14.2 Priority Road Sections for Feasibility Study

The evaluation of priority road section is carried out to examine the technical and economic view points of view as well as the environmental conditions.

As the result of evaluation study for the selection of priority road sections, the Alcalde Diaz and Sabanitas Sections have been selected for implementation of Short and Medium Term Plans. The reasons are give below and the Feasibility Study is conducted based on the two road sections. The comparison of the two Section is given in Table 14.2.1.

It is recommended that road construction is prepared in the Alcalde Diaz and Sabanitas Sections as soon as possible, and the work in the Chagres Section should be done before the year 2010.

(1) From the Viewpoint of Future Traffic Volume

The traffic volumes in the year 2000 in the Alcalde Diaz, Chagres and Sabanitas Sections are forecast to be about 31,000 PCU/D,19,000 PCU/D and 21,000 PCU/D respectively. Considering that the traffic capacity which is about 10,000 V/D per lane, 4-lanes will be required in the Alcalde Diaz and Sabanitas Sections. However, traffic volume in the year 2000 in the Chagres Section will not yet have reached the traffic capacity.

(2) From the Viewpoint of Traffic Congestion on the Road

In the traffic counting survey conducted in February 1993, the traffic congestion on the Alcalde Diaz, Chagres and Sabanitas Sections of the existing Panama-Colon Highway were calculated to be 1.5, 0.7 and 1.3 respectively. Traffic congestion in 2000 on the three sections of the existing road are calculated to be 2.0, 0.9 and 1.5 respectively. The traffic in Alcalde Diaz and Sabanitas Sections is now move their capacities, but, the Chagres Section has not reached its capacity yet.

(3) From the Economic Viewpoint

As shown in Table 14.2.1, the values of total time saving and vehicle * Km / construction cost on the Alcalde Diaz and Sabanitas Sections are higher values than the Chagres Section. From the economic viewpoint therefore the Alcalde Diaz and Sabanitas Sections are should be constructed earlier than the Chagres Section.

(4) From other Viewpoints

Many traffic accidents own on the Alcalde Diaz and Sabanitas Sections. Though it is difficult to identify causes of these accidents, a new road will help to reduce them.

The horizontal and vertical alignments of the existing road in the Sabanitas Section has many small curves. So this section is very dangerous for drivers and traffic cannot below smoothly on it. It is very difficult to widen the existing road in Sabanitas Section, because this area has steep mountain slopes.

Table 14.2.1 Comparison of Proposed Road Sections

Items /Section	Alcalde Diaz	Chagres	Sabanitas
Section Length (Km)	22	12	26
Construction Cost(1,000/B)	83,205	43,076	132,327
Traffic Accidents(in 1991) (per Km)	14.4	4.3	9.0
Traffic Volume (in 2010) (PCU/D/Km)	60,000	33,000	58,000
Traffic Volume (in 2000) (PCU/D/Km)	31,000	19,000	25,000
Vehicle * Km (in 2000)	682,000	55,000	546,000
Vehicle * Hr (in 2000)	12,000	3,400	12,000
Traffic Congestion (V/C) on Existing Road(in 1993)	$0.7 < V/C < 1.5$	$V/C < 0.8$	$0.7 < V/C < 1.3$
Traffic Congestion (V/C) on Existing Road(in 2000)	$1.0 < V/C < 2.0$	$V/C < 1.0$	$1.0 < V/C < 1.5$
Vehicle * Km / Const. Cost (V/B 1000)	8.19	1.27	4.13
Time Cost Saving (Hr/D)	65,100	19,500	52,400

15 GEOGRAPHIC CONDITIONS

15.1 Topographic Mapping

15.1.1 Outline of the Work

Topographic maps with a scale of 1:5,000 were prepared for the Feasibility Study on the Improvement of Panama-Colon Highway. The work included a ground control survey and field identification, aerial photography, preparation of uncontrolled photo mosaics, photogrammetric mapping and field completion.

The ground control survey established vertical and horizontal ground controls which were used as control points for the aerial triangulation and photogrammetric mapping.

The aerial photography, which had a scale of 1:20,000, covered the whole Study area. The aerial photographs were enlarged up to 1:10,000 for the preparation of uncontrolled photo mosaics. The photographs were also used for the aerial triangulation and the 1:5,000 photogrammetric mapping.

The uncontrolled photo mosaics covered the whole Study area at a scale of 1:10,000 and were used mostly for the Master Plan Study. Field identification was carried out with 1:5,000 enlarged aerial photographs, covering the whole Study area in order to identify and collect the data necessary for the 1:5,000 topographic map. Data was collected on features which were difficult or impossible to identify by photo interpretation.

The results were used for the photogrammetric mapping carried out in Japan. The areas on which aerial photography, uncontrolled photo mosaic and ground control survey were carried out are shown in Figure 15.1.1. Coordinated Data of existing and established ground controls are shown in Table 15.1.1 The areas and maps prepared in the topographic are shown in Figure 15.1.2.

15.1.2 Projection, Coordinates and Datum Elevation

The geodetic specifications used for the survey and mapping were as follows:

a) Projection : Transverse Mercator
b) Spheroid:Clarke 1886, a=6378206m b=6356584m c=1:294.987
c) Coordinates: Universal Transverse Mercator(UTM), Zone 17
Origin of the coordinates is 81 Degree West as the central meridian and the Equator
d) Origin of geographic coordinates: North American 1927
Meads Ranch 269
e) Datum elevation: Mean Sea Level(MSL) at water gauge in Cristobal port as 0 meter.

15.1.3 Accuracy and Evaluation

(1) Leveling

A Leveling of 36 kilometers in 13 routes out to determine the elevation of the 13 ground controls. The double run method was employed for the observation.

The disclosures of 13.75 millimeters $\sqrt{S}$ as maximum and 0millimeter $\sqrt{S}$ as minimum sufficiently satisfied the accuracy of 20 millimeters in the Specifications.

(2) Traversing

Traversing of 108 kilometers was carried out on 13 routes to establish horizontal coordinates for the 13 ground control points. For the reference points for the traversing were existing triangulation points in and around the study area.

