JAPAN INTERNATIONAL COOPERATION AGENCY

MINISTRY OF PUBLIC WORKS AND COMMUNICATIONS
THE REPUBLIC OF PARAGUAY

THE FEASIBILITY STUDY FOR THE IMPROVEMENT OF THE NATIONAL ROAD ROUTE 2 AND ROUTE 7 IN THE REPUBLIC OF PARAGUAY

FINAL REPORT (Summary)

MARCH, 2000

YACHIYO ENGINEERING CO., LTD. (JAPAN)

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Exchange Rates: December 1999

US$ 1.00 = Guaranies Gs 3,300

US$ 1.00 = ¥ 105

Preface

In response to a request from the Government of the Republic of Paraguay, the Government of Japan decided to conduct the Feasibility Study for the Improvement of the National Road Route 2 and Route 7 in the Republic of Paraguay and entrusted the study to the Japan International Cooperation Agency (JICA).

JICA selected and dispatched a study team headed by Mr. Toshihiro HOTTA of Yachiyo Engineering Co., Ltd., to Paraguay, three times between March 1999 and January 2000. In addition, JICA set up an advisory committee headed by Hiromi SAITO, Tohoku Region Construction Bureau, Ministry of Construction between April 1999 and January 2000, which examined the Study from specialist and technical points of view.

The team held discussions with the officials concerned of the Government of Paraguay and conducted a field survey in the study area. Upon returning to Japan, the team conducted further studies and prepared this final report.

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

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

March 2000

Kimio FUJITA
President
Japan International Cooperation Agency

Letter of Transmittal

March 2000

Mr. Kimio FUJITA
President
Japan International Cooperation Agency

Dear Sir:

It is a great honor for me to submit herewith the final reports of the Feasibility Study for the Improvement of the National Road Route 2 and Route 7 in the Republic of Paraguay.

A study team of Yachiyo Engineering Co., Ltd., headed by myself, conducted field surveys, data analysis and planning works of the feasibility study in Paraguay based on the instructions from the Japan International Cooperation Agency (JICA) from March 1999 to January 2000.

The study team held thorough discussions and investigations with officials concerned of the Government of Paraguay, accordingly, various traffic surveys, present conditions analysis, preliminary engineering design, environmental impact assessment, preparation of implementation program, and project evaluation. The results were compiled in the final report, main and summary volumes.

On behalf of the team, I wish to express my heartfelt appreciation to the officials concerned of the Government of Paraguay for their warm friendship and cooperation extended to us during our stay in Paraguay.

I also wish to express my sincere appreciation to JICA, the Ministry of Public Works and Communications, Technical Planning Secretariat, the Embassy of Japan in Paraguay, and other concerned government authorities for their valuable advice and cooperation given to us in the course of the Study.

Yours Faithfully,

Toshihiro HOTTA
Team Leader,
The Feasibility Study for the Improvement
of the National Road Route 2 and Route 7
in the Republic of Paraguay

<table>
<tr><td>Study Name</td><td>The Republic of Paraguay
The Feasibility Study for the Improvement of the National Road Route 2 and Route 7</td></tr>
<tr><td>Study Period</td><td>March 1999 to March 2000</td></tr>
<tr><td>Counterpart Agency</td><td>Directorate of Highway, Ministry of Public Works and Communications</td></tr>
<tr><td>Objectives of the Study</td><td>1) To conduct a feasibility study for the improvement of the National Road Route 2 and Route 7 with a target year of 2010; and
2) To transfer relevant technology to the Paraguayan counterpart personnel in the course of the Study.</td></tr>
<tr><td>Study Schedule</td><td>The Study in Paraguay commenced in March 1999 and completed in January 2000. Afterwards, the Study continued in Japan until March 2000 when the Final Report was submitted</td></tr>
<tr><td>Proposed Projects</td><td>1) Mini-bypasses
The existing road passes through the built-up areas of Ypacarai, Caacupe, Itacurubi, and San Jose, where heavy vehicle often run in front of houses. The road width in these cities is narrower than that on the inter-city sections and often causes accidents resulting from mixed traffic of inter-city high-speed vehicles and local traffic. Since it is necessary to separate them to ensure safety, it is proposed that bypasses be constructed to circumvent the built-up areas.
2) Provision of Climbing Lanes
Ascending sections with a long, steep gradient slow down the traveling speed of heavy vehicles and reduce the road capacity as a result. In such sections, many traffic accidents occur, involving those trying to overtake slow vehicles. Based on the AASHTO design standard, another lane will be provided for slow heavy vehicles to travel in sections with a gradient of over 3% continuing for more than 500m.
3) Flyover Intersection in Coronel Oviedo
At the existing intersection near the town of Coronel Oviedo, many traffic accidents occur. In order to realize smooth traffic flows from Coronel Oviedo, where urbanization is taking place, and Routes 2 and 7, the rotary intersection will be grade separated, and a flyover will be constructed.
<table>
<tr><th></th><th>EIRR</th><th>NPV (Gs. Million)</th><th>B/C</th></tr>
<tr><td>Whole Project</td><td>25%</td><td>87,069</td><td>2.3</td></tr>
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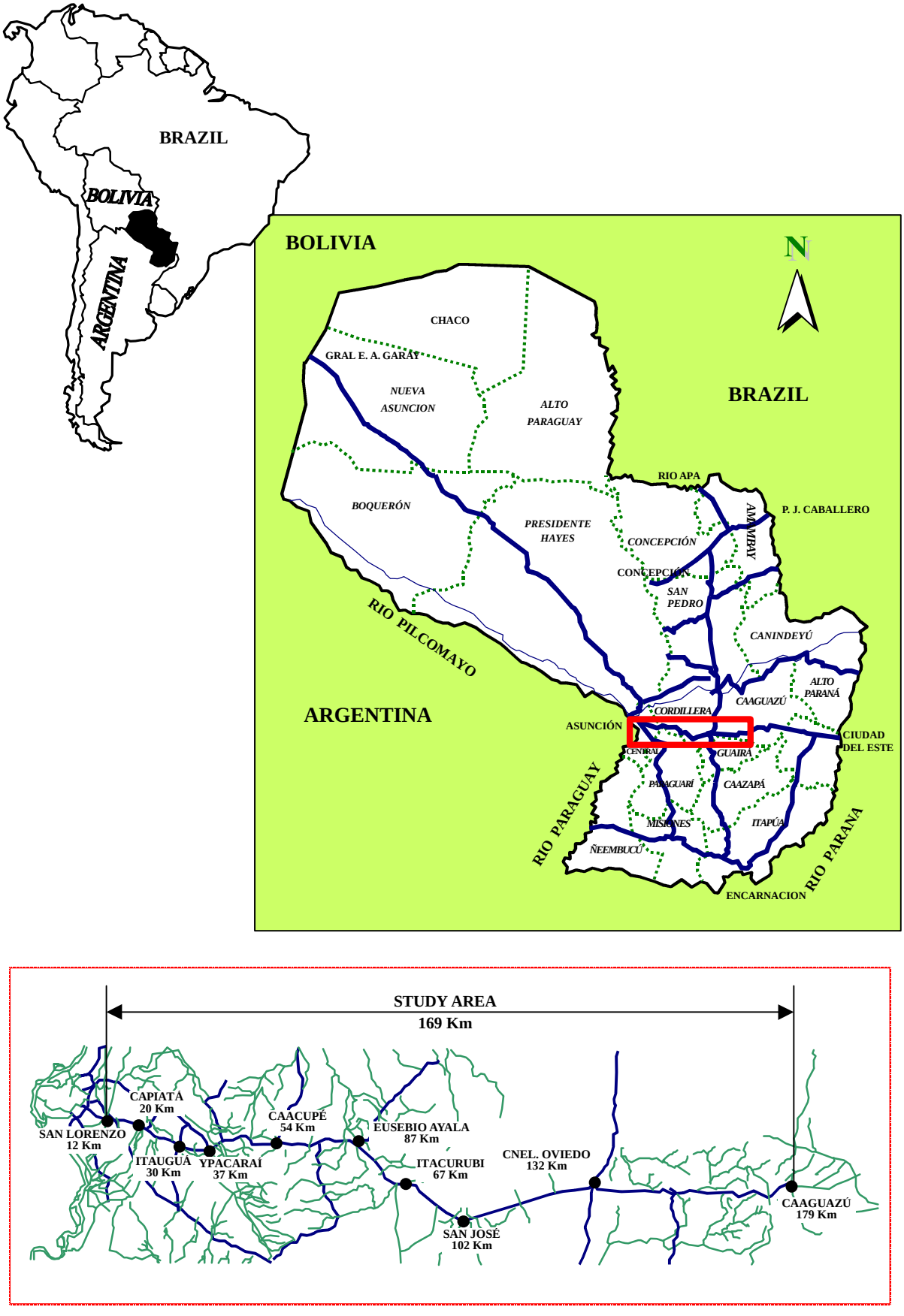
(0.7)</td></tr>
<tr><td>Flyover</td><td>9%</td><td>- 652</td><td>0.8</td></tr>
</table>
A rapid increase in traffic demand on National Road Route 2 and Route 7 and its growing importance in MERCOSUR will require the provision of four lanes for the entire section before 2020. For the target year, 2010, various road improvements have been proposed in this Study on the basis of this assumption of a complete four-lane road.</td></tr>
</table>



