CHAPTER 5

SURVEY RESULT AND IDENTIFICATION OF POTENTIAL SPOTS

CHAPTER 5 SURVEY RESULT AND IDENTIFICATION OF POTENTIAL SPOTS

5.1 NIC.1

5.1.1 Geological Characteristics

The volcanic rocks of Tertiary Era (after 25 million years) widely distributed along the whole section of NIC.1 starting from San Benito. These volcanic rocks belong to Group Coyol and those as spouted out alternately andesite lava flow and volcanic ash, and the then volcanic ash turned into solid mass and became bedrock called tuff. This history of eruption lasted long and similar lava flow and tuff were repeatedly distributed from the hilly area starting the West-side of Las Maderas on NIC.1 and reaching the border with Honduras. Figure 5.1.1 shows the schematic profile.

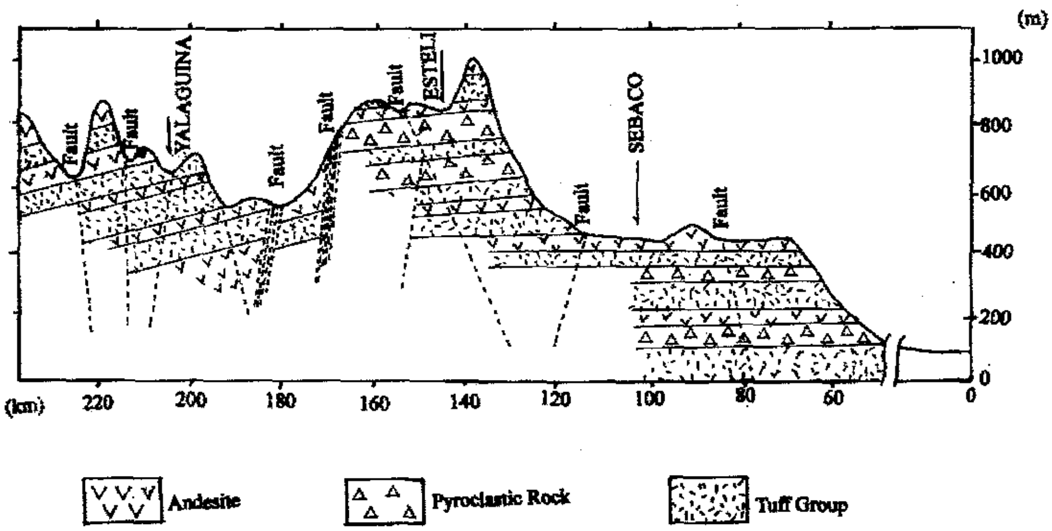

Figure 5.1.1 Schematic Profile of NIC.1

Pyroclastic rock with some red-color and tuff are distributed and the top of the hilly area is consisted of andesite lava flow forming Mesa topography. The height of this hilly area is some 350 m but the topographic feature of the Tertiary Rock landslide is still left. And there also found the topographic feature of landslide in East-side faced with the National Highway and West-side which lies between the ridge. At present, no problems are found as debris soil is falling out but water will seep out easily as water catchment topography is still left. At the location about 9 km North of this site (joint of 2953-II and 2953-I of 1/50000 map), rain water is flowing into a mountain stream along the road surface as affected by the topography peculiar to lava plateau. Therefore, embankment is prone to damages due to surface water and seepage water so drainage should be facilitated. Catchment area at the area near Luguna Lake can be functioned as adjustment reservoir. The area between Ciudad Dario through Sebaco is also lava plateau and scattered with weathered andesite in rubble stones. In some parts, round gravels also distribute so there exist a thin Alluvial deposits. There are no topography forming soft soil ground, rather weathered as it is the surface of the lava flow and only weeds are infested (pastureland) as there found no soil. The section of 13 km between Sebaco and San Isidro is the edge of the lava plateau of Mesa topography and water will come out easily. This route passes along the sharp cliff of the lower part of the lava plateau in Mesa topography starting San Isidro, so the short primary valleys continue on the South of the road. Therefore, slight collapse occurred on the weathered zone of pyroclastic rocks and tuff. There found no geological problems in the section of 17 km between Esteli and Santa Adalaide as it is located on the lava plateau, but large cut continues as it goes up the lava plateau from Santa Adelaide. Most of them are composed of alternate layers of andesite lave and tuff but there found small faults, pyroclastic or weathered zone of tuff, therefore, small falling rocks are seen due to loosening after cutting. Meantime, the valleys at around 170 km is complicated and composed of wide stream system including tertiary valley as the topography is those as peculiar to lava plateau, and the construction is underway to prevent water to easily come out. Mainly weathered tuff is distributed between Oondega and Yalaguina. Weathered zone is developed irregularly on the slope face and is prone to exfoliation from non-permeability bedrock when it rains. There seems to be many faults of North-East/South-West in the section from Yalaguina to the border of Honduras. As the typical slope, the tuff of the slope under construction located at 7.9 km from Yalaguina is chloritized as affected by fault activities and by thermal metomorphism , and has become to be clayey. Therefore, displacement is seen considerably on the slope.

5.1.2 Condition of Cut/ Embankment Slopes

Stability study for the slope is described in the preceding Chapter as the factors are closely related to topography and geology. Evaluation of each site is also discussed in Sub-section 5.1.4 and so the main features of the site is stated here (distance is calculated from Managua);

The site at 60 km, the road was largely displaced because the embankment was on the sheep slope of the mountain valley and the drainage facilities of the road surface were not sufficient.

For the section at 17 km from San Isidro (about 120 km), small collapse of the weathered zone of the primary valley's tuffs occurred at 9 locations on the sharp cliff of Mesa plateau.

For the section at 13 km from Santa Adelaida (about 160 km point), the slope also corresponds to the sharp cliff of Mesa plateau as in the preceding item. Therefore, some parts have complicated stream system of the tertiary valley and the primary valley as a matter of course, and the reinforcement construction works are being carried out. Weathering is seen on the slope which is caused by the loosening after the construction.

There found many faults from Yalaguina to the border with Honduras, especially the displacement of the slope at 7.9 km from Yalabuina is remarkable.

5.1.3 Condition of Bridges

1) General

NIC.1 runs 205 km between SanBenito and El Espino through the Departments of Managua, Matagalpa, Eesteli, and Madriz. MTI is currently making a list of all the bridges on this section. This Bridge Inventory shows the station number, name, present condition, length, total width, effective width, effective span, clearance, type, design load and age of the bridge. This is shown as Table 5.1.1. A reconnaissance was made of each site and the information in the Bridge Inventory was confirmed. There are twenty five (25) object bridges in NIC.1.

Table 5.1.1 Bridge Inventory for NIC.1

No.	STATION PKM	NOMBRE DEL TRAMO	NAME	PRESENT SITUATION	BRIDGE LENGTH (M)	ROAD WIDTH (M)	TOTAL WIDTH (M)	SPAN LENGTH (M)	FREE SPACE (M)	TYPE	DESIGN LOAD
1	35+190	Emp. San Benito - La Trinidad	Los Novios	BUENO	6.70	9.70	10.30	5.60	4.50	CONC.	HS-15-44
2	39+868	Emp. San Benito - La Trinidad	La Estatua	BUENO	8.70	9.70	10.30	7.50	4.40	CONC.	HS-15-44
3	40+960	Emp. San Benito - La Trinidad	Qda. Honda	BUENO	7.00	9.70	10.30	5.00	5.50	CONC.	HS-15-44
4	42+433	Emp. San Benito - La Trinidad	El Matadero	BUENO	14.30	9.70	10.30	13.50	5.30	CONC.	HS-15-44
5	50+460	Emp. San Benito - La Trinidad	Las Maderas	BUENO	53.50	7.90	10.90	47.50	7.60	CONC.	HS-15-44
6	84+430	Emp. San Benito - La Trinidad	El Venado	BUENO	72.50	9.70	10.20	19+29+19	16.00	CONC.	HS-15-44
7	87+437	Emp. San Benito - La Trinidad	Qda. La Chingastosa	BUENO	21.00	9.70	10.30	19.50	8.20	CONC.	HS-15-44
8	103+640	Emp. San Benito - La Trinidad	Sébaco	BUENO	52.00	7.90	13.00	38.00	7.00	CONC.	HS-20+25%
9	107+992	Emp. San Benito - La Trinidad	Zajón Negro	BUENO	21.70	7.40	8.60	20.70	4.60	MIXTO	HS-15-44
10	108+980	Emp. San Benito - La Trinidad	Río Viejo	BUENO	99.00	7.40	8.60	26.8+(3)22.6	16.00	MIXTO	HS-15-44
11	113+190	Emp. San Benito - La Trinidad	Zanjón Blanco	BUENO	29.30	7.30	8.60	9+9+9	3.60	CONC.	HS-15-44
12	125+220	Emp. San Benito - La Trinidad	La Trinidad	BUENO	63.80	7.40	8.60	18.7+23.4+18.7	7.00	MIXTO	HS-15-44
13	135+640	La Trinidad - Esteli	San Nicolas	BUENO	18.60	7.30	8.60	17.60	7.70	MIXTO	HS-15-44
14	135+860	La Trinidad - Esteli	El Hatillo	BUENO	15.50	7.30	8.60	14.50	5.50	CONC.	HS-15-44
15	150+330	Esteli - Emp. Yalaguina	Las Chanillas (R.Esteli)	BUENO	62.00	7.30	8.60	17.8+24+17.8	7.00	MIXTO	HS-15-44
16	150+925	Esteli - Emp. Yalaguina	El Rastro	BUENO	19.00	7.30	8.60	18.00	6.00	CONC.	HS-15-44
17	151+850	Esteli - Emp. Yalaguina	San Ramón	BUENO	15.50	7.30	8.00	13.80	4.60	CONC.	HS-15-44
18	158+650	Estelí - Emp. Yalaguina	La Sirena	BUENO	54.00	7.30	8.60	14.4+21.8+14.4	15.00	MIXTO	HS-15-44
19	159+470	Estelí - Emp. Yalaguina	Río El Tular	BUENO	56.00	7.30	8.60	14.5+20.8+14.5*	10.50	CONC.	HS-15-44
20	184+670	Esteli - Emp. Yalaguina	Condega (Río Pire)	BUENO	63.60	7.30	8.60	18.6+23.4+18.6	7.00	MIXTO	HS-15-44
21	191+680	Estelí - Emp. Yalaguina	Ducualí(Río Pueblo Nuevo)	BUENO	82.00	7.30	9.40	19.3+39.3+19.3	8.50	MIXTO	HS-20-44+25%
22	192+033	Estelí - Emp. Yalaguina	Qda. Ducualí	BUENO	7.45	7.30	8.60	6.50	4.70	CONC.	HS-15-44
23	203+238	Esteli - Emp. Yalaguina	Los Encuentros	BUENO	40.60	6.90	8.80	39.00	7.50	CONC	HS-20-44+25%
24	226+890	Somoto - El Espino	Río Inalí	Bueno	64	7.2	8.6	19+24+19	7	MIXTO	HS-15-44
25	233+245	Somoto . El Espino	RíoTapacalí	Bueno	109	7.2	8.6	17.8+21.3+26.7 +21.3+17.8	9.5	MIXTO	HS-15-44

Natural conditions on NIC.1 are shown in Table 5.1.2.

