2.6 TOPOGRAPHIC SURVEY

2.6.1 General

A topographic survey was carried out to obtain the data required for the feasibility study.

2.6.2 Scope of Survey

The scope of the survey was as follows:

① Longitudinal and cross-sectional survey

- Center line survey : 200 km
- Road spot height survey : 200 km
- Cross-sectional survey

② 1/10,000-scale map compilation : 40 km^2

③ 1/1,000-scale topographic survey : 100 ha

④ Existing drainage facilities survey

⑤ Survey of the Intersection of Colonia Centroamérica

2.6.3 Instruments Used

The main equipment used to conduct this survey was as follows:

① G.P.S. : (2) 4000SE and 4000ST - Trimble

② Theodolite : T2 and T16 - Wild

③ E.D.M. : DI3000 and DI1000 - Wild

④ Level : (3)NA2 - Wild

⑤ Micro-computer 386

2.6.4 Survey Method

All surveys were conducted, both horizontally and vertically, based on the local geodetic system - NORTH AMERICAN 1927 (Central American).

(1) Longitudinal and Cross-Sectional Survey

a) Center-Line Survey

A center-line survey was carried out along the existing roads by setting up 27 GPS control points and connecting these GPS control points through a traversing survey. At the same time, all bridges and culverts were observed, while these geodetic coordinates were calculated. Steel pins were set up at the GPS points and wooden pegs were staked and marked on the ground at approximately 400 m intervals through a transversing survey.

b) Road Spot Height Survey

A leveling survey approximately 200 km long, and spot elevation of the road center at 200 m intervals were conducted by referring to the existing bench mark.

c) Cross-Sectional Survey

A cross-sectional survey of the roads was conducted at intervals of 500 m over the flat area, and at intervals of 200 m over the hilly area, with a width of 120 m. All cross-sections were plotted on sepia-colored tracing paper at a scale of 1/200 both vertically and horizontally.

GPS observations were conducted simultaneously at 3 points by applying three units of Trimble (USA) 4000 as receiving devices, and during 2:30 hours of receiving five to eight satellites. The average of the closure errors of the respective session was 1.44 p.p.m. for a mean length of 48 km, and 4.35 cm for the Dh.

A leveling survey was carried out within the tolerance of the specified closure 6 cm/S, where S is the route length in kilometers.

(2) 1/10,000-Scale Map Compilation

Maps on a scale of 1/10,000 were prepared using enlarged versions of existing 1/50,000-scale printing maps.

The road center, main bridges and culverts, as well as the results of spot height leveling were plotted. The contour lines were revised by the cross-sectional survey data. The number of sheets was 18 for 5 routes (Figures 2-29 and 2-30).

(3) 1/1,000-Scale Topographic Map

Four sheets of 1/1,000-scale topographic map between Las Pilas and Cristalito (Telica-San Isidro Road) covering 100 ha were produced by a topographic survey to study the road center line modification (Figure 2-31).

(4) Existing Drainage Facilities Survey

To study bridges and culverts, a survey of existing drainage facilities survey was conducted. 1/10,000-scale topographic maps were produced for the five bridges and the river erosion site next to the road. Moreover, three cross-sectional and one longitudinal river surveys were conducted (Figures 2-32 and 2-33). Data on other surveyed bridges and culverts was also compiled.

(5) Survey of the Intersection of Colonia Centroamérica

A cross-sectional survey was conducted at intervals of 100 m at the approach portion to the intersection.

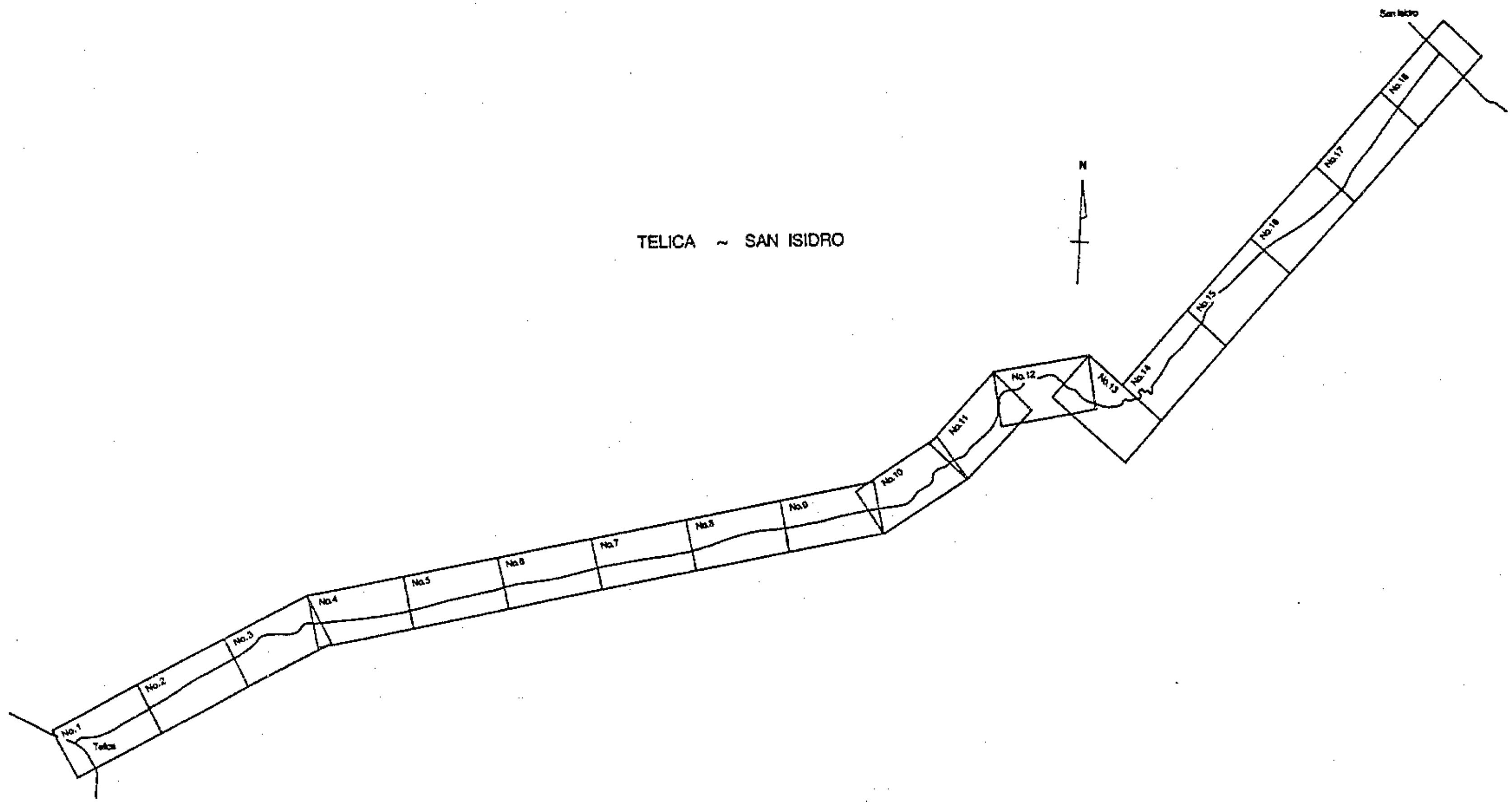

Figure 2-29 1/10,000-Scale Map Compilation (Telica-San Isidro Road)

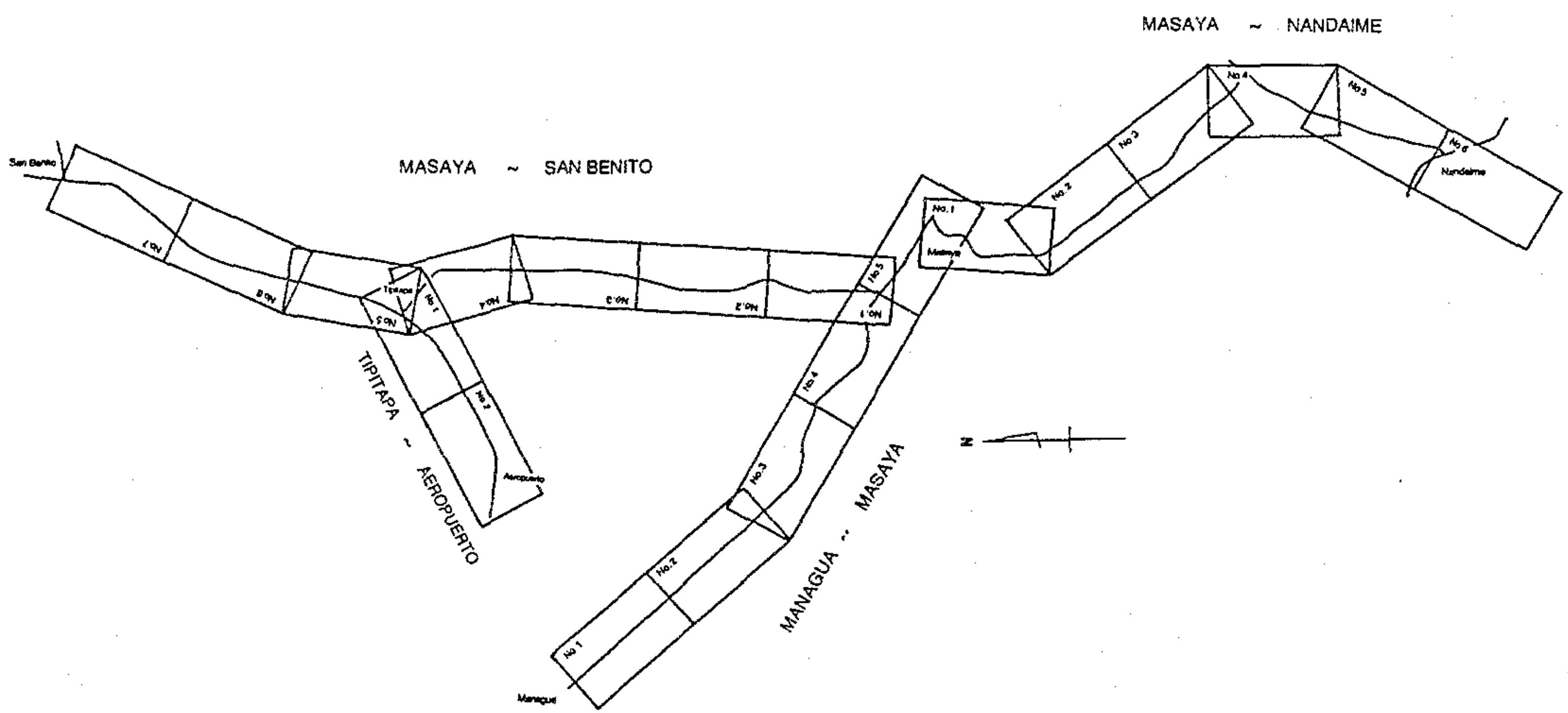

Figure 2-30 1/10,000-Scale Map Compilation (Other Project Road)

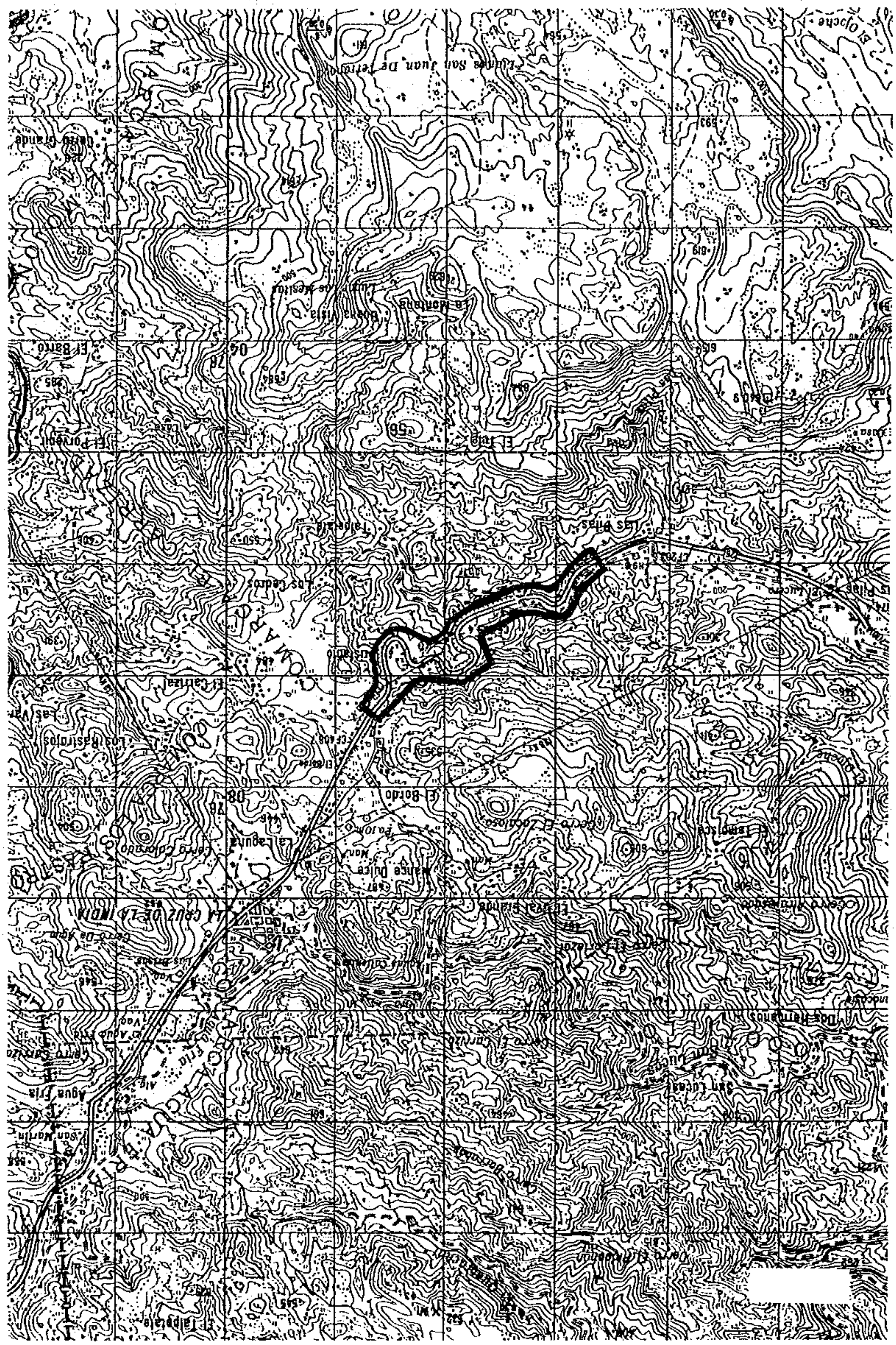

Figure 2-31 Survey Location of Road Center Line (Telica-San Isidro Road)