Location Map

OUTLINE OF THE STUDY

The Republic of Paraguay
The Feasibility Study for the Improvement of the National Road Route 2 and Route 7

Study Period:	March 1999 to March 2000
Counterpart Agency:	Directorate of Highway, Ministry of Public Works and Communications

1. Background of the Study

National Road Route 2 and Route7, with an extension of 320km, are the main arterial highways linking the capital city, Asuncion (population of approximately 455,000) with the second largest city, Ciudad del Este (population of about 62,000). Running through the country from the east to west, this road leads to Brazil and Argentina and helps connect the Atlantic and Pacific sides of the continent. Moreover, this is Paraguay's busiest route in terms of traffic volume and designated as the country's main artery in the Master Plan Study of National Transportation in Paraguay conducted by JICA in 1993.

Furthermore, since the establishment of MERCOSUR (Mercado Comun del Cono Sur, or South American Common Market) in January 1995, freight traffic has intensified between Paraguay and neighboring countries. In recent years, the export volume in ton has been increasing by roughly 10%, and the number of automobiles is projected to increase, from the level in 1998, by 1.77 times in 2010 and by 2.62 times in 2020. In addition, since 80% of the domestic freight transport takes place on roads, road construction and improvements are essential for developing industry and promoting trade in the country.

However, most sections of Routes 2 and 7 have only two lanes with a width of 6.5m and do not have left-turning lanes or climbing lanes. It is obvious that a further increase in traffic volume in future will make it difficult for the routes to accommodate traffic.

In this context, the Road Department of the Ministry of Public Works and Communications (MOPC), acting through the Government of Paraguay, requested the Government of Japan to provide technical cooperation in conducting a feasibility study for a plan to improve National Road Route 2 and Route 7 so as to realize a smooth traffic flow on the routes.

2. Objectives of the Study

The objectives of the Study are the following:

1) To conduct a feasibility study for the improvement of the National Road Route 2 and Route 7 with a target year of 2010; and
2) To transfer relevant technology to the Paraguayan counterpart personnel in the course of the Study.

3. Study Area

The study area covers the section between San Lorenzo (km 14) and Caaguazu (km 183) of the National Road Route 2 and 7 (approximately 169 km).

4. Study Schedule

The Study in Paraguay commenced in March 1999 and completed in January 2000. Afterwards, the Study continued in Japan until March 2000 when the Final Report was submitted.

5. Contents of the Study

The Study mainly consisted of the following items.

1) Collection and analysis of the existing data and information
2) Various surveys, including traffic, environment, topography, and soils
3) Selection of basic planning policies and design standards
4) Traffic demand forecast
5) Preliminary designs of priority projects
6) Environmental impact assessment
7) Formulation of an implementation plan
8) Economic evaluation and financial analysis
9) Overall project evaluation

6. Proposed Projects

(1) Mini-bypasses

Table 6.1 shows the summary of the proposed mini-bypass projects. All the projects are found feasible from technical, environmental, and economic perspectives.

Table 6.1 Mini-bypass Projects

Items	Description
Classification	Regional Arterial Road
Designed Speed	60 to 80km/hour
Forecast Traffic Volume in 2010	Ypacarai 8,900 pcu/day Caacupe 11,200 pcu/day Itacurubi 13,300 pcu/day San Jose 13,300 pcu/day
Number of Lanes	Four: Ypacarai and Caacupe Two: Itacurubi and San Jose
Road Structure	
Length	Ypacarai: 5,175m, Caacupe: 7,000m Itacurubi: 6,120m, San Jose: 5,420m
Total Project Cost	US$ 43.4 million
EIRR	25%

(2) Climbing Lanes

Based on the design standards defined in the AASHTO, climbing lanes will be provided in sections with gradient of over 3% continuing for more than 500m.

Table 6.2 Climbing Lane Projects

Items	Description	
Classification	Regional Arterial Road	
Designed Speed	Passenger Vehicles:	60km/hour
	Heavy Vehicles:	30 to 40km/hour
Road Structure	Roadway: 3m	Shoulder: 1.5m
Length	13.4km in total	
Project Cost	US$ 27.9 million in total	
EIRR	20%	

(3) Grade Separation of Intersection

The existing rotary intersection near Coronel Oviedo causes many traffic accidents. Thus, grade-separation has been proposed in order to ensure a safe, smooth traffic flow into and from Coronel Oviedo where urbanization is taking place.

Table 6.3 Grade Separation of Intersection

Items	Description
Classification	Regional Arterial Road
Designed Speed	60km/hour
Road Width	Two lane (1.50 + 3.65 + 3.65 + 1.50)
Road Structure	PC Concrete Bridge (2@25.85+35.85+2@25.85)
Length	500m
Project Cost	US$ 2.5 million
EIRR	9%

(4) Urgent Maintenance

The road inventory survey identifies locations with frequent occurrence of traffic accidents, inadequate traffic facilities, and decreasing traffic capacity. Based on these findings, improvement schemes have been proposed to increase traffic capacity.

a. Intersection Improvements

Many existing at-grade intersections on the study section do not have left-turning lanes and needs some improvements. The following intersections will be installed with left-turning lanes within their right-of-ways to increase the road capacity and reduce potential risks of traffic accidents.

- Built-up area between San Lorenzo-Ypacarai: 5 locations.
- Caaguazu : 1 location

b. Installment of Traffic Safety Facilities

The reduction of shoulder widths just before crossing the bridge often leads to crashes against bridge structures. In addition, other sections that need to improve safety facilities include acute curves and intersections lacking in traffic safety signs.

It is necessary for MOPC to launch these proposed urgent projects immediately within a budgetary limit. Thus, this plan does not suggest large-scale improvements in the facilities posing impediments but warning devices for road users to foresee potential dangers. Such devices are as follows.

- Installment of studs on the road surface before and after bridges
- Installment of waning signs before acute curves
- Improvement of intersections of new bypasses and existing roads

c. Maintenance and Renovation

The road and bridge inventory survey shows those bridges that require urgent renovation. In particular, some bridges deserve urgent treatments because of its age and heavy weight repeatedly placed by the traffic. The improvement plan identifies these locations and renovation schemes. The following projects have been proposed:

- Repair of bridges
- Overlay

7. Project Evaluation

7.1 Environmental Evaluation

a. Resettlement

All mini-bypass projects and the construction of a climbing lane in Coronel Oviedo will require resettlement of some residents. According to the interview survey conducted to 266 households to be affected by the projects, most of them, or 265, expressed their support for the implementation of the projects.

b. Natural Environment

A bypass route will pass near a nature protection area around Ypacarai Lake. Road design should consider means for minimizing impact on this swamp area, such as an adequate drainage plan.