Table 5.1.2 Natural Conditions on NIC.1

Section (Department)	The lay of the land	Elevation	Temperature (℃)	Precipitation (mm)	Bridge name	River name
San Benito ~ Las Maderas (Managua)	Low land	30m ~ 100m	27.5	700 ~ 1200	Los Novios La Estatua Qda.Honda El Matadero Las Maderas	(Managua lake)
Las Madoras ~ Sebaco (Matagalpa)	Mountain	400m ~ 600m	27.5 ~ 25.6	500 ~ 1000	El Venado Qda.LaChing Sebaco	Grande de Matagalpa
Sebaco ~ La Trinidad (Matagalpa)	Basin	600m	25.6	500 ~ 1700	Zajón Negro Río Viejo Zanj ó n	Rio Viejo
La Trinidad ~ Esteli (Esteli)	Mountain	600m ~ 800m	25.6 ~21.4	800 ~ 1500	La Trinidad El Hato El Hatillo	La Trinidad (Rio Viejo)
Esteli (Esteli)	Basin	600m ~ 800m	21.4	800 ~ 1500	Las (R.Estelí) El Rastro San Ramón	Rio Esteli (RioCoco)
Esteli ~ Yalaguina (Esteli)	Mountain	700m ~ 800m	21.4 ~ 24.2	500 ~ 1300	La Sirena Río El Tular Condega (R Ducualí (Río Pueblo Qda. Ducual Los	(RioCoco)
Yalaguina ~ El Espino (Madriz)	Mountain land	700m	24.2	700 ~ 1500	Río Inalí RíoTapacalí	(Rio Coco)

2) History of Past Disaster

Many of the bridges between Esteli and El Espino suffered serious damage from Hurricane Mitch. Ducuali Bridge and Los Encuentros Bridge were destroyed, and these were reconstructed in 2000. The main damage to the other bridges was to river-banks in front of abutments, and to piers and approach roads.

Las Maderas Bridge and Sebaco Bridge were completed one year before Hurricane Mitch and survived the vent without damage. The other major disaster that affected NIC.1 was the Managua Eatthquake of December 23rd 1972. A report of this earthquake, by American Iron and Steel Institute, recorded that the only observed earthquake effect on these bridges was a minor settling of approach fills.

3) Condition of Bridges

The lengths of the four new bridges on NIC.1 (Las Maderas, Sebaco, Ducuali and Los Encuentros), are all more than 50m. Las Maderas and Sebaco bridges were constructed as single spans in 1997 with aid from the Government of Japan, replacing old deteriorated bridges. Ducuali and Los Encuentros bridges were reconstructed with the help of BCIE. Ducuali Bridge is now a three-span costruction with a rigid frame pier. Los Encuentros Bridge is a single span (shown as Photo5.1.4). The remaining bridges have the following characteristics:

i) The minimum distance between abutment and pier, or pier and pier is too short;
ii) Abutments protrude into the river; and
iii) The river channel is constrained by with bridge.

MTI supplied drawings to the study team of Zanjon Blanco Bridge, La Sirena Bridge, Condega Bridge, Ducuali Bridge and Los Encuertros Bridge. These were reviewed and it was confirmed that the river blockage ratio, lies in the range 5% to 7 %.

The riverbed in the low land near Managua, and in basin areas of Sebaco and Esteli, consists of soils or sand and the grade of the bed is gradual. In the mountainous region, from Las Maderas to Sebaco, from La Trinidad to Esteli, and from Esteli to El Espino, riverbeds consist of rock or gravel mixed with cobble and the grade of the beds are steep.

No scouring of the riverbed, in the flatland near Managua and periphery of Sebaco, was observed. However, traces of major scouring were observed in the mountainous region of Esteli and Northward. It is unsurprising that Hurricane Mitch caused such severe damage in this area. In addition, the Study Team observed damage to the bank and revetement at RíoTapacalí Bridge, traces of serious scouring at San Nicolas Bridge, and traces of scouring around the pier and erosion damage to the wingwall.

5.1.4 Survey Results of Screening

1) Survey of Slopes

NIC.1 runs through a mountainous area North of San Benito town,between Esteli town and the border village of El Espino. 36 screening spots were identified on NIC.1 consisting 13 rock fall locations and 23 rock collapsing sites.

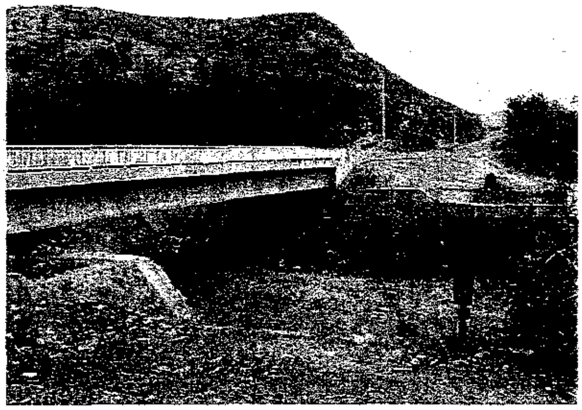

Photo 5.3.1 Las Maderas Bridge

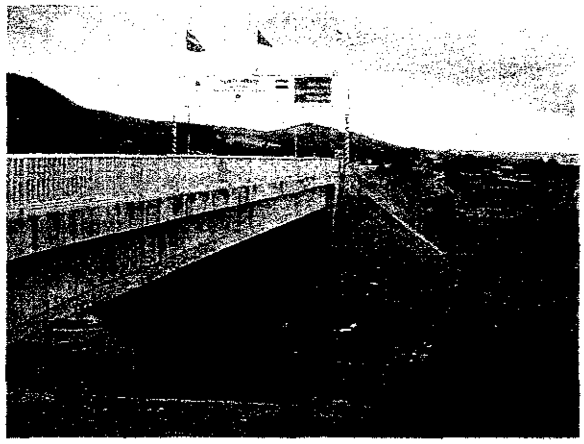

Photo5.1.2 Sebaco Bridge

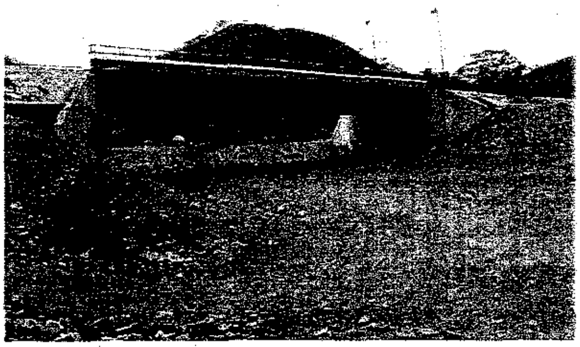

Photo 5.1.3 Ducuali Bridge

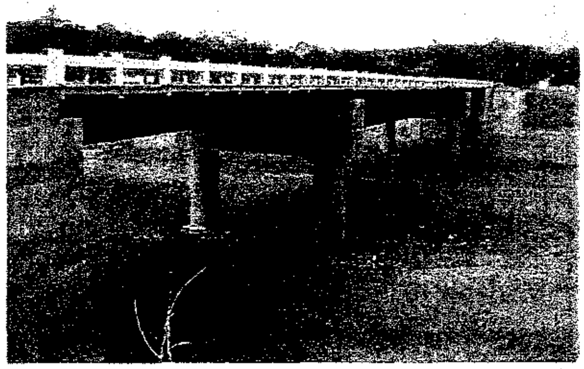

Photo 5.1.4 Los Encuentros Bridge

Photo 5.1.5 San Nicolas Bridge

Photo5.1.6 RíoTapacalí Bridge

2) Survey of Bridges

Las Maderas, Sebaco and Los Encuentros are single span bridges without piers, and there are good revetments around the abutments in all cases. Therefore these three bridges were excluded from the detailed survey, but site visits confirmed the above.

There are five bridges in NIC.1 with a span of less than 15 meters. These bridges were included as survey objects, after site visits because :

i) The river flows are natural and not controlled or trained;

ii) All are very old bridges and depth of the foundations at the abutments are not known;

iii) Erosion damage at wingwalls were observed

As a result, 22 bridges were investigated for stability of the riverbed and revetment, and characteristics of the substructure.

5.1.5 Identification of Disaster Potential Spots

1) Slopes

Disaster Potential Spots are identified at places where the score of the stability survey exceeded 60 points.

a) Rock Fall

Of the 13 spots screened for Rock Fall, 10 were identified as Disaster Potential Spots with over 60 points of the stability score.

b) Rock Collapsing

Of the 23 spots screened for Rock Collapsing, 14 spots were identified as Disaster Potential Spots for Rock Collapsing.

These identified disaster potential spots are shown in Table 5.1.3.

2) Bridges

The results of the site survey is shown in Table5.1.4. 11 bridges were identified as Disaster Potential Spots for Bridges detailed in Table5.1.5. This table provide data on :

i) Evaluation of the stability of the riverbed and revetment

ii) Presence of the damage of scouring.

iii) Position and form of the substructure.

Measurement surveys and stability surveys are recorded a Table of Inspection Results and a Table of Record by Inspection Site.

Table 5.1.3 Identified Disaster Potential Spots on NIC.1

NIC.1

No	Distance from Managua(km)	Serial No.	Type of disaster	Length (m)	Height (m)	Angle (degree)	Score	Disaster Potential 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	*

R.F. :Rock Fall
R.C. :Rock Callaping
S.S. :Slop slide
D.F. :Debris Flow

Table 5.1.4 Field Survey Results on NIC.1

No.	STATION PKM	NAME	BRIDGE LENGTH (M)	DIMENSIONES (M) SPAN LENGTH	YEAR	Stabirity of abutment (F)	Stabirity of Pier (H)	Remark
1	35+190	Los Novios	6.70	5.80	1938	50	0	
2	39+868	La Estatua	8.70	7.50	1938	50	0	
3	40+960	Qda. Honda	7.00	5.00	1938	45	0	
4	42+433	El Matadero	14.30	13.50	1938	35	0	
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	0	
7	107+992	Zajón Negro	21.70	20.70	1957	20	0	
8	108+980	Rio Viejo	99.00	26.8+(3)22.6	1953	55	55	
9	113+190	Zanjón Blanco	29.30	9+9+9	1956	75	80	
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	45	0	scouring
12	135+860	El Hatillo	15.50	14.50	1957	30	0	scouring
13	150+330	Las Chanillas (R.Esteli)	62.00	17.8+24+17.8	1958	70	60	
14	150+925	El Rastro	19.00	18.00	1957	30	0	
15	151+850	San Ramón	15.50	13.80	1957	30	0	scouring
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 Nuev	82.00	19.3+39.3+19.3	2000	45	50	The abutment in the river and Pire is rigid frame
20	192+033	Qda. Ducualí	7.45	6.50	1954	60	0	
21	226+890	Río Inalí	64	19+24+19	1954	90	100	
22	233+245	RíoTapacalí	109	17.8+21.3+26.7 +21.3+17.8	1954	75	70	

Table 5.1.5 Disaster Potential Spots for Bridges on NIC.1

No.	STATION PKM	NAME	BRIDGE LENGTH (M)	DIMENSIONES (M) SPAN LENGTH	YEAR	Aabutment Stabirity (F)	Aabutment transfor mation(D)	Pire Stabirity (H)	Pire transfor mation(D)	Total evaluation
1	113+190	Zanjón Blanco	29.30	9+9+9	1956	75	70	80	90	90
2	125+220	La Trinidad	63.80	18.7+23.4+18.7	1957	70	30	60	50	70
3	135+640	San Nicolas	18.60	17.60	1957	45	100	0	0	100
4	135+860	El Hatillo	15.50	14.50	1957	30	70	0	0	70
5	150+330	Las Chanillas (R.Esteli)	62.00	17.8+24+17.8	1958	70	70	60	90	90
6	151+850	San Ramón	15.50	13.80	1957	30	100	0	0	100
7	159+470	Río El Tular	56.00	14.5+20.8+14.5*	1956	80	30	85	50	85
8	184+670	Condega (Río Pire)	63.60	18.6+23.4+18.6	1954	70	30	60	20	70
9	191+680	Ducualí(Río Pueblo Nuev	82.00	19.3+39.3+19.3	2000	45	30	50	50	50
10	226+890	Río Inalí	64	19+24+19	1954	90	50	100	50	100
11	233+245	RíoTapacalí	109	17.8+21.3+26.7 +21.3+17.8	1954	75	100	70	90	100

5.2 NIC.3

5.2.1 Geological Characteristics

The geology of NIC.3 basically belongs to Group Coyol of volcanic rocks of the Tertiary Era similarly to NIC.1. But the rock faces are remarkably different. The biggest difference lies in the degree of weathering, tuff are becoming soil, andesite lava flow have come to be bloc as its cracks are open. And falling stones are seen here and there on the slope, not so many though. One of the reasons is that the slope collapse at the time of Mitch is still left not rehabilitated. But there is a method for investigating the soundness of other similar slope by predicting the thickness of weathering of fine sand, shape of circular sliding and C and of weathered zone. However, the thicknesses of extent of weathering are varied and many examples are of thin in thickness, so applicable cases will be limited. Figure 5.2.1 shows the schematic profile of NIC.3.