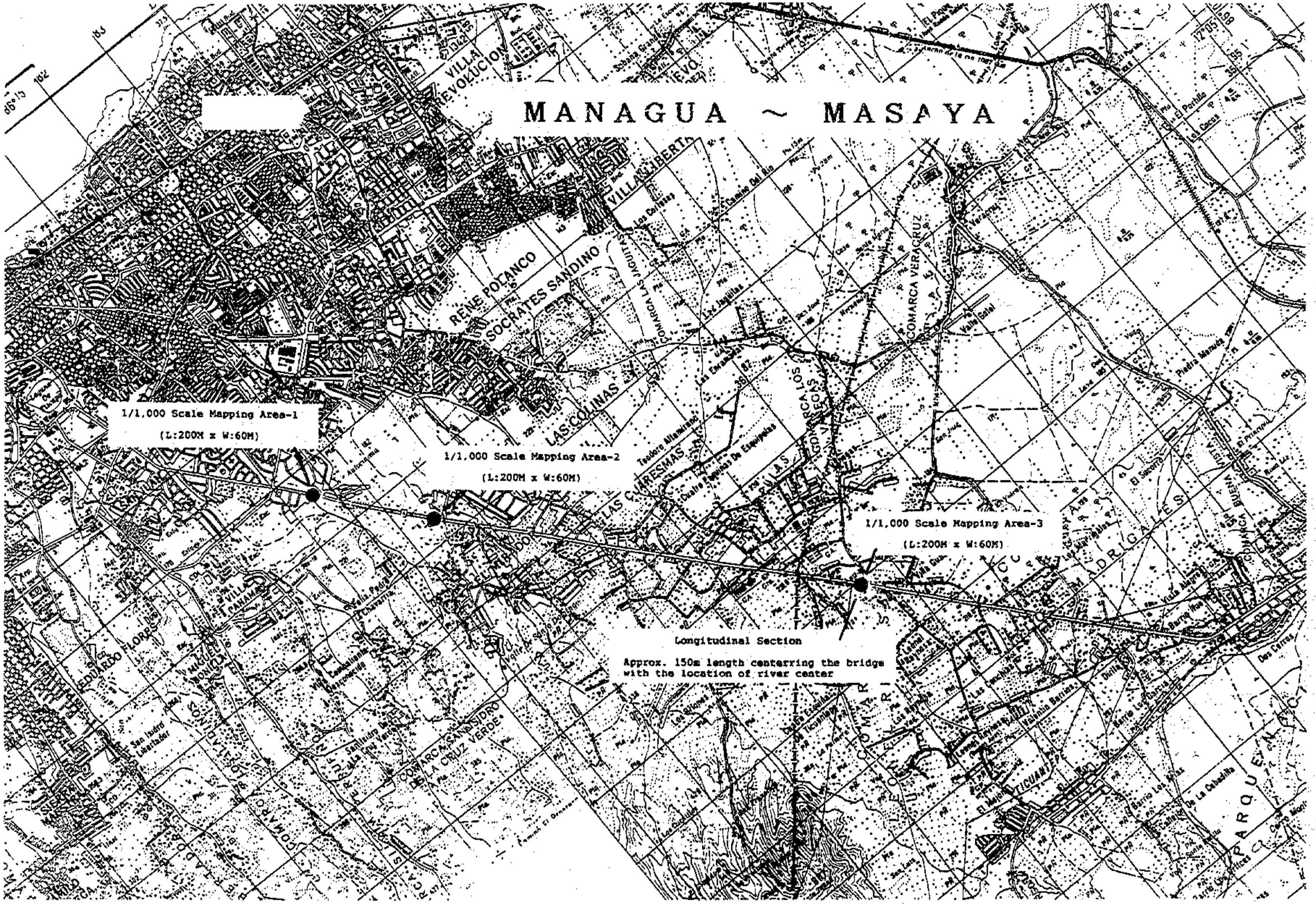

Figure 2-32 Location of Drainage Facilities (Managua-Masaya Road)

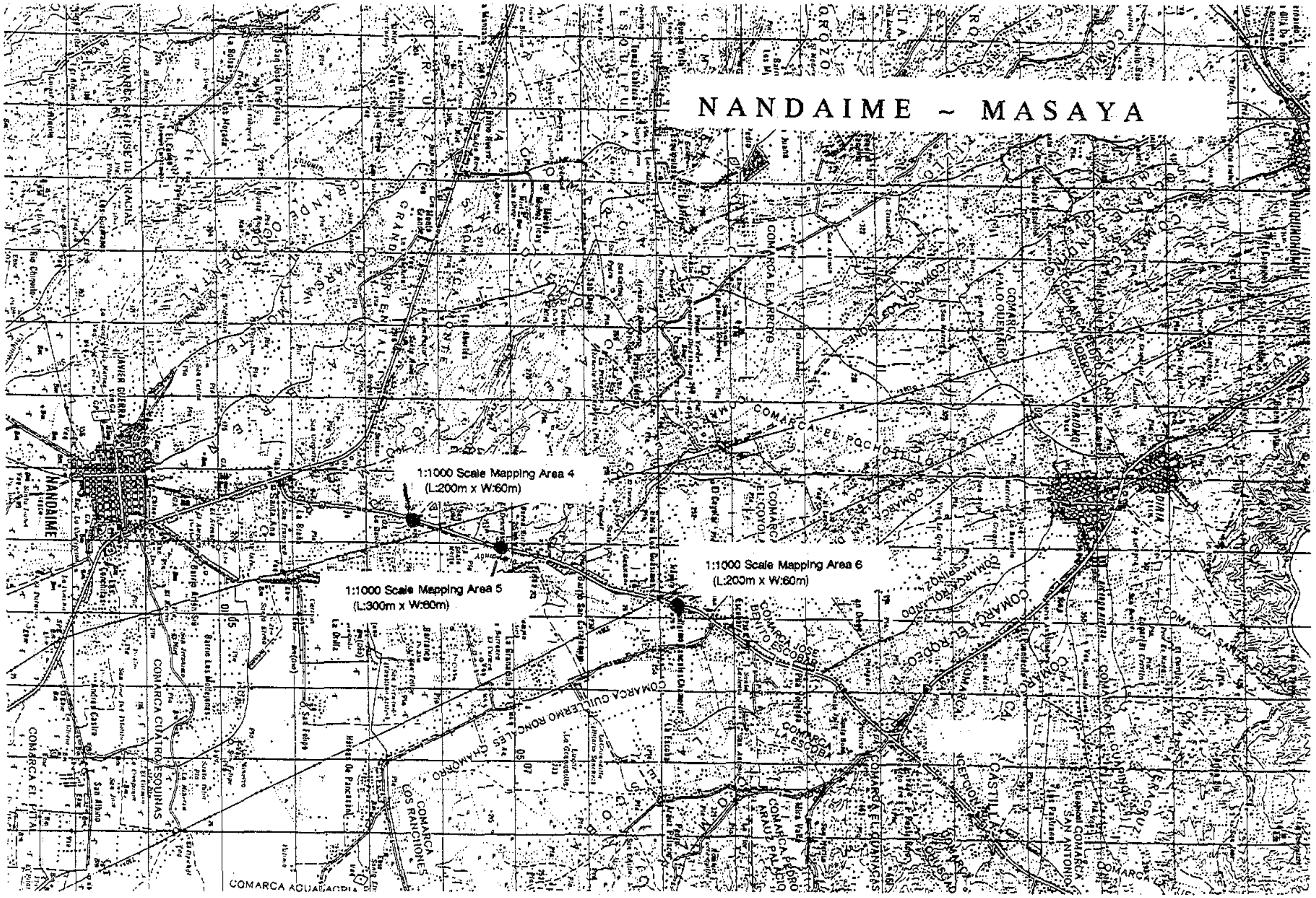

Figure 2-33 Location of Drainage Facilities (Nandaime-Masaya Section)

CHAPTER 3

PRESENT AND FUTURE TRAFFIC VOLUME

CHAPTER 3 PRESENT AND FUTURE TRAFFIC VOLUME

3.1 PREFACE

In the Master Plan Study, the future traffic volume was forecast for the major primary and secondary national roads on the basis of the current traffic volume and socio-economic situation. The process of this projection and the relevant results are indicated in the Master Plan Report.

As described in Chapter 1 of this report, four Project Roads (listed in Table 1-1) were selected for the Feasibility Study. The aim of this chapter is to project the future traffic volume on the Project Roads in more detailed in order to provide more detailed information about traffic volume, as this is necessary for assessing the economic feasibility of the Project Roads.

For this purpose, the national level O-D Table (composed of 33 traffic zones), which is shown in Chapter 9 of the Master Plan Report, was first divided into 57 zones. Then, present and future O-D Tables were established on the basis of these new zones. This process is shown in the Figure 3-1.

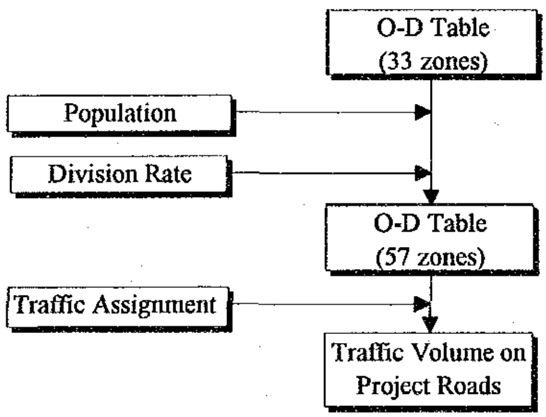

Figure 3-1 Process for Dividing O-D Table

3.1.1 Division of Zones

In order to clarify traffic movement in and around Managua, Masaya, Granada, etc. (the Project Roads are passing through these Departments except the Telica-San Isidro Road), Zones 4, 9, 10, 11, 12, and 31, listed in Table 4-8 in the Master Plan Report, were divided by the populations of the communities found in these zones. Table 3-1 summarizes the number of division, the populations of the communities, and the rate of division in each zone. The area along the Telica-San Isidro Road was not divided, since most of the main traffic passing along this road is through traffic. The divided O-D zone map is shown in Figure 3-2.

Table 3-1 Division of Zones

Old Zone	New Zone	1993		2000		2010	
		Population	Rate	Population	Rate	Population	Rate
4 Granada	4-1 Granada	91,527	0.575	114,121	0.575	148,600	0.586
	4-2 Dirimo	22,236	0.140	27,760	0.140	36,148	0.148
	4-3 Didia	9,058	0.057	11,292	0.057	14,701	0.058
	4-4 Nandaime	36,4411	0.229	45,399	0.229	59,115	0.233
9 Catarina	9-1 Catarina	6,340	0.082	7,906	0.082	10,296	0.082
	9-2 Oriente	3,003	0.039	3,746	0.039	4,880	0.039
	9-3 Concepción	24,416	0.317	30,443	0.317	39,640	0.317
	9-4 Others	43,305	0.562	53,988	0.562	70,293	0.562
10 Masaya	10-1 Masaya	101,433	0.725	126,471	0.725	164,678	0.725
	10-2 Nindri	26,085	0.186	32,523	0.196	42,348	0.186
	10-3 Tisama	12,466	0.089	15,545	0.089	20,243	0.089
11 Managua	11-1 Managua 1	324,024	0.333	403,100	0.333	524,308	0.333
	11-2 Managua 2	324,024	0.333	403,100	0.333	524,308	0.333
	11-3 Managua 3	324,024	0.333	403,100	0.333	524,300	0.300
12 Tipitapa	12-1 Tipitapa	75,024	0.906	93,334	0.906	121,400	0.906
	12-2 Others	7,804	0.094	9,710	0.094	12,632	0.094
31 Ticuantepe	31-1Ticuantepe	16,162	0.172	20,109	0.202	26,158	0.172
	31-2 Others	77,714	0.828	79,593	0.798	125,758	0.828

Note : Zone 11 Managua was divided into three equal zones, because traffic movement was equally distributed within Managua city.

3.1.2 Division of OD Table

Based on the rate of division indicated in Table 3-1, the present and the future O-D Tables (33 zones) estimated in the Master Plan were divided into 57 zones. The zonal trip generation and trip attraction of the divided zones are shown in Table 3-2.

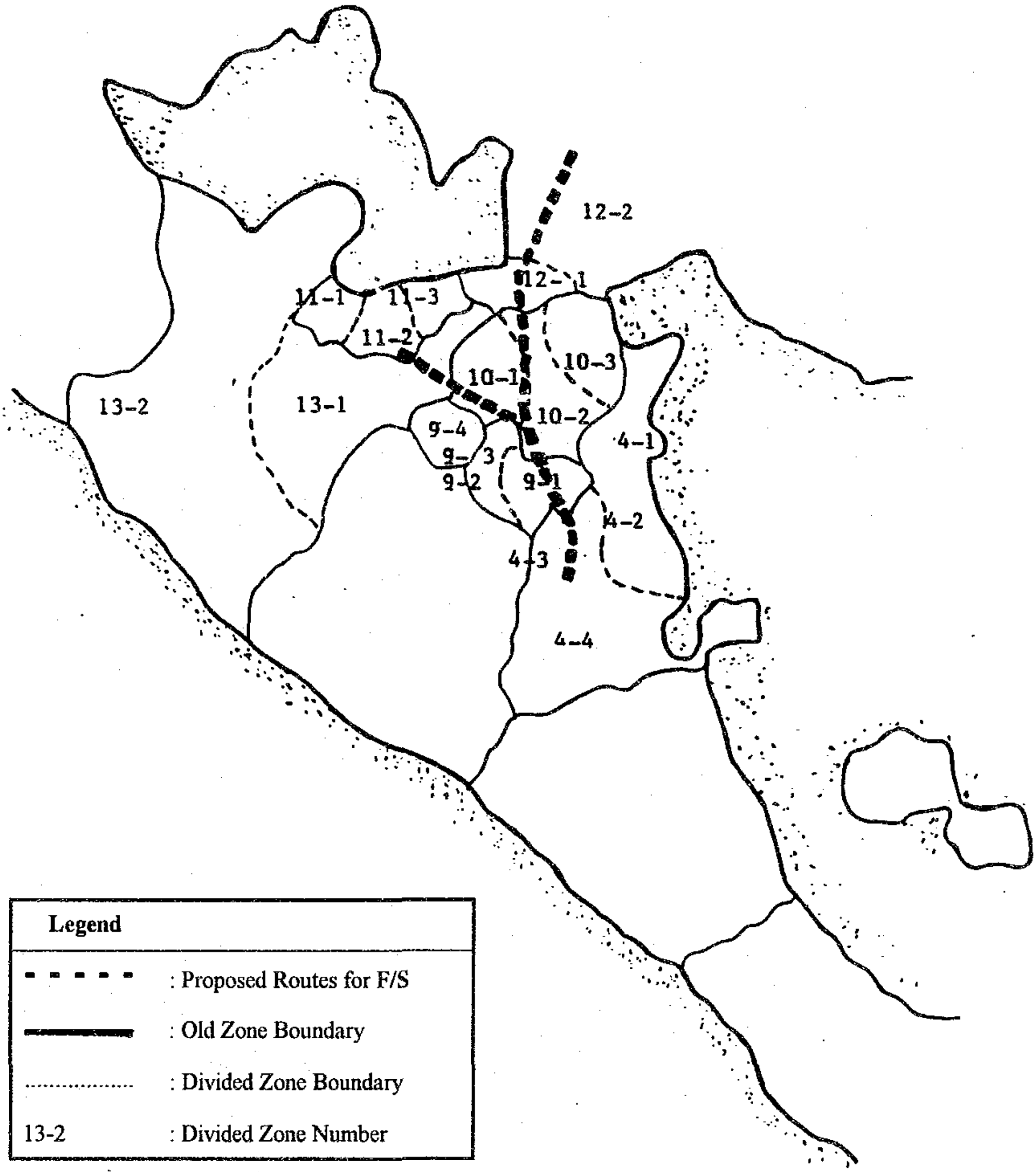

Figure 3-2 Divided Zone Map

Table 3-2 Trip Generation and Attraction of Divided Zones

Zone No.	1993		2000		2010	
	Trip Generation	Trip Attraction	Trip Generation	Trip Attraction	Trip Generation	Trip Attraction
4-1	1,250	1,319	1,736	1,822	2,617	2,705
4-2	322	338	448	468	678	699
4-3	128	134	182	186	273	281
4-4	522	550	725	761	1,096	1,127
9-1	48	43	71	60	109	98
9-2	21	19	32	26	48	43
9-3	206	190	290	260	437	401
9-4	368	348	517	472	779	727
10-1	2,871	3,025	4,098	4,303	6,229	6,681
10-2	740	781	1,055	1,115	1,611	1,730
10-3	345	369	505	529	764	825
11-1	16,612	16,461	23,152	22,967	35,109	34,885
11-2	16,612	16,461	23,152	22,967	35,109	34,885
11-3	16,612	16,461	23,152	22,967	35,109	34,885
12-1	521	544	721	751	1,097	1,160
12-2	60	61	83	88	128	139
31-1	113	133	118	180	244	268
31-2	573	645	574	877	1204	1,309

Since intra-traffic volume in Zone 11 (zone name Managua) is a total of projected intra-traffic volume based on the surveyed data at Traffic Survey Points 9, 11 and 12 (See Figure 4-2 in the Master Plan Report), the intra-traffic volume for each sub-divided zone (Zones 11-1, 11-2 and 11-3) was estimated by using the intra-traffic volume rate obtained at each survey point. The intra-traffic volume rates for vehicles passing the above three survey points are as follows:

Table 3-3 Intra-Traffic Volume Rate

Survey Point	Passenger Car	Micro Bus	Large Bus	Pick-up	Truck	Trailer
9	0.2	0.39	0.16	0.17	0.3	0.5
11	0.58	0.35	0.34	0.61	0.3	0.1
12	0.22	0.26	0.49	0.21	0.39	0.4

The divided O-D Tables are shown in Tables 3-4 to 3-6.

