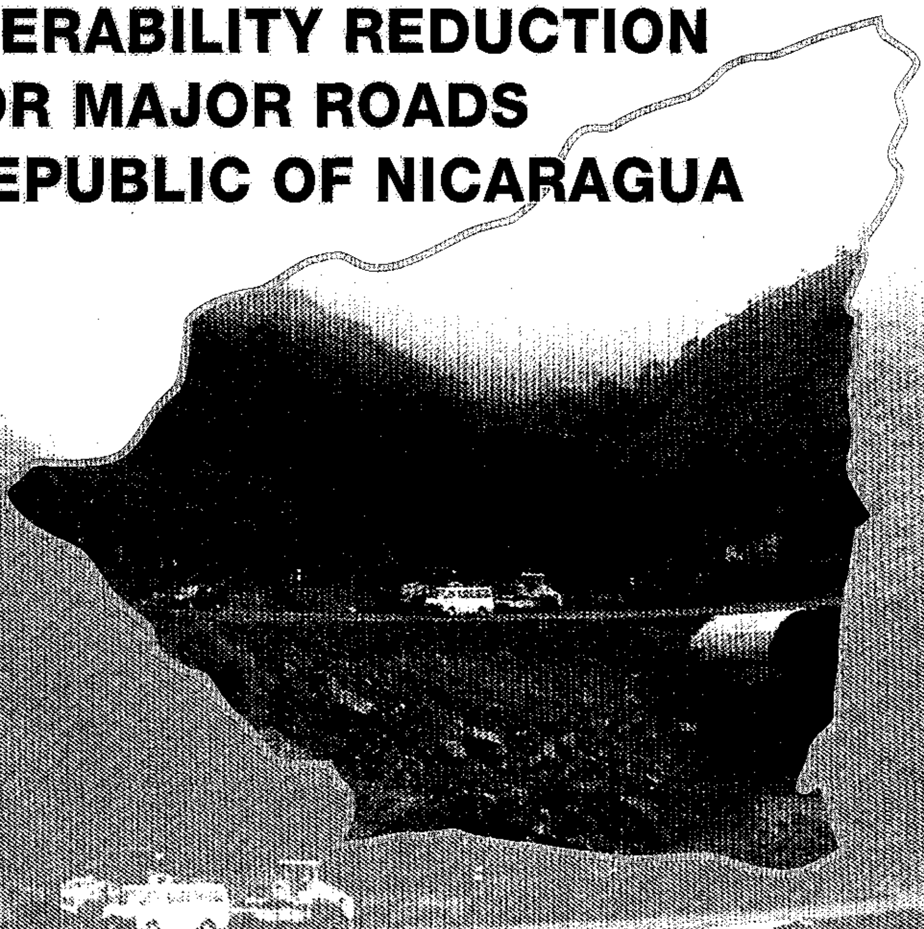
JAPAN INTERNATIONAL
COOPERATION AGENCY (JICA)

MINISTRY OF TRANSPORT AND
INFRASTRUCTURE
REPUBLIC OF NICARAGUA

# THE STUDY ON VULNERABILITY REDUCTION FOR MAJOR ROADS IN THE REPUBLIC OF NICARAGUA



## FINAL REPORT

Volume 1 of 5

## SUMMARY



January 2003

Oriental Consultants Company Limited
Japan Engineering Consultants Company Limited

JAPAN INTERNATIONAL
COOPERATION AGENCY (JICA)

MINISTRY OF TRANSPORT AND
INFRASTRUCTURE
REPUBLIC OF NICARAGUA

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*Volume 1 of 5*

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# PREFACE

In response to a request from the Government of the Republic of Nicaragua, the Government of Japan decided to conduct the Study on Vulnerability Reduction for Major Roads in the Republic of Nicaragua and entrusted the study to the Japan International Cooperation Agency (JICA).

JICA selected and dispatched a study team headed by Mr. Keigo Konno of Oriental Consultants Co., Ltd. and consist of Oriental Consultants Co., Ltd. and Japan Engineering Consultants Co., Ltd. to Nicaragua, three times between January 2002 and January 2003.

In addition, JICA set up an advisory committee consist of Mr.Tetsuo Hirose, Chief of Maintenance Planning Division, Maintenance and Facility Department, Hanshin Expressway Public Corporation and Mr. Yoshifumi Nagata, Chief of Public Relations Division, General Affairs Department, Metropolitan Expressway Public Corporation between January 2002 and January 2003, which examined the study from specialist and technical points of view.

The team held discussions with the officials concerned of the Government of Nicaragua and conducted the field surveys at the study area. Upon returning to Japan, the team conducted further studies and prepared this final report.

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

Finally, I wish to express my sincere appreciation to the officials concerned of the Government of Nicaragua for their close cooperation extended to the team.

January 2003

Takao Kawakami
President
Japan International Cooperation Agency

# Letter of Transmittal

January 2003

Mr. Takao Kawakami
President
Japan International Cooperation Agency

Dear Sir,

We are pleased to submit to you the final report on The Study on The Vulnerability Reduction for Major Roads in The Republic of Nicaragua.

This study was conducted by Oriental Consultants Company Limited and Japan Engineering Consultants Company Limited, under a contract to Japan International Cooperation Agency（JICA）, during the period from January 2002 to January 2003. In conducting the study, we examined the feasibility and rationale of road disaster measures with due consideration to the present status of Nicaragua's roads and formulated the most appropriate project incorporating the results of the examination.

We wish to take this opportunity to express our sincere gratitude to the concerned officials of JICA, the Ministry of Foreign Affairs, the Ministry of Land, Infrastructure and Transport, Hanshin Expressway Public Corporation, and Metropolitan Expressway Public Corporation. In addition, we wish to deep thank the Ministry of Transport and Infrastructure, the JICA Nicaragua office and the Embassy of Japan in the Republic of Nicaragua for their cooperation and assistance to the study team during its stay in Nicaragua.

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

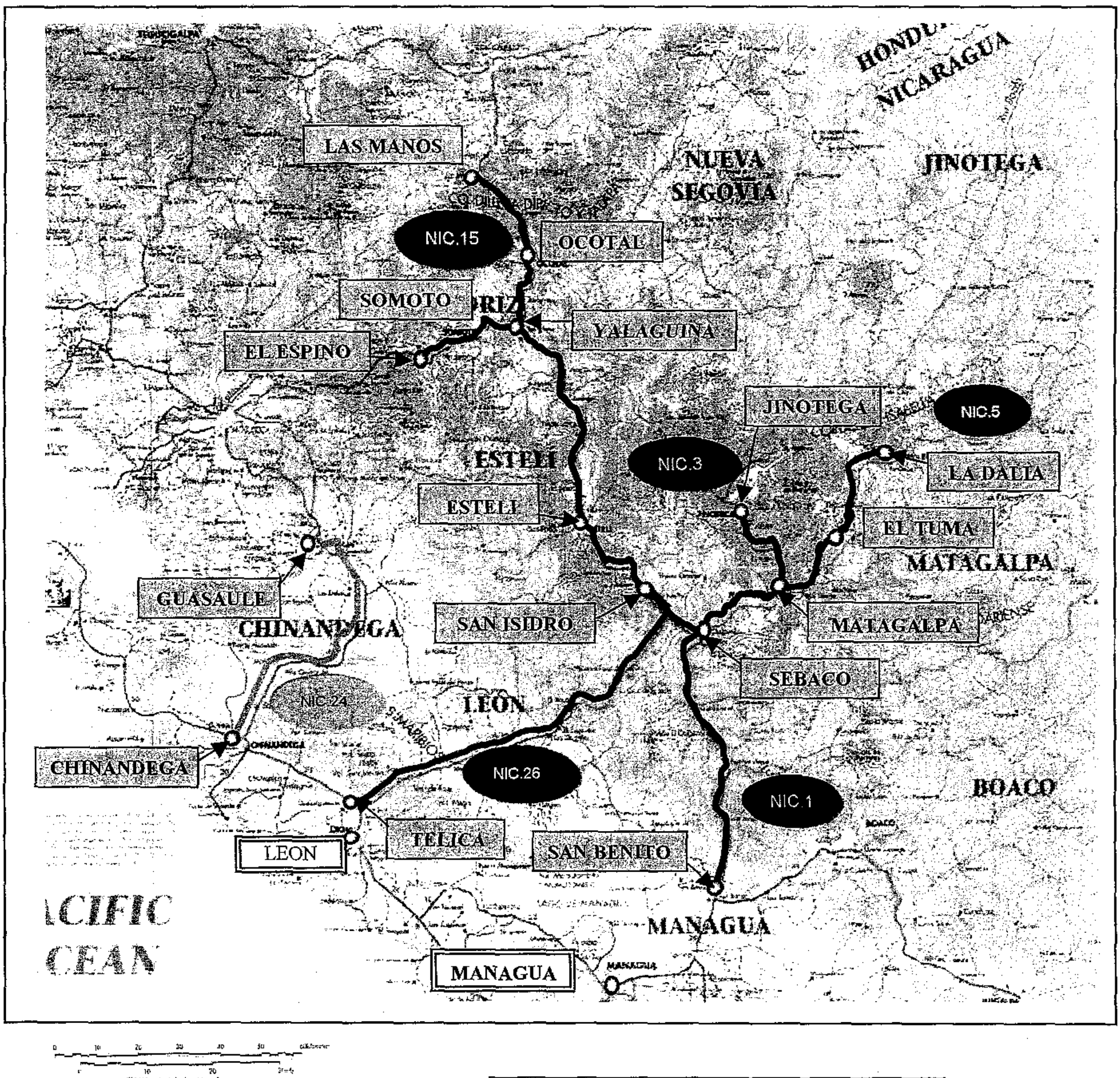
Very truly yours,

今野啓悟

Keigo Konno, Team Leader
The Study on Vulnerability Reduction
for Major Roads in the Republic of Nicaragua,
Oriental Consultants Company Limited

# LOCATION MAP

## THE STUDY ON VULNERABILITY REDUCTION FOR MAJOR ROADS IN THE REPUBLIC OF NICARAGUA




**Legend**

NIC. 1 El Espino～San Benito
NIC. 3 Sebaco～Jinotega
NIC.5 Matagalpa～La Dalia
NIC.15 Yalagüina～Las Manos
NIC.24 Chinandega～Guasaule
NIC.26 Telica～San Isidro

Route No. NIC.26

# Project Summary

| | |
|---|---|
| **1. Country** | Republic of Nicaragua |
| **2. Name of Study** | The Study on Vulnerability Reduction for Major Roads in The Republic of Nicaragua |
| **3. Counterpart Agency** | Ministry of Transport and Infrastructure (MTI) |
| **4. Objective of Study** | -To identify disaster critical spots of vulnerable spots on the major roads, and to conduct a Feasibility Study of disaster prevention spots due to the emergent countermeasures.<br>-To prepare a disaster prevention plan and a manual for road vulnerability reduction. |

**1. Study Roads:** There are 6 roads on NIC1,NIC3,NIC5,NIC15,NIC24 and NIC26 within major roads in Nicaragua.

**2. Plan Policy of Road Disaster Prevention**

1) Whole Policy of the Project: Problems dissolution of vulnerability spots (Unstable cut/ embankment slopes, Bridge foundation scouring), Strengthening of maintenance system in MTI, Environmental safeguard of roadsides located in disaster critical spots, Enhancement of the PRSP and the BHN,
2) Planning of vulnerability reduction: Inspection methods of Vulnerability spots, Evaluation methods of Inspection, Identification methods of disaster potential spots/ critical spots/ prevention spots,
3) Planning of disaster prevention countermeasures: Planning of local machines/ materials, Planning of countermeasure types,
4) Road maintenance plan: Strengthening of maintenance division in MTI, Efficiency road maintenance work (Establishment of rural offices, Management of efficiency relative data), Establishment/management of Database for the maintenance work.

