## 4.3 RESULTS OF THE TRAFFIC SURVEY

### 4.3.1 Setting the Traffic Zone

Before the analysis of the traffic survey results, traffic zones were set up as the objective areas. The basic criteria used to set these traffic zones were as follows:

① In Nicaragua, traffic zones were set up by MCT in "Plan Nacional de Transporte Resultados Prella Inares de O/D por Carrestras (Methodologia) 1990 Marzo". Therefore, the traffic zone in the Study was made nearly the same as the above traffic zones to simplify comparison of these two traffic surveys.

② Recently, some of the administrative boundaries were modified by the government so that they would be consistent with the new administrative territory, which was officially announced in "Reforming Law of the Former Law on Political-Administrative Division of the Republic of Nicaragua" in 1991 (9 Regions, 15 Departments, and 143 Municipalities). As a result, the boundaries of the new traffic zones were made to coincide with the new administrative boundaries.

③ Each zone was composed of at least one municipality, and population data was available for each with the municipality. Accordingly, no municipality was divided into two or more traffic zones. In addition, no zone included municipalities from other regions and/or departments.

④ Managua was set up as an independent zone, since traffic there is very heavy. Moreover, Puerto Corinto and Puerto Sandino were also set up as independent zones, since the former handles about 90% of all domestic export and import cargoes, and the latter will in the future be developed as one of the country's most important harbors.

⑤ Two foreign zones, Honduras and Costa Rica, were also set up, considering international traffic flow.

As a result, a total number of 33 zones were set up. The zone code table and zone map are shown in Table 4-8 and Figure 4-7, respectively.

## Table 4-8 Zone Code (1)

| Zone | Region | Department | D-Number | Municipality (District) | Statistic M-number | Each Zone M-number | Area (km²) |
|---|---|---|---|---|---|---|---|
| 1 | 9 | Río San Juan | 17 | Moritto | 1 | 1 | 677 |
| 1 | 9 | Río San Juan | 17 | El Almendro | 2 | 2 | 993 |
| 1 | 9 | Río San Juan | 17 | San Miguelito | 3 | 3 | 923 |
| 1 | 9 | Río San Juan | 17 | San Carlos | 4 | 4 | 1,462 |
| 1 | 9 | Río San Juan | 17 | El Castillo | 5 | 5 | 1,656 |
| 2 | 4 | Rivas | 10 | Tola | 1 | 1 | 474 |
| 2 | 4 | Rivas | 10 | Belén | 2 | 2 | 282 |
| 2 | 4 | Rivas | 10 | Potosí | 3 | 3 | 146 |
| 2 | 4 | Rivas | 10 | Buenos Aires | 4 | 4 | 65 |
| 2 | 4 | Rivas | 10 | Rivas | 5 | 5 | 139 |
| 2 | 4 | Rivas | 10 | San Jorge | 6 | 6 | 22 |
| 2 | 4 | Rivas | 10 | Cárdenas | 8 | 7 | 163 |
| 2 | 4 | Rivas | 10 | Moyogalpa | 9 | 8 | 63 |
| 2 | 4 | Rivas | 10 | Altagracia | 10 | 9 | 203 |
| 3 | 4 | Rivas | 10 | San Juan del Sur | 7 | 1 | 598 |
| 4 | 4 | Granada | 9 | Granada | 1 | 1 | 531 |
| 1 | 4 | Granada | 9 | Diriá | 2 | 2 | 16 |
| 4 | 4 | Granada | 9 | Diriomo | 3 | 3 | 42 |
| 4 | 4 | Granada | 9 | Nandaime | 4 | 4 | 340 |
| 5 | 5 | Chontales | 12 | Comalapa | 1 | 1 | 586 |
| 5 | 5 | Chontales | 12 | Juigalpa | 2 | 2 | 1,037 |
| 5 | 5 | Chontales | 12 | La Libertad | 3 | 3 | 761 |
| 5 | 5 | Chontales | 12 | Santo Domingo | 4 | 4 | 717 |
| 5 | 5 | Chontales | 12 | San Pedro de Lóvago | 5 | 5 | 604 |
| 5 | 5 | Chontales | 12 | Santo Tomás | 6 | 6 | 450 |
| 5 | 5 | Chontales | 12 | Acoyapa | 7 | 7 | 1,055 |
| 5 | 5 | Chontales | 12 | Villa Sandino | 8 | 8 | 1,168 |
| 6 | 5 | Boaco | 11 | Sn.José de los Remates | 1 | 1 | 254 |
| 6 | 5 | Boaco | 11 | Teustepe | 2 | 2 | 669 |
| 6 | 5 | Boaco | 11 | Santa Lucía | 3 | 3 | 120 |
| 6 | 5 | Boaco | 11 | Boaco | 4 | 4 | 1,042 |
| 6 | 5 | Boaco | 11 | Camoapa | 5 | 5 | 1,478 |
| 6 | 5 | Boaco | 11 | Sn.Lorenzo | 6 | 6 | 681 |
| 7 | 8 | Atlántico Sur | 16 | Paiwas | 1 | 1 | 1,478 |
| 7 | 8 | Atlántico Sur | 16 | El Rama | 5 | 2 | 5,618 |
| 7 | 8 | Atlántico Sur | 16 | Muelle de los Bueyes | 6 | 3 | 1,391 |
| 7 | 8 | Atlántico Sur | 16 | Nueva Guinea | 7 | 4 | 2,774 |
| 8 | 4 | Carzo | 8 | San Marcos | 1 | 1 | 108 |
| 8 | 4 | Carzo | 8 | Diriamba | 2 | 2 | 345 |
| 8 | 4 | Carzo | 8 | Dolores | 3 | 3 | 25 |
| 8 | 4 | Carzo | 8 | Jinotepe | 4 | 4 | 257 |
| 8 | 4 | Carzo | 8 | El Rosario | 5 | 5 | 11 |
| 8 | 4 | Carzo | 8 | La Paz de Carazo | 6 | 6 | 19 |
| 8 | 4 | Carzo | 8 | Santa Teresa | 7 | 7 | 194 |
| 8 | 4 | Carzo | 8 | La Conquista | 8 | 8 | 91 |
| 9 | 4 | Masaya | 7 | La Concepción | 1 | 1 | 73 |
| 9 | 4 | Masaya | 7 | Masatepe | 5 | 2 | 62 |
| 9 | 4 | Masaya | 7 | Nandasmo | 6 | 3 | 13 |
| 9 | 4 | Masaya | 7 | Catarina | 7 | 4 | 13 |
| 9 | 4 | Masaya | 7 | Niquinohomo | 8 | 5 | 35 |
| 9 | 4 | Masaya | 7 | San Juan de Oriente | 9 | 6 | 13 |
| 10 | 4 | Masaya | 7 | Nindirf | 2 | 1 | 132 |
| 10 | 4 | Masaya | 7 | Masaya | 3 | 2 | 141 |
| 10 | 4 | Masaya | 7 | Tisma | 4 | 3 | 108 |

## Table 4-8 Zone Code (2)

| Zone | Region | Department | D-Number | Municipality (District) | Statistic M-number | Each Zone M-number | Area (km²) |
|---|---|---|---|---|---|---|---|
| 11 | 3 | Managua | 6 | Managua | 6 | 1 | 683 |
| 12 | 3 | Managua | 6 | San Francisco Libre | 1 | 1 | 664 |
| 12 | 3 | Managua | 6 | Tipitapa | 2 | 2 | 973 |
| 13 | 6 | Matagalpa | 14 | San Isidro | 1 | 1 | 150 |
| 13 | 6 | Matagalpa | 14 | Sébaco | 2 | 2 | 282 |
| 13 | 6 | Matagalpa | 14 | Ciudad Dario | 3 | 3 | 806 |
| 13 | 6 | Matagalpa | 14 | Terrabona | 4 | 4 | 282 |
| 14 | 6 | Matagalpa | 14 | San Dionisio | 5 | 1 | 152 |
| 14 | 6 | Matagalpa | 14 | Esquipulas | 6 | 2 | 216 |
| 14 | 6 | Matagalpa | 14 | Muy Muy | 7 | 3 | 375 |
| 14 | 6 | Matagalpa | 14 | Matagalpa | 8 | 4 | 644 |
| 14 | 6 | Matagalpa | 14 | San Ramón | 9 | 5 | 487 |
| 14 | 6 | Matagalpa | 14 | El Tuma-La Dalia | 10 | 6 | 462 |
| 14 | 6 | Matagalpa | 14 | Rancho Grande | 11 | 7 | 648 |
| 14 | 6 | Matagalpa | 14 | Matiguás | 12 | 8 | 1,335 |
| 14 | 6 | Matagalpa | 14 | Río Blanco | 13 | 9 | 2,684 |
| 15 | 7 | Atrántico Norte | 15 | Bonanza | 2 | 1 | 2,039 |
| 15 | 7 | Atrántico Norte | 15 | Rosita | 3 | 2 | 4,418 |
| 15 | 7 | Atrántico Norte | 15 | Waslala | 5 | 3 | 1,291 |
| 15 | 7 | Atrántico Norte | 15 | Siuna | 6 | 4 | 4,238 |
| 16 | 7 | Atrántico Norte | 15 | Puerto Cabezas | 4 | 1 | 5,787 |
| 16 | 7 | Atrántico Norte | 15 | Prinzapolka | 7 | 2 | 6,253 |
| 17 | 2 | León | 5 | León | 1 | 1 | 820 |
| 17 | 2 | León | 5 | Quezalguaque | 2 | 2 | 80 |
| 17 | 2 | León | 5 | Telica | 3 | 3 | 400 |
| 17 | 2 | León | 5 | Larreynaga | 4 | 4 | 888 |
| 17 | 2 | León | 5 | La Paz Centro | 9 | 5 | 606 |
| 17 | 2 | León | 5 | Nagarote | 10 | 6 | 581 |
| 18 | 2 | León | 5 | El sauce | 5 | 1 | 727 |
| 18 | 2 | León | 5 | Achuapa | 6 | 2 | 333 |
| 18 | 2 | León | 5 | Santa Rosa del Penón | 7 | 3 | 238 |
| 18 | 2 | León | 5 | El Jicaral | 8 | 4 | 434 |
| 19 | 1 | Estelí | 3 | Pueblo Nuevo | 1 | 1 | 224 |
| 19 | 1 | Estelí | 3 | Condega | 2 | 2 | 398 |
| 19 | 1 | Estelí | 3 | San Juan de Limay | 3 | 3 | 535 |
| 19 | 1 | Estelí | 3 | Estelí | 4 | 4 | 754 |
| 19 | 1 | Estelí | 3 | Lá Trinidad | 5 | 5 | 261 |
| 19 | 1 | Estelí | 3 | San Nicolás | 6 | 6 | 163 |
| 20 | 6 | Jinotega | 13 | Wiwilí | 1 | 1 | 3,011 |
| 20 | 6 | Jinotega | 13 | Cúa-Bocay | 2 | 2 | 4,234 |
| 20 | 6 | Jinotega | 13 | San Sebastián de Yali | 3 | 3 | 311 |
| 20 | 6 | Jinotega | 13 | La Concordia | 4 | 4 | 122 |
| 20 | 6 | Jinotega | 13 | San Rafael del Norte | 5 | 5 | 395 |
| 20 | 6 | Jinotega | 13 | Santa María de Pantasma | 6 | 6 | 563 |
| 20 | 6 | Jinotega | 13 | Jinotega | 7 | 7 | 1,119 |
| 21 | 2 | Chinandega | 4 | Corinto | 11 | 1 | 49 |
| 22 | 2 | Chinandega | 4 | El Viejo | 1 | 1 | 1,308 |
| 22 | 2 | Chinandega | 4 | Puerto Morazán | 2 | 2 | 264 |
| 22 | 2 | Chinandega | 4 | Chinandega | 9 | 3 | 647 |
| 22 | 2 | Chinandega | 4 | El Realejo | 10 | 4 | 97 |
| 22 | 2 | Chinandega | 4 | Chichigalpa | 12 | 5 | 257 |
| 22 | 2 | Chinandega | 4 | Posoltega | 13 | 6 | 124 |
| 23 | 2 | Chinandega | 4 | Somotillo | 3 | 1 | 1,089 |
| 23 | 2 | Chinandega | 4 | Santo Tomás del Norte | 4 | 2 | 50 |
| 23 | 2 | Chinandega | 4 | Cinco Pinos | 5 | 3 | 79 |

## Table 4-8 Zone Code (3)

| Zone | Region | Department | D-Number | Municipality (District) | Statistic M-number | Each Zone M-number | Area (km²) |
|---|---|---|---|---|---|---|---|
| 23 | 2 | Chinandega | 4 | San Pedro del Norte | 6 | 4 | 60 |
| 23 | 2 | *Chinandega* | *4* | *San Francisco del Norte* | 7 | 5 | *121* |
| 23 | 2 | Chinandega | 4 | Villanueva | 8 | 6 | 781 |
| 24 | 1 | Madriz | 2 | Somoto | 1 | 1 | 474 |
| 24 | 1 | Madriz | 2 | Totogalpa | 2 | 2 | 137 |
| 24 | 1 | Madriz | 2 | Telpaneca | 3 | 3 | 272 |
| 24 | 1 | Madriz | 2 | San Juan del Río Coco | 4 | 4 | 221 |
| 24 | 1 | Madriz | 2 | Yalagüina | 5 | 5 | 53 |
| 24 | 1 | Madriz | 2 | Palacagüina | 6 | 6 | 136 |
| 24 | 1 | Madriz | 2 | San Lucas | 7 | 7 | 139 |
| 24 | 1 | Madriz | 2 | Las Sabanas | 8 | 8 | 69 |
| 24 | 1 | Madriz | 2 | San José de Cusmapa | 9 | 9 | 101 |
| 25 | 1 | Nueva Segovia | 1 | Santa María | 1 | 1 | 168 |
| 25 | 1 | Nueva Segovia | 1 | Macuelizo | 2 | 2 | 250 |
| 25 | 1 | Nueva Segovia | 1 | Dipilto | 3 | 3 | 85 |
| 25 | 1 | Nueva Segovia | 1 | Ocotal | 4 | 4 | 104 |
| 25 | *1* | *Nueva Segovia* | *1* | *Monzonte* | *5* | *5* | 242 |
| 25 | 1 | Nueva Segovia | 1 | San Fernando | 6 | 6 | 269 |
| 25 | 1 | Nueva Segovia | 1 | Ciudad Antigua | 7 | 7 | 154 |
| 25 | 1 | Nueva Segovia | 1 | El Jicaro (Ciudad Sandino) | 8 | 8 | 404 |
| 25 | 1 | Nueva Segovia | 1 | Jalapa | 9 | 9 | 629 |
| 25 | 1 | Nueva Segovia | 1 | Murra | 10 | 10 | 479 |
| 25 | 1 | Nueva Segovia | 1 | Quilalí | 11 | 11 | 339 |
| 26 | 9 | Río San Juan | 17 | San Juan del Norte | 6 | 1 | 1,762 |
| 27 | 8 | Atlántico Sur | 16 | Bluefilds | 8 | 1 | 4,639 |
| 27 | 8 | Atlántico Sur | 16 | Corn Island | 9 | 2 | 9 |
| 28 | 8 | Atlántico Sur | 16 | La Cruz de Río Grande | 2 | 1 | 6,360 |
| 28 | 8 | Atlántico Sur | 16 | Laguna de Perlas | 3 | 2 | 3,876 |
| 28 | 8 | Atlántico Sur | 16 | Kukra Hill | 4 | 3 | 1,262 |
| 29 | 7 | Atrántico Norte | 15 | Waspán | 1 | 1 | 8,133 |
| 30 | 2 | León | 5 | Pro.Sandíno | 11 | 1 | 0 |
| 31 | 3 | Managua | 6 | Mateare | 3 | 1 | 328 |
| 31 | 3 | Managua | 6 | Villa Carlos Fonseca | 4 | 2 | 581 |
| 31 | 3 | Managua | 6 | San Rafael del Sur | 5 | 3 | 375 |
| 31 | 3 | Managua | 6 | Ticuantepe | 7 | 4 | 68 |
| 32 | 10 | Frontera Norte | 18 | Honduras | 1 | 1 | |
| 32 | 10 | Frontera Norte | 18 | El Salvador | 2 | 2 | |
| 32 | 10 | Frontera Norte | 18 | Guatemala | 3 | 3 | |
| 32 | 10 | Frontera Norte | 18 | Mexico | 4 | 4 | |
| 32 | 10 | Frontera Norte | 18 | U.S.A. | 5 | 5 | |
| 32 | 10 | Frontera Norte | 18 | Canada | 6 | 6 | |
| 33 | 11 | Frontera Sur | 19 | Costa Rica | 1 | 1 | |
| 33 | 11 | Frontera Sur | 19 | Panamá | 2 | 2 | |
| 33 | 11 | Frontera Sur | 19 | South America | 3 | 3 | |

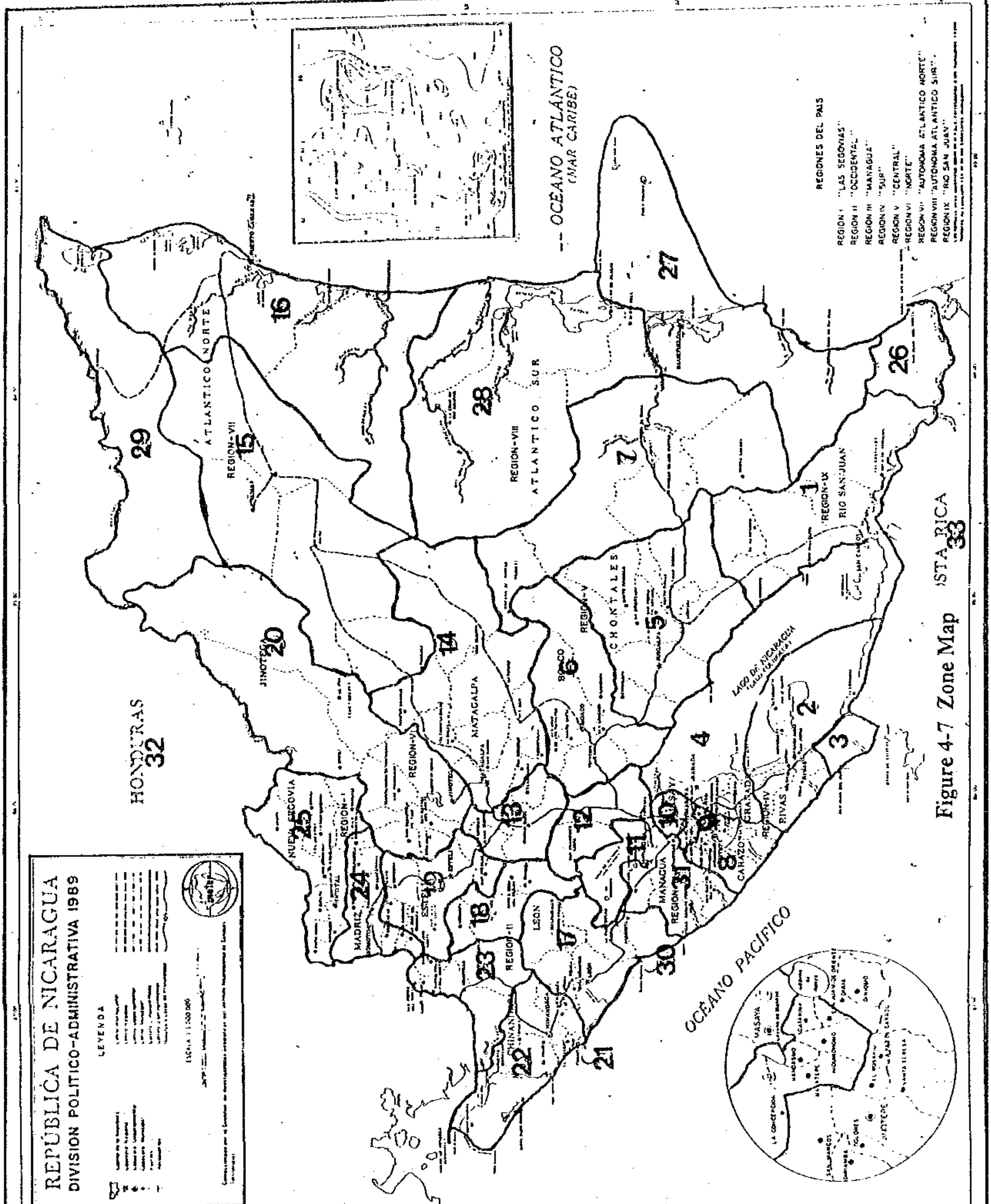



Figure 4-7 Zone Map

### 4.3.2 Data Processing

As described in 4.2, the following traffic surveys were conducted during the first two months of the Study:

① Roadside O-D survey
② Traffic volume counting survey
③ Vehicle speed survey
④ Axle weight survey

In addition, the following survey and data collection were conducted, given the necessity for a future transportation plan.

⑤ Bus passenger survey
⑥ O-D data collection at the axle weighing station near Puerto Corinto (Paso Caballos)

Of the above surveys, the data obtained from ①, ⑤ and ⑥ was analyzed using computers because it was so voluminous. Before undergoing computer analysis, all the data was coded, checked, corrected and input into the computer memory. The format of this data is as follows;

(1) Format of Roadside O-D Survey Data

Column 1 - 2 : Survey Station No.
Column 3 : Direction
Column 4 - 7 : Survey Time
Column 8 : Type of Vehicle
Column 9 - 10 : Makers
Column 11 - 18 : Zone Code of Origin
Column 19 - 26 : Zone Code of Destination
Column 27 : Trip Purpose
Column 28 - 30 : Capacity
Column 31 - 33 : Type of Cargo Loaded Most
Column 34 - 37 : Weight of the Above Cargo
Column 38 - 40 : Type of Cargo Loaded Second
Column 41 - 44 : Weight of the Above Cargo
Column 45 - 47 : Type of Cargo Loaded Third
Column 48 - 51 : Weight of the Above Cargo
Column 52 - 54 : Number of Passengers (Excluding the Driver)
Column 55 : Identification of car as Private or Public
Column 56 - 62 :Data Identification Code

(2) Bus Passenger O-D Survey Data

Column 1 - 4 : Survey Time
Column 5 : Type of Bus
Column 6 - 7 : Zone Code of Origin
Column 8 - 9 : Zone Code of Destination
Column 10 : Trip Purpose
Column 11 - 13 : Number of Passengers
Column 14 : Salary
Column 15 : How much salary do you need if you take the same trip?
Column 16 - 20 : Bus Fair

(3) O-D Survey Data at the axle weighing station near Puerto Corinto

Column 1 - 4 : Survey Time
Column 5 - 6 : Zone Code of Origin
Column 7 - 8 : Zone Code of Destination
Column 9 - 10 : Type Vehicle
Column 11 - 14 : Axle Load
Column 15 - 18 : Type of Cargo
Column 19 - 24 : Survey Time

### 4.3.3 Results of Roadside O-D survey

A total number of 19,808 vehicles were stopped during the roadside O-D survey except "motorcycle" and "unknown (station number)" as shown in Table 4-9. The sample rate of each station ranged from 15.5% (Survey Station 12) to 88.7% (Survey Station 3) depending on the passing traffic volume. The average sample rate was 28.5%. At Survey Station 11, traffic volume was greatest and about 3,000 drivers were interviewed. The results of the O-D survey are summarized below.

(1) Vehicle Type by Direction

Of the vehicles going to and from Managua, passenger cars accounted for 38.9% (8,234 vehicles), followed by pick-ups, which accounted for 27.5% (5,821 vehicles). In addition, trucks, including trailers, accounted for 15.9% (3,379 vehicles). The number of vehicles by direction ( to Managua and from Managua) was almost the same, even when classified by vehicle type. Table 4-10 shows the direction and vehicle type.

## Table 4-9 Summary of O-D Survey

| | Survey Point | Traffic Volume | | | No. of Samples Interviewed | | | Sampling Rate (%) | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | To Managua | From Managua | Total | To Managua | From Managua | Total | To Managua | From Managua | Total |
| 1 | Chinandega | 1,300 | 1,394 | 2,694 | 279 | 236 | 515 | 21.5 | 16.9 | 19.1 |
| 2 | Intersection to Chichigalpa | 2,209 | 2,267 | 4,476 | 509 | 551 | 1,060 | 23 | 24.3 | 23.7 |
| 3 | Telica | 386 | 359 | 745 | 386 | 275 | 661 | 100 | 76.6 | 88.7 |
| 4 | León | 2,019 | 2,115 | 4,134 | 527 | 857 | 1,384 | 26.1 | 40.5 | 33.5 |
| 5 | Izapa | 318 | 209 | 527 | 112 | 73 | 185 | 35.2 | 34.9 | 35.1 |
| 6-1 | Santa Rita | 103 | 101 | 204 | 53 | 93 | 146 | 51.5 | 92.1 | 71.6 |
| 6-2 | Santa Rita | 176 | 157 | 333 | 46 | 100 | 146 | 26.1 | 63.7 | 43.8 |
| 7 | San Benito-Road to Matagalpa | 939 | 995 | 1,934 | 367 | 479 | 846 | 39.1 | 48.1 | 43.7 |
| 8 | San Benito-Road to Lama | 673 | 684 | 1,357 | 236 | 275 | 511 | 35.1 | 40.2 | 37.7 |
| 9 | Ctra. Nueva León, Entrance of Sandino Town | 2,381 | 2,084 | 4,465 | 579 | 912 | 1,491 | 24.3 | 43.8 | 33.4 |
| 10 | Km 8 Sur.Frente Rest. | 3,835 | 3,766 | 7,601 | 1,142 | 1,115 | 2,257 | 29.8 | 29.6 | 29.7 |
| 11 | Ctra. Masaya | 8,350 | 8,448 | 16,798 | 1,419 | 1,471 | 2,890 | 17 | 17.4 | 17.2 |
| 12 | Ctra. Norte, Agraria Univ. | 4,180 | 4,536 | 8,716 | 652 | 702 | 1,354 | 15.6 | 15.5 | 15.5 |
| 13 | Ctra Masaya-Tipitapa | 924 | 837 | 1,761 | 283 | 92 | 375 | 30.6 | 11 | 21.3 |
| 14 | Las Conchitas | 301 | 396 | 697 | 152 | 125 | 277 | 50.5 | 31.6 | 39.7 |
| 15 | Granada | 1,563 | 1,319 | 2,882 | 699 | 546 | 1,245 | 44.7 | 41.4 | 43.2 |
| 16 | Diriomo | 615 | 604 | 1,219 | 97 | 338 | 435 | 15.8 | 56 | 35.7 |
| 17 | Nandaime | 1,045 | 1,016 | 2,061 | 432 | 266 | 698 | 41.3 | 26.2 | 33.9 |
| 18 | Rivas | 745 | 846 | 1,591 | 264 | 207 | 471 | 35.4 | 24.5 | 29.6 |
| 19 | Juigalpa-Rama | 567 | 537 | 1,104 | 456 | 401 | 857 | 80.4 | 74.7 | 77.6 |
| 20 | Ctra. Matagalpa-Sébaco | 693 | 599 | 1,292 | 216 | 208 | 424 | 31.2 | 34.7 | 32.8 |
| 21 | Estelí | 702 | 657 | 1,359 | 251 | 302 | 553 | 35.8 | 46 | 40.7 |
| 22 | Condega | 436 | 447 | 883 | 389 | 263 | 652 | 89.2 | 58.8 | 73.8 |
| 23 | Ocotal | 298 | 336 | 634 | 263 | 112 | 375 | 88.3 | 33.3 | 59.1 |
| | Total | 34,758 | 34,709 | 69,467 | 9,809 | 9,999 | 19,808 | 28.2 | 28.8 | 28.5 |
| | Motorcycle | | | | | | 1,281 | | | |
| | Unknown | | | | | | 69 | | | |
| | Grand Total | | | | | | 21,158 | | | |

## Table 4-10 Direction by Vehicle Type

| Direction | Passenger Car | Micro-bus | Bus | Pick-up | Truck | Semi-trailer | Others | Motor-cycle | Unknown | Total |
|---|---|---|---|---|---|---|---|---|---|---|
| To Managua | 4,091 | 604 | 494 | 2,864 | 1,275 | 401 | 80 | 685 | 4 | 10,498 |
| (%) | 39.0 | 5.8 | 4.7 | 27.3 | 12.1 | 3.8 | 0.8 | 6.5 | 0.0 | 100.0 |
| From Managua | 4,143 | 638 | 484 | 2,957 | 1,271 | 432 | 74 | 596 | 65 | 10,660 |
| (%) | 38.9 | 6.0 | 4.5 | 27.7 | 11.9 | 4.1 | 0.7 | 5.6 | 0.6 | 100.0 |
| Total | 8,234 | 1,242 | 978 | 5,821 | 2,546 | 833 | 154 | 1,281 | 69 | 21,158 |
| (%) | 38.9 | 5.9 | 4.6 | 27.5 | 12.0 | 3.9 | 0.7 | 6.1 | 0.3 | 100.0 |

(2) Purpose by Direction

Of the drivers interviewed, most gave "going to works" as the trip purpose (account for 46.2%). The second most common purpose was "business" (21.2%). Other purposes accounted for less than 10% of the total. The purpose by direction was almost the same except "going back home". Because people go to Managua for various reasons, however, they merely go back home after completing their business. Table 4-11 shows purposes and direction.

## Table 4-11 Direction by Purpose

| Direction | Business | Go to Work | Go to School | Social | Tourism, Pleasure | Shopping | Go back Home | Others | Unknown | Total |
|---|---|---|---|---|---|---|---|---|---|---|
| To Managua | 2,396 | 4,807 | 381 | 716 | 328 | 476 | 773 | 594 | 27 | 10,498 |
| (%) | 22.8 | 45.8 | 3.6 | 6.8 | 3.1 | 4.5 | 7.4 | 5.7 | 0.3 | 100.0 |
| From Managua | 2,084 | 4,971 | 411 | 618 | 312 | 345 | 1,335 | 570 | 14 | 10,660 |
| (%) | 19.5 | 46.6 | 3.9 | 5.8 | 2.9 | 3.2 | 12.5 | 5.3 | 0.1 | 100.0 |
| Total | 4,480 | 9,778 | 792 | 1,334 | 640 | 821 | 2,108 | 1,164 | 41 | 21,158 |
| (%) | 21.2 | 46.2 | 3.7 | 6.3 | 3.0 | 3.9 | 10.0 | 5.5 | 0.2 | 100.0 |

(3) Vehicle Type and Purpose

"Passenger cars" were mostly used for the purpose of "going to work" (45.0%), and for "business" (17.7%). Combining these two purposes shows that more than 60% of all "passenger cars" were used for trips related to work. Buses show the almost same pattern. Naturally, this tendency becomes much greater for trucks. Table 4-12 shows the vehicle type and purpose.