Table 3-4 Divided Present O-D Table (1993)

	1	2	3	4-1	4-2	4-3	4-4	5	6	7	8	9-1	9-2	9-3	9-4	10-1	10-2	10-3	11-1	11-2	11-3	12-1	12-2	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31-1	31-2	32	33	Total
1	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1	0	0	11	23	14	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	51
2	0	0	7	14	2	0	4	1	0	0	56	0	0	0	2	19	3	1	112	254	148	0	0	0	0	0	0	1	0	2	0	1	2	0	0	0	0	0	0	0	0	0	0	0	178	807
3	0	13	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	4	11	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	34
4-1	0	15	0	0	29	11	48	0	0	0	37	1	0	7	16	206	49	23	179	371	206	2	0	0	3	0	0	0	0	1	0	1	1	0	0	0	0	0	0	0	0	0	0	0	2	1208
4-2	0	3	0	29	0	1	10	0	0	0	7	0	0	1	3	48	11	3	41	88	48	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	293
4-3	0	0	0	11	1	0	4	0	0	0	2	0	0	0	1	19	2	0	16	34	17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	107
4-4	0	5	0	48	10	4	0	0	0	0	14	0	0	3	6	81	19	8	69	147	79	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	495
5	1	7	1	2	0	0	0	0	45	0	1	0	0	0	0	8	1	0	46	105	59	8	0	8	3	0	0	0	0	4	0	0	1	0	1	0	0	0	0	0	0	0	2	0	9	312
6	0	9	0	4	1	0	1	50	0	1	0	0	0	0	0	5	0	0	71	144	86	1	0	5	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	380
7	0	0	0	2	0	0	0	1	0	0	0	0	0	0	0	4	0	0	50	69	63	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	189
8	1	89	0	69	16	4	25	3	3	3	0	0	0	0	0	0	0	0	329	817	396	9	0	2	1	0	0	1	0	0	2	0	12	0	1	4	0	0	0	0	0	5	29	1	0	1822
9-1	0	1	0	3	0	0	1	0	0	0	0	0	0	0	0	0	0	0	8	18	9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	40
9-2	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	7	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	14
9-3	0	5	0	20	2	1	7	0	0	0	0	0	0	0	0	0	0	0	36	71	43	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	187
9-4	1	11	0	38	8	2	14	0	0	0	0	0	0	0	0	0	0	0	66	128	78	0	0	0	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	350
10-1	0	45	0	244	57	22	95	6	11	0	7	1	0	6	12	0	17	7	448	1151	532	66	0	4	23	2	0	7	0	21	2	5	30	0	3	0	0	0	0	0	0	0	1	3	2	2830
10-2	0	11	0	60	12	3	23	1	1	0	1	0	0	1	3	17	0	1	113	292	135	15	0	0	5	0	0	1	0	4	0	0	7	0	0	0	0	0	0	0	0	0	0	0	0	706
10-3	0	3	0	27	5	1	9	0	0	0	0	0	0	0	1	7	1	0	53	139	64	6	0	0	1	0	0	0	0	1	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	320
11-1	10	152	6	160	37	12	61	46	67	42	290	7	2	36	66	519	131	61	0	7273	6299	97	0	21	75	1	0	167	3	61	26	58	221	17	10	24	0	0	0	0	11	32	162	163	50	16476
11-2	21	329	16	336	80	30	132	107	138	73	649	14	6	65	116	1270	324	152	12297	0	13090	218	0	53	178	1	0	353	4	123	54	80	371	33	19	37	0	1	0	0	3	50	253	72	26	31174
11-3	12	187	6	194	44	16	75	57	79	58	319	12	5	52	94	639	161	75	7543	9310	0	111	0	30	108	1	0	219	2	78	33	63	251	17	13	27	0	0	0	0	9	35	183	146	44	20308
12-1	0	0	0	6	0	0	1	1	2	0	15	0	0	0	1	54	12	4	91	203	104	0	0	2	13	0	0	3	0	2	1	0	1	4	0	0	0	0	0	0	0	0	0	0	0	520
12-2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
13	0	0	0	0	0	0	0	5	1	0	0	0	0	1	3	5	0	0	19	39	24	0	0	0	147	1	0	24	0	43	9	0	9	0	0	2	0	0	0	0	0	0	0	0	0	332
14	0	2	0	4	1	0	1	0	0	1	0	0	0	0	0	11	1	0	84	202	115	5	0	126	0	0	0	10	1	63	3	2	9	0	0	0	0	0	0	0	0	0	0	0	0	641
15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4
16	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
17	0	4	0	0	0	0	0	1	0	0	4	0	0	0	0	52	11	5	133	273	155	0	0	39	16	0	0	0	35	13	4	36	424	32	0	1	0	0	0	0	2	0	0	7	2	1249
18	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	3	3	0	0	1	3	1	0	27	0	0	0	0	5	0	0	0	0	0	0	0	1	0	4	0	0	51
19	2	0	0	0	0	0	0	6	0	0	0	0	0	0	1	4	0	0	57	127	73	2	0	41	76	0	0	10	0	0	28	0	4	0	53	122	0	0	0	0	0	0	0	1	0	607
20	0	0	0	0	0	0	0	0	0	0	0	0	0	2	3	2	0	0	18	43	23	0	0	0	25	0	0	3	0	27	0	0	0	0	0	3	0	0	0	0	0	0	0	0	0	149
21	0	5	0	2	0	0	1	0	0	0	1	0	0	0	1	2	0	0	52	54	50	0	0	0	2	0	0	23	0	0	0	0	40	0	1	4	0	0	0	0	0	0	0	0	0	238
22	0	12	0	0	0	0	0	0	0	0	2	0	0	0	0	5	0	0	224	381	265	0	0	10	3	0	0	377	4	8	0	35	0	173	11	0	0	0	0	0	0	0	0	26	0	1536
23	0	6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	20	40	24	0	0	0	3	0	0	7	3	0	0	9	224	0	0	0	0	0	0	0	0	0	1	0	15	352
24	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	10	21	14	2	0	0	7	0	0	0	0	128	0	0	2	0	0	109	0	0	0	0	0	0	0	1	0	296
25	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1	0	0	23	48	28	0	0	3	0	0	0	0	0	108	0	2	1	0	151	0	0	0	0	0	0	0	0	0	2	368
26	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
27	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
28	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
29	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
30	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	7	9	7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	23
31-1	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	26	48	30	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	105
31-2	0	0	0	3	0	0	1	2	0	0	10	0	0	0	1	1	0	0	127	243	157	2	0	0	2	0	0	3	1	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	556
32	0	0	0	0	0	0	0	0	0	0	2	0	0	0	1	1	0	0	128	66	114	0	0	0	8	0	0	0	0	2	0	0	22	0	1	0	0	0	0	0	0	0	0	0	25	370
33	0	88	0	4	1	0	1	1	0	0	7	0	0	0	0	0	0	0	72	47	67	0	0	0	0	0	0	2	0	0	0	0	9	0	0	0	0	0	0	0	0	0	0	20	0	319
Total	48	1002	36	1281	306	107	514	291	347	178	1429	35	13	174	331	2981	743	340	22590	22300	22628	544	0	345	713	7	0	1238	53	692	162	292	1648	276	264	333	0	1	0	0	26	122	635	440	356	85821

Table 3-5 Divided Future O-D Table (2000)

	1	2	3	4-1	4-2	4-3	4-4	5	6	7	8	9-1	9-2	9-3	9-4	10-1	10-2	10-3	11-1	11-2	11-3	12-1	12-2	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31-1	31-2	32	33	Total
1	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1	0	0	14	31	18	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	66
2	0	0	10	22	4	1	9	1	0	0	86	0	0	2	4	30	6	2	168	390	215	0	0	0	0	0	0	1	0	2	0	1	2	0	0	0	0	0	0	0	0	0	0	0	198	1154
3	0	18	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	7	16	7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	49
4-1	0	22	0	0	41	16	70	0	0	0	52	3	1	12	24	290	72	33	243	525	281	3	0	0	6	0	0	0	0	1	0	1	2	0	0	0	0	0	0	0	0	0	0	0	3	1701
4-2	0	4	0	41	0	3	15	0	0	0	12	0	0	2	5	69	14	6	58	126	66	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	422
4-3	0	1	0	16	3	0	5	0	0	0	3	0	0	0	1	26	5	2	21	49	26	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	158
4-4	0	8	0	70	15	5	0	0	0	0	20	0	0	4	8	114	27	11	95	207	109	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	695
5	1	9	1	2	0	0	0	0	61	0	1	0	0	0	0	11	3	0	67	148	84	12	0	10	3	0	0	0	0	4	0	0	1	0	1	0	0	0	0	0	0	0	2	0	9	430
6	0	12	0	5	1	0	2	67	0	1	0	0	0	0	0	8	1	0	102	206	123	0	0	6	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	536
7	0	0	0	2	0	0	1	1	0	0	0	0	0	0	0	4	0	0	70	97	87	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	262
8	1	129	0	95	22	6	35	4	4	4	0	0	0	0	0	0	0	0	473	1192	568	11	0	2	1	0	0	1	0	0	2	0	17	0	1	5	0	0	0	0	0	7	39	1	0	2620
9-1	0	1	0	6	1	0	1	0	0	0	0	0	0	0	0	0	0	0	11	26	14	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	60
9-2	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	10	6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	23
9-3	0	8	0	29	6	1	9	0	0	0	0	0	0	0	0	0	0	0	51	105	61	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	273
9-4	1	17	0	53	11	2	20	0	0	0	0	0	0	0	0	0	0	0	93	187	109	0	0	0	6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	499
10-1	0	66	0	348	82	33	137	8	13	0	10	1	0	9	17	0	23	11	640	1667	758	87	0	5	31	2	0	11	0	29	2	8	40	0	4	0	0	0	0	0	0	0	1	3	3	4049
10-2	0	16	0	88	20	7	34	2	2	0	2	0	0	1	3	23	0	2	161	427	192	19	0	1	6	0	0	1	0	7	0	1	9	0	0	0	0	0	0	0	0	0	0	0	0	1024
10-3	0	6	0	41	9	3	14	0	0	0	1	0	0	0	1	11	2	0	76	202	92	8	0	0	3	0	0	0	0	2	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0	474
11-1	11	211	8	213	50	19	84	63	90	56	406	10	3	50	90	742	188	88	0	10181	8290	137	0	29	101	1	0	233	3	83	34	78	303	23	13	30	0	0	0	0	2	44	217	183	56	22423
11-2	28	471	22	464	111	43	183	150	193	97	943	21	9	91	162	1849	472	224	17819	0	18940	316	0	71	243	1	0	510	7	173	73	114	539	46	25	50	0	1	0	0	0	70	351	75	30	44987
11-3	15	260	10	260	61	23	101	80	107	76	450	16	5	68	123	901	230	108	9877	12889	0	159	0	42	144	1	1	306	4	104	45	85	344	25	16	35	0	0	0	0	2	49	245	162	50	27479
12-1	0	0	0	8	1	0	1	1	2	0	21	0	0	0	1	76	18	7	125	289	142	0	0	3	17	0	0	4	0	3	1	0	1	6	0	0	0	0	0	0	0	0	0	0	0	727
12-2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
13	0	0	0	0	0	0	0	5	1	0	0	0	0	2	5	7	1	0	27	55	35	0	0	0	200	1	0	28	0	57	11	0	10	0	0	2	0	0	0	0	0	0	0	0	0	447
14	0	2	0	6	1	0	2	0	0	1	0	0	0	0	0	14	2	1	117	281	157	6	0	172	0	0	0	13	1	81	4	2	12	0	0	0	0	0	0	0	0	0	0	0	0	875
15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4
16	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
17	0	5	0	0	0	0	0	1	0	0	6	0	0	0	0	65	16	6	185	394	218	0	0	49	21	0	0	0	52	18	6	53	630	49	0	1	0	0	0	0	0	0	0	5	1	1781
18	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	4	5	0	0	1	4	1	0	39	0	0	0	0	5	0	0	0	0	0	0	0	0	1	5	0	0	69
19	2	0	0	0	0	0	0	7	0	0	0	0	0	0	1	5	0	0	83	184	104	3	0	58	105	0	0	13	0	0	34	0	5	0	73	169	0	0	0	0	0	0	0	1	0	847
20	0	0	0	0	0	0	0	0	0	0	0	0	0	3	5	2	0	0	25	59	33	0	0	0	35	0	0	4	0	37	0	0	0	0	0	3	0	0	0	0	0	0	0	0	0	206
21	0	7	0	3	0	0	1	0	0	0	1	0	0	1	2	3	0	0	69	78	67	0	0	0	2	0	0	32	0	0	0	0	61	0	1	5	0	0	0	0	0	0	0	0	0	333
22	0	18	0	0	0	0	0	0	0	0	2	0	0	0	0	8	1	0	315	562	369	0	0	13	3	0	0	564	5	11	0	52	0	260	16	0	0	0	0	0	0	0	0	25	0	2224
23	0	8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	30	61	35	0	0	0	4	0	0	10	4	0	0	14	320	0	0	0	0	0	0	0	0	0	2	0	17	505
24	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	14	30	20	3	0	0	9	0	0	0	0	180	0	0	2	0	0	157	0	0	0	0	0	0	0	1	0	418
25	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1	0	0	32	67	41	0	0	4	0	0	0	0	0	149	0	3	1	0	205	0	0	0	0	0	0	0	0	0	2	506
26	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
27	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
28	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
29	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
30	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	4	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	13
31-1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	24	58	29	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	111
31-2	0	0	0	0	0	0	0	0	0	0	4	0	0	0	1	0	0	0	121	289	145	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	560
32	0	0	0	0	0	0	0	0	0	0	2	0	0	0	1	1	0	0	146	80	131	0	0	0	8	0	0	0	0	2	0	0	25	0	1	0	0	0	0	0	0	0	0	0	28	425
33	0	112	0	5	1	0	2	1	0	0	9	0	0	0	0	0	0	0	85	61	80	0	0	0	0	0	0	2	0	0	0	0	10	0	0	0	0	0	0	0	0	0	0	21	0	389
Total	59	1411	51	1779	440	162	726	394	473	235	2035	51	18	245	454	4261	1081	501	31458	31238	31664	764	0	466	961	7	1	1772	76	943	212	412	2342	409	356	457	0	1	0	0	4	171	862	477	398	119827

Table 3-6 Divided Future O-D Table (2010)