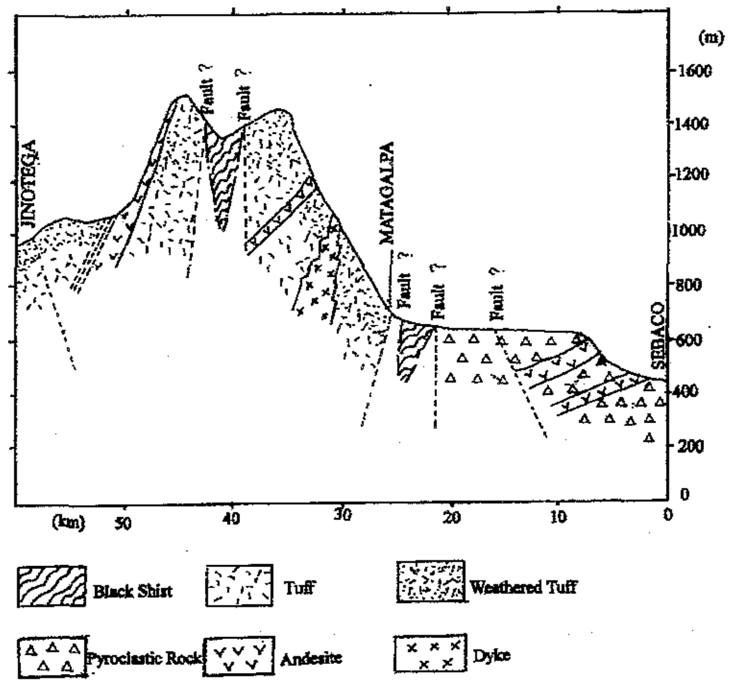

Figure 5.2.1 Schematic Profile of NIC.3

At the point 3.9 km from Sebaco, andesite lava flow turned into clayey and the cracks are open thereby toppling occurred and many stones fell. This weathering is the special feature of NIC.3 and thick tuff continue from this point and up to the point of 20 km. These tuff have various shapes with deep weathering, therefore, a clear slip-off cliff is recognized where the slope was collapsed. Black shale are found just before Matagarupa, and weathering of these bedrock is fast so falling stones and scaling-off will continue. Although it does not directly connected with NIC.3, there found the landslide (with lava flow as cap rock) on the Mesa plateau in the South of Matagarupa, and shallow landslide of tuff rock's weathered zone has occurred. It also seems the traces of Mitch but the tuff is stretching to North and shallow landslide topography is also found at some locations as faced with NIC.3. Included is the road landslide near 6 km North of Matagarupa. The mountain surface at around 40 km from Sebaco where a flash flood occurred is predicted to be collapsed quite soon, therefore, preventive work of the mountain slope is necessary along with the rehabilitation works for the road as washed away by the debris flow. Black schist is distributed on the site after 40 km but it is not certain if it is the hard rocks as brought up by the fault or the ground foundation appeared by chance. For NIC.3, the route in problem is that where the collapse of weathered tuff rock layer as distributed in the sharp cliff under cap-rock.

5.2.2 Condition of Cut/ Embankment Slopes

As in the preceding Chapter, the problems are classified from view points of factors.

i) The tuff and andesite lava flow are both weathered remarkably through the whole route. The damages at the time of Mitch are still left un-repaired.

ii) Small landslide topography is found as the tuff causing landslide in the South of Matagalpa is stretching to North.

iii) Jinotega 27 km from the point 2 km South of Matagarupa contains many problems such as sliding of weathering zone on the slope and possible collapse of embankment. Each section will be evaluated in Chapters hereafter.

5.2.3 Condition of Bridges

1) General

The object section of NIC.3 is the stretch from Sebaco to Jinotega, located in a mountainous area with an elevation of between 500 m to 700 m. The mean annual temperature of here is 20° C with an annual precipitation of 1000 to 2000mm.

MTI's Bridge Inventory was checked by field survey. As a result, it was found that El Guayacan Bridge was not in the Bridge Inventory and this should be investigated.

There are three object bridges in NIC.3 on section between Sebaco and Matagalpa, as follows:

i) El Guayacan Bridge (Crossing EL Coyotepe)

ii) Los Cocos Bridge (Crossing La Tijerina)

iii) Waswali Bridge (Crossing Waswali that is branch of Grande de Matagalpa)

2) History of Past Disaster

The whole NIC.3 suffered serious damage from Hurricane Mitch in 1998. At Waswali Bridge, the approach road embankments have failed. The culvert box failed at El Guayacan Bridge. There is also evidence that floods often occurred before Hurricane Mitch near El Guayacan Bridge.

3) Condition of Bridges

Waswali Bridge was reconstructed in 2001 with aid of the Government of Japan. It is shown in Photo 5.2.1. The other bridges were constructed in 1940's.

El Guayacan Bridge is a 20 meter arched bridge with three spans each about five meters, with small wingwalls. It has a blockage ratio of more than 7%, and the free height underneath the girder is less than four meters. A wingwall and embankment was destroyed by A2 abutment differential settlement (Photos 5.2.2 and 5.2.3).

Los Cocos Bridge is a seven meters single span with protection of the riverbed. (Photo 5.2.4) There were no traces of scouring, but many problems regarding the river profile and river grade.

5.2.4 Survey Results of Screening

1) Survey of Slopes

Most of NIC.3 is located within mountainous or hilly areas with cuttings and embankment sections. 40 screening spots have been identified on NIC.3 based on the pre-conditions introduced in the screening procedure for Rock Fall, Rock Collapsing, Slope Slide and Debris Flow.

a) Rock Fall

There are total 20 numbers of the screening spots for Rock Fall on NIC.3 consisting about half of the total screening spots on NIC. 3 and the stability survey has also been conducted on 20 spots of Rock Fall as shown in Table 5.2.1.

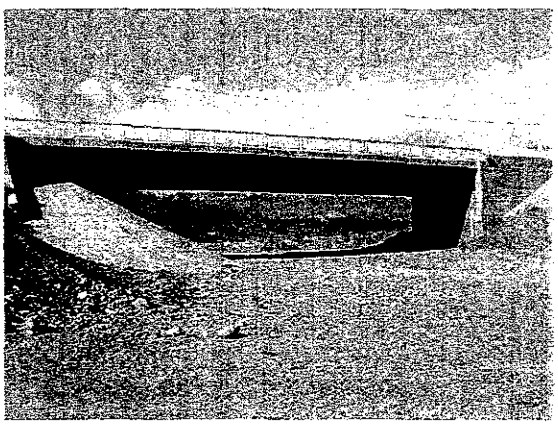

Photo 5.2.1 Waswali Bridge

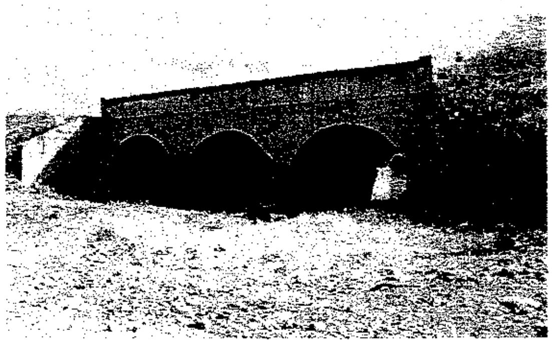

Photo 5.2.2 El Guayacan Bridge (Up stream side)

Photo 5.2.3 El Guayacan Bridge (Down stream side)

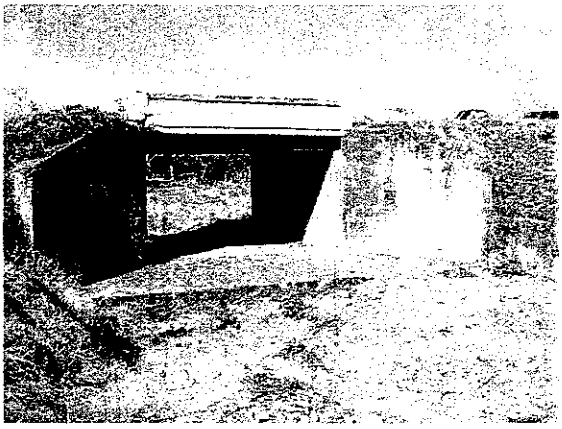

Photo 5.2.4 Los Cocos Bridge (Down stream side)

b) Rock Collapsing

15 numbers of Rock Collapsing spots for the screening has been selected and the stability survey has also been conducted on the 15 spots as shown in Table 5.2.1.

c) Slop Slide

4 spots for Slop Slide have been selected for the screening and the stability survey has also been conducted as shown in Table 5.2.1.

d) Debris Flow

Very large scale of the debris flow at one spot (35 km from Sebaco) was identified for the screening and a stability survey was also conducted as shown in Table 5.2.1.

2) Survey of Bridges

Waswali Bridge a single span bridge without piers, and there is a sound revetment around the abutment. This bridge was excluded from the survey following confirmation of the above by site inspection.

Los Cocos Bridge is less than 15 meters long, but is included in the survey object, because:

i) The river is the natural and not be trained.

ii) The bridge is old and the depth of the foundation at the abutment was not able to be identified.

iii) Erosion damages at the wingwalls were observed.

As a result, two bridges, Los Cocos Bridge and El Guayacan Bridge, were investigated to determine the stability of the riverbeds and revetments, and the characteristics of the substructures.

5.2.5 Identification of Disaster Potential Spots

1) Slopes

Based on the Basic Indicator introduced in this study, Disaster Potential Spots are identified at places where the value exceeds 60 points from the stability survey for Rock Fall, Rock Collapsing, Slop Slide and Debris Flow.

a) Rock Fall

Among the 20 spots screened for Rock Fall, 9 spots scored with over 60 points in the stability rating have been identified as the Disaster Potential Spots for further evaluation.

b) Rock Collapsing

Of the 15 spots screened for Rock Collapsing, 9 Disaster Potential Spots were identified. At one point (8.3 km from Sebaco) there was a stability score of 74 points, but there is not enough space along side the road for averting any disaster by from rock collapsing.

c) Slope Slide

All 4 spots of Slope Slide were identified as Disaster Potential spots, having score of 60 or more from the stability survey.

d) Debris Flow

There is one potential spot of Debris Flow at 35.2 km from Sebaco, having a score of 100 from the stability survey.

2) Bridges

As the result of the site survey, (Table5.2.2) El Guayacan Bridge was identified as a Disaster Potential Spots for Bridges due to :

- i) Instability of the riverbed and revetment.
- ii) Damage to a wingwall, the embankment and some A2 abutment differential settlement.
- iii) Poor position and form of the substructure.

Results of a measurement survey and the stability survey, are recorded in the Table of Inspection Result and The Table of Record by Inspection Site.

