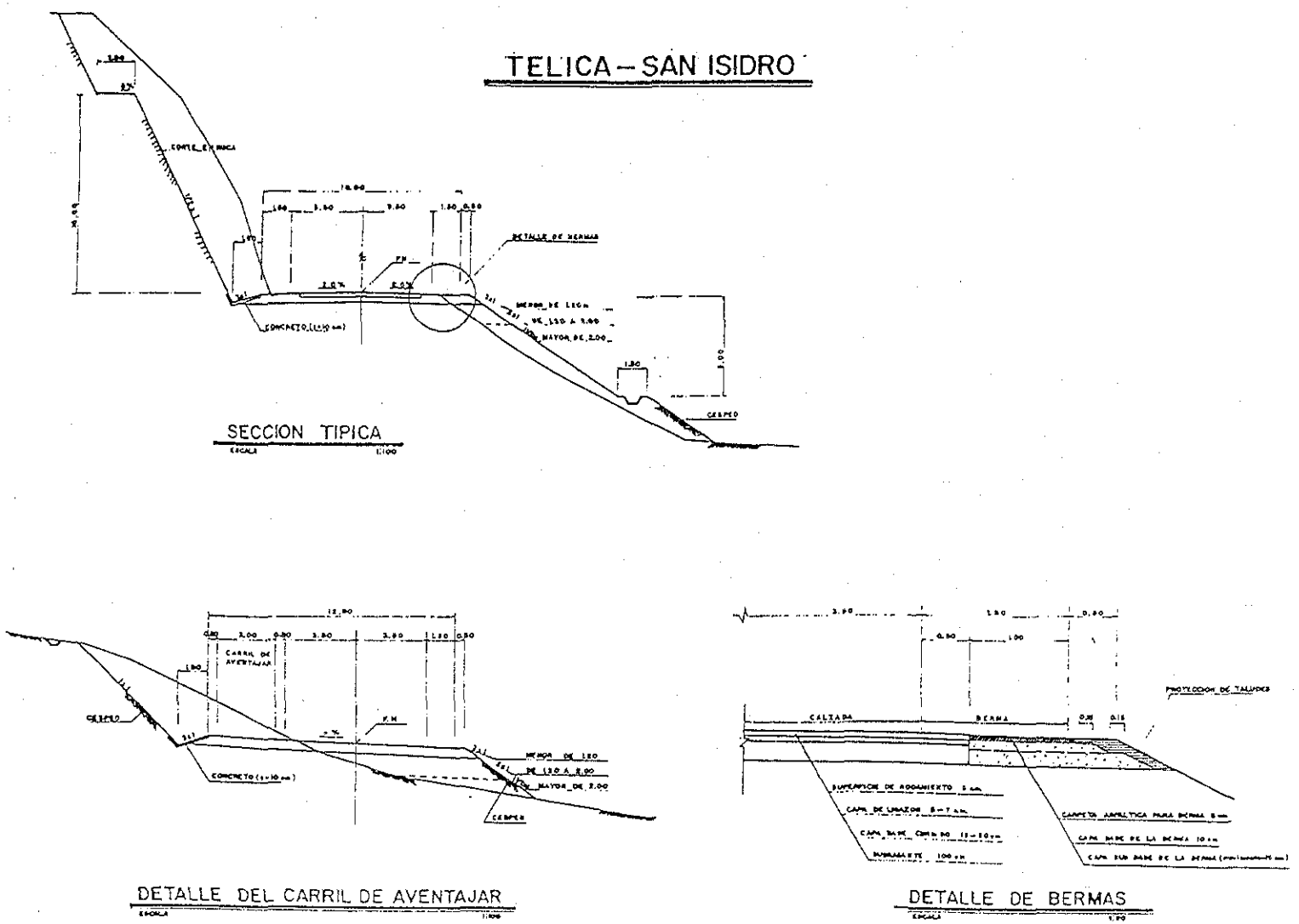


Figure 2-3 Typical Cross Section (3)

① Managua-Masaya Road

- Two alternatives were proposed for Improving the intersection Colonia Centro América.
  - Improving the existing at-grade intersection by installing a sufficient number of lanes and storage length (Alternative-1).
  - Construction of a flyover for through traffic from/to Tiscapa/Masaya (Alternative-2).
- Shifting the center line on the La Morita Bridge
- Shifting the center line and improving the vertical alignment on the El Arroyo Bridge, and avoiding transmission line tower.
- Improving the at-grade railway crossing at Est.21+860, and improving the vertical alignment of the intersection with NIC-11.