	1	2	3	4-1	4-2	4-3	4-4	5	6	7	8	9-1	9-2	9-3	9-4	10-1	10-2	10-3	11-1
1	0	0	0	1	0	0	0	0	0	0	2	0	0	0	0	3	0	0	19
2	0	0	17	36	8	2	14	2	0	0	142	0	0	4	7	51	13	4	259
3	0	32	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	11
4-1	0	39	0	0	62	23	103	1	0	0	85	5	1	20	36	454	115	51	354
4-2	0	9	0	62	0	4	23	0	0	0	20	0	0	3	8	107	25	11	84
4-3	0	2	0	23	4	0	8	0	0	0	7	0	0	1	3	41	9	3	32
4-4	0	15	0	103	23	8	0	0	0	0	33	1	0	7	14	179	44	18	139
5	1	15	2	4	0	0	0	0	93	0	2	0	0	0	0	18	4	1	98
6	0	20	0	8	2	0	3	101	0	2	0	0	0	0	0	14	3	1	147
7	0	0	0	4	1	0	1	2	0	0	0	0	0	0	0	8	2	0	97
8	2	208	0	150	35	11	58	6	7	6	0	0	0	0	0	0	0	0	725
9-1	0	3	0	10	1	0	2	0	0	0	0	0	0	0	0	0	0	0	18
9-2	0	1	0	2	0	0	1	0	0	0	0	0	0	0	0	0	0	0	7
9-3	0	14	0	43	8	2	16	0	0	0	0	0	0	0	0	0	0	0	76
9-4	2	25	0	79	17	6	29	0	0	0	0	0	0	0	0	0	0	0	138
10-1	1	106	0	530	127	51	210	14	22	0	15	3	1	14	25	0	35	16	964
10-2	0	26	0	135	31	10	52	2	4	0	3	0	0	3	6	35	0	3	246
10-3	0	12	0	62	13	4	24	1	1	0	1	0	0	1	3	16	3	0	114
11-1	18	320	13	306	72	28	120	92	130	83	619	18	7	75	135	1142	291	138	0
11-2	42	718	35	670	162	64	265	218	284	149	1471	34	15	140	252	2872	734	350	27555
11-3	26	396	16	376	89	35	147	119	159	116	694	24	11	104	187	1389	354	170	14621
12-1	0	0	0	11	1	0	4	3	5	0	33	0	0	1	2	124	29	11	187
12-2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
13	0	0	0	0	0	0	0	7	2	0	0	0	0	3	8	11	2	0	39
14	0	4	0	10	2	0	3	0	0	2	0	0	0	0	1	20	4	1	165
15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2
16	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
17	0	8	0	2	0	0	0	2	0	0	9	0	0	0	2	102	24	10	279
18	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	7
19	2	0	0	1	0	0	0	11	0	0	0	0	0	1	2	8	1	0	122
20	0	0	0	1	0	0	0	0	0	0	0	1	0	4	8	5	1	0	37
21	0	12	0	6	1	0	2	0	0	0	2	0	0	2	3	6	1	0	102
22	0	30	0	3	0	0	0	0	0	0	4	0	0	0	0	14	2	0	475
23	0	15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	49
24	0	0	0	1	0	0	0	3	0	0	0	0	0	0	0	0	0	0	21
25	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	2	0	0	47
26	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
27	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0
28	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0
29	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
30	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
31-1	0	0	0	1	0	0	0	1	0	0	4	0	0	0	0	0	0	0	53
31-2	0	0	0	6	1	0	2	4	0	0	21	0	0	2	4	3	0	0	266
32	0	0	0	0	0	0	0	0	0	0	3	0	0	0	1	2	0	0	182
33	0	165	0	8	2	0	3	0	0	0	15	0	0	0	0	0	0	0	107
Total	94	2195	83	2655	662	248	1090	591	707	358	3191	86	35	385	707	6626	1696	788	47845

	11-2	11-3	12-1	12-2	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31-1	31-2	32	33	Total
1	41	27	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	94
2	613	336	1	0	0	0	0	0	2	0	4	0	2	4	0	0	0	0	0	0	0	0	0	0	0	281	1802
3	28	14	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	87
4-1	782	413	5	0	1	9	0	2	0	0	2	0	2	3	1	0	0	0	0	0	0	0	0	1	0	5	2575
4-2	188	98	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	644
4-3	74	39	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	246
4-4	309	163	1	0	0	3	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	2	1063
5	219	122	20	0	15	6	0	0	0	0	7	0	0	2	0	1	0	0	0	0	0	0	1	4	0	14	649
6	302	179	2	0	9	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	797
7	139	125	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	379
8	1851	870	20	0	3	2	0	0	2	0	0	4	0	28	0	1	8	0	0	0	0	0	12	62	2	0	4073
9-1	38	20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	92
9-2	18	9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	38
9-3	159	92	0	0	0	6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	416
9-4	285	164	0	0	0	11	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	758
10-1	2534	1143	134	0	9	47	5	0	18	0	48	5	14	62	0	7	0	0	0	0	0	0	0	3	6	5	6174
10-2	648	291	31	0	1	11	1	0	3	0	11	1	2	14	0	1	0	0	0	0	0	0	0	0	1	1	1573
10-3	308	138	13	0	0	5	0	0	1	0	4	0	0	6	0	0	0	0	0	0	0	0	0	0	0	0	730
11-1	15429	12091	210	0	43	148	2	0	355	6	124	49	113	451	38	19	45	0	0	0	0	6	64	319	229	71	33419
11-2	0	29287	490	0	98	346	3	0	776	10	265	105	176	834	77	40	78	0	2	0	0	1	106	523	103	44	69394
11-3	19691	0	244	0	61	211	2	1	467	5	160	65	127	519	42	26	53	0	0	0	0	5	73	362	208	66	41421
12-1	434	214	0	0	5	26	0	0	7	0	4	2	1	5	12	0	1	0	0	0	0	0	0	0	0	0	1122
12-2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
13	77	49	0	0	0	283	2	0	45	0	89	17	0	17	0	0	4	0	0	0	0	0	0	0	0	0	655
14	395	224	11	0	245	0	0	0	20	2	123	6	4	19	0	0	0	0	0	0	0	0	0	1	0	0	1262
15	2	2	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	8
16	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
17	603	333	2	0	78	34	0	0	0	84	28	9	87	1027	76	0	2	0	0	0	0	1	0	1	8	0	2811
18	7	7	0	0	2	6	2	0	64	0	0	0	0	10	0	0	0	0	0	0	0	0	2	10	0	0	117
19	279	154	6	0	90	157	0	0	22	0	0	50	0	7	0	113	255	0	0	0	0	0	0	1	2	0	1284
20	81	46	0	0	0	52	0	0	7	0	56	0	0	0	0	0	6	0	0	0	0	0	0	0	0	0	305
21	124	102	0	0	0	4	0	0	56	0	0	0	0	102	0	2	9	0	0	0	0	0	0	1	0	0	537
22	874	564	2	0	20	6	0	0	928	8	19	0	87	0	424	26	0	0	0	0	0	0	0	0	39	0	3525
23	103	58	0	0	0	7	0	0	16	6	0	0	22	511	0	0	0	0	0	0	0	0	0	4	0	26	817
24	45	29	5	0	0	17	0	0	0	0	275	0	0	3	0	0	232	0	0	0	0	0	0	0	2	0	633
25	97	59	0	0	5	0	0	0	0	0	223	0	4	2	0	303	0	0	0	0	0	0	0	0	0	3	747
26	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
27	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2
28	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2
29	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
30	2	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4
31-1	106	65	0	0	0	1	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	233
31-2	525	326	4	0	0	4	0	0	7	3	6	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1185
32	99	163	0	0	0	8	0	0	0	0	3	0	0	30	0	0	0	0	0	0	0	0	0	0	0	39	530
33	82	103	0	0	0	0	0	0	4	0	0	0	0	12	0	0	0	0	0	0	0	0	0	0	31	0	532
Total	47591	48121	1201	0	685	1418	17	3	2802	124	1452	314	641	3670	670	539	693	0	2	0	0	13	258	1292	631	558	182737

3.1.3 Traffic Counting Survey at Intersection

(1) Aim of the Survey

Intersections are often the sites of the worst traffic bottlenecks. Therefore, conducting the traffic volume counting surveys at the major intersections, for assessing traffic movement, is necessary if improvements are to be implemented. In the Study, the intersection of the La Centro América Road and the Managua-Masaya Road (intersection of Colonia Centro América) was judged to be improved, as explained in Chapter 5 of this Report. Therefore, an intersection traffic counting survey was performed on September 8, 1993 at this intersection to obtain the traffic volume by direction from 6:00 a.m. to 10:00 p.m. The types of vehicles surveyed was the same as those surveyed in the traffic volume counting survey conducted in March 1993.

(2) Results of the Traffic Counting Survey at this Intersection

The results of the traffic counting survey at the intersection of Colonia Centro América are summarized in Table 3-7. Almost half of the vehicles coming from Masaya pass directly to Managua; however, about 45% of the vehicles coming from Managua turn left at this intersection. Furthermore, traffic flow from Managua to Unan and from Mercado Roberto Hember to Masaya includes as many as 500 large vehicles.

Table 3-8 summarizes traffic volume passing through this intersection by hour. According to this table, from 7:00 a.m. to 6:00 p.m. more than 5,000 vehicles pass through this intersection per hour. The peak hours are 7:00-9:00 in the morning. At this time, traffic volume is about 6,800 vehicles per hour. Composition rate of large vehicles is less than 7% at this time, however, it exceeds 20% in the early morning hours (6:00 to 7:00 a.m.).

Table 3-7 Results of the Traffic Counting Survey at the Intersection of Colonia Centro América

Direction	Small and Medium-Size Vehicles	Large Vehicle	Total
1-1	3,701	51	3,752
1-2	4,199	196	4,395
1-3	3,482	163	3,645
2-1	2,456	55	2,511
2-2	4,473	272	4,745
2-3	2,045	321	2,366
3-1	2,728	527	3,255
3-2	1,861	251	2,112
3-3	1,922	363	2,285
4-1	4,914	168	5,182
4-2	3,894	197	4,091
4-3	2,343	582	2,925

Note : Directions are as follows:

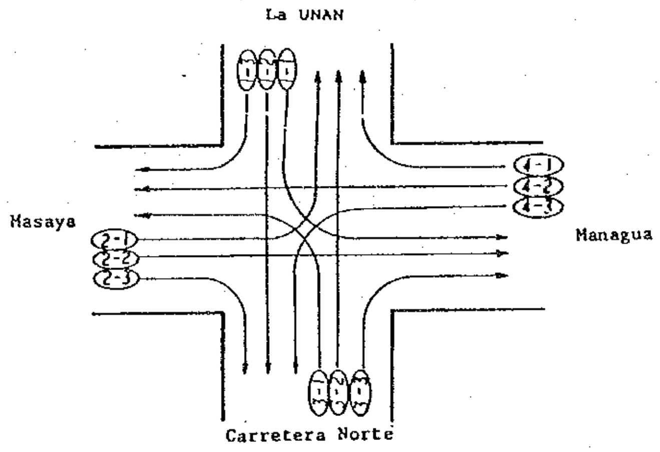

Table 3-8 Traffic Volume at the Intersection of Colonia Centro América

Time	Small and Medium-Size Vehicle		Large Vehicle		Total		Composition Rate of Large Vehicles (%)
	Volume	Ratio (%)	Volume	Ratio (%)	Volume	Ratio (%)	
06:00-07:00	1,403	1.9	351	6.9	1,754	2.2	20.0
07:00-08:00	6,389	8.7	426	8.4	6,815	8.7	6.3
08:00-09:00	5,365	7.3	435	8.5	5,800	7.4	7.5
09:00-10:00	4,631	6.3	316	6.2	4,947	6.3	6.4
10:00-11:00	4,842	6.6	357	7.0	5,199	6.7	6.9
11:00-12:00	4,898	6.7	372	7.3	5,270	6.7	7.1
12:00-13:00	6,038	8.3	409	8.0	6,447	8.3	6.3
13:00-14:00	5,683	7.8	402	7.9	6,085	7.8	6.6
14:00-15:00	5,475	7.5	389	7.6	5,864	7.5	6.6
15:00-16:00	5,307	7.3	325	6.4	5,632	7.2	5.8
16:00-17:00	5,170	7.1	364	7.1	5,534	7.1	6.6
17:00-18:00	5,287	7.2	338	6.6	5,625	7.2	6.0
18:00-19:00	4,255	5.8	251	4.9	4,506	5.8	5.6
19:00-20:00	3,495	4.8	191	3.7	3,686	4.7	5.2
20:00-21:00	2,862	3.9	101	2.0	2,963	3.8	3.4
21:00-22:00	1,930	2.6	70	1.4	2,000	2.6	3.5
Total	73,030	100.0	5,097	100.0	78,127	100.0	6.5

3.2 FUTURE TRAFFIC ASSIGNMENT

(1) Traffic Assignment on the Project Roads

On the basis of the 57-zone O-D Table projected above, traffic volume on the Project Roads was estimated by using the QV traffic assignment method (explained Section 9.2 of the Master Plan Report).

Moreover, the QV relationship for the traffic volume at the intersection of Colonia Centro América was modified by the following idea:

- During an analysis of the signalized intersection (refer to Chapter 5), the optimum cycle length was calculated as 80 seconds in the case of a grade-separated intersection and 70 seconds in the case of an at-grade intersection. In the latter case, the waiting time of vehicles turning left from Masaya to Managua was calculated to be about 54 seconds for a signal cycle (70 seconds). Since one hour is 3,600 seconds, this means that vehicles have to wait about 2,777 seconds per hour (based on a calculation of 3,600/70×54). In the same way, vehicles turning left in the case of a grade-separated intersection have to wait 2,475 second per hour, since they must stop about 55 seconds for one signal period (80 seconds). Therefore, it is possible to make the waiting time 302 seconds per hour shorter in the case of a grade-separated intersection than in the case of an at-grade intersection to accommodate traffic turning left.

- Moreover, in the case of through traffic, there is no waiting time at a grade-separated intersection, although vehicles have to wait about 2,982 seconds per hour at an at-grade intersection (3,600/70×58). Therefore, it is possible to make the waiting time 2,982 seconds per hour shorter in the case of a grade-separated intersection than in the case of an at-grade intersection.

The difference of the waiting time deduction is applied to set the QV formula at an intersection.

(2) Traffic Assignment Results

The traffic assignment was performed for two cases -- "Without Project" and "Road Improvement". In the latter case, the traffic assignment in the first section of Managua-Masaya Road was performed for two cases -- "With Flyover" and "Without Flyover", as explained in Chapter 5 of this Report. Equal traffic volume were assigned for these cases because there was no alternative route in the road network. Nevertheless, vehicle speed differed. Future traffic volume on the Project Roads was projected as shown in Table 3-9 and Figure 3-3.