Table 5.2.1 Identified Disaster Potential Spots on NIC.3

NIC.3

No.	Distance from Sebaco(km)	Serial No.	Type of disaster	Length (m)	Height (m)	Angle (degree)	Score	Disaster Potential
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	

R.F. :Rock Fall
R.C. :Rock Callaping
S.S. :Slop slide
D.F. :Debris Flow

Table5.2.2 Field Survey Results for Bridges on NIC.3

No.	STATION PKM	NAME	BRIDGE LENGTH (M)	DIMENSIONES (M) SPAN LENGTH	YEAR	Stabirity of abutment (F)	Stabirity of Pier (H)	Remark
1	119+050	El Guayacan	17.5	3.3	1945	100	100	wingwall destroyed
2	122+053	Los Cocos	7	3.3	1945	70	0	

5.3 NIC.5

5.3.1 Geological Characteristics

For the geology of NIC.5, there found in some places the hydrogenous sedimentary layers of muddy tuff and coarse sandy tuff but basically the volcanic rocks of Tertiary Era are widely and thickly distributed. The site of the slope failure at the point of 24.6 km starting at Esso Gas. in Matagalpa City as additionally requested is also distributed with tuff and pyroclastic andesite.

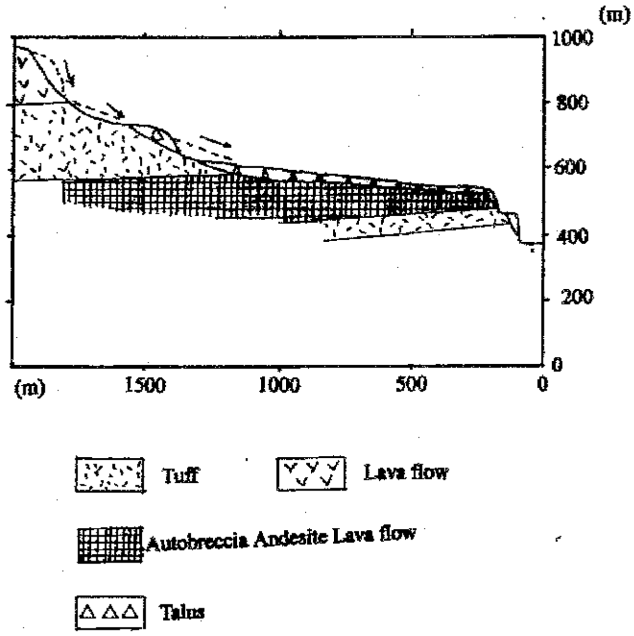

Figure 5.3.1 Schematic Profile of Collapse Site on NIC.5

As seen from the figure, it is presumed that the collapse occurred when the flat area on the upper part of the slope became catchment area and infiltrated into the talus deposits and the weathered zone of bedrock from near the boundary of talus deposits and pyroclastic lava flow which appeared on the slope by chance were engulfed. The tuff near the slope end and the bedrock thereupon are left as it is, and such deep landslide as passing under the national road of NIC.5 is not found. The angle of repose of the collapsed soil as left behind being 20-30° , it can be presumed that some parts of the collapsed soil fell down into the marsh over the road taking into account the water conditions at the time the collapse. The thickness of talus deposits is over 10 m even at the point going round in the direction of North, and clear collapsed topography is seen on the mountain above the slope. Therefore, it is judged that the whole ridge on the slope with 1.2 km width has problems as bedrock. Moreover, old cracks are found on the slope shoulder of NIC.5 in villages at El Tuma near 9.8 km point from Ladaria, therefore, any alteration should be checked in rainy season.

5.3.2 Condition of Cut/ Embankment Slopes

Collapsed debris is talus deposits containing considerably weathered rock mass and fine soil. The volume is much so the collapsed topography of the mountain above the slope is the supplier thereof. As it is estimated that considerable volume of unstable soil mass are still left on the upper part thereof, the collapsed soil of the mountain should be investigated in regard to the slope.

The pyroclastic andesite is so structured as 40° anti-dip slope but has become fine stone and many of them are floating which makes the situation unstable. Especially, the averaged incline of the slope is so gentle as 45° thereby falling rocks were repeated during construction. It seems that the embankment was constructed by bench cut at the sharp slope of Yasica River, but it is not sure if it has been altered through the influence of the collapse this time.

5.3.3 Survey Results of Screening

On NIC.5, there is one place for the screening where the large scale of failure was occurred at the cutting section of 24.6 km far from Matagalpa village.
After the screening, the score of the stability survey become 76 points for Rock Fall.

5.3.4 Identification of Disaster Potential Spots

After the scoring the stability survey, this spot is also selected as Disaster Potential Spot.

Table 5.3.1 Identified Disaster Potential Spots on NIC.5

NIC.5								
No	Distance from Matagalpa(km)	Serial No.	Type of disaster	Length (m)	Height (m)	Angle (degree)	Score	Disaster Potential Spot
1	24.6	1	R.F.	200	87	50°	76	*

R.F. :Rock Fall
R.C. :Rock Callaping
S.S. :Slop slide
D.F. :Debris Flow

5.4 NIC.15

5.4.1 Geological Characteristics

The geology and topography are classified into those in the Southern and Northern parts putting Ocotal between them. In the Southern part, volcanic rocks of Tertiary Era is distributed mainly by andesite lava flow and tuff, but the Northern part is consisted of black schist and granodiorite. They are faced at faults but the special feature is that the granodiorite have become decomposed granite soil. Figure 5.4.1 shows the schematic profile of NIC.15.

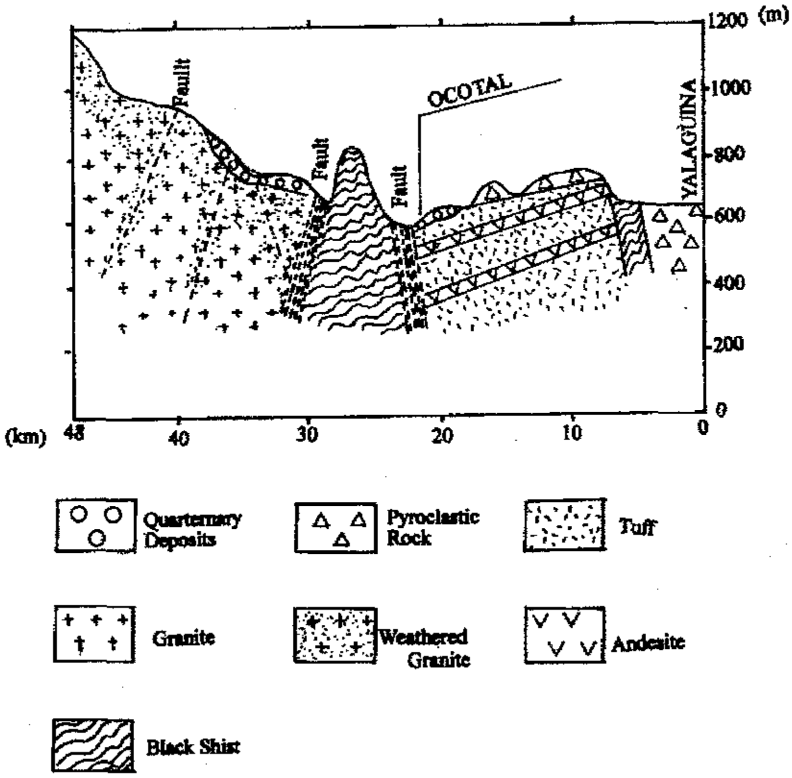

Figure 5.4.1 Schematic Profile of NIC.15

The geology of the section between Yalaguina-Ocotal is mostly composed of the volcanic rocks of Tertiary Era with much volcanic pyroclastic rocks. It is the mixture of volcanic rocks and ash but there found various weathering even on the same slope depending upon the properties of the mixture. In general, the tuff rocks of alternate layer with volcanic pyroclastic rocks have much weathering and the volcanic pyroclastic rock thereupon are over-hung. Such volcanic pyroclastic stones are falling or collapsing where weathering has advanced thereby the slope is made irregular. Weathering of the slope progresses even after the construction, and cracks and combination of rocks are loosened, therefore, they are changing by rainfall after rainfall. It seems that the slope gradient is so gentle as 45- 60° as being influenced by such situations. The tuff at 16 km of Yalaguina is cut with such gentle gradient as 40° or less because the slope was a failure at the time of construction. This failure in weathering zone is similar to the tuff of NIC.3. The geology from the location near Ocotal turns into black schist but at present no collapse is found due to the fact that it is hardly cemented and not weathered and that there is no high slope. However, there will occur full-scale rockslide when weathering is progressed or joint plane is of dip-slope layer, so the structure of bedrock must be taken notice at the time of route selection or new cutting work. For this black schist, granodiorite are distributed for the section between Yalaguina and the border with Honduras and becoming to decomposed granite soil. Coarse decomposed granite soil is forming gully by surface water from the slope shoulder. When Mitch attacked, the slope was collapsed entirely or there also found the trace of erosion by piping for the fine decomposed granite soil. For the hillside with decomposed granite soil, there occurred the slope collapse causing debris flow which covered the whole riverbed of Dipilto River. This debris flow seems to have been repeated since the Diluvial Epoch and the sand layer of around 10-20 m thick is distributed up to the junction with Coco River covering the hilly surface and diluvial surface. This feature cannot be seen in other routes.

5.4.2 Condition of Cut/ Embankment Slopes

The slope of this section is maintained and managed by Swedish engineer's judgement. And the embankment prone to erosion is placed with concrete so it is presumed that the construction works will continue according to the rockbed conditions.

5.4.3 Condition of Bridges

1) General

NIC.15 between Yalaguina and Las Manos run through a mountainous area, around 700 m to 1000 m high. Each bridge site was surveyed to check the contents of the MTI Bridge Inventory. There are five bridges in NIC.15.

Table 5.4.1 Bridge Inventory for NIC.15

No.	STATION PKM	NOMBRE DEL TRAMO	NAME	PRESENT SITUATION	BRIDGE LENGTH (M)	ROAD WIDTH (M)	TOTAL WIDTH (M)	SPAN LENGTH (M)	FREE SPACE (M)	TYPE	DESIGN LOAD	YEAR
1	223+591	Emp.Yalaguina - Las Manos	Ocotal (Rio Coco)	BUENO	131.50	7.00	8.60	21+3(26)+21	12.70	MIXTO	HS-15-44	1954-79
2	235+807	Emp.Yalaguina - Las Manos	San Fabián	BUENO	24.00	7.30	7.90	23.00	3.00	CONC.	HS-15-44	
3	236+936	Emp.Yalaguina - Las Manos	Paso El Guayabo	BUENO	24.00	7.30	7.90	23.00	4.20	CONC.	HS-15-44	1969
4	237+640	Emp.Yalaguina - Las Manos	Dipilto (Río Dipilto)	BUENO	20.40	7.30	7.90	19.40	7.50	CONC.	HS-15-44	1969
5	240+964	Emp.Yalaguina - Las Manos	Dipilto Viejo	BUENO	16.30	7.70	8.30	14.90	7.50	CONC.	HS-15-44	1969

Ocotal Bridge (Photo5.4.1) crosses the Rio Coco and other bridges cross the Dipilot river, which is a tributary of Rio Coco. Road and bridges in this section are under rehabilitation and improvement work to damage cuased by Hurricane Mitch (aided by the Government of

Sweden). Ocotal Bridge, Paso El Guayabo Bridge, Dipilto (Río Dipilto) Bridge and Dipilto Viejo Bridge were completed in 1999, and work continues at San Fabian Bridge.

The mean annual temperature of this section is 24.2° with an annual precipitation of 1000 to 2000mm.