## Table 4-12 Vehicle Type by Purpose

| Vehicle Type | Business | Go to Work | Go to School | Social | Tourism, Pleasure | Shopping | Go back Home | Others | Unknown | Total |
|---|---|---|---|---|---|---|---|---|---|---|
| Passenger Car | 1,454 | 3,708 | 514 | 524 | 333 | 338 | 1,007 | 343 | 13 | 8,234 |
| | 17.7 | 45.0 | 6.2 | 6.4 | 4.0 | 4.1 | 12.2 | 4.2 | 0.2 | 100.0 |
| | 32.5 | 37.9 | 64.9 | 39.3 | 52.0 | 41.2 | 47.8 | 29.5 | 31.7 | 38.9 |
| Microbus | 261 | 542 | 44 | 118 | 51 | 45 | 110 | 68 | 3 | 1,242 |
| | 21.0 | 43.6 | 3.5 | 9.5 | 4.1 | 3.6 | 8.9 | 5.5 | 0.2 | 100.0 |
| | 5.8 | 5.5 | 5.6 | 8.8 | 8.0 | 5.5 | 5.2 | 5.8 | 7.3 | 5.9 |
| Bus | 211 | 321 | 28 | 142 | 17 | 5 | 29 | 223 | 2 | 978 |
| | 21.6 | 32.8 | 2.9 | 14.5 | 1.7 | 0.5 | 3.0 | 22.8 | 0.2 | 100.0 |
| | 4.7 | 3.3 | 3.5 | 10.6 | 2.7 | 0.6 | 1.4 | 19.2 | 4.9 | 4.6 |
| Pick-up | 1,319 | 2,676 | 155 | 409 | 164 | 267 | 564 | 254 | 13 | 5,821 |
| | 22.7 | 46.0 | 2.7 | 7.0 | 2.8 | 4.6 | 9.7 | 4.4 | 0.2 | 100.0 |
| | 29.4 | 27.4 | 19.6 | 30.7 | 25.6 | 32.5 | 26.8 | 21.8 | 31.7 | 27.5 |
| Truck | 825 | 1,193 | 7 | 63 | 36 | 89 | 163 | 165 | 5 | 2,546 |
| | 32.4 | 46.9 | 0.3 | 2.5 | 1.4 | 3.5 | 6.4 | 6.5 | 0.2 | 100.0 |
| | 18.4 | 12.2 | 0.9 | 4.7 | 5.6 | 10.8 | 7.7 | 14.2 | 12.2 | 12.0 |
| Semi-trailer | 252 | 465 | 3 | 11 | 6 | 22 | 29 | 43 | 2 | 833 |
| | 30.3 | 55.8 | 0.4 | 1.3 | 0.7 | 2.6 | 3.5 | 5.2 | 0.2 | 100.0 |
| | 5.6 | 4.8 | 0.4 | 0.8 | 0.9 | 2.7 | 1.4 | 3.7 | 4.9 | 3.9 |
| Others | 22 | 94 | 0 | 4 | 5 | 1 | 13 | 15 | 0 | 154 |
| | 14.3 | 61.0 | 0.0 | 2.6 | 3.2 | 0.6 | 8.4 | 9.7 | 0.0 | 100.0 |
| | 0.5 | 1.0 | 0.0 | 0.3 | 0.8 | 0.1 | 0.6 | 1.3 | 0.0 | 0.7 |
| Motorcycle | 118 | 754 | 36 | 60 | 27 | 53 | 184 | 48 | 1 | 1,281 |
| | 9.2 | 58.9 | 2.8 | 4.7 | 2.1 | 4.1 | 14.4 | 3.7 | 0.1 | 100.0 |
| | 2.6 | 7.7 | 4.5 | 4.5 | 4.2 | 6.5 | 8.7 | 4.1 | 2.4 | 6.1 |
| Unknown | 18 | 25 | 5 | 3 | 1 | 1 | 9 | 5 | 2 | 69 |
| | 26.1 | 36.2 | 7.2 | 4.3 | 1.4 | 1.4 | 13 | 7.2 | 2.9 | 100.0 |
| | 0.4 | 0.3 | 0.6 | 0.2 | 0.2 | 0.1 | 0.4 | 0.4 | 4.9 | 0.3 |
| Total | 4,480 | 9,778 | 792 | 1,334 | 640 | 821 | 2,108 | 1,164 | 41 | 21,158 |
| | 21.2 | 46.2 | 3.7 | 6.3 | 3.0 | 3.9 | 10.0 | 5.5 | 0.2 | 100.0 |
| | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |

Note : Upper - Number of trips
Middle - Percent share of each trip purpose.
Lower - Percent share of each vehicle type.

(4) Survey Time and Direction

Figure 4-8 shows the survey time and direction. The movement of vehicles is heaviest between 7 a.m. and 9 a.m. (about 35 % of the drivers interviewed). There is almost no difference between "from Managua" and "to Managua" in the case of survey time.

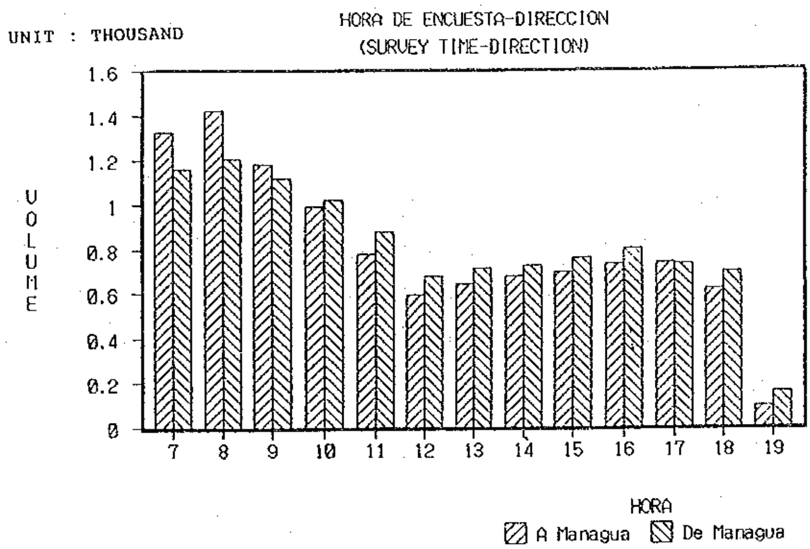



**Figure 4-8 Survey Time and Direction**

(5) Survey Time and Vehicle Type

The number of large buses microbuses was greatest between 7 a.m. and 8 a.m., accounting for more than 30% of all vehicles. Passenger cars accounted for 10 to 12% between 7 a.m. and 9 a.m. On the other hand, trucks are mainly observed between 8 a.m. and 10 a.m.. Survey times by vehicle type are shown Table 4-13.

(6) Survey Time and Trip Purpose

Drivers were "going to work" mostly before 10 a.m.; during the same hours, many drivers were also traveling for "business". On the other hand, most drivers were "going back home" between 5 p.m. and 6 p.m.. Table 4-14 shows the survey time by trip purpose.

# Table 4-13 Survey Time by Vehicle Type

| Survey Time | Passenger Car | Microbus | Bus | Pick-up | Truck | Semi-trailer | Others | Motor-cycle | Unknown | Total |
|---|---|---|---|---|---|---|---|---|---|---|
| 7:00- 8:00 | 1,062 | 179 | 177 | 512 | 245 | 65 | 18 | 218 | 3 | 2,479 |
| | 42.8 | 7.2 | 7.1 | 20.7 | 9.9 | 2.6 | 0.7 | 8.8 | 0.1 | 100.0 |
| | 12.9 | 14.4 | 18.1 | 8.8 | 9.6 | 7.8 | 11.7 | 17.0 | 4.3 | 11.7 |
| 8:00- 9:00 | 1,064 | 187 | 142 | 699 | 259 | 68 | 24 | 176 | 10 | 2,629 |
| | 40.5 | 7.1 | 5.4 | 26.6 | 9.9 | 2.6 | 0.9 | 6.7 | 0.4 | 100.0 |
| | 12.9 | 15.1 | 14.5 | 12.0 | 10.2 | 8.2 | 15.6 | 13.7 | 14.5 | 12.4 |
| 9:00-10:00 | 839 | 129 | 126 | 709 | 269 | 70 | 26 | 130 | 0 | 2,298 |
| | 36.5 | 5.6 | 5.5 | 30.9 | 11.7 | 3.0 | 1.1 | 5.7 | 0.0 | 100.0 |
| | 10.2 | 10.4 | 12.9 | 12.2 | 10.6 | 8.4 | 16.9 | 10.1 | 0.0 | 10.9 |
| 10:00-11:00 | 805 | 112 | 107 | 571 | 228 | 69 | 16 | 104 | 0 | 2,012 |
| | 40.0 | 5.6 | 5.3 | 28.4 | 11.3 | 3.4 | 0.8 | 5.2 | 0.0 | 100.0 |
| | 9.8 | 9.0 | 10.9 | 9.8 | 9.0 | 8.3 | 10.4 | 8.1 | 0.0 | 9.5 |
| 11:00-12:00 | 626 | 83 | 74 | 463 | 239 | 79 | 11 | 85 | 1 | 1,661 |
| | 37.7 | 5.0 | 4.5 | 27.9 | 14.4 | 4.8 | 0.7 | 5.1 | 0.1 | 100.0 |
| | 7.6 | 6.7 | 7.6 | 8.0 | 9.4 | 9.5 | 7.1 | 6.6 | 1.4 | 7.9 |
| 12:00-13:00 | 514 | 58 | 51 | 363 | 148 | 71 | 6 | 60 | 7 | 1,278 |
| | 40.2 | 4.5 | 4.0 | 28.4 | 11.6 | 5.6 | 0.5 | 4.7 | 0.5 | 100.0 |
| | 6.2 | 4.7 | 5.2 | 6.2 | 5.8 | 8.5 | 3.9 | 4.7 | 10.1 | 6.0 |
| 13:00-14:00 | 543 | 66 | 55 | 356 | 201 | 64 | 8 | 52 | 14 | 1,359 |
| | 40.0 | 4.9 | 4.0 | 26.2 | 14.8 | 4.7 | 0.6 | 3.8 | 1.0 | 100.0 |
| | 6.6 | 5.3 | 5.6 | 6.1 | 7.9 | 7.7 | 5.2 | 4.1 | 20.3 | 6.4 |
| 14:00-15:00 | 520 | 87 | 46 | 421 | 186 | 74 | 10 | 65 | 1 | 1,410 |
| | 36.9 | 6.2 | 3.3 | 29.9 | 13.2 | 5.2 | 0.7 | 4.6 | 0.1 | 100.0 |
| | 6.3 | 7.0 | 4.7 | 7.2 | 7.3 | 8.9 | 6.5 | 5.1 | 1.4 | 6.7 |
| 15:00-16:00 | 521 | 79 | 46 | 439 | 214 | 66 | 10 | 80 | 2 | 1,457 |
| | 35.8 | 5.4 | 3.2 | 30.1 | 14.7 | 4.5 | 0.7 | 5.5 | 0.1 | 100.0 |
| | 6.3 | 6.4 | 4.7 | 7.5 | 8.4 | 7.9 | 6.5 | 6.2 | 2.9 | 6.9 |
| 16:00-17:00 | 580 | 81 | 51 | 449 | 196 | 69 | 8 | 101 | 0 | 1,535 |
| | 37.8 | 5.3 | 3.3 | 29.3 | 12.8 | 4.5 | 0.5 | 6.6 | 0.0 | 100.0 |
| | 7.0 | 6.5 | 5.2 | 7.7 | 7.7 | 8.3 | 5.2 | 7.9 | 0.0 | 7.3 |
| 17:00-18:00 | 552 | 77 | 53 | 429 | 179 | 70 | 7 | 103 | 1 | 1,471 |
| | 37.5 | 5.2 | 3.6 | 29.2 | 12.2 | 4.8 | 0.5 | 7.0 | 0.1 | 100.0 |
| | 6.7 | 6.2 | 5.4 | 7.4 | 7.0 | 8.4 | 4.5 | 8.0 | 1.4 | 7.0 |
| 18:00-19:00 | 527 | 72 | 40 | 357 | 151 | 60 | 7 | 99 | 0 | 1,313 |
| | 40.1 | 5.5 | 3.0 | 27.2 | 11.5 | 4.6 | 0.5 | 7.5 | 0.0 | 100.0 |
| | 6.4 | 5.8 | 4.1 | 6.1 | 5.9 | 7.2 | 4.5 | 7.7 | 0.0 | 6.2 |
| Unknown | 81 | 32 | 10 | 53 | 31 | 8 | 3 | 8 | 30 | 256 |
| | 31.6 | 12.5 | 3.9 | 20.7 | 12.1 | 3.1 | 1.2 | 3.1 | 11.7 | 100.0 |
| | 1.0 | 2.6 | 1.0 | 0.9 | 1.2 | 1.0 | 1.9 | 0.6 | 43.5 | 1.2 |
| Total | 8,234 | 1,242 | 978 | 5,821 | 2,546 | 833 | 154 | 1,281 | 69 | 21,158 |
| | 38.9 | 5.9 | 4.6 | 27.5 | 12.0 | 3.9 | 0.7 | 6.1 | 0.3 | 100.0 |
| | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |

Note : Upper - Number of trips
Middle - Percent share of trip purpose
Lower - Percent share of each vehicle type

**Table 4-14 Survey Time by Purpose**

| Survey Time | Business | Go to Work | Go to School | Social | Tourism, Pleasure | Shopping | Go Back Home | Others | Unknown | Total |
|---|---|---|---|---|---|---|---|---|---|---|
| 7:00- 8:00 | 566 | 1,232 | 304 | 135 | 36 | 63 | 49 | 93 | 1 | 2,479 |
| | 22.8 | 49.7 | 12.3 | 5.4 | 1.5 | 2.5 | 2.0 | 3.8 | 0.0 | 100.0 |
| | 12.6 | 12.6 | 38.4 | 10.1 | 5.6 | 7.7 | 2.3 | 8.0 | 2.4 | 11.7 |
| 8:00- 9:00 | 540 | 1,547 | 64 | 167 | 45 | 99 | 61 | 90 | 16 | 2,629 |
| | 20.5 | 58.8 | 2.4 | 6.4 | 1.7 | 3.8 | 2.3 | 3.4 | 0.6 | 100.0 |
| | 12.1 | 15.8 | 8.1 | 12.5 | 7.0 | 12.1 | 2.9 | 7.7 | 39.0 | 12.4 |
| 9:00-10:00 | 527 | 1,242 | 34 | 133 | 64 | 113 | 56 | 124 | 5 | 2,298 |
| | 22.9 | 54.0 | 1.5 | 5.8 | 2.8 | 4.9 | 2.4 | 5.4 | 0.2 | 100.0 |
| | 11.8 | 12.7 | 4.3 | 10.0 | 10.0 | 13.8 | 2.7 | 10.7 | 12.2 | 10.9 |
| 10:00-11:00 | 454 | 1,044 | 30 | 132 | 64 | 110 | 82 | 95 | 1 | 2,012 |
| | 22.6 | 51.9 | 1.5 | 6.6 | 3.2 | 5.5 | 4.1 | 4.7 | 0.0 | 100.0 |
| | 10.1 | 10.7 | 3.8 | 9.9 | 10.0 | 13.4 | 3.9 | 8.2 | 2.4 | 9.5 |
| 11:00-12:00 | 402 | 769 | 43 | 99 | 61 | 68 | 113 | 100 | 6 | 1,661 |
| | 24.2 | 46.3 | 2.6 | 6.0 | 3.7 | 4.1 | 6.8 | 6.0 | 0.4 | 100.0 |
| | 9.0 | 7.9 | 5.4 | 7.4 | 9.5 | 8.3 | 5.4 | 8.6 | 14.6 | 7.9 |
| 12:00-13:00 | 288 | 535 | 77 | 65 | 39 | 45 | 150 | 75 | 4 | 1,278 |
| | 22.5 | 41.9 | 6.0 | 5.1 | 3.1 | 3.5 | 11.7 | 5.9 | 0.3 | 100.0 |
| | 6.4 | 5.5 | 9.7 | 4.9 | 6.1 | 5.5 | 7.1 | 6.4 | 9.8 | 6.0 |
| 13:00-14:00 | 322 | 540 | 64 | 83 | 47 | 40 | 176 | 85 | 2 | 1,359 |
| | 23.7 | 39.7 | 4.7 | 6.1 | 3.5 | 2.9 | 13.0 | 6.3 | 0.1 | 100.0 |
| | 7.2 | 5.5 | 8.1 | 6.2 | 7.3 | 4.9 | 8.3 | 7.3 | 4.9 | 6.4 |
| 14:00-15:00 | 337 | 625 | 30 | 88 | 54 | 75 | 114 | 87 | 0 | 1,410 |
| | 23.9 | 44.3 | 2.1 | 6.2 | 3.8 | 5.3 | 8.1 | 6.2 | 0.0 | 100.0 |
| | 7.5 | 6.4 | 3.8 | 6.6 | 8.4 | 9.1 | 5.4 | 7.5 | 0.0 | 6.7 |
| 15:00-16:00 | 328 | 605 | 29 | 108 | 60 | 75 | 171 | 81 | 0 | 1,457 |
| | 22.5 | 41.5 | 2.0 | 7.4 | 4.1 | 5.1 | 11.7 | 5.6 | 0.0 | 100.0 |
| | 7.3 | 6.2 | 3.7 | 8.1 | 9.4 | 9.1 | 8.1 | 7.0 | 0.0 | 6.9 |
| 16:00-17:00 | 296 | 584 | 36 | 111 | 57 | 57 | 296 | 96 | 2 | 1,535 |
| | 19.3 | 38.0 | 2.3 | 7.2 | 3.7 | 3.7 | 19.3 | 6.3 | 0.1 | 100.0 |
| | 6.6 | 6.0 | 4.5 | 8.3 | 8.9 | 6.9 | 14.0 | 8.2 | 4.9 | 7.3 |
| 17:00-18:00 | 206 | 517 | 48 | 99 | 47 | 41 | 404 | 106 | 3 | 1,471 |
| | 14.0 | 35.1 | 3.3 | 6.7 | 3.2 | 2.8 | 27.5 | 7.2 | 0.2 | 100.0 |
| | 4.6 | 5.3 | 6.1 | 7.4 | 7.3 | 5.0 | 19.2 | 9.1 | 7.3 | 7.0 |
| 18:00-19:00 | 163 | 418 | 32 | 100 | 61 | 22 | 404 | 113 | 0 | 1,313 |
| | 12.4 | 31.8 | 2.4 | 7.6 | 4.6 | 1.7 | 30.8 | 8.6 | 0.0 | 100.0 |
| | 3.6 | 4.3 | 4.0 | 7.5 | 9.5 | 2.7 | 19.2 | 9.7 | 0.0 | 6.2 |
| Unknown | 51 | 120 | 1 | 14 | 5 | 13 | 32 | 19 | 1 | 256 |
| | 19.9 | 46.9 | 0.4 | 5.5 | 2.0 | 5.1 | 12.5 | 7.4 | 0.4 | 100.0 |
| | 1.1 | 1.2 | 0.1 | 1.0 | 0.8 | 1.6 | 1.5 | 1.6 | 2.4 | 1.2 |
| Total | 4,480 | 9,778 | 792 | 1,334 | 640 | 821 | 2,108 | 1,164 | 41 | 21,158 |
| | 21.2 | 46.2 | 3.7 | 6.3 | 3.0 | 3.9 | 10.0 | 5.5 | 0.2 | 100.0 |
| | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |

Note : Upper - Number of trips
Middle - Percent share of each trip purpose
Lower - Percent share of each vehicle type

### 4.3.4 Traffic Volume Counting Survey

The traffic volume counting survey was conducted at the same survey stations used for the roadside O-D survey. The results are shown in Figure 4-9. The heaviest traffic was observed on the road section between Managua and Masaya (16,798 vehicles), followed by the road section between Managua and San Benito (8,716 vehicles), and the road section between Managua and Nandaime (7,601 vehicles).

Between Managua and Honduras, there are two Central American Highways, CA-1 (Managua - San Benito Condega - Honduras) and CA-3 (Managua - León - Chinandega - Honduras). The latter has more traffic volume than the former because it is faster. Between Managua and León there are also two routes, the road passing near Managua Lake and the road running via Santa Rita. The latter is now under construction on the section between Managua and Izapa. Therefore, traffic on this road is not so heavy.

Table 4-15 shows a comparison of these survey results with those obtained by MCT in 1989. Since the survey stations in 1989 were not same as those in the Study, traffic volume was studied by comparing the survey stations nearest each other. The 24-hour traffic volume at 12-hour survey stations were calculated by multiplying a day-night ratio which were determined from data at the 24 hour survey stations (a day-night ratio of 1.25 was applied to survey stations near Managua, while 1.28 was applied to other survey stations) to 12-hour traffic volume. In terms of traffic growth, the vicinity of Managua (Stations No.10 and 11) shows the highest rate. With respect to the large vehicle ratio, the lowest rate is to be found in the vicinity of the large cities (Stations No.1, 2, 10, 11 and 15). The large vehicle ratio at other survey stations show more than 20%.

**Table 4-15 Comparison of Traffic Volume**

| Survey Point No. | JICA Study, 1993.3 (12hr) | (24hr) | 1989 (MCT) (24hr) | Growth Rate | Day/Night Ratio | Heavy Vehicle Ratio |
|---|---|---|---|---|---|---|
| 1 | 2,694 | 3,448 | 1,624 | 2.12 | 1.28 | 15.7% |
| 2 | 4,476 | 5,729 | 3,447 | 1.66 | 1.28 | 18.5% |
| 3 | 740 | 947 | 589 | 1.61 | 1.28 | 31.8% |
| 4 | 4,134 | 5,283 | 4,730 | 1.12 | 1.28 | 27.1% |
| 5 | 527 | 675 | 563 | 1.20 | 1.28 | 49.9% |
| 6-1 | 204 | 261 | 563 | 0.46 | 1.28 | 52.5% |
| 6-2 | 333 | 426 | - | - | - | 49.2% |
| 7 | 1,934 | 2,482 | 1,465 | 1.69 | 1.28 | 34.6% |
| 8 | 1,357 | 1,737 | 1,131 | 1.54 | 1.28 | 38.0% |
| 9 | 4,465 | 5,581 | 3,555 | 1.57 | 1.25 | 22.8% |
| 10 | 7,601 | 9,501 | 2,206 | 4.31 | 1.25 | 9.3% |
| 11 | 16,798 | 20,882 | 7,942 | 2.63 | 1.25 | 10.2% |
| 12 | 8,716 | 10,895 | 6,023 | 1.81 | 1.25 | 23.0% |
| 13 | 1,761 | 2,254 | 1,358 | 1.66 | 1.28 | 47.2% |
| 14 | 697 | 892 | 589 | 1.51 | 1.28 | 42.8% |
| 15 | 2,882 | 3,689 | 2,667 | 1.38 | 1.28 | 17.7% |
| 16 | 1,219 | 1,560 | 1,224 | 1.27 | 1.28 | 35.2% |
| 17 | 2,061 | 2,638 | 885 | 2.98 | 1.28 | 31.6% |
| 18 | 1,591 | 2,036 | 291 | 7.00 | 1.28 | 24.5% |
| 19 | 1,104 | 1,413 | 1,110 | 1.27 | 1.28 | 29.8% |
| 20 | 1,292 | 1,654 | 1,292 | 1.28 | 1.28 | 27.2% |
| 21 | 1,359 | 1,740 | — | — | — | 29.2% |
| 22 | 883 | 1,130 | 742 | 1.52 | 1.28 | 34.2% |
| 23 | 634 | 812 | 441 | 1.84 | 1.28 | 31.4% |

Note : 24 Hours Survey Point (No.4, No.7 and No.11)

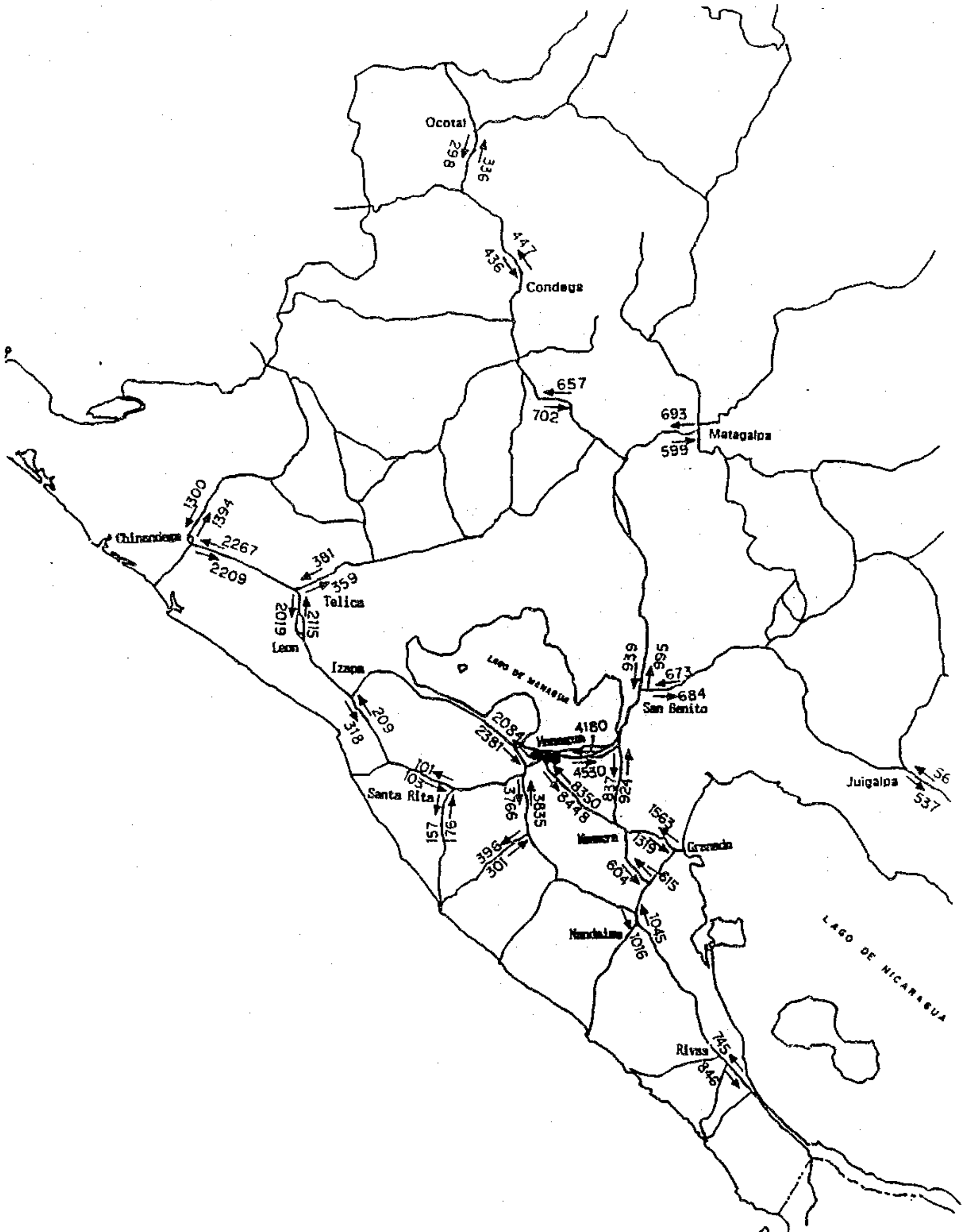



**Figure 4-9 Traffic Volume Counting Survey Results**

### 4.3.5 Vehicle Speed Survey

The results of the vehicle speed survey is shown in Table 4-16. Vehicle speed was not closely related to traffic volume on any route. It is believed that there is still enough room between the existing traffic volume and the maximum road capacity on almost all survey roads. The average vehicle speed was around 50 km/hr - 70 km/hr.

**Table 4-16 Vehicle Speed Survey Results**

| Section No. | Survey Time | Traffic Volume | | Travel Time (km/hr) | | Remarks |
|---|---|---|---|---|---|---|
| | | To Managua | From Managua | To Managua | From Managua | |
| 1 | 7:00- 9:00 | 239 | 266 | 57.2 | 57.7 | Traffic Survey Point No. 1 |
| | 10:00-12:00 | 166 | 209 | 57.6 | 58.2 | |
| | 17:00-19:00 | 284 | 259 | 55.2 | 48.8 | |
| 2 | 7:00- 9:00 | 435 | 435 | 39.1 | 53.3 | Traffic Survey Point No. 2 |
| | 10:00-12:00 | 363 | 391 | 41.6 | 51.5 | |
| | 17:00-19:00 | 376 | 351 | 39.4 | 55.3 | |
| 3 | 7:00- 9:00 | 435 | 435 | 67.7 | 70.3 | Traffic Survey Point No. 2 |
| | 10:00-12:00 | 363 | 391 | 59.3 | 69.7 | |
| | 17:00-19:00 | 376 | 351 | 70.2 | 61.5 | |
| 4 | 7:00- 9:00 | 76 | 47 | 64.0 | 65.5 | Traffic Survey Point No. 3 |
| | 10:00-12:00 | 57 | 64 | 72.1 | 65.5 | |
| | 17:00-19:00 | 64 | 53 | 60.0 | 61.3 | |
| 5 | 7:00- 9:00 | 330 | 420 | 59.1 | 59.3 | Traffic Survey Point No. 4 |
| | 10:00-12:00 | 317 | 356 | 49.7 | 52.4 | |
| | 17:00-19:00 | 390 | 296 | 53.7 | 57.7 | |
| 6 | 7:00- 9:00 | 360 | 393 | 59.4 | 53.5 | Traffic Survey Point No. 9 |
| | 10:00-12:00 | 395 | 304 | 54.9 | 62.2 | |
| | 17:00-19:00 | 406 | 395 | 55.9 | 59.2 | |
| 7 | 7:00- 9:00 | 1,764 | 1,356 | 53.0 | 57.1 | Traffic Survey Point No. 11 |
| | 10:00-12:00 | 1,289 | 1,218 | 69.3 | 60.3 | |
| | 17:00-19:00 | 1,085 | 1,684 | 52.8 | 57.8 | |
| 8 | 7:00- 9:00 | 187 | 128 | 68.5 | 67.7 | Traffic Survey Point No. 7 |
| | 10:00-12:00 | 151 | 163 | 67.2 | 66.9 | |
| | 17:00-19:00 | 183 | 207 | 64.1 | 64.2 | |
| 9 | 7:00- 9:00 | 91 | 120 | 71.0 | 65.3 | Traffic Survey Point No. 16 |
| | 10:00-12:00 | 82 | 91 | 61.1 | 62.8 | |
| | 17:00-19:00 | 146 | 88 | 58.1 | 56.5 | |
| 10 | 7:00- 9:00 | 91 | 142 | 65.4 | 51.0 | Traffic Survey Point No. 18 |
| | 10:00-12:00 | 153 | 148 | 60.2 | 57.1 | |
| | 17:00-19:00 | 134 | 123 | 60.5 | 53.8 | |

### 4.3.6 Establishment of the Present O-D Table

Based on the obtained O-D survey data, the present O-D Table was established by vehicle type (7 vehicle types are included). The present O-D Table was created in the following manner.

① Step 1 : Creating the present O-D Table using only the sample data.

② Step 2 : Creating an expanded OD Table using the expansion rate and day/night traffic volume rate.

③ Step 3 : Modifying the O-D Table by using a screen line check.

④ Step 4 : Establishing the present O-D Table by adjusting it using weekly and seasonal variation rates

Figure 4-10 shows the procedures used to create the present O-D Table.