② Nandaime-San Benito Road

- Improving the vertical alignment of the whole Masaya-Catarina section, as well as between Est.9+000 and Est.12+400 in the Catarina-El Guanacaste section
- Shifting the center line on the El Arroyo No. 1 Bridge
- Providing countermeasures for river bank erosion along the Agua Agria River by installing stone masonry.
- Considering a bypass to NIC-1 to avoid the need for land acquisition in central area of Tipitapa.
- Improving the vertical alignment at possibly flooded sections before and after Est.3+000 on Río Panamá-San Benito section.

③ Telica-San Isidro

- Considering a new alignment before and after Est.+63+600, and between Est.68+200 and Est.71+100.

b) Pavement Design

Considering the present economic situation of Nicaragua, a flexible pavement was recommended because it requires lower initial investment costs, and a shorter construction time, while offering more comfortable riding conditions

The thickness was designed based on time constraints (analysis period : 20 years, performance period : 15 years), traffic forecast, axle load model and roadbed soil characteristics.

c) Drainage Design

To ensure proper drainage, longitudinal side ditches not only in the cut section but also on the embankment slope were considered. The lateral pipe/box culverts at appropriate intervals were also considered.

d) Bridge Design

- The existing La Morita Bridge and El Arroyo Bridge on the Managua-Masaya Road must be completely reconstructed and widened.
- The existing El Arroyo No. 1 Bridge on Nandaime-San Benito Road must also be reconstructed.

(3) Construction Plan

a) Construction Method

The intensive equipment construction method should be adopted to keep costs down and shorten the required construction period.

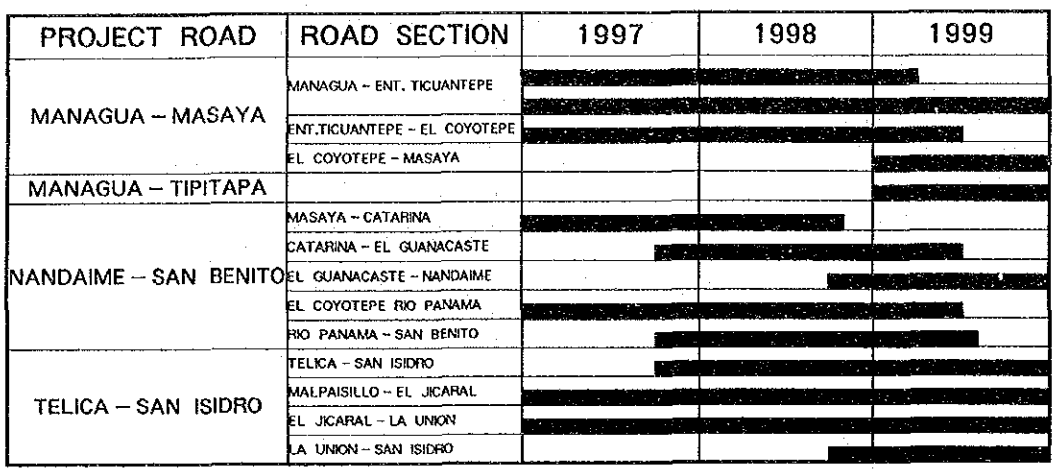
b) Construction Time Schedule

Taking into account the scale of construction, the maximum construction period was set at 3 years. The construction time schedule for each project road was prepared as shown in Figure 2-4.

(4) Maintenance Program

The maintenance program dividing the main activities into routine maintenance, periodic maintenance and incidental maintenance, was proposed.

Figure 2-4 Construction Time Schedule



(5) Project Cost Estimation

a) Estimation Conditions

The basic premises in estimating project costs were the followings:

- All construction works will be executed by contractors employed for the development of the project roads.
- The unit price of each cost component has been determined based on economic conditions prevailing in 1993.
- Project costs were divided into local and foreign portions. Equipment and imported materials were assumed to be part of the foreign portion.
- Nicaraguan taxes will be imposed on all construction work and engineering services.
- Physical contingency was estimated to be 10% of the total construction costs and engineering costs.

b) Estimated project costs

Project costs were estimated as shown in Table 2-10.