2) History of Past Disaster

The whole NIC.15 suffered serious damage from Hurricane Mitch in 1998. Ocotal Bridge was partially destroyed. According to the report of "Yalaguina - Las Manos rehabilitation and improvement project" a discharge of flood was produced by Hurricane Mitch of 7980m^3/s with water reaching around one meter above the road level. The water velocity was approximately 5m/s. Tapacali and Rio Inali, that cross NIC.1 are tributaries of the Rio Coco, but Tapacali Bridge and Inali Bridge survived. Road embankments have failed and the river has taken a new course. Along the Rio Coco, the gorge is too deep and narrow and the watercourse has remained in place.

The improvement project reported four other bridges had some erosion damage at the feet of the stone masonry abutments and at the wingwalls. At San Fabian bridge, the road embankments were completely washed away during flood.

3) Condition of Bridges

The catchment area of the Rio Coco at Ocotal Bridge is more than 1000 km^2, with a design discharge of 2880m^3/s (100year Hurricane event). The grade of the riverbed is not so steep despite the mountainous area, and riverbed consists of sand mixed with cobble.

There were two plans for reconstruction of Ocotal Bridge. The first is to replace the superstructure on existing substructure, (capable of meeting 100 year demand) and the second one is the construction of a new bridge 30m downstream side that could deal with a disaster on the scale of Hurricane Mitch. The first plan seems to have been carried out, new bridge is observed to using the existing substructure with good protection for revetment around abutment. However traces of scouring around the pier we observed by this study team at the Ocotal Bridge site.

The River Dipilto flows alongside NIC.15 and crosses the road between Ocotal and Las Manos. The grade of riverbed is very steep, and the bridge is on a bend in the river. The riverbed is rock.

Many potential sites which would benefit from protection of riverbanks by Gabion mats, as well as around bridges, were observed.

Traces of erosion damages can be seen at all wingwalls and the traces of scour problems are apparent in some places, with some these already repaired by Gabion (see Photos 5.4.2 to 5.4.5)

5.4.4 Survey Results of Screening

1) Survey of Slopes

NIC.15 passes a a narrow ledge between mountainous area and river area from Las Manos, the border village, to Ocotal and runs through a hilly area up to the intersection with NIC.1 at Yalaguina. 24 screening spots were identified on the section between Las Manos and Ocotal where the construction works are going on (Expected to be completed by July 2002).

a) Rock Fall

9 sites for Rock Fall were identified for the screening as shown in Table 5.4.2.

b) Rock Collapsing

9 sites for Rock Collapsing were identified for the screening.

c) Slope Slide

No places of potential Slope Slide were identified.

d) Debris Flow

4 places where debris flow had occurred were identified for screening.

2) Survey of Bridges

The four bridges that cross over the Dipilto, are single spans more than 20 m long except for San Fabian bridge which is under construction.

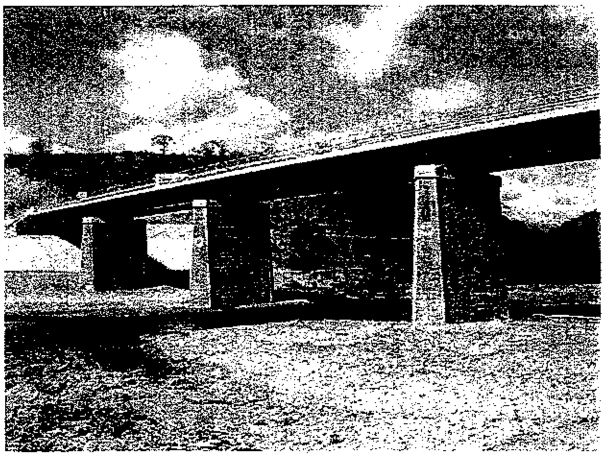

Photo 5.4.1 Ocotal Bridge

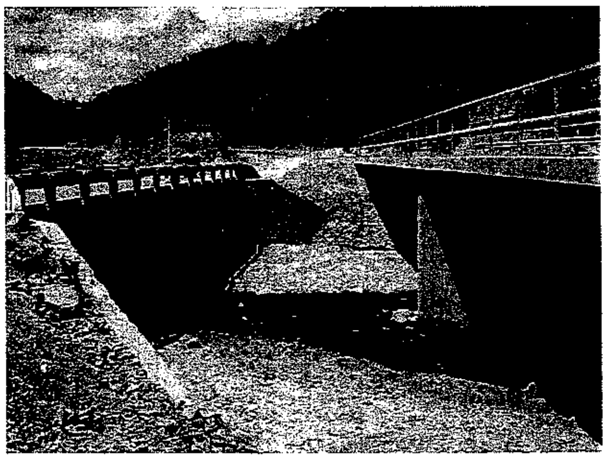

Photo 5.4.2 San Fabian Bridge

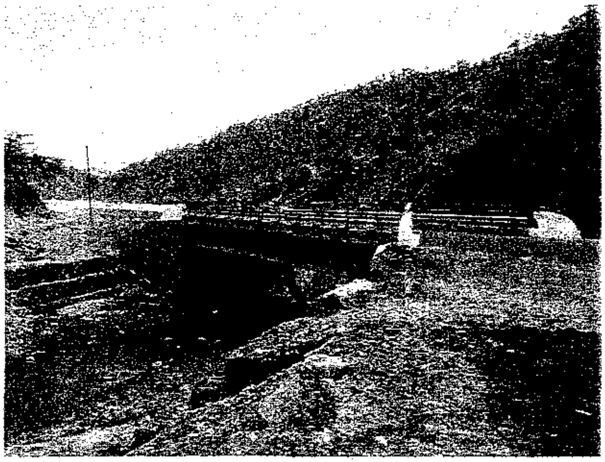

Photo 5.4.3 Paso El Guayabo Bridge

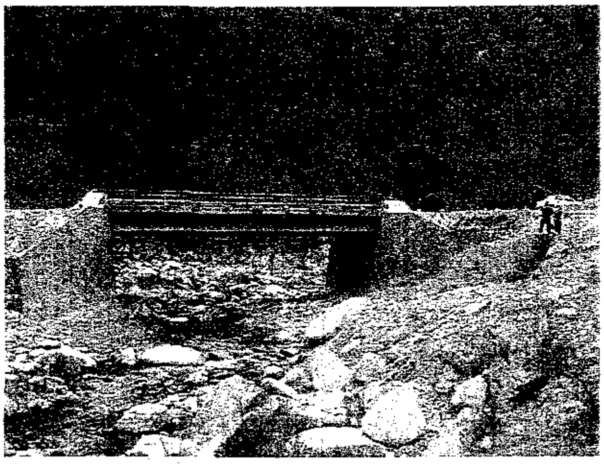

Photo 5.4.4 Dipilto Bridge

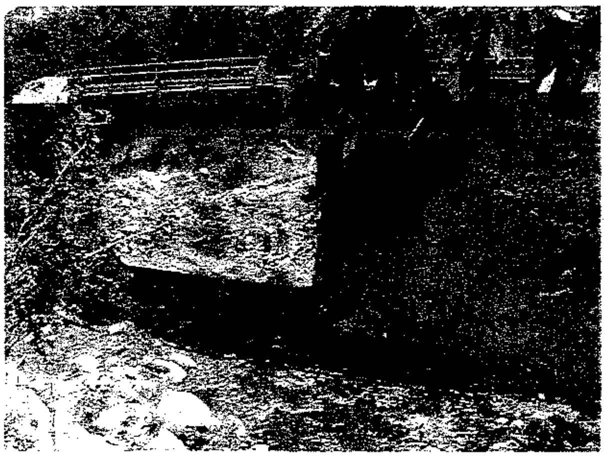

Photo 5.4.5 Dipilto Viejo

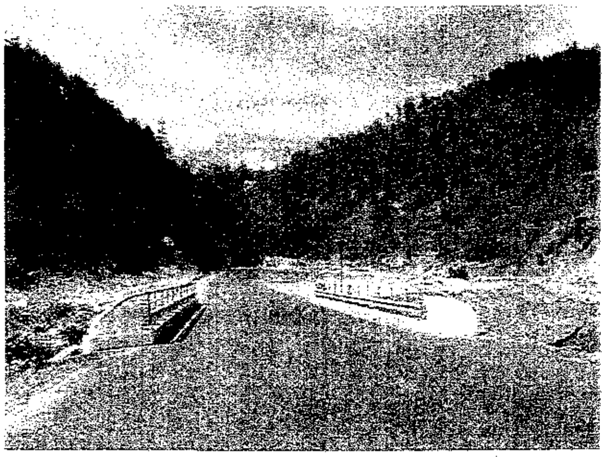

Photo 5.4.6

Four bridges were identified for survey because:

i) The river flow is natural and not trained
ii) The gradient of the riverbed is very steep
iii) The abutment is on a bend in the river
iv) The riverbank is protected only by gabion
v) Erosion damage at wingwalls were observed

These bridges were inspected for stability of riverbed and revetment and characteristics of substructure.

5.4.5 Identification of Disaster Potential Spot

1) Slopes

6 Disaster Potential Spots were identified as follows.

a) Rock Fall

Among 9 places screened for Rock Fall, two places were selected as Disaster Potential Spots for further evaluation.

b) Rock Collapsing

Within 5 places screened for Rock Collapsing, no Potential Disaster Spots identified due to low stability scores.

c) Slope Slide

No places.

d) Debris Flow

All four places screened for Debris Flow were identified as Disaster Potential Spots having over 70 points from the stability survey.

2) Bridges

The site survey, (shown in Table5.4.3), evaluated only Ocotal Bridge as a Disaster Potential Spots for Bridges on NIC.15, as a result of:

- i) Evaluation of the stability of the riverbed and revetment,
- ii) Presence of damage from scouring,
- iii) Position and form of the substructure.

The survey results are set out in The Table of Inspection Result and The Table of Record by Inspection Site.

Table 5.4.2 Identified Disaster Potential Spots on NIC.15

NIC.15								
No	from SanBenito(km)	Serial No.	Type of disaster	Length (m)	Height (m)	Angle (degree)	Score	Disaster Potential 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	

R.F. :Rock Fall
R.C. :Rock Callaping
S.S. :Slop slide
D.F. :Debris Flow

Table5.4.3 Field Survey Results for Bridges on NIC.15

No.	STATION PKM	NAME	BRIDGE LENGTH (M)	DIMENSIONES (M) SPAN LENGTH	YEAR	Stabirity of abutment (F)	Stabirity of Pier (H)	Remark
1	223+591	Ocotal (Rio Coco)	131.50	21+3(26)+21	1954-79	55	65	scouring around pire
2	236+936	Paso El Guayabo	24.00	23.00	1969	40	0	
3	237+640	Dipilto (Rio Dipilto)	20.40	19.40	1969	50	0	
4	240+964	Dipilto Viejo	16.30	14.90	1969	40	0	

5.5 NIC.24

5.5.1 Geological Characteristics

For the geology of NIC.24, there found not cut points as gently-sloping is spread as this area is the skirts of Volcar San Cristbal up to the section around 35 km of Chinandega. Low land of 8-10 m is spread from the point of 35 km and it will be flooded when it rains heavily. Diluvium Terrace of about 20 m starts from the point of 50 km and there found natural outcrop with columnar joint of basaltic andesite belonging to Tertiary Era. It may be adjusted a little bit but it has the properties of making sheer cliffs. It is feared of falling stone as cracks are seen vertically but such cracks are intact with each other so at present there found no conditions of rock collapse. However, small stones sometimes fall so there should be a space of about 3 m to protect pedestrians, although no damage against cars is predicted (now there is the shoulder of about 1.5 m making a buffer). There found no problems starting this point and up to the border with Honduras as this section is continued with the slope of hard tuff with 3-6 m height. There is only one point with the slope of the tuff of 2-3 m height and weathering is being progressed and becoming soil. Although small berm are made but periodic checking will be required for weathering progress.