The ratio of disclosure on the routes,1.094 m/ 9,915 m (1:9,000) as maximum and 0.293 m/11,337 m (1:38,655) as minimum sufficiently satisfied the accuracy of 1:4,000 in the Specifications.

(3) Aerial Triangulation

Aerial triangulation was carried out to establish photo control points on 124 stereo models in 10 flight lines. The flight lines 2, 3 and 4 were divided into 2 lines for the flight lines containing over 30 stereo models. The aerial triangulation covered the whole Study area, so that any portion of the area could be mapped.

The accuracy of the aerial triangulation could be known from the residuals in the vertical and horizontal ground controls after the adjustment was done. The standard deviation of residuals in vertical and horizontal ground controls were 0.50 and 1.24 meters, respectively sufficient to satisfy cleared the accuracy of 2.4 meters in the Specifications.

15.1.4 Inspection

The 1:5,000 topographic maps were inspected and proofed by the Japan Survey Association and certified by them.

15.1.5 Results

The results obtained from the survey and mapping operations were as follows:

(1) Ground controls survey

a) Monumentation of ground control points — 13 points
b) Signalization of existing and new ground control points — 25 points
c) Pricking of the existing triangulation points — 4 points
d) Leveling to determine elevation of the ground controls — 36 km2
e) Traversing to determine 13 horizontal coordinates of the ground controls — 108 km
f) Pricking of existing bench marks along the Panama-Colon highway — 70 km2

(2) Aerial photography

1:20,000 aerial photography of 125 stereo models in 5 flight lines — 520 km2

(3) Uncontrolled photo mosaics

1:10,000 photo mosaics covering Panama-Colon area (20 sheets x 3 in A1 size) — 520 km2

(4) Photogrammetric mapping

a) Aerial triangulation to establish photo control points in 5 flight lines — 124 models
b) 1:5,000 photogrammetric plotting 13 sheets of B1 size — 115 km2
c) Field completion of 1:5,000 draft maps 13 sheets of B1 size — 115 km2
d) Editing and drawing of 1:5,000 topographic maps 12 sheets of B1 size — 110 km2