**3. Project Cost**

| Package No. | Sub Package | Site No. | ID No. | Road | Cost (US$) |
|---|---|---|---|---|---|
| 1 | 1a | 2 | N001A280 | Nic1 | 12,339 |
| | | 3 | Junquilal | Nic7 | 51,825 |
| | | 4 | San Nicolas | Nic1 | 30,849 |
| | | 6 | San Ramon | Nic1 | 11,105 |
| | | 7 | N001A240 | Nic1 | 32,082 |
| | | 8 | N001B230 | Nic1 | 7,404 |
| | | 12 | N001B150 | Nic1 | 33,316 |
| | Cost | | | | 178,921 |
| | 1b | 24 | N003B400 | Nic3 | 49,358 |
| | | 27 | N003B320 | Nic3 | 294,912 |
| | Cost | | | | 344,289 |
| | 1c | 51 | N026A160 | Nic26 | 16,041 |
| | | 52 | San Juan de Dios | Nic26 | 6,170 |
| | | 54 | Papalon | Nic26 | 62,931 |
| | Cost | | | | 85,142 |
| Package 1 Cost | | | | | 608,333 |

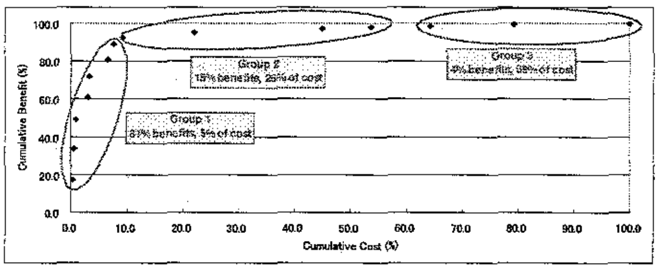
| Package No. | Sub Package | Site No. | ID No. | Road | Cost (US$) |
|---|---|---|---|---|---|
| 2 | 2a | 1 | N001A290 | Nic1 | 413,370 |
| | Cost | | | | 413,370 |
| | 2b | 25 | N003B370 | Nic3 | 215,940 |
| | | 26 | El Guayacan | Nic3 | 1,701,604 |
| | | 30 | N003E170 | Nic3 | 382,521 |
| | Cost | | | | 2,300,064 |
| | 2c | 35 | N005A010 | Nic5 | 480,003 |
| | Cost | | | | 480,003 |
| | 2d | 45 | La Bandarita | Nic26 | 38,252 |
| | | 55 | Solis | Nic26 | 81,440 |
| | Cost | | | | 119,692 |
| Package 2 Cost | | | | | 3,313,129 |

| Package No. | Sub Package | Site No. | ID No. | Road | Cost (US$) |
|---|---|---|---|---|---|
| 3 | 3a | 5 | Las Chanillas | Nic1 | 233,215 |
| | | 11 | N001B170 | Nic1 | 1,961,965 |
| | | 13 | N001B120 | Nic1 | 1,004,427 |
| | | 18 | Rio Inali | Nic1 | 1,021,702 |
| | | 19 | Rio Tapacali | Nic1 | 347,971 |
| | Cost | | | | 4,569,280 |
| | 3b | 29 | N003C230 | Nic3 | 404,732 |
| | | 32 | N003C150 | Nic3 | 1,132,757 |
| | | 33 | N003C140 | Nic3 | 924,221 |
| | Cost | | | | 2,461,711 |
| | 3c | 44 | N026A060 | Nic26 | 388,925 |
| | | 49 | N026B140 | Nic26 | 1,115,482 |
| | | 50 | N026A150 | Nic26 | 259,127 |
| | Cost | | | | 1,764,534 |
| Package 3 Cost | | | | | 8,795,526 |
| Grand Total | | | | | 12,716,988 |

30 disaster prevention spots are divided into 3 groups. Those groups provide the basis for prioritising investment, and creating work packages.

**4. Benefit by Project Execution**

The creation of prioritised packages of work that maximise benefits, whilst minimising costs. **Priority Group 1** account for 66% of total benefits and 12% of total costs. **Priority Group 2** make up 24% and 31% of the total benefits and costs, respectively. As for **Priority Group 3**, it accounts for 10% of the total benefits and 57% of the total cost.




**5. Implementation Programme and Recommendation**

**1) Project Packaging**

- Group 1 (construction period: 2 years): NIC1 (7 spots), NIC3 (2 spots), NIC26 (3 spots) = Total 12 spots
- Group 2 (construction period: 2 years): NIC1(1 spot), NIC3 (3 spot), NIC5 (1 spot), NIC26 (2spots) = Total 7 spots
- Group 3 (construction period: 2 years): NIC1 (5 spots), NIC3 (3 spots), NIC26(3 spots) = Total 11 spots

**2) Conclusion and Recommendation**

**①Conclusion**

- **Early execution of the disaster prevention spots:** The disaster prevention works should be executed as early as possible in order to protect the safety of road users and the stability of traffic movement and economy.

**②Recommendation**

- **Execution of screening, emergency/ routine/ periodic inspection survey:** The screening and inspection surveys should be carried out for not only the objective roads but also other major roads and the rural roads.
- **Strengthening of maintenance division in MTI:** In order to carry out sustainable maintenance works, the division of road maintenance of the general division of roads in MTI should be strengthened.
- **Establishment of regional offices:** In order to get information of disaster quickly, regional offices should be established at main towns on major roads.
- **Secure the special budget for road disasters:** In order to safeguard road safety and economic development to the road users, MTI should itself secure a special budget for road disasters.

<u>**List of Abbreviations**</u>

**(In alphabetical order)**

| | | |
|---|---|---|
| AADT | : | Annual Average Daily Traffic |
| AASHTO | : | American Association of State Highway and Transportation Officials |
| AHP | : | Analytic Hierarchy Process |
| ASTM | | American Society for Testing and Materials |
| B/C | : | Benefit to Cost ratio |
| BH | | Boring Hole |
| BHN | : | Basic Human Needs |
| BIT | | Central American Development Bank |
| DID | | Densely Inhabitant District |
| EIA | : | Environmental Impact Assessment |
| GDP | : | Gross Domestic Product |
| GRN | : | The Government of Republic of Nicaragua |
| ID | | Identification |
| IDF | : | Rainfall Intensity Duration Frequency |
| IEE | : | Initial Environmental Examination |
| INETER | : | Institution of National Territorial Study |
| IRR | : | Internal Rate of Return |
| JICA | | Japan International Cooperation Agency |
| MARENA | : | The Ministry of Natural Resources and Environment |
| MTI | : | The Ministry of Transport and Infrastructure |
| OD | : | Origin and Destination |
| PRSP | : | Poverty Reduction Strategy paper |
| QV | : | Volume capacity |
| ROW | : | Right of Way |
| STRADA | | System for Traffic Demand Analysis |
| VAT | | Value Added Tax |
| VOC | : | Vehicle Operation Cost |
| WB | | World Bank |
| pcu | : | Passenger Car Unit |

The following foreign exchange rate is applied in the study :

1 US dollar = 14.40 Cordovas = 125.00 Japanese Yen (October 2002), or

1 Cordovas = 8.68 Japanese Yen

# Summary of the Study

## 1. Background of the Study

Nicaragua is the frequent occurrence country of natural disaster and it influences recurs the undesirable progress of the recovery of infrastructures. Especially, about 1,500 km of the paved roads and about 6,000 km of unpaved roads were disrupted by the hurricane "Mitch" occurred in October 1998 and also as for the bridge, complete collapse on 22 bridges and partial destruction on 46 bridges suffered. In such situation, the Government of Republic of Nicaragua (hereinafter referred to as the "GRN") was established the National Transportation Plan (hereinafter referred to as the "NTP") including the improvement of the road network in February 2001. However the disaster prevention plan was not established in the NTP clearly, and the reliability of the traffic is in low condition such as the case of the bad weather.

The GRN requested assistance of the Japanese Government to implement the Study on Vulnerability Reduction for Major Roads in the Republic of Nicaragua (hereinafter referred to as the "Study"). In response to this request from the GRN, the Government of Japan has decided to carry out a study to identify disaster critical spots and execute a Feasibility Study for the Study.

Therefore, the ultimate goal of this Study is to assist the GRN in prioritising and recommending those road disaster prevention projects that are to identify disaster critical spots, to execute a Feasibility Study for urgent disaster prevention spots, to prepare the road disaster prevention plan and the manuals. The area of the Study shall cover the following Project Roads within major roads in the Republic of Nicaragua;

1) El Espino - San Benito (NIC. 1)
2) Sebaco - Jinotega (NIC. 3)
3) Matagalpa – Da Lida (NIC. 5)
4) Yalaguina - La Dalia (NIC. 15)
5) Chinandega - Guasaule (NIC. 24)
6) Telica - San Isidro (NIC. 26)

## 2. Study Approach

The major focus of the Study is to identify disaster critical spots, to identify disaster prevention spots for a Feasibility Study, and the to examine the technical, environmental and economic validity of this project in the Feasibility Study.

1) To collect and analyze the background and situation of the natural and environment conditions and the development plan, and to examine the relation to the road disasters.
2) To carry out the site investigations regarding the spots of disaster potential cut/ embankment slope damages and bridge foundation scouring, and to select disaster potential spots for disaster prevention, furthermore to identify high potential disaster critical spots.
3) To evaluate stability level, to forecast traffic demand, to assess environment, to examine technically for the Feasibility Study (target year: 2020).
4) To examine countermeasures for identified disaster prevention spots and to confirm the validity of environment, economic and countermeasures for disaster spots.
5) To prepare the disaster prevention manuals for maintenance work.

**I. Identification of Study Spots**

1) Review of the natural condition, related development plans, socio-economic data.
2) Examine of the assessment ways for road disaster spots.
3) Identify of the disaster potential spots and disaster critical spots by site survey.
4) Examine of countermeasures and estimate of rough construction costs.
5) Investigate of natural conditions and initial environmental examination.
6) Analysis of socio-economic framework.
7) Forecast of future traffic demand.
8) Identify of disaster prevention spots.

**II. Feasibility Study**

1) Arrange of the design standards.
2) Detailed examine of countermeasures.
3) Construction plan and construction cost estimate.
4) Assess of environmental impact.
5) Project evaluation.
6) Implementation programme.
7) Management and operations system.
8) Conclusion and recommendation

## 3. Topography and Geology of Study Area

The topographical characteristic of Nicaragua is divided into three areas:

- Pacific plains area (including the volcanic mountain range area);
- Central mountains range area;
- Atlantic coast plains area.

The land of the Pacific plains area is very fertile, being covered by weathered volcanic ash soil or alluvium. The Nicaraguan rift valley is laid between volcanic mountain range and central mountains range in this area and is mainly subsidence land. It contains two large lakes (Lake Managua and Lake Nicaragua). A volcanic mountain range is laid in middle of the Pacific plains area and running parallel with coast.

The main rocks of volcanic lava distributed in the Study area are basaltic, andesite-basalt, andesite, rhyolite and other lava, with such effusive rocks as tuffbreccia, dacitic agglomerate of the Palaeocene Period, and lavas of quarts-andesite, pyroclastic rock, and welded tuff belonging to the Eocene Period. They are widely distributed along NIC.1, NIC.3, and NIC.26. These lava flows display erosion in combination with tuffs. The Mesa Plateau is composed of lava on top, with tuffs underneath, which, when weathered make a sharp slope. NIC.1 displays this topography a good deal. Along NIC.24, the volcanic rocks of the Quaternary Era are recognizable by the white Pleistocene tuffs, agglomerate, tuffs with pumice, andesite-quartz/andesite, and ryyolite. Relatively new un-cemented volcanic ash covers them

## 4. Factors of Environmental Impact

The Study projects are not assessed as the objective project shown in the environmental impact assessment in Nicaragua. However, all of projects need the permission of the Ministry of Natural Resources and Environment (hereinafter referred to as the "MARENA") in spite of the scale of projects. Furthermore in order to apply the permission for projects, a private company and a public agency must procedure respectively under Nicaragua law. Ten items have been selected to evaluate negative impacts: resettlement, economic activity, traffic and public facilities, waste, groundwater, lakes and rivers, fauna and flora, landscape, water pollution, and noise and vibration.

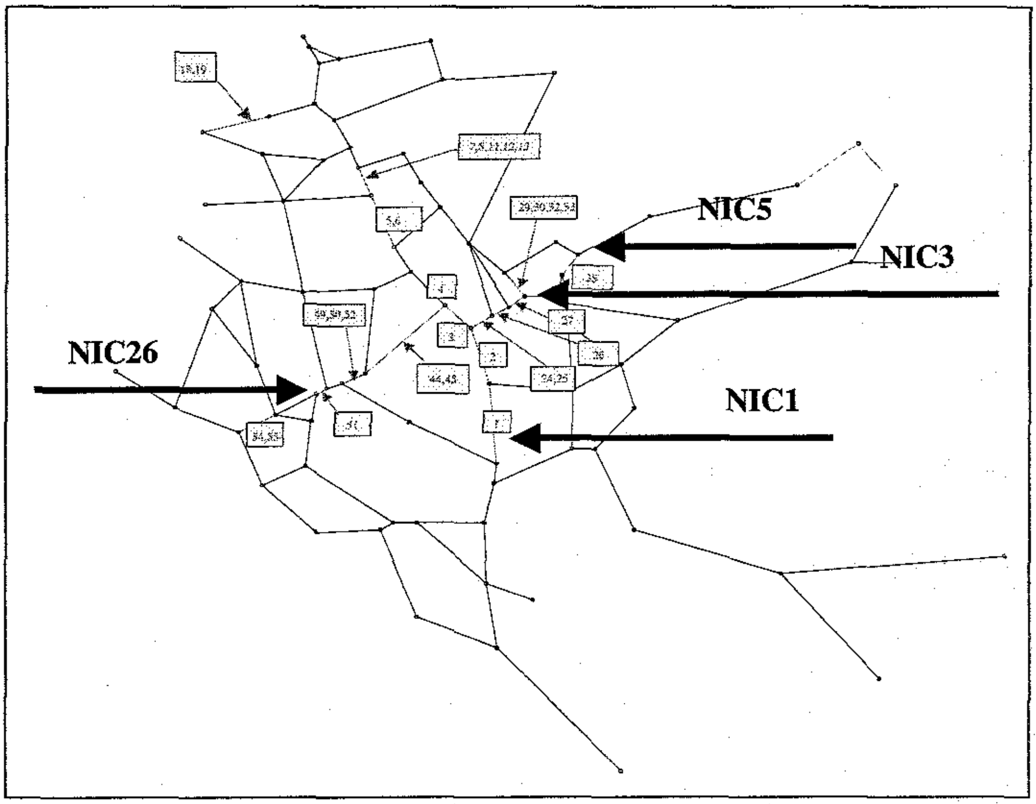
## 5. Identification of Disaster Prevention Spots

The disaster critical spots identified in Chapter 6 of the Study require urgent, temporary or permanent countermeasures so that they can be transformed into disaster prevention spots. These spots are identified using various factors. It is difficult to designate a point a disaster critical spot based on economics only, since there are some spots where there are low traffic volumes. Therefore, when evaluating roads and road sections for disaster criticality, a broader approach that incorporates level of stability, traffic volume, environmental impacts, development potential, natural conditions, benefits, required level of restoration, should be considered.