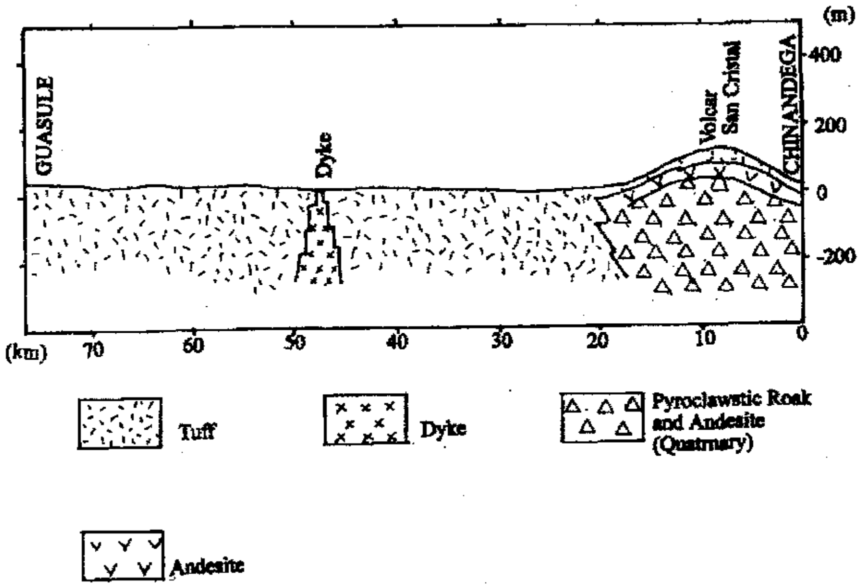

Figure 5.5.1 Schematic Profile of NIC.24

5.5.2 Conditions of Cut/ Embankment Slopes

There seems no specific points but new volcanic eruption might be expected.

5.5.3 Condition of Bridges

1) General

The object section of NIC.24 is an 80km stretch from Chinandega to Guasaule, located on a flat area in the North-Western part of Nicaragua where the ground is about 10 m to 50 m above sea level. The MTI Bridge Inventory was checked by survey and results shown in Table 5.5.1.

Table 5.5.1 Bridge Inventory for NIC.24

No.	STATION PKM	NOMBRE DEL TRAMO	NAME	PRESENT SITUATION	BRIDGE LENGTH (M)	ROAD WIDTH (M)	TOTAL WIDTH (M)	SPAN LENGTH (M)	FREE SPACE (M)	TYPE	DESIGN LOAD
1	132+055	Chinandega - Pte.Río Guasaule	El Hogar (La Mora)	Bueno	5.6	7	8.6	4.5	4	Conc.	H15-S12-44
2	132+763	Chinandega - Pte.Río Guasaule	El Guarumo (R.Acome)	Bueno	60	7	9.5	18.5+19+18.5	9.3	Conc.	NK-80
3	143+390	Chinandega - Pte.Río Guasaule	San Ramón	Bueno	5	6.9	7.3	4.1	2	Conc.	H15-S12-44
4	160+565	Chinandega - Pte.Río Guasaule	El Obraje	Bueno	6.8	7.6	9.3	3.1+ 3.1	3.1	Conc.	H15-S12-44
5	168+388	Chinandega - Pte.Río Guasaule	Estero Real	Bueno	57	7	8.6	4(9)+16	6.5	Mixto	H15-S12-44
6	171+013	Chinandega - Pte.Río Guasaule	El Marimbero	Bueno	6.5	7	8.6	5.5	5.3	Conc.	H15-S12-44
7	174+577	Chinandega - Pte.Río Guasaule	La Venada	Bueno	15	7	8.6	6+6	4.4	Conc.	H15-S12-44
8	177+396	Chinandega - Pte.Río Guasaule	La Chepa	Bueno	12.5	7	8.6	6+6	4.1	Conc.	H15-S12-44
9	179+059	Chinandega - Pte.Río Guasaule	El Nancital	Regular	7	7	8.6	6	4.3	Conc.	H15-S12-44
10	179+499	Chinandega - Pte.Rio Guasaule	Las Pozas	Bueno	7.3	7	8.6	6	4.3	Conc.	H15-S12-44
11	183+988	Chinandega - Pte.Rio Guasaule	Chocolatero	Bueno	8.6	7	8.6	7.7	3.9	Conc.	H15-S12-44
12	187+944	Chinandega - Pte.Río Guasaule	Hato Grande	Malo	64.7	Destruído	Destruido			Mixto	H15-S12-44
13	189+111	Chinandega - Pte.Río Guasaule	La Culebra	Bueno	14.4	7	8.6	13	6.7	Conc.	H15-S12-44
14	197+929	Chinandega - Pte.Río Guasaule	Río Negro	Malo	64.8	Destruído	Destruído			Conc.	NK-80
15	198+675	Chinandega - Pte.Río Guasaule	San Antonio	Bueno	10.3	7	8.6	9	4.2	Conc.	H15-S12-44
16	200+712	Chinandega - Pte.Río Guasaule	El Gallo	Malo	32.7	0	0	-	0	Mixto	H15-S12-44
17	201+520	Chinandega - Pte.Río Guasaule	Tecomapa	Bueno	16.3	7	8.6	15	6.4	Conc.	H15-S12-44
18	207+323	Chinandega - Pte.Rio Guasaule	Rio Guasaule	Regular	150	7.6	10.4	29+29+29+29+29	14.6	Mixto	H15-S12-44

A new bridge that was not listed in the Bridge Inventory was found. Seven of the bridges in the inventory are culverts. There are seven bridges on NIC.24 shown in Table5.5.2.

Table 5.5.2 Bridges on NIC.24

No.	STATION PKM	NAME	PRESENT SITUATION	BRIDGE LENGTH (M)	ROAD WIDTH (M)	TOTAL WIDTH (M)	SPAN LENGTH (M)	FREE SPACE (M)	TYPE	DESIGN LOAD	YEAR
1	132+055	El Hogar (La Mora)	Bueno	5.6	7	8.6	4.5	4	Conc.	H15-S12-44	
2	143+000	San Ramón1	Bueno	20.5	7	8.6			MIXTO	HS-20+25%	
3	183+988	Chocolatero	Bueno	8.6	7	8.6	7.7	3.9	Conc.	H15-S12-44	
4	189+111	La Culebra	Bueno	14.4	7	8.6	13	6.7	Conc.	H15-S12-44	
5	197+929	Río Negro	Malo	64.8	10.4	10.9	29.9+2(30)+29.9	8.5	Conc.	HS-20+25%	2001
6	198+675	San Antonio	Bueno	10.3	7	8.6	9	4.2	Conc.	H15-S12-44	1968
7	201+520	Tecomapa	Bueno	16.3	7	8.6	15	6.4	Conc.	H15-S12-44	1968

The mean annual temperature of the Chinandega area is more than 27^{o} with an annual precipitation of 800to 1500mm.

NIC.24 is part of the Pan American Highway (CA-3), and is one of the most important roads in Nicaragua. It connects Corinto Port and Potosi Port with Honduras. Corinto Port is the third largest port on the Pacific Ocean coast of central America. NIC.24 carries large traffic volumes with a high proportion of heavy goods vehcicles (Photo 5.5.1).

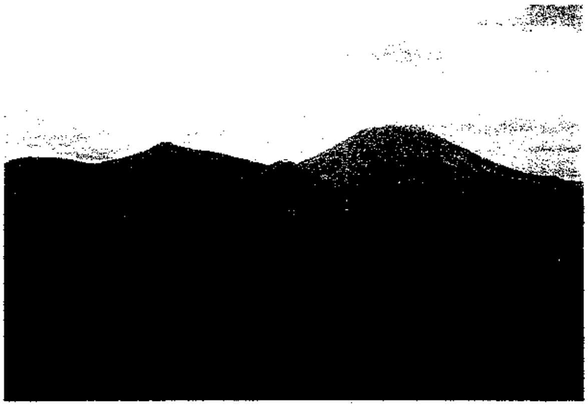

Photo 5.5.1 Volcano S.Cristobal

Photo 5.5.2 Articulated trucks

2) History of Past Disaster

Hurricane Mitch caused 1300 mm of rain to fall within a week in North-Western area of Nicaragua close to the border with Honduras. Guasaule Bridge, El Gallo Bridge, and Hato Grande Bridge were destroyed. Hato Grande Bridge piers and superstructure were washed away, following heavy scouring caused by the constrained space for the river flow and batterings from driftwood.

Rio Negro's first bridge was constructed in 1964, but it was washed away by flood in the 1970's. A second bridge, reconstructed after the flood, was destroyed by the civil war in 1982. The debris of the ruined bridge obstructed the river flow causing the river to branch and expand its course. It broke its banks again due to Hurricane Alleta and flooded adjacent cultivated land.

El Guarumo Bridge and Estero Real Bridge, located at the Western end of NIC.24, did not suffer much damage. However the area around Estero Real Bridge is very low lying and floods every three years. On average the water overflows the bridge every five years, owing to tidal influences (Photo 5.5.3).

3) Condition of Bridges

NIC.24 runs North the active Volcano S. Cristobal (Photo 5.5.2) and crosses Rio Acome, Estero Real, Villanueva, Rio Negro and El Gallo. Rio Negro is biggest river that NIC.24 crosses, with a catchment area of this river of more than 1000 km^2 and a design flood discharge of 2250m^3/s.

Four main bridges are under construction, with the Rio Negro Bridge being completed in 2000. Riverbeds with a gradient more than 5° and a number of small rivers cross NIC.24 with soil or sand riverbeds. There are thick layers of weak strata in and around Estero Real Bridge. Most scouring has already been repaired., but traces of scouring around the substructure on Rio Negro Bridge and La Culebara Bridge were found (Photos 5.5.4, 5.5.5).

Photo 5.5.3 Estero Real

Photo 5.5.4 Rio Negro Bridge

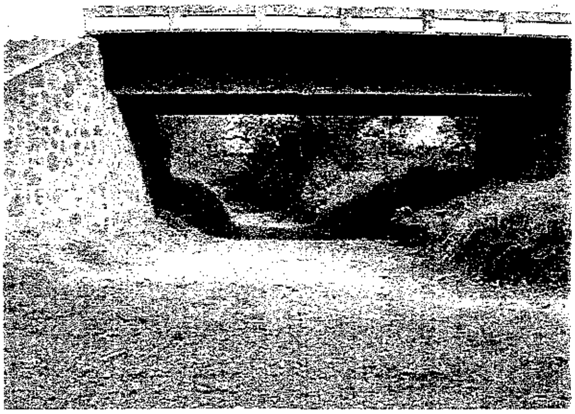

Photo 5.5.5 La Culebara Bridge

5.5.4 Survey Results of Screening

1) Survey of Slopes

16 candidate places for the screening were reduced to two sites for surveying as follows:

a) Rock Fall

There is one place for the screening for Rock Fall 17.5 km from the border town, Guasaule.

b) Rock Collapsing

One place for the screening of Rock Collapsing 28.5 km from Guasaule.

2) Survey of Bridges

El Guarumo Bridge, Estero Real Bridge, Hato Grande Bridge, El Gallo Bridge and Rio Guasaule Bridge were included in the survey. Four bridges on NIC.24 have spans less than

15 meters : El Hoger Bridge, Chocolatero Bridge, La Culebra Bridge and San Antonio. These four bridges were included in the survey for the following reasons :

i) The river is natural and trained

ii) Depths of the foundations at the abutments were notable to be identified

iii) Traces of scouring were observed

As a result, seven bridges were investigated for stability of riverbed and revetment, and for characteristics of substructure.