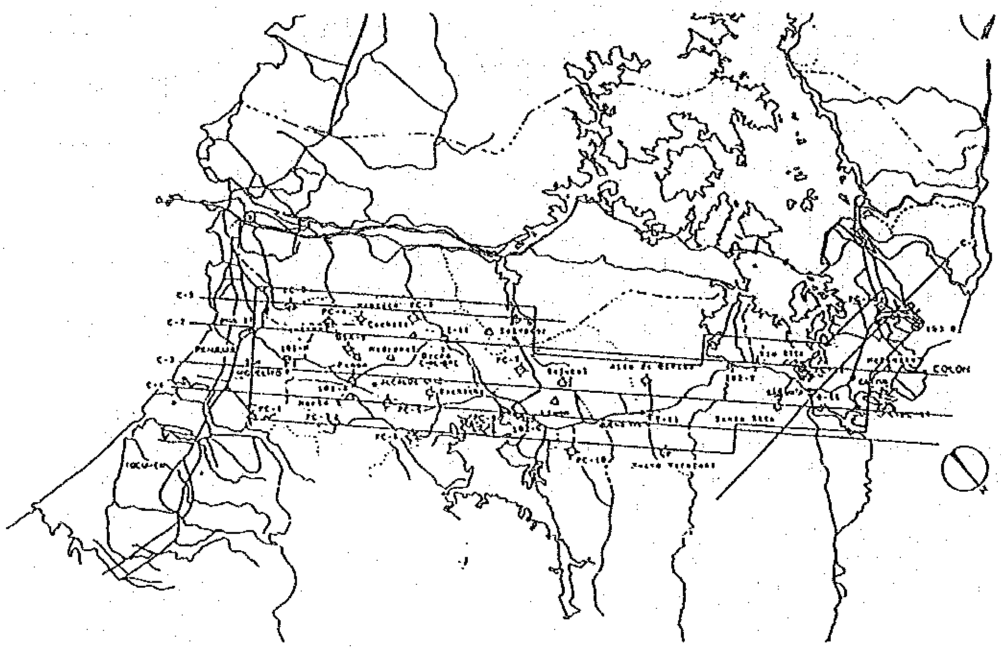


Figure 15.1.1 Aerial Photography Flight Lines

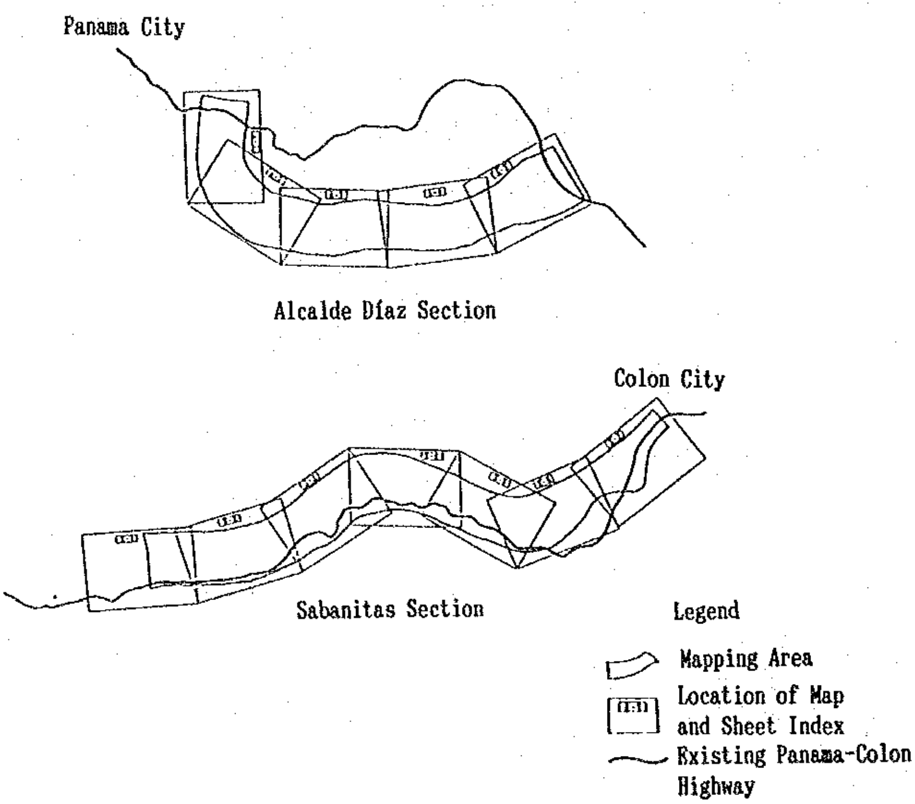


Figure 15.1.2 Mapping Area and Sheet Index

Table 15.1.1 Coordinates Data of the Existing and Established Ground Controls

Station	Northing(m)	Easting(m)	Height(m)	Code in Triangulation	Remarks
PC-1	1,004,345,872	668,294,646	71.901	1013	
PC-2	998,816,742	660,392,541	108.831	1001	
PC-3	1,008,906,175	664,016,312	165.711	1014	
PC-4	1,001,375,644	658,618,249	71.328	1002	
PC-5	1,010,300,934	659,079,159	111.814	1016	
PC-6	1,014,378,563	658,270,910	123.916	1017	
PC-7	1,015,807,206	650,962,954	102.415	Not used	for the A. triangulation
PC-7-2	1,015,674,760	649,417,201	46.913	1011	Alternative to PC-7
PC-8	1,006,819,060	653,402,994	115.400	1004	
PC-9	1,018,036,027	654,122,023	111.673	1018	
PC-10	1,023,550,284	649,495,435	61.631	Not used	for the A. triangulation
PC-10-2	1,023,024,327	648,920,049	53.374	1024	Alternative for PC-10
PC-11	1,037,154,673	629,416,453	8.809	1026	
PC-12	1,032,632,416	629,351,523	41.080	1022	
PC-13	10,313,986,488	621,931,313	18.165	1028	
USA-5	1,004,699,266	659,037,294	44,491.00	1006	
Oscuro-2	1,010,875,712	652,975,074	21,122.00	1008	Data from GPS observation
Rio Rita	1,028,475,216	632,976,161	179.26	1021	-ditto-
Bejucal2	1,018,511,071	646,778,229	122.85	1012	-ditto-
Maria-E	1,008,097,868	661,049,101	198.85	1015	
Ventana2	1,001,661,409	661,243,333	275.48	1005	
Bachiche	1,011,909,558	656,473,738	316.65	1009	
Manteca	1,003,398,508	656,726,738	249.83	1003	
Cachete	1,007,684,200	654,457,081	210.77	1019	
N.Veragu	1,028,611,400	643,848,996	269.05	1025	Data from GPS observation
Mckenzie	1,035,963,195	625,183,193	-	1027	
Washingt	1,035,137,658	620,010,839	-	1029	
Colina	1,003,007,181	664,823,273	125.60		Azimuth for traversing
St.Rita	1,030,891,157	633,751,849	268.22	1023	Data from GPS observation
Madronal	1,007,837,427	656,506,794	225.63	1007	
IDAAN	1,016,430,341	654,724,261	87.14	1010	
USA-4	1,009,995,194	665,785,690	304.19		Azimuth for traversing
A.Divisa	1,022,961,385	641,654,542	311.88	1020	

(Coordinates:UTM. Zone 17. elevation: Mean Sea Level)

15.2 Hydrological Study

15.2.1 Climate

(1) Climate

The Republic of Panama has a climate of subtropical rain forest, with the temperature registering about 80 F and humidity about 60 to 70 percent throughout the year.

(2) Precipitation

Precipitation has been studied according to the Instituto de Recursos Hidraulicos y Electrificacion (IRHE) precipitation data collected at three points of observation; Tocumen (on the Pacific side, Buena Vista (middle region) and San Pedro (on the Caribbean side).

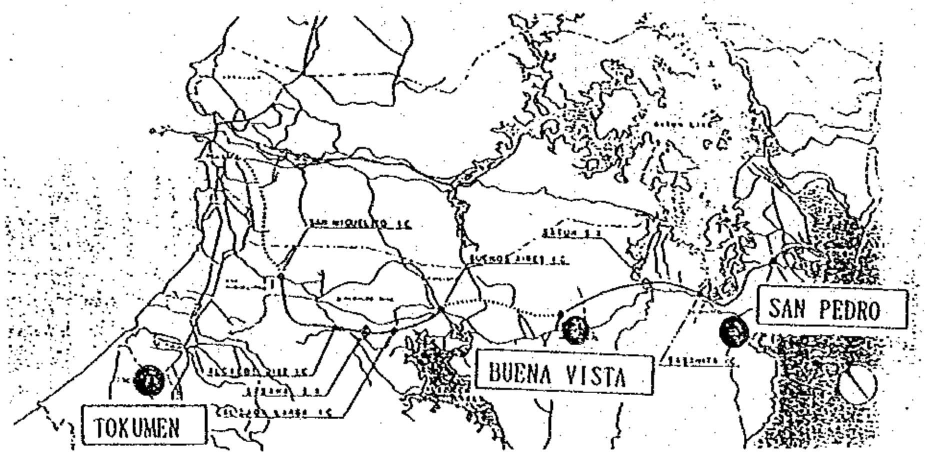


Figure 15.2.1 Points of Observation (precipitation)

1) Annual Precipitation

Figure 15.2.2 illustrate rearranged of precipitation data for the last ten years. The approximate annual average precipitation is 1,800 millimeters on the Pacific side, 2,400 millimeters in the middle region and 2,900 millimeters on the Caribbean side, the figure on the Caribbean side showing 1.5 times that on the Pacific side. The precipitation in the rainy season accounts for over 90 percent of the total annual volume in each area, and the rainfall, especially in the three-month period from September to November, accounts for 40 to 50 percent of the total figure.