The evaluation score of a disaster critical spot differs depending on the scale of a disaster. Moreover, note that it is very difficult to identify disaster prevention spots in terms of cost only. Therefore, it is necessary to create an evaluation index to assess overall importance. Therefore, in this Study, the selection of disaster prevention spots is carried out using the Analytic Hierarchy Process (hereafter referred to as "AHP"). AHP is a multi-criteria decision-making technique that assigns numerical values (or weights) to various types of evaluation criteria. AHP was applied to select 30 disaster prevention spots for urgent spots and basis of disaster prevention in Nicaraguan country from the 55 disaster critical spots.

## 6. Proposed Project and Implementation Schedule

Locations of vulnerable spots are shown in the below figure.



Disaster prevention works are shown in the below figures.

### NIC.1 Countermeasures for Slope Failure

| No. | ID. No | Type of Disaster | Type of Countermeasure | | Unit | Qty | Cost (US$1000) |
|---|---|---|---|---|---|---|---|
| 1 | N001A290 | R.F | Removal + Prevention net + Drainage | T | $m^2$ | 23,286 | 335 |
| 2 | N001A280 | R.F | Horizontal drainage | P | m | 100 | 10 |
| 7 | N001A240 | R.F | Removal + Prevention net | T | $m^2$ | 950 | 26 |
| 8 | N001B230 | R.C | Removal + Prevention net | T | $m^2$ | 228 | 6 |
| 11 | N001B170 | R.C | Recutting + Drainage | P | $m^3$ | 36,028 | 1,590 |
| 12 | N001B150 | R.C | Recutting + Shotcrete + Drainage | P | $m^2$ | 252 | 27 |
| 13 | N001B120 | R.C | Recutting + Drainage | P | $m^3$ | 10,655 | 814 |
| Total | | | | | | | 2,808 |

Note) R.F: Rock fall; R.C: Rock collapsing; P: Permanent countermeasure; T: Temporary countermeasure

### NIC.1 Countermeasures for Bridge Foundation Scouring

| No. | ID. No | Type of Disaster | Type of Countermeasure | | Unit | Qty | Cost (US$1000) |
|---|---|---|---|---|---|---|---|
| 3 | Junquillal | Bridge | Gabion mat | T | $m^3$ | 435 | 42 |
| 4 | San Nicolas | Bridge | Gabion mat | T | $m^3$ | 114 | 25 |
| 5 | Las Chanillas | Bridge | Concrete block | T | $m^3$ | 288 | 189 |
| 6 | San Ramon | Bridge | Gabion mat | T | $m^3$ | 86 | 9 |
| 18 | Inali | Bridge | Gabion mat<br>Revetment +Stone masonry | T | $m^3$<br>$m^2$ | 1,138<br>1,758 | 828 |
| 19 | Tapacali | Bridge | Gabion mat<br>Revetment | T | $m^3$<br>$m^2$ | 238<br>640 | 282 |
| Total | | | | | | | 1,375 |

Note) Bridge: Scouring of foundation; T: Temporary countermeasure

### NIC.3 Countermeasures for Slope Failure

| No. | ID. No | Type of Disaster | Type of Countermeasure | | Unit | Qty | Cost (US$1000) |
|---|---|---|---|---|---|---|---|
| 24 | N003B400 | R.C | Recutting + Drainage | P | $m^3$ | 290 | 40 |
| 25 | N003B370 | R.C | Recutting + Drainage | P | $m^3$ | 1,676 | 175 |
| 27 | N003B320 | R.C | T-shaped retaining wall +Refilling+ Vegetation+ Drainage | P | $m^3$ | 3,168 | 239 |
| 29 | N003C230 | S.S + R.C | Recutting + Cribwork + Vegetation+ Drainage<br>Embankment + Vegetation + Drainage | P | $m^2$<br>$m^3$ | 638<br>4,934 | 328 |
| 30 | N003E170 | D.F + R.C | Concrete dam + Box culvert<br>Recutting + Drainage | P | m<br>$m^3$ | 20<br>2,670 | 310 |
| 32 | N003C150 | S.S + R.C | Recutting + Drainage<br>Embankment +Vegetation+ Drainage | P | $m^3$ | 9,221<br>16,076 | 918 |
| 33 | N003C140 | S.S + R.C | Recutting +Horizontal drainage + Drainage<br>Embankment +T-shaped retaining wall + Vegetation + Drainage | P | $m^3$ | 5,408<br>3,176 | 749 |
| Total | | | | | | | 2,759 |

Note) R.C: Rock collapsing; S.S: Slope Slide; D.F: Debris flow; P: Permanent countermeasure

### NIC.3 Countermeasures for Bridge Foundation Scouring

| No. | ID. No | Type of Disaster | Type of Countermeasure | | Unit | Qty | Cost (US$1000) |
|---|---|---|---|---|---|---|---|
| 26 | El Guayacan | Bridge | New bridge construction | P | $m^2$ | 500 | 1,379 |

Note) Bridge: Scouring of foundation; P: Permanent countermeasure

## NIC.5 Countermeasures for Slope Failure

| No. | ID. No | Type of Disaster | Type of Countermeasure | | Unit | Qty | Cost (US$1000) |
|---|---|---|---|---|---|---|---|
| 35 | N005A010 | R.F | Recutting + Drainage | P | $m^3$ | 10,760 | 389 |

Note) R.F: Rock fall; P: Permanent countermeasure

## NIC.26 Countermeasures for Slope Failure

| No. | ID. No | Type of Disaster | Type of Countermeasure | | Unit | Qty | Cost (US$1000) |
|---|---|---|---|---|---|---|---|
| 44 | N026A060 | R.F | Recutting + Shotcrete + Drainage | P | $m^2$ | 3,604 | 316 |
| 33 | N026A140 | R.C | Recutting + Horizontal drainage + Drainage | P | $m^3$ | 11,495 | 904 |
| 50 | N026A150 | R.F | Recutting +Drainage | P | $m^3$ | 2,113 | 210 |
| 49 | N026B160 | R.C | Removal + Prevention net +Drainage | T | $m^2$ | 1,568 | 13 |
| Total | | | | | | | 1,443 |

Note) R.F: Rock fall; R.C: Rock collapsing; P: Permanent countermeasure; T: Temporary countermeasure

## NIC.26 Countermeasures for Bridge Foundation Scouring

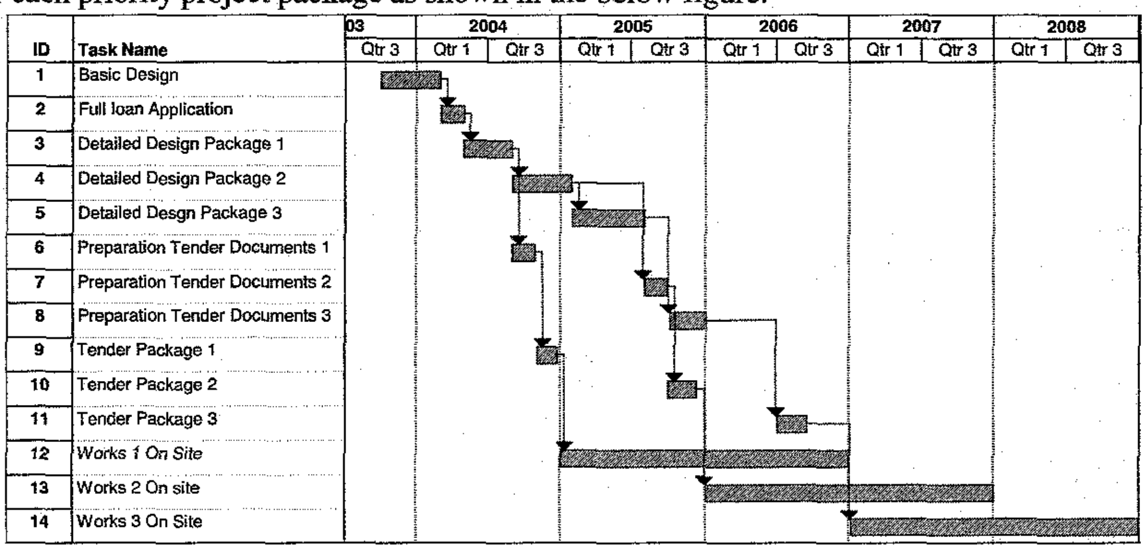
| No. | ID. No | Type of Disaster | Type of Countermeasure | | Unit | Qty | Cost (US$1000) |
|---|---|---|---|---|---|---|---|
| 55 | Solis | Bridge | Stone riprap with mortar<br>Gabion mat | T | $m^3$ | 72<br>546 | 66 |
| 54 | Papalon | Bridge | Stone riprap with mortar<br>Gabion mat | T | $m^3$ | 50<br>408 | 51 |
| 52 | San Juan de Dios | Bridge | Gabion mat | T | $m^3$ | 115 | 5 |
| 45 | La Banderita | Bridge | Stone riprap wall<br>Gabion mat | T | $m^2$<br>$m^3$ | 162<br>375 | 31 |
| Total | | | | | | | 153 |

Note) Bridge: Scouring of foundation; P: Permanent countermeasure

## Total Construction Cost by Route (Direct Cost)

| Objective Route | Cost (US$1000) | | |
|---|---|---|---|
| | Slope | Bridge | Total |
| NIC.1 | 2,808 | 1,375 | 4,183 |
| NIC.3 | 2,759 | 1,379 | 4,138 |
| NIC.5 | 389 | 0 | 389 |
| NIC.26 | 1,443 | 153 | 1,596 |
| Total | 7,399 | 2,907 | 10,306 |

The implementation schedule was set up taking account of the construction period estimated for each priority project package as shown in the below figure.



**FINAL REPORT**

**Volume 1 of 5 : Summary**

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# CHAPTER 1 INTRODUCTION

## 1.1 Background of the Study

Nicaragua is the frequent occurrence country of natural disaster and it influences recurs the undesirable progress of the recovery of infrastructures. Especially, about 1,500 km of the paved roads and about 6,000 km of unpaved roads were disrupted by the hurricane "Mitch" occurred in October 1998 and also as for the bridge, complete collapse on 22 bridges and partial destruction on 46 bridges suffered.

In such situation, the Government of Republic of Nicaragua (hereinafter referred to as the "GRN") was established the National Transportation Plan (hereinafter referred to as the "NTP") including the improvement of the road network in February 2001. However the disaster prevention plan was not established in the NTP clearly, and the reliability of the traffic is in low condition such as the case of the bad weather.

The Nicaraguan Government requested assistance of the Japanese Government to implement the Study on Vulnerability Reduction for Major roads in the Republic of Nicaragua (hereinafter referred to as the "Study").

## 1.2 Objectives of the Study

The objectives of the Study are listed below;

1) To formulate a reduction plan of road vulnerability for the major roads in the Republic of Nicaragua,
2) To prepare detailed countermeasures for the high priority roads,
3) To prepare a manual for road vulnerability reduction, and
4) To execute technology transfer to the counterpart personnel in the course of the Study.

## 1.3 Area covered by the Study

The area of the Study shall cover the following Project Roads within major roads in the Republic of Nicaragua;

1) El Espino - San Benito (NIC. 1)
2) Sebaco - Jinotega (NIC. 3)
3) Matagalpa – La Dalia (NIC. 5)
4) Yalaguina - Las Manos (NIC. 15)
5) Chinandega - Guasaule (NIC. 24)
6) Telica - San Isidro (NIC. 26)

## 1.4 Work Schedule of the Study and Organization of the Study Team

The Study began in the beginning of February 2002 and has conducted for the draft final report at the beginning of December 2002. An overall work flow illustrating interrelationship of each activity in the Study is shown in Figure 1.4.1. The organization of the Study Team, the Advisory Committee of Japan International Cooperation Agency (hereinafter referred to as the "JICA") the Steering Committee of the GRN and the counterpart personnel assigned are summarized in Figure 1.4.2.