5.5.5 Identification of Disaster Potential Spots

1) Slopes

After the scoring through the stability survey, only one place of Rock Collapsing was identified as a Disaster Potential Spot and for the further evaluation one place for Rock Fall was also temporally selected as a Disaster Potential Spot.

Table 5.5.3 Identified Disaster Potential Spots on NIC.24

NIC.24

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

R.F. :Rock Fall
R.C. :Rock Callaping
S.S. :Slop slide
D.F. :Debris Flow

2) Bridges

Result of the site survey are shown in Table5.5.2. Three bridges were identified as Disaster Potential Spots for Bridges as shown in Table5.5.3, due to the following :

i) Evaluation of the stability of the riverbed and revetment

ii) Presence of damage from scouring

iii) Position and form of the substructure.

The results of the measurement survey and stability survey are set out in the Table of Inspection Result and the Table of Record by Inspection Site.

Table5.5.4 Field Survey Results for Bridges on NIC.24

No.	STATION PKM	NAME	BRIDGE LENGTH (M)	DIMENSIONES (M) SPAN LENGTH	TYPE	DESIGN LOAD	YEAR	Stabirity of abutment (F)	Stabirity of Pier (H)
1	132+055	El Hogar (La Mora)	5.6	4.5	Conc.	H15-S12-44		20	0
2	143+000	San Ramón1	20.5	20	Conc.	HS-20+25%	2001	70	55
3	183+988	Chocolatero	8.6	7.7	Conc.	H15-S12-44		50	0
4	189+111	La Culebra	14.4	13	Conc.	H15-S12-44		70	0
5	197+929	Rio Negro	64.8	29+2(30)+29	Conc.	HS-20+25%	2001	30	40
6	198+675	San Antonio	10.3	9	Conc.	H15-S12-44	1968	35	0
7	201+520	Tecomapa	16.3	15	Conc.	H15-S12-44	1968	40	0

Table5.5.5 Disaster Potential Spots for Bridges on NIC.24

No.	STATION PKM	NAME	BRIDGE LENGTH (M)	DIMENSIONES (M) SPAN LENGTH	TYPE	DESIGN LOAD	YEAR	Aabutment		Pire		Total evaluation
								Stabirity (F)	transfor mation(D)	Stabirity (H)	transfor mation(D)	
1	143+000	San Ramón1	20.5	20	Conc.	HS-20+25%	2001	70	30	55	0	70
2	189+111	La Culebra	14.4	13	Conc.	H15-S12-44		70	50	0	50	70
3	197+929	Rio Negro	64.8	29+2(30)+29	Conc.	HS-20+25%	2001	30	50	40	0	50

5.6 NIC.26

5.6.1 Geological Characteristics

For the geology of NIC.26, the flat land is spread up to the point of 20 km from about 4 km South of San Ishidro in NIC.1 but two faults in the direction of North-East/South-West in parallel thereof and sandwiching NIC.26 are predicted so they will affect the slope between San Ishidro and the point of 50 km. After the point of 50 km, Cero Amapla of Quaternary Era is making gentle slope of the skirts thereby no cut work is found. But this section is subject to the influence of volcano. Figure 5.6.1 shows the schematic profile of NIC.26.

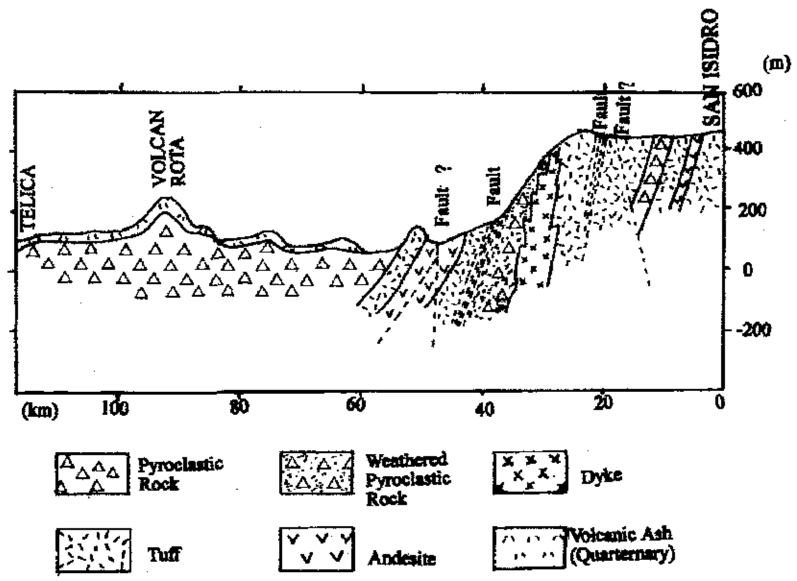

Figure 5.6.1 Schematic Profile of NIC.26

For the geology of NIC.26, there occurred falling rocks and collapse in the section between 9 km and San Ishidro at the time of Mitch and the slope is those as formulated by cutting the low hilly area. Now it is improved but formerly the bedrock collapse occurred due to blocks by the collapse of tuff through rainfall and by the formulation of weathering zone which has become soil. It makes an alternate layer with andesite lava flow up to the point of 10 km but volcanic pyroclastic rocks with fast weathering and welded tuff are repeatedly distributed after the point of 10 km. There found alteration and loosing of the slope with the influence of fault, especially, the fault of 2-3 m entered obliquely into the slope at the point of 36 km thereby large blocks fell at the time of Mich. These conditions continue up to the point of 55 km but there found no large cut soil after the point of 40 km from which low hilly area starts. There found the skirts of Ceo Amapla of Quaternary Era volcano starting the point of 55 km, therefore, there is no cut slope.

5.6.2 Condition of Cut/ Embankment Slopes

As described earlier, the weathering of the cut slope and natural slope is progressing irregularly and as affected by the fault. From San Ishidro and up to the point of 20 km, the mountainous road is running in zigzagging so about three points will be hit directly by debris collapse from the primary valley. But if the sample of Mitch is taken as reference, there is a possibility that the weathered zone of tuff will fall down from the boundary of impermeable rocks either in case of cut slope or natural slope. As discussed above, the weathering of tuff is progressing with the influence of fault at the section between 20 km and 50 km. Precaution is necessary for possible collapse of rocks in this section and the result of evaluation will be described in Sub-section 5.5.4 and 5.5.5.

5.6.3 Condition of Bridges

1) General

The object section of NIC.26 is 100km road from Telica in Department of Leon to San Isidoro in Department of Matagalpa. And change of grand height above sea level is full of variety ,from 30m to500mabove sea level.

MTI is making the list of the bridge of this section as the Bridge Inventory for NIC.26 that show the station No., name, present condition, length, total width, effective width, effective span, clearance, type, design load and age of the bridge (see Table 5.6.1).
Therefore, we do the reconnaissance of each site and confirmed that the situation of location is not different from the contents of this Bridge Inventory.

Table 5.6.1 Bridge Inventory for NIC.26

No.	STATION PKM	NOMBRE DEL TRAMO	NAME	PRESENT SITUATION	BRIDGE LENGTH (M)	ROAD WIDTH (M)	TOTAL WIDTH (M)	SPAN LENGTH (M)	FREE SPACE (M)	TYPE	DESIGN LOAD	YEAR
1	104+182	Emp. Telica - Emp. San Isidro	La Cotorra	Bueno	8.6	7	8.6	7	4.7	Conc.	HS-15-44	1963
2	104+657	Emp. Telica - Emp. San Isidro	Figueroa	Bueno	9.4	7	8.6	5.5	5	Conc.	HS-15-44	1963
3	105+300	Emp. Telica - Emp. San Isidro	Santa Ana	Bueno	8.2	7	8.6	5.5	5	Conc.	HS-15-44	1963
4	106+020	Emp. Telica - Emp. San Isidro	Los Pedrones	Bueno	6.4	7	8.6	3.7	3.5	Conc.	HS-15-44	1963
5	106+687	Emp. Telica - Emp. San Isidro	Quimera	Regular	17.7	7	8.6	5+5+5	3.4	Conc.	HS-15-44	1964
6	107+533	Emp. Telica - Emp. San Isidro	Solis	Regular	7.2	7	8.6	4.6	5.3	Conc.	HS-15-44	1963
7	108+154	Emp. Telica - Emp. San Isidro	Papalón	Bueno	5.1	7	8.6	3.5	4.8	Conc.	HS-15-44	1963
8	108+784	Emp. Telica - Emp. San Isidro	*La Higuera*	*Bueno*	*9.5*	*7*	*8.6*	*5.8*	*4.3*	*Conc.*	*HS-15-44*	*1963*
9	114+044	Emp. Telica - Emp. San Isidro	San Jacinto	Bueno	7.6	7	8.6	6.9	3.3	Conc.	HS-15-44	1964
10	119+963	Emp. Telica - Emp. San Isidro	La Milagrosa	Malo	8.6	7	8.6	7	5.5	Conc.	HS-15-44	1964
11	125+674	Emp. Telica - Emp. San Isidro	Santa Amalia (Malpaisillo)	Regular	16.5	7	8.6	15.4	5	Conc.	HS-15-44	1964
12	145+617	Emp. Telica - Emp. San Isidro	El Caimito	Bueno	31.8	7	8.6	10+10.2+10	5	Conc.	HS-15-44	1966
13	148+051	Emp. Telica - Emp. San Isidro	Tionoste	Bueno	19	7	8.6	18	5.8	Conc.	HS-15-44	1966
14	156+785	Emp. Telica - Emp. San Isidro	San Juan de Dios	Bueno	17.9	7	8.6	7.5+7.5	2.8	Conc.	HS-15-44	1965
15	164+125	Emp. Telica - Emp. San Isidro	El Jicaral	Malo	75	Destr.	Destr.	Destruído	Destr.	Conc.	HS-15-44	
16	169+544	Emp. Telica - Emp. San Isidro	Las Pilas	Bueno	8.5	7.4	9	8	5.5	Conc.	HS-15-44	1966
17	170+952	Emp. Telica - Emp. San Isidro	La Banderita	Bueno	31.6	7	8.6	6.6+15.4+6.6	9	Conc.	HS-15-44	1966
18	190+265	Emp. Telica - Emp. San Isidro	La Manga No. 1	Regular	10.6	7	8.6	9.3	3.5	Conc.	HS-15-44	1966
19	190+503	Emp. Telica - Emp. San Isidro	La Manga No. 2	Malo	24.8	Destr.	Destr.	Destruído	Destr.	Conc.	HS-15-44	
20	197+636	Emp. Telica - Emp. San Isidro	S.Pablo (Los Eucaliptos)	Regular	18	7	8.6	5.1+5.6+5.1	3.8	Conc.	HS-15-44	1966

As a result, one (1) bridge in Bridge Inventory is culvert, therefore there are nineteen (19) object bridges in NIC.26 without S.Pablo.

NIC.26 is able to classify it two kind of area, one is lowland area between Telica and El Jicaral Bridge that height is less than 100m above sea level and other is mountain between El Jicaral Bridge and San Isidro that height is from100m to 500m above sea level.

Mean annual temperature of low land area is more than 27℃ with an annual precipitation of 800to 1500mm and mean annual temperature of mountain area is about 25℃ with an annual precipitation of 500to 1000mm

2) History of Past Disaster

In Quimera Bridge and La Milagrosa Bridge embankment of approach road flowed out and in San Juan de Dios Bridge, erosion damage appears at wing wall. And also El Jicaral Bridge and Las Mangas No.2 Bridgewere destroyed. In addition to this, there a lot of damages that are landslide and slope collapse in mountain area.

3) Condition of Bridges

La Manga Bridge No.2 and El Jicaral Bridge were reconstructed by the help of Denmark in 2001(Photo5.6.1, 5.6.2), Other bridges were constructed 1960's. Almost half number of bridge's length is less than 10m.