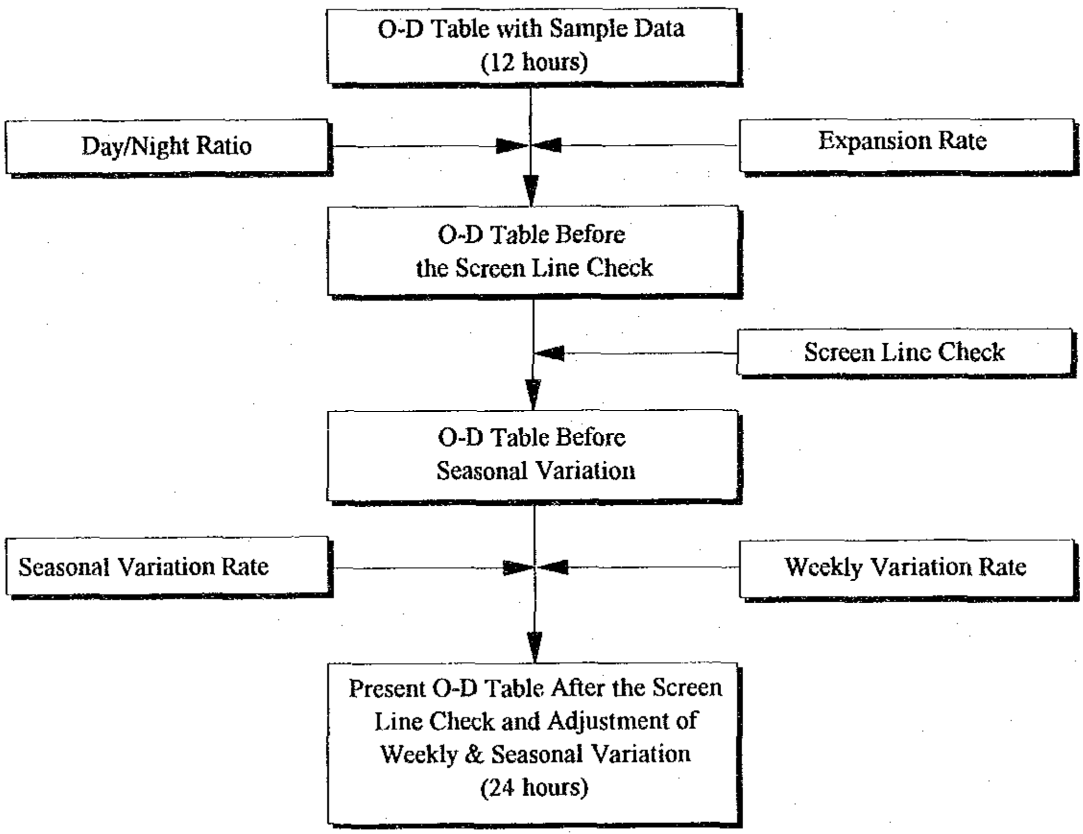



**Figure 4-10 Procedures Used to Create the Present O-D Table**

(1) Step 1

The present O-D Table was created using only the sampled data obtained at each traffic survey station. This is known as an O-D Table before expansion. There were 21,158 total trips with Traffic Zone 11 (including the capital city of Managua) accounting for 42.8% of them.

(2) Step 2

The O-D Table obtained in Step 1 shows only the sampled O-D trips over a 12-hour period. Therefore, the following two rates are necessary to create the 24-hour, daily O-D Table:

①Sample rates for each survey station
②Daytime - nighttime traffic volume ratio (day/night ratio, defined total volume/daytime volume).

Sample rates were calculated for each vehicle type at each survey station, and day-night ratios were determined by the 24-hour traffic volume counting survey stations, as shown in Table 4-17. The average sample rate was 28.6% (referred to Table 4-9), while the day/night ratio was 1.25 - 1.28 (refer to Table 4-15). First, the sample rates were multiplied for each trip by vehicle type, and then the day/night ratios were multiplied for the related OD trips.

(3) Step 3

The above O-D Table is still a provisional O-D Table. The trip distribution of the above provisional O-D Table was corrected for traffic volume at the following three screen lines on the road network, as shown in Figure 4-11.

①Screen Line 1 on CA1
②Screen Line 2 on CA3
③Screen Line 3 on Carrtera Masaya

After checking the provisional O-D Table, the present O-D Table was established by vehicle type (passenger car, microbus, large bus, pick-up, truck, trailer, tractor, unknown vehicles). Motorcycles were excluded from the O-D Table since sufficient O-D samples for motorcycles to compare with other types of vehicles could not be obtained.

### Table 4-17 Sample Rates and Day/Night Ratios

**Survey Point : 4 (León)**

| Direction | Item | Passenger Car | Microbus | Bus | Pick-up | Truck | Semi-trailer | Others | Total |
|---|---|---|---|---|---|---|---|---|---|
| To Managua | Traffic Volume | 615 | 162 | 200 | 641 | 250 | 125 | 26 | 2,019 |
| | No. of Sample | 224 | 25 | 37 | 131 | 52 | 45 | 13 | 527 |
| | Sampling Rate | 36.4 | 15.4 | 18.5 | 20.4 | 20.8 | 36.0 | 50.0 | 26.1 |
| | Day/Night Rate | 1.33 | 1.28 | 1.25 | 1.31 | 1.20 | 1.30 | 1.42 | 1.29 |
| From Managua | Traffic Volume | 701 | 154 | 210 | 671 | 228 | 115 | 36 | 2,115 |
| | No. of Sample | 296 | 43 | 60 | 259 | 97 | 90 | 12 | 857 |
| | Sampling Rate | 42.2 | 27.9 | 28.6 | 38.6 | 42.5 | 78.3 | 33.3 | 40.5 |
| | Day/Night Rate | 1.23 | 1.24 | 1.21 | 1.28 | 1.29 | 1.47 | 1.17 | 1.26 |
| Total | Traffic Volume | 1,316 | 316 | 410 | 1,312 | 478 | 240 | 62 | 4,134 |
| | No. of Sample | 520 | 68 | 97 | 390 | 149 | 135 | 25 | 1,384 |
| | Sampling Rate | 39.5 | 21.5 | 23.7 | 29.7 | 31.2 | 56.3 | 40.3 | 33.5 |
| | Day/Night Rate | 1.28 | 1.26 | 1.23 | 1.29 | 1.24 | 1.38 | 1.27 | 1.28 |

**Survey Point : 7 (San Benito)**

| Direction | Item | Passenger Car | Microbus | Bus | Pick-up | Truck | Semi-trailer | Others | Total |
|---|---|---|---|---|---|---|---|---|---|
| To Managua | Traffic Volume | 262 | 27 | 62 | 368 | 182 | 35 | 3 | 939 |
| | No. of Sample | 87 | 3 | 43 | 135 | 71 | 25 | 3 | 367 |
| | Sampling Rate | 33.2 | 11.1 | 69.4 | 36.7 | 39.0 | 71.4 | 100.0 | 39.1 |
| | Day/Night Rate | 1.19 | 1.22 | 1.21 | 1.24 | 1.76 | 1.84 | 1.67 | 1.35 |
| From Managua | Traffic Volume | 267 | 25 | 68 | 384 | 215 | 32 | 4 | 995 |
| | No. of Sample | 116 | 9 | 56 | 162 | 100 | 32 | 4 | 479 |
| | Sampling Rate | 43.4 | 36.0 | 82.4 | 42.2 | 46.5 | 100.0 | 100.0 | 48.1 |
| | Day/Night Rate | 1.23 | 1.24 | 1.21 | 1.28 | 1.29 | 1.47 | 1.17 | 1.26 |
| Total | Traffic Volume | 529 | 52 | 130 | 752 | 397 | 67 | 7 | 1,934 |
| | No. of Sample | 203 | 12 | 99 | 297 | 171 | 57 | 7 | 846 |
| | Sampling Rate | 38.4 | 23.1 | 76.2 | 39.5 | 43.1 | 85.1 | 100.0 | 43.7 |
| | Day/Night Rate | 1.19 | 1.25 | 1.16 | 1.22 | 1.47 | 1.80 | 1.43 | 1.28 |

**Survey Point : 11 (Ctra.Masaya)**

| Direction | Item | Passenger Car | Microbus | Bus | Pick-up | Truck | Semi-trailer | Others | Total |
|---|---|---|---|---|---|---|---|---|---|
| To Managua | Traffic Volume | 4,815 | 316 | 353 | 2,326 | 369 | 74 | 97 | 8,350 |
| | No. of Sample | 786 | 70 | 25 | 468 | 68 | 2 | 0 | 1,419 |
| | Sampling Rate | 16.3 | 22.2 | 7.1 | 20.1 | 18.4 | 2.7 | 0.0 | 17.0 |
| | Day/Night Rate | 1.22 | 1.25 | 1.30 | 1.23 | 1.33 | 1.59 | 1.19 | 1.24 |
| From Managua | Traffic Volume | 4,695 | 358 | 380 | 2,456 | 419 | 70 | 70 | 8,448 |
| | No. of Sample | 959 | 93 | 60 | 297 | 58 | 4 | 1 | 1,472 |
| | Sampling Rate | 20.4 | 26.0 | 15.8 | 12.1 | 13.8 | 5.7 | 1.4 | 17.4 |
| | Day/Night Rate | 1.27 | 1.23 | 1.27 | 1.24 | 1.16 | 1.29 | 1.19 | 1.25 |
| Total | Traffic Volume | 9,510 | 674 | 733 | 4,782 | 788 | 144 | 167 | 16,798 |
| | No. of Sample | 1,745 | 163 | 85 | 765 | 126 | 6 | 1 | 2,891 |
| | Sampling Rate | 18.3 | 24.2 | 11.6 | 16.0 | 16.0 | 4.2 | 0.6 | 17.2 |
| | Day/Night Rate | 1.24 | 1.24 | 1.28 | 1.23 | 1.24 | 1.44 | 1.19 | 1.25 |

(4) Step 4

The O-D Table obtained through the above steps must be modified using the weekly and seasonal variation rate, since this O-D Table was created on the basis of the traffic survey data obtained for a specific day, although the traffic volume fluctuates weekly as well as seasonally. Using the weekly and seasonal variation data available in Nicaragua, the above O-D Table was therefore modified. The weekly and seasonal variation data are shown in Appendix 4-4.

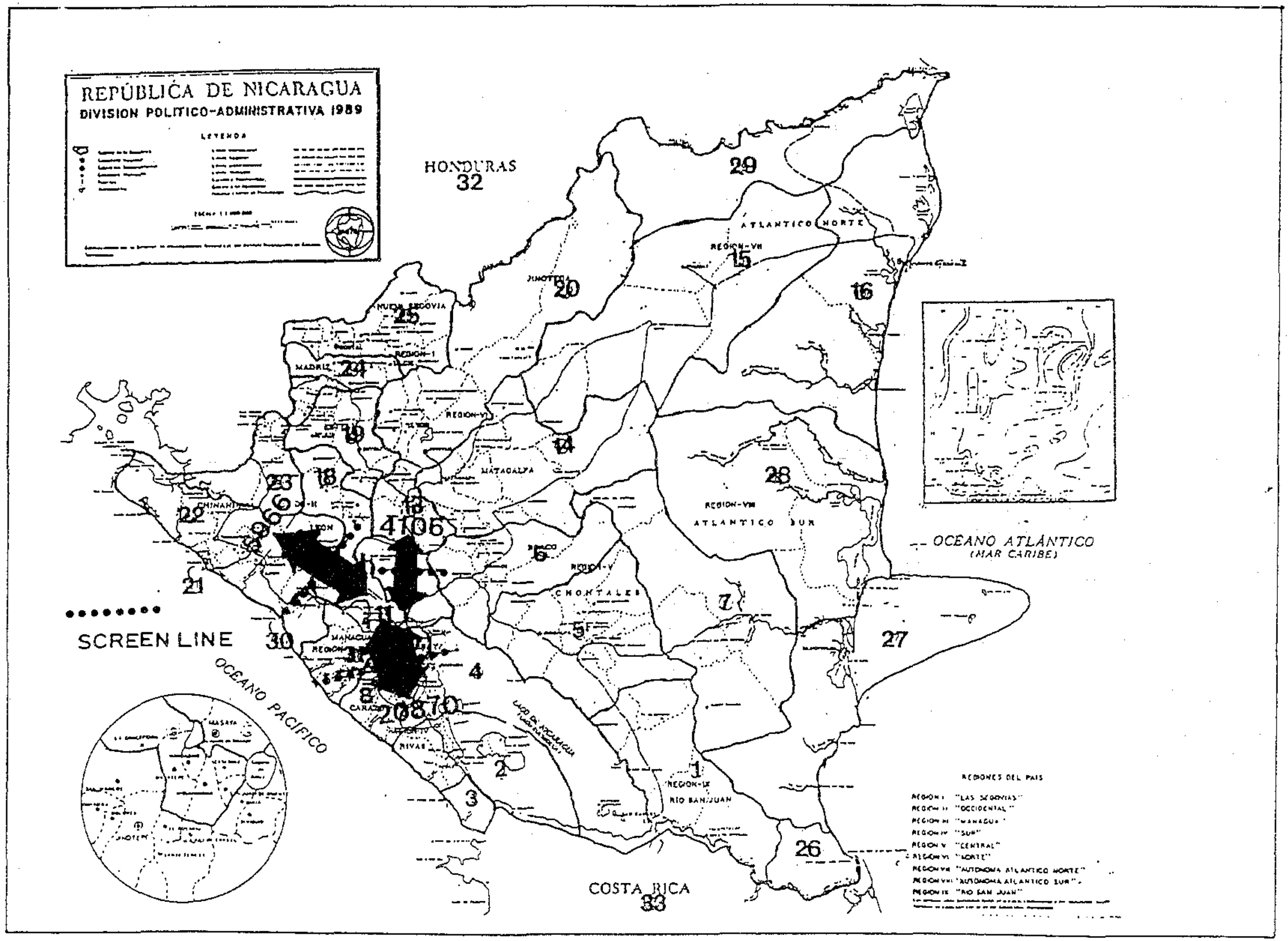



Figure 4-11 Traffic Volume on the Screen Line

There were a total of 30,868 vehicular trips recorded in the established present O-D Table, which excluded intra-zonal traffic, motorcycles and unknown vehicles. Of these, passenger cars accounted for 34.0% (10,486 trips), followed by pick-ups with 30.0% (9,500 trips), and trucks with 15.3% (4,732 trips). The composition of vehicular trips by vehicle type is shown in Table 4-18.

**Table 4-18 Composition of Vehicular Trips**

| Vehicle Type | Vehicular Trip | Composition Rate |
|---|---|---|
| Passenger Car | 10,486 trips | 34.0% |
| Microbus | 1,492 trips | 4.8% |
| Bus | 2,176 trips | 7.0% |
| Pick-up | 9,500 trips | 30.8% |
| Truck | 4,732 trips | 15.3% |
| Trailer | 2,253 trips | 7.3% |
| Tractor | 229 trips | 0.7% |
| Total | 30,868 trips | 100.0% |

Looking at the trip distribution shown in Figure 4-12, most of trips were concentrated in Zone 1 (the capital city of Managua), accounting for about 40%. This was followed by trips generated/attracted in Zone 10 (Masaya), Zone 4 (Granada), Zone 22 (Chinandega), and Zone 17 (León).

Table 4-19 shows trip generation and attraction by zone and vehicle type. Zone 11 accounted for at least 60% of each vehicle type. The O-D Table for all vehicles is shown in Table 4-20.

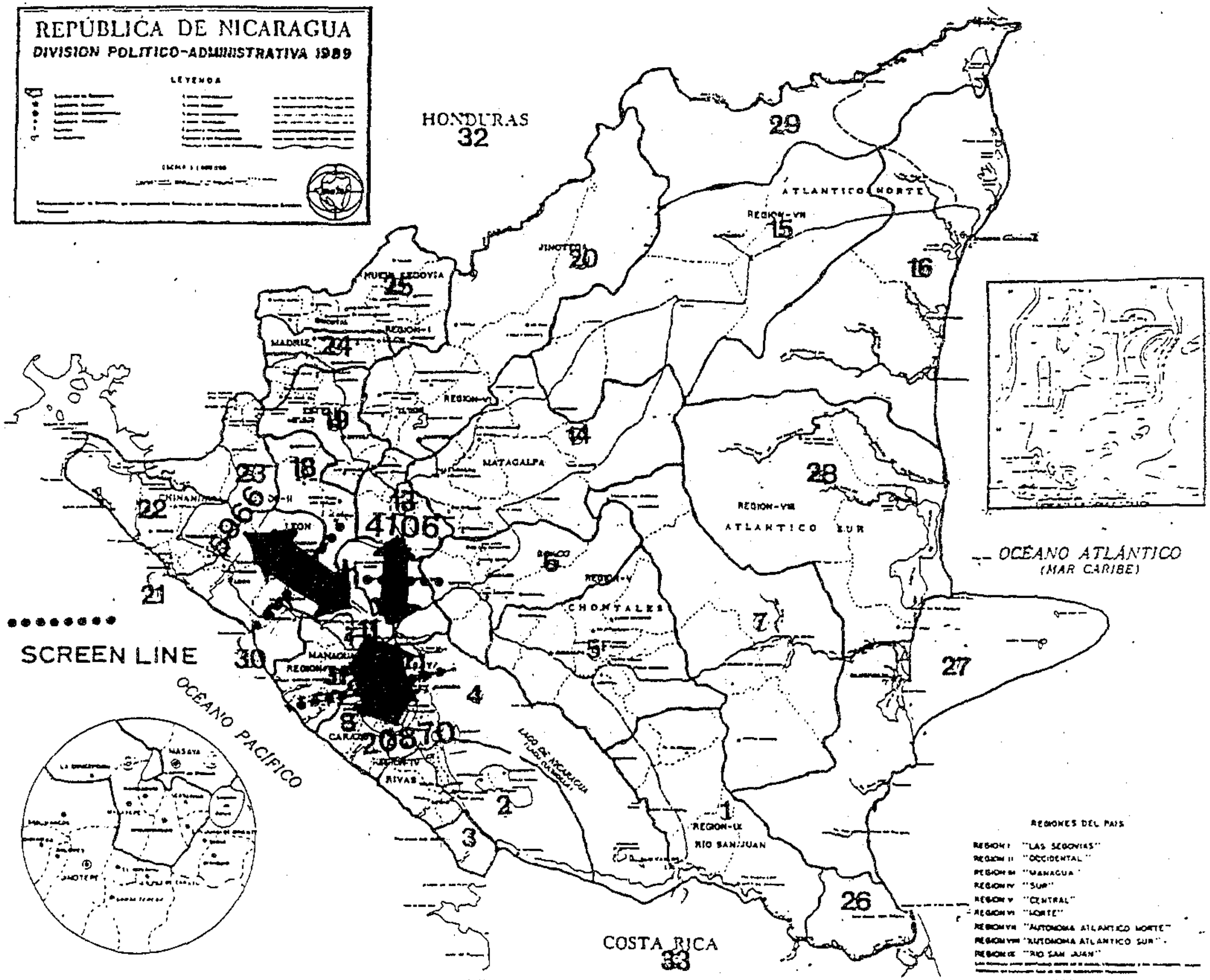



Figure 4-12 Desired Line 1993

### Table 4-19 Trip Generation and Attraction by Zone

| Zone | Passenger Car | | Truck | | Total | |
|---|---|---|---|---|---|---|
| | Generation | Attraction | Generation | Attraction | Generation | Attraction |
| 1 | 35 | 45 | 23 | 14 | 58 | 59 |
| 2 | 658 | 765 | 174 | 265 | 832 | 1,030 |
| 3 | 31 | 31 | 10 | 9 | 41 | 40 |
| 4 | 1,571 | 1,663 | 423 | 460 | 1,994 | 2,123 |
| 5 | 221 | 233 | 111 | 77 | 332 | 310 |
| 6 | 265 | 281 | 131 | 84 | 396 | 365 |
| 7 | 84 | 110 | 121 | 79 | 205 | 189 |
| 8 | 1,584 | 1,226 | 269 | 231 | 1,853 | 1,457 |
| 9 | 480 | 458 | 184 | 176 | 664 | 634 |
| 10 | 3,394 | 3,449 | 546 | 696 | 3,040 | 4,145 |
| 11 | 9,464 | 9,625 | 3,006 | 2,761 | 12,484 | 12,021 |
| 12 | 486 | 473 | 91 | 126 | 577 | 599 |
| 13 | 269 | 288 | 80 | 73 | 349 | 361 |
| 14 | 512 | 575 | 151 | 170 | 663 | 745 |
| 15 | 1 | 3 | 5 | 9 | 6 | 12 |
| 16 | 0 | 1 | 2 | 4 | 2 | 5 |
| 17 | 1,048 | 1,065 | 229 | 192 | 1,277 | 1,257 |
| 18 | 38 | 41 | 21 | 18 | 59 | 59 |
| 19 | 468 | 516 | 158 | 194 | 626 | 710 |
| 20 | 92 | 121 | 72 | 52 | 164 | 173 |
| 21 | 140 | 204 | 112 | 103 | 252 | 307 |
| 22 | 1,243 | 1,330 | 315 | 342 | 1,558 | 1,672 |
| 23 | 318 | 262 | 42 | 26 | 360 | 288 |
| 24 | 226 | 212 | 81 | 61 | 307 | 273 |
| 25 | 299 | 228 | 79 | 114 | 378 | 342 |
| 26 | 1 | 0 | 0 | 0 | 1 | 0 |
| 27 | 1 | 2 | 0 | 1 | 1 | 3 |
| 28 | 0 | 0 | 0 | 0 | 1 | 0 |
| 29 | 0 | 0 | 0 | 1 | 0 | 1 |
| 30 | 12 | 3 | 16 | 25 | 28 | 28 |
| 31 | 438 | 460 | 267 | 333 | 705 | 793 |
| 32 | 90 | 104 | 290 | 348 | 380 | 425 |
| 33 | 166 | 222 | 166 | 145 | 332 | 671 |
| Total | 23,636 | 23,636 | 7,189 | 7,189 | 30,825 | 30,825 |

Note : Excluding motorcycles and unknown vehicles

## Table 4-20 Present O-D Table

| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 | 32 | 33 | 99 | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 0 | 3 | 52 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 58 |
| 2 | 0 | 0 | 7 | 26 | 1 | 0 | 0 | 56 | 6 | 29 | 522 | 1 | 0 | 0 | 0 | 0 | 1 | 0 | 2 | 0 | 1 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 178 | 0 | 832 |
| 3 | 0 | 13 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 27 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 41 |
| 4 | 1 | 28 | 0 | 0 | 1 | 0 | 0 | 66 | 56 | 494 | 1312 | 6 | 1 | 9 | 0 | 2 | 0 | 0 | 3 | 0 | 2 | 3 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 3 | 0 | 6 | 1 | 1995 |
| 5 | 1 | 7 | 1 | 4 | 0 | 45 | 0 | 1 | 0 | 13 | 220 | 11 | 8 | 3 | 0 | 0 | 0 | 0 | 4 | 0 | 0 | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 3 | 0 | 9 | 0 | 332 |
| 6 | 0 | 9 | 0 | 7 | 50 | 0 | 1 | 0 | 0 | 9 | 310 | 3 | 5 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 396 |
| 7 | 0 | 0 | 0 | 4 | 1 | 0 | 0 | 0 | 0 | 6 | 194 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 205 |
| 8 | 1 | 89 | 0 | 123 | 3 | 3 | 3 | 0 | 0 | 0 | 1558 | 12 | 2 | 1 | 0 | 0 | 1 | 0 | 0 | 2 | 0 | 12 | 0 | 1 | 4 | 0 | 0 | 0 | 0 | 0 | 37 | 1 | 0 | 3 | 1856 |
| 9 | 3 | 22 | 0 | 122 | 0 | 0 | 0 | 0 | 0 | 0 | 504 | 0 | 0 | 11 | 0 | 0 | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 664 |
| 10 | 1 | 65 | 0 | 579 | 11 | 17 | 0 | 10 | 31 | 0 | 2965 | 98 | 8 | 34 | 4 | 0 | 11 | 0 | 32 | 3 | 10 | 45 | 0 | 5 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 5 | 4 | 9 | 3949 |
| 11 | 50 | 680 | 32 | 1199 | 221 | 294 | 184 | 1271 | 509 | 3380 | 0 | 445 | 113 | 374 | 6 | 2 | 752 | 14 | 270 | 121 | 209 | 855 | 76 | 49 | 96 | 0 | 3 | 0 | 1 | 25 | 736 | 391 | 126 | 22 | 12506 |
| 12 | 0 | 0 | 0 | 13 | 3 | 5 | 0 | 18 | 2 | 79 | 416 | 0 | 4 | 16 | 0 | 0 | 4 | 0 | 3 | 2 | 1 | 4 | 6 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 577 |
| 13 | 0 | 0 | 0 | 1 | 5 | 1 | 0 | 0 | 8 | 9 | 90 | 0 | 0 | 147 | 1 | 0 | 24 | 0 | 43 | 9 | 0 | 9 | 0 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 349 |
| 14 | 0 | 2 | 0 | 9 | 0 | 0 | 1 | 0 | 1 | 16 | 412 | 7 | 126 | 0 | 0 | 0 | 10 | 1 | 63 | 3 | 2 | 9 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 663 |
| 15 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 5 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 6 |
| 16 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 |
| 17 | 0 | 4 | 0 | 2 | 1 | 0 | 0 | 4 | 2 | 76 | 574 | 2 | 39 | 16 | 0 | 0 | 0 | 35 | 13 | 4 | 36 | 424 | 32 | 0 | 1 | 0 | 0 | 0 | 0 | 2 | 1 | 7 | 2 | 0 | 1277 |
| 18 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 15 | 0 | 1 | 3 | 1 | 0 | 27 | 0 | 0 | 0 | 0 | 5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 6 | 0 | 0 | 0 | 59 |
| 19 | 2 | 0 | 0 | 1 | 6 | 0 | 0 | 0 | 2 | 7 | 267 | 5 | 41 | 76 | 0 | 0 | 10 | 0 | 0 | 28 | 0 | 4 | 0 | 53 | 122 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 626 |
| 20 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 7 | 4 | 94 | 0 | 0 | 25 | 0 | 0 | 3 | 0 | 27 | 0 | 0 | 0 | 0 | 0 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 164 |
| 21 | 0 | 5 | 0 | 6 | 0 | 0 | 0 | 1 | 3 | 4 | 162 | 0 | 0 | 2 | 0 | 0 | 23 | 0 | 0 | 0 | 0 | 40 | 0 | 1 | 4 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 252 |
| 22 | 0 | 12 | 0 | 3 | 0 | 0 | 0 | 2 | 0 | 9 | 883 | 2 | 10 | 3 | 0 | 0 | 377 | 4 | 8 | 0 | 35 | 0 | 173 | 11 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 26 | 0 | 0 | 1558 |
| 23 | 0 | 6 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 91 | 0 | 0 | 3 | 0 | 0 | 7 | 3 | 0 | 0 | 9 | 224 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 0 | 15 | 0 | 360 |
| 24 | 0 | 0 | 0 | 1 | 2 | 0 | 0 | 0 | 0 | 0 | 53 | 4 | 0 | 7 | 0 | 0 | 0 | 0 | 128 | 0 | 0 | 2 | 0 | 0 | 109 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 307 |
| 25 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 2 | 108 | 0 | 3 | 0 | 0 | 0 | 0 | 0 | 108 | 0 | 2 | 1 | 0 | 151 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 0 | 378 |
| 26 | 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 | 1 |
| 27 | 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 | 1 |
| 28 | 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 | 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 |
| 30 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 27 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 28 |
| 31 | 0 | 0 | 0 | 8 | 3 | 0 | 0 | 15 | 5 | 3 | 653 | 3 | 0 | 3 | 0 | 1 | 4 | 2 | 4 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 705 |
| 32 | 0 | 0 | 0 | 3 | 0 | 0 | 0 | 2 | 2 | 2 | 313 | 0 | 0 | 8 | 0 | 0 | 0 | 0 | 2 | 0 | 0 | 22 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 0 | 380 |
| 33 | 0 | 88 | 0 | 8 | 1 | 0 | 0 | 7 | 0 | 0 | 197 | 0 | 0 | 0 | 0 | 0 | 2 | 0 | 0 | 0 | 0 | 9 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 20 | 0 | 0 | 332 |
| 99 | 0 | 0 | 0 | 5 | 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 | 0 | 0 | 0 | 0 | 8 |
| Total | 59 | 1030 | 40 | 2128 | 312 | 366 | 189 | 1457 | 634 | 4145 | 12026 | 599 | 361 | 745 | 12 | 5 | 1257 | 59 | 710 | 173 | 307 | 1672 | 288 | 273 | 342 | 0 | 3 | 0 | 1 | 28 | 793 | 452 | 367 | 35 | 30868 |

Note : 99 - Unknown

# CAHPTER 5

# GEOLOGICAL CONSIDERATIONS

# CHAPTER 5 GEOLOGICAL CONSIDERATIONS

## 5.1 GENERAL GEOLOGY

Nicaragua is generally divisible into four geologic and geographic provinces, i.e., the Pacific Coastal Plain, the Nicaragua Depression, the Interior Highlands, and the Atlantic Coastal Plain. (Figure 5-1) These geographic divisions reflect the geology of the country. The slopes of the Pacific Coastal Plain correspond to the littoral sedimentary region facing the Pacific Ocean. The Nicaragua Depression, a graben structure between the Pacific Coastal Plain and the Interior Highlands, contains a numerous Quaternary volcanoes surrounded by alluvial plains. The Interior Highlands is divided into four units, i.e. the Interior Tertiary Volcanic area, which is located at the northeast of the Nicaragua Depression, the Pre-Tertiary Metamorphic Basements to the northern center of the area, the Iyas Graben to the southwestern side of the Pre-Tertiary Metamorphic Basements, and the Nicaraguan Central Highlands, which extend in a southeastern adjacent to the Iyas Graben. The Atlantic Coastal Plain corresponds to the Quaternary Alluvial Sedimentary Region, which is called as the Mosquito Valley or Bluefields area. (Figure 5-2)

The oldest rocks in Nicaragua, which consist the Pre-Tertiary Metamorphic Basements, locate in the northern center portion of the country, and show a most elevated mountainous region of the country. The main rocks observed are sericite, chlorite-sericite, graphite and argillaceous schists, quartzites, marble, amphibolites, metavolcanics, and various clastic sediments like arkoses and conglomerates, and defined as pre-Tertiary chronologically although they may belong to the Paleozoic in geological age. The distribution of these undifferentiated metamorphic rocks including plutonic intrusives in Mesozoic age is limited to the northwestern center, forming the "Cordillera de Dipilto y Jalapa", which borders the country from Honduras.

After the Mesozoic age, the development of the geological formations was diversified into four regions; the West, the Center, the East and the Northwest, as shown in Figure 5-3. The West includes rocks from the Pacific coast to the northeast margin of the Nicaragua Depression. The Center refers to the broad belt of Tertiary volcanic rocks to the northeast of the Nicaragua Depression. The East refers to the Bluefields area, and the Northeast refers to the Bonanza-Siuna mining districts where Bonanza volcanics are assigned to the Metagalpa Group, and those from Siuna are assigned to the Metapan Formation.