The road section of La Centro América - 2.5 km Point showed the largest traffic volume, reaching about 43,000 vehicles by the year 2010. In addition, the composition rate of large vehicles in this section was the lowest of any Project Road, since this section is located in an urban area, which accommodates many passenger cars

Table 3-9 Traffic Volume on Project Roads

(Unit ;vehicles/day)

Section	Year	Small Vehicle	Large Vehicle	Total	Composition Rate of Large Vehicle (%)
Managua-Masaya Road					
Managua - Est.02+410	1993	20,307	1,769	22,076	8.0
	2000	26,435	2,050	28,486	7.2
	2010	40,532	2,960	43,492	6.8
Est.02+410 - Entrada a Veracruz	1993	8,568	3,056	11,624	26.3
	2000	11,178	3,543	14,721	24.1
	2010	17,107	5,112	22,219	23.0
Entrada a Veracruz - El Coyotepe	1993	8,568	3,056	11,624	26.3
	2000	11,178	3,543	14,721	24.1
	2010	17,107	5,112	22,219	23.0
El Coyotepe - Masaya	1993	8,914	3,270	12,184	26.8
	2000	12,632	4,049	16,681	24.3
	2010	18,340	5,621	23,961	23.5
Managua-Tipitapa Road					
Río Panamá - San Cristobal	1993	2,899	1,809	4,708	38.4
	2000	4,860	2,489	7,349	33.9
	2010	6,218	3,313	9,531	34.8
Nandaime-San Benito Road					
Masaya - Catarina	1993	1,973	1,362	3,335	40.8
	2000	2,624	1,569	4,193	37.4
	2010	4,828	2,493	7,321	34.1
Catarina - El Guanacaste	1993	1,205	785	1,990	39.4
	2000	1,629	895	2,524	35.5
	2010	3,117	1,482	4,599	32.2
El Guanacaste - Nandaime	1993	1,259	799	2,058	38.8
	2000	1,668	899	2,567	35.0
	2010	2,606	1,301	3,907	33.3
El Coyotepe - Río Panamá	1993	346	214	560	38.2
	2000	1,233	444	1,677	26.5
	2010	1,454	571	2,025	28.2
Río Panamá - San Benito	1993	2,424	1,797	4,221	42.6
	2000	3,134	2,198	5,332	41.2
	2010	4,540	3,200	7,740	41.3
Telica-San Isidro Road					
Telica - San Isidro	1993	173	104	277	37.5
	2000	433	265	698	38.0
	2010	662	411	1,073	38.3

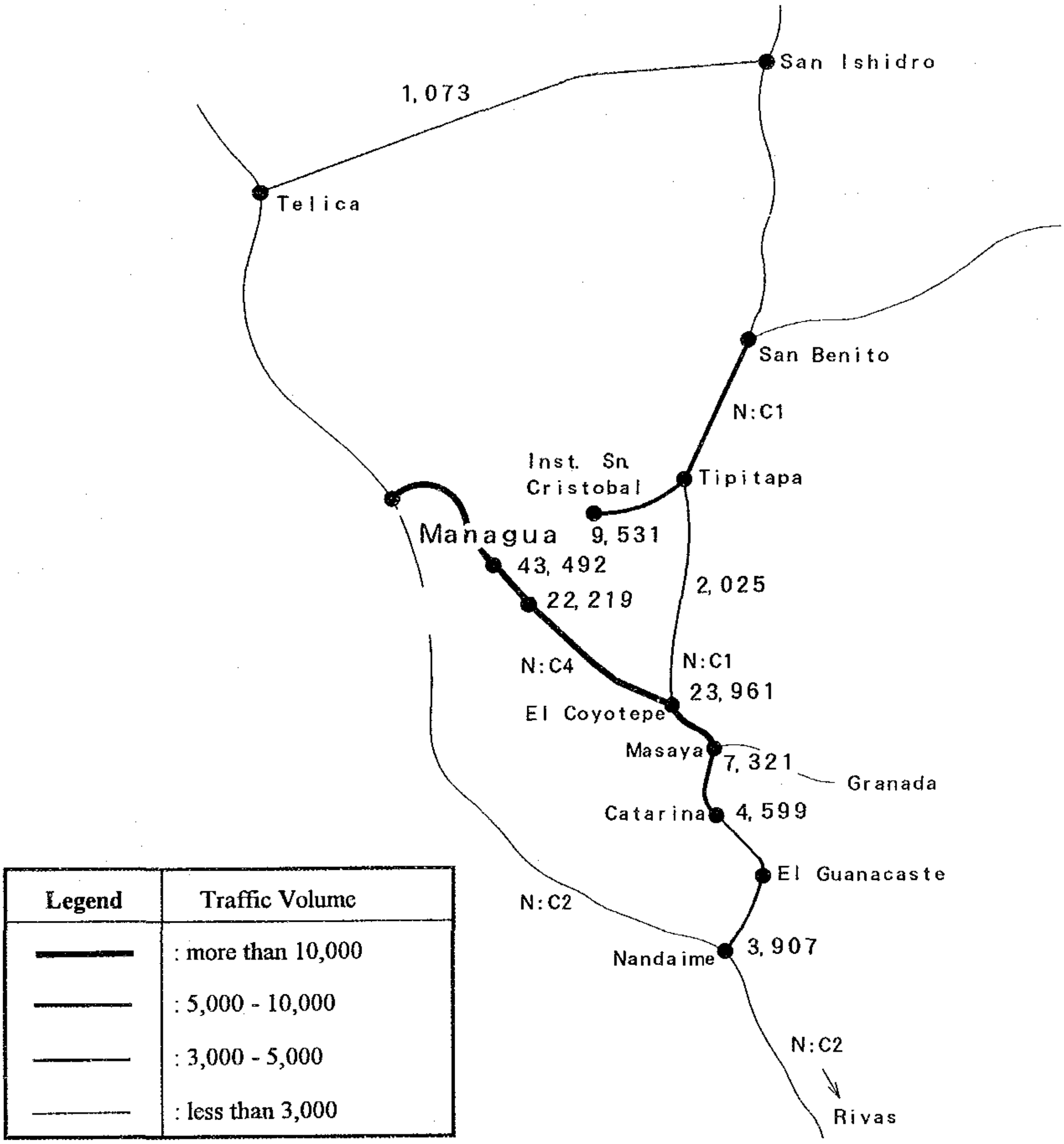

Figure 3-3 Traffic Volume on Project Roads in 2010

CHAPTER 4

ENVIRONMENTAL IMPACT ASSESSMENT

CHAPTER 4 ENVIRONMENTAL IMPACT ASSESSMENT

4.1 INTRODUCTION

4.1.1 General

An Environmental Impact Assessment on the Project Roads was conducted to ensure the *preservation of the natural and living environment and to establish the necessary environ*mental management plan. These analyses results are summarized in this Chapter, and detailed results are shown in Annex III.

4.1.2 Legal Conditions

Laws and regulations relating to environmental aspects, as well as national parks and protected areas, are shown in Table 4-1. Legislation to create an environmental institution has not yet been passed in Nicaragua; however, discussions on creating environmental laws have recently begun in the Diet. Therefore, it is expected that environmental impact assessment will soon be institutionalized.

4.1.3 Environmental Studies

According to Figure 4-1 (explained in Chapter 7 of the Master Plan Report), an Initial Environmental Examination was first conducted. As a result, the need for Environmental Impact Assessment at the stage of the Feasibility Study was recognized. The flowchart of the Environmental Impact Assessment is shown in Figure 4-2.

Table 4-1 Legislation Relating to the Environment

Number, Year	Name
Dec.No.56, 1979	Creación del Instituto Nicaraguense de Recursos Naturales y del Ambiente
Dec.No.79, 1979	Ley Creadora del Parque Nacional Volcan Masaya
Dec.No.112, 1979	Ley Organica del Instituto Nicaraguense de Recursos Naturales y del Ambiente
Dec.No.13, 1980	Zona de Refugio para la Vide Silvestre - Protección a los Animales Silvestres Cosiguina, Zona de Asilo
Dec.No.1194, 1983	Creación del Parque Nacional "Archipiélago Zapatera"
Dec.No.1294, 1983	Creación de Refugio de Vida Silvestre Rio Escalante-Chacocente
Dec.No.1320, 1983	Creación de Reservas Naturales en el Pacífico de Nicaragua
Dec.No.336, 1988	Ley de Extinción de Irena e Integración de su Sus Funciones al Midinra
Dec.No.340, 1988	La Junta de Gobierno de R4 Construcción Nacional de la República de Nicaragua
Dec.No.572, 1990	Creación de las Areas Naturales Protegidas del Sureste de Nicaragua
Dec.No.42, 1991	Declaración de Areas Protegidas en Varios Cerros Macizos Montañosos, Volcanes y Lagunas del País
Dec.No.43, 1991	Declaración de la Reserva Biológica Marina "Cayos Miskitos y Franja Costera Inmediata"
Dec.No.44, 1991	Declaración de la Reserva Nacional de Recursos Naturales "Bosawas"
Dec.No.38, 1992	Creación de Reservas Forestales

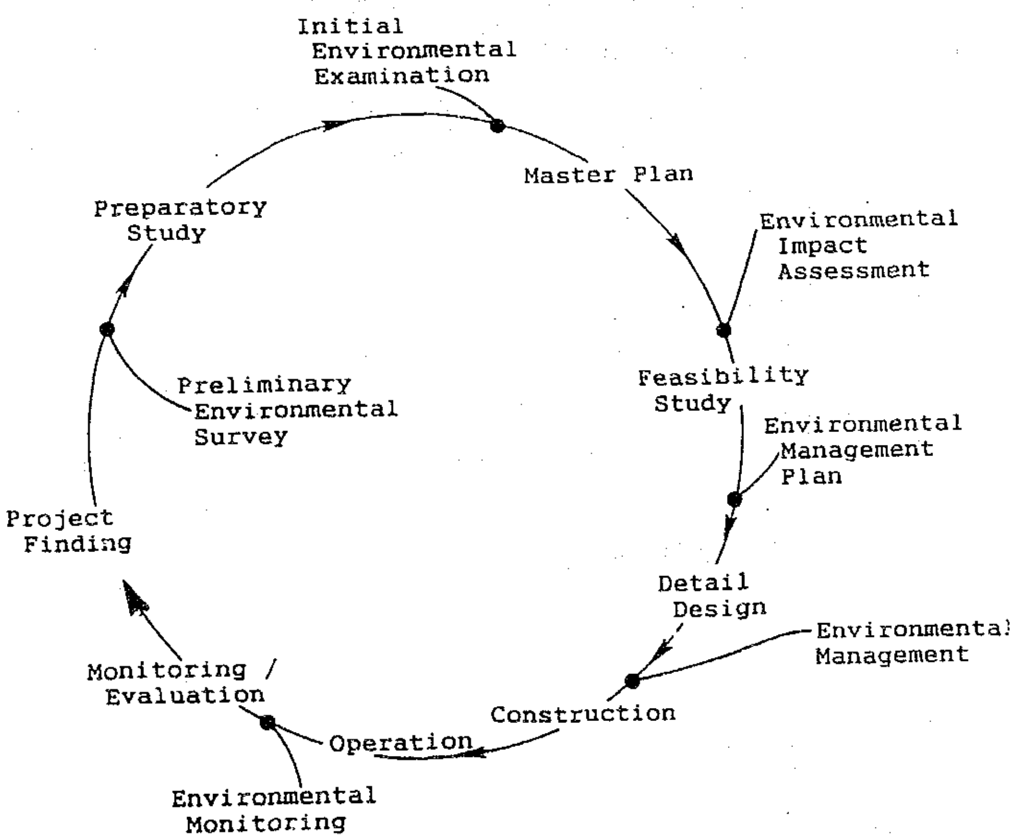

Figure 4-1 Flow of Environmental Consideration of Project Cycle

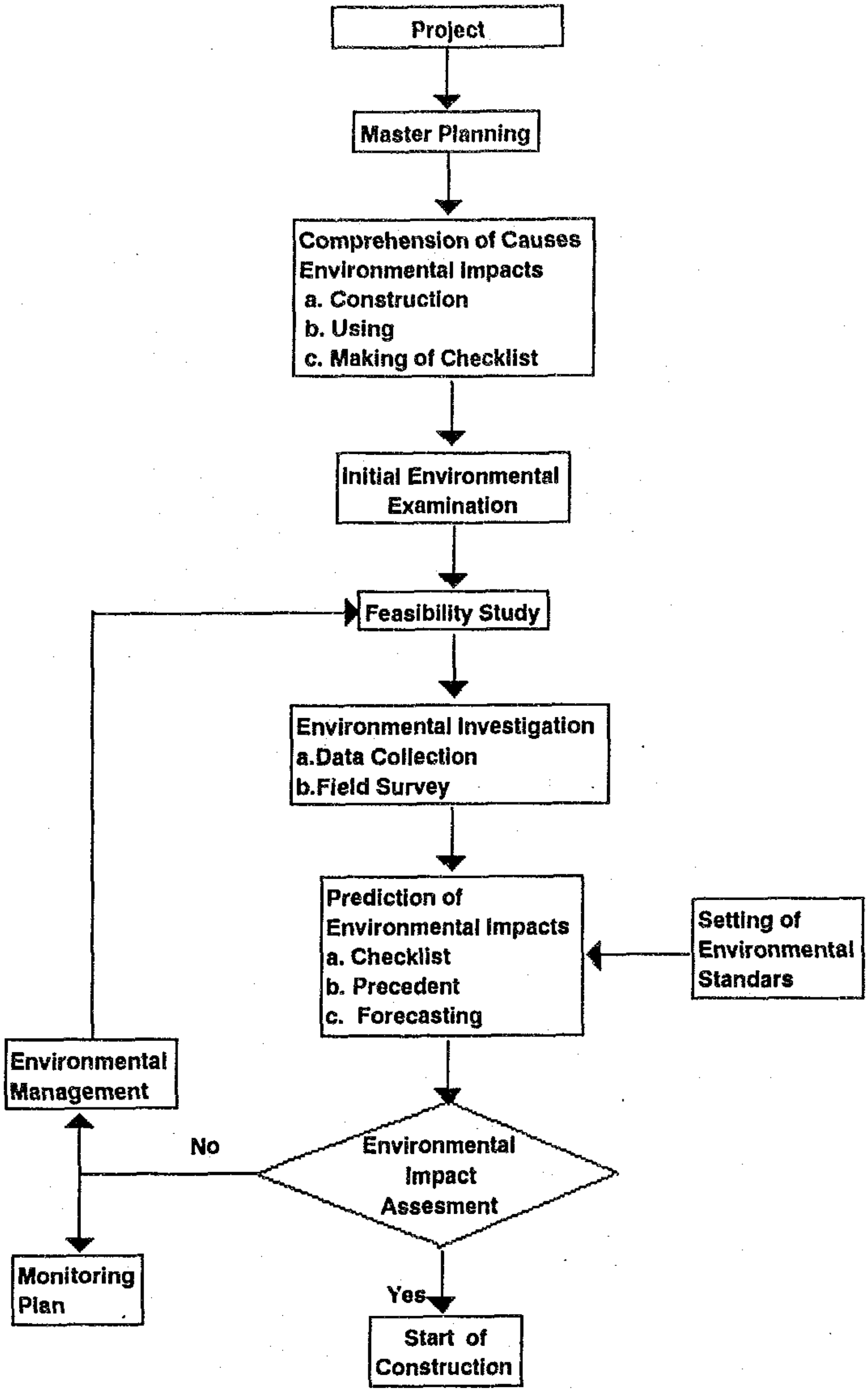

Figure 4-2 Flow of Environmental Impact Assessment

4.2 ESTABLISHMENT OF ENVIRONMENTAL ITEMS

4.2.1 Environmental Factors

Based on the contents of the project, road construction and road use are the activities that will have the greatest environmental impact.

Road construction work affecting the environment can be divided into the following:

① Construction stage

1) Forest cleaning
2) Earth work (cutting, embankment, stripping, etc.)
3) Use of heavy machines and dump trucks for transportation
4) Bridge
5) Culvert
6) Water control
7) Waste (domestic waste, unused soil, soil dumping area)
8) Aggregate and sand quarry
9) Pavement and asphalt plant
10) Concrete plant
11) Facilities for worker

② Road use

12) Road facilities (road, bridge, culvert, sidewalk, etc.)
13) Traffic and traffic safety

4.2.2 Establishment of Environmental Items

The environmental items generally related to road construction are listed below.

① Living environment (pollution)

1) Air quality
2) Water quality
3) Soil contamination

4) Noise and Vibration

5) Land subsidence

6) Odor

7) Light

② Natural environment

7) Land (topography and geology)

8) Soil

9) Water (rivers, lakes, etc.)