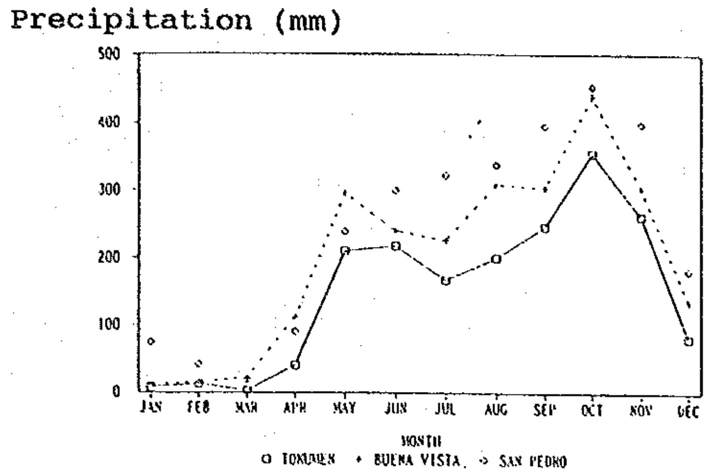


Figure 15.2.2 Average Monthly Precipitation for Ten Years

2) Annual Rainy Days

There are about 160 days on the Pacific side and in the middle region, and about 190 days on the Caribbean side which are the annual average numbers of rainy days in the last ten years. And there are about 50 days on the Pacific side, about 70 days in the middle region and about 80 days on the Caribbean side which are the numbers of rainy days where daily precipitation is over 10 millimeters.

3) Maximum Daily Rainfall

The probability maximum daily precipitation has been obtained by statistical treatment of the maximum annual precipitation, and is shown in Table 15.2.1.

Table 15.2.1 Probability Maximum Daily Precipitation
(Unit; Millimeters)

Return Period	Tocumen	Buena Vista	San Pedro
2 Years	89.9	96.1	108.8
5 years	108.1	117.7	133.2
10 Years	118.4	129.3	146.6
20 Years	127.4	139.2	158.1
50 Years	138.0	150.5	171.3

15.2.2 Probability Precipitation Intensity

The precipitation intensity in Panama City is known from the precipitation intensity prepared on the basis of the Talbot type precipitation data for 56 years. This is in conformity to "Informe de Drenaje Pluvial Cuidad de Panama" prepared by MOP in 1972.

Table 15.2.2 Probability Precipitation Intensity

Return Period (Years)	Probability Intensity (Inch/ Hr.)	(mm/Hr.)
2	237/(29+t)	67.6
5	294/(36+t)	77.8
10	323/(36+t)	84.5
20	357/(37+t)	93.5
25	370/(37+t)	96.9
30	370/(36+t)	97.9
50	370/(33+t)	101.1

Source; MOP informe de Dre-naje
Pluvial Cudad De Panama

15.3 Subsurface Investigation

15.3.1 Overview of Topography

The central isthmus where Panama is located connects the North American Continent with the South American Continent. According to the plate tectonics theory, four plates Cocos, Nazca, Caribbean and Americas plates are concentrated in this area. The Republic of Panama is located at the southwestern end of the Caribbean plate, a crossing point with the Cocos plate, which stretches in the northeastern direction from the southwest along the fault running from south to north, and extends under the Caribbean plate.

The Isthmus of Panama where the projected route is located stretches about 60 km in width from south to north in the center of Panama, and the watershed is located 10 to 15 meters further up in the country along the Pacific Ocean.

On the Pacific Ocean side of this watershed, the gradually sloping hill is formed by the igneous rock and sedimentary rock of the Tertiary period; whereas on the Caribbean side the basalt or dacide are encroached to form projected plateau or conical features.

Gatun Lake and Alhajuela Lake around the Panama Canal are artificial lakes, where many rivers including Chagres River, Gatun River and their tributaries empty themselves. These lakes supply water into the Panama Canal; not only that, Gatun Lake serves as a water source to provide drinking water to Sabanitas and other places, while Arauera Lake supplies it to Panama City.

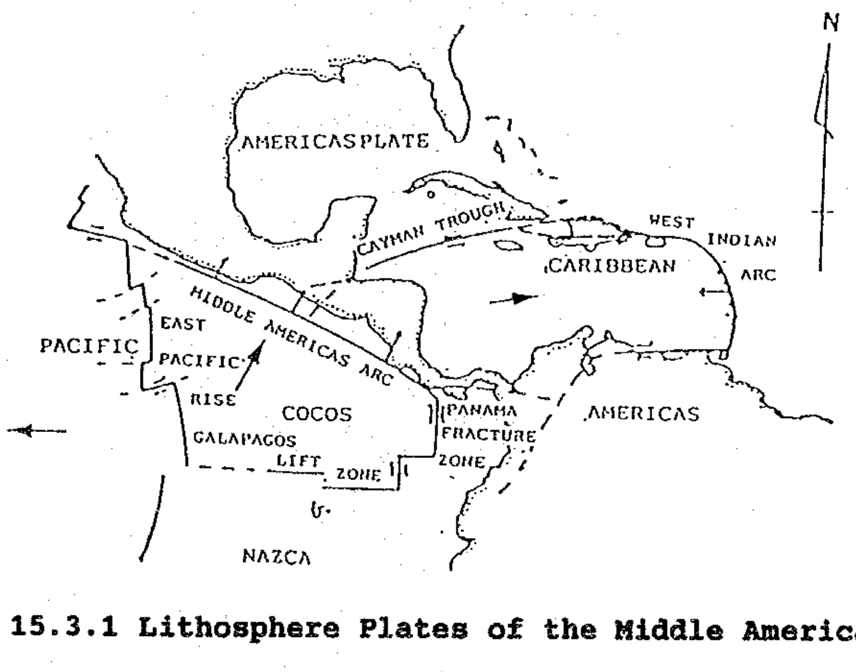


Figure 15.3.1 Lithosphere Plates of the Middle America Region

15.3.2 Earthquake

No big earthquake is recorded in the Republic of Panama in recent years. The biggest earthquake having occurred on September 7, 1882 in Panama is estimated at VII in Panama City and VIII in Colon in terms of the modified Mercalli scale.