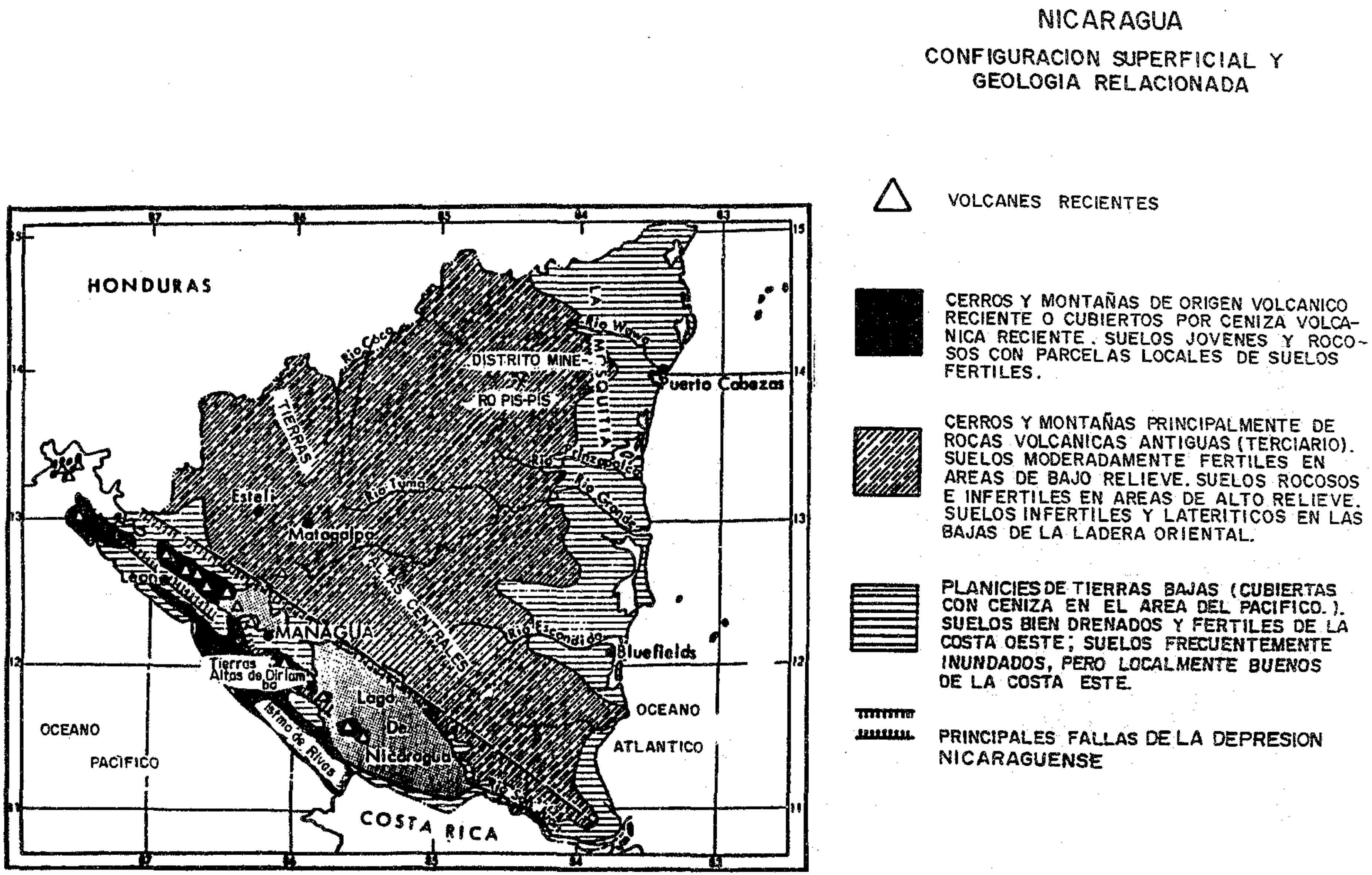
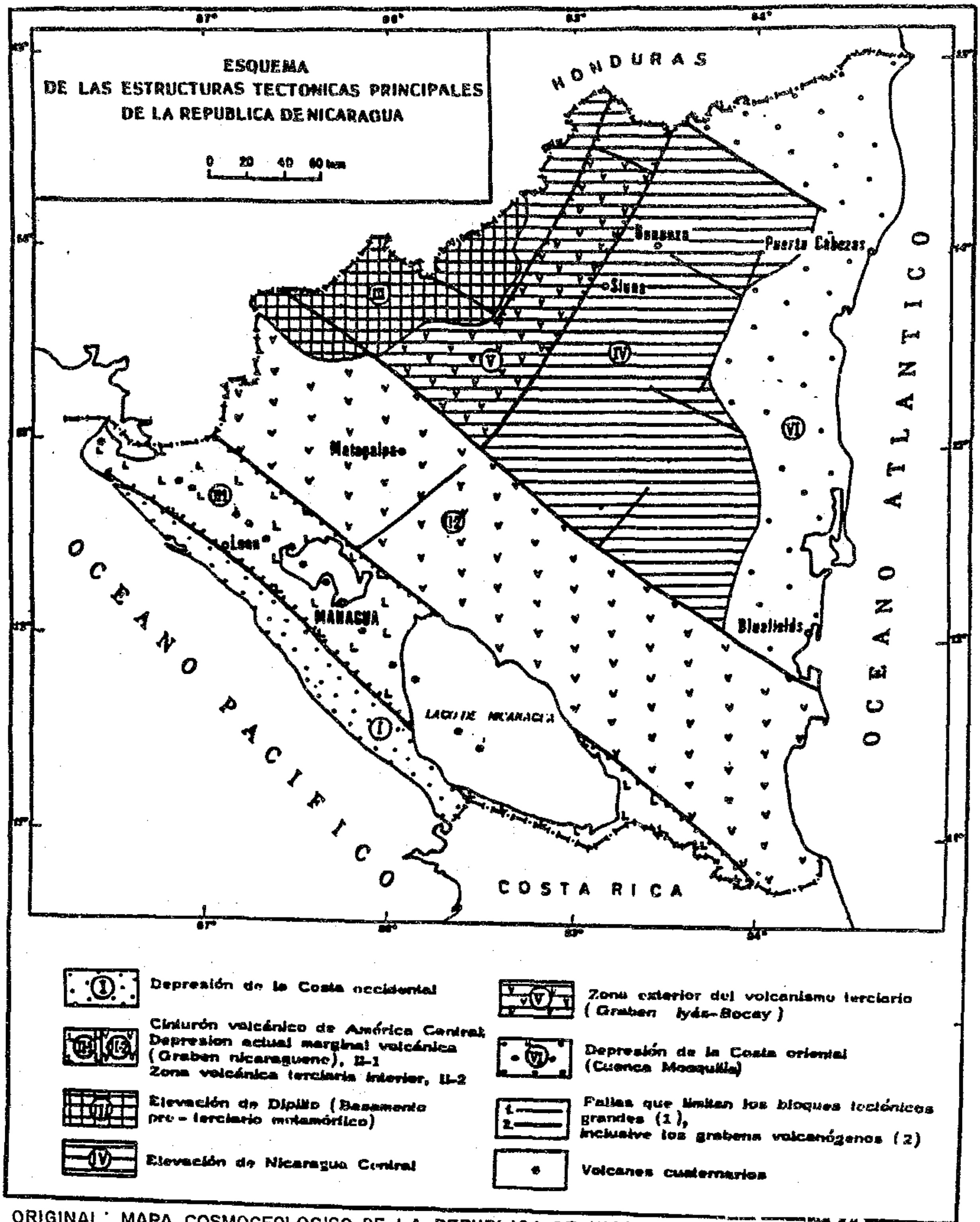


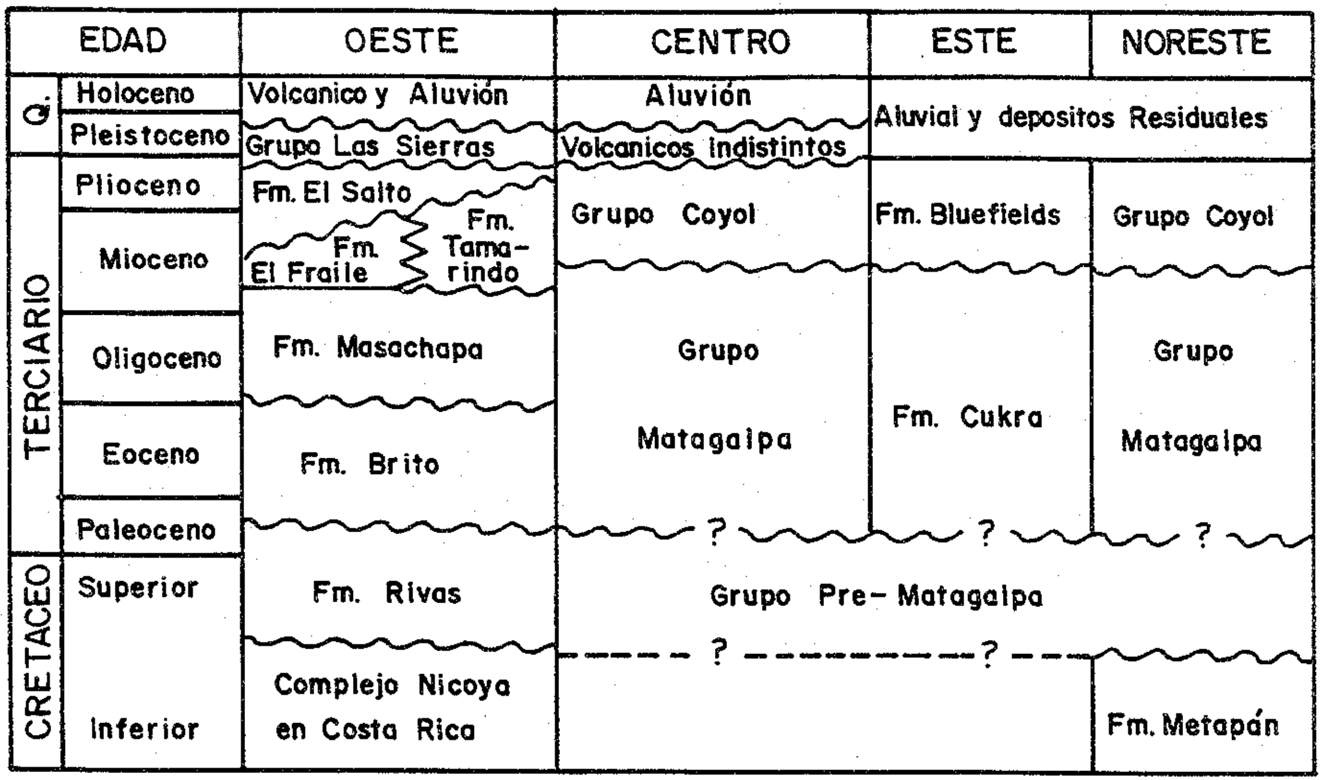

Figure 5-1 Nicaraguan Structures, Soil and Landforms




ORIGINAL: MAPA COSMOGEOLOGICO DE LA REPUBLICA DE NICARAGUA

ESCALA: 1: 1,500,000. Dr. M. DARCE Y OTROS 1990

**Figure 5-2 General Tectonic Structure Map of Nicaragua**




( ORIGINAL: Dr. M. DARCE Y OTROS 1989 )

Figure 5-3 Preliminary Stratigraphic Correlaton within the Traverse

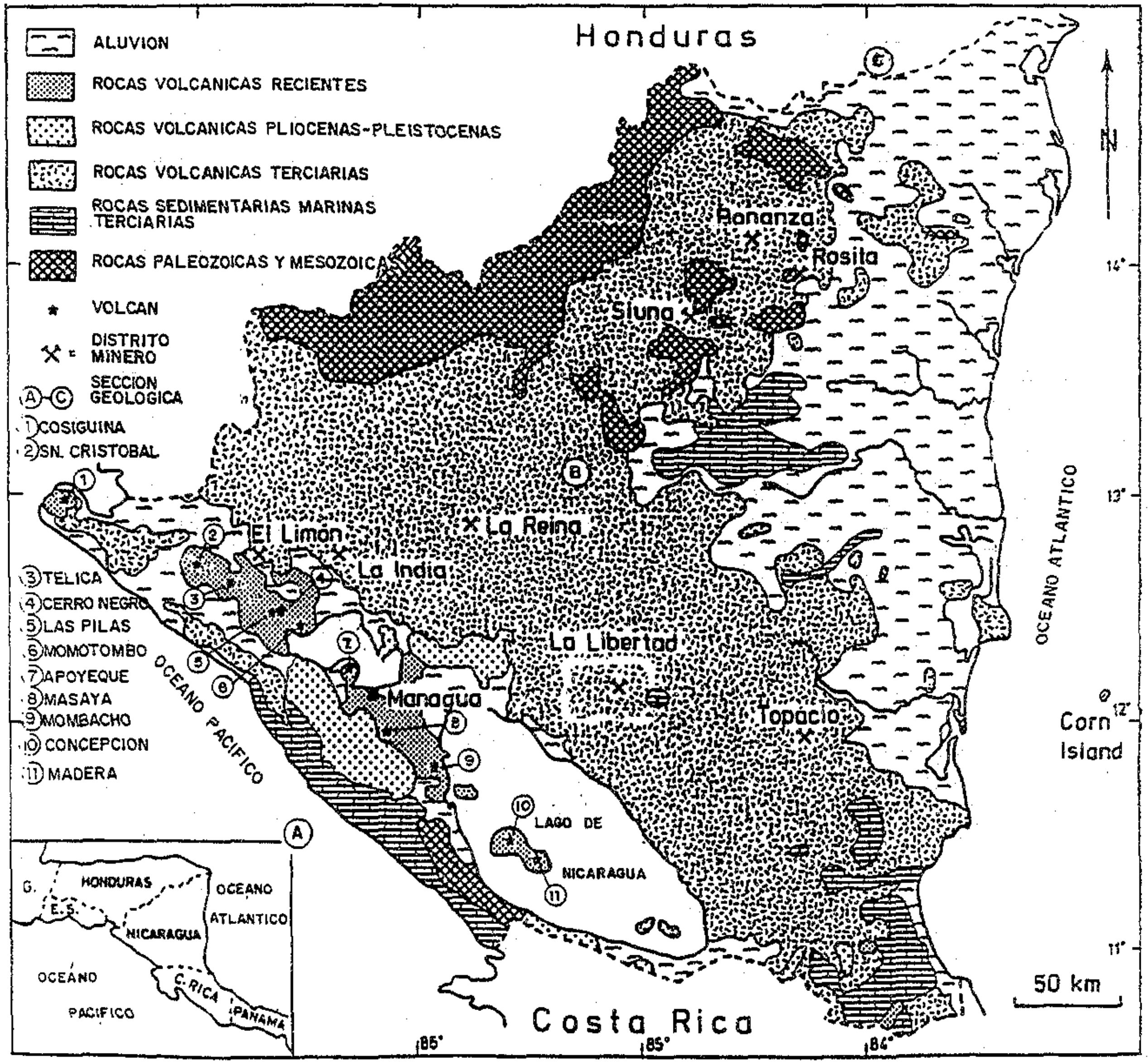
The Mesozoic age is divided into two formations, the Jurassic-Lower Cretaceous Metapan Formation (Todos Santos Formation) and the Upper Cretaceous Rivas Formation in the West area or the Pre-Matagalpa Group in rest of the areas. The Metapan Formation distributes on the northeastern side of the Metamorphic Basement and also on the southeastern margin of the Iyas Graben. The main rocks are arkosic sandstone with intercalations of conglomerates, calcareous shale, marl, limestone, and dolomites. The Rivas Formation is developed at the southwestern area of the Pacific Coastal Plain region, and consists of some marine clastic sediment of a turbidite origin, such as arkosic sandstone, fine sandstone, shale, and others, i.e. marls, limestone, andesites, and andesitic tuffs.

In the Paleogene age, the rock faces are clearly different between the Pacific Coastal Plain region and the rest of the regions. In the West area, the Brito Formation of the Paleocene-Eocene age, in which sandstone, limestone, and marls of a littoral origin exceed the pyroclastic rocks of some tuffs, agglomerates and andesitic-basaltic lavas, overlies the Cretaceous Rivas formation unconformably on its northeastern side, and be overlaid by the Oligocene Masachapa Formation, which is more pyroclastic rich sediment consisting of tuffaceous sandstone, tuffaceous fine sandstone, shale and pebbly sandstone with lenses of calcareous conglomerates, at its southwestern side. In the Center and Northeast areas, the Matagalpa Group characterized by extensive intermediate-acidic pyroclastic rocks, such as rhyolitic and rhyodacitic tuffs with some andesitic lava, basaltic lava and brecciated lava, the agglomeratic tuffs of andesitic-dacites, tuffaceous sandstone, sandy-clayey breccia, developed through the Paleogene age, and some igneous rocks intrude the volcanic members. In the Bluefields, the Paleogene group is called as Cukra Formation.

Extensive volcanic activities continued into the Neogene age especially in the Interior Highlands region. The Paleogene Group is unconformably covered by the thick basic pyroclastics of the Miocene Lower Coyol Group, which consist of basaltic and andesite-basaltic lava, andesite-dacitic and rhyo-dacitic tuffs and tuff breccia, rhyolitic and dacitic agglomerates, etc. The Upper Coyol Group of the Pliocene age, which consists of basic lava and acidic ignimbrites, successively overlies on the Lower Coyol Group and makes a mesa-type residual scarp together with the Lower Coyol Group. In the Pacific Central Plain region, the Miocene El Fraile Formation consisting of tuffaceous sandstone, shale, tuffaceous fine sandstone, limestone, lenses of calcareous conglomerates and agglomerates, and basaltic and andesitic tuffs conformably overlies on the Masachapa Formation. In the Bluefields area, the Miocene and Pliocene members are called as the Bluefields Formation. In the West area, the Pliocene El Salto Formation unconformably covers the El Fraile Formation, and comprises reefal detritus limestone, marls, calcareous sandstone, and conglomerates.

In the Quaternary, the Las Sierras Group in Pleistocene age developed mainly in the West area and comprises andesitic tuffs and agglomerates, andesite-rhyodacites and dacites, pumice tuffs, and tuffaceous sandstone. However, only an undifferential volcanics are identical in the Center area, and also alluvial and residual deposits are only recognized through the Quaternary in the East and Northeast areas. The deposits in the Holocene in the West and Center areas are alluvial deposits along the rivers and the surrounding area of the lakes, and large amount of the volcanic effusives of active volcanoes which mainly consist of basaltic lava and pyroclastics.

A generalized geological map and a representative geological section across the country are attached in Figures 5-4 and 5-5.




(ORIGINAL: Dr. M. DARCE. INMINE 1990)

**Figure 5-4 Simplified Geological Map of Nicaragua**

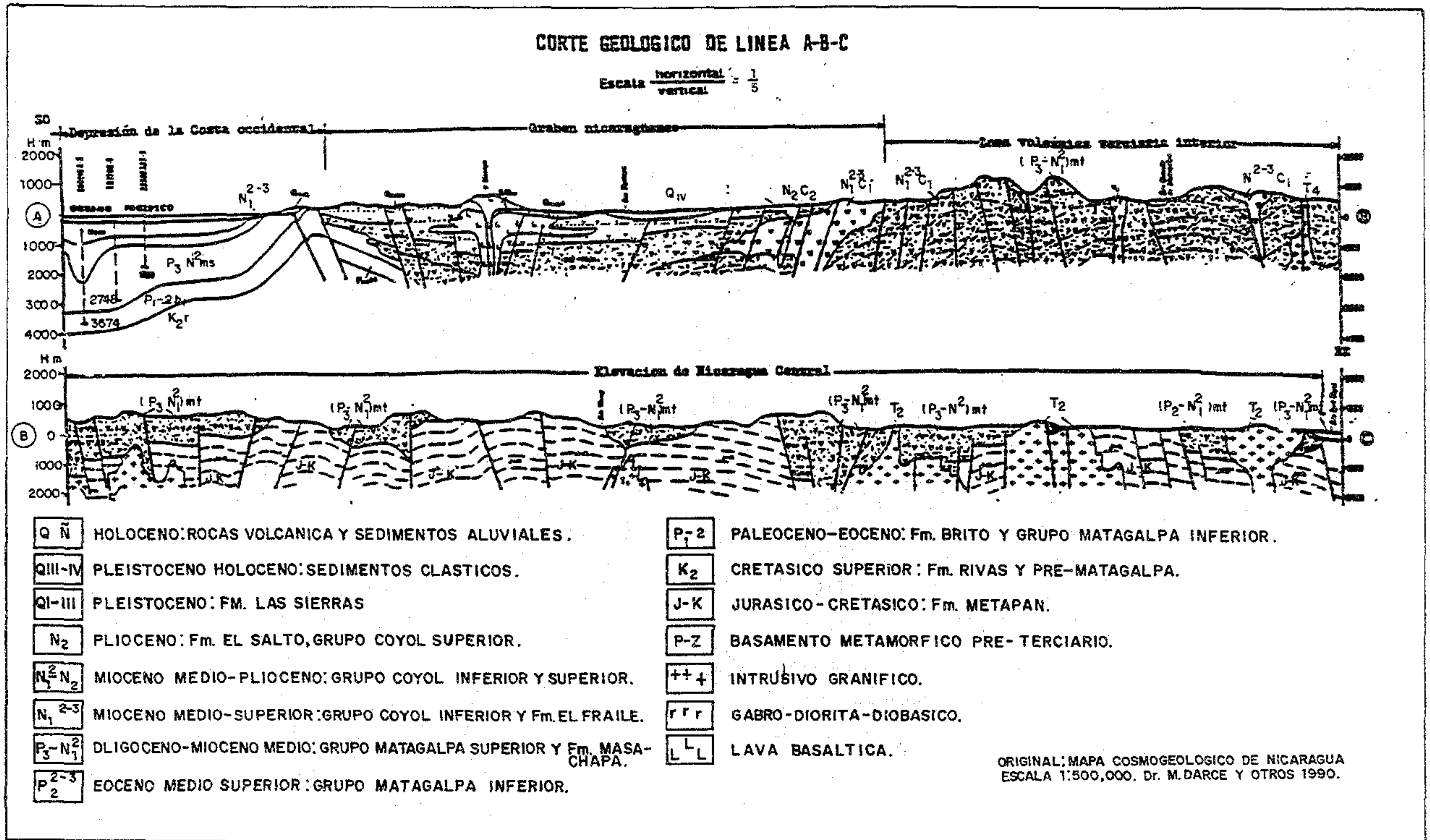



Figure 5-5 Geological Section Across Nicaragua

## 5.2 RECENT VOLCANISM

The Pacific coast side of Central America related to the active volcanic chain consists of four countries, Guatemala, El Salvador, Nicaragua, and Costa Rica. Active volcanoes are ranging nearly parallel to the Pacific coast, but the chain has a slight shift at eight points to make seven isolated segments. (Figure 5-6)

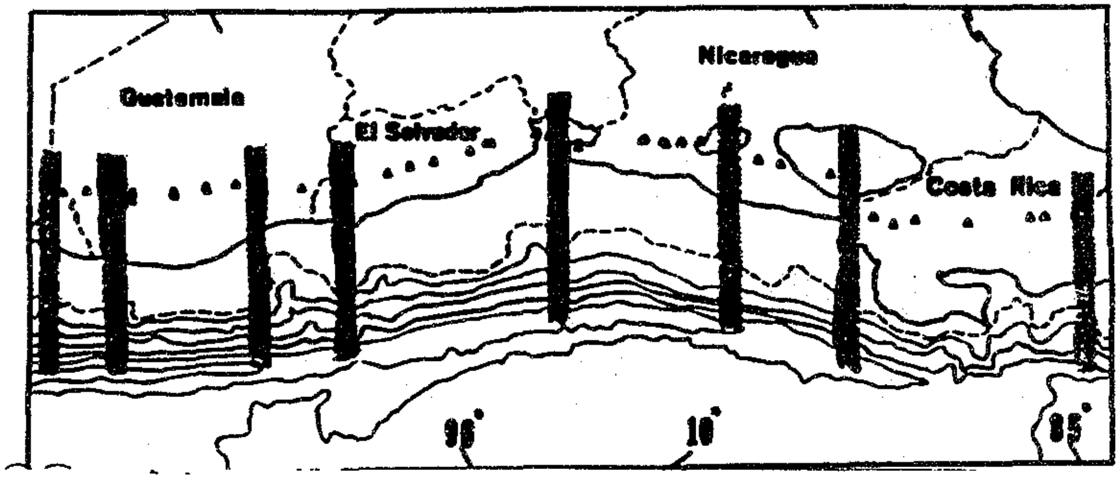
The boundary areas between the segments are characterized by faulting perpendicular to the volcanic lineaments, frequently accompanied by basaltic cinder cone fields, by concentrations of shallow earthquakes, and by historically catastrophic eruptions. These phenomena will be explained by an idea of segmented converging plate margin. An underthrusting lithosphere is broken along tear faults into 100 to 300 km-long segments in a shallow depth. Each separated segment descends into the mantle with a different strike and dip and becomes to have own geology each other.

In Central America, the Cocos Plate is submerged under the American and Caribbean Plates along the Middle American Arc which truncates Central America at its southwestern margin as shown in Figure 5-7.

In Nicaragua, two segments, called Western Nicaragua and Eastern Nicaragua, are recognized. Western Nicaragua segment of 175 km long comprises 7 volcanoes, i.e. Cosiguina, San Cristobal, Telica, Cerro Negro, Las Pilas, Momotombo, and Apoyeque from the northwest to the southeast, and Eastern Nicaragua segment of 120 km long consists of 4 volcanoes, i.e. Masaya, Mambacho, Concepción, and Madera from the northwest to the southeast.

Usually the volcanoes near the boundary of adjacent segments make giant eruptions, like Cosiguina in 1935 and Sta. María in 1902. The Masaya volcano, however, shows historically unusual volcanic eruptions, such as with an active lava lakes like Hawaiian type volcanoes. The volcanic centers of Western Nicaragua segment are composed of many vents which form both transverse and parallel alignments, especially with N-S alignment being the most prominent.

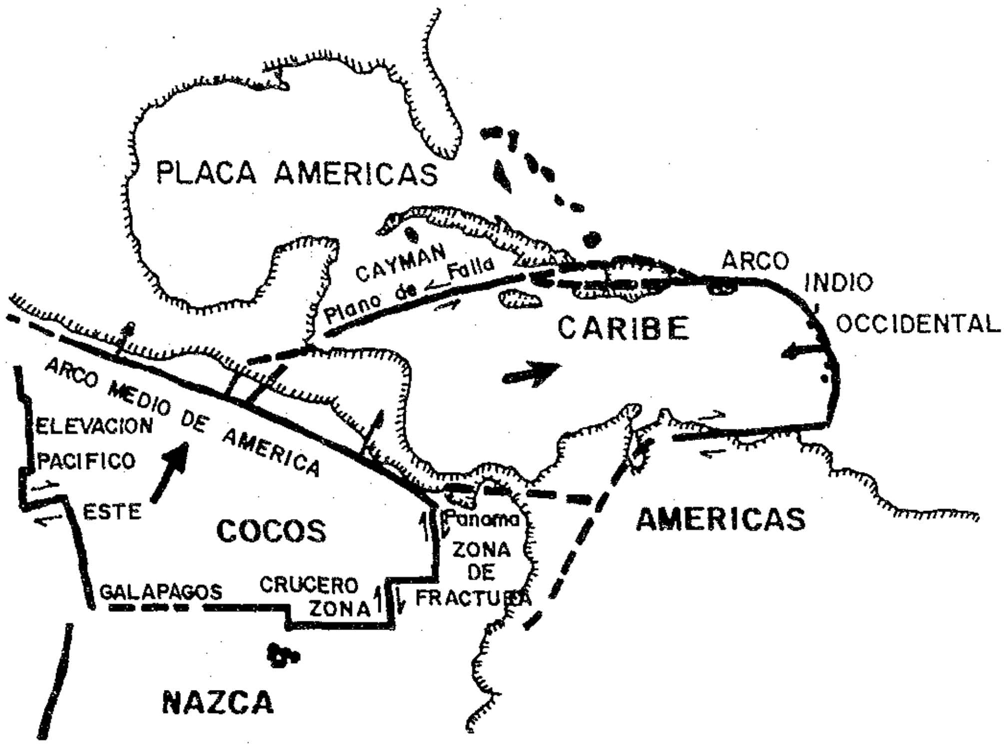
The volumes of the volcanic centers are small in Nicaragua. The ratios between the total volume of volcanoes ($km^3$) in the segment and the length (km) of the segment are 1.5 for Western Nicaragua segment and 1.2 for Eastern Nicaragua segment while 4.3 for El Salvador and 5.2 for Costa Rica segments.




- LOS TRIANGULOS REPRESENTAN A LOS VOLCANES CON ERUPCIONES HISTORICAS.
- EL CONTORNO A RAYAS CORRESPONDE A UNA SUPERFICIE DE 100. FATHOM.
- EL SIGUIENTE CONTORNO CORRESPONDE A UNA SUPERFICIE DE 500. FATHOM.
- LAS BARRAS PUNTEADAS REPRESENTAN LAS AREAS FRONTERIZAS ENTRE LOS SEGMENTOS VOLCANICOS

ORIGINAL: R.E. STOIBER Y M.J. CARR. (OCTUBRE, 1980)

Figure 5-6 Volcanic Segments of Central America




- LOS LIMITES DE LOS DIFERENTES TIPOS DE LITOSFERA ESTAN REPRESENTADOS POR LAS LINEAS MARCADAS.
- LOS NOMBRES DE LAS PLACAS APARECEN EN LETRAS GRANDES.
- LAS FLECHAS MARCADAS MUESTRAN LAS DIRECCIONES DE LA ACCION DE ESTAS PLACAS CON RESPECTO A LA PLACA AMERICAS
- LAS FLECHAS PEQUEÑAS MUESTRAN LA DIRECCION DEL MOVIMIENTO RELATIVO DE LAS PLACAS EN LAS FRONTERAS.

**Figure 5-7 Summary Map of the Plates of the Lithosphere in Central America**

This might be caused from no accumulations of old volcanoes in the geologic age. They are clearly recognizable remnants of late Tertiary volcanoes which lie to the northeast of the present lineaments. Important eruptions of Nicaraguan active volcanoes are listed in the following Table 5-1. (Figure 5-4)

**Table 5-1 Summary of Main Eruptions of Active Volcanoes in Nicaragua**

| Name | Elevation | 1st Eruption | Main Eruption | Population Affected |
|---|---|---|---|---|
| Cosiguina | 846.7 m | 1835 | 1835:Krakatoan (×1) | — |
| San Cristóbal | 1,745.0 m | 1680 | 1680-1982:lava (×4)<br>1971-84:gas (×3) | 70,000<br>(77) |
| Telica | 1,040.0 m | 1529 | 81-82:lava (×2)<br>87:Es*1 (×1) | 100,000<br>(87) |
| Cerro Negro | 490.0 m | 1850 | 1850-1968:lava (×9)<br>71&92:big ash | 20,000<br>(71) |
| Las Pilas | 1,072.0 m | 1952 | 52:gas<br>54:ash | — |
| Momotombo | 1,258.0 m | XVI C | 1609-1909:lava (×6)<br>1976:gas | 20,000<br>(76) |
| Masaya | 623.7 m | 1529 ? | 1529-1989:lava (×12)<br>1965-88:gas (big-76) | 20,000<br>(76) |
| Concepción | 1,610.0 m | 1883 | 1883-1957:lava (×6)<br>1906-88:gas (×5) | 500,000<br>(57) |

*Note : Es*1-Estromboliano type eruption*

Populated towns are gathered mostly in the surrounding area of Managua. This region corresponds to the boundary area between Western and Eastern Nicaragua segments. In the past, volcanoes belong to the Western Nicaragua segment show gas and ash dominated eruptions compared with those of Eastern Nicaragua segment where the basaltic lava flows have been more frequently. Recently, the volcanoes belonging to Eastern Nicaragua segment show more gas emission type. Therefore, precautions for sudden catastrophic eruptions have to be taken.

In June 25, 1993, a new hole of 7 m diameter was opened in the intercrater of the Santiago volcano which is located about 800 m west of the Masaya crater. According to the news paper, this hole might be generated from moderate scale vapor explosions originated from the contact of water and magma, which is assumed about 600 m below the second parking of the volcanic observatory. The temperature inside the intercrater became once approximately 1,200°C having been shown an incandescence in the truncated cone of the volcano on the night of its discovery. At the moment, the $SO_2$ gas emission is already falling down, and the temperature inside of the intercrater becomes of red-orange color through the infrared thermometer from USA. Volcanologists are alarmed that there still remains a possibility of explosive eruptions which may affect the agricultural crops although the remaining volcanoes in the country are not active at present.

## 5.3 EARTHQUAKES IN NICARAGUA

Recently, most destructive earthquakes recorded in Nicaragua have been those of 1931 and 1972. As mentioned in the previous paragraph, Managua town locates on the boundary area between Western and Eastern Nicaragua segments which are parallel to the Middle American Arc. Therefore, major faults and accompanied numerous minor faults transverse the volcanic lineaments arc hiding under Managua town. Among them, the active faults related to the 1972 and 1931 earthquakes are shown in Figure 5-8.