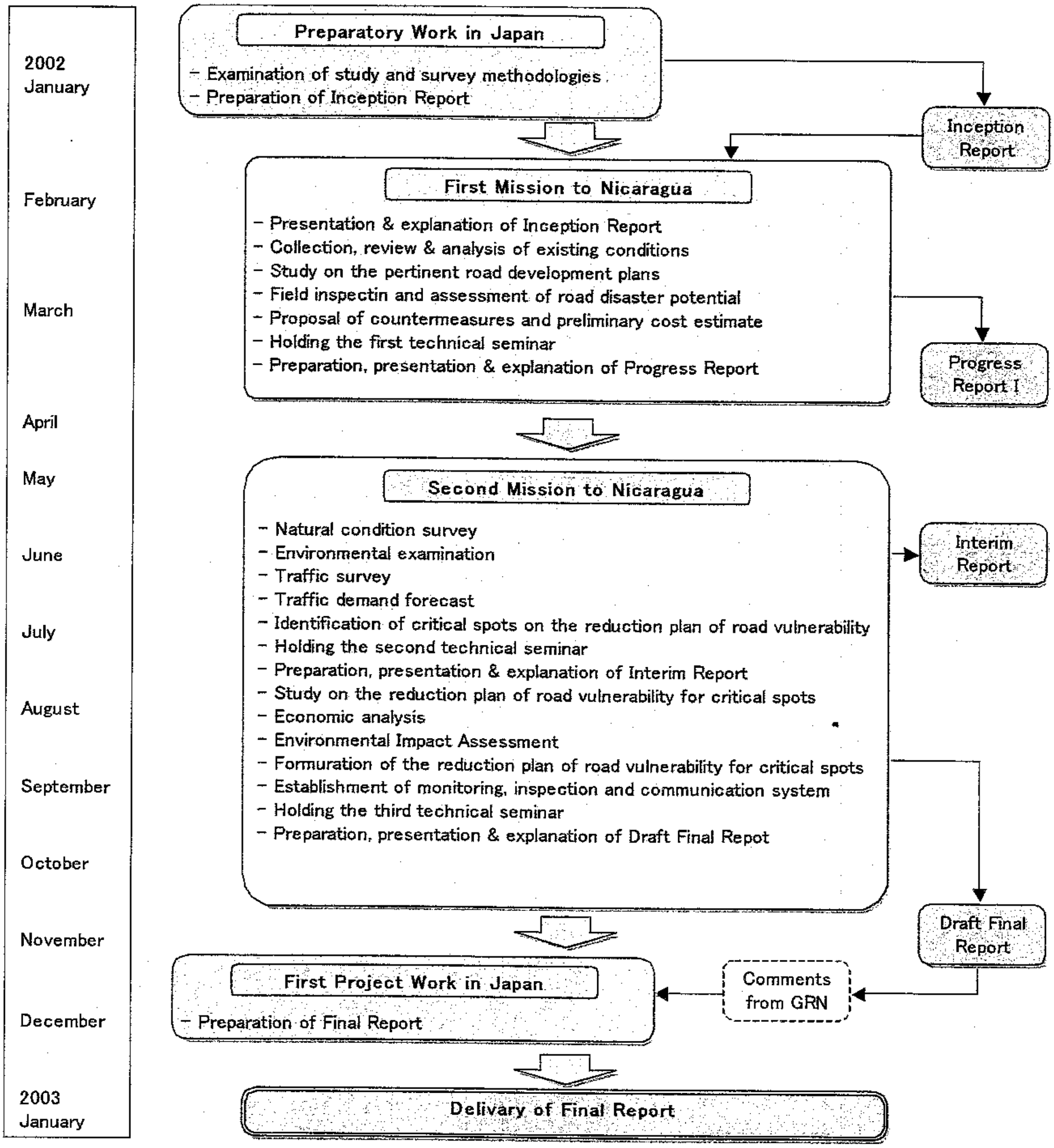



**Figure 1.4.1 Work Flow**

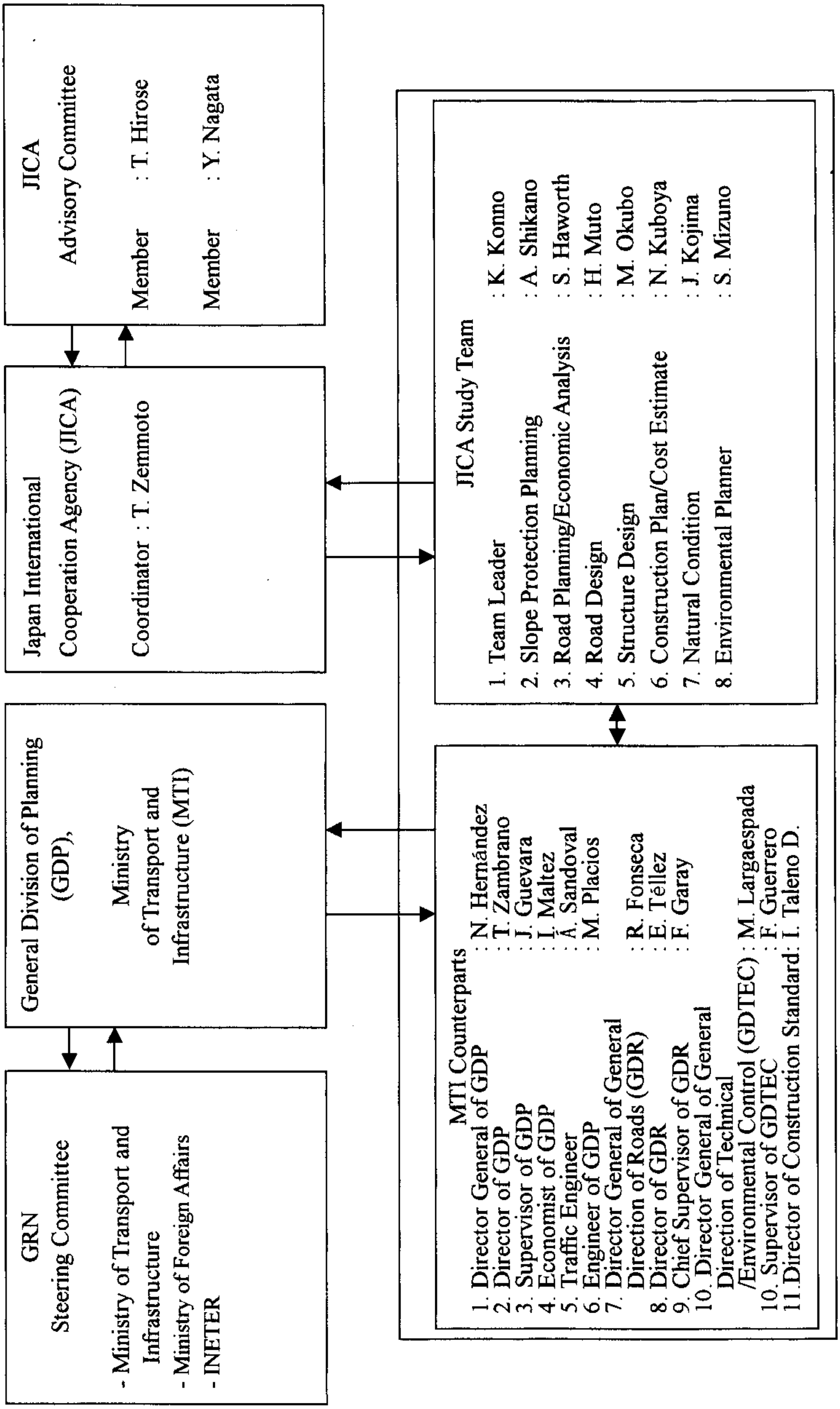



**Figure 1.4.2 Organization chart**

# PART A

## *IDENTIFICATION OF STUDY SPOTS*

# CHAPTER 2 NATURAL CONDITION OF STUDY AREA

## 2.1 Topography

The topographical characteristic of Nicaragua is divided into three areas :

- Pacific plains area (including the volcanic mountain range area);
- Central mountains range area;
- Atlantic coast plains area.

The land of the Pacific plains area is very fertile, being covered by weathered volcanic ash soil or alluvium. The Nicaraguan rift valley is laid between volcanic mountain range and central mountains range in this area and is mainly subsidence land. It contains two large lakes (Lake Managua and Lake Nicaragua). A volcanic mountain range is laid in middle of the Pacific plains area and running parallel with coast.

The central mountains range area consists of three Cordillera (Isabelia, Dariense and Chontalena) that radiate in all directions, with a large basin and mountain table less than 1, 500m high. This area decreases in altitude and falls to reach alluvial plains in the western lowlands.

The Atlantic coast plains area is typically 100m high, and around 150km wide. This area has many major rivers (Segovia, San Juan, Coco, Laguun de Perlas, Grande and Wawa). The south portion of this area is tropical and humid marshland.

The Study area of the roads NIC.1, NIC.3, NIC.5 and NIC.15 are located in the central mountains range area. NIC.24 and NIC.26 are located in the Pacific plains area.

## 2.2 Geology

Most of the bed rock in Nicaragua is composed of Mesozoic sedimentary rock, divided into the Matagalpa Facies and Rivas Facies of Jurassic, Upper and Lower Cretaceous periods. These rocks are covered widely with volcanic rock of the Tertiary Era which subsequently gushed out. They tend to be distributed in south-east of Iyas glabious zone of metamorphic rock. The black schist of Rivas Facies is distributed in a narrow area around NIC.1, NIC.3, NIC.15 and NIC.26.

The main rocks of volcanic lava distributed in the Study area are basaltic, andesite-basalt, andesite, rhyolite and other lava, with such effusive rocks as tuffbreccia, dacitic agglomerate of the Palaeocene Period, and lavas of quarts-andesite, pyroclastic rock, and welded tuff belonging to the Eocene Period. They are widely distributed along NIC.1, NIC.3, and NIC.26. These lava flows display erosion in combination with tuffs. The Mesa Plateau is composed of lava on top, with tuffs underneath, which, when weathered make a sharp slope. NIC1 displays this topography a good deal.

Along NIC.24, the volcanic rocks of the Quaternary Era are recognizable by the white Pleistocene tuffs, agglomerate, tuffs with pumice, andesite-quartz/andesite, and ryyolite. Relatively new un-cemented volcanic ash covers them

A hazard map is officially published based upon records of these volcanic activities. It is clear from this that NIC.24 and NIC.26 are most susceptible to volcanic activity due to the Western Nicaragua fracture. Records for all the seismic scale and seismic center distribution for 1992-1998 are also available and the distribution centres with 4.0 or more on the seismic scale is shown in Figure 2.2.1. The figure does not show the fracture but it can be used to forecast plate subsidence.

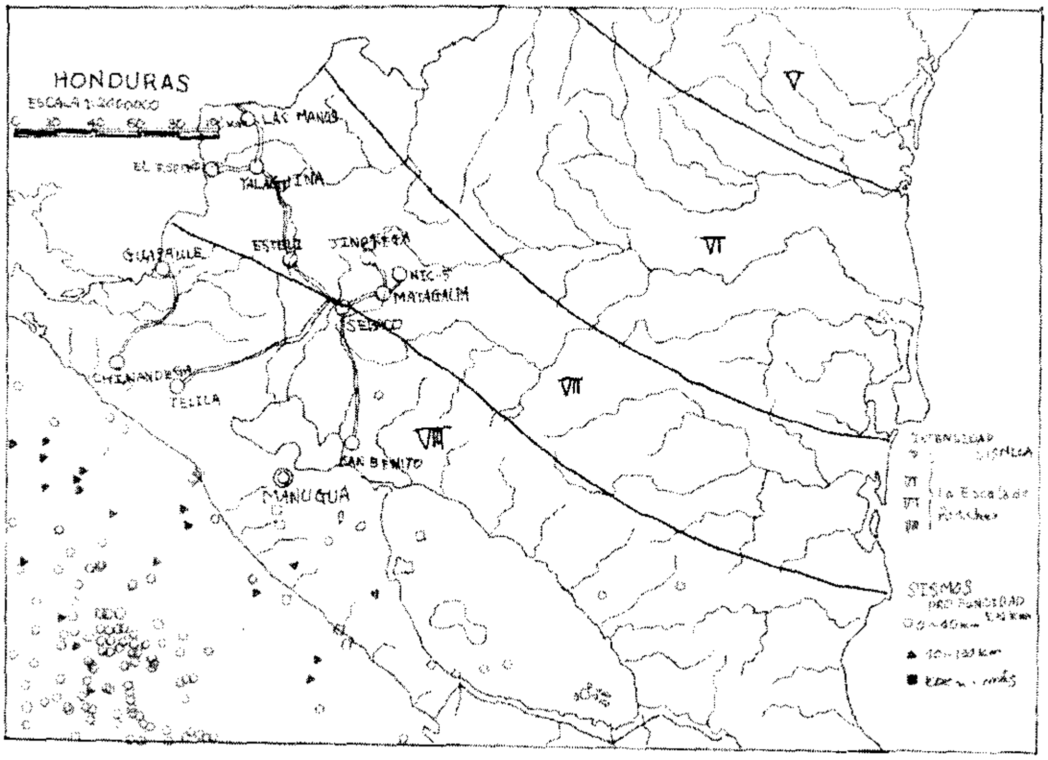
## 2.3 Meteorology

Nicaragua is in the tropics and semi-tropics. It has a rainy season and a dry season. The rainy season is from April to November, with the dry season period between December and March. The characteristic of precipitation and mean annual temperature around Study area are shown in Table 2.3.1.