10) Underground water

11) Meteorology

12) Sea and seashore

13) Flora and fauna

14) Landscape

③ Social environment

15) Waste

16) Historical and cultural monuments

17) Traffic conditions

18) Sanitation

19) Hazards

20) Cutting district

21) Relocation

22) Socio-economic conditions

23) Safety

24) Community

25) Recreation facilities

26) Water rights and rights of common

Environmental items have been selected on the basis of a matrix method as shown in Table 4-2. This table shows the relationship between environmental items and environmental factors as well as the extent of the influence of each environmental factor.

Environmental items including odor, land subsidence, soil contamination, light, meteorology, sea and seashore, fauna, sanitation, cutting district, socio-economic conditions, community, recreation facilities, water rights and rights of common are excluded from the investigation items because the facilities do not exist or because their influence is negligible.

Therefore, only the following environmental items have been selected.

① Living environment (pollution)

1) Air quality

2) Water quality

3) Noise and vibration

② Natural environment

4) Land (topography and geology)

5) Soil

6) Water (rivers, lakes, underground water)

7) Flora

8) Landscape

③ Social environment

9) Traffic conditions

10) Social conditions (including waste, relocation, safety, etc.)

4.2.3 Checklist

The Environmental Impact Assessment checklist is based on the selected environmental factors. This checklist consists of environmental items same as the matrix method and their sub-divisions, checking present environmental conditions, an environmental evaluation based on the results of environmental investigations and predictions by simulation, application of precedent and experience, and extraction of environmental problems.

Table 4-2 Selection of Environmental Items

Environmental Factors *1	Stage of Construction									Use of Road		Selection
Environmental Items	1	2	3	4	5	6	7	8	9	10	11	of Item *2
I. Living environment												
1) Air quality	-	B	B	-	-	-	-	-	-	-	A	Selected
2) Water quality	B	A	-	B	B	B	B	B	B	-	-	Selected
3) Soil contamination	-	-	-	-	-	-	-	-	-	-	-	-
4) Noise and vibration	-	B	B	-	-	-	-	-	-	-	A	Selected
5) Land subsidence	-	-	-	-	-	-	-	-	-	-	-	-
6) Odor	-	-	-	-	-	-	-	-	-	-	-	-
II. Natural environment												
7) Land	-	A	-	B	-	A	-	-	-	-	B	Selected
8) Soil erosion	B	A	-	-	A	-	-	-	-	-	-	Selected
9) Water	B	A	-	A	-	B	-	-	-	A	-	Selected
10) Underground water	-	-	-	-	-	-	-	-	-	-	-	-
11) Meteorology	-	-	-	-	-	-	-	-	-	-	-	-
12) Sea and sea shore	-	-	-	-	-	-	-	-	-	-	-	-
13) Flora and fauna	A	-	-	-	B	B	-	-	-	A	-	Selected
14) Landscape	A	A	-	-	B	B	-	-	-	A	-	Selected
III. Social environment												
15) Waste	B	A	-	B	A	-	B	B	B	B	-	Selected
16) Historical and Cultural monuments	-	B	-	-	-	-	-	-	-	B	-	Selected
17) Traffic	-	B	-	B	-	-	-	-	-	-	-	Selected
18) Sanitation	-	-	-	-	-	-	-	-	-	-	-	-
19) Hazards	-	B	-	B	-	-	-	-	-	B	-	Selected
20) Relocation	-	-	-	-	-	-	-	-	-	A	-	Selected
21) Socio-economic conditions	-	-	-	-	-	-	-	-	-	-	-	-
22) Cutting district	-	-	-	-	-	-	-	-	-	-	-	-
23) Safety	-	B	-	-	-	-	-	-	-	A	-	Selected
24) Community	-	-	-	-	-	-	-	-	-	-	-	-
25) Recreation facilities	-	-	-	-	-	-	-	-	-	-	-	-
26) Water rights and right of common	-	-	-	-	-	-	-	-	-	-	-	-

Note : *1 Environmental factors
- Stage of construction
1. Clearing of forests
2. Earth works
3. Use of heavy machinery
4. Bridge and culvert
5. Waste
6. Aggregate and sand quarry
7. Pavement and asphalt plant
8. Concrete plant
9. Facilities for worker
- Use of road
10. Road facilities
11. Traffic and traffic safety

*2 A : Major influence
B : Minor influence
- : No influence

4.3 ENVIRONMENTAL QUALITY STANDARD

American standards are utilized as the environmental quality standards to assess air quality. Meanwhile, since water quality standards in Nicaragua are still being discussed, Japanese standards will tentatively be applied. Japanese standards are also tentatively applied to assess noise and vibration. In addition, minimization of influence is also the target for the other environmental items, including land subsidence, odor, waste, land, water, flora and fauna, landscape, hazards, traffic safety and socio-economic problems, in the project area.

Environmental standards for air quality, water quality, noise and vibration are shown in Tables 4-3 to 4-6, respectively.

Table 4-3 Environmental Air Quality Standards

Items	*Standard Value*
CO	10 mg/m³/ 8 hours (9 p.p.m.) 40 mg/m³/ 1 hour (35 p.p.m.)
SO_2	80 ug/m³/ day (0.03 p.p.m.) 365 ug/m³/ 24 hours (0.14 p.p.m.)
NO_x	100 ug/m³/ year (0.05 p.p.m.) variable in 24 hours with NO_2
HC	160 mg/m³/ 3 hours (0.24 p.p.m.)
Macro-Particular	25 mg/m³/ year or 260 g/m³/ 24 hours
Suspended Particulate Matter	260 mg/m³/ day 75 mg/m³ *1
O_3	235 mg/m³/ hour (0.12 p.p.m.)
Pb-Ps	1.5 mg/m³/ 3 months

Note - *1 : Annual arithmetic mean

Table 4-4 Environmental Water Quality Standards

Items	Standard Value
pH	Effluent to coastal sea : 5.0 - 9.0 Others : 5.8 - 8.6
Biolochemical Oxygen Demand	160 mg/l (daily average : 120 mg/l)
Chemical Oxygen Demand	160 mg/l (daily average : 120 mg/l)
Suspended Solid	200 mg/l (daily average : 150 mg/l)
Normal hexane extraction matter	5 mg/l (mineral oil) 30 mg/l (animal and vegetable oil)
Copper	3 mg/l
Zinc	5 mg/l
Dissolved iron	10 mg/l
Dissolved manganese	10 mg/l
Chromium	2 mg/l
Fluorine	15 mg/l
Number of Coliform bacteria	3,000 points/cm³ (daily average)
Nitrogen	120 mg/l (daily average)
Phosphorus	16 mg/l (daily average)

Table 4-5 Environmental Noise Standards

(Unit : dB(A))

Item	Area	Environmental Standards		
		Daytime	Morning/Evening	Night
General	AA*2	< 45	< 40	< 35
	A *3	< 50	< 45	< 40
	B *4	< 60	< 55	< 50
Area Facing the Road	A *5	< 55	< 50	< 45
	A *6	< 60	< 55	< 50
	B *5	< 65	< 60	< 55
	B *6	< 65	< 65	< 60

Note - *1 : Standard value : dB(A)
*2 : Quiet area required, medical care facilities.
*3 : Residential area.
*4 : Industrial and commercial areas.
*5 : Two-lane road
*6 : Road greater than two lanes

Table 4-6 Environmental Vibration Standards

Standard vibration value : 50 dB(B) on the boundary	
– Influence of vibrations on the human body –	
Vibration Level dB(B)	**Influence on the Human Body**
< 60	No perceptible feeling. Does not influence sleep.
60 - 65*	Can be felt. Complaints of slight vibration is 50 %.
65 - 70*	Disturbs sleep slightly. Complaints of vibration become 30 %.
70 - 75*	Complaints of vibration become 40 %.
75 - 80*	Light physical damage occurs. Complaints of vibration become 40 %.
> 80	Vibrations can be felt strongly. Physiological influence.

Note - * : ≤

4.4 ENVIRONMENTAL INVESTIGATION AND METHODOLOGY

4.4.1 Environmental Investigation

Environmental Impact Assessment consists of the following items which are selected on the basis of the matrix method.

- Traffic conditions
- Air quality
- Water quality
- Noise and vibration
- Land
- Soil
- Water
- Flora
- Landscape
- Social conditions

4.4.2 Methodology

The contents of the environmental investigation and method of prediction used for each selected environmental item are shown in Tables 4-7 and 4-8, respectively. The area of investigation is limited to the periphery of each road section of the project.

Table 4-7 Environmental Investigation

Items	Components
1. Traffic conditions	Examination of present conditions, control points, hazard records, etc.
2. Air quality	SOx : Measurement point: intersections in major urban area
3. Water quality	20 items : Ca, Mg, Na, K, HCO_3, SO_4, Cl, SiO_2, Fe, PO_4, NO_3N, NH4N, Cd, PB, Cr, As, Hg, Mn, pH, EC. Sampling point : main water courses and springs/water wells
4. Noise and vibration	Environmental noise and vibration. Measurement point : intersections in major cities
5. Land	Morphological and geological field survey
6. Soil	Soil investigation; Soil section, Jar test
7. Water	Data collection ; water level and volume of outflow at major rivers, underground water, springs
8. Flora	Base-line survey of flora, 200 m long
9. Landscape	Extraction of major landscape sites
10. Social conditions	Interview survey in each municipality

Table 4-8 Contents and Method of Prediction

Items	Contents : Method
1. Traffic	Forecasting traffic volume in 2000 and 2010.
2. Air quality	Concentration of NOx and CO in 2000 and 2010, plume-diffusion method.
3. Water quality	Suspended Solids (SS) : complete mixing method.
4. Noise and vibration	Road traffic noise and vibration : Sound level (dB(A)) and vibration level (dB).
5. Land	Cutting and embankment : Standard slope gradient.
6. Soil	Soil erosion and generation of SS.
7. Water	Volume of river, flood, drainage outflow.
8. Flora	Disappearance of flora due to forest clearing, planting.
9. Landscape	Extraction of major landscape site.
10. Social conditions	Examination of waste, relocation, monuments, traffic safety, hazards.

4.5 ANALYSIS RESULTS

Environmental Impact Assessment results are integrated and re-examined for each road section by the environmental analyses results as shown in Tables 4-9 to 4-11. Overall environmental evaluation results by the Environmental Checklist are shown in Table 4-12.

Bu using Environmental Checklist, the minor influences of air quality, water quality, noise and vibration, land, soil, water, flora, social conditions (including waste, relocation and safety) were evaluated. These results obtained mirrored those obtained by the Environmental Impact Assessment.

Detailed analysis results are shown in Annexes III.

Table 4-9 Environmental Analysis Results for Road Section-1 (Managua-Masaya Road) (1)

Environmental Items	Condition *1		Problems
	Present Environmental Conditions	Environmental Evaluation	
I. Living Environment			
1) Air quality	3	2	
- Heavy machinery			- ground dust from cutting
- Transportation			and building embankments.
- Dust			
- Quarries			- nonexistent
- Traffic			- gas omitted from vehicles
2) Water quality	2 - 3	2 - 3	- SS from the ground
- Cutting			from cutting and building
- Embankment			embankments.
- Discharge of pumped water			- treatment of SS
- Quarries			- nonexistent
- Waste			
- Drainage			- drainage, inundation
3) Soil contamination	3	3	
- Waste			
4) Noise and vibration	2 - 3	2	
- Heavy machinery			- construction by heavy
- Transportation			machinery
- Traffic			- traffic increase
5) Land subsidence	3	3	
- Excavation			
- Pumping			
6) Odor:	3	3	
- Waste			
- Asphalt plant			
II. Natural Environment			
7) Land	2 - 3	2 - 3	
- Cutting			- slope failure
- Embanking			- falling stone
- Quarries			- waste soil
- Waste dump site			
8) Soil	2 - 3	2 - 3	
- Soil erosion			- gutter, ditch
- Soil dump site			- drainage
- Drainage			- re-sedimentation
9) Water	2 - 3	2 - 3	
- Cutting			- water course
- Embankment			
- Water course			
- Bridge			
- Drainage			
10) Underground water	3	3	- water wells
- Cutting			
- Pumping			
- Waste			
11) Meteorology	3	3	
12) Sea and seashore	3	3	- nonexistent
- Filling			
- Water course			
- Drainage			

Table 4-9 Environmental Analysis Results for Road Section-1 (Managua-Masaya Road) (2)

Environmental Items	Condition *1		Problems
	Present Environmental Conditions	Environmental Evaluation	
13) Flora and fauna	3	2 - 3	
- Clearing			- cutting
- Cutting			- domestic animals
- Embankment			
- Parking area			
- Greening			
14) Landscape	3	2 - 3	
- Clearing			- planting
- Cutting			
- Embankment			
- Greening			
III. Social Environment			
15) Waste	3	2 - 3	
- Waste			- bus stop
- Worker facilities			- waste soil
16) Historical and Cultural monuments	3	3	- access road
17) Traffic conditions	3	2	- traffic safety
18) Sanitation	3	3	
19) Hazards	2 - 3	2 - 3	
- Flood			- inundation
- Earthquake			- water course
20) Relocation	3	2 - 3	
21) Socio-economic conditions	3	3	
22) Cutting district	3	3	
23) Safety	2	2	
- Sidewalks			- sidewalks in urban areas
- Domestic animals			- traffic increase
24) Community	3	3	
25) Recreation facilities	3	3	
26) Water rights and rights of common	3	3	

Note : *1 1 - Major influence
2 : Minor influence
3 : Very minor or no influence

Table 4-10 Environmental Analysis Results for Road Section-2 (Managua-Tipitapa Road) and Road Section-3 (Nandaime-San Benito Road) (1)

Environmental Items	Condition *1		Problems
	Present Environmental Conditions	Environmental Evaluation	
I. Living Environment			
1) Air quality	3	3	
- Heavy machinery			- ground dust from cutting
- Transportation			and building embankments.
- Dust			
- Quarries			- nonexistent
- Traffic			- gas emitted from vehicles
2) Water quality	3	2 - 3	- SS from the ground from
- Cutting			cutting and building
- Embankment			embankments.
- Discharge of pumped water			- treatment of SS
- Quarries			- nonexistent
- Waste			
- Drainage			- drainage, inundation
3) Soil contamination	3	3	
- Waste			
4) Noise and vibration	3	3	
- Heavy machinery			- construction by heavy
- Transportation			machinery
- Traffic			- traffic increase
5) Land subsidence	3	3	
- Excavation			
- Pumping			
6) Odor:	3	3	
- Waste			
- Asphalt plant			- nonexistent
II. Natural Environment			
7) Land	2 - 3	2 - 3	
- Cutting			- slope failure
- Embanking			- falling stones
- Quarries			- waste soil
- Waste dump site			
8) Soil	2 - 3	2 - 3	
- Soil erosion			- gutter, ditch
- Soil dump site			- drainage
- Drainage			- re-sedimentation
9) Water	2 - 3	2 - 3	
- Cutting			- water course
- Embankment			
- Water course			
- Bridge			
- Drainage			
10) Underground water	3	3	- water wells
- Cutting			
- Pumping			
- Waste			
11) Meteorology	3	3	
12) Sea and seashore	3	3	- nonexistent
- Filling			
- Water course			
- Drainage			

Table 4-10 Environmental Analysis Results for Road Section-2 (Managua-Tipitapa Road) and Road Section-3 (Nandaime-San Benito Road) (2)