The Managua earthquake, which was recorded at a Richter magnitude of 5.6 and a surface-wave magnitude of 6.2, occurred on December 23, 1972, and its aftershocks strongly affected an area of approximately 27 km² centered on Managua. Over 11,000 people were killed and 20,000 were injured. Nearly 75% of all houses were destroyed or uninhabitable to leave 200,000 to 250,000 people homeless. The property damage exceeded half a billion US dollars. The collapse of the economy and the government brought the entire country into severe conditions.

As shown in Figure 5-8, there were at least four subparallel strike-slip faults spaced from 270 to 1,150 m in Managua area, and shown a predominantly left-lateral slips during the earthquake. According to aftershock studies, at least one of these north-trending faults extends from the surface to a depth of 8 to 10 km over a maximum length of approximately 15 km. The mappable length of each fault on land is 1.6 km, 5.1 km, 5.9 km, and 2.7 km, respectively. Horizontal displacements vary with a maximum aggregate lateral-slip of 2.0 to 38.0 cm. A local small down-to-the-southeast vertical component of slip was recognized in three of the four faults. The nature and distribution of the surface faulting are considered as a tectonic origin of the earthquake.

Extensive destruction and casualties were caused by a combination of the following factors: a) Less attenuation of the shocks because the origin of the earthquake was directly beneath the city, b) poor structures of houses and some buildings, such as wooden frame and adobe or masonry, against earthquakes, c) direct displacement of structures, streets, and utilities by the faulting.

Historical records of earthquakes and the existence of many active faults suggest that Managua area is an unusually high risk area and various precautions against theses hazards should be taken into account primarily in evaluating constructions of every item in the future.

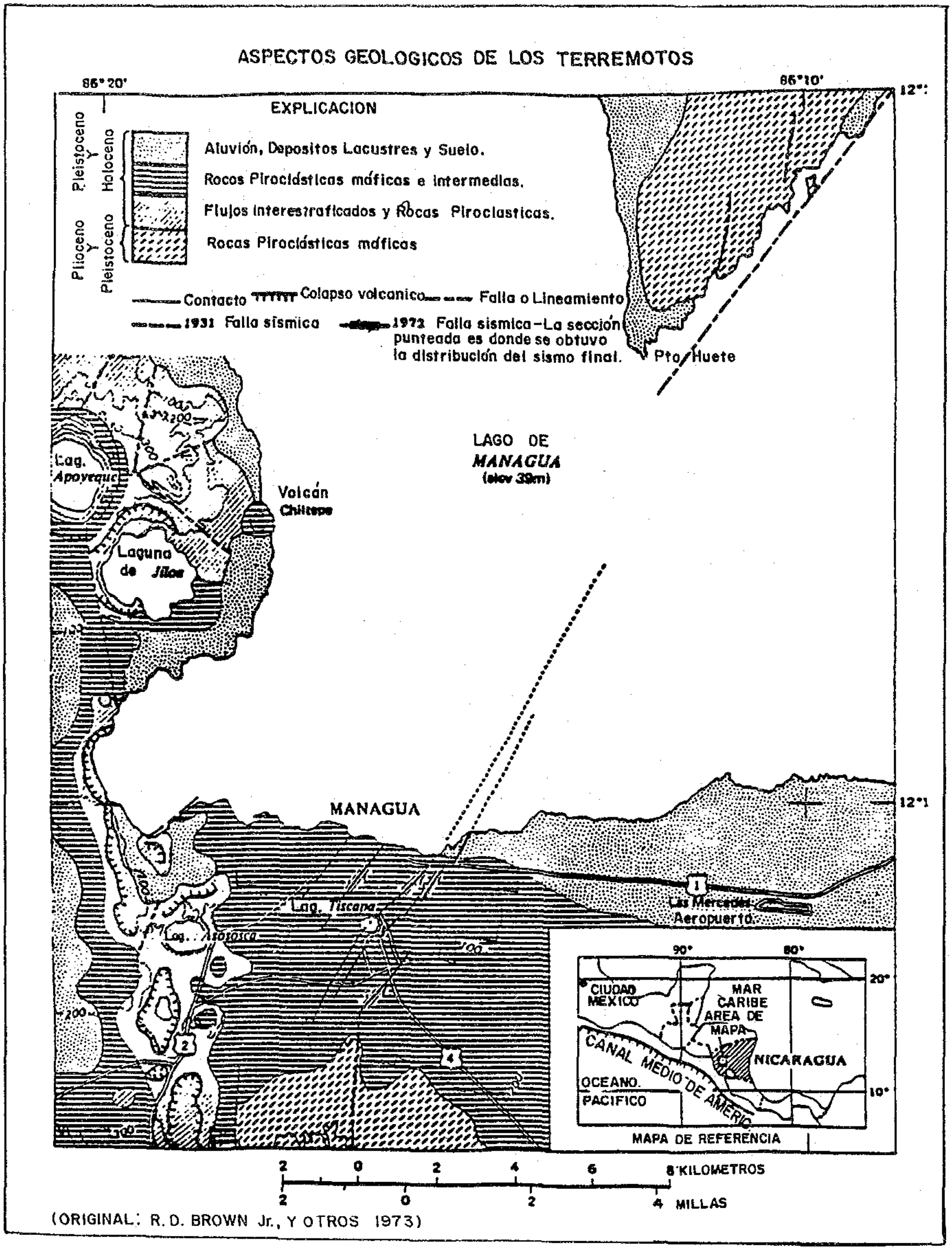



**Figure 5-8 Generalized Geological Map of the Managua Area Showing Faults Related to the 1931 and 1972 Earthquake**

According to the "Catalogue of Nicaraguan Earthquakes" during the period 1520 to 1973 by David J. Leeds (1974), historically large scale earthquakes except those in Managua area are the destruction of the former capital at León in 1609, 1663, and 1885. The maximum magnitude ever recorded is 7.7, and many are listed with magnitude of 6.0 among 457 cases including 70 cases with a volcanic origin. The map of Nicaraguan epicenters during the period from 1570 to 1973 is attached as Figure 5-9.

In September 2, 1992, a large tsunami attacked the Pacific coast of Nicaragua. In spite of the small seismic intensity of 2 to 3, the average maximum height of waves reached to 6 to 7 m above mean sea level (a.m.s.l.) over the area more than 200 km long along the southern coast on the Pacific ocean. (Figure 5-10) The tsunami hit the coast 2 or 3 times and took the life of about 100 people including missing. The source of the earthquake that caused the tsunami is assumed a kind of thrust fault occurred in the Middle American Trough at the contact plain between the superior Caribbean plate and the submerging Coco plate. The scale of the fault is inferred at about 200 km long and 100 km wide at the depth of about 2,000 m below s.l. and generated the earthquake of a magnitude of about 7.2 at the fault. As the intensity of the tsunami far exceeded that of the earthquake, a kind of elastic rebound could be occurred at the fault plain. (Figure 5-11)

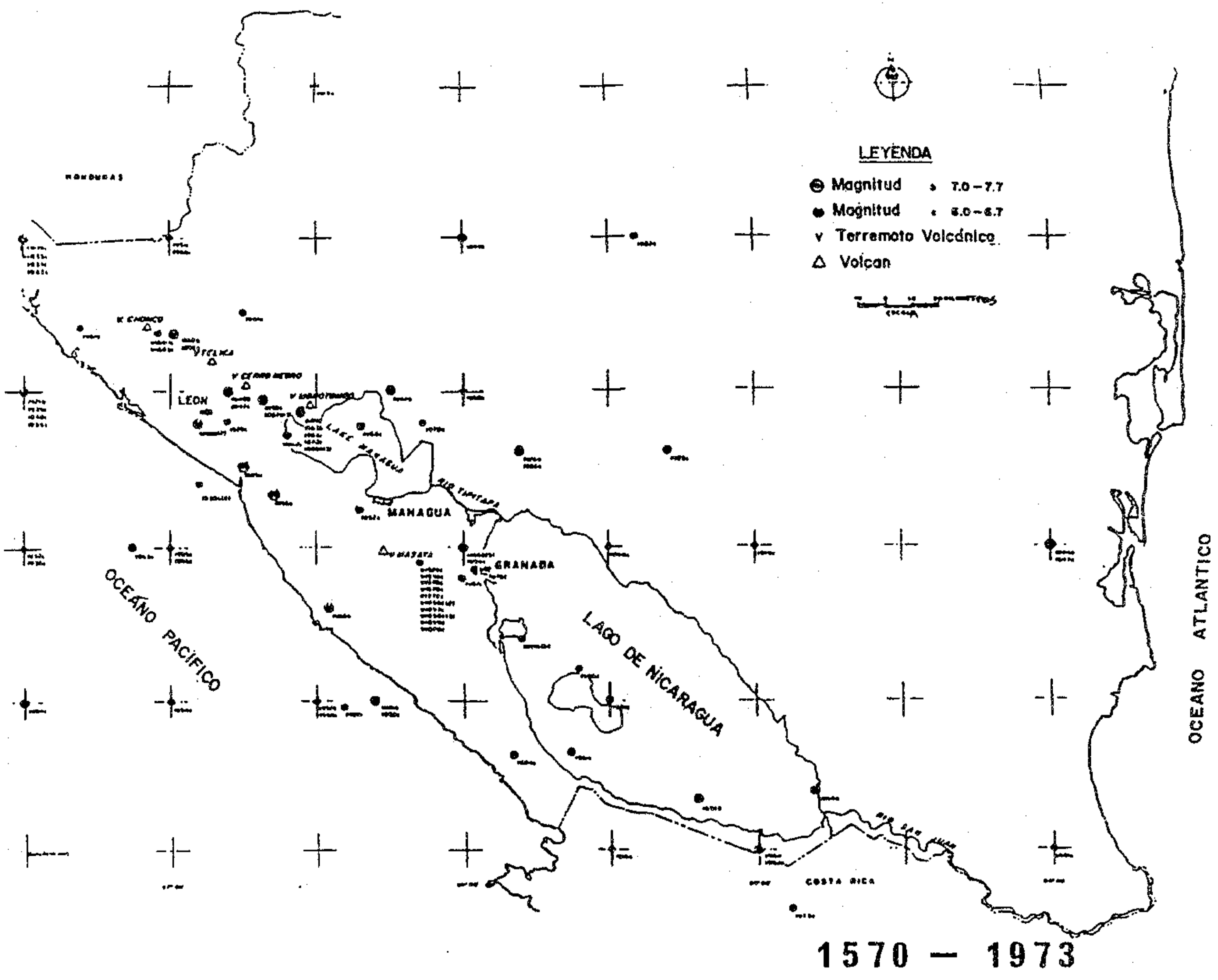
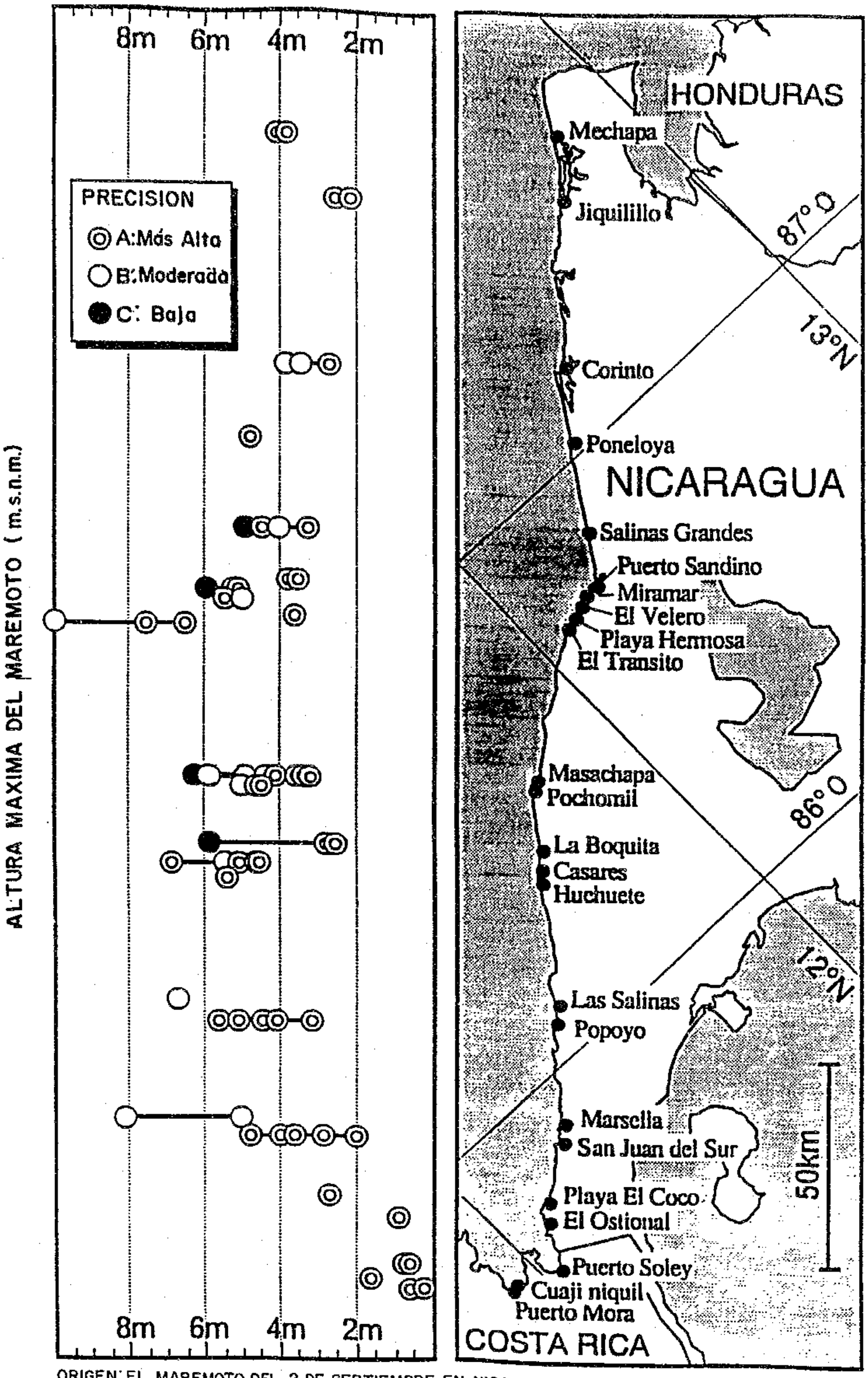



Figure 5-9 Nicaraguan Epicenter, 1570 - 1973




ORIGEN: EL MAREMOTO DEL 2 DE SEPTIEMBRE EN NICARAGUA (K. ABET. Y OTROS 1993)

**Figure 5-10 Records of the Maximum Height of the 1992 Tsunami in Nicaragua**

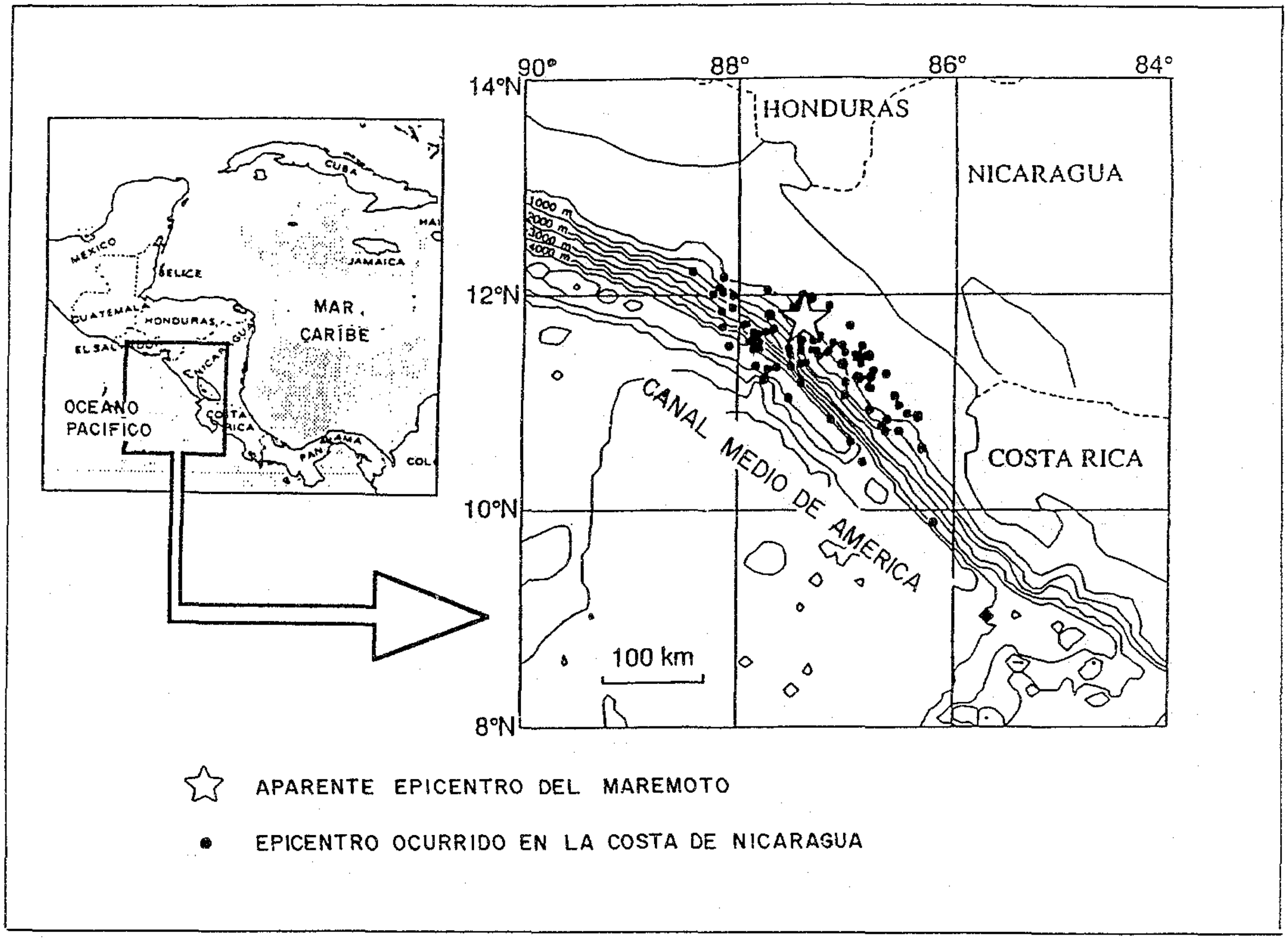



Figure 5-11 Distribution of Epicenters Offshore Nicaragua

## 5.4 LANDSLIDES AND CREEPS

Landslides in Nicaragua are classified into several types, such as so called landslides, rapid slopes (slip of rocks and soil on a steep slope), debris flows (slide of debris on a slope), and creeps. INETER made a distribution map for landslides as shown Figure 5-12. In 1993, one boy died from a debris flow that occurred to the northeast of Morrito town.

As active and resting Holocene volcanoes generally show a rapidly elevated topography from the lowlands, pyroclastic debris flows are used to occur on the slope, and if a volcano erupts more ash and tuff breccias, a debris flow consisting of soft ash and pyroclastic rocks will be generated even on gentle slopes like mud flows with volcanic boulders. And in areas where the older volcanic formations of the Tertiary age are distributed and showing a steep topography, landslides or creeps will occur at the area where large faults are passing or where highly altered mineralization zones exist.

Few landslides affect existing main roads. However, creeps and stone falls in cutting areas are quite common especially where the topography is ragged and the road has severe curves and steep cuttings.

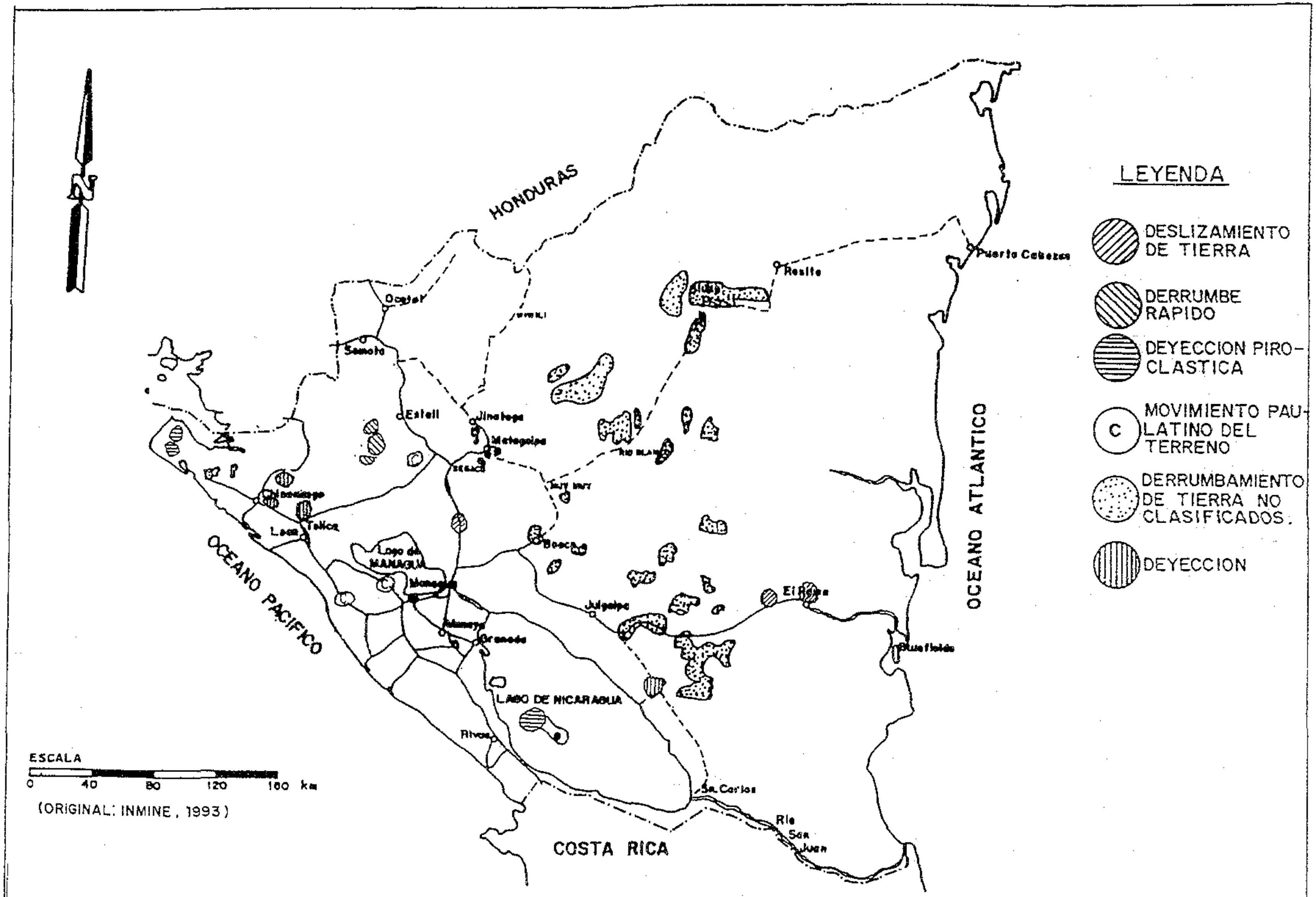


Figure 5-12 Distribution Map of Landslides in Nicaragua

## 5.5 SOFT GROUND

In the objective areas, soft grounds usually occur in the place where large faults are passing, and sometimes deformed into a clay, mineral-rich rocks. These cases are found more frequently in areas occupied by the geological formations of Pre-Tertiary and early Tertiary ages.

On the other hand, areas where younger geological formations predominate are mainly occupied by volcanic effusives including lava, ash and the other pyroclastic materials, although the lowlands by the rivers and lakes mainly consist of alluvial deposits.

There exists a special example of rapid erosion of the river bank beside roads by rivers where soft pyroclastic materials, such as soft tuff, tuffite and loose volcanic sand including pumice lapilli, etc., belonging to the Upper Las Sierras Group of Plio-Pleistocene age are exceeding. These materials are easily eroded by water flow and allow seepage of underground water due to their high permeability. In such cases, a sufficient revetment against the river would be required to maintain a road.

# CHAPTER 6

# METEOROLOGICAL AND HYDROLOGICAL CONSIDERATIONS

# CHAPTER 6 METEOROLOGICAL AND HYDROLOGICAL CONSIDERATIONS

## 6.1 METEOROLOGY

### 6.1.1 Meteorological Information

Information on the general meteorological features of Nicaragua was provided by INETER. In addition to this information, meteorological records which had been registered by INETER were also collected for 12 selected meteorological stations. The locations of the meteorological stations are shown in Figure 6-1. The following presents the meteorological features of Nicaragua with reference to the information and records mentioned above.

### 6.1.2 Rainfall

The monthly rainfall pattern in Nicaragua shows the obvious wet and dry season in a year as shown in Table 6-1. The wet season is between May and October, while the dry season is from November to April. Figure 6-2 shows an the isohyetal map of the annual rainfall. The regional characteristic of rainfall can be identified as two by the annual rainfall isohyetal line of 2,000 mm.

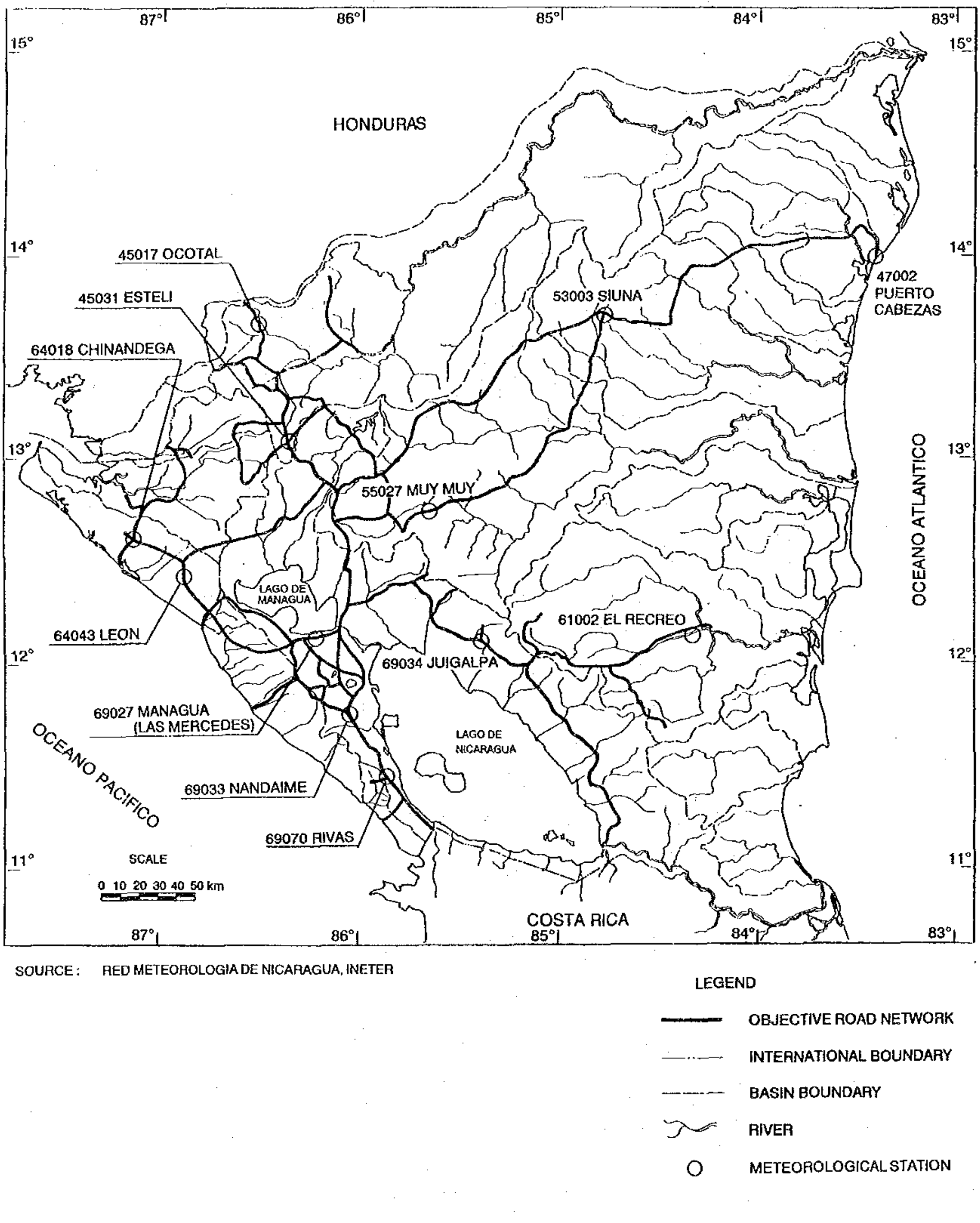
**Table 6-1 Monthly and Annual Rainfall**

(Unit : mm)

| No. | Station | Jan. | Feb. | Mar. | Apr. | May | Jun | Jul. | Aug. | Sep. | Oct. | Nov. | Dec. | Annual |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 45017 | Ocotal | 3 | 3 | 11 | 30 | 160 | 168 | 70 | 97 | 176 | 109 | 24 | 7 | 857 |
| 45031 | Estelí | 4 | 4 | 16 | 25 | 209 | 156 | 56 | 96 | 189 | 128 | 31 | 5 | 918 |
| 47002 | Puerto Cabezas | 127 | 83 | 53 | 66 | 187 | 395 | 414 | 424 | 312 | 381 | 279 | 213 | 2,933 |
| 53003 | Siuna | 58 | 42 | 42 | 38 | 138 | 337 | 309 | 284 | 264 | 239 | 130 | 86 | 1,966 |
| 55027 | Muy Muy | 37 | 20 | 16 | 33 | 126 | 270 | 265 | 226 | 203 | 192 | 92 | 59 | 1,541 |
| 61002 | El Recreo | 122 | 69 | 45 | 67 | 175 | 448 | 546 | 490 | 323 | 357 | 217 | 193 | 3,053 |
| 64018 | Chinandega | 1 | 1 | 5 | 14 | 224 | 325 | 203 | 280 | 385 | 337 | 59 | 6 | 1,839 |
| 64043 | León | 3 | 0 | 5 | 15 | 215 | 214 | 115 | 171 | 387 | 267 | 63 | 4 | 1,462 |
| 69027 | Managua* | 4 | 3 | 5 | 7 | 152 | 182 | 139 | 151 | 206 | 187 | 51 | 9 | 1,097 |
| 69033 | Nandaime | 5 | 1 | 3 | 19 | 236 | 238 | 126 | 165 | 270 | 284 | 61 | 15 | 1,423 |
| 69034 | Juigalpa | 7 | 2 | 3 | 10 | 150 | 207 | 124 | 155 | 226 | 208 | 102 | 13 | 1,208 |
| 69070 | Rivas | 7 | 4 | 2 | 12 | 179 | 229 | 161 | 184 | 270 | 241 | 95 | 31 | 1,414 |

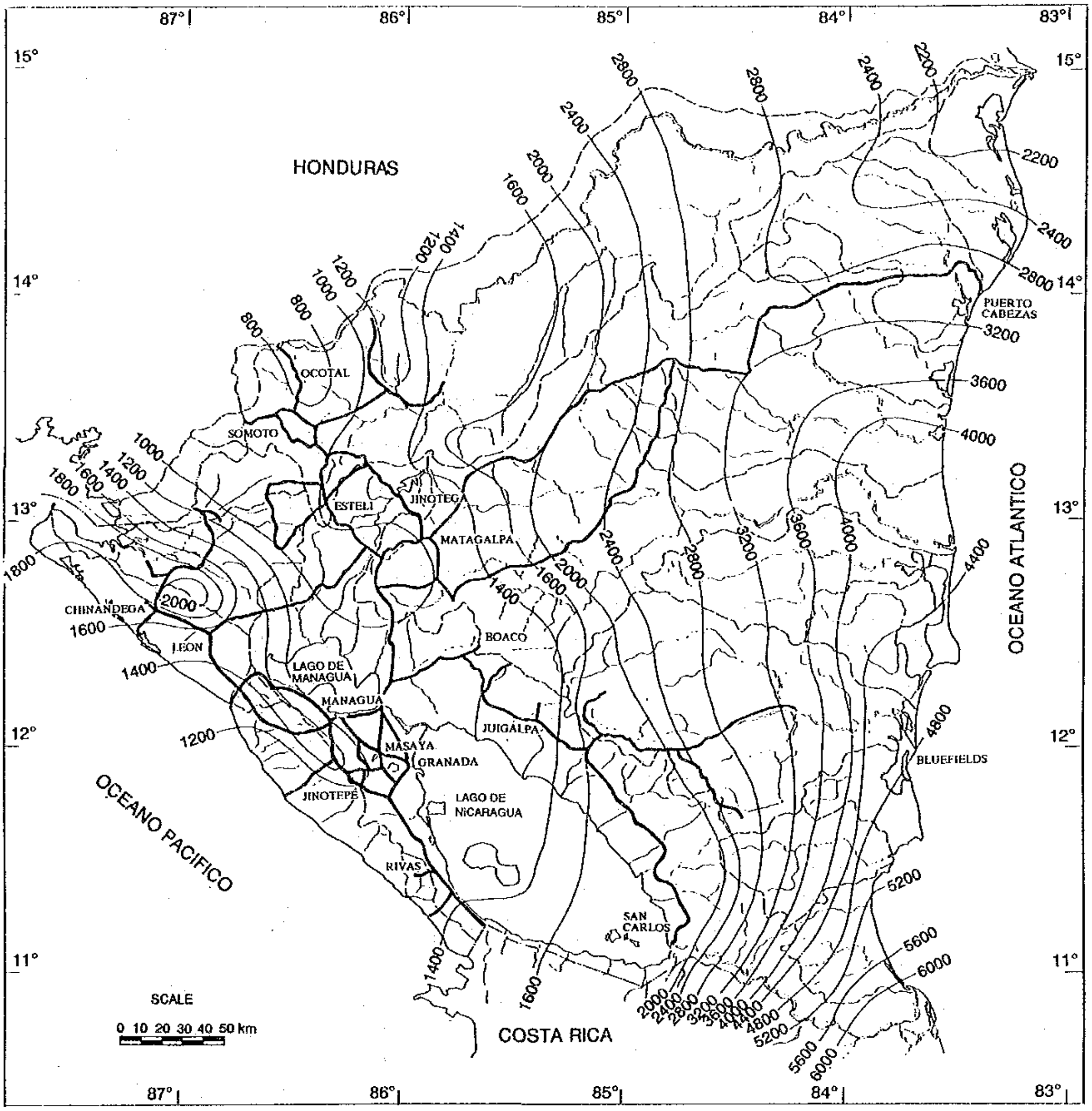
Note : * Las Mercedes (Aeropuerto C. Sandino)
Source : INETER (average for 1974-1988)

The zone which has annual rainfall ranging from 800 mm to 2,000 mm is situated in the Pacific and Central regions. Seasonal variation in rainfall is very great different between the two seasons. Rainfall in the period from May to October accounts for about 90% of the total annual rainfall.