**Table 2.3.1 Annual Mean Temperature and Precipitation**

| Direction | Area ($km^2$) | Annual mean Temperature (°C) | Annual mean Precipitation (mm) | Mean Altitude (m) |
|---|---|---|---|---|
| Chinandega | 4,926 | 27 | 800 - 1,500 | 144 |
| Esteli | 2,335 | 20 | 800 - 1,500 | 645 |
| Jinotenga | 9,755 | 20 | 1,000 - 2,000 | 736 |
| Leon | 5,107 | 26 | 800 - 1,300 | 134 |
| Matagalpa | 8,523 | 18 | 700 - 1,700 | 490 |
| Nueva Segovia | 3,123 | 20 | 1,000 - 1,700 | 688 |
| Madriz | 1,602 | 20 | 800 - 1,500 | 700 |

*Sources:* INTER




**Legend (Explanation for Seismic Intensity)**

| | | |
|---|---|---|
| **V** | Most people perceive and many are awakened. Unstable things fall down. | Acceleration: 10 - 21 |
| **VI** | All people perceive and many rush outdoor with surprise. | Acceleration: 21 - 44 |
| **VII** | Most people rush outdoor and poorly made things are damaged. | Acceleration: 44 - 94 |
| **VIII** | Strong buildings are damaged. Chimneys, monument, and walls fall down, and furniture falls sideways. Sand and mud gushes out and well water will change. | Acceleration: 94 - 202 |

Sources: INTER

**Figure 2.2.1 Seismic Intensity**

## 2.4 Hydrology

The hydrological watershed of Nicaragua is divided 2 directions, the Pacific watershed and Atlantic watershed. The Pacific watershed is subdivided into eight, and the Atlantic one is subdivided into 13. The characteristics of the watershed of Pacific side are generally cramped with rivers of less than 20km except for the Estero Real River. Their flows are not continuous and stream widths are narrow. Within the study area, NIC.1 NIC.3, NIC.5 and NIC.15 fall in the Atlantic watershed. NIC.24 and NIC.26 are mainly in the Pacific watershed.

# CHAPTER 3 NATIONAL DEVELOPMENT PLAN

## 3.1 Present Situation of Development Plan

The Government operates on a five year planning cycle. In addition, MTI published a National Transport Plan in 2001. The conclusions of the study were reported to the Government by MTI in January 2002. The study for this included the following:

- Volume I ; Survey Profile,
- Volume II ; Demand of Transport,
- Volume III ; Inventory of Road Net,
- Volume IV ; Road Net Department,
- Volume V ; Water System,
- Volume VI ; Air System,
- Volume VII; Road Diagnostic,
- Volume VIII; Model of Road Traffic,
- Volume IX ; Infrastructure Plan,
- Volume X ; Institutional Aspect, and
- Volume XI ; Action Plan.

## 3.2 Future Perspective

### 3.2.1 Economic Forecasts, 2000 – 2020

The macro-economic projections are based on the hypothesis of economic growth up to 6 % per year to 2010 followed by growth of 5.0 % to 5.5 % in next decade. By controlling growth the government aims to keep inflation in the first decade to around 6.5%, falling in the second decade to an annual average of 3.7%. The annual average rate of total investment in the economy is forecast to increase to 33.2% of GDP during by 2010, decreasing thereafter to an annual average of 30.2% of GDP.

Almost 80% of the public sector debt is committed to multilateral organizations and the Paris Club. Debt exceeds GDP almost threefold in Nicaragua. In the future, loans and donations of around US$400 million per year are expected during the 2000-2010 period. In the following second decade, external resources are expected to rise US$590 million per year, comprising transfers and foreign investments and income from the privatization of ports, airports, roads, energy, drinking water and communications.

### 3.2.2 Production Forecasts

GDP is forecast to grow from US$2,516.2 M in 2000 to US$4,613.5 M by 2010. During the following ten years, growth will decline resulting in a GDP of US$7,695.3 M by 2020, as shown in Table 3.2.1.

The main sectors contributing to GDP are agriculture, cattle, handicraft industry, construction, commerce, transport and communications. GDP per capita is forecast to rise from US$491.7 in 2000 to US$656.5 by 2010, and to US$800.0 level by 2020.

**Table 3.2.1 Production Forecasts 2000 – 2020 (Million US dollars)**

| CONCEPT | 2000 | 2005 | 2010 | 2015 | 2020 |
|---|---|---|---|---|---|
| GDP (constant) | 2,516.2 | 3,447.4 | 4,613.5 | 6,029.5 | 7,695.3 |
| Primary Sector | 737.2 | 1,013.5 | 1,370.2 | 1,802.8 | 2,324.0 |
| Agricultural & farm | 681.9 | 951.5 | 1,301.0 | 1,718.4 | 2,231.6 |
| Secundary Sector | 676.8 | 937.7 | 1,259.4 | 1,658.1 | 2,108.5 |
| Handcraft industry | 503.2 | 706.7 | 955.0 | 1,254.1 | 1,608.3 |
| Construction | 130.8 | 179.3 | 244.5 | 331.6 | 423.2 |
| Tertiary Sector | 1,102.2 | 1,496.2 | 1,983.9 | 2,568.6 | 3,262.8 |
| Commerce | 451.7 | 620.5 | 830.4 | 1,085.3 | 1,369.8 |
| General Goverment | 161.0 | 206.8 | 267.6 | 331.6 | 423.2 |
| Transport & Communication | 122.0 | 168.9 | 226.1 | 295.4 | 377.1 |
| **GDP per capita** | **491.7** | **574.1** | **656.2** | **732.1** | **797.4** |

Source: Own estimation

### 3.2.3 Fiscal Forecasts

The government expects savings to rise to around 10% of the GDP during the forecast period. Debt alleviation in combination with public investment should reduce the fiscal deficit, from 2.2% of GDP in 2000, to 1.0% of GDP by 2020. These forecasts are amplified in Table 3.2.2.

### 3.2.4 Monetary Perspectives

The regeneration of the financial system to support economic growth is forecast to be characterized by private sector credit rising from 44% of GDP in 2000, to 54.2% in 2010, and 60% by 2020, shown in Table 3.2.3.

### 3.2.5 Economic Sustainability

The ESAF programmes for the last three years relied on IMF, World Bank and the international community for financial assistance. In the future, the country needs to execute the full programme of structural reforms agreed with the above mulit-lateral organizations in a Policy Framework Paper (PFP).

From 1994, Nicaragua was admitted to the club of countries with ESAF programs. In 1998 second ESAF was signed.

The Nicaraguan economy has maintained some sustainability and stability since 1994. It is to be hoped that a reduction in the fiscal deficit can be achieved.

**Table 3.2.2 Fiscal Forecasts (Million US dolars)**

| CONCEPTS | 2000 | 2005 | 2010 | 2015 | 2020 |
|---|---|---|---|---|---|
| Current Saving of NFPS 1/ | 256,1 | 339,3 | 435,2 | 544,8 | 668,9 |
| Respect to GDP % | 10,0 | 10,0 | 10,0 | 10,0 | 10,0 |
| General deficit of PS 1/ | -56,1 | -50,6 | -64,8 | -56,1 | -68,9 |
| Respect to GDP % | -2,2 | -1,5 | -1,0 | -1,0 | -1,0 |
| General income of NFPS | 953,9 | 1229,9 | 1533,9 | 1920,4 | 2358,0 |
| Respect to GDP % | 37,3 | 36,3 | 35,3 | 35,3 | 35,3 |
| General Expense of NFPS | 989,5 | 1280,5 | 1598,7 | 1976,5 | 2426,9 |
| Respect to GDP % | 38,6 | 37,7 | 36,7 | 36,3 | 36,3 |
| Public Investment | 221,2 | 296,5 | 380,3 | 451,1 | 553,9 |
| Respect to GDP % | 8,6 | 8,7 | 8,7 | 8,3 | 8,3 |

1/: NFPS= Non Financial Public Sector; PS= Public Sector, include Central Bank.

Source: Own Estimation.

**Table 3.2.3 Monetary Forecasts (Million US dollars)**

| CONCEPTS | 2000 | 2005 | 2010 | 2015 | 2020 |
|---|---|---|---|---|---|
| Credit for Private Sector | 1125,5 | 1736,6 | 2357,0 | 3106,6 | 4036,1 |
| Respect to GDP % | 44,0 | 52,0 | 54,2 | 57,0 | 60,3 |
| Ready Cash (M3A) 1/ | 1868,3 | 3081,4 | 4399,9 | 5836,7 | 7376,0 |
| Respect to GDP % | 73,0 | 90,8 | 101,1 | 107,1 | 110,3 |
| Circulant | 303,5 | 554,4 | 911,2 | 1391,6 | 2011,1 |
| Respect to GDP% | 11,9 | 16,3 | 20,9 | 25,5 | 30,1 |
| Quasi Money | 332,1 | 547,7 | 782,1 | 1037,4 | 1311,0 |
| Respect to GDP % | 13,0 | 16,1 | 18,0 | 19,0 | 19,6 |
| Foreign Money deposits | 1232,8 | 1979,3 | 2706,7 | 3407,7 | 4053,9 |
| Respect to GDP % | 48,1 | 58,3 | 62,2 | 62,6 | 60,6 |

1/: Include deposits of Public Sector. Source: Own estimations.

# CHAPTER 4 ASSESSMENT OF ROAD DISASTER PREVENTION SPOTS

## 4.1 Assessment Procedure of Road Disaster Prevention

Road disasters are mainly classified into the following five items;

- Rockfolls, collapsing,
- Rock collapsing,
- Slope Slide,
- Debris Flow, and
- Scouring of Bridge foundation.

In order to execute the most effective road disaster prevention and to maintain road safety, road disaster prevention should satisfy the following assessment procedures.

- Execution of the screening for suggesting vulnerable spots,
- Execution of stability survey,
- Assessment of disaster potential spots,
- Assessment of disaster critical spots,
- Studies of countermeasures to the disaster critical spots, and
- Validity evaluation of each countermeasure.

The screening, the stability survey, and the assessment of disaster potential spots and disaster critical spots are described in this Chapter. Other items are described in each chapter.

## 4.2 Screening

The objectives of screening are as follows:

- Objective inspection of all potentially vulnerable spots,
- Early detection of vulnerable spots, and
- Characteristic grasp of vulnerable spots.

In screening inspection spots should be made an objective assessment. The check list to select inspection spots covers :

- Locations where clear disaster potential is confirmed; and
- Spots where it is necessary to inspect against past disaster records.

Screening against each disaster item is executed as follows.

**<Rockfalls, collapsing>**

- Spots at a cutting or embankment with a natural slope of fifteen (15) meters height or more, or with a natural slope of more than forty-five (45) degrees;
- Spots where there are unfixed stones or boulder stones on slope surfaces,
- Spots where there are vulnerable mechanics of soil or rock mechanics, and
- Spots at old or deteriorated countermeasures or where countermeasures need to be inspected.

**<Rock collapsing>**

- Spots at cuts and natural slopes of seven meters or higher.

**<Slope slide>**

- Critical spots;
- Potential disaster sites; and
- Sites where disaster prevention measures are require

**<Debris flow>**

- Spots where streams cross roads, bridges, and culverts (except where the stream is taken by a sunk tunnel, or where there is a clearance under the bridge deck height of 10 metres or more, or a span width of 20 meters over the stream;
- Spots with a basin area of 0.01 km2 or more,
- Spots where the stream bed above the road has a gradient of 10 degree or more; and
- Spots where the culvert gradient or stream bed beneath the road is 2 degrees or more.

**<Scouring of bridge foundation>**

- Where no scouring is evident at slow flowing rivers there is little risk;
- Simple span bridges without piers, with sturdy riverbank protection, and complete river improvements up and down stream are very low risk;,
- Where there is no damage at scouring protection around bridge foundations, and/or there is adequate scouring protection around the bridge foundations, then prevention measures adequate;
- There is little risk where there is adequate embedment depth, (15 meters or more) or it is eight times more than the pier width of the transverse direction, for pile and caisson foundation against either the deepest riverbed or design riverbed (the depth from riverbed to bearing stratum), and
- Bridges is less than 15 meters span have a high potential disaster risk

## 4.3 Stability Survey

Following screening, inspection spots should be subjected to a stability survey by using the stability survey sheets. Furthermore the calibration should be carried out after taking notes of the result to the stability survey sheets to reflect a balanced view of the team. The calibration method is shown in below example.

| Order | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
|---|---|---|---|---|---|---|---|
| Inspection spot (score) | A (80) | F (80) | G (60) | B (55) | D (50) | C (40) | E (30) |
| Calibration result (re-score) | ditto | ditto | ditto | B (70) | ditto | C (60) | E (40) |

After both engineers checked and discussed the survey results, the order of the stability survey results was changed as below.

| Order | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
|---|---|---|---|---|---|---|---|
| Inspection spot (score) | A (80) | F (80) | B (70) | G (60) | C (60) | D (50) | E (40) |

## 4.4 Assessment of Disaster Potential Spots

The stability survey sheets should be prepared in order to assess stability of each disaster potential spot. Disaster potential spots should be assessed by considering the following items:

- Topographical factors, soil/ rock mechanics, slope surface condition, its shape and transformation,
- Existing countermeasures,
- Disaster history.