Environmental Items	Condition *1		Problems
	Present Environmental Conditions	Environmental Evaluation	
13) Flora and fauna	3	3	
- Clearing			- cutting
- Cutting			- domestic animals
- Embankment			
- Parking area			
- Greening			
14) Landscape	3	3	
- Clearing			- planting
- Cutting			
- Embankment			
- Greening			
III. Social Environment			
15) Waste	3	2 - 3	
- Waste			- bus stop area
- Worker facilities			- waste soil
16) Historical and Cultural monuments	3	3	- access road
17) Traffic conditions	3	3	- traffic safety
18) Sanitation	3	3	
19) Hazards	2 - 3	2 - 3	
- Flood			- water course
- Earthquake			
20) Relocation	3	3	
21) Socio-economic conditions	3	3	
22) Cutting district	3	3	
23) Safety	2 - 3	2 - 3	
- Sidewalks			- sidewalks in urban areas
- Domestic animals			- traffic increase
24) Community	3	3	
25) Recreation facilities	3	3	
26) Water rights and rights of common	3	3	

Note - * 1: 1 : Major influence
2 : Minor influence
3 : Very minor or no influence

Table 4-11 Results of Environmental Analysis for Road Section-4 (Telica-San Isidro Road) (1)

Environmental Items	Condition *1		Problems
	Present Environmental Conditions	Environmental Evaluation	
I. Living Environment			
1) Air quality	3	3	
- Heavy machinery			- ground dust from cutting
- Transportation			and building embankment.
- Dust			
- Quarries			- nonexistent
- Traffic			- gas emitted from vehicles
2) Water quality	2 - 3	2 - 3	- SS from the ground from
- Cutting			cutting and building
- Embankment			embankments
- Discharge of pumped water			- treatment of SS
- Quarries			- nonexistent
- Waste			
- Drainage			- drainage, inundation
3) Soil contamination	3	3	
- Waste			
4) Noise and vibration	3	3	
- Heavy machinery			- construction by heavy
- Transportation			machinery
- Traffic			- traffic increase
5) Land subsidence	3	3	
- Excavation			
- Pumping			
6) Odor:	3	3	
- Waste			
- Asphalt plant			- nonexistent
II. Natural Environment			
7) Land	2	2	
- Cutting			- slope failure
- Embanking			- falling stones
- Quarries			- waste soil
- Waste dump site			
8) Soil	2 - 3	2 - 3	
- Soil erosion			- gutter, ditch
- Soil dump site			- drainage
- Drainage			- re-sedimentation
9) Water	2 - 3	2 - 3	
- Cutting			
- Embankment			
- Water course			- water course
- Bridge			
- Drainage			
10) Underground water	3	3	- water wells
- Cutting			
- Pumping			
- Waste			
11) Meteorology	3	3	
12) Sea and seashore	3	3	- nonexistent
- Filling			
- Water course			
- Drainage			

Table 4-11 Results of Environmental Analysis for Road Section-4 (Telica-San Isidro Road) (2)

Environmental Items	Condition *1		Problems
	Present Environmental Conditions	Environmental Evaluation	
13) Flora and fauna	3	2 - 3	
- Clearing			- cutting
- Cutting			- domestic animals
- Embankment			
- Parking area			
- Greening			
14) Landscape	3	2 - 3	
- Clearing			- planting
- Cutting			
- Embankment			
- Greening			
III. Social Environment			
15) Waste	3	2 - 3	
- Waste			- bus stop
- Worker facilities			- waste soil
16) Historical and Cultural monuments	3	3	- access road
17) Traffic conditions	3	3	- traffic safety
18) Sanitation	3	3	
19) Hazards	2 - 3	2 - 3	
- Flood			- inundation
- Earthquake			- water course
20) Relocation	3	3	
21) Socio-economic conditions	3	3	
22) Cutting district	3	3	
23) Safety	2 - 3	2 - 3	
- Sidewalks			- sidewalks in urban areas
- Domestic animals			- traffic increase
24) Community	3	3	
25) Recreation facilities	3	3	
26) Water rights and rights of common	3	3	

Note - * 1: 1 : Major influence
2 : Minor influence
3 : Very minor or no influence

Table 4-12 Environmental Evaluation

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

Note - * 1: 1 : Major influence
2 : Minor influence
3 : Very minor or no influence

4.6 ENVIRONMENTAL MANAGEMENT PLAN

The environmental management plan has been prepared based on the evaluation and prediction results of each environmental item, as shown in Table 4-13.

Table 4-13 Environmental Management Plan

Environmental Item	Influence	Location	Countermeasures
1. Traffic conditions	Traffic safety	Urban area, village	Sidewalk, bus stop, parking area
2. Air quality	NOx, CO	Managua - Masaya	Traffic control, emission control
3. Water quality	SS	Ground, Asphalt plant	Drainage, settling pond, plantation
4. Noise and vibration	Noise, vibration	Managua-Masaya, Managua-Tipitapa	Vehicle restriction, speed restriction
5. Soil	SS, erosion	Ground, drainage, waste dump site	Drainage, slope and bank protection, planting
6. Land	Slope failure, landslides, falling stones	Cutting, embankment	Slope protection
7. Water	Inundation	Drainage	Drainage system, bridge, culvert, ditch, gutter
8. Flora	-	Cutting, Alignment	Replanting
9. Landscape	-	Cutting, bypass, Alignment	Planting, parking area
10. Social conditions	Waste, relocation, surplus soil, waste soil, safety	Bus stop, Masaya	Garbage cans, relocation, communication, sidewalk, bus stop

4.6.1 Traffic Conditions

Pedestrian safety as well as the safety of transportation system users in urban areas, villages and school zones will be influenced by the increase in the number of vehicles.

Therefore, it is necessary to ensure the safety of pedestrians by providing sidewalks, pedestrian crossings (including pedestrian bridges at roundabouts, if possible) and traffic signs. Moreover, it is also necessary to secure the safety of transportation system users by providing bus stops, parking areas and traffic signs at the urban areas, villages, and school zones.

Countermeasures

Item	Countermeasures	Area
Traffic safety	Sidewalks, Pedestrian crossings, Bus stops, Parking areas, Traffic signs	Urban areas, around villages, school zones

4.6.2 Air Quality

Air quality is influenced by exhaust gas, the dust produced by heavy machinery, and ground dust during construction stage, and by exhaust gas and dust raised by vehicles during the service stage.

The forecast levels of NOx and CO indicate that the environment will be little affected everywhere except along the Managua-Masaya Road. Forecast levels of NOx and CO along the Managua-Masaya Road are closed to environmental quality standard limits for air quality, although they do not exceed standard values. Nevertheless, it is necessary to establish a monitoring system to analyze air quality. Thereafter, if air pollution resulting from gas emitted by vehicles is found to be serious, it will be necessary to implement traffic control and emission control measures.

Countermeasures

Item	Countermeasures	Area
Air quality	Traffic control, Emission control	Managua-Masaya Road
	Air pollution monitoring system	All sections

4.6.3 Water Quality

The elements which affect water quality are suspended solids (SS) flowing from the ground during the construction stage, namely in areas where surplus soil and waste will be dumped or kept. These areas include temporary and/or permanent machinery stockyards, temporary asphalt plant areas, temporary worker facilities, etc. (if these are planned).

Forecast levels of SS indicate that the ground will generate 100~190 p.p.m. of SS. Although the influence of the SS on the environment is relatively small, it will be necessary to set up drainage systems and settling ponds for SS precipitation.

In addition, replanting should be carried out in areas where permanent facilities are located or where there are storage areas of temporary facilities after the completion of the construction stage.

Countermeasures

Item	Countermeasures	Area
Water quality	Drainage system (ditches), settling pond, replanting	All sections

4.6.4 Noise and Vibration

Noise and vibration are caused by vehicles on the roads. Noise levels exceed acceptable standards in many places, particularly along the Managua-Masaya Road.

Forecast levels of noise and vibration indicate that noise and vibration conditions along the Managua-Masaya Road. However, noise and vibration in other sections will have little effect on the environment.

Nevertheless, it will be necessary to implement traffic control measures to deal with noise and vibration pollution along the Managua-Masaya Road. As a result, it will be necessary to set up a monitoring system to control noise pollution. Moreover, trees will have to be planted along the road.

Countermeasures

Item	Countermeasures	Area
Noise and Vibration	Traffic control (traffic volume, speed)	Managua-Masaya Road
	Noise pollution monitoring system Roadside tree planting	All sections

4.6.5 Soil

Elements which affect the soil are suspended solids (SS) flowing from the ground during the construction stage, primarily in the surplus soil and waste dump site and other facilities, including temporary and/or permanent machinery stockyards, temporary asphalt plant areas, temporary worker facilities, etc. (if planned), and soil erosion around the roads.

Forecast levels indicate that 101 to 186 p.p.m. of SS will be generated from the ground. The influence of SS on the environment is relatively small. However, it will be necessary to set up a drainage system and settling ponds to handle SS precipitation. Moreover, stream banks will be more eroded by changes caused by the drainage system. As a result, it will be necessary to take measures to protect the bank.

In addition, where permanent facilities are surrounded by barren land and at the storage areas of temporary facilities after completion of the construction stage, replanting will be required.

Countermeasures

Item	Countermeasures	Area
Water quality	Drainage system (ditches, bank protection), settling pond, replanting	All sections

4.6.6 Land

The slopes of cut areas and embankments may be stabilized by a standard slope gradient, drainage system and slope protection measures, including retaining walls, shotcreting, sodding, etc. In addition, steep slopes may be stabilized by retaining walls, shotcreting, etc.

Some of the slopes facing to the Masaya Lake at Nindiri are eroded (gully erosion), hence it will be necessary to take slope protection measures in this section.

Countermeasures

Item	Countermeasures	Area
Land	Cutting areas, embankments (Slope protection, retaining walls, shotcreting) Drainage system (Gutter, ditch)	All sections

4.6.7 Water

The elements that affect water are the volume of river outflow and road drainage. An analysis of outflow results indicates that present condition will change little.

To deal with road drainage, it will be necessary to set up drainage facilities, including gutters, ditches, etc. and to drain water smoothly to the existing drains and rivers.

Countermeasures

Item	Countermeasures	Area
Water	Drainage system (Gutter, ditch)	All sections

4.6.8 Flora and Fauna

Plans call for minimizing cutting and the building of embankments in several places. Since most of the greenery in the project area would be preserved, it is assumed that the influence on local fauna will be limited.

In addition, soil and waste dump sites, slopes, etc. would be replanted and resodded as shown in Figure 4-3. The trees to be planted would be selected from existing species around the project area, including Acacia, Eucalipto, Chilamate, etc.

Countermeasures

Item	Countermeasures	Area
Flora and Fauna	Planting (Selection of trees) Replanting, Sodding	All sections

4.6.9 Landscape

The viewing spheres where the topography would be changed by road improvements are limited to those along existing roads, since cutting and the building of embankments will be minimized. Therefore, it is assumed that the influence on the landscape of road improvements can be minimized. In addition, there are several scenic areas along the road, which means that it is possible to set up a parking area as illustrated in Figure 4-4.

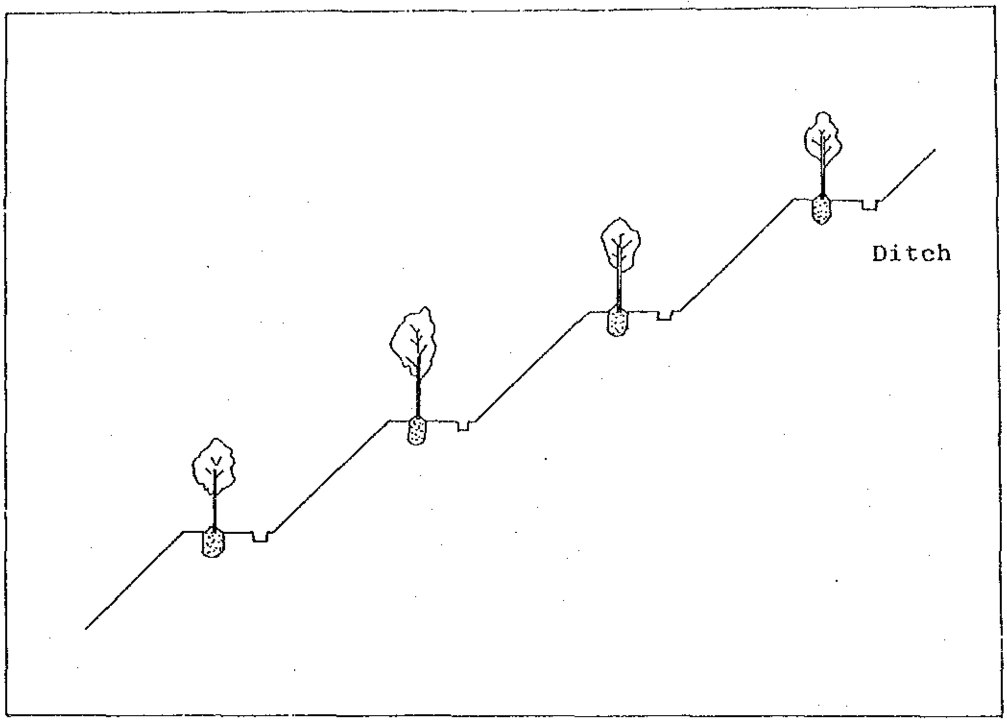

Figure 4-3 Planting

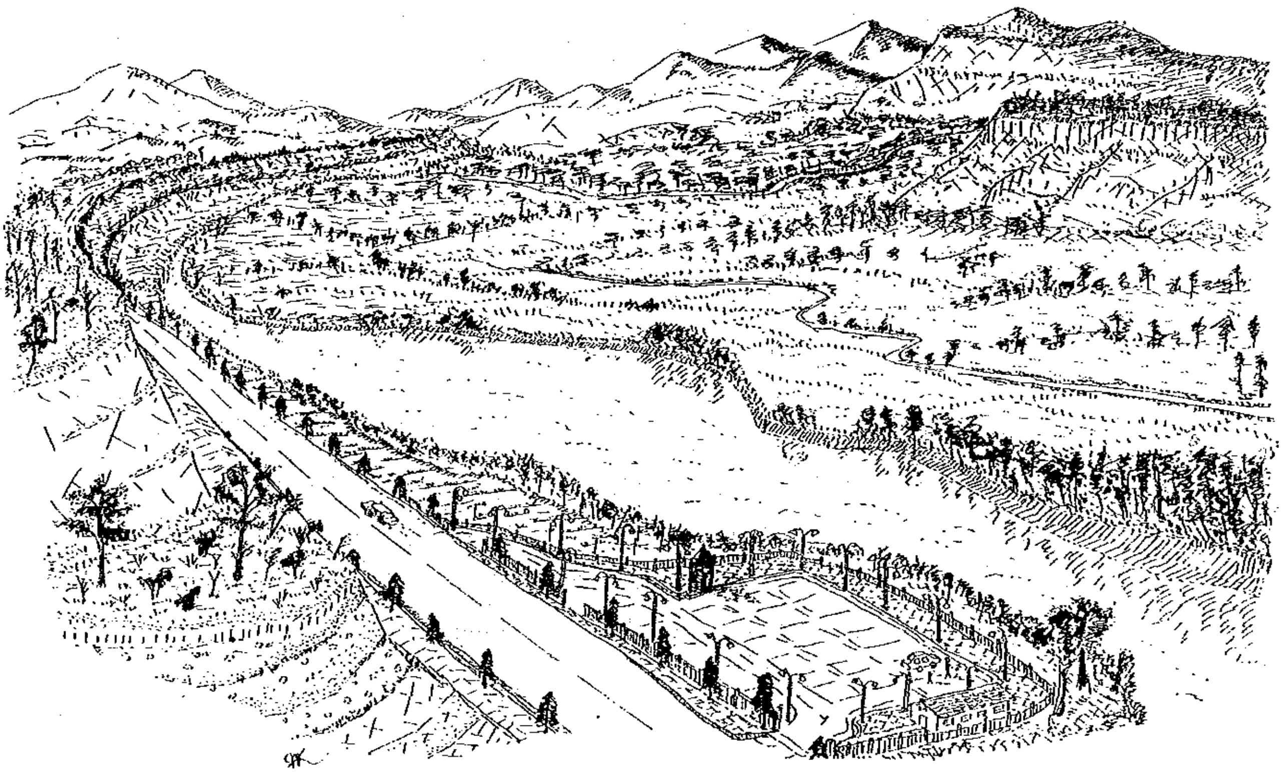

Figure 4-4 Parking Area

4.6.10 Social Conditions

The surplus and waste soil resulting from road construction would be treated at the soil dump site.