SOURCE : RED METEOROLOGIA DE NICARAGUA, INETER

**Figure 6-1 Locations of Meteorological Stations**




SOURCE : PRECIPITACION TOTAL ANUAL, PERIOD 1971-1985
INETER, 1992

LEGEND

| | |
|---|---|
| ——— | OBJECTIVE ROAD NETWORK |
| —·—·— | INTERNATIONAL BOUNDARY |
| — — — | BASIN BOUNDARY |
| ~ | RIVER |
| —2000— | ISOHYETAL LINE (mm) |

**Figure 6-2 Annual Rainfall**

On the Atlantic side, where the annual rainfall exceeds 2,000 mm, the seasonal variation in rainfall is similar. However, this area has the most abundant rainfall, especially along the coast. The isohyetal map shows that the southeastern part of the territory has the most rainfall, amounting to 4,000 mm to 6,000 mm per year.

### 6.1.3 Temperature

The annual mean temperature of Nicaragua is shown in Figure 6-3. This Figure indicates that the 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. As shown in Table 6-2, the seasonal variation of the monthly mean temperature is not so great, remaining within a range of 4°C throughout the year. The higher temperatures are observed at the end of dry season (March/April), while the lower temperatures occur in the beginning of the dry season (December/January). The recorded absolute maximum temperatures are 42.0°C in Chinandega, 39.6°C in León, and 38.0°C in Managua. Meanwhile, the absolute minimums are 5.0°C in Estelí, 7.7°C in Ocotal and 12.2°C in Muy Muy.

**Table 6-2 Mean Monthly and Annual Temperature**

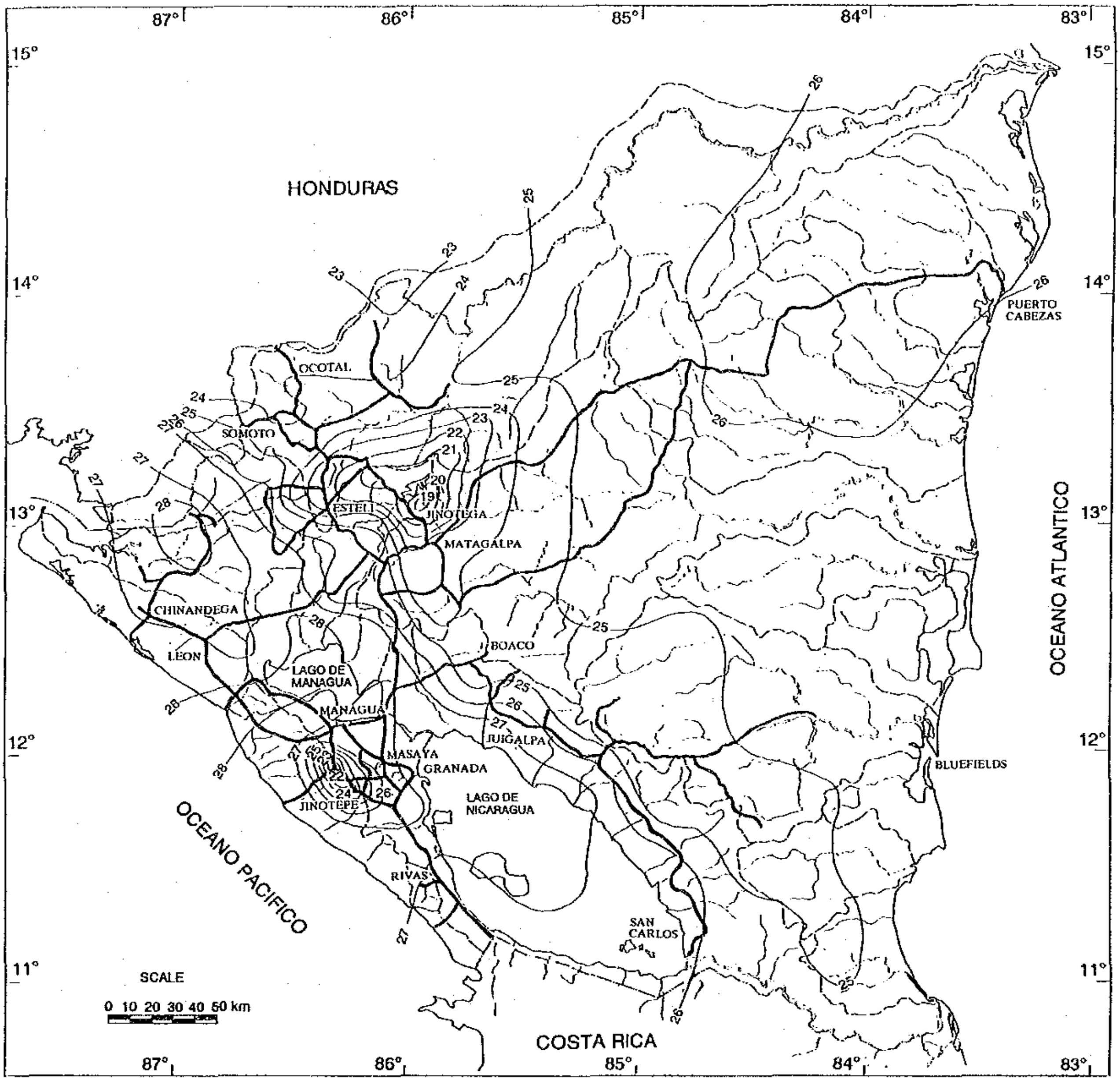
(Unit : °C)

| No. | Station | Jan. | Feb. | Mar. | Apr. | May | Jun. | Jul. | Aug. | Sep. | Oct. | Nov. | Dec. | Annual |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 45017 | Ocotal | 22.4 | 23.3 | 25.0 | 26.0 | 26.5 | 25.0 | 24.3 | 24.7 | 24.7 | 24.1 | 23.4 | 22.8 | 24.3 |
| 45031 | Esteli | 20.8 | 21.7 | 22.9 | 24.0 | 24.4 | 23.3 | 22.6 | 23.2 | 23.2 | 22.6 | 21.9 | 21.2 | 22.6 |
| 47002 | Puerto Cabezas | 24.5 | 25.1 | 26.1 | 26.8 | 27.7 | 26.0 | 26.9 | 26.8 | 26.8 | 25.9 | 25.5 | 25.2 | 26.1 |
| 55027 | Muy Muy | 23.2 | 24.0 | 25.4 | 26.4 | 27.1 | 25.5 | 24.7 | 25.1 | 25.3 | 25.0 | 24.5 | 23.6 | 25.0 |
| 61002 | El Recreo | 24.2 | 24.6 | 25.6 | 26.6 | 27.3 | 26.4 | 25.7 | 26.1 | 26.4 | 26.1 | 25.7 | 25.0 | 25.8 |
| 64018 | Chinandega | 26.2 | 27.1 | 28.0 | 28.6 | 27.9 | 26.6 | 26.9 | 26.9 | 26.0 | 26.0 | 25.9 | 26.1 | 26.9 |
| 64043 | León | 26.9 | 27.9 | 28.7 | 29.4 | 28.1 | 27.0 | 27.2 | 27.0 | 26.1 | 25.8 | 26.0 | 26.4 | 27.2 |
| 69027 | Managua | 25.6 | 26.6 | 27.7 | 28.8 | 28.6 | 26.8 | 26.3 | 26.4 | 26.2 | 26.1 | 26.0 | 25.6 | 26.7 |
| 69033 | Nandaime | 26.0 | 26.7 | 27.7 | 28.5 | 28.2 | 26.7 | 26.5 | 26.6 | 26.1 | 24.0 | 25.9 | 26.1 | 26.6 |
| 69034 | Juigalpa | 25.4 | 26.0 | 27.2 | 28.0 | 28.1 | 26.6 | 26.1 | 26.4 | 25.9 | 25.8 | 25.9 | 25.7 | 26.4 |
| 69070 | Rivas | 25.4 | 26.0 | 26.9 | 27.7 | 27.7 | 26.7 | 26.4 | 26.5 | 26.1 | 26.1 | 26.0 | 25.6 | 26.4 |

Source : INETER (average for 1974-1988)

### 6.1.4 Relative Humidity

Table 6-3 shows the mean relative humidity. The annual mean relative humidity by region varies from 75% to 80% in the Pacific region, from 65% to 80% in the Central region, and from 85% to 90% in the Atlantic region. The difference in the monthly values between the wet season and the dry season is 15% to 20% in the Pacific and Central regions. On the other hand, the relative humidity in the Atlantic region shows little seasonal variation in its higher relative humidity of 80% to 90%.




SOURCE : ISOTERMAS MEDIAS ANUALES (°C), PERIOD 1972-1981
INETER, 1992

LEGEND

OBJECTIVE ROAD NETWORK
INTERNATIONAL BOUNDARY
BASIN BOUNDARY
RIVER
—25— ISOTHERMAL LINE (°C)

**Figure 6-3 Annual Mean Temperature**

Table 6-3 Mean Monthly and Annual Relative Humidity

(Unit : %)

| No. | Station | Jan. | Feb. | Mar. | Apr. | May | Jun. | Jul. | Aug. | Sep. | Oct. | Nov. | Dec. | Annual |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 45017 | Ocotal | 65 | 61 | 55 | 54 | 62 | 73 | 74 | 73 | 77 | 75 | 71 | 68 | 67 |
| 45031 | Estelí | 68 | 63 | 59 | 57 | 67 | 75 | 73 | 73 | 80 | 80 | 75 | 71 | 70 |
| 47002 | Puerto Cabezas | 85 | 82 | 80 | 80 | 83 | 86 | 86 | 87 | 88 | 88 | 87 | 86 | 85 |
| 55027 | Muy Muy | 78 | 75 | 70 | 68 | 71 | 84 | 87 | 86 | 87 | 85 | 82 | 81 | 80 |
| 61002 | El Recreo | 86 | 83 | 80 | 78 | 81 | 89 | 90 | 90 | 89 | 90 | 89 | 89 | 86 |
| 64018 | Chinandega | 70 | 66 | 65 | 68 | 79 | 84 | 79 | 81 | 87 | 84 | 82 | 76 | 77 |
| 64043 | León | 69 | 66 | 69 | 70 | 79 | 84 | 80 | 82 | 88 | 89 | 83 | 75 | 78 |
| 69027 | Managua | 70 | 66 | 64 | 62 | 72 | 80 | 81 | 82 | 84 | 83 | 79 | 74 | 75 |
| 69033 | Nandaime | 68 | 65 | 62 | 62 | 70 | 80 | 79 | 80 | 81 | 82 | 77 | 73 | 73 |
| 69034 | Juigalpa | 74 | 70 | 69 | 69 | 74 | 81 | 82 | 81 | 83 | 81 | 77 | 74 | 76 |
| 69070 | Rivas | 77 | 75 | 72 | 71 | 77 | 83 | 82 | 83 | 84 | 84 | 81 | 80 | 79 |

Source : INETER (average for 1974-1988)

### 6.1.5 Evaporation

Table 6-4 shows the monthly and annual 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, with higher values observed north of the highlands (Ocotal) and along the lake shore (Managua and Nandaime).

Few records of A-pan evaporation have been kept on the Atlantic region. However, the available records do show that annual evaporation ranges from 1,000 mm to 1,500 mm.

Table 6-4 Monthly and Annual Evaporation

(Unit : mm)

| No. | Station | Jan. | Feb. | Mar. | Apr. | May | Jun. | Jul. | Aug. | Sep. | Oct. | Nov. | Dec. | Annual |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 45017 | Ocotal | 200 | 216 | 275 | 274 | 234 | 176 | 182 | 196 | 170 | 157 | 154 | 173 | 2,407 |
| 45031 | Estelí | 188 | 198 | 239 | 233 | 197 | 140 | 153 | 159 | 139 | 135 | 138 | 156 | 2,075 |
| 64018 | Chinandega | 182 | 195 | 218 | 215 | 158 | 132 | 149 | 137 | 124 | 128 | 127 | 157 | 1,922 |
| 64043 | León | 224 | 250 | 280 | 260 | 175 | 129 | 169 | 167 | 109 | 113 | 134 | 184 | 2,195 |
| 69027 | Managua | 216 | 232 | 291 | 286 | 241 | 168 | 166 | 170 | 154 | 157 | 156 | 179 | 2,416 |
| 69033 | Nandaime | 228 | 262 | 311 | 316 | 246 | 163 | 170 | 173 | 158 | 162 | 161 | 195 | 2,546 |
| 69034 | Juigalpa | 222 | 205 | 257 | 260 | 215 | 132 | 154 | 153 | 143 | 149 | 174 | 178 | 2,241 |
| 69070 | Rivas | 190 | 197 | 251 | 256 | 207 | 145 | 142 | 143 | 131 | 139 | 133 | 161 | 2,094 |

Source : INETER (average for 1974-1988)

### 6.1.6 Daylight Hours

As shown in Table 6-5, annual daylight hours by region vary from approximately 2,000 to 2,700 hours. Higher values exceeding 2,500 hours are observed at Ocotal, Chinandega, and Managua. Lower values of less than 2,200 hours are observed at Puerto Cabezas and Muy Muy. Seasonal variation amounts to a difference of 100 to 130 hours between the dry season and the wet season except in Ocotal, where there is little variation.

**Table 6-5 Monthly and Annual Daylight Hours**

(Unit : hour)

| No. | Station | Jan. | Feb. | Mar. | Apr. | May | Jun. | Jul. | Aug. | Sep. | Oct. | Nov. | Dec. | Annual |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 45017 | Ocotal | 240 | 230 | 263 | 243 | 228 | 193 | 204 | 226 | 198 | 203 | 213 | 228 | 2,669 |
| 47002 | Puerto Cabezas | 194 | 193 | 235 | 227 | 206 | 123 | 132 | 153 | 149 | 156 | 156 | 173 | 2,099 |
| 55027 | Muy Muy | 199 | 198 | 236 | 220 | 200 | 134 | 131 | 154 | 165 | 187 | 191 | 184 | 2,199 |
| 64018 | Chinandega | *265* | *248* | *259* | *215* | *177* | *164* | *202* | *196* | *173* | *201* | *219* | *253* | *2,573* |
| 69027 | Managua | 253 | 253 | 281 | 259 | 220 | 164 | 180 | 197 | 186 | 207 | 224 | 242 | 2,666 |
| 69034 | Juigalpa | 232 | 225 | 253 | 226 | 194 | 122 | 131 | 146 | 157 | 183 | 190 | 207 | 2,268 |
| 69070 | Rivas | 245 | 239 | 252 | 237 | 202 | 143 | 156 | 163 | 156 | 180 | 198 | 220 | 2,392 |

Source : INETER (average for 1974-1988)

### 6.1.7 Wind

Seasonal variation of the mean wind velocity shows that it is higher in the dry season, except in Puerto Cabezas (see Table 6-6). The wind direction in Chinandega varies seasonally, prevailing from the southwest in the dry season and from the north/northeast in the wet season. Obvious seasonal variation in the wind direction could not be observed at the other stations, where the wind prevails from the east/northeast or east/southeast throughout the year.

**Table 6-6 Mean Monthly and Annual Wind Velocity**

(Unit : m/sec)

| No. | Station | Jan. | Feb. | Mar. | Apr. | May | Jun. | Jul. | Aug. | Sep. | Oct. | Nov. | Dec. | Annual |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 45017 | Ocotal | 3.1 | 3.3 | 3.4 | 3.3 | 2.5 | 2.3 | 2.7 | 2.6 | 2.0 | 1.8 | 2.1 | 2.7 | 2.6 |
| 45031 | Estelí | 1.4 | 1.4 | 1.3 | 1.2 | 0.8 | 0.7 | 1.0 | 0.9 | 0.6 | 0.6 | 0.8 | 1.2 | 1.0 |
| 47002 | Puerto Cabezas | 4.7 | 4.7 | 5.1 | 5.2 | 5.0 | 5.5 | 5.7 | 5.1 | 4.1 | 4.1 | 4.6 | 5.0 | 4.9 |
| 55027 | Muy Muy | 2.5 | 2.7 | 2.9 | 2.9 | 2.3 | 1.8 | 1.9 | 1.7 | 1.4 | 1.5 | 1.7 | 2.1 | 2.1 |
| 61002 | El Recreo | 0.5 | 0.4 | 0.5 | 0.5 | 0.4 | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 | 0.4 | 0.4 | 0.4 |
| 64018 | Chinandega | 2.0 | 2.1 | 2.1 | 2.0 | 1.7 | 1.3 | 1.4 | 1.4 | 1.2 | 1.3 | 1.2 | 1.6 | 1.6 |
| 69027 | Managua | 2.5 | 2.8 | 3.0 | 2.8 | 2.1 | 1.5 | 1.7 | 1.4 | 1.2 | 0.9 | 1.2 | 1.9 | 1.9 |
| 69034 | Juigalpa | 4.2 | 3.8 | 3.6 | 3.4 | 2.4 | 2.5 | 2.9 | 2.6 | 2.0 | 2.2 | 2.9 | 3.7 | 3.0 |
| 69070 | Rivas | 5.1 | 4.9 | 4.4 | 4.2 | 2.9 | 2.8 | 3.5 | 3.1 | 2.2 | 2.4 | 3.2 | 4.7 | 3.6 |

Source : INETER (average for 1974-1988)

## 6.2 HYDROLOGY

### 6.2.1 River Systems

The territory of Nicaragua is generally divided into two hydrological regions, the Pacific Watershed with an area of 12,072 km², and the Atlantic Watershed with an area of 116,882 km². In the Atlantic Watershed, the San Juan river basin includes two large lakes, Lake Managua and Lake Nicaragua. Moreover, the watersheds include sub-divided river systems. As shown in Figure 6-4, Nicaragua has 21 river systems. The river systems in the respective hydrological regions are listed in Table 6-7.

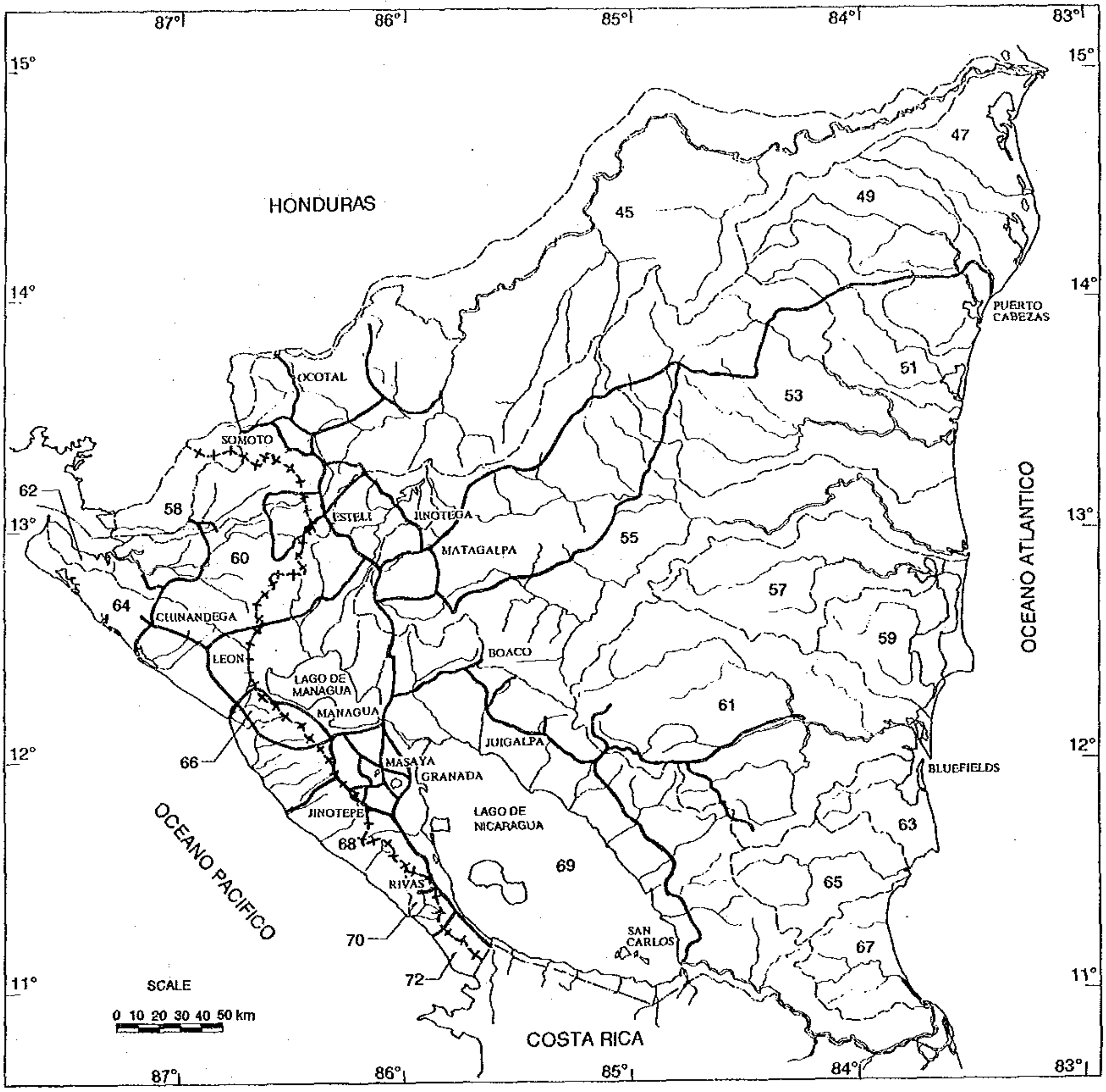
**Table 6-7 River Systems**

| Pacific Watershed | | Atlantic Watershed | |
|---|---|---|---|
| **River System** | **Area (km²)** | **River System** | **Area (km²)** |
| 58 Negro | 2,353 (3,278) | 45 Coco | 19,969 (24,476) |
| 60 Estero Real | 3,610 | 47 Coco/Wawa | 3,993 |
| 62 Estero Real/Cosiguina | 429 | 49 Wawa | 5,455 |
| 64 Cosiguina/Tamarindo | 2,969 | 51 Kukalaya | 3,730 |
| 66 Tamarindo | 307 | 53 Prinzapolka | 11,136 |
| 68 Tamarindo/Brito | 2,730 | 55 Matagalpa | 17,365 |
| 70 Brito | 274 | 57 Kurinwas | 4,861 |
| 72 Brito/Sapoa | 325 | 59 Kurinwas/Escondido | 2,239 |
| | | 61 Escondido | 11,650 |
| | | 63 Escondido/Punta Gorda | 1,593 |
| | | 65 Punta Gorda | 2,867 |
| | | 67 Punta Gorda/San Juan | 2,199 |
| | | 69 San Juan | 29,824 (42,213) |

Note : ( ) indicates total drainage area including land outside of Nicaragua.
Source : INETER

The Pacific Watershed includes 8 river systems. Most of the rivers have a relatively small drainage area, and are less than 20 km of length. The only exception is the Estero Real River. This river has a narrow channel width with discontinuous flow due to its small drainage area and the great 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 southeast. Rivers flow abundantly down to the Atlantic Coastal Plain. The wetlands spread over the most downstream reaches, which are affected by the tide and are occasionally inundated.




SOURCE: Fenzel, Norbert
NICARAGUA : GEOGRAFIA, CLIMA, GEOLOGIA Y HIDROGEOLOGIA
BELEM, UFPA/INETER/INAN, 1988

LEGEND

| | | | |
|---|---|---|---|
| ▬▬ | OBJECTIVE ROAD NETWORK | - - - - | BASIN BOUNDARY |
| - · - · | INTERNATIONAL BOUNDARY | ~ | RIVER |
| ++++ | BOUNDARY OF PACIFIC AND ATLANTIC WATERSHED | 45 | BASIN NUMBER |

**Figure 6-4 River Systems**

The San Juan river basin extends along the Nicaraguan Depression. There are two large lakes in the San Juan basin. The surface areas of the lakes are 1,040 $km^2$ for Lake Managua and 8,200 $km^2$ for Lake Nicaragua. The annual mean water level of Lake Managua is 38.20 m, which is slightly higher than that of Lake Nicaragua, which has a level of 31.21 m. When the level of Lake Managua reaches 40.75 m, the two lakes are connected via the Tipitapa River. However, these lakes are usually separated, and have only been connected rarely.

The rivers that flow into these lakes have a small drainage area with flow conditions similar to those of the rivers on the Pacific coast. Some of these rivers dry up during the dry season.

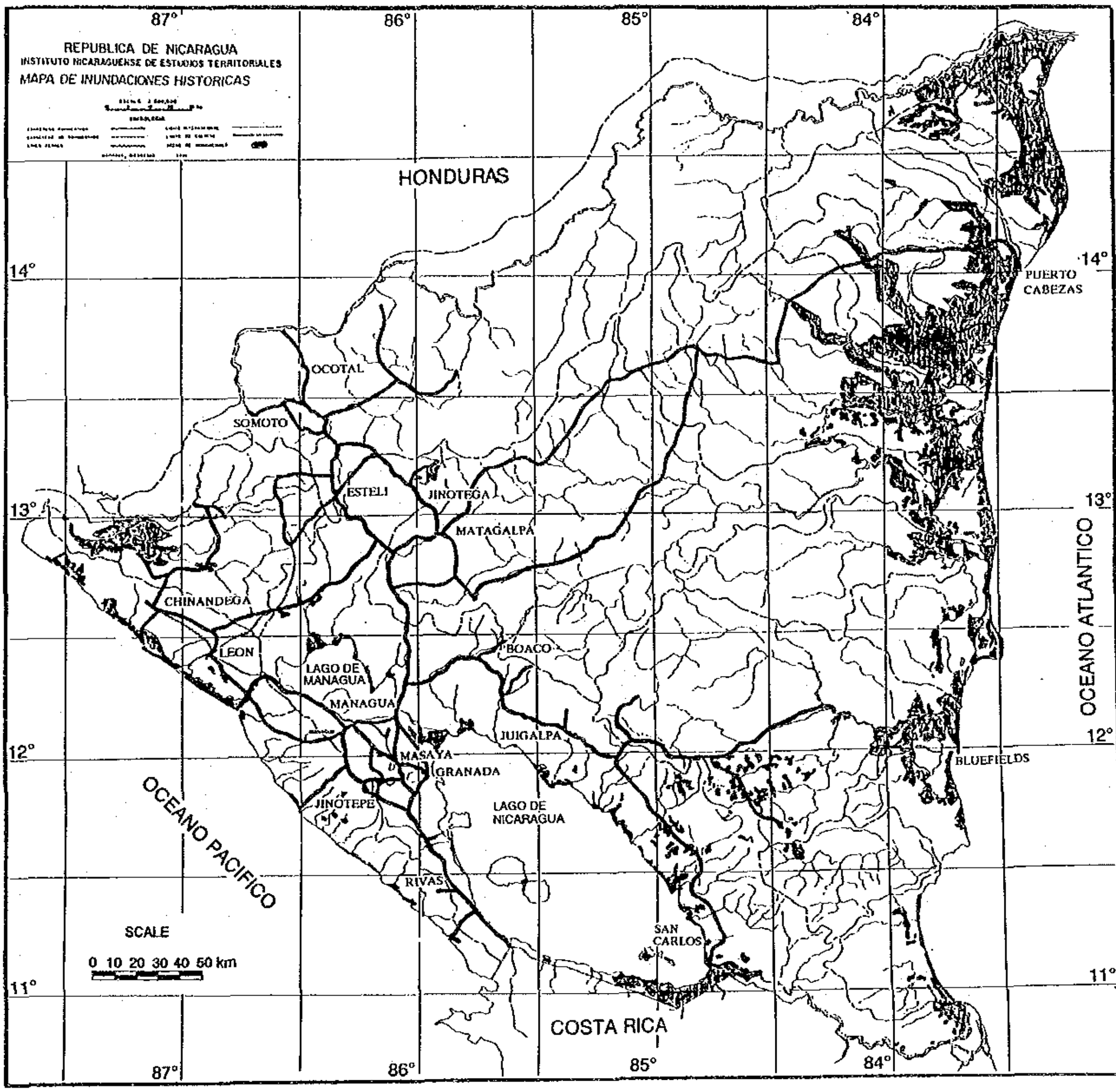
### 6.2.2 Flood Inundation Area

In Nicaragua, floods are caused by the heavy rainstorms that occur during wet season. Moreover, Nicaragua has occasionally suffered from hurricanes or tropical depressions which have caused severe flooding and have seriously damaged the country. The worst case in recent years was hurricane "Joan", which struck in October 1988.