Lowland area between Telica and El Jicaral Bridge is almost flat, but the lay of the land small undulate relief cause NIC.26 go through between two Volcanos El Telica and Rota. Therefore riverbed grade is steep a little in this place, but in other place riverbed grade is gradual.

There a lot of short span bridges that length is less than 10m in lowland area, and we confirmed that abutment protrude into the river at some bridges. Quimera Bridge and La Milagrosa bridge already repaired, existing approach road replaced new arched bridge with three (3) spans. Furthermore in Los Pedrones Bridge , there is new barrage in downstream side for improvement riverbed grade. But some bridges haven't repaired as shown in Photo 5.6.4 and 5.6.5

In the mountain area between El Jicaral Bridge and San Isidro, there only five (5) bridges, but bridge length is longer than lowland one. And riverbed is consisted of rock or gravel mixed with cobble and grade of riverbed is steep.

El Jicaral is a biggest river in the NIC.26. According to design report of new bridge, catchment area size of El Jicaral at object bridge site is 427 km^2, design discharge is $1740m^3/s$

(50year Hurricane event). And also a discharge of flood that was produced by Hurricane Mitch was 2610m^3/s. New bridge is 4spaned continuous girder bridge, and is constructed 200m downstream of existing bridge.

La Manga Bridge No.2, that was constructed same time El Jicaral Bridge, is single span bridge and catchment area size of this bridge at site is 52 km^2, design discharge is 360m^3/s (50 years Hurricane event).

We confirmed that some erosion damage appears at the foot of abutments and erosion damages at the wingwalls. And also we confirmed the trace of scouring around pier in El Jicaral Bridge (Photo 5.6.6).

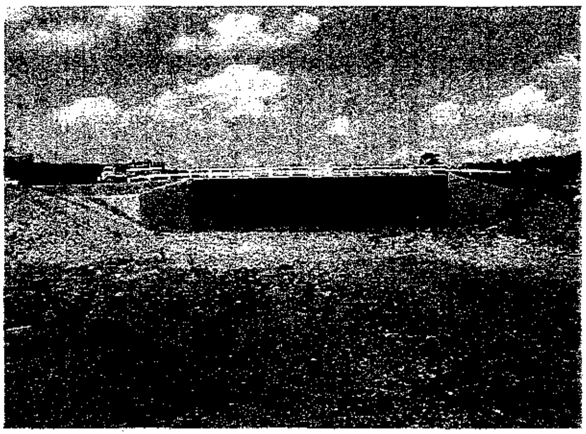

Photo 5.6.1 La Manga Bridge No.2

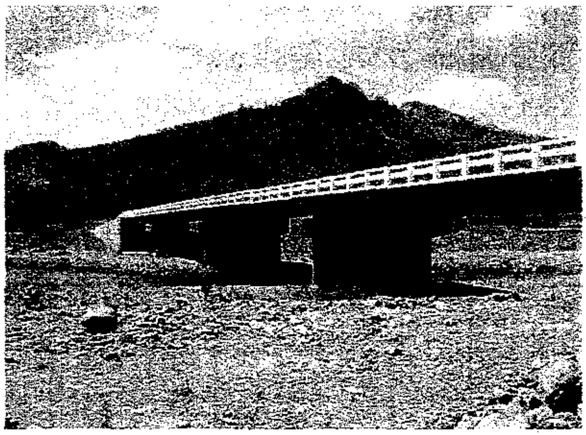

Photo 5.6.2 El Jicaral Bridge

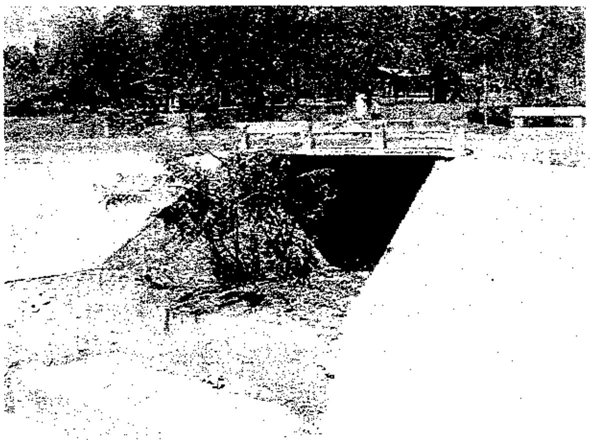

Photo 5.6.3 Los Pedrones

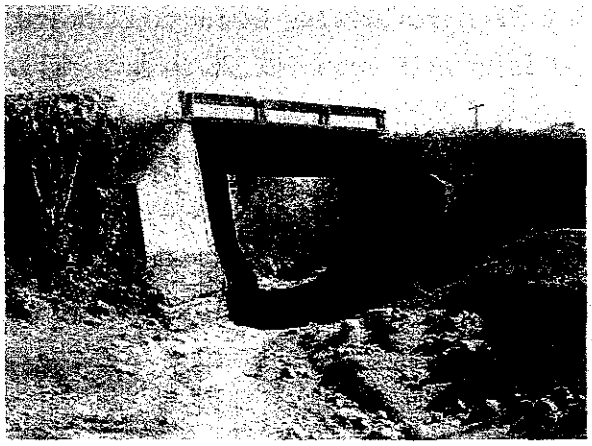

Photo 5.6.4 Solis Bridge

Photo 5.6.5 Las Pilas Bridge

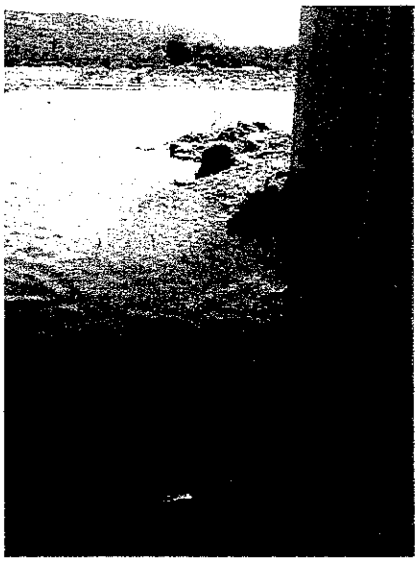

Photo 5.6.6 Pier of El Jicaral Bridge

5.6.4 Survey Results of Screening

1) Survey of Slopes

There are totally 21 places of the screening spots at the mountainous and hilly section of about 35 km on NIC.26 based on the pre-condition introduced in the screening.

a) Rock Fall

15 places of Rock Fall are identified for the screening.

b) Rock Collapsing

There are 6 places of Rock Collapsing Spots located about 29 km to 45 km far from the intersection with NIC.1 at San Isidro.

c) Slope Slide

No place.

d) Debris Flow

No place.

2) Survey for Bridges

La Manga Bridge is the single span bridge without pier, and there is good revetment around the abutment. Therefore we exclude this bridge from the survey object, and we did only confirmation of the site situation.

And there are eleven (11) bridges in NIC.26 that length of bridge is less than fifteen (15) meter.

However we nominate these eleven bridges for the survey object, after confirming in these bridge sites, from the following reason.

i) The river is the natural and not be controlled
ii) Depth of the foundation at the abutment were unidentified
iii) Traces of scouring were observed

As a result, eighteen (18) bridges had been investigated about the stability of riverbed and revetment and about characteristic of substructure.

5.6.5 Identification of Disaster Potential Spot

1) Slopes

Among the 21 places of the screening spots, totally 14 places are identified as Disaster Potential Spots on NIC. 26 for further evaluation.

a) Rock Fall

9 places of Rock Fall are selected as Disaster Potential Spots except one place where the stability score of 64 points are exceeding but having enough space along side of the road for reducing impact of the disaster of Rock Fall.

b) Rock Collapsing

Within 6 places of the screening spots, 5 places are identified as Disaster Potential Spots.

2) Spots of Bridges

As the result of the site survey, that show it to Table5.6.3, we evaluated 6 bridges, as the Disaster Potential Spots for Bridges that show it to Table5.6.4, in consideration of as following matter;

i) Evaluation to the stability of the riverbed and revetment
ii) Presence of the damage of scouring etc.
iii) Position and form of the substructure.

And we carried out a simple measurement survey and also stability survey, and we arranged the survey result in The Table of Inspection Result and The Table of Record by Inspection Site.

Table 5.6.2 Identified Disaster Potential Spots on NIC.26

NIC.26								
No	Distance from Nic.1[1)]	Serial No	Type of disaster	Length (m)	Height (m)	Angle (degree)	Score	Disaster Potential 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	*

R.F. :Rock Fall
R.C. :Rock Callaping
S.S. :Slop slide
D.F. :Debris Flow

Table5.6.3 Field Survey Results for Bridges on NIC.26

No.	STATION PKM	NAME	BRIDGE LENGTH (M)	DIMENSIONES (M) SPAN LENGTH	TYPE	DESIGN LOAD	YEAR	Stabirity of abutment (F)	Stabirity of Pier (H)
1	104+182	La Cotorra	8.6	7	Conc.	HS-15-44	1963	40	0
2	104+657	Figueroa	9.4	5.5	Conc.	HS-15-44	1963	40	0
3	105+300	Santa Ana	8.2	5.5	Conc.	HS-15-44	1963	55	0
4	106+020	Los Pedrones	6.4	3.7	Conc.	HS-15-44	1963	60	0
5	106+687	Quimera	17.7	5+5+5	Conc.	HS-15-44	1964	65	65
6	107+533	Solís	7.2	4.6	Conc.	HS-15-44	1963	75	0
7	108+154	Papalón	5.1	3.5	Conc.	HS-15-44	1963	75	0
8	108+784	La Higuera	9.5	5.8	Conc.	HS-15-44	1963	55	0
9	114+044	San Jacinto	7.6	6.9	Conc.	HS-15-44	1964	50	0
10	119+963	La Milagrosa	8.6	7	Conc.	HS-15-44	1964	60	0
11	125+674	Santa Amalia (Malpaisillo)	16.5	15.4	Conc.	HS-15-44	1964	30	0
12	145+617	El Caimito	31.8	10+10.2+10	Conc.	HS-15-44	1966	55	45
13	148+051	Tionoste	19	18	Conc.	HS-15-44	1966	30	0
14	156+785	San Juan de Dios	17.9	7.5+7.5	Conc.	HS-15-44	1965	80	70
15	164+125	El Jicaral	130	4(32.5)	Conc.	HS-20+25%	2001	70	55
16	169+544	Las Pilas	8.5	8	Conc.	HS-15-44	1966	70	0
17	170+952	La Banderita	31.6	6.6+15.4+6.6	Conc.	HS-15-44	1966	65	65
18	190+265	La Manga No. 1	10.6	9.3	Conc.	HS-15-44	1966	55	0

Table5.6.4 Disaster Potential Spots for Bridges on NIC.26

No.	STATION PKM	NAME	BRIDGE LENGTH (M)	DIMENSIONES (M) SPAN LENGTH	TYPE	DESIGN LOAD	YEAR	Aabutment Stabirity (F)	Aabutment transformation(D)	Pire Stabirity (H)	Pire transformation(D)	Total evaluation
1	107+533	Solis	7.2	4.6	Conc.	HS-15-44	1963	75	100	0	0	100
2	108+154	Papalón	5.1	3.5	Conc.	HS-15-44	1963	75	90	0	0	90
3	156+785	San Juan de Dios	17.9	7.5+7.5	Conc.	HS-15-44	1965	80	90	70	0	90
4	164+125	El Jicaral	130	4(32.5)	Conc.	HS-20+25%	2001	70	50	55	50	70
5	169+544	Las Pilas	8.5	8	Conc.	HS-15-44	1966	70	70	0	0	70
6	170+952	La Banderita	31.6	6.6+15.4+6.6	Conc.	HS-15-44	1966	65	100	65	20	100