It will also be necessary to set up garbage cans and to handle waste at bus stops and in parking areas.

In the urban area of Masaya, several temporary workshops and private lands will have to be relocated to accommodate road improvements. Hence, it will be necessary to manage communications so that there will be no misunderstandings concerning the land rights.

Traffic safety is described under Section 4.6.1 (Traffic conditions).

Countermeasures

Item	Countermeasures	Area
Social conditions	Construction waste (Soil dump sites) Waste (Waste disposal) Relocation (Communication)	All sections

4.6.11 Integrated Environmental Evaluation

The integrated Environmental Checklist examined by the environmental management plan is shown in Table 4-14.

The influence on the environmental items other than air quality, noise and vibration is expected to be very small, or will be minimized by the environmental management plan. However, air quality, noise and vibration may be worsened in some places. Therefore, it will be necessary to set up air quality, noise and vibration monitoring systems, and to control traffic conditions on the basis of the monitoring results.

Table 4-14 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.

4.7 MONITORING PLAN

Monitoring is necessary to preserve the environment during road construction and service. The environmental items to be monitored are air quality, water quality, noise and vibration. Monitoring contents are shown in Table 4-15.

Air quality, noise and vibration would affect the environment of Managua and Masaya urban areas depending on the increase of traffic volume. Therefore, it is necessary to set up air quality, noise and vibration monitoring systems along the Managua-Masaya Road as shown in Table 4-15, as well as to control traffic conditions by, for example, restricting traffic volume and reducing the speed of vehicles.

Suspended solids (SS) in water may affect the environment during road construction. Water containing a lot of SS drained from the ground should be treated in settling ponds before being discharged to existing drainage systems or water courses. Because of this, it will be necessary to enforce the monitoring and conduct analyses of suspended solids in the field.

Table 4-15 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

4.8 CONCLUSIONS AND RECOMMENDATIONS

4.8.1 Conclusions

Environmental Impact Assessment of the project area was carried out during the Feasibility Study. Ten (10) environmental items, namely, traffic conditions, air quality, water quality, noise and vibration, land, soil, water, flora, landscape and social conditions were selected.

Environmental investigations of the present condition of each environmental item, were carried out and environmental conditions in 2000 and 2010 were forecast and evaluated. As a result of these examinations, the influences of traffic conditions, air quality, water quality, noise and vibration, land, soil, flora, landscape and social conditions could be determined, as shown in Table 4-16.

The influences of the various environmental items including land, soil, flora, landscape and social conditions were found to be very small or are expected to be minimized by the environmental management plan. However, air quality, water quality, noise and vibration are expected to worsen in some places. Therefore, it will be necessary to set up air quality, water quality, noise and vibration monitoring systems, as well as to control traffic conditions on the basis of the monitoring results.

4.8.2 Recommendations

Monitoring is recommended, as it will be necessary to preserve the environment during road construction and service. The environmental items to be monitored are air quality, water quality, noise and vibration. The contents of monitoring are shown in Table 4-15.

Table 4-16 Integrated Environmental Evaluation

Environmental Items	Evaluation of the Whole Area *1	Integrated Evaluation *1	Countermeasures and Monitoring
1. Traffic conditions	3	3	Sidewalks, bus stops, parking areas, traffic signs
2. Air quality	2-3	3	Traffic and speed control Air pollution monitoring system
3. Water quality	2-3	3	Drainage, settling ponds for suspended solids, SS monitoring
4. Noise and Vibration	2-3	3	Traffic and speed control Noise and vibration monitoring system
5. Land	2-3	3	Slope protection, planting, sodding, drainage
6. Soil	2-3	3	Drainage, bank protection
7. Water	2-3	3	Drainage
8. Flora	2-3	3	Planting
9. Landscape	3	3	Planting
10. Social conditions *2	2-3	3	Waste disposal, communication, soil dump sites, sidewalks, bus stops

Note - *1 : 1 : Major influence
2 : Minor influence
3 : Very minor or no influence
*2 : Including waste, relocation, traffic safety and hazards

CHAPTER 5

PRELIMINARY ENGINEERING STUDY

CHAPTER 5 PRELIMINARY ENGINEERING STUDY

5.1 ROAD IMPROVEMENT PLAN

5.1.1 Basic Policies

The objectives of the priority projects are understood to be as follows:

- To strengthen the north-south and east-west road links in the trunk road network.
- To promote realization of high-capacity transport in the trunk road network.

In addition to the above, the following objective also applies to the Managua-Masaya Road:

- To strengthen the road link between Managua and Masaya to prevent the traffic congestion now and in the future on the main road connecting these two major cities.

Taking the above objectives into account, the road improvement plan considered the following.

(1) Functions of the Project Roads

The Project Roads should function as a part of the north-south or east-west trunk roads in the network. The Managua-Masaya Road should also be considered as a suburban road with few intersections.

The Projects Roads should have the appropriate number of lanes corresponding to the traffic demand in 2010, which is the target year.

(2) Considerations in Establishing Design Criteria

The design criteria used to formulate the improvement plan should refer to both existing design criteria in Nicaragua and AASHTO recommendations.

(3) Determination of Appropriate Geometric Design

The geometric design criteria, including minimum radius curvature, maximum vertical gradient and rate of vertical curvature, were determined according to the established design speed. The cross-sectional elements, comprising lane, shoulder, median and sidewalk widths, were also determined/reviewed by referring to existing design criteria in Nicaragua, other projects, and AASHTO recommendations.

Basic geometric design policies to be applied to the project road were established after a detailed study of the surrounding conditions. Horizontal and vertical alignment designs were prepared by carrying out integral studies on the various geometric, structural, hydrological drainage and geological aspects.

The following is an outline of design policies and controls for determining of horizontal and vertical alignment:

- The safe and efficient movement of large traffic volumes at the specified design speed should be realized by providing good roadway alignment.
- Where vertical and horizontal curves are found occur in combination or in close proximity to each other, a flowing alignment should be designed by coordinating these curves well.
- Countermeasures should be provided to maintain the functions of existing rivers, waterways, and public facilities (i.e. roads, railways, and utilities), which the Project Road crosses.

(4) Road Surface Improvement

An appropriate pavement structure was selected to make improvements, considering time constraints, construction economy, utilization of local materials, and traffic overloading.

(5) Improvement of Existing Bridges

Reconstruction of existing bridges, i.e. El Arroyo Bridge and La Morita Bridge on the Managua-Masaya Road and El Arroyo N° 1 Bridge on the Nandaime-San Benito Road, was considered to make these bridges conform to new design loads (HS-20). Alternative bridge types were also examined.

(6) Drainage Rehabilitation/Improvement

The installation of side ditches not only in the cutting section but also on the toes of embankment slopes was considered for the purpose of improving drainage. The appropriate interval of pipe/box culverts was also considered.

(7) Consideration of Sidewalks and Busbays

To ensure safety, the installation of sidewalks in densely populated areas along the road, and in the vicinity of schools was considered.

The installation of busbays in appropriate locations such as in town areas along the road and near the major intersections was also proposed.

(8) Project Year

Project Roads are expected to be opened in 2000 under the following assumptions:

- Financial arrangements : 1994-1996
- Tender Procedures : 1996-1997
- Construction : 1997-1999

The project life was determined as 20 years as to 2020 after opening of the Project Roads in 2000. In addition, the following plans for the Managua-Masaya Road were proposed.

(9) Widening of Existing Roads

According to the traffic demand forecast in the target year 2010, which is described in Chapter 3, existing two-lane carriageway will have to be widened to dual-carriageways,

(10) Improvement of Existing Intersections

The existing major intersection is located at the start of the Project Road. The intersection of Colonia Centro América crosses traffic from/to Carretera Norte with traffic from/to Masaya, which frequently causes traffic congestion. Improving signalization or constructing a flyover will be necessary to deal with future traffic volume. Several alternative improvements were considered.

5.1.2 Road Class and Number of Lanes

The road class (improvement level) for each project road was established on the basis of determinations made in the Master Plan Stage. The number of lanes were determined by analyzing the highway capacity using the method given in the Highway Capacity Manual, Special Report 209. The results are shown in Table 5-1.

Table 5-1 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

The above design capacity and design hour volume were analyzed in accordance with the procedure shown in Table 5-2.

5.1.3 Design Criteria

This section discusses the design criteria to be applied in the plan to improve the Project Roads.

The design criteria in Nicaragua were used to a maximum extent where available. AASHTO recommendations, the Japanese Standard, and recommendations on "Diagnóstico de la Infraestructura Vial del País" in May 1989 (hereinafter referred to as "The 1989 Study") were referred to for items not covered in the Nicaraguan Criteria.

Table 5-2 Analysis of Highway Capacity

Description		Application			
		Managua-Managua	**Managua-Tipitapa**	**Nandaime-San Benito**	**Telica-San Isidro**
Type of Terrain		Flat	Flat	Flat	Hilly
Highway Classification (Rural/Suburban)		Suburban	Rural	Rural	Rural
Lane Width (m)		3.50	3.50	3.50	3.50
Shoulder Width	Outer	2.50	2.50	2.50	1.50
	Inner	0.50	-	-	-
Heavy Vehicles Composition (%)	Trucks	9.30	27.9	34.1	26.2
	Buses	4.40	6.90	7.30	12.10
	Recreation Vehicles	0.00	0.00	0.00	0.00
Passenger Car Equivalent (PCU)	E_t for trucks	1.70	1.70	1.70	4.00
	E_b for buses	1.50	1.50	1.50	3.00
	E_r for RV's	1.60	1.60	1.60	3.00
	f_w for Lateral Clearance	1.00	1.00	1.00	1.00
Adjustment Factors	f_{hv} for Heavy Vehicles	0.92	0.81	0.78	0.49
	f_e for develop. environment	1.00	0.95	0.95	0.95
	f_p for driver population	1.00	1.00	1.00	1.00
Basic Capacity (PCU/hr/lane)		2,000	2,000	2,000	2,000
V/C Value		0.75	0.50	0.50	0.50
Possible Capacity (PCU/hr/lane)		1,500	1,000	1,000	1,000
Design Capacity (veh/hr/lane)		1,400	800	700	500
Future Traffic Volume in 2010 (AADT)		43,516	9,513	7,740	1,073
Peak Factor (%)		<10	<15	<15	<15
Directional Factor (%)		<60	<65	<65	<65
Directional Design Hour Volume (veh/hr)		2,600	900	800	100

(1) Geometric Design Criteria

The recommended geometric design criteria for the project roads are shown in Table 5-3. The major points are discussed in the following paragraphs:

① The Project Roads except for Telica-San Isidro Road are classified into TP-I. However, the criteria corresponding to the TP-I defined in the Master Plan Study has not been stated in the Nicaraguan standard. Therefore, recommendations in the 1989 Study were applied to determine the design speed.

② The 1989 Study recommends design speed of 65 km/hr, 80 km/hr or 100 km/hr for Troncal Principal depending on topographic conditions. The design speed for the Project Roads classified as TP-I was applied in the following manner on the basis of topographic conditions:

Table 5-3 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

- Managua-Masaya Road : 80 km/hr (Hilly Section)

  Although this is regarded as a flat section, a 80 km/hr design speed should be applied because the area along the road is densely populated.
- Managua-Tipitapa Road : 100 km/hr (Flat Section)
- Nandaime-San Benito Road
  - Nandaime-Masaya Section : 80 km/hr (Hilly Section)
  - El Coyotepe-San Benito Section : 100 km/hr (Flat Section)

③ The Telica-San Isidro Road is classified as TS-I. According to the Nicaraguan Standard, the TS-I which defined in the Master Plan Study corresponds to the "Nacional 2a" class. The design speed is stated as 80 km/hr, 60 km/hr or 40 km/hr depending on the topographical conditions. Therefore, the following design speeds are applied:

- Telica-El Jicaral : 80 km/hr (Flat Section)
- El Jicaral-La Unión: 60 km/hr (Hilly Section)
- La Unión-San Isidro: 80 km/hr (Flat Section)

④ Lanes with a 3.5 m width are recommended in order to keep the desirable lateral clearance of 0.5 m at each side of heavy vehicles with a maximum width of 2.5 m.

⑤ According to AASHTO recommendations, a 3.0 m shoulder width is preferable for highways corresponding to TP-I. On the other hand, a width of more than 1.8 m is preferable to secure a lateral clearance of more than 3.5 m. Therefore, the most practical solution is to apply a 2.5 m shoulder width (as the median value) to TP-I class highways. In addition to this, since the Managua-Masaya Road is considered to be a suburban road, it is safe to assume that vehicles will frequently be parked along the road. Thus, this offers yet another reason for requiring a 2.5 m shoulder width.

As described above, the Telica-San Isidro Road corresponds to the Nacional 2a class in the Nicaraguan Standards, and generally a 1.5 m shoulder width is applied to Nacional 2a class highways. Therefore, a 1.5 m shoulder width should also be applied to the Project Roads.

⑥ The median width is expressed as the dimension between the through-lane edges including the inner shoulders. The principal functions of a median width are:

- To provide freedom from desirable interference of opposing traffic.
- To minimize headlight glare.
- To provide an open green space.
- To prevent vehicle U-turns and ensure a smooth traffic flow.
- To reserve left-turn lanes at intersections.

It is recommendable to provide a 4.0 m median including 0.5 m inner shoulders with a 3.0 m width raised. A 3.0 m width is generally sufficient to ensure the above functions.

⑦ A 3.0 m sidewalk width should be installed where necessary, considering the landscape and the environment along the road to ensure sufficient space for utilities. On the other hand, a 5.0 m sidewalk width is recommendable to add a green belt space (2.0 m) to the Managua-Masaya Road, since this road functions as a suburban road.

⑧ In addition to the above design considerations for slope gradients and large slopes, the following should also be considered:

- For embankment slopes, the following gradient (depending on the height of the slope) was adopted on the basis of existing criteria in Nicaragua.
  - $h \leq 2.0$ m : 3.0 to 1
  - 1.2 m $< h \leq 2.0$ m : 2.0 to 1
  - $h > 2.0$ m : 1.5 to 1
- For cut slopes, the following gradient (depending on geological mechanics) was adopted on the basis of obtained structure boring results.
  - Hard rock : 0.25 to 1
  - Soft rock : 0.50 to 1
  - Weathered rock : 0.67 to 1
  - Soil : 1.00 to 1

⑧ In embankment sections, berms should have a width of 1.5 m and a height of 5.0 m when the height of a slope is greater than 8.0 m. For cut sections, the berms were calculated on the basis of the following geological mechanics:

- Hard/Soft rock : Slope height 10 m,
  Berm width = 2.0 m
- Weathered rock/soil : Slope height 7 m,
  Berm width = 2.0 m

⑨ From an economical viewpoint the use of slope protection works, as shown in Table 5-4, were also considered in order to prevent slope failure.

Table 5-4 Slope Protection Works

Type of Works	Application	Slope Gradient	Limit of Slope Height
Stone Masonry	Embankment slope	0.5:1	5.0m
Retaining Wall	Cut slope on soil	0.5:1	7.0m
Gravity Type Retaining Wall	Embankment slope	-	3.0m
Concrete Spraying	Cut slope on Weathered Rock	0.5:1	7.0m
	Cut slope on soft rock	0.25:1	10.0m

(2) Pavement Design Standard

The flexible pavements design method described in the "AASHTO Guide for the Design of Pavement Structures 1986" was applied to the design of pavements for the Project Roads.