INETER has been trying to assess potential flood damage in Nicaragua. Figure 6-5 shows a map indicating potential flood inundation areas investigated by INETER.

Most inundations occur in the northeast along the Atlantic coast. It seems that this area is frequently inundated because the river slope is very gentle in the low-lying plain, which is affected by tides that regularly cause floods. However, significant flood damage is never likely because most of the land is uncultivated, and the area's population density is low.

Other inundation areas are found in the Pacific region, mainly around the lake shore and the coast. Flooding in these areas seem to be caused primarily by heavy rain coupled with drainage problems on the lake shore and in the coastal area. In contrast with the Atlantic region, the potential damage in the Pacific region is high because population density is high and the land is generally intensively cultivated.




SOURCE : MAPA DE INUNDACIONES HISTORICAS, INETER, 1991

LEGEND

- OBJECTIVE ROAD NETWORK
- INTERNATIONAL BOUNDARY
- BASIN BOUNDARY
- RIVER
- HISTORICAL FLOOD INUNDATION AREA

**Figure 6-5 Historical Flood Inundation Areas**

## 6.3 FLOOD DISASTERS ON ROAD NETWORK

The road network in Nicaragua has a total length of 15,011 km. These roads and related structures have occasionally been severely damaged due to heavy rainstorms, floods, and especially hurricanes. Serious damage caused by such natural disasters leads to significant losses for the country. For example, socio-economic activities are discouraged by the interruption of traffic and the resulting huge restoration costs. As a result, the identification of disasters is necessary basic information prior to the creation of any plan to maintain or improve the country's road network.

In Nicaragua, information on historical flood disasters specifying routes affected by such floods is limited. Some of the information provided by MCT describes damage to roads and related structures caused by hurricane "Joan" in October 1988. Table 6-8 summarizes this information.

**Table 6-8 Damage by Hurricane "Joan" in October 1988**

| Region | Damaged Section | Bridge | | | Drainage | | Damage to Road Surface | |
|---|---|---|---|---|---|---|---|---|
| | | Destroyed | | Partially Damaged | Destroyed | Partially Damaged | Slope Collation | Road Bank Erosion |
| | (km) | (nos.) | (m) | (nos.) | (nos.) | (nos.) | ($m^3$) | (nos.) |
| I | - | - | - | - | 1 | - | - | 1 |
| II | - | - | - | - | - | - | - | - |
| III | 30.0 | 1 | 50 | 3 | - | 3 | 8,000 | - |
| IV | 18.7 | - | - | 5 | - | 3 | 5,000 | 12 |
| V | 278.2 | 15 | 208 | 9 | 12 | 19 | 8,000 | 2 |
| VI | 320.0 | 13 | 508 | 14 | 1 | 3 | 52,700 | 12 |
| Z.E.III | 15.0 | 2 | 65 | - | - | - | - | - |
| Total | 661.9 | 31 | 881 | 31 | 14 | 28 | 73,700 | 27 |

Source : MCT

Damage caused to the specific sections is summarized in Appendix 6.1. The total length of the route affected was 661.9 km, which is equivalent to 4.6% of Nicaragua's road network. Repair and reconstruction cost were estimated at US$ 183 million (as of 1988). According to a damage report, the following problems were encountered in the damaged sections.

① Slope collation, road bank erosion and cracking due to a loosening of the slope or bank by water were commonly detected. This suggests that insufficient slope protection and drainage works were provided.

② A total of 31 bridges were destroyed. This report does not clarify the cause of such damage, but scouring may be major reason for the destruction of these bridges since most of them were located in mountainous regions and spanned rivers having a rapid stream flow during flooding. Structural problems may also have been the cause, since most of these bridges had relatively relaxed design criteria for foundations or structural life time have almost over.

In order to provide effective means to minimize damage on the road network, further investigations and studies are required, especially to obtain more detail information on each of the relevant route sections.

# CHAPTER 7

# INITIAL ENVIRONMENTAL EXAMINATION

# CHAPTER 7 INITIAL ENVIRONMENTAL EXAMINATION

## 7.1 GENERAL

This chapter emphasizes the need to preserve the natural, living and social environment, and to identify the necessity of an environmental impact assessment at the next stage, during the Feasibility Study. In Nicaragua, there has not yet been any environmental legislation. However, the Nicaraguan Congress has recently begun to discuss environmental laws. It is therefore expected that environmental impact assessment will soon be institutionalized.

## 7.2 OUTLINE OF INITIAL ENVIRONMENTAL EXAMINATION

### 7.2.1 Flow of Initial Environmental Examination

Figure 7-1 shows how environmental factors are considered during the initial environmental examination, and how environmental impact of the project is assessed. The Initial Environmental Examination performed prior to outlining the Master Plan examines the project from a general point of view and, if necessary, is followed by the Environmental Impact Assessment conducted during the Feasibility Study. The flow of Initial Environmental Examination is shown in Figure 7-2.

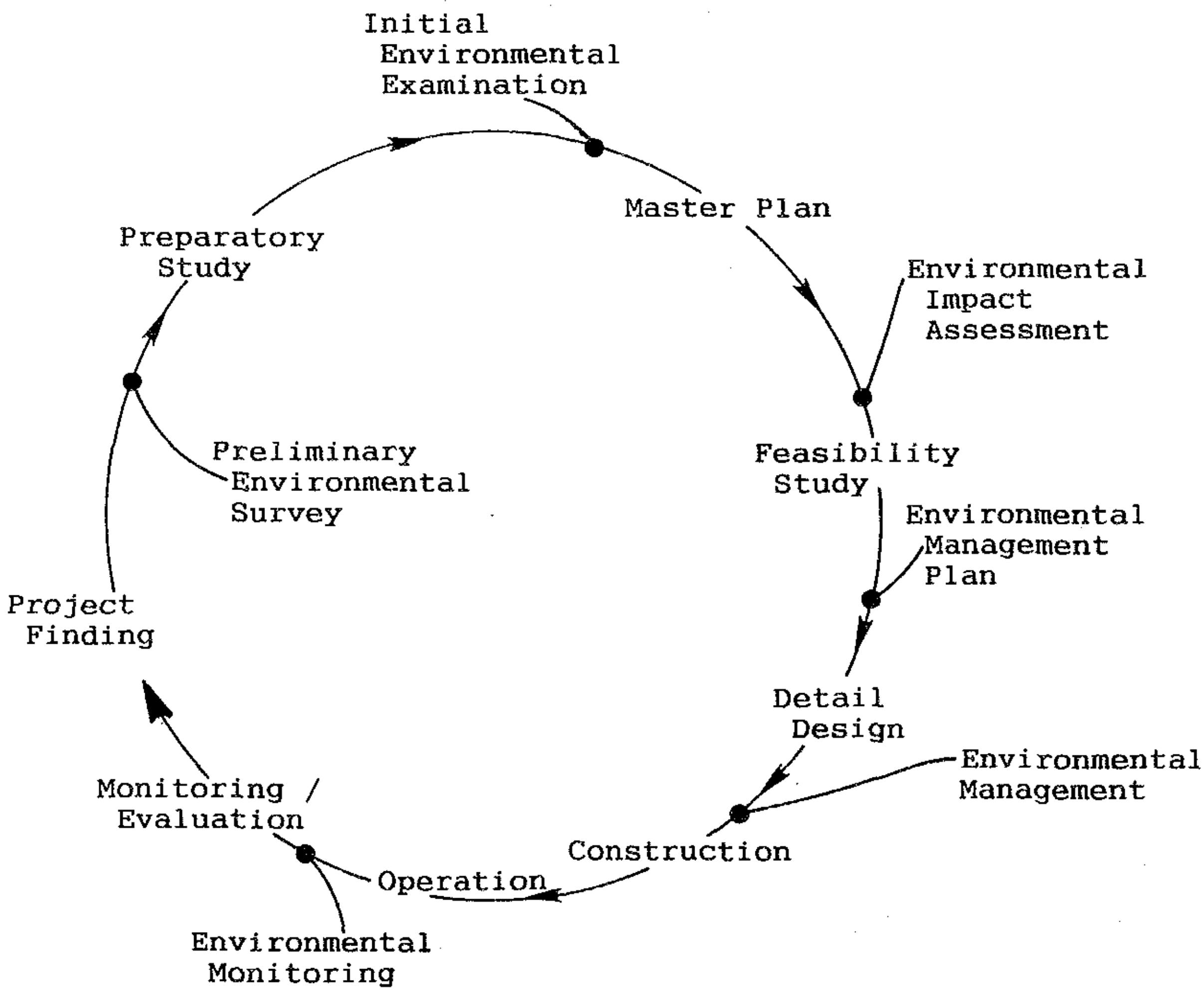



**Figure 7-1 Flow of Environmental Considerations of the Project**

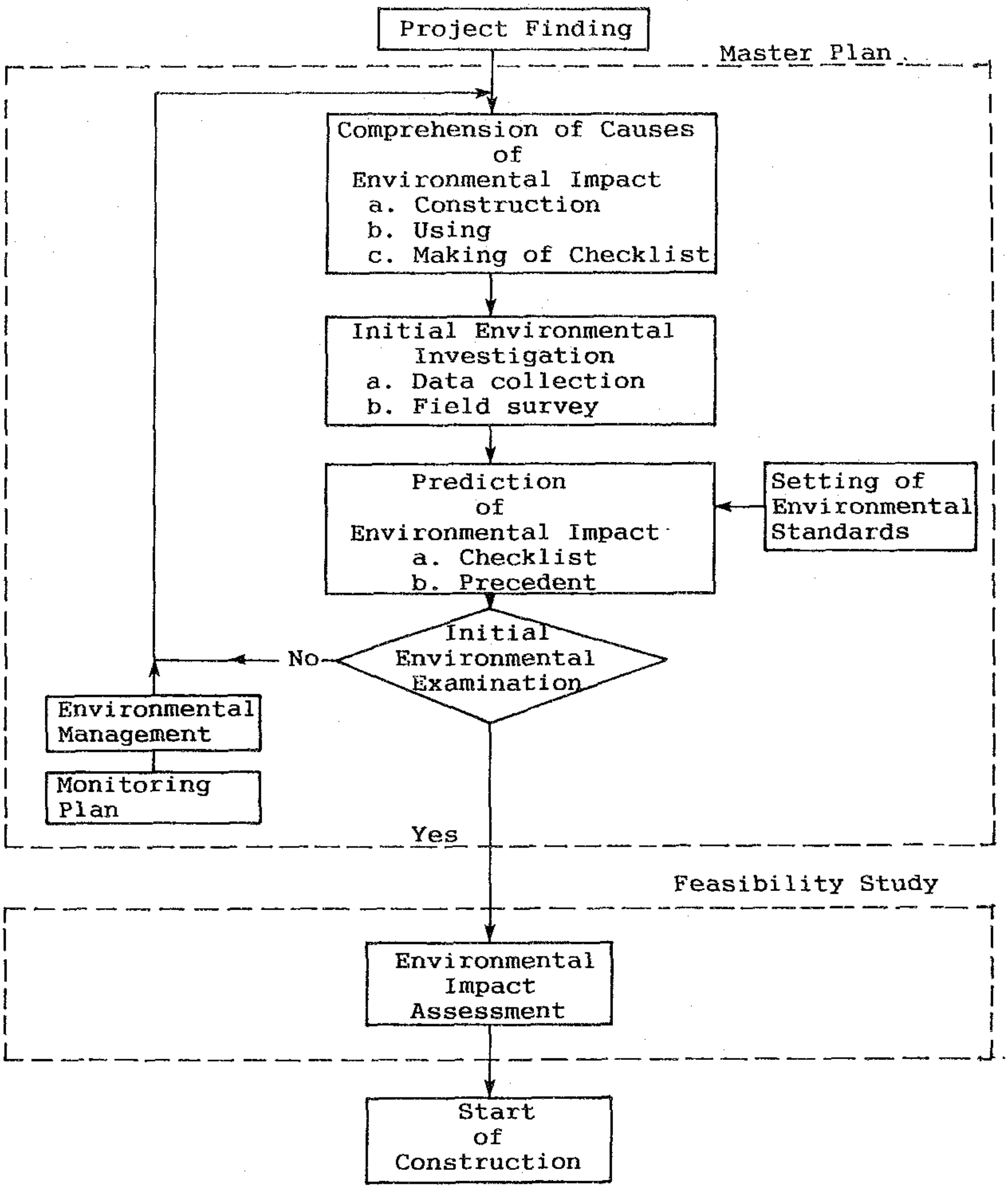



**Figure 7-2 Flow of Initial Environmental Examination**

### 7.2.2 Selection of Environmental Items

(1) Environmental Factors

Based on the nature of the project, it is believed that the construction and use of roads have the greatest environmental impact. From an environmental viewpoint; roads have the following two aspects.

- Construction stage
  1) Clearance of forests
  2) Cutting and embankment construction
  3) Use of heavy machines and dump tracks for transportation
  4) Foundation work
  5) Water control work
  6) Treatment of underground water
  7) Soil dumping sites
  8) Aggregate quarry
  9) Sand quarry
  10) Pavement
  11) Asphalt plant
  12) Concrete plant
  13) Waste
  14) Traffic safety
  15) Worker facilities

- Road use
  16) Existing road facilities
  17) Traffic
  18) Traffic safety
  19) Transport of passengers, goods, and materials

(2) Selection of Environmental Items

The relevant environmental items should be selected by using the matrix method as shown in Table 7-1, since this Table integrates the relationship between environmental items and environmental factors.

## Table 7-1 Selection of Environmental Items

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

*Note :

- Stage of construction
  1. Clearing of forests
  2. Cutting and embankment construction
  3. Use of heavy machines
  4. Foundation work
  5. Water control work
  6. Treatment of underground water
  7. Soil dumping sites
  8. Aggregate quarry
  9. Sand quarry
  10. Pavement
  11. Asphalt plant
  12. Concrete plant
  13. Waste of materials
  14. Traffic safety
  15. Worker facilities
- Use of roads
  16. Existing road facilities
  17. Traffic
  18. Traffic safety
  19. Transport of passengers, goods, and materials

Consequently, after applying the above-mentioned method, the following environmental items were selected:

1) Air quality
2) Water quality
3) Noise and vibration
4) Land (topography and geology)
5) Soil
6) Water (rivers, lakes, water courses)
7) Flora and fauna
8) Landscape
9) Traffic
10) Social conditions

### 7.2.3 Present Environmental Conditions

(1) Flora and Fauna

The vegetation in Nicaragua can generally be classified into four zones, Ecological Region I (Pacific), Ecological Region II (North-central), Ecological Region III (Central) and Ecological Region IV (Atlantic), as shown in Figure 7-3.

a) Ecological Region I (Pacific Side, 21% of the country)

This region, which is made up of hot, dry, and semi-humid zones, generally consists of deciduous forests similar to the evergreen forests found in the cool-humid zones of the highlands.

b) Sociological Region II (North-central mountainous area, 16%)

This region, which is made up of dry, hot and cool zones, consists of deciduous forests similar to the pinewood forests in the cool and humid zones of the highlands.

c) Ecological Region III (eastern half of the central mountains, 17%)

This region, which is made up of moderately warm and humid zones, mainly consists of evergreen forests similar to the evergreen forests found in the cool and humid zones of the highlands.

d) Ecological Region IV (Atlantic side, 46%)

This region, which is made up of moderately warm and humid zones, consists of evergreen forests similar to the pinewood forests found in very humid and cool zones.

At present, Nicaragua has 4.3 million hectares of forests, accounting for approximately 33% of the country's land. At present, deforestation is continuing at a pace of approximately 100,000 hectares a year. Figure 7-4 shows the difference of extinct vegetation between 1940 and 1992. It is anticipated that most currently existing rain forests will disappear within the next 10 to 15 years if urgent measures for preservation of rain forests will not be taken.

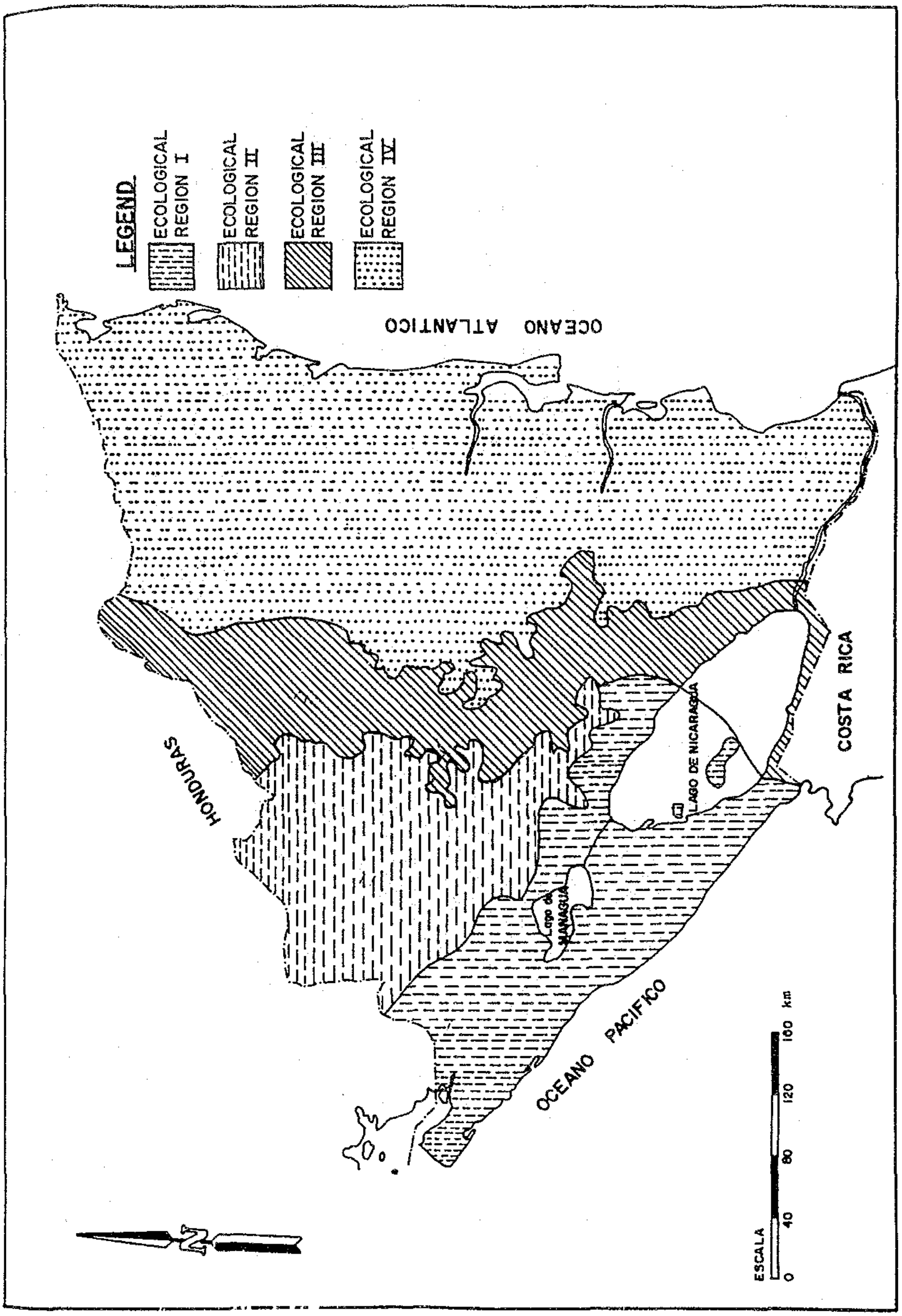



Figure 7-3 Vegetation Map of Nicaragua

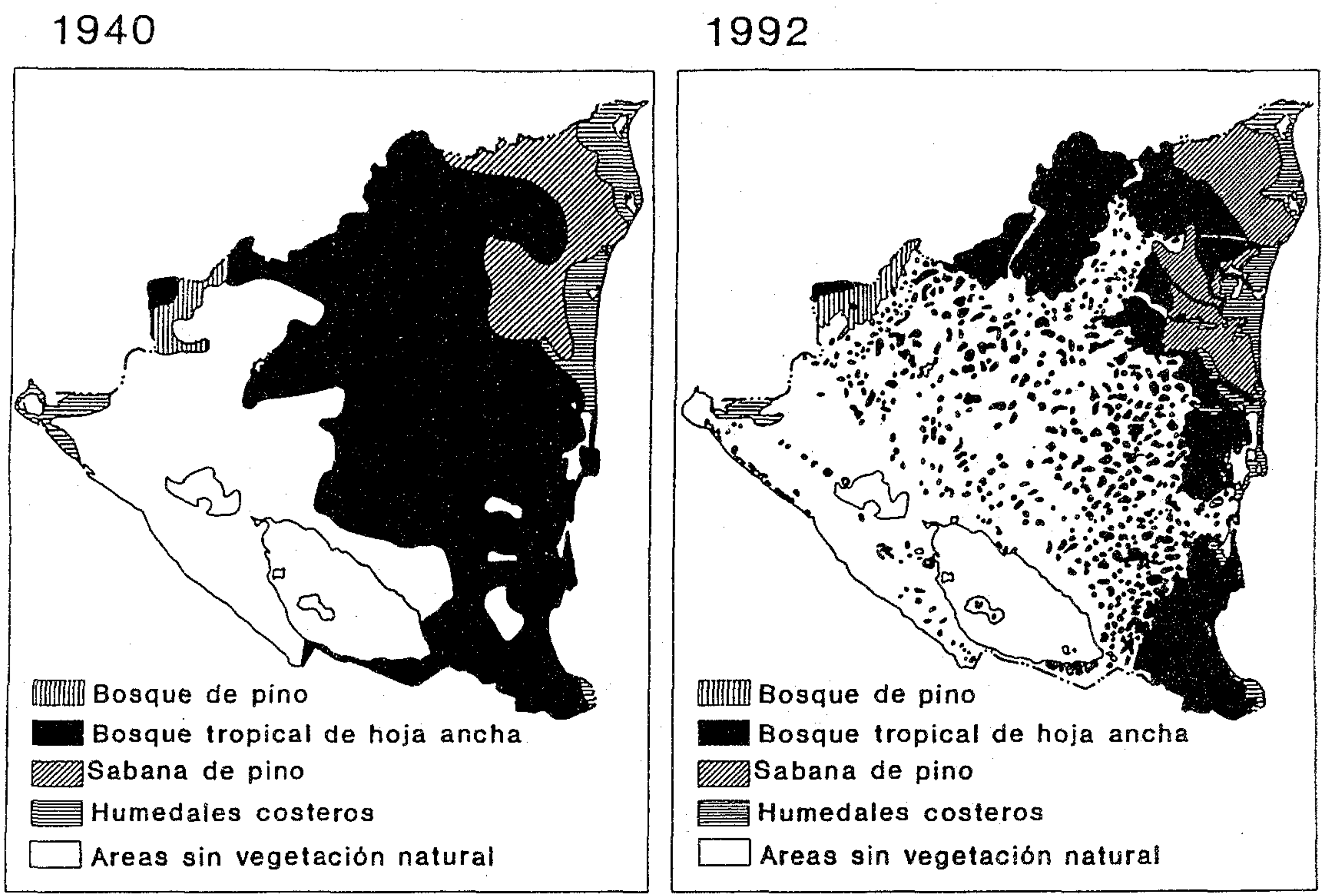



Figure 7-4 Deforestation from 1940 to 1992

Deforestation has seriously affected through the extinction of valuable species of flora and fauna, desertification, precipitation, soil erosion, etc., and has also adversely affected the living environment through agricultural soil erosion, flood, desertification, etc.

The Forestry Action Plan of Nicaragua (PAF-NIC) has been established to manage sustainable development and natural conservation. Toward this end, the following five programs have been proposed by PAF-NIC.

① Forestry activities related to land use

② Management of natural forests and industrial development

③ Firewood and energy

④ Conservation of forest ecosystems and bio-diversity

⑤ Institutional reinforcement

Present forest legislation consists of various laws and regulations. Although these laws have the spirit of conservation, their application has been very inefficient (IRENA-PAF, 1992). Areas for the reservation, preservation and protection of forests, wild life and marine fauna are legislated as shown in Figure 7-5.

Moreover, Nicaragua has been a regular participant in the "Convention on International Trade in Endangered Species of Wild Fauna and Flora", the so-called Washington treaty. Twenty-five species of fauna and one species of flora have been registered as endangered species. These are shown in Table 7-2. Furthermore, 117 species of fauna and 8 species of flora have been registered as endangered extinction species.

(2) Landscape

There are three national parks in Nicaragua, Masaya Volcano, Zapatera Archipielago and Saslaya, as shown in Figure 7-6.

## Table 7-2 Fauna and Flora Registered as Endangered Species

| Family Name | Scientific name |
|---|---|
| FAUNA (Mammalian) | |
| Family Cebidae | 1. Ateles geoffroyi frontatus |
| | 2. Alouatta palliata |
| Family Mustelidae | 3. Lutra longicaudis |
| Family Felidae | 4. Felis concolor costaricencia |
| | 5. Felis pardalis meamsi |
| | 6. Felis tigrina oncilla |
| | 7. Felis yagouaroundi fossata |
| | 8. Felis yagouaroundi panamensis |
| | 9. Felis wiedii nicaraguae |
| | 10. Felis onca |
| | 11. Tapirus bairdii |
| Family Trichechidae | 12. Trichechus manatus |
| Family Ciconiidae | 13. Jabirus mycteria |
| Family Accipitridae | 14. Chondroierax uncinatus |
| | 15. Harpia harpyja |
| Family Psittacidae | 16. Ara macao |
| | 17. Ara ambigua |
| FAUNA (Reptiles) | |
| Family Trogonidae | 18. Pharomachrus mocinno mocinno (Reptiles) |
| Family Cheloniidae | 19. Caretta caretta |
| | 20. Chelonia agassizi |
| | 21. Chelonia mydas |
| | 22. Eretmochelys imbricata |
| | 23. Lepidochelys olivacea |
| Family Dermochelydae | 24. Dermochelys coriacea |
| Family Crocodylae | 25. Crocodylus acutus |
| FLORA | |
| Orchidaceae | 1. Cattleya skinneri |

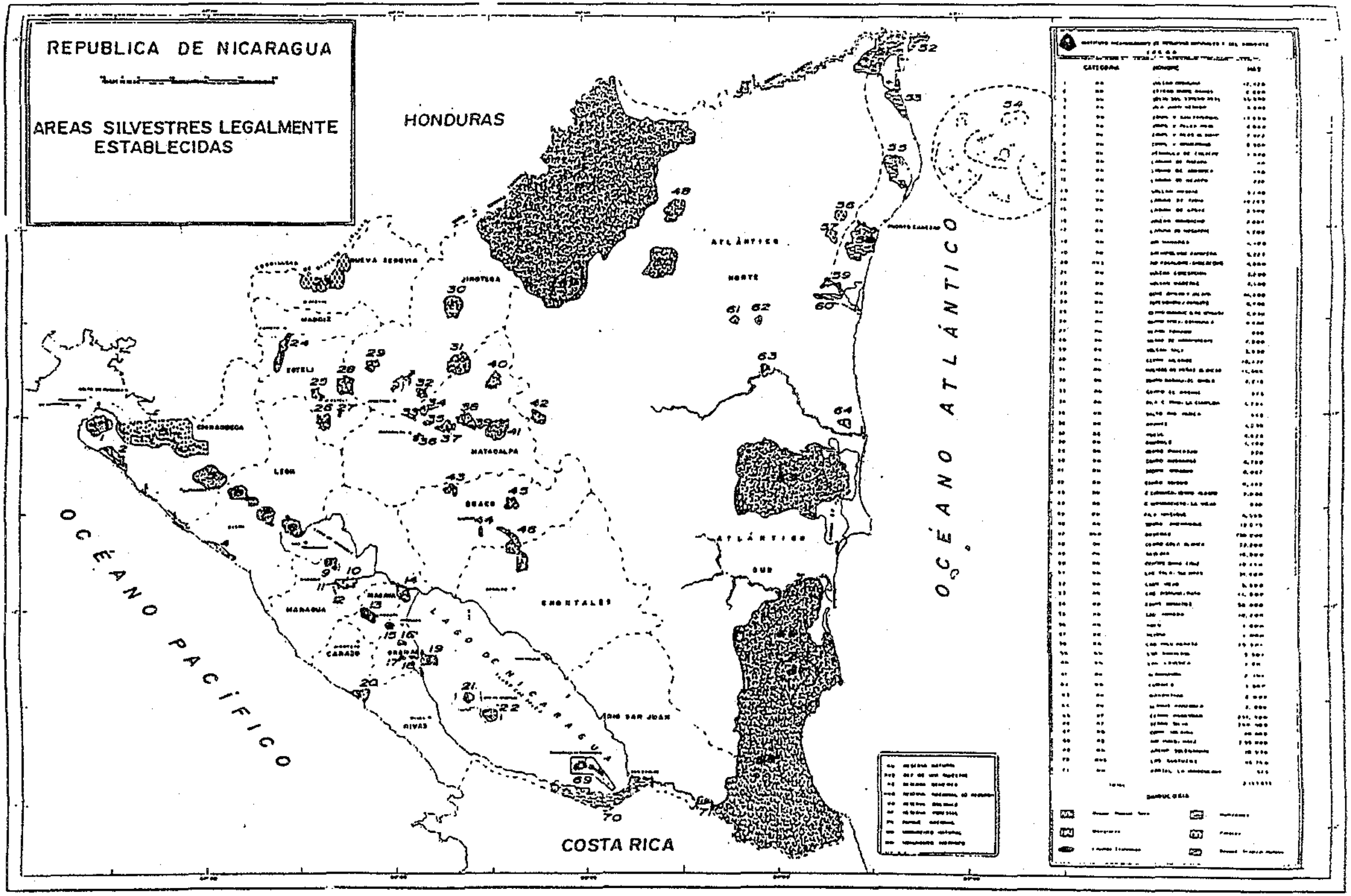



Figure 7-5 Natural Conservation Areas in Nicaragua

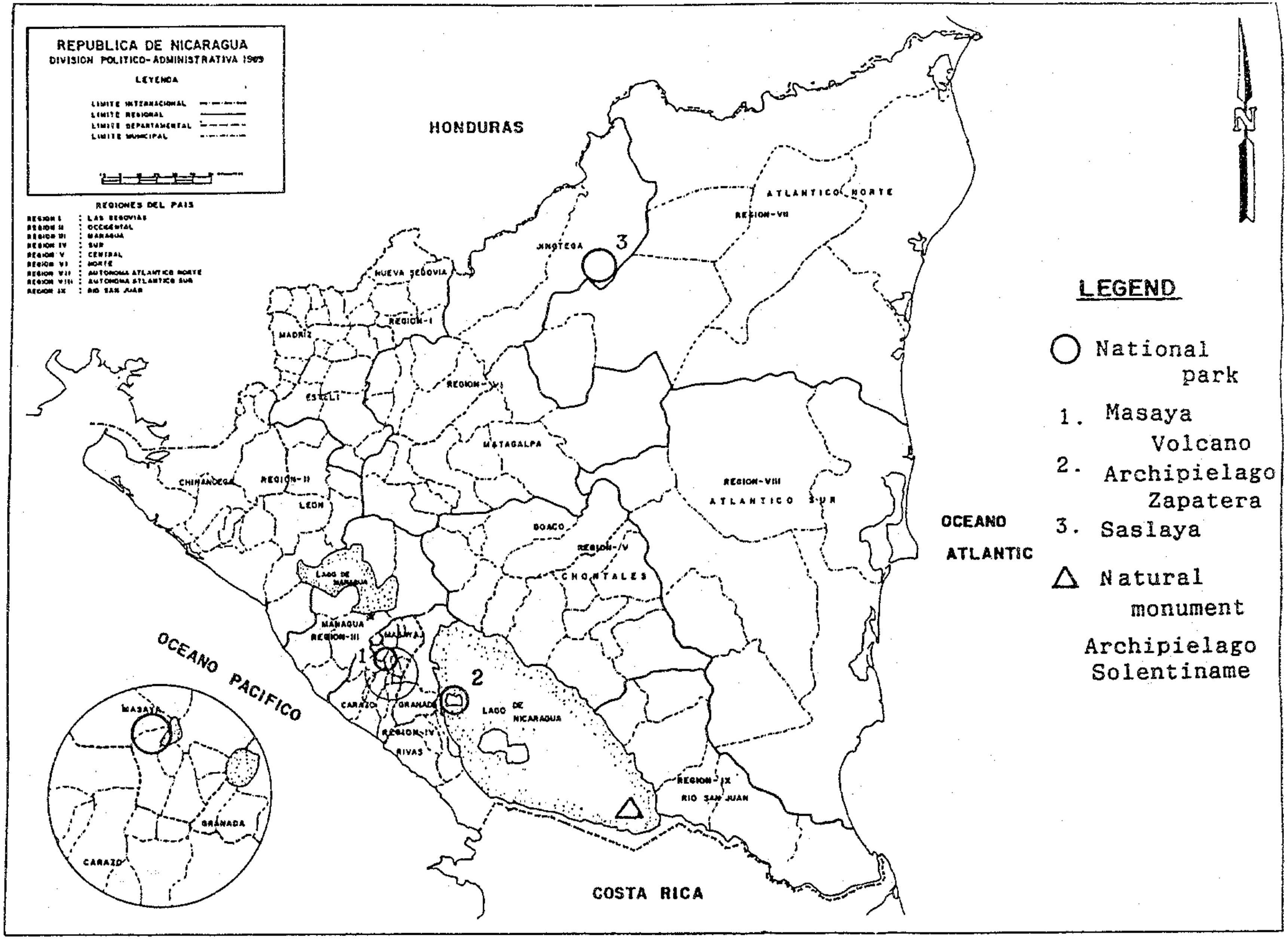



Figure 7-6 Map of National Parks and National Monuments in Nicaragua

(3) Education

The educational system in Nicaragua consists of elementary, secondary and higher education. The period of compulsory education is presently six years of elementary school. The country's educational system classified by region from 1987 to 1991 is shown in Table 7-3. The percentages of private elementary schools and students in 1990 were 3.4% and 5.0%, respectively.