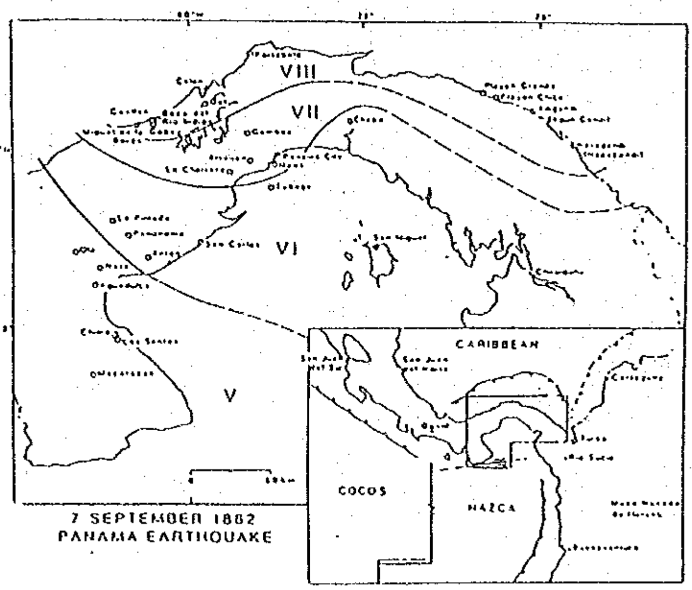


Figure 15.3.2 Panama Earthquake(7 Sep. 1882)

Table 15.3.1 Seismic Coefficient

Modified Mercal Scale	Acceleration as Proportion of Gravity
I	0.0001
II	0.0005
III	0.001
IV	0.002
V	0.01
VI	0.02
VII	0.05
VIII	0.10
IX	0.15
X	0.31

Source: IOCS Memorandum PCC-3

15.3.3 Geology

The bedrock of the projected route of the Panama-Colon Highway consists of the volcanic bedrock containing a variety of sedimentary rocks, and can be divided broadly into the following seven areas as shown in Figure 15.3.3.

Around 60 percent of the alignment, in its middle, is inside of a Synclinal with basically three geological formations, Panama, Las Cascadas and Gatuncillo. The next 30 percent is crossing Ocu Formations tuffs and limestones and final 10 percent is over the Gatun Formation. It is possible to find quarry for the subbase materials in the Panama Formation and in the limestones of the Ocu Formation. In the other formations it is very difficult. In the Colon area, Gatun Formation, it is extremely difficult to find suitable quarries for rock like materials.

1) San Miguelito ------ Alcalde Diaz (TO - PA)

Panama Formation, marine facies, Oligocene. Tuffaceous sandstone, tuffaceous siltstone, algal and foraminiferal limestone.Sandy siltstone in basal part of formation in Quebrancha syncline.

2) Alcalde Diaz ------ Calzada Larga (TE - G)

Gatuncillo Formation, Eocene. Mudstone, siltstone, quartz sandstone, algal and foraminiferal limestone.

3) Calzada Larga ------ Buenos Aires (TM - CAS)

Las Cascadas Formation, Miocene. Volcanic formation. Agglomerate and soft, fine-grained tuff and andesite.

4) Buenos Aires ------ Rio Chagres (TO- PA)

Panama Formation, marine facies, Oligocene. Tuffaceous sandstone, tuffaceous siltstone, algal and foraminiferal lime stone.Sandy siltstone in basal part of formation in Quebrancha syncline.

5) Rio Chagres ------ Buena Visita (TE - G)

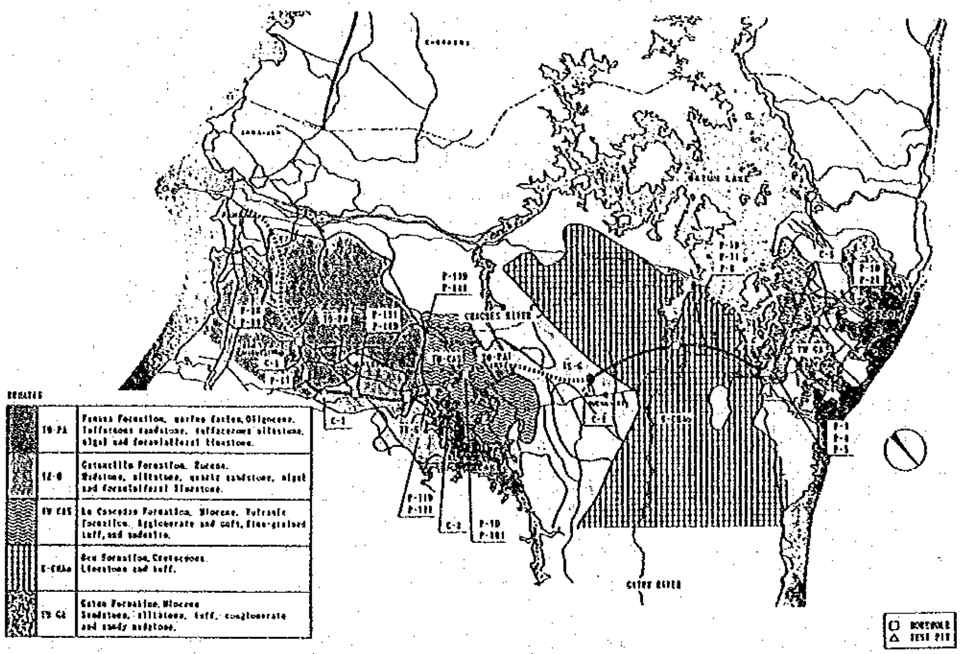
Gatuncillo Formation, Eocene. Mudstone, siltstone, quartz sandstone, algal and foraminiferal limestone.

6) Buena Vista ------ Sabanita (K - CHAo)

Ocu Formation, Cretaceous. Limestone and tuff.

7) Sabanita ------ Coco Solo (TM -GA)

Gatun Formation, Miocene. Sandstone, siltstone, tuff, conglomerate and sandy mudstone.



Source:Direction de Recursos Minerales and Stewart and Woodring

Figure 15.3.3. Geological Map with Location of Boring Loges

15.3.4 Soil Quality

Before the route is selected, soil quality survey was made at segments B (San Miguelito to Buenos Aires), D (Buena VistaS to abanitas) and F (Sabanita to Colon) between Panama and Colon to have a correct understanding on the soil quality in both the plane and longitudinal terms and to study the possibility of application to the construction materials, civil engineering, pavement and structure foundation.