7.2 Economic Evaluation

The total project cost amounts to US$82 million, including US$73.6 million for construction and US$8.4 for compensation and land acquisition.

Table 7.1 Results of Economic Evaluation

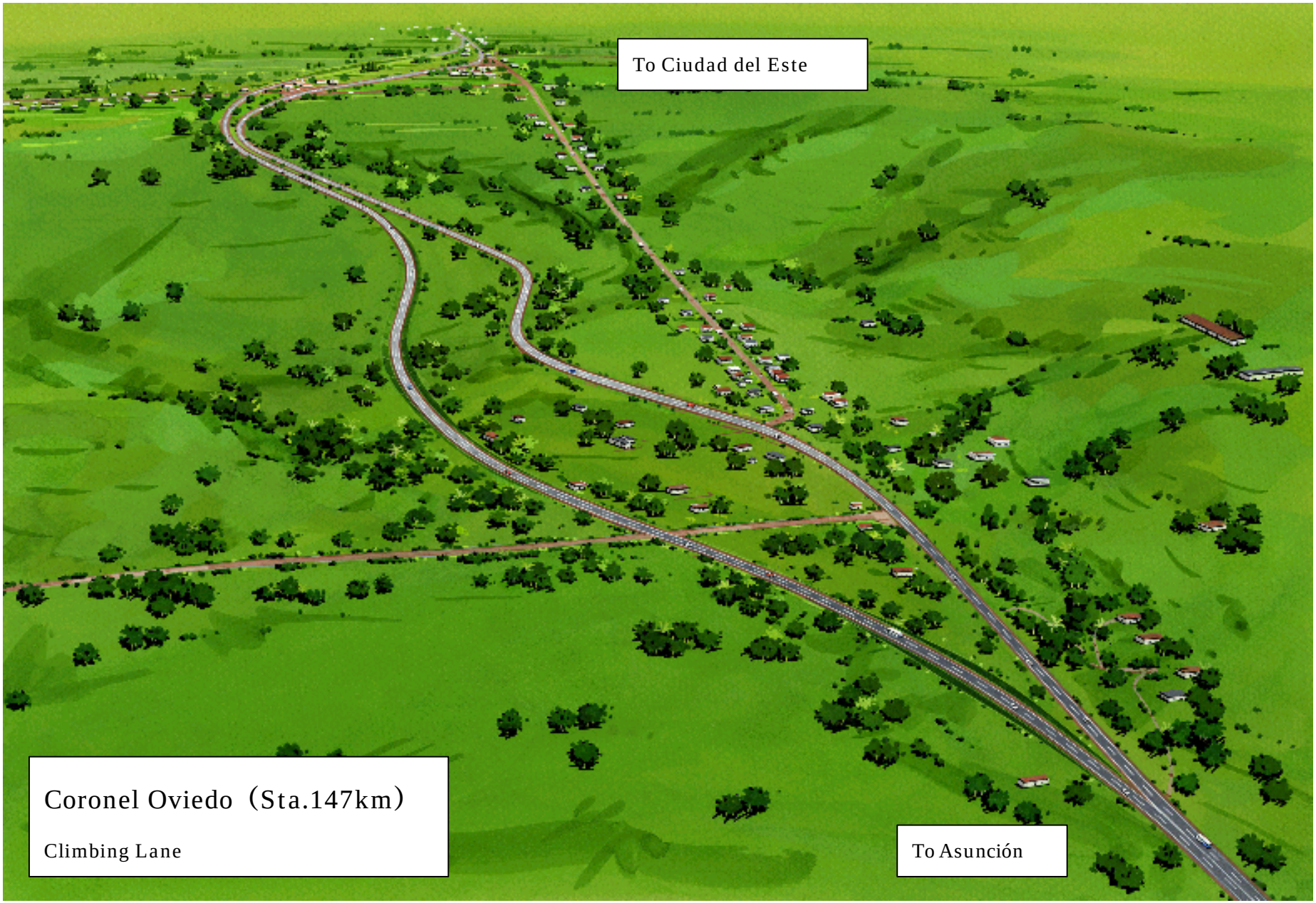
	EIRR	NPV (Gs. Million)	B/C
Whole Project	25%	87,069	2.3
Bypass	28%	73,585	2.5
Climbing Lane (Coronel Oviedo)	20% (8%)	14,137 (- 2,835)	1.8 (0.7)
Flyover	9%	- 652	0.8

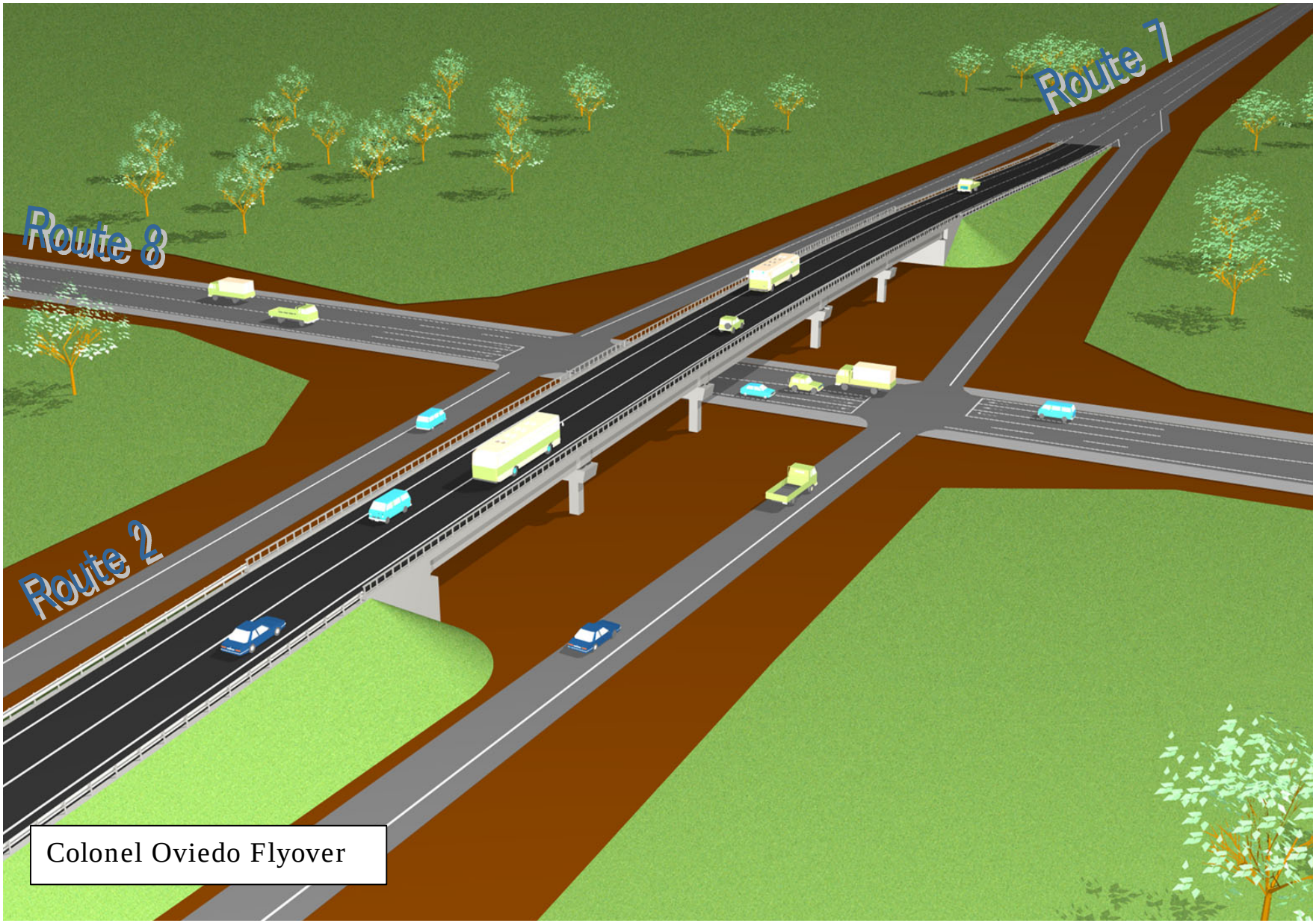
An EIRR for the whole project, excluding the urgent maintenance, has been found to be 25%, and the benefit-cost ratio found to be 2.3. Both indicators show that the project is economically feasible. For each individual project, when not accounting for benefits of accident reduction, the climbing lane project in Coronel Oviedo and the flyover project register low EIRRs. However, in considering the importance of the road and the need for keeping consistency in design standards, the improvement project is worth implementing.