The objective roads for this Study have different traffic volumes with large increases to 2020. Therefore, in this section, traffic volume is not considered as the assessment factor.

The score of each spots is different against disaster type. Therefore, selection of disaster potential spots should be assessed in order of highest score first. Where scores are higher than the threshold indicated below for each disaster type below, then the site is deemed a potential disaster spot.

Furthermore, disaster potential spots are defined as the following items:

- To exist boulder on slope surface,
- To exist many cracks on rock surfaces,
- To exist small rocks falling, and
- To exist disaster records regarding rock-fall, rock collapsing, slope slide, scouring of bridge foundation, and so on.

Important : Total scores for each disaster type vary, and should be factored to a common total of 100. All scores should therefore be factored by the appropriate ratio.

**For Bridges: 70 score over**

The score should be assessed from the following (on the stability survey sheet) : riverbed incline (15), bridge location (20), minimum span length (15), ratio of river flow blockage by piers (15), and clearance under the deck (10). The maximum score is 75 points. Therefore, the threshold for potential disaster spots for bridges is 70 score over. However, bridges with a score less than 70 should also be designated potential disaster spots where the bridge is located on a bend in the river, or where abutments protrude into the river, or where foundation piles are bent.

**For Cut/ embankment slope: 60 score over**

**Rockfalls and collapsing**. The most important factors are soil or rock structure (8 or 12), vulnerable mechanics (14), unfixed stones or boulder stones of slope surfaces (12), slope incline or height (18), and slope transformation (12). The maximum score of each factor is 64 or 68 points. The threshold for potential disaster spots for rockfalls and collapsing is 60 score over.

**Rock collapsing**. The most important factors are crack scale of rocks (30), continuous horizontal cracks (10), condition of soft or hard rocks (11 or 15), direction of bedrock (15). The maximum score 76 or 80 points. However, as total score is 126 points, an equivalent to 100 scores is calculated by 0.79. Each maximum score will be converted 60 points or 63 points. The threshold for potential disaster spots for rock collapsing is 60 score over.

**For Debris Flow: 60 score over**

Scoring factors are area of basin (10), steepest mountain torrents incline (10), area of slope incline of 30 degrees or more (8), and area of meadow, or trees (8). The maximum score in this way is 36 points. However, as total score is 56 points, an equivalent to 100 scores is calculated by 1.78. The maximum score will be converted 64 points. The threshold score is 60 score over.

## 4.5 Identification for Disaster Critical Spots

Disaster critical spots should be identified by considering the following items :

- Disaster scale/ records at area of spots,
- Spots where emergency treatment is required,
- Critical spots for third parties
- Topographic data by preliminary topographic survey, and
- Sketch of site conditions

### 1) Definition of Rockfalls/ Collapsing

[Factor A]

| Item | | Factor | Talud de corte: Clasificación | Notas | Potencial: Nota de Evaluación | Critico: Nota de Evaluación |
|---|---|---|---|---|---|---|
| Topografía | Topografía que tiene factor del colapso | G1:Talud deterítico en cono<br>G2:Huellas de desprendimiento :Línea de mella (nick line) es clara | Uno corresponde G1 | 3 | | |
| | | | No corresponde G1 | 0 | | |
| | | G3:Falda de terraza erosionada, voladizo, talud que concentra agua, huella de flujo de sedimentos | Varios corresponden G2,3 | 3 | | |
| | | | Corresponde G2,3 | 2 | | |
| | | | No corresponde G2,3 | 0 | | |
| | | G4:En la cresta hay cumbre, voladizo | Corresponde a G4 | | (6) | (6) |
| Suelo, Geología, Estructura | Suelo que se degrada | Suelo que fácilmente se erosiona (Suelo que pierde resistencia por absorver agua, otros) | Notable | 8 | | |
| | | | Algo notable | 4 | 8 | 8 |
| | | | No corresponde | 0 | (8) | (8) |
| | Calidad de roca erodable | Alta densidad de grietas o capa frágil<br>Rocas blandas facílmente erosionado<br>Calidad de erosionarse rápidamente | Notable | 12 | | |
| | | | Algo notable | 6 | 12 | 12 |
| | | | No corresponde | 0 | (12) | (12) |
| | Estructura de colapso | Capa de dirección deslizable (estratificación = línea débil) | Corresponde | 8 | | |
| | | | No corresponde | 0 | | |
| | | Suelos sobre rocas impermeables (Roca dura en la parte superior/la parte inferior blanda) | Notable | 6 | | |
| | | | Algo notable | 4 | | 14 |
| | | | No corresponde | 0 | (14) | (14) |
| Condición de la superficie del suelo | Condición del suelo superficial, roca desprendida y canto rodado | | Inestable | 12 | | |
| | | | Algo inestable | 6 | | |
| | | | estable | 0 | 12 | 12 |
| | Roca desprendida y canto rodado son inestable-algo inestable | | Corresponde | | (12) | (12) |
| | Situación de agua manantial | | Hay manantial | 8 | | |
| | | | Se rezuma un poco | 4 | | |
| | | | No hay | 0 | (8) | (8) |
| | Estado del cubrimiento del suelo | | Tierra desnuda-vegetación | 5 | | |
| | | | Compuesto (vegetación, estructura) | 3 | | |
| | | | Estructuras | 1 | (5) | (5) |
| Forma | Inclinación(i), Altura | | Suelo: H>30m | 18 | | |
| | | | Suelo: H≦30, i>norma | 15 | | |
| | | | Suelo: i≦norma,15 | 10 | | |
| | | | Suelo: i≦norma,15≦H<30 | 5 | | |
| | | | Roca: H≧50m | 18 | | |
| | | | Roca: 30≦H<50m | 16 | | |
| | | | Roca: 15≦H<30m | 12 | 18 | 18 |
| | | | Roca: H<15m | 10 | (18) | (18) |
| Deformación | Deformación de talud y pendiente (fisilidad, caída de rocas pequeñas, cárcavas, socavación, agujero de escorrentía, hundimiento, hinchamiento, árbol caide, grieta, grieta abierta, deformación de obras hechas) | | [illegible] | 12 | | |
| | | | Corresponde. No tan clar | 8 | 12 | 12 |
| | | | No hay | 0 | (12) | (12) |
| | Deformación de talud y pendiente cercanas (caída de rocas, derrumbe, grieta, hinchamiento, otros) | | Varios corresponden,algo claro | 5 | | |
| | | | Corresponde. No tan clar | 3 | | |
| | | | No hay | 0 | (5) | (5) |
| | | Total | talud: Total de notas | | 62 (A1) | 76 (A1) |

Yellow color items indicate the high factor in disaster potential spots. Therefore, the total score of each item should be 60 scores over at least.
Red color items indicate the much higher in disaster critical spots. Therfore, the total score of each item should be 70 scores over at least.

## 2) Rock Collapsing

[Factor A]

| Item | Factor | Clasificación | Nota | Potencial | Critico |
|---|---|---|---|---|---|
| Fenómeno, sintoma | Tamaño de grieta abierta | Grande | 30 | | |
| | | Pequeño | 15 | 30 | 30 |
| | | No existe | 0 | (30) | (30) |
| | Dirección de grieta continua horizontal | Hacia la dirección degradable | 10 | | |
| | | Hacia la dirección estable | 5 | 10 | 10 |
| | | No existe | 0 | (10) | (10) |
| | Derrumbe pequeño, caída de rocas | Existe | 7 | | |
| | | No existe | 0 | (7) | (7) |
| Estado de grietas | Roca dura | Existencia regular, distancia de cada una más de 1 m. | 15 | | |
| | | Existencia regular, distancia de cada una menos de 1 m. | 11 | | |
| | | Irregular | 7 | 15 | 15 |
| | | No existe | 0 | (15) | (15) |
| | Roca blanda | Existencia regular, distancia de cada una más de 1 m. | 11 | | |
| | | Existencia regular, distancia de cada una menos de 1 m. | 7 | | |
| | | Irregular | 4 | | |
| | | No existe | 0 | (11) | (11) |
| Composición de masa de roca | Parte superior es dura/parte inferior es blanda | | 7 | | |
| | Parte superior es blanda/parte inferior es dura | | 5 | | |
| | Todo blanda | | 2 | | |
| | Todo dura | | 0 | (7) | (7) |
| Buzamiento | Buzamiento quebradizo (dip slope) | | 15 | | |
| | Buzamiento estable | | 5 | 15 | 15 |
| | No existe | | 0 | (15) | (15) |
| Topografía | Inclinación de talud y pendiente | Voladizo | 4 | | |
| | | Más de 60° | 2 | | |
| | | Menos de 60° | 0 | (4) | (4) |
| | Altura de precipicio | Más de 100m. | 10 | | |
| | | 50-100m. | 7 | | |
| | | 30-50m. | 4 | 10 | 10 |
| | | Menos de 30m. | 2 | (10) | (10) |
| | Forma de pendiente | Pendiente de forma de cresta | 4 | | |
| | | Pendiente de talud deterítico | 3 | | |
| | | Pendiente de forma de valle | 1 | | 4 |
| | | Pendiente de forma intermedia de cresta y valle | 0 | (4) | (4) |
| | Línea de mella (Nick line) | Claro | 7 | | |
| | | irregular | 4 | | |
| | | No claro | 0 | (7) | (7) |
| Agua freática, lluvia | Manantial | Existe manantial | 4 | | |
| | | Después de lluvia se sale agua. | 2 | | 4 |
| | | | | (4) | (4) |
| | Sitio Donde Existe Manantial | Dentro de grietas verticales | 2 | | |
| | | Límita de estratos horizontales | 1 | | |
| | | Casi no se observa | 0 | (2) | (2) |
| | | Total | (A) | 80 (126) | 88 (126) |

Yellow color items indicate the high factor in disaster potential spots. Therefore, the total score of each item should be 60 scores over at least.
Red color items indicate the much higher in disaster critical spots. Therfore, the total score of each item should be 70 scores over at least.

### 3) Slope Slide

[Factor] (A)

| Item | | Punto de observación | | Nota | Potencial | Crituco |
|---|---|---|---|---|---|---|
| Terreno formado por deslizamiento de tierra | | Pendiente formada por deslizamiento de tierra, Terreno tipo meseta, Terreno de inclinación suave, Desorden de curva de nivel, Terreno fluido hacia el río, etc. | Claro | 30 | **30**<br>(30) | **30**<br>(30) |
| | | | Algo claro | 15 | | |
| | | | No claro | 7 | | |
| Geología, etc. | Estructura geológica | Falla, Zona de trituración | | 18 | <br>(18) | **18**<br>(18) |
| | | Zona de alteración volcánica, Suelo solfatárico | | 18 | | |
| | | Dirección deslizable de capa | | 14 | | |
| | | dirección estable de capa | | 7 | | |
| | | Forma de bloques (Estructura de roca intrusiva, de roca de cubierta) | | 3 | | |
| | | Otros | | 0 | | |
| | Edad geológica y Calidad de roca madre | Estrato mesozóico y paleozóico (esquisto cristalino, roca sedimentaria) | | 7 | <br>(7) | <br>(7) |
| | | Estrato terciario (roca sedimentaria) | | 7 | | |
| | | Estrato cuaternario (Sedimentos no solidificados o roca sedimentaria) | | 3 | | |
| | | Otros (Roca volcánica, Roca ígnea) | | 0 | | |
| | Manantial | Hay (incluye huella) | | 10 | **10**<br>(10) | **10**<br>(10) |
| | | No hay | | 0 | | |
| | | Total | | (A) | **40**<br>(65) | **58**<br>(65) |

Yellow color items indicate the high factor in disaster potential spots. Therefore, the total score of eac should be 60 scores over at least.
Red color items indicate the much higher in disaster critical spots. Therfore, the total score of each ite should be 70 scores over at least.