Based on the result of this survey and the ensuing laboratory test, soil quality was classification in the region covered by the project.

According to this result, almost all the areas belong to the silt clay having a high compressibility, and can be classified as A-7-5 (84.2 percent). The area of P-9D and P-101 can be made of silt, clay sand or gravel and can be classified as A-2-6 (10.5 percent). The area close to P-6D consists of the silt having high compressibility, and is classified as A-4 (5.4 percent). The average liquid limit is 51.5 percent, and the plastic limit is 34.6 percent.

The following shows the CBR value classified in terms of soil quality:

a) A-2 14 =< CBR =< 21

b) A-4 CBR = 14
c) A-7 6 =< CBR =< 16

However, the CBR value is about 3 around Colon. Table 15.3.2 illustrates the resultant physical properties, and Table 15.3.3 illustrates the soil quality classification and the characteristics.

(1) San Miguelito - Alcalde Diaz

1) P-19 (Chivo Chivo I)

he layer about 11 meters deep from the surface is composed of the mud having the N value of 3 to 26 with CBR 6 to 8, A-7-5. The layer over 11 meters deep consists of the conglomerate.

2) P-18 (Chivo Chivo D)

The layer about 7.5 meters deep from the surface is composed of the muddy clay having the N value of 5 to 11 with CBR 5, A-7-5. The layer from 7.5 to 10 meters consists of the mud with coarse sands having the N value of 49 to 86 with CBR 9, A-7-5. The layer over 10 meters deep consists tuff and conglomerate.

3) P-17 (Gonzalillo)

The layer about 1 meter, deep from the surface is composed of the clayey mud having the N value of 39 with CBR 6, A-7-5. The layer from 1 meter to 2.5 meters consists of andesiteand , and the layer over 2.5 meters deep consists of andesite and conglomerate.

(2) Alcalde Diaz - Calzada Larga

1) P-16D (Hacia Cemento Bayano D)

The surface layer consists of the gravel of A-1. The layer 3 meters deep from the surface consists of the clayey mud having the N value of 14, A-7-5. The layer from 3 to 15.5 meters consists of the mud or the clayey mud having the N value of 2 to 80, CBR 3 to 10, A-7-5 and A-7-6. The layer over 15.5 meters deep consists of limestone.

2) P-15I (Hacia Cemento Bayano I)

The surface layer is the humus of A-8. The layer 3 meters from the surface is clayey mud having the N value of 8, CBR5, A-7-5. The layer over 3 meters deep is andesite.

3) P-14I (Rio Chilibrillo Abajo I)

The surface layer is humus of A-8. The layer 2.5 meters from the surface is clayey mud having the N value of 27, A-7-5. The layer over 2.5 meters deep is sandstone.

4) P-13D (Rio Chilibrillo Abajo D)

The surface layer is the humus of A-8. The layer 2 meters from the surface is clayey mud having the N value of 9,CBR 5, A-7-5. The layer over 2 meters deep is sandy mudstone and sandstone.

(3) Calzada Larga - Buenos Aires

1) P-12I (Rio Chilibrillo I)

The surface layer is the clayey mud, the layer 1 meter from the surface is weathered sandstone, and the layer over 1 meter deep is sandstone.

2) P-11D (Rio Chilibrillo D)

The surface layer is the clayey mud, the layer 1 meter from the surface is sandstone having uniform grain size, and the layer over 1 meter deep is sandstone.

3) P-10I (Planta Portabilizadora I)

The layer 3 meters from the surface is sand and gravel having the N value of about 17 , CBR 17 to 18, A-2-4 and A-2-6, and the layer over 3 to 4 meters deep consists of the clayey mud having the N value of about 13 with A-7-5. The layer over 4 meters deep is limestone.

4) P-9D (Planta Portabilizadora D)

The layer 4 meters from the surface is sand and gravel having the N value of about 10 to 60, CBR 17, A-2-4 and A-2-6, and the layer over 4 meters deep consists of the limestone.

(4) Buena Visita - Sabanitas

1) P-8 (Rio Gatun Sector 2)

The surface layer is humus of A-8. The layer about 7 meters from the surface is the clay and muddy clay having the N value of about 2 to 10 with CBR 6 to 9, A-7-5, and the layer 7 to 9 meters from the surface is clayey sand with gravel, having the N value of about 70 to 90, CBR 26, A-2-6, with the layer over 9 meters deep consisting of weathered mudstone and conglomerate.

2) P-7I (Rio Gatun I)

The surface layer is humus of A-8. The layer about 4 meters from the surface is the muddy clay having the N value of about 3, CBR 10, A-7-5, and the layer 4 to 6 meters from the surface is sandy clay having the N value of about 4, A-7-5. The layer 6 to 9 meters from the surface is sand and gravel having the N value of about 20 to 30 , CBR 8, A-1-b.

The layer 9 to 11 meters from the surface is muddy sand having the N value of about 40 to 50, CBR 14, A-2, and the layer 11 m to 16 meters from the surface is the gravel, CBR 19, A-1-a, with the layer over 16 meters deep consisting of sandstone.

3) P-6D (Rio Gatun D)

The surface layer is humus of A-8. The layer about 2 meters from the surface is the sandy mud having the N value of about 2 with CBR 14, A-4, and the layer 2 to 4.5 meters from the surface is sandy clay having the N value of about 2, CBR 8, A-6. The layer 4.5 to 6 meters from the surface is the sandy clay having the N value of about 3, A-7-6, and the layer over 6 meters deep consists of sandstone.

(5) Sabanitas - Coco Solo

1) P-5 (Toma de Agua)

The surface layer is humus of A-8. The layer about 3 meters from the surface is the clayey mud having the N value of about 10, CBR 16, A-7-5, and the layer over 3 meters deep consists of limonite (Gatun layer).