7.3 Financial Evaluation

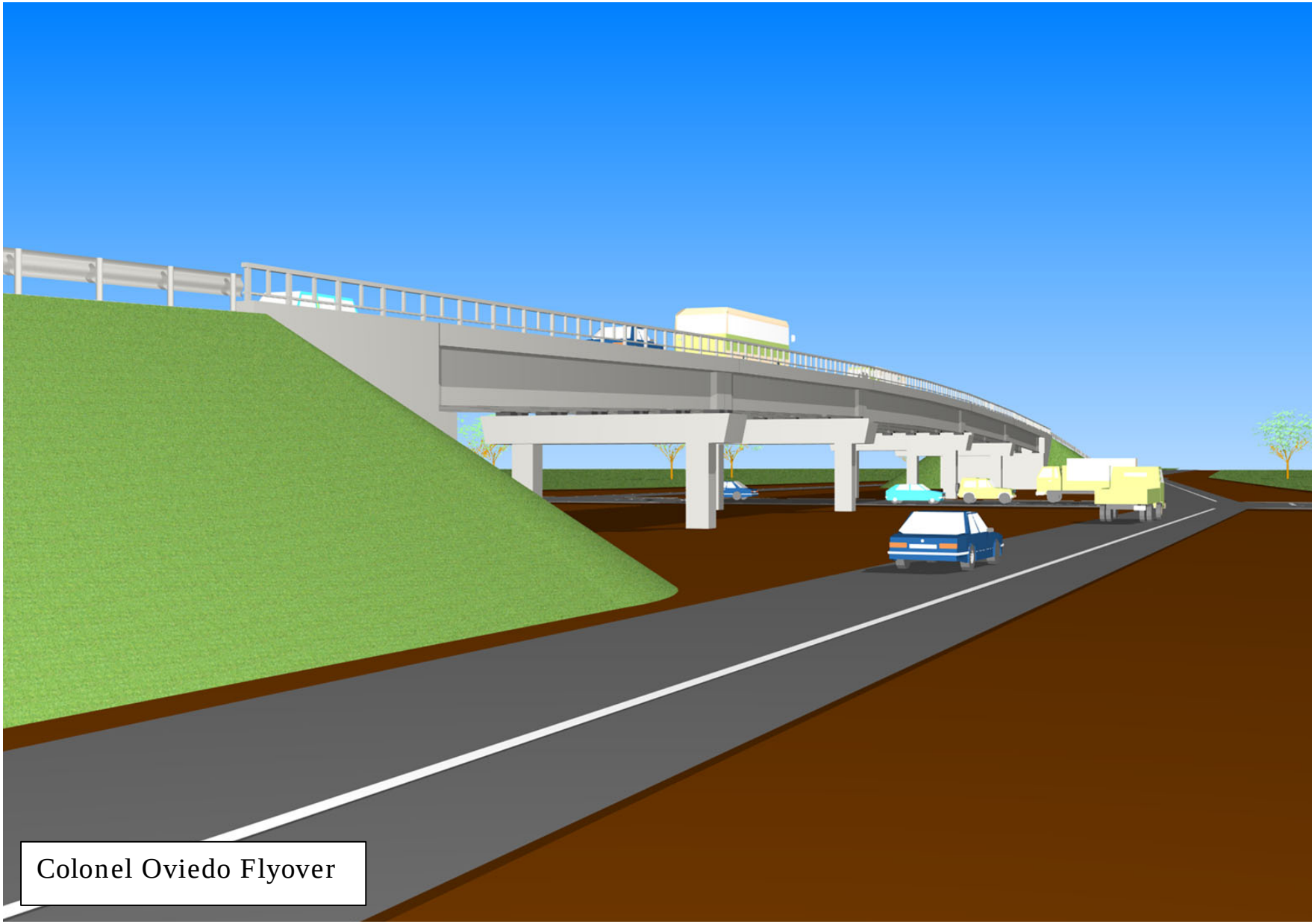
Based on an assumption that the study section will be operated as a tolled highway with the same toll rate and collection method as today (Gs5,000 for passenger vehicles, Gs10,000 for buses, and Gs15,000 for trucks), a financial analysis has been conducted to examine financial viability of the project through toll collection. The project costs include every cost item including the urgent projects except for land acquisition and compensations. As a result, the FIRR has been found to be around 15%. In case the toll is raised to a similar level currently employed in the tolled section on Route 7 (likewise, Gs6,000, Gs12,000, and Gs18,000, respectively), it will increase to 20%.

It is supposed that this project were to be implemented with private capital. The current interest rate from private banks ranges from 22% to 24%. With the annual inflation rate of 5%, the real interest rate in Paraguay is estimated at 17% to 19%. Therefore, the FIRR with current toll level may not be so attractive for a private venture.


To Ciudad del Este
Coronel Oviedo（Sta.147km）
Climbing Lane
To Asunción



Colonel Oviedo Flyover



Colonel Oviedo Flyover

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LIST OF ABBREVIATIONS

GSP	**:**	**Gross Domestic Products.**
MOPC	**:**	**Ministerio de Obras Públicas y Comunicaciones.**
MERCOSUR	**:**	**Mercado Común del Cono Sur. (South American Common Market)**
JICA	**:**	**Japan International Cooperation Agency.**
MAG	**:**	**Ministerio de Agricultura y Ganadría.**
IDB	**:**	**Interamerican Development Bank.**
BIRF	**:**	**International Reconstruction and Development Bank.**
CADEX	**:**	**Brazilian Chamber of Commerce.**
CAF	**:**	**Andean Development Corporation.**
OECF	**:**	**Oversea of Economic Cooperation Found of Japan.**
S. Estanislao	**:**	**San Estanislao.**
Corr. de Exportac.	**:**	**Corredor de Exportación.**
Pav. Ruta 3	**:**	**Pavimentación Ruta 3.**
SIAMV	**:**	**Sistema Integral de Mantenimiento Vial.**
S.A.	**:**	**Sociedad Anónima.**
PIB	**:**	**Producto Bruto Interno.**
BCP	**:**	**Banco Central de Paraguay.**
CONAVI	**:**	**Consejo Nacional de Viviendas.**
Cnel. Oviedo	**:**	**Coronel Oviedo.**
OD	**:**	**Origen - Destino.**
EPEI	**:**	**Equivalente del Peso sobre cada Eje Individual.**
CI	**:**	**Comisión Inter Institucional.**
NTA	**:**	**Normas Técnicas Ambientales.**
ETAG	**:**	**Especificaciones Técnicas Ambientales Generales.**
MSPBS	**:**	**Ministerio de Salud Pública y Bienestar Social.**
CORPOSANA	**:**	**Corporación de Obras Sanitarias.**
SNF	**:**	**Servicio Nacional Forestal.**
DPNVS	**:**	**Dirección de Parques Nacionales y Vida Silvestre.**
DOA	**:**	**Dirección de Ordenamiento Ambiental.**
EIA	**:**	**Evaluación de Impacto Ambiental.**
INDI	**:**	**Instituto Paraguayo del Indígena.**
IBR	**:**	**Instituto de Bienestar Rural.**
SFN	**:**	**Servicio Forestal Nacional.**
DMA	**:**	**Dirección de Medio Ambiente.**
SENASA	**:**	**Servicio Nacional de Saneamiento Ambiental.**
MIC	**:**	**Ministerio de Industria y Comercio.**
IGM	**:**	**Instituto Geográfico Militar.**
CDC	**:**	**Centro de dato para la Conservación.**
PRODEP	**:**	**Proyecto de Descentralización del Paraguay.**
USAID	**:**	**Agencia Estadounidense para el Desarrollo Internacional.**
EAI	**:**	**Examen Ambiental Inicial.**
VOC	**:**	**Costos Operativos de Vehículos.**
TTC	**:**	**Costo de Tiempo de Viaje.**