## 4) Debris Flow

[Factor] (A)

| Item | Factor | Clasificación | Nota | Potencial | Critico |
|---|---|---|---|---|---|
| Característica de arroyo | Superficie de la cuenca dañada por alud de fango. Superficie que tiene más de 15° de inclinación de lecho | Más de 0.50km2 | 10 | 10 (10) | 10 (10) |
| | | Más de 0.15km2 menos de 0.50km2 | 8 | | |
| | | Menos de 0.15km2 | 4 | | |
| | Inclinación máxima del lecho | Más de 40° | 10 | 10 (10) | 10 (10) |
| | | Más de 30° menos de 40° | 5 | | |
| | | Menos de 30° | 0 | | |
| Característica de pendiente | Superficie del pendiente que tiene más de 30° de inclinación | Más de 0.20km2 | 8 | 8 (8) | 8 (8) |
| | | Más de 0.08km2 menos de 0.20km2 | 6 | | |
| | | Menos de 0.08km2 | 2 | | |
| | Superficie ocupada por hierbas y arbustos (menos de 10m. de altura) | Más de 0.20km2 | 8 | 8 (8) | 8 (8) |
| | | Más de 0.02km2 menos de 0.20km2 | 4 | | |
| | | Menos de 0.02km2 | 0 | | |
| | Existencia de obra de suelo con suelos inestables | Existe | 5 | (5) | (5) |
| | | No | 0 | | |
| | Existencia de grietas y pendiente formada por desplazamiento nuevas | Existe | 5 | (5) | (5) |
| | | No | 0 | | |
| | Historia de derrumbe de dimensión relativamente grande | Existe | 10 | (10) | 10 (10) |
| | | No | 0 | | |
| | | Total | (A) | 36 (56) | 46 (56) |

Yellow color items indicate the high factor in disaster potential spots. Therefore, the total score of each item should be 60 scores over at least.
Red color items indicate the much higher in disaster critical spots. Therfore, the total score of each item should be 70 scores over at least.

## 5) Scouring of Bridge Foundation

(Items comúnes de estribo y pila de puente)

| Item | Factor | Clasificación | Nota | Potencial | Critico |
|---|---|---|---|---|---|
| Características de lecho y estructura de puente | Inclinación de lecho (es rápidos) | Más de 1/100 | 15 | 15 | 15 |
| | | Menos de 1/100 más de 1/250 | 10 | | |
| | | Menos de 1/250 | 0 | | |
| | Sitio de construcción (Estribo y pila de puente existen en sitio de mayor impacto de aguas o en sitio socavado) | Corresponde | 20 | 20 | 20 |
| | | No corresponde | | | |
| | Edad de puente | año≧50 años | 10 | | |
| | | 30≦ año<50 años | 5 | | |
| | | año<30 años | 0 | | |
| | Distancia mínima entre pilas | Menos de 10m. | 15 | 15 | 15 |
| | | Más de 10m. menos de 20m. | 10 | | |
| | | Más de 20m. | 0 | | |
| | Razón de bloqueo por pila | Más de 7% | 15 | 15 | 15 |
| | | Más de 5% menos de 7% | 5 | | |
| | | Menos de 5% | 0 | | |
| | Espacio libre debajo de viga | Menos de 30cm. | 10 | 10 | 10 |
| | | Más de 30cm. menos de 60cm. | 5 | | |
| | | Más de 60cm. | 0 | | |

| Item | Frecuencia (Promedio) | Nota (α) | Subtotal | | (A) (100-0) | (A) (100-0) |
|---|---|---|---|---|---|---|
| Rectificación por la frecuencia de ocurrencia de desastres | Los desastres ocurren más de 1 vez por cada 10 años alrededor del puente | 15 | (15) | Total | 75 | 90 |
| | Los desastres ocurren más de 1 vez por cada 5 años en el río | 10 | 15 | | | |
| | Los desastres ocurren más de 1 vez por cada 10 años en el río | 5 | | | | |
| | Otros | 0 | | | | |

Yellow color items indicate the high factor in disaster potential spots. Therefore, the total score of each item should be 70 scores over at least.
Red color items indicate the much higher in disaster critical spots. Therfore, the total score of each item should be 90 scores over at least.

# CHAPTER 5 IDENTIFICATION OF DISASTER POTENTIAL SPOTS

## 5.1 General

Based on the screening, the stability surveys were investigated at 167 vulnerable spots. As a result of the surveys, the whole disaster potential spots were identified at 90 spots. The identified spots of the objective roads are shown in from Table 5.2.1 to Table 5.2.10.

## 5.2 *Disaster potential Spots*

### 5.2.1 NIC. 1

**1) Vulnerable Slope**

**Table 5.2.1 Identified Disaster potential/ Critical Spots of Slopes on NIC. 1**

| No | Distance from Managua( km) | Serial No. | Type of disaster | Length (m) | Height (m) | Angle (degree) | Score | Disaster Potential Spot | Disaster Critical Spot |
|---|---|---|---|---|---|---|---|---|---|
| 1 | 50.0 | 30 | R.F. | 230 | 64 | 43° | 61 | * | |
| 2 | 52.4 | | R.F. | | | | 59 | | |
| 3 | 54.0 | | R.C. | | | | 54 | | |
| 4 | 55.7 | | R.F. | | | | 57 | | |
| 5 | 57.4 | | R.C. | | | | 57 | | |
| 6 | 59.3 | | R.C. | | | | 59 | | |
| 7 | 60.5 | | R.C. | | | | 45 | | |
| 8 | 60.9 | 29 | R.F. | 890 | 24 | 56° | 70 | * | * |
| 9 | 71.6 | | R.C. | | | | 42 | | |
| 10 | 73.2 | 28 | R.F. | 350 | 8 | 40° | 78 | * | * |
| 11 | 84.0 | | R.C. | | | | 50 | | |
| 12 | 129.1 | | R.C. | | | | 42 | | |
| 13 | 142.7 | 27 | R.C. | 370 | 50 | 63° | 68 | * | |
| 14 | 157.0 | 26 | R.C. | 110 | 12 | 63° | 68 | * | |
| 15 | 167.2 | 25 | R.C. | 280 | 8 | 66° | 55 | | |
| 16 | 168.4 | 24 | R.F. | 600 | 30 | 66° | 84 | * | * |
| 17 | 168.6 | 23 | R.C. | 280 | 30 | 70° | 72 | * | * |
| 18 | 169.0 | 22 | R.F. | 120 | 50 | 70° | 69 | * | |
| 19 | 169.8 | 20 | R.C. | 200 | 28 | 60° | 72 | * | * |
| 20 | 170.7 | 19 | R.C. | 440 | 64 | 60° | 72 | * | * |
| 21 | 171.3 | 17 | R.C. | 460 | 30 | 63° | 78 | * | * |
| 22 | 173.9 | 16 | R.F. | 500 | 30 | 43° | 67 | * | |
| 23 | 175.0 | 15 | R.C. | 130 | 15 | 60° | 76 | * | * |
| 24 | 176.2 | 12 | R.C. | 360 | 40 | 60° | 74 | * | * |
| 25 | 178.7 | 11 | R.F. | 240 | 28 | 60° | 76 | * | * |
| 26 | 183.5 | | R.F. | | | | 39 | | |
| 27 | 184.3 | | R.C. | | | | 47 | | |
| 28 | 187.3 | 10 | R.C. | 220 | 10 | 60° | 73 | * | * |
| 29 | 195.8 | 8 | R.C. | 120 | 8 | 60° | 68 | * | |
| 30 | 204.7 | 7 | R.C. | 120 | 16 | 63° | 73 | * | * |
| 31 | 206.4 | | R.C. | | | | 56 | | |
| 32 | 214.7 | 5 | R.F. | 110 | 12 | 43° | 70 | * | * |
| 33 | 231.9 | 4 | R.C. | 400 | 50 | 60° | 66 | * | |
| 34 | 232.5 | 3 | R.C. | 200 | 50 | 60° | 75 | * | * |
| 35 | 233.7 | 2 | R.F. | 230 | 28 | 50° | 73 | * | * |
| 36 | 235.6 | 1 | R.F. | 145 | 9 | 80° | 73 | * | * |
| Total | | | | | | | | 23 | 16 |

| | | Potential | Critical |
|---|---|---|---|
| R.F. | :Rock Fall | : 10 | : 7 |
| R.C. | :Rock Collapsing | : 13 | : 9 |
| S.S. | :Slop slide | : 0 | : 0 |
| D.F. | :Debris Flow | : 0 | : 0 |

## 2) Vulnerable Bridge

### Table 5.2.2 Identified Disaster Potential/ Critical Spots of Bridges on NIC. 1

| No. | Station (km) | Bridge Name | Length (m) | Span Length (m) | Year | Score | | Disaster Spots | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | Abutment | Pier | Potential | Critical |
| 1 | 35+190 | Los Novios | 6.70 | 5.60 | 1938 | 50 | -- | | |
| 2 | 39+868 | La Estatua | 8.70 | 7.50 | 1938 | 50 | -- | | |
| 3 | 40+960 | Qda. Honda | 7.00 | 5.00 | 1938 | 45 | -- | | |
| 4 | 42+433 | El Matadero | 14.30 | 13.50 | 1938 | 35 | -- | | |
| 5 | 84+430 | El Venado | 72.50 | 19+29+19 | 1973 | 30 | 25 | | |
| 6 | 87+437 | Qda. La Chingastosa | 21.00 | 19.50 | 1973 | 30 | -- | | |
| 7 | 107+992 | Zajón Negro | 21.70 | 20.70 | 1957 | 20 | -- | | |
| 8 | 108+980 | Río Viejo | 99.00 | 26.8+(3)22.6 | 1953 | 55 | 55 | | |
| 9 | 113+190 | Zanjón Blanco | 29.30 | 9+9+9 | 1956 | 75 | 90 | * | * |
| 10 | 125+220 | La Trinidad | 63.80 | 18.7+23.4+18.7 | 1957 | 70 | 60 | * | |
| 11 | 135+640 | San Nicolas | 18.60 | 17.60 | 1957 | 100 | -- | * | * |
| 12 | 135+860 | El Hatillo | 15.50 | 14.50 | 1957 | 70 | -- | * | |
| 13 | 150+330 | Las Chanillas (R.Estelí) | 62.00 | 17.8+24+17.8 | 1958 | 70 | 90 | * | * |
| 14 | 150+925 | El Rastro | 19.00 | 18.00 | 1957 | 30 | -- | | |
| 15 | 151+850 | San Ramón | 15.50 | 13.80 | 1957 | 100 | -- | * | * |
| 16 | 158+650 | La Sirena | 54.00 | 14.4+21.8+14.4 | 1956 | 60 | 65 | | |
| 17 | 159+470 | Río El Tular | 56.00 | 14.5+20.8+14.5* | 1956 | 80 | 85 | * | |
| 18 | 184+670 | Condega (Río Pire) | 63.60 | 18.6+23.4+18.6 | 1954 | 70 | 60 | * | |
| 19 | 191+680 | Ducualí(Río Pueblo Nuevo)* | 82.00 | 19.3+39.3+19.3 | 2000 | 45 | 50 | * | |
| 20 | 192+033 | Qda. Ducualí | 7.45 | 6.50 | 1954 | 60 | -- | | |
| 21 | 226+890 | Río Inalí | 64.0 | 19+24+19 | 1954 | 90 | 100 | * | * |
| 22 | 233+245 | RíoTapascalí | 109.0 | 17.8+21.3+26.7+21.3+17.8 | 1954 | 75 | 90 | * | * |
| | | | Total | | | | | 11 | 6 |

*The Ducuali Bridge length is less than the river width.