Table 2-10 Estimated Project Costs

(Unit : 1,000 Córdobas)

Item		Managua-Masaya		Managua-Tipitapa	Nandaime - San Benito	Telica - San Isidro
		1st Section	2nd Section			
Construction Cost	Local	41,524	52,247	7,734	118,685	131,435
	Foreign	35,624	44,785	5,322	91,258	99,014
	Total	77,148	97,032	13,056	209,943	230,449
Engineering Cost	Local	5,465	6,876	1,018	15,620	17,298
	Foreign	4,688	5,894	700	12,011	13,031
	Total	10,153	12,770	1,718	27,631	30,329
Subtotal	Local	46,989	59,123	8,752	134,305	148,733
	Foreign	40,312	50,679	6,022	103,269	112,045
	Total	87,301	109,802	14,774	237,574	260,778
Contingency	Local	4,699	5,912	875	13,431	14,873
	Foreign	4,031	5,068	602	10,327	11,205
	Total	8,730	10,980	1,477	23,758	26,078
Total	Local	51,688	65,035	9,627	147,736	163,606
	Foreign	44,343	55,747	6,624	113,596	123,250
	Total	96,031	120,782	16,251	261,332	286,856
Annual Operation and Maintenance Cost	Local	107	219	54	821	1,207
	Foreign	0	0	0	0	0
	Total	107	219	54	821	1,207
Overlay Cost	Local	3,727	6,302	851	15,421	20,289
	Foreign	4,532	7,655	1,038	18,941	24,818
	Total	8,259	13,957	1,889	34,362	45,107

Note : 1st Section - Managua-Entrada Ticuantepe
2nd Section - Entrada Ticuantepe-Masaya

2.6 ECONOMIC EVALUATION

(1) Economic Analysis Premises

The four Project Roads were economically evaluated. The following selected road cases were examined.

Table 2-11 Selected Road Projects

Project Road	Project No.
(1) Managua-Masaya	
* Managua-Entrada a Ticuantepe	
- At-grade intersection	Project-1
- Grade-separated intersection	Project-2
* Entrada a Ticuantepe-Masaya	Project-3
(2) Managua-Tipitapa	Project-4
(3) Nandaime-San Benito	Project-5
(4) Telica-San Isidro	
- Including improvement of alignment	Project-6
- Partial improvement	Project-7

The basic assumption for this evaluation are summarized as below:

- Construction period : from 1997 to 1999
- Project life : 23 years from 1997 to 2019
- Basic price : 1993 price
- Residual Value : None

Several of the benefits of the project described in previous section were assessed qualitatively:

- Vehicle Operation Cost Saving
- Travel Time Cost Saving
- Maintenance Cost Saving

(2) Economic Project Cost

Project costs, maintenance costs and periodic overlay costs in economic cost terms were calculated as shown in Table 2-12.

Table 2-12 Economic Project Costs, Economic Maintenance Costs and Economic Overlay Costs

Project No.	Financial Cost *			Economic	Economic	Economic
	Local Portion	Foreign Portion	Total	Project Cost	Maintenance Cost	Overlay Cost
Project-1	46,989	40,313	87,302	67,563	89	6,255
Project-2	52,389	55,612	108,001	82,754	89	6,225
Project-3	59,124	35,475	109,803	84,981	183	10,571
Project-4	8,752	6,022	14,774	11,549	45	1,431
Project-5	134,305	103,269	237,574	184,787	686	26,012
Project-6	148,734	112,045	260,779	203,027	1,009	34,152
Project-7	99,652	75,070	174,722	136,028	1,009	34,152

Note : * - Financial cost excluding contingency

(3) Economic Evaluation

By applying flow of economic costs and benefit, Internal Rate of Return (IRR), Net Present Value(NPV) and Benefit Cost Ratio (B/C) were calculated for each project. Table 2-12 shows the results of this evaluation.