OPIT	**:**	**Oficina de Planificación Integral de Transporte.**
FCE	**:**	**Factor de Conversión Estándar.**
COC	**:**	**Costo de Oportunidad del Capital.**
TIRE	**:**	**Tasa Interna de Retorno Económico.**
VCN	**:**	**Valor Corriente Neto.**
INF. INCL.	**:**	**Informe Inicial.**
INF. PROG.	**:**	**Informe Progreso.**
INF. INT.	**:**	**Informe Intermedio.**
Org. de la Inpl. del Plan	**:**	**Organización de la Implementación del Plan.**
Cost. Est.	**:**	**Costo Estimativo.**
Brr.	**:**	**Borrador.**
Res. Alt.	**:**	**Resultado Alternativo.**
INF. B. FINAL	**:**	**Informe Borrador Final.**
Eval.	**:**	**Evaluación.**
INF. FIN.	**:**	**Informe Final.**
Ha.	**:**	**Hectáreas.**
Kg.	**:**	**Kilogramo.**
Ton.	**:**	**Tonelada.**
Incre.	**:**	**Incremento.**
Ao	**:**	**Arroyo.**
Nº	**:**	**Número.**
DINAC	**:**	**Dirección Nacional de Aeronáutica Civil.**
CUD	**:**	**Carga Uniformemente Distribuida.**
CP	**:**	**Carga Puntual.**
STP	**:**	**Secretaría Técnica de Planificación.**
EST.	**:**	**Estación.**
ESAL	**:**	**Eje de Carga Simple Equivalente.**
CITES	**:**	**Convención sobre el Comercio Internacional de Especies amenazadas de Fauna y Flora Silvestre.**
SPM	**:**	**Materia de Partícula Suspendida.**
COV	**:**	**Costos de Operación del Vehículo.**
CTV	**:**	**Costo de Tiempo de Viaje.**
NS	**:**	**Nivel de Servicio.**
ESAL	**:**	**Carga de Eje Único Equivalente.**
CBC	**:**	**Carga de Borde de Cuchilla.**
SMA	**:**	**Sistema de Mantenimiento y Administración de Tráfico.**
CPM	**:**	**Centro Principal de Mantenimiento.**
OM	**:**	**Oficina de Mantenimiento.**
FD	**:**	**Franjas de Dominio.**
ONG	**:**	**Organizaciones no Gubernamentales.**
SIG	**:**	**Sistema de Información Geográfica.**
SAP	**:**	**Sistema de Administración de Pavimento.**
FOB	**:**	**Free on Board.**
TIRF	**:**	**Tasa Interna de Retorno Financiero.**

1. INTRODUCTION

(1) Background of the Study

National Road Route 2 and Route7, with an extension of 320km, are the main arterial highways linking the capital city, Asuncion (population of approximately 455,000) with the second largest city, Ciudad del Este (population of about 62,000). Running through the country from the east to west, this road leads to Brazil and Argentina and helps connect the Atlantic and Pacific sides of the continent. Moreover, this is Paraguay's busiest route in terms of traffic volume and designated as the country's main artery in the Master Plan Study of National Transportation in Paraguay conducted by JICA in 1993.

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Most sections of Routes 2 and 7 have only two lanes with a width of 6.5m and do not have any left-turning lanes or climbing lanes. A further increase in traffic volume in future will make it difficult for the routes to accommodate traffic.

In this context, the Road Department of the Ministry of Public Works and Communications (MOPC), acting through the Government of Paraguay, requested the Government of Japan to provide technical cooperation in conducting a feasibility study for a plan to improve National Road Route 2 and Route 7 so as to realize a smooth traffic flow on the routes.

(2) Objectives of the Study

The objectives of the Study are the following:

1) To conduct a feasibility study for the improvement of the National Road Route 2 and Route 7 with a target year of 2010; and
2) To transfer relevant technology to the Paraguayan counterpart personnel in the course of the Study.

(3) Study Area

The study area covers the section between San Lorenzo (km 14) and Caaguazu (km 183) of the National Road Route 2 and 7 (approximately 169 km).

(4) Study Organization

The JICA study team consisted of ten experts. JICA organized an Advisory Committee headed by Mr. Hiromi SAITO to supervise the Study and offer technical advice. On the Paraguayan side, a counterpart team was called upon under MOPC and conducts the Study jointly. The two teams formed a study team and discussed major issues with relevant institutions by through a Technical Working Group. MOPC also organized a Steering Committee, which consisted of representatives from relevant institutions for a smooth implementation of the Study. Finally, the study team opened workshops periodically and attempted to transfer technology to the Paraguayan side.