**Table 7-3 Educational System from 1987 to 1991**

**(1) Elementary education**

| Year | 1987 | | | 1991 | | |
|---|---|---|---|---|---|---|
| **Region** | **School** | **Teacher** | **Student** | **School** | **Teacher** | **Student** |
| I | 571 | 2,310 | 64,640 | 660 | 2,207 | 70,080 |
| II | 766 | 3,459 | 107,765 | 805 | 3,303 | 123,343 |
| III | 391 | 4,176 | 163,082 | 455 | 4,135 | 178,235 |
| IV | 592 | 3,451 | 107,602 | 607 | 3,430 | 122,352 |
| V | 520 | 1,677 | 47,701 | 614 | 1,164 | 39,159 |
| VI | 738 | 2,027 | 68,754 | 978 | 2,312 | 82,846 |
| VII | 118 | 596 | 15,254 | 147 | 581 | 19,693 |
| VIII | 53 | 404 | 9,770 | 80 | 436 | 13,941 |
| IX | 49 | 217 | 5,438 | 56 | 771 | 24,396 |
| **Total** | 3,798 | 18,317 | 590,006 | 4,402 | 18,339 | 674,045 |

**(2) Secondary education**

| Year | 1987 | | | 1991 | | |
|---|---|---|---|---|---|---|
| **Region** | **Schools** | **Teachers** | **Students** | **Schools** | **Teachers** | **Students** |
| I | 27 | 485 | 15,105 | 24 | 281 | 16,085 |
| II | 58 | 1,043 | 31,055 | 70 | 748 | 29,164 |
| III | 71 | 1,860 | 70,411 | 108 | 1,390 | 68,172 |
| IV | 54 | 974 | 28,906 | 90 | 902 | 34,717 |
| V | 29 | 398 | 11,216 | 38 | 345 | 10,722 |
| VI | 27 | 404 | 12,438 | 47 | 388 | 14,161 |
| VII | 13 | 125 | 2,697 | 15 | 50 | 3,911 |
| VIII | 12 | 127 | 2,605 | 9 | 68 | 2,197 |
| IX | 5 | 33 | 728 | 6 | 18 | 983 |
| **Total** | 296 | 5,449 | 175,161 | 407 | 4,191 | 180,112 |

**(3) Higher education**

| Name of University | Location | Number of Student | |
|---|---|---|---|
| | | **1987** | **1991** |
| Universidad Centro Americana | Managua | 3,284 | 5,041 |
| Universidad Nac. Autonoma de Nic. Managua | Managua | 8,336 | 10,289 |
| Universidad Nacional de Ingeniería | Managua | - | 6,049 |
| Universidad Nacional de Agricultura | Managua | 1,419 | 2,316 |
| Universidad Nac. Autonoma de Nic.- León | León | - | 4,407 |
| Centro Universitario Regional - Estelí | Estelí | 611 | 429 |
| Inst. Politecnico de Salid | Managua | - | 474 |
| Centro Popular de Est. Sup. Matagalpa | Matagalpa | - | 451 |
| Centro Univ. Regional de Chontales | Chontales | - | 138 |
| Centro Univ. Regional de Carazo | Carazo | - | 219 |
| **Total 10 University** | | 13,650 | 29,813 |

Source: MED

(4) Public Health

Public health services in each region from 1987 to 1991 are shown in Tables 7-4 and 7-5.

**Table 7-4 Hospitals and the Number of Beds**

| Year | Hospitals | | Clinics | Health Centers | | |
|---|---|---|---|---|---|---|
| | Centers | Beds | | Centers | Beds | *1 |
| 1987 | 26 | 3,997 | 482 | 22 | 485 | 85 |
| 1988 | 26 | 3,904 | 488 | 21 | 488 | 74 |
| 1989 | 26 | 3,827 | 482 | 24 | 482 | 85 |
| 1990 | 29 | 3,826 | 471 | 25 | 471 | 96 |
| 1991 | 29 | 4,050 | 498 | 25 | 498 | 96 |

Note : *1 Health center without beds.

**Table 7-5 Hospitals and Beds by Region in 1991**

| Region | Hospitals | | Clinics | Health Centers | | |
|---|---|---|---|---|---|---|
| | Centers | Beds | | Centers | Beds | *1 |
| I | 4 | 376 | 85 | 3 | 45 | 10 |
| II | 5 | 650 | 172 | 6 | 123 | 18 |
| III | 8 | 1,440 | 132 | 2 | 18 | 16 |
| IV | 5 | 789 | 83 | 3 | 43 | 20 |
| V | 2 | 245 | 67 | 4 | 99 | 6 |
| VI | 2 | 310 | 65 | 3 | 75 | 12 |
| VII | 1 | 71 | 31 | 4 | 95 | 3 |
| VIII | 1 | 118 | 29 | - | - | 7 |
| IX | 1 | 51 | 18 | - | - | 4 |

Source: MINSA, 1992

(5) Water Use

The country's farms are mainly irrigated with water from wells, particularly in the pacific region, since most of the area's rivers dry up during the dry season, because the region is widely covered by recent and sub-recent thick volcanic sediment, which has a relatively peameable layer.

Approximately 75% of Managua's drinking water comes from wells (underground water), while the remainder (25%) comes from the lake.

(6) Natural and Historical Monuments

The Slentiname Archipelago in the southeastern part of Nicaragua Lake which consists of many small islands and occupies 18,930 hectares, has been designated a natural monument. La Inmaculada at Fortal on the border with of Costa Rica has been designated a historical monument.

(7) Air Pollution

Managua has suffered from typical air pollution related to $SO_2$ (sulfur dioxide) and $Cl_2$ (chlorine) since the 1980's. The results of an investigation by INETER are shown in Figure 7-7 and Table 7-6.

Factories and automobiles are the main sources of $SO_2$ and $Cl_2$ pollutants. As a result, a chemical factory ceased operation in 1990 in order to decrease the level of Cl pollution in the city.

**Table 7-6 Monthly Density of Pollutants**

(1) $SO_2$ ($mg/m^3$)

| Location / Month, 1989 | 1 Tanic | 2 Texnicsa | 3 San. Domingo | 4 La Fosforera |
|---|---|---|---|---|
| June | 2.21 | 0.60 | 0.278 | 0.364 |
| July | 0.615 | 0.333 | 0.216 | 0.316 |
| August | 0.11 | 0.068 | 0.196 | 0.211 |

Note : Air quality standard $SO_2$ : 0.5 $mg/m^3$

(2) $Cl_2$ ($mg/m^3$)

| Location / Month, 1989 | 5 Penwalt | 6 Ciudad Sandino |
|---|---|---|
| June | 0.534 | 0.03 |
| July | 0.148 | 0.051 |
| August | 0.185 | 0.096 |

Note : Air quality standard of $Cl_2$ : 0.1 $mg/m^3$

The amount of air pollution caused by automobiles in the major cities, especially in Managua, has been gradually increasing.

The E.P.A. standard, which is shown in Table 7-7, is generally applied in Nicaragua to assess the quality of air (emission standards). However, regulations controlling automobile emissions are nonexistent.

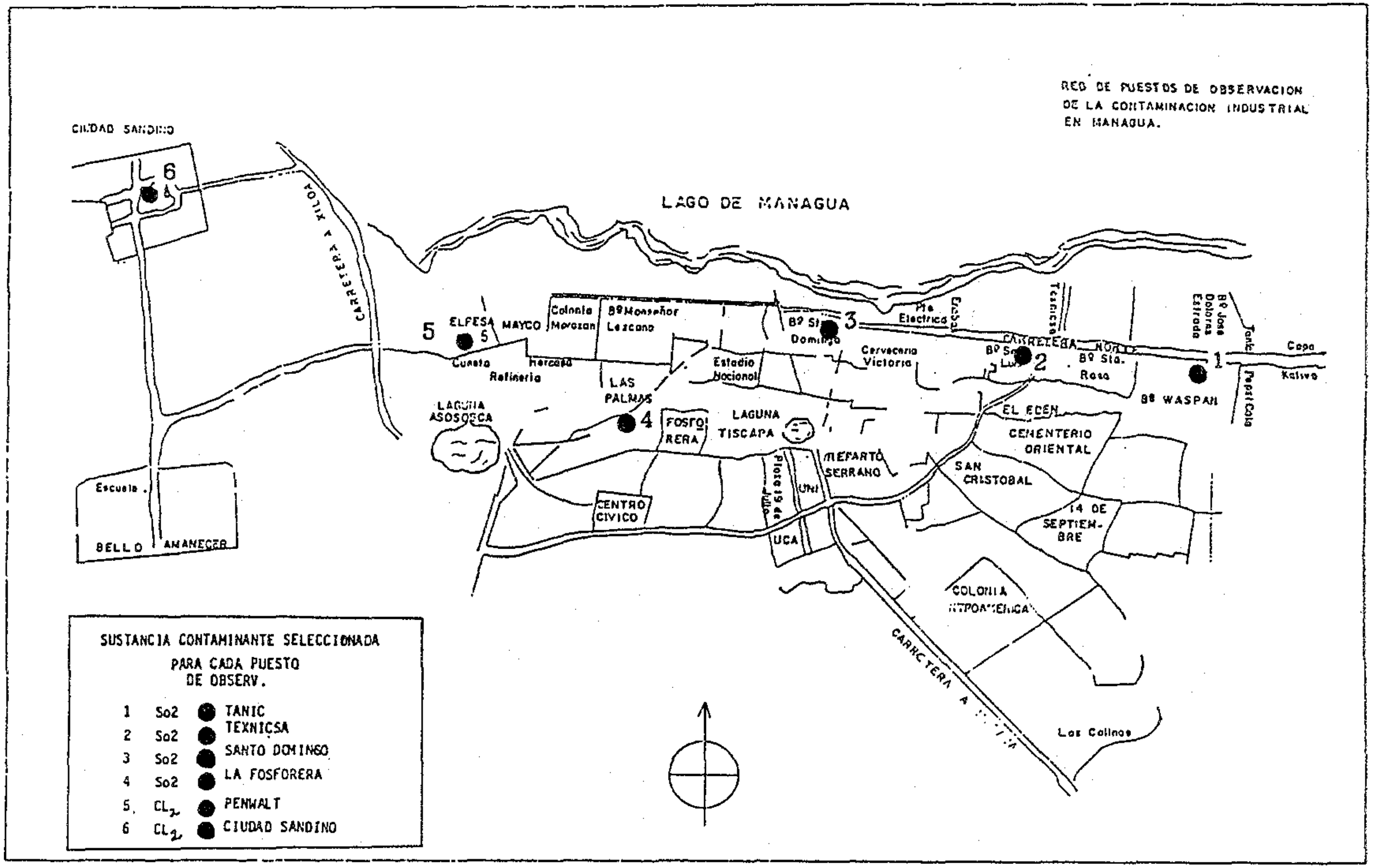



Figure 7-7 Survey Points of Air Quality

**Table 7-7 Air Quality Standards**

| Substance | Standard *1 |
|---|---|
| CO | 10 mg/m³/8 hours (9 ppm) |
| | 35 mg/m³/1 hour (35 ppm) |
| $SO_2$ | 80 mg/m³/day (0.03 ppm) |
| | 365 mg/m³/24 day (0.14 ppm) |
| $NO_x$, COMO, $NO_2$ | 100 mg/m³/year (0.05 ppm) |
| | variable 24 hours, with $NO_2$ |
| HC | 160 mg/m³/year (0.24 ppm) |
| Macro-particulars | 25 mg/m³/year-260 g/m³/24 hours |
| SPM | 260 mg/m³/day |
| | 75 mg/m³ in maximum |
| $O_3$ | 235 mg/m³/hour (0.12 ppm) |
| Pb -Ps | 1.5 mg/m³/3 months |

Note : *1 E.P.A.

(8) Water Pollution

Managua Lake is polluted. Topographical conditions (closed system) as well as domestic and industrial waste seem to be the main sources of the contamination. Thermal activity associated with hot springs also contributes to enriching the ionic properties of the lake's water.

Domestic and industrial wastewater has introduced large quantities of phosphorous causing eutrophication (total-P) of the lake. Intense evaporation has also led to increasing salinization of the lake. In addition, the lake's dropping water level, and the deposition of lake and river-discharged sediment have also promoted contamination of the lake.

The present condition of Managua Lake is shown in Table 7-8. The contamination of the lake adversely affects the environment, that is, irrigation, the drinking water supply, eutrophication, and the underground water. Moreover, the lake's surface sediments has been contaminated by mercury.

Contamination of surface and underground water, particularly in the pacific region, has rapidly gotten worse because of domestic and industrial waste.

(9) Noise and Vibration

No official complaints of excessive noise or vibrations have yet been reported. However, several intersections in the capital have been recognized as excessively noisy because of the large number of automobiles. The noise problem is expected to become much worse in the future.

**Table 7-8 Present Condition of Managua Lake (1988-89)**

| Items | Value |
|---|---|
| Lake surface | 1,016 $km^2$ |
| Watershed basin area | 6,668 $km^2$ |
| Total volume | 7.97×E6 $m^3$ |
| Mean depth | 7.8 m |
| Maximum depth | 26 m |
| Lake elevation (max., 1953) | 43.44 m |
| pH | 9.22 |
| Temperature | 29.1°C |
| Conductivity | 1,773 mS |
| Ca 2+ | 7.49 mg/l |
| Mg 2+ | 18.67 mg/l |
| Na + | 402.6 mg/l |
| K + | 56.45 mg/l |
| Fe 2+ | 0.57 mg/l |
| Cl - | 236.9 mg/l |
| B 3+ | 2.31 mg/l |
| $NO_3$ - | 3.12 mg/l |
| $NO_2$ - | 0.13 mg/l |
| $SO_4$ | 41.39 mg/l |
| $CaCO_3$ | 93.79 mg/l |
| $HCO_3$ | 470.0 mg/l |
| Alkalynity | 541.75 mg/l |
| $O_2$ | 7.8 mg/l |
| $PO_4$ 3- | 0.14 mg/l |

Source : S.M. Gullen,1991

(10) Soil Contamination

No official claims of soil contamination have yet been registered.

(11) Odor

No official claims of foul odors have yet been registered. However, foul odors will be emanating from the Managua lake.

(12) Land Subsidence

No land subsidence is currently being caused by pumping water.

(13) Hazards

Natural disasters such as volcanic eruptions, earthquakes, hurricanes, floods, landslides, etc. have occurred in the past. Particularly, the eruption of Masaya Volcano in 1976 caused severe damage. Momotombo and Cerro Negro Volcanoes are now active, and they are expected to erupt with great force in the future. The country's major earthquakes and volcanic eruptions are shown in Table 7-9.

Nicaragua is greatly damaged every year by hurricanes every year. Usually, hurricane damage is associated with flooding, landslides, mudflows, etc. However, no data concerning these damages is available.

No records of landslide damage are available. The areas most prone to landslides are listed in Figure 7-8. These areas are mostly located in the active volcanic zone and the Tertiary volcanic rocks region.

**Table 7-9 Records of Major Earthquakes and Volcanic Eruptions in Nicaragua (1520 - 1973)**

| Year | E/V*1 | Name /Location | Magnitude | Damage |
|---|---|---|---|---|
| 1520-28 | V | V.Telica, Masaya | - | |
| 1609 | V | V.Momotombo | - | |
| 1630 | V | V.Masaya | - | Felt strongly in Managua |
| 1663 | E | V.Momotombo-Granada | Unknown | |
| 1764 | V | V.Momotombo | - | |
| 1772 | E | V.Masaya | - | Granada |
| 1809 | V | V.Cosiguina | - | |
| 1822 | E | Cartago | Unknown | Cartago |
| 1835 | V | V.Cosiguina | - | Falling ash in México |
| 1844 | E | San Juan | Unknown | San Juan |
| 1847 | V | V.Irazu | - | |
| 1858 | V | V.Nindiri | - | Landslide in Granada |
| 1858-60 | V | V.Masaya | - | Lava flow |
| 1882-83 | V | V.Concepción | - | |
| 1884 | E | Managua | Unknown | Strong eqe. |
| 1898 | E | León | Unknown | Much damage in León |
| 1926 | E | Managua/135 km *2 | 7.0 | Half of all houses damaged |
| 1931 | E | Managua | 5.6 | Surface faulting |
| 1938 | E | Telica | - | Telica completely destroyed |
| 1947 | V | V.Concepción | - | |
| 1955 | E | Central America | 6.2 | Managua damaged |
| 1961 | E | Managua/138 km *2 | 5.5 | Houses damaged in León |
| 1963-68 | V | V.Cerro Negro | - | Damage in León |
| 1968 | E | Masaya/162 km *2 | 6.2 | Masaya, Granada |
| 1971 | V | V.Cerro Negro | - | |
| | V | V.Telica | - | |
| 1972 | E | Managua/5 km *2 | 6.2 | Managua destroyed, surface faulting, 6,000 dead, repeat of the 1931 earthquake |
| 1973 | E | Guanacaste | 6.7 | 15 dead |

Source : D.J. Leeds, 1974
Note : *1 E=Earthquake, V=Volcanic eruption
*2 Depth of epicenter

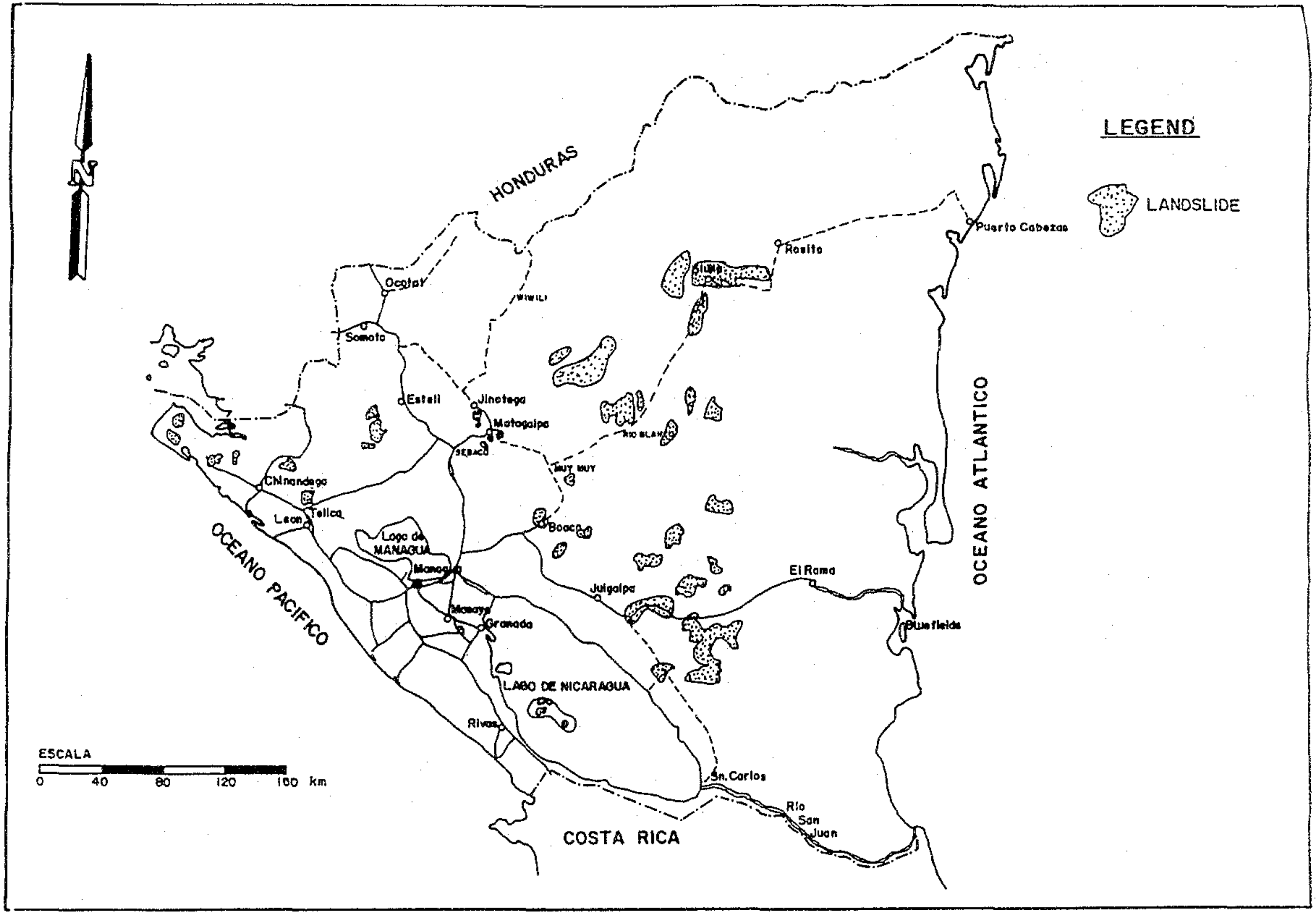



Figure 7-8 Distribution of Landslides

(14) Waste

Domestic waste in major cities is basically treated at waste disposal sites. In Managua, domestic waste is disposed of in Acahualinca, which has an area of approximately 25 ha. This site disposes of 1,100 m³ of waste daily.

With the future development of industry and the expected increase in population, the volume of industrial and domestic waste is undoubtedly greatly increase.

### 7.2.4 Environmental Problems

Environmental problems in Nicaragua mainly consist of air pollution, water pollution, endangerment of flora and fauna, soil erosion, and water, as shown in Table 7-10.

**Table 7-10 Environmental Problems**

| Items | Problems |
|---|---|
| 1. Air pollution | - Gas emitted from a chemical factory in the 1980s. The pollutant was $Cl_2$. Operations ceased in 1990.<br>- Exhaust gas from automobiles. |
| 2. Water pollution | - Contamination of lakes and rivers caused by domestic and industrial waste-water, eutrophication. |
| 3. Endangerment of Flora and fauna | - Deforestation mainly due to shifting agriculture and logging, estimated at 100,000 ha. yearly.<br>- Endangerment of valuable fauna and flora, and damaged to ecosystem caused by deforestation. |
| 4. Soil erosion | - Soil erosion because of deforestation. |
| 5. Water | - Desertification because of deforestation in the southeastern area, Region-IX, Río San Juan.<br>- Decreasing underground water level, due to deforestation, pumping of water, etc.<br>- Flooding, erosion and sedimentation in water course, deforestation. |
| 6. Others | - Noise and vibrations caused by automobiles and factories.<br>- Underground water contamination.<br>- Waste, increasing volume of domestic and industrial waste.<br>- Sewage, surface and underground water contamination, eutrophication.<br>- Foul odors caused by waste and eutrophication of the lake. |

## 7.3 INITIAL ENVIRONMENTAL EXAMINATION

### 7.3.1 Setting of Environmental Quality Standards

American Standards are applied in assessing air quality. Effluent standards for assessing water quality in Nicaragua are now under discussion. Therefore, Japanese standards may tentatively be applied.

Japanese standards may also tentatively be applied noise, vibrations and soil contamination. This project's influence on other environmental items, such as land subsidence, foul odors, waste, land, water, flora and fauna, landscape, hazards, traffic safety and socio-economic problems should be minimized.

Environmental standards for air quality, water quality, noise, vibrations and soil contamination are shown in Tables 7-11 to 7-15, respectively.

**Table 7-11 Air Quality Standards**

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

Note :*1 Annual arithmetic mean

## Table 7-12 Water Quality Standards

| Items | Standard Value |
|---|---|
| pH | Effluent to seaside : 5.0 - 9.0<br>Others : 5.8 - 8.6 |
| Biochemical Oxygen Demand | 160 mg/l (daily average : 120 mg/l) |
| Chemical Oxygen Demand | 160 mg/l (daily average : 120 mg/l) |
| Suspended Solids | 200 mg/l (daily average : 150 mg/l) |
| Normal hexane extraction matter | 5 mg/l (mineral oil)<br>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) |
| N | 120 mg/l (daily average) |
| P | 16 mg/l (daily average) |

## Table 7-13 Noise Standards

(Unit : dB(A))

| Item | Area | Environmental Standards Value | | |
|---|---|---|---|---|
| | | Daytime | Morning/Evening | Nighttime |
| General | AA*1 | <45 | <40 | <35 |
| | A *2 | <50 | <45 | <40 |
| | B *3 | <60 | <55 | <50 |
| Road | A *4 | <55 | <50 | <45 |
| | A *5 | <60 | <55 | <50 |
| | B *4 | <65 | <60 | <55 |
| | B *5 | <65 | <65 | <60 |

Note : *1 Quiet required, medical care facilities.
*2 Residential area.
*3 Industrial and commercial areas.
*4 Two-lane road.
*5 Road with more than two lanes.

## Table 7-14 Vibration Standards

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

**Table 7-15 Soil Contamination Standards**

| Items | Standard Value |
|---|---|
| Cadmium | 0.01 mg/l |
| Cyanide | Not detectable |
| Organic Phosphorous | Not detectable |
| Lead | 0.1 mg/l |
| Hexavalent chromium | 0.05 mg/l |
| Arsenic | 0.05 mg/l |
| Total mercury | 0.0005 mg/l |
| Alkyl mercury | Not detectable |
| Polychlorinated biphenyls | Not detectable |
| Copper | 125 mg/ 1 kg soil |

### 7.3.2 Initial Environmental Examination

The environmental checklist for the initial environmental examination, which is based on various environmental factors, is shown in Table 7-17. This checklist consists of environmental items and their sub-divisions, and is used to check present environmental conditions. The environment is evaluated by referring to the checklist, which is created on the basis of the data collected by the field surveys conducted as part of the Study.

Using the above checklist, an environmental examination can tentatively be performed for four road sections in the Feasibility Study area, as shown in Table 7-16.

**Table 7-16 Tentatively Selected Roads for the Feasibility Study**

| F/S Section | Road Section | Road Name | Distance |
|---|---|---|---|
| Section 1 | Managua - Masaya | N.R. 4 | 26.0 km |
| Section 2 | Masaya - San Benito | N.R. 11, 1 | 37.6 km |
| Section 3 | Masaya - Nandaime | N.R. 11, 18, 4, 2 | 32.8 km |
| Section 4 | Telica - San Isidro | N.R. 26 | 97.1 km |
| Total | | | 193.5 km |

Note : N.R. National Road

Table 7-17 summarizes the above results. The obtained evaluation results indicate that an environmental impact assessment is required.

## Table 7-17 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

## 7.4 CONCLUSIONS AND RECOMMENDATIONS

### 7.4.1 Conclusions

(1) Environmental Problems in Nicaragua

The main environmental problems in Nicaragua are listed below.

① Air pollution caused by factories and automobiles.

② Contamination of lakes and rivers caused by domestic and industrial wastewater, eutrophication.

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

④ Soil erosion caused by deforestation.

⑤ Desertification, flooding, etc. concerning water.

⑥ Others.

- Noise and vibrations caused by automobiles and factories.
- Underground water contamination.
- Waste increase.
- Sewage .
- Foul odors caused by waste and eutrophication of lakes.

(2) Initial Environmental Examination

An initial environmental examination was tentatively carried out in the four road sections to prepare for the next stage of the Feasibility Study.

The greatest environmental impact of any project will result during the construction stage and as a result of the use of roads. Air quality, water quality, soil contamination, noise and vibrations, land subsidence foul odors, 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 right of common have been selected as environmental items to be considered.

Impact on air quality, water quality, noise and vibrations, land subsidence , foul odors, land, soil, water, flora and fauna, landscape, waste, traffic, hazards, socio-economic conditions, safety, recreation facilities, water rights, and right of common was initially evaluated on the basis of examination results. Consequently, it shall be necessary to carry out an environmental impact assessment during the Feasibility Study.

### 7.4.2 Recommendations

(1) Environmental Impact Assessment

An environmental impact assessment should be carried out during the Feasibility Study. Any environmental investigation should include the following items:

- Air quality
- Water quality
- Noise and vibrations
- Land
- Soil
- Water
- Underground water
- Flora and Fauna
- Landscape
- Traffic conditions
- Social conditions

(2) Environmental Investigation

The recommended components of any environmental investigations are shown in Table 7-18.

**Table 7-18 Environmental Investigation**

| Items | Components |
|---|---|
| 1. Air quality | $SO_x$<br>Measurement point: intersections in major cities<br>($NO_x$, SPM: no analysis) |
| 2. Water quality | 20 items: Ca, Mg, Na, K, $HCO_3$, $SO_4$, Cl, $SiO_2$, Fe, $PO_4$, $NO_3N$, $NH_4N$, Cd, CN, PB, Cr, As, Hg, Mn, pH.<br>Sampling point : main water courses and spring water wells. |
| 3. Noise and Vibration | Environmental noise and vibration.<br>Measurement point : intersections in major cities. |
| 4. Land | Morphological and geological field survey. |
| 5. Soil | Soil investigation : soil section. |
| 6. Water | Data collection : water level, and volume of discharge into major water courses. |
| 7. Underground Water | Data collection : water level, pumping capacity, water quality, etc. of well and spring water. |
| 8. Flora and Fauna | Baseline survey of flora, 400 m wide. |
| 9. Landscape | Extraction of major site of landscape. |
| 10. Traffic Conditions | Examination of present conditions, control points, hazard records, etc. |
| 11. Social Condition | Interview surveys in each municipality. |