## 5.2.2 NIC. 3

### 1) Vulnerable Slope

**Table 5.2.3 Identified Disaster potential/ Critical Spots of Slopes on NIC. 3**

| No | Distance from Managua( km) | Serial No. | Type of disaster | Length (m) | Height (m) | Angle (degree) | Score | Disaster Potential Spot | Disaster Critical Spot |
|---|---|---|---|---|---|---|---|---|---|
| 1 | 3.9 | 42 | R.C. | 130 | 13 | 55° | 74 | * | * |
| 2 | 5.4 | 41 | R.C. | 60 | 15 | | 57 | | |
| 3 | 6.9 | 40 | R.C. | 170 | 20 | 46° | 72 | * | * |
| 4 | 7.4 | 37 | R.C. | 90 | 20 | 48° | 80 | * | * |
| 5 | 7.8 | 36 | R.F. | 93 | 23 | 46° | 61 | * | |
| 6 | 8.3 | 35 | R.C. | 60 | 15 | | 74 | * | |
| 7 | 9.3 | 34 | R.C. | 90 | 20+20 | | 42 | | |
| 8 | 9.6 | 33 | R.C. | 30 | 7+20 | | 42 | | |
| 9 | 22.1 | 32 | R.C. | 150 | 14 | 76° | 74 | * | * |
| 10 | 23.5 | 31 | R.C. | 170 | 13 | 55° | 69 | * | |
| 11 | 24.8 | 30 | R.C. | 55 | 12 | 53° | 64 | * | |
| 12 | 26 | 29 | R.C. | 220 | 20 | 51° | 69 | * | |
| 13 | 26.8 | 28 | R.F. | 50 | 12+20 | | 54 | | |
| 14 | 27.3 | 27 | R.F. | 80 | 7+20 | | 54 | | |
| 15 | 28.8 | 26 | R.C. | 60 | 10 | | 59 | | |
| 16 | 30.8 | 25 | R.F. | 140 | 23 | 40° | 62 | * | |
| 17 | 32.7 | 24 | R.C. | 110 | 14 | 57° | 70 | * | * |
| 18 | 32.9 | 23 | S.S. | 180 | 26 | 40° | 73 | * | * |
| 19 | 33.8 | 22 | R.F. | 80 | 15 | 37° | 64 | * | |
| 20 | 34 | 21 | R.F. | 50 | 15 | | 53 | | |
| 21 | 34.4 | 20 | R.F. | 68 | 12 | 43° | 69 | * | |
| 22 | 34.8 | 19 | R.F. | 55 | 15 | 48° | 67 | * | |
| 23 | 35 | 18 | R.F. | 125 | 21 | 49° | 61 | * | |
| 24 | 35.2 | 17 | D.F. | 150 | 30 | 43° | 83 | * | * |
| 25 | 35.9 | 16 | S.S. | 140 | 26 | 52° | 71 | * | * |
| 26 | 38.9 | 15 | S.S. | 192 | 30 | 34° | 90 | * | * |
| 27 | 39.4 | 14 | S.S. | 45 | 9 | 62° | 90 | * | * |
| 28 | 39.8 | 13 | R.F. | 90 | 30 | | 58 | | |
| 29 | 40 | 12 | R.C. | 180 | 28 | 67° | 81 | * | * |
| 30 | 40.7 | 11 | R.F. | 70 | 25 | | 50 | | |
| 31 | 45.9 | 10 | R.F. | 50 | 20 | | 56 | | |
| 32 | 49.5 | 9 | R.F. | 20 | 15 | | 46 | | |
| 33 | 51.2 | 8 | R.F. | 60 | 12 | 56° | 57 | | |
| 34 | 51.6 | 7 | R.F. | 20 | 15 | | 56 | | |
| 35 | 51.9 | 6 | R.F. | 40 | 15 | | 59 | | |
| 36 | 54.9 | 5 | R.F. | 90 | 16 | 50° | 63 | * | |
| 37 | 55.3 | 4 | R.F. | 86 | 20 | 64° | 63 | * | |
| 38 | 55.6 | 3 | R.F. | 60 | 15 | | 56 | | |
| 39 | 57.1 | 2 | R.F. | 150 | 10 | | 49 | | |
| 40 | 57.5 | 1 | R.C. | 90 | 15 | | 52 | | |
| Total | | | | | | | | 23 | 11 |

| | | Potential | Critical |
|---|---|---|---|
| R.F. | :Rock Fall | : 8 | : 0 |
| R.C. | :Rock Collapsing | : 10 | : 6 |
| S.S. | :Slop slide | : 4 | : 4 |
| D.F. | :Debris Flow | : 1 | : 1 |

### 2) Vulnerable Bridge

**Table 5.2.4 Identified Disaster Potential/ Critical Spots of Bridges on NIC. 3**

| No. | Station (km) | Bridge Name | Length (m) | Span Length (m) | Year | Score | | Disaster Spots | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | Abutmrent | Pier | Potential | Critical |
| 1 | 119+050 | El Guayacan | 17.5 | 3.3 | 1945 | 100 | 100 | * | * |
| 2 | 122+053 | Los Cocos | 7.0 | 3.3 | 1945 | 70 | -- | * | |
| Total | | | | | | | | 2 | 1 |

## 5.2.3 NIC. 5

**Table 5.2.5 Identified Disaster potential/ Critical Spots of Slopes on NIC. 5**

| No | Distance from Matagalpa (km) | Serial No. | Type of disaster | Length (m) | Height (m) | Angle (degree) | Score | Disaster Potential Spot | Disaster Critical Spot |
|---|---|---|---|---|---|---|---|---|---|
| 1 | 24.6 | 1 | R.F. | 200 | 87 | 50° | 76 | * | * |
| Total | | | | | | | | 1 | 1 |

| | | Potential | Critical |
|---|---|---|---|
| R.F. | :Rock Fall | : 1 | : 1 |
| R.C. | :Rock Collapsing | : 0 | : 0 |
| S.S. | :Slop slide | : 0 | : 0 |
| D.F. | :Debris Flow | : 0 | : 0 |

## 5.2.4 NIC. 15

**Table 5.2.6 Identified Disaster potential/ Critical Spots of Slopes on NIC. 15**

| No | Distance from Managua(km) | Serial No. | Type of disaster | Length (m) | Height (m) | Angle (degree) | Score | Disaster Potential Spot | Disaster Critical Spot |
|---|---|---|---|---|---|---|---|---|---|
| 1 | 9.9 | 1 | D.F. | 45 | 7 | | 70 | * | * |
| 2 | 11.1 | 2 | D.F. | 65 | 8 | | 70 | * | * |
| 3 | 11.2 | 3 | R.F. | 135 | 50 | 44° | 67 | * | |
| 4 | 11.5 | 4 | R.F. | 80 | 24 | 45° | 65 | * | |
| 5 | 11.7 | 5 | D.F. | 70 | 3 | | 70 | * | * |
| 6 | 13.6 | 6 | D.F. | 100 | 1 | | 70 | * | * |
| 7 | 21.1 | | | | | | 50 | | |
| 8 | 26.2 | | | | | | 58 | | |
| 9 | 26.6 | | | | | | 50 | | |
| 10 | 27.6 | | | | | | 49 | | |
| 11 | 28.0 | | | | | | 46 | | |
| 12 | 28.8 | | | | | | 43 | | |
| 13 | 29.5 | | | | | | 56 | | |
| 14 | 31.3 | | | | | | 56 | | |
| 15 | 32.7 | | | | | | 43 | | |
| 16 | 34.9 | | | | | | 51 | | |
| 17 | 41.7 | | | | | | 54 | | |
| 18 | 42.1 | | | | | | 48 | | |
| | | | | | | | | | |
| Total | | | | | | | | 6 | 4 |

| | | Potential | Critical |
|---|---|---|---|
| R.F. | :Rock Fall | : 2 | : 0 |
| R.C. | :Rock Collapsing | : 0 | : 0 |
| S.S. | :Slop slide | : 0 | : 0 |
| D.F. | :Debris Flow | : 4 | : 4 |

### 5.2.5 NIC. 24

#### 1) Vulnerable Slope

**Table 5.2.7 Identified Disaster potential/ Critical Spots of Slopes on NIC. 24**

| No | Distance from Managua( km) | Serial No. | Type of disaster | Length (m) | Height (m) | Angle (degree) | Score | Disaster Potential Spot | Disaster Critical Spot |
|---|---|---|---|---|---|---|---|---|---|
| 1 | 17.5 | 1 | R.F. | 190 | 21 | 44° | 55 | | |
| 2 | 28.5 | 2 | R.C. | 140 | 16 | 55° | 63 | * | |
| Total | | | | | | | | 1 | 0 |

| | | Potential | Critical |
|---|---|---|---|
| R.F. | :Rock Fall | : 1 | : 0 |
| R.C. | :Rock Collapsing | : 1 | : 0 |
| S.S. | :Slop slide | : 0 | : 0 |
| D.F. | :Debris Flow | : 0 | : 0 |

#### 2) Vulnerable Bridge

**Table 5.2.8 Identified Disaster potential/ Critical Spots of Bridges on NIC. 24**

| No. | Station (km) | Bridge Name | Length (m) | Span Length (m) | Year | Score | | Disaster Spots | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | Abutmrent | Pier | Potential | Critical |
| 1 | 132+055 | *El Hogar (La Mora)* | 5.6 | 4.5 | | 20 | -- | | |
| 2 | 143+000 | San Ramón1 | 20.5 | 20.0 | 2001 | 70 | 55 | * | |
| 3 | 183+988 | Chocolatero | 8.6 | 7.7 | | 50 | -- | | |
| 4 | 189+111 | La Culebra | 14.4 | 13.0 | | 70 | -- | * | |
| 5 | 197+929 | Río Negro | 64.8 | 29+2(30)+29 | 2001 | 50 | 40 | | |
| 6 | 198+675 | San Antonio | 10.3 | 9.0 | 1968 | 35 | -- | | |
| 7 | 201+520 | Tecomapa | 16.3 | 15.0 | 1968 | 40 | -- | | |
| Total | | | | | | | | 2 | 0 |

### 5.2.6 NIC. 26

#### 1) Vulnerable Slope

**Table 5.2.9 Identified Disaster potential/ Critical Spots of Slopes on NIC. 26**

| No | Distance from Managua( km) | Serial No. | Type of disaster | Length (m) | Height (m) | Angle (degree) | Score | Disaster Potential Spot | Disaster Critical Spot |
|---|---|---|---|---|---|---|---|---|---|
| 1 | 9.0 | 1 | R.F. | 105 | 18 | 43° | 71 | * | * |
| 2 | 12.7 | 2 | R.F. | 235 | 13 | 62° | 70 | * | * |
| 3 | 19.9 | 3 | R.F. | 160 | 20 | 53° | 71 | * | * |
| 4 | 20.9 | 4 | R.F. | 115 | 19 | 65° | 72 | * | * |
| 5 | 22.7 | 5 | R.F. | | | | 64 | * | |
| 6 | 24.7 | 6 | R.F. | 160 | 16 | 55° | 70 | * | * |
| 7 | 26.6 | 7 | R.F. | | | | 37 | | |
| 8 | 28.5 | 8 | R.F. | 65 | 12 | 50° | 67 | * | |
| 9 | 29.1 | 9 | R.F. | | | | 59 | | |
| 10 | 29.3 | 10 | R.F. | 77 | 19 | 41° | 76 | * | * |
| 11 | 29.8 | 11 | R.C. | 110 | 13 | 58° | 73 | * | * |
| 12 | 30.0 | 12 | R.C. | 100 | 16 | 66° | 68 | * | |
| 13 | 33.6 | 13 | R.F. | 60 | 11 | 58° | 72 | * | * |
| 14 | 34.0 | 14 | R.C. | 300 | 16 | 65° | 80 | * | * |
| 15 | 34.2 | 15 | R.F. | 150 | 52 | 54° | 85 | * | * |
| 16 | 37.0 | 16 | R.C. | 90 | 24 | 76° | 86 | * | * |
| 17 | 39.1 | 17 | R.F. | | | | 41 | | |
| 18 | 39.8 | 18 | R.F. | | | | 40 | | |
| 19 | 40.3 | 19 | R.F. | | | | 50 | | |
| 20 | 40.8 | 20 | R.F. | | | | 53 | | |
| 21 | 45.5 | 21 | R.C. | 280 | 32 | 52° | 71 | * | * |
| Total | | | | | | | | 15 | 12 |

| | | Potential | Critical |
|---|---|---|---|
| R.F. | :Rock Fall | : 10 | : 8 |
| R.C. | :Rock Collapsing | : 5 | : 4 |
| S.S. | :Slop slide | : 0 | : 0 |
| D.F. | :Debris Flow | : 0 | : 0 |

#### 2) Vulnerable Bridge

**Table 5.2.10 Identified Disaster potential/ Critical Spots of Bridges on NIC. 26**

| No. | Station (km) | Bridge Name | Length (m) | Span Length (m) | Year | Score | | Disaster Spots | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | Abutment | Pier | Potential | Critical |
| 1 | 104+182 | La Cotorra | 8.6 | 7.0 | 1963 | 40 | -- | | |
| 2 | 104+657 | Figueroa | 9.4 | 5.5 | 1963 | 40 | -- | | |
| 3 | 105+300 | Santa Ana | 8.2 | 5.5 | 1963 | 55 | -- | | |
| 4 | 106+020 | Los Pedrones | 6.4 | 3.7 | 1963 | 60 | -- | | |
| 5 | 106+687 | Quimera | 17.7 | 5+5+5 | 1964 | 65 | 65 | | |
| 6 | 107+533 | Solís | 7.2 | 4.6 | 1963 | 100 | -- | * | * |
| 7 | 108+154 | Papalón | 5.1 | 3.5 | 1963 | 90 | -- | * | * |
| 8 | 108+784 | La Higuera | 9.5 | 5.8 | 1963 | 55 | -- | | |
| 9 | 114+044 | San Jacinto | 7.6 | 6.9 | 1964 | 50 | -- | | |
| 10 | 119+963 | La Milagrosa | 8.6 | 7.0 | 1964 | 60 | -- | | |
| 11 | 125+674 | Santa Amalia (Malpaisillo) | 16.5 | 15.4 | 1964 | 30 | -- | | |
| 12 | 145+617 | El Caimito | 31.8 | 10+10.2+10 | 1966 | 55 | 45 | | |
| 13 | 148+051 | Tionoste | 19 | 18.0 | 1966 | 30 | -- | | |
| 14 | 156+785 | San Juan de Dios | 17.9 | 7.5+7.5 | 1965 | 90 | 70 | * | * |
| 15 | 164+125 | El Jicaral | 130 | 4(32.5) | 2001 | 70 | 55 | * | |
| 16 | 169+544 | Las Pilas | 8.5 | 8.0 | 1966 | 70 | -- | * | |
| 17 | 170+952 | La Banderita | 31.6 | 6.6+15.4+6.6 | 1966 | 100 | 65 | * | * |
| 18 | 190+265 | La Manga No. 1 | 10.6 | 9.3 | 1966 | 55 | -- | | |
| Total | | | | | | | | 6 | 4 |