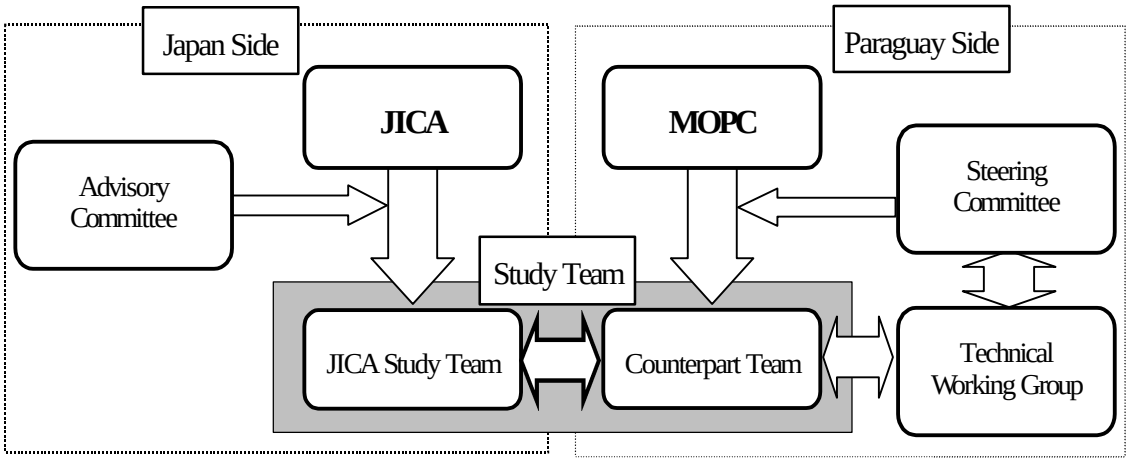


Figure 1.1 Study Organization

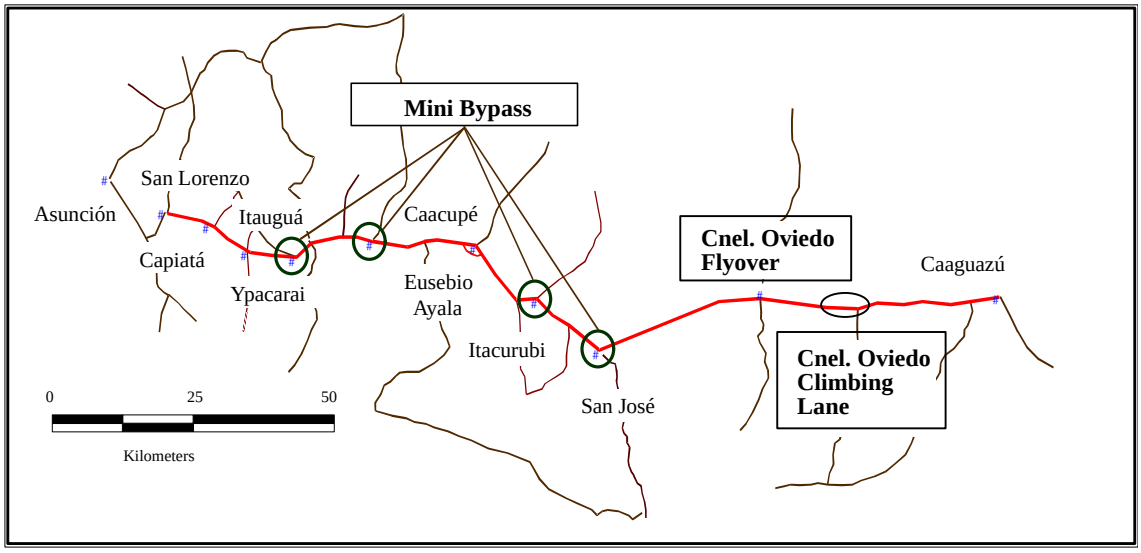


Figure 1.2 Location Map of the Study Area

2. TOPOGRAPHY AND GEOLOGY

(1) General Description

The Republic of Paraguay borders on Brazil, Argentina, and Bolivia and has its land area of about 406,750km^2 and the population of approximately 5.08 million (in 1997). Paraguay River divides the country into two large regions, Occidental and Oriental.
In terms of aerial size, the Occidental region accounts for 61% (247,000km^2) of the country, but only 2% of the national population live in this region. The Oriental region is surrounded by Paraguay River on the west, Parana River on the east and south, and Brazil on the north. National Road Routes 2 and 7 cross this region from the west to east, a little to the south from the center of Oriental region. Topography between these two cities is generally flat, and the altitude does not exceed 600m.

(2) Climate

The climate of the study area is characterized as subtropical. In July, the coldest month in the year, the average temperature stays around 22°C, whereas from December to February, the hottest season, it exceeds 35°C. The precipitation remains almost unchanged throughout the year although it is a bit less between June and September. Ciudad del Este has more precipitation, or 1800mm a year, and the volume generally decreases toward the west, or 1400mm in Asuncion.

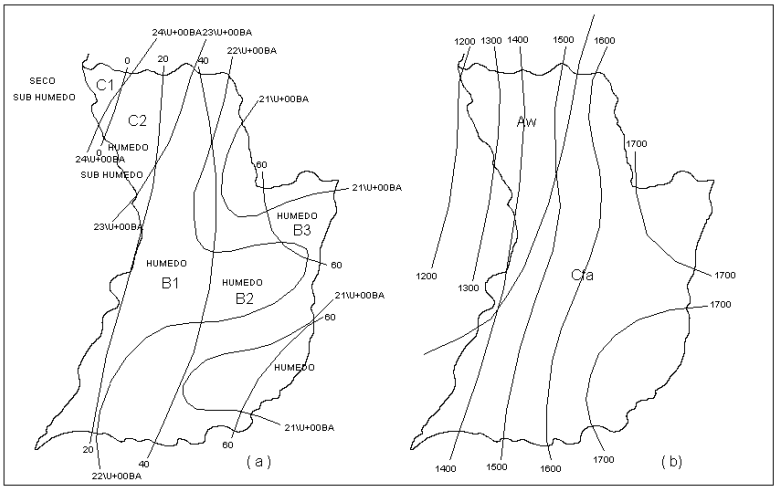


Figure 2.1 Annual Precipitation and Temperature Distribution

(3) Geology

Geological conditions in the eastern region of Paraguay River are based on the Carboniferous period in the Paleozoic era, basalt, sandstone, limestone, granite and formations of the Jurassic and Triassic period. The basalt-originated soils contain red colored fertile soil called *tierra Rusia*, and are distributed along the Parana River. This is considered one of the best soils in the tropical and subtropical regions of South America. This geological area produces 80% of the total agricultural output in Paraguay.

3. SOCIOECONOMIC FRAMEWORK

(1) Population

Population of Paraguay grew from 4.45 million in 1992 to 5.08 million in 1995, or by an annual average rate of 2.7%. Further in future, it is expected to increase by 2.5% annually, or reaches almost 6.98 million in 2010. Until 2020 it will increase by 2.0% per year and reach 8.57 million, which is 1.69 times larger than the population of 1997. The labor force between the age of 15 and 65 is projected to grow by 2.9% since 1997, and in 2020 it will be 1.92 times larger than the size of 1997 (2.84 million), or 5.34 million.

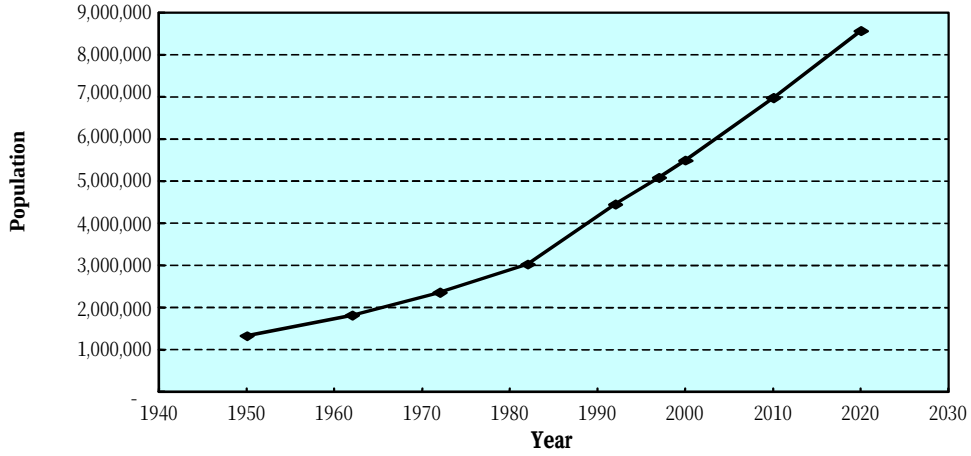


Figure 3.1 Present and Future Population Trend in Paraguay

(2) GDP

The trend of GDP growth from 1982, at constant prices of 1982, increases almost linearly up to 1997 by 3.5% per year. Assuming that labor productivity improves by 0.6% annually, GDP will record Gs1,805 billion and Gs2,547 billion in 2020.

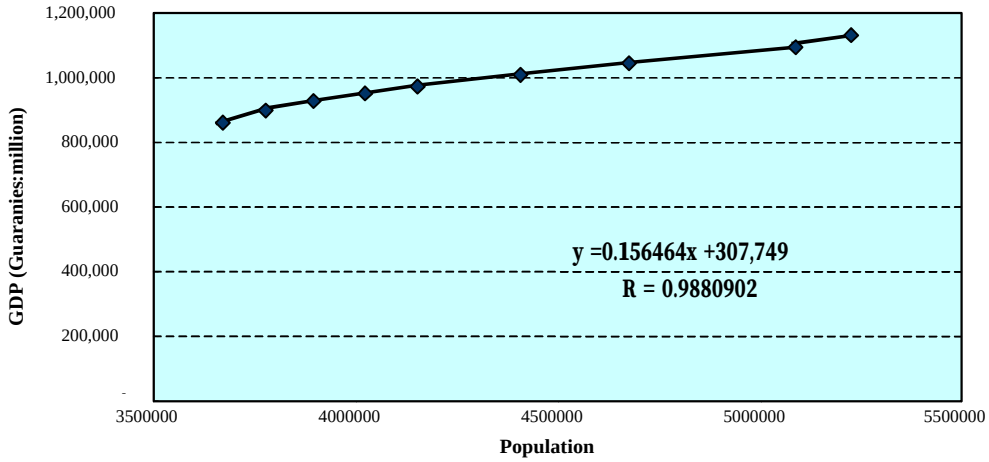


Figure 3.2 Past Trend of GDP in Paraguay

(3) Industry

The principal industry in Paraguay is agriculture, and the major products include cotton, soybeans, cassava, sugar canes, corns, and wheat. Although the production growth of cotton slows down, its total output still increases by 4.1% annually and registers 7.74 million tons in 1991 and 10.21 million tons in 1997. The total production has been extrapolated by taking into account the growth trend of each crop production mentioned above. As a result, the annual rate of growth up to 2020 is estimated 2.3% on average, and the output in 2010 will be 13.71 million tons, or 1.34 times more than that in 1997 and in 2020, 17.09 million tons, or 1.67 times.