2) P-4 (Lago Gatun)

The surface layer is humus of A-8. The layer about 2.5 meters from the surface is the muddy clay and clayey mud, having the N value of about 15 to 40 , CBR 6 to 13, A-7-5, and the layer over 2.5 meters deep consists of limonite (Gatun layer).

3) P-3 (Lago Gatun)

The surface layer is humus of A-8. The layer about 1 meters from the surface is the clayey mud having the N value of about 40 with CBR 10, A-7-5, and the layer over 1 meters deep consists of limonite (Gatun layer).

4) P-2I (Coco Solo I)

The layer about 5 meters from the surface is the muddy clay and clayey mud having the N value of about 5 to 29, CBR 15, A-7-5, and the layer over 5 meters deep consists of limonite (Gatun layer).

5) P-1D (Coco Solo D)

The layer about 4 meters from the surface is the muddy clay and clayey mud having the N value of about 6, CBR 16, A-7-5, and the layer over 4 meters deep consists of limonite (Gatun layer).

Table 15.3.2 Soil Classification of AASHTO

	A-1		A-2				A-3	A-4	A-5	A-6	A-7
	A-1-a	A-1-b	A-2-4	A-2-5	A-2-6	A-2-7					A-7-5* A-7-6*
Percentage Past No. 10 No. 40 No. 200	max50 max30 max15	— max50 max25	— — max35	— — max35	— — max35	— — max35	— min51 max10	— — min36	— — min36	— — min36	— — min36
Percentage Past No. 40 Liquid Limit Plastic Limit	— max6		max40 max10	min41 max10	max40 min11	min41 min11	— N. P	max40 max10	min41 max10	max40 min11	min41 min11
DESCRIPTION	Gravel. Sand		Silty or Clayey-Gravel. sand				Fine Sand	Silt		Clay	
QUALITY	Excellent to Good				Regular to poor		Excellent to Good	Regular to poor			

*(A-7-5 $I\rho \leq \omega\iota$ -30, (A-7-6 $I\rho$) $> \omega\iota$ -30

Table 15.3.3 Soil Classifications

	Soil Classifications (AASHOT)	Natural Water Content(%)	Liquid Limit LL (%)	Plastic Limit PL (%)	CBR (%)
P-1D	A-7-5	31 ~ 69	42 ~ 70	34 ~ 56	16
P-2I	A-7-5	52 ~ 68	60 ~ 69	49 ~ 56	15
P-3	A-7-5	32	50 ~ 55	35 ~ 38	10
P-4	A-7-5	27 ~ 52	48 ~ 71	32 ~ 39	6 ~ 13
P-5	A-7-5	31 ~ 39	57	35 ~ 41	6 ~ 16
P-6D	A-4, A-6, A-7-6	34 ~ 42	43 ~ 74	39 ~ 42	8 ~ 14
P-7I*	A-7-5, A-1-b, A-2, A-1-a	12 ~ 48	44 ~ 51	31 ~ 43	8 ~ 19
P-8	A-7-5, A-2-6	12 ~ 48	36 ~ 63	25 ~ 37	6 ~ 26
P-9D	A-2-4, A-2-6	22 ~ 58	80	52	17
P-10I	A-2-6, A-7-5	9 ~ 53	27 ~ 80	18 ~ 52	17 ~ 27
P-11D	------	36	—	—	—
P-12I	------	39	—	—	—
P-13D	A-7-5	18 ~ 38	57	36	
P-14I	A-7-5	15 ~ 40	60	33	
P-15I	A-7-5	11 ~ 42	52	36	5
P-16D	A-7-5	11 ~ 71	39 ~ 96	27 ~ 67	3 ~ 10
P-17	A-7-5	12 ~ 36	56	40	6
P-18	A-7-5	20 ~ 56	47 ~ 70	30 ~ 35	4 ~ 9
P-19	A-7-5	18 ~ 59	47 ~ 72	30 ~ 37	4 ~ 8

*P-7I LL. PL are NP over 6m deep from the ground surface.

16. DESIGN CONDITIONS

16.1 Premises used in Design

The Feasibility Study is carried out based on the following design premises.

(1) Route Location Area

The Feasibility Study is carried out on the selected road segments in the Master Plan. The starting point of the route would be located on the planned alignment of the Corredor Norte in Panama City and the end point would be located on the existing of Los Cuatro Altos intersection on the Panama-Colon Highway in Colon City.

(2) Corredor Norte

The detailed design of Corredor Norte was completed in 1989 by MOP. However, its construction has not been started yet. This Feasibility Study is based on the detailed design of Corredor Norte as a premise.

In the detailed design (final design) of the Corredor Norte, the intersection between Corredor Norte and the existing Panama-Colon Highway is designed as an At-Grade Intersection. However, when Corredor Norte will be constructed at the same time as the proposed road, this intersection will have to be constructed as a grade separated intersection in consideration of the functions and characteristics of the road and the future traffic demand forecast.

(3) Existing Panama-Colon Highway

The detailed design (final design) of the improvement of the existing Panama-Colon Highway was being carried out by MOP. The Feasibility Study is carried out without referring to the detailed design of the improvement of the existing Panama-Colon Highway due to the difference in progress being made between this Study and the above detailed design.

16.2 Design Criteria

16.2.1 Routes to be Designed

As mentioned in the previous section, Alternative Plan C is recommended for the Master Plan of the road network between the cities of Panama and Colon in 2010. Alternative Plan C is divided into three road sections: Alcalde Diaz, Chagres and Sabanitas. The Feasibility Study is conducted on the sections selected as the most effective for implementation in 2000, for Short and Medium Term Plans. The Alcalde Diaz and Sabanitas Sections have been selected as the routes to be subjected to the Feasibility Study as shown in Figure 16.2.1.

16.2.2. Topographic Map Used

An aerial photogrammetric survey at a scale of 1:20,000 were conducted by the JICA Study Team. Based on the above aerial photographs, topographic maps at a scale of 1:5,000 for the selected routes for the Feasibility Study were prepared by JICA Study Team.