- All projects except Project-6 and Project-7 show high indicator values of, therefore, these projects can be considered feasible.
- In the case of Project-7, the value of IRR is not so high. Nevertheless, it can also be considered feasible, since the IRR value of 12.24% exceeds the lending criteria of CABEI.
- Project-6 is not feasible, therefore, it is recommended that the implementation of this project be postponed.

Table 2-13 Result of Evaluation

	Project-1	Project-2	Project-3	Project-4	Project-5	Project-6	Project-7
IRR (%)	46.00	41.97	38.43	31.90	21.07	4.42	12.24
NPV (1000C$)	256,409	235,530	213,505	11,909	120,358	(73,239)	1,392
B/C	5.56	4.48	4.10	2.38	1.80	0.53	1.02

(4) Financial Considerations

According to maintenance expenditures for paved roads determined by MCT in 1992 and 1993, about 3 million Córdobas are allocated to road maintenance each year. Considering the present financial situation of MCT, project costs should be covered by low-interest loan from international lending agencies or foreign donor countries.

2.7 CONCLUSIONS AND RECOMMENDATION

(1) Conclusions

The selected projects are of great importance for development of Nicaragua, and are expected to play the following important roles in the future:

a) Managua-Masaya Road

- Relief of traffic congestion at the intersection of Colonia Centro América, one of the biggest bottlenecks in traffic flow in the capital.
- Contribution to the improvement of urban transport in Managua, where traffic demand has recently been increasing at a remarkable pace.
- Strengthening and supporting urban development in the area between Managua and Masaya, where new housing projects are expanding at a rapid pace.
- Contribution to the realization of high-capacity transport in response to inter-regional and international transport demand.

b) Managua-Tipitapa Road

- Strengthening and supporting the transport of agricultural products from the Central Regions, a major productive area, to Managua, the center of consumption.
- Contributing to the realization of high-capacity transport in response to inter-regional transport demand.

c) Nandaime-San Benito Road

- Strengthening the trunk road network in the Managua-Masaya Metropolitan Area.
- Strengthening and supporting the transport of agricultural products from the Central Regions, a major productive area, to Managua, the center of consumption.
- Contributing to the realization of high-capacity transport in response to the inter-regional and international demand.

d) Telica-San Isidro Road.

- Contributing to the strengthening of east-west trunk roads in the nation-wide road network.
- Contributing to the promotion of export by supporting the expected future increase in the transport of agricultural products from the Central Regions to the major port, Corinto.

(2) Recommendations

a) Feasibility of Projects

The results of the Study indicate that all Projects are technically and economically feasible, except for Telica-San Isidro Road. Taking into account the direct and enormous indirect benefits for regional development, besides the quantified savings in travel costs, the Projects should be implemented at the earliest opportunity.

b) Establishment of a Monitoring System to Assess Environmental Impacts

Monitoring is considered necessary to preserve the environment during and after construction of the Project. Establishment of air pollution, water quality, and noise and vibration monitoring system for this purpose in the detailed design stage is strongly recommended.

c) Relocation of Utilities

Detailed investigations, and negotiations with related offices for relocation of utilities will be necessary in the detailed design stage of the project.

d) Need for Rehabilitation of the Managua-Masaya Road after the Year 2010

A preliminary engineering study and economic evaluation for this Project Road were conducted based on the predicted traffic volume after 2010. This study proposed that the Project Road be overlaid with pavement in 2014.

e) Maintenance Program

Basically, maintenance work in Nicaragua is neither classified by implementation period nor scale. Hence, the maintenance program are required for the project roads, dividing the main maintenance activities into routine maintenance, periodic maintenance and incidental maintenance.

f) Feasibility of the Telica-San Isidro Road Project

For the Telica-San Isidro Road, upgrading of the existing road section including improvement of road alignment (Project-6) was judged as unfeasible by the evaluation. On the other hand, Project-7, consists of the improvement of the asphalt course, base course, shoulder and drainage, was judged as feasible with high indicators for the evaluation.

Therefore, it is recommended to implement the improvement of the asphalt course for the whole section and partial improvement of the base course, shoulder and drainage for a certain stretch of the Project Road. It is also recommended that the road classification of this Project Road will be upgraded to a level proposed in the Study in compliance with the increase of traffic volume in the future.

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