(4) Export and Import

a. Export

Although the export of cotton has substantially decreased, that of cereal has sharply increased. The total volume of export in tons has grown with a rate of around 10% during the 1993-97 period. Taking into account the data on exports for the last seven years, the total export is projected to be 7.52 million tons, or 1.98 times more than that in 1998 and 10.52 million tons or 2.77 times in 2020.

Table 3.1 Estimated Total Export in 2010 and 2020

(Unit: tons)

Year	Export	Remarks
1998	3,802,705	(actual figure)
1999	4,226,151	
2010	7,521,070	(1.98 times of that in 1998)
2020	10,516,450	(2.77 times of that in 1998)

b. Import

It has been forecast that the total import will increase to 3.49 million tons in 2010, or 1.36 times larger than that in 1997 and to 4.2 million tons in 2020, or 1.64 times.

c. Imports and Exports in Capital Area (Asuncion) and Ciudad del Este

For estimation of the future volume of export and import through the capital area (near Asuncion) and Ciudad del Este, the trend of the share of each area to the national total is analyzed. As a result, the volume of export through the two cities will reach 6.24 million tons in 2010 and 9.15 million in 2020. The volume of import is estimated at 2.93 million tons in 2010 and 3.53 million tons in 2020.

(5) Automobile Ownership

Th number of automobiles owned in Paraguay for the last 10 years has a strong correlation with the population and GDP and increases by 8.7% per year. It has been estimated that the number is 700,000 vehicles in 2010 or 1.77 times more than the current figure and 1.03 million in 2020 or 2.62 times. In 2020, the car ownership per 1,000 people in Paraguay will be 121 vehicles and is almost equal to the figure of Asuncion metropolitan area and Central Department in 1999.

Table 3.2 Estimated Number of Registered Vehicles in Paraguay

Year	2010	2020
Car and utility car	619,000 veh.	912,000 veh.
Truck	60,000	87,000
Bus	22,000	35,000
Total	701,000	1,034,000
Growth rate to 1998	1.77 times	2.62 times
Car ownership (per 1000 habitants)	100	121

4. LAND USE IN THE STUDY AREA

The existing urban areas are expected to continue growing outward except for areas like wetland that pose physical constraints to urban development, following the current trend of expansion. It is also predicted that agricultural land will be put into more efficient use, mechanization will be further introduced, and there will be less land for cultivation.

Table 4.1 Basic Data on Three Departments in the Study Area

Item	Dept. of Central	Dept. of Cordillera	Dept. of Caaguazu
Related City of National Road Route 2 and 7	• San Lorenzo • Capiata • Itagua • Ypacarai	• Caacupe • Eusebio Ayala • Itacurubí	• San Jose • Cnel. Oviedo • Caaguazu
Area	258,200 ha	494,800 ha	1,147,400 ha
Population	1,174,212	215,663	442,161
Capital of Dept.	Jurisdiction of Asuncion	Caacupé	Cnel. Oviedo
Climate	Annual Temperature : 22.5º C Annual Rainfall : 1,400 mm	: 22.5º C : 1,400 ~ 1,500 mm	: 22º C : 1,600 mm
Basin	Paraguay River	Paraguay River	Paraguay River Parana River
Land Use	Forest: 5,431 ha (2%) Agriculture: 122,056 ha (47%) Pasture: 116,088 ha (45%) - High 24% - Low 76%	Forest: 25,999 ha (5%) Agriculture: 213,867 ha (43%) Pasture: 252,526 ha (51%) - High 48% - Low 52%	Forest: 234,461 ha (20%) Agriculture: 698,410 ha (61%) Pasture: 182,037 ha (16%) - High 51% - Low 49%

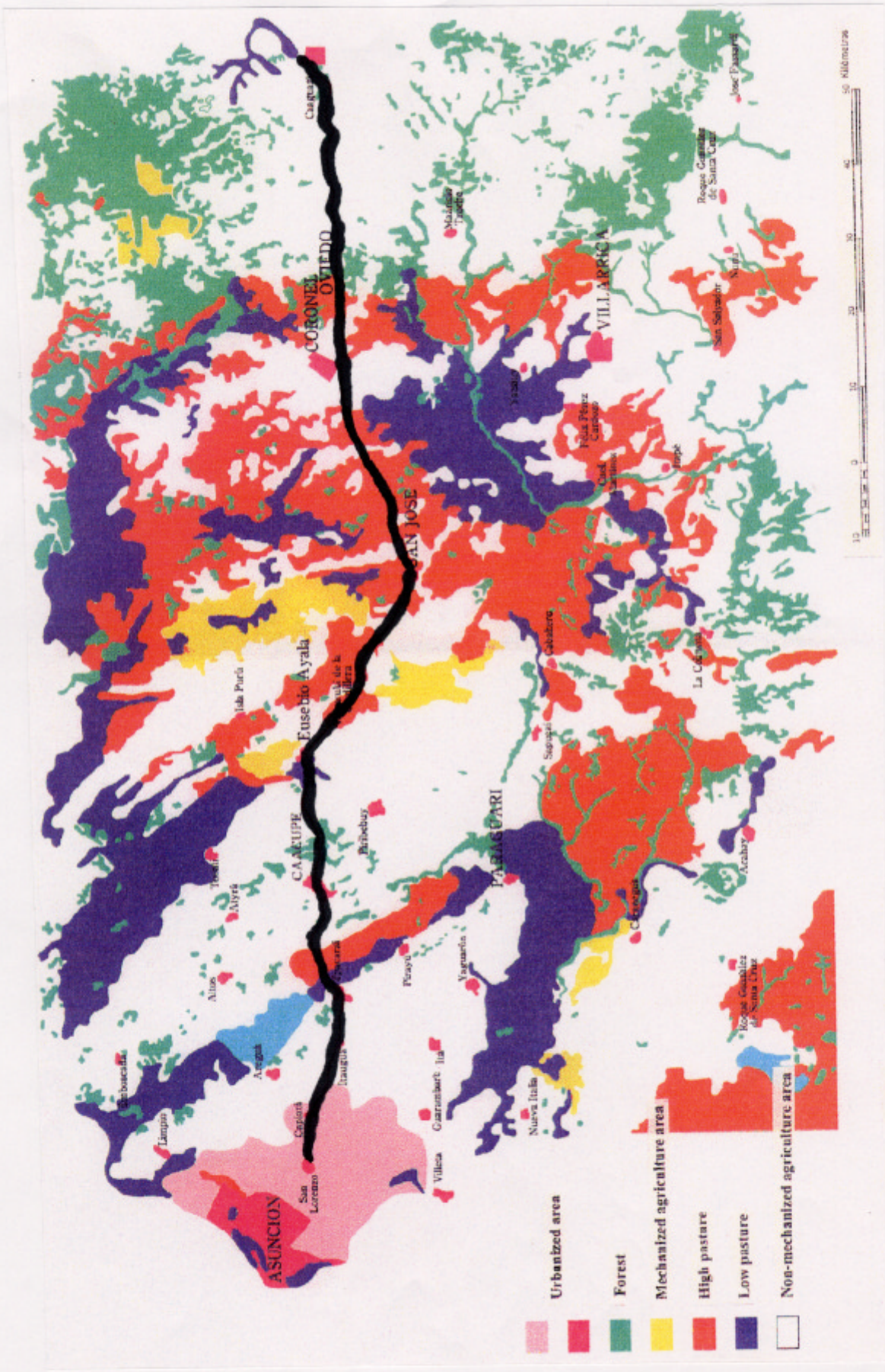


Figure 4.1 Present Land Use

5. URBAN DEVELOPMENT PLAN OF ROADSIDE CITIES

(1) Ypacarai

Ypacarai is located within the commuting distance to Asuncion and experiencing rapid urban development. It has a good access to Ypacarai Lake and nearby hills and presents itself as a center for tourism development. In order to avoid swamp areas of Ypacarai Lake, new urban centers are planned in the south and beyond the eastern side of the swamps around the rivers flowing into the lake. The northeastern area borders on a natural protection area and a flood plain.