16.2.3 Dimensions to be Used.

The following dimensions are adopted for the Study.

a) Linear measure : metric system
b) Square measure : metric system
c) Cubic measure : metric system
d) Liquid measure : liter system
e) Weight measure : gram system

16.2.4 Design Criteria.

(1) Design Speed

In the Master Plan stage, the proposed new Panama-Colon Highway is classified as a primary road. Therefore, a higher design speed is required. A study to compare the design speeds of 80 km/hr and 110 km/hr is carried out for the proposed road. From this study it is decided that a design speed of 110 km/hr would be better from the economic part of view. So a design speed of 110 km/hr is adopted for the proposed road.

(2) Design Standards to be Adopted

Basically, the standards in Policy on Geometric Design of Highways and Streets (ASSHTO) is adopted as the design standards of the Study, as a result of discussions with the Panamanian counterparts.

(3) **Elements of Design Standards**

The dimensions of design elements in AASHTO are in feet and inches; however, in the Study, these dimensions are changed to the metric system. The main design elements for 110 km/h design speed are shown in Table 16.2.1. The main design elements adopted in the Study are also shown in this table.

Table 16.2.1 Main Design Elements (110 km/h)

Items	Standards Value	Adopted Value
Minimum Radius (m)		
(e=0.06 f=0.10)	630	-
(e=0.08 f=0.10)	580	600
(e=0.10 f=0.10)	500	-
Maximum Grades (%)		
Level	3	3
Rolling	4	3
Mountainous	5	3
Minimum Grades (%)	0.3	0.3
Superelevation (e)	0.06-0.08	0.08
Stopping Sight Distance (m).	200-260	-
Vertical Curves (m)		
Crest Vertical Length(m)	160	-
Sag Vertical	620	-
Lane Width (m)	3.65	3.65
Median Width (m)	3.0-18.0	10.0
Right Shoulder Width (m)	3.0	3.0
Left Shoulder Width (m)	1.2	1.5
Cross Slope (%)	1.5-2.0	2.0

(4) **Introduction of Full Access Control System.**

In order to control traffic flow and maintain traffic safety, a Full Access Control System should be introduced on the proposed road. In this system the movement of traffic between the existing road and the proposed road would be controlled at interchanges.

(5) **Consideration of a Toll System in the Future.**

Taking this contribution into account, the introduction of a toll system may be in order in the future.

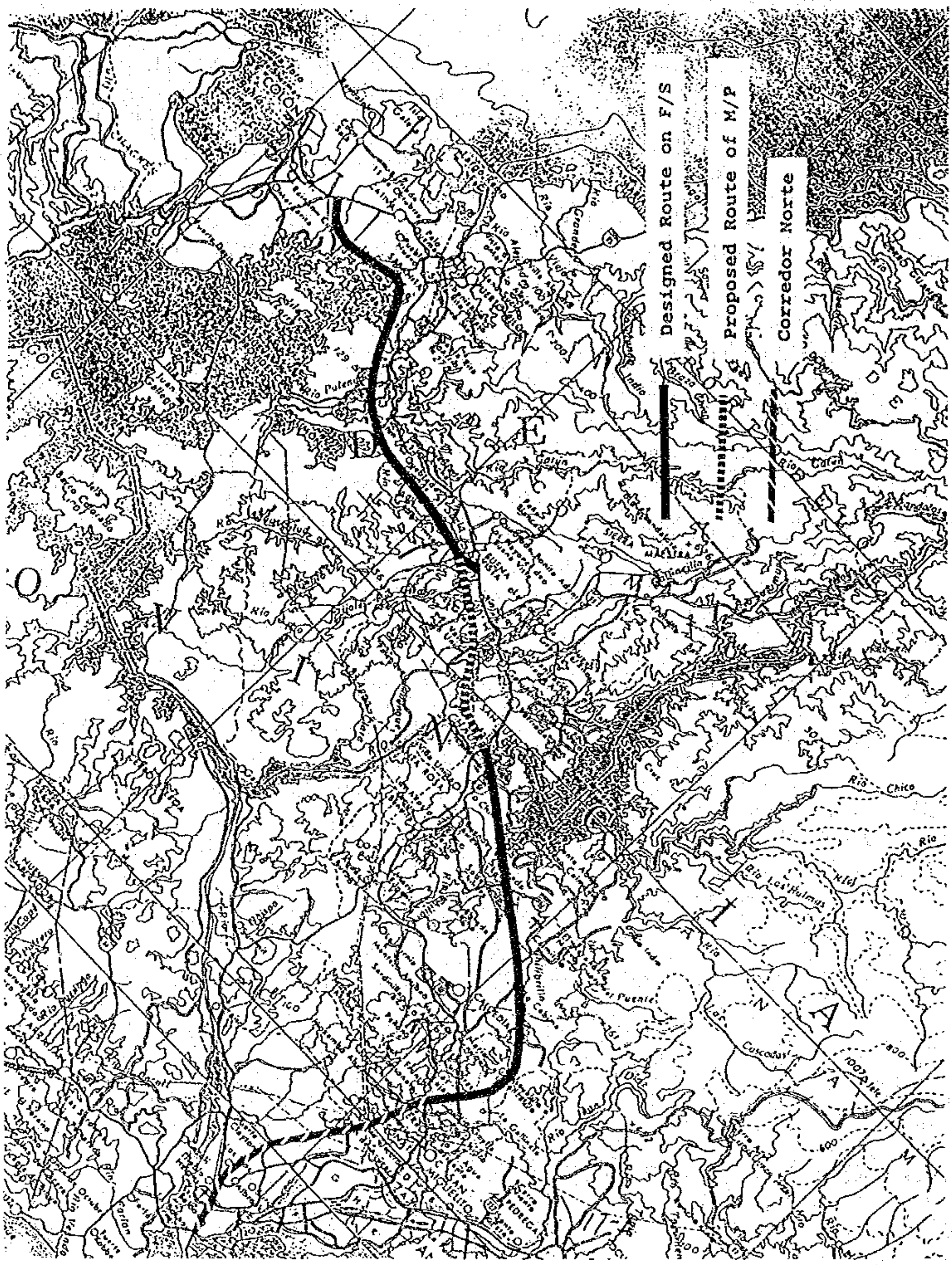


Figure 16.2.1 Selected Route for F/S