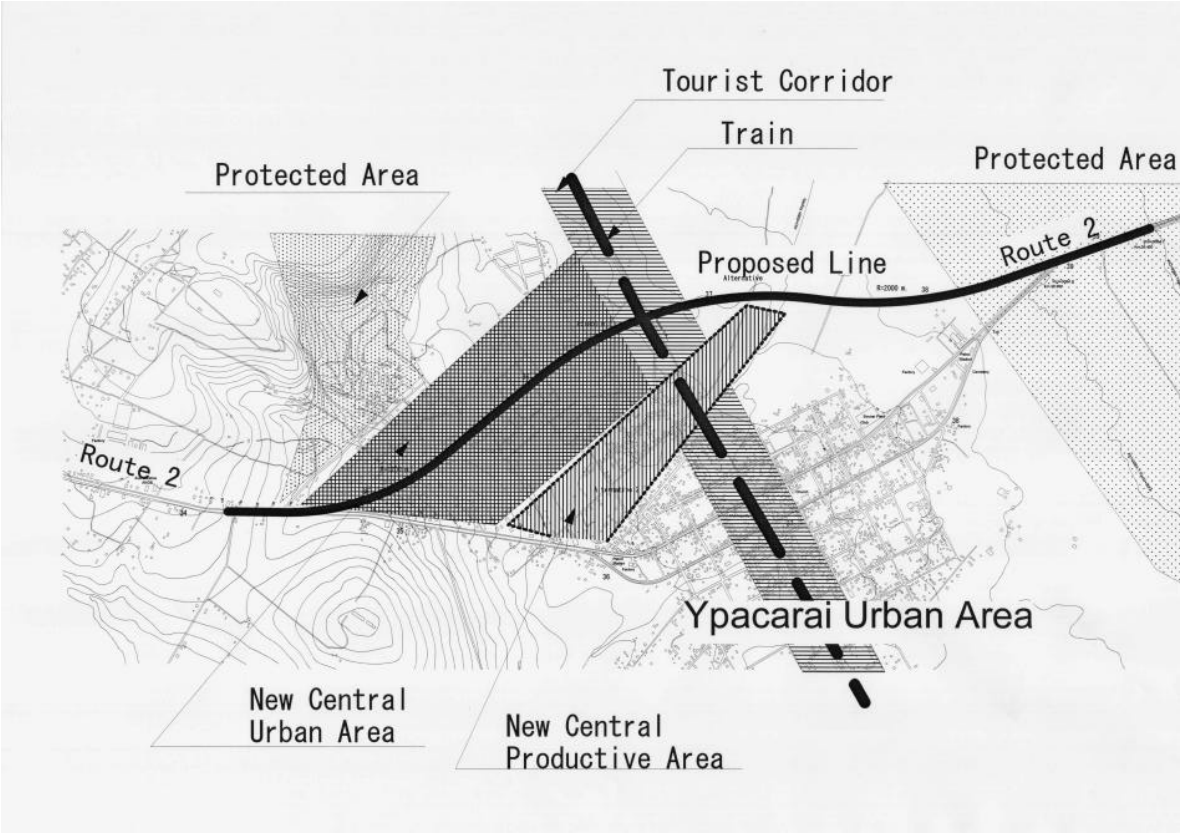


Figure 5.1 Future Land Use of Ypacarai

(2) Caacupe

The town currently has population of 12,000 but plans for an expansion to accommodate about 80,000 residents. This plan supposes that the existing built-up area of about 6km^2 will be expanded to 36km^2. However, development policies have not been specified yet.

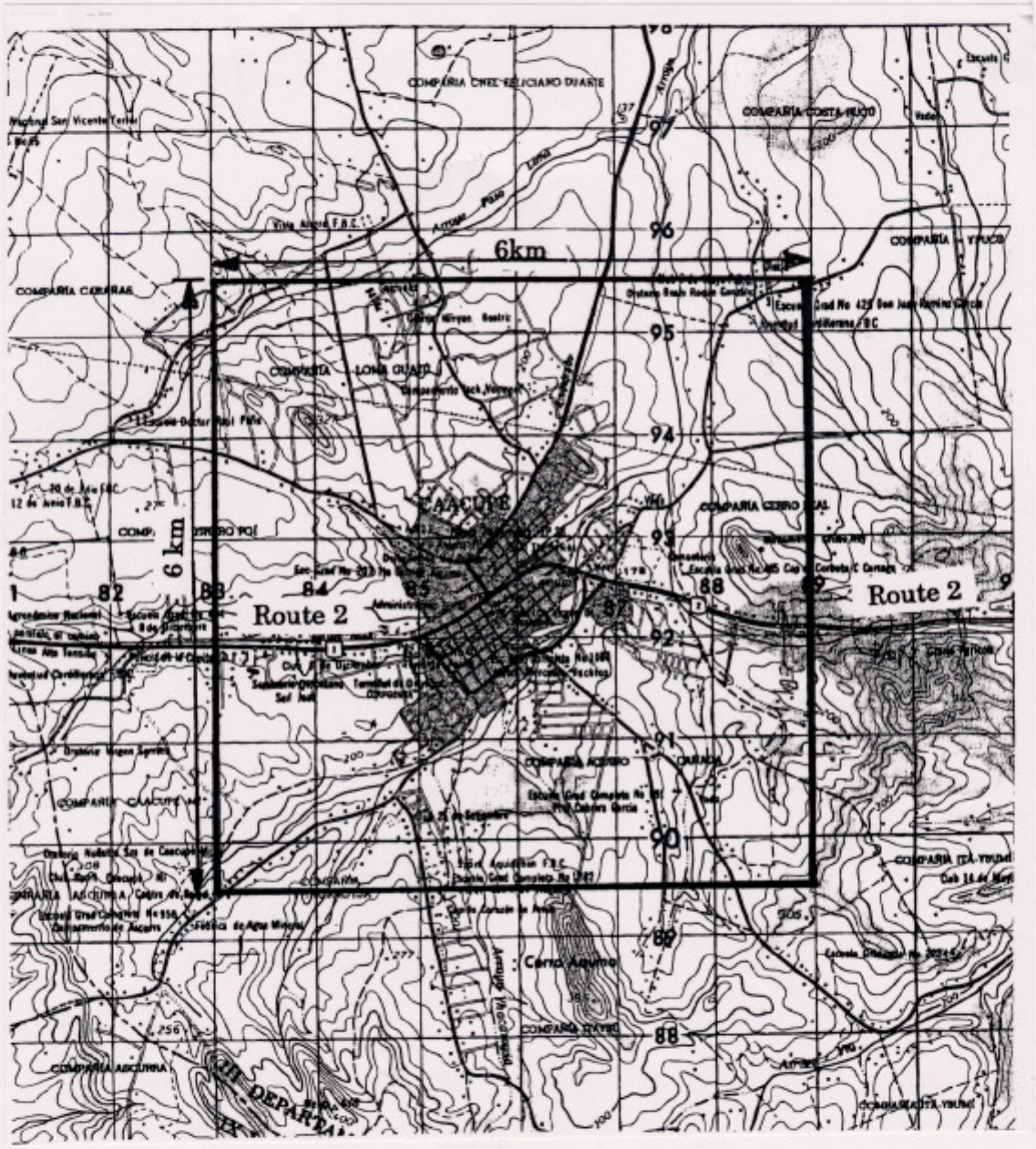


Figure 5.2 Expansion of Built-up Area of Caacupe

(3) Itacurubi

It is a small town with 8,000 residents but receives many tourists who visit Yhacui River in the north for swimming and boating. The municipality is attempting to develop tourism while protecting natural forests along the river.

Figure 5.3 Itacurubi Recreation Area and its Development Area

(4) San Jose

Low wetlands are located on the north and south of San Jose. Route 2 does not pass the wetland and instead run in the south. It is predicted that further urbanization will occur on heights in the south and avoid the wetlands. A weight control center of MOPC is under construction outside the town, and road development should take it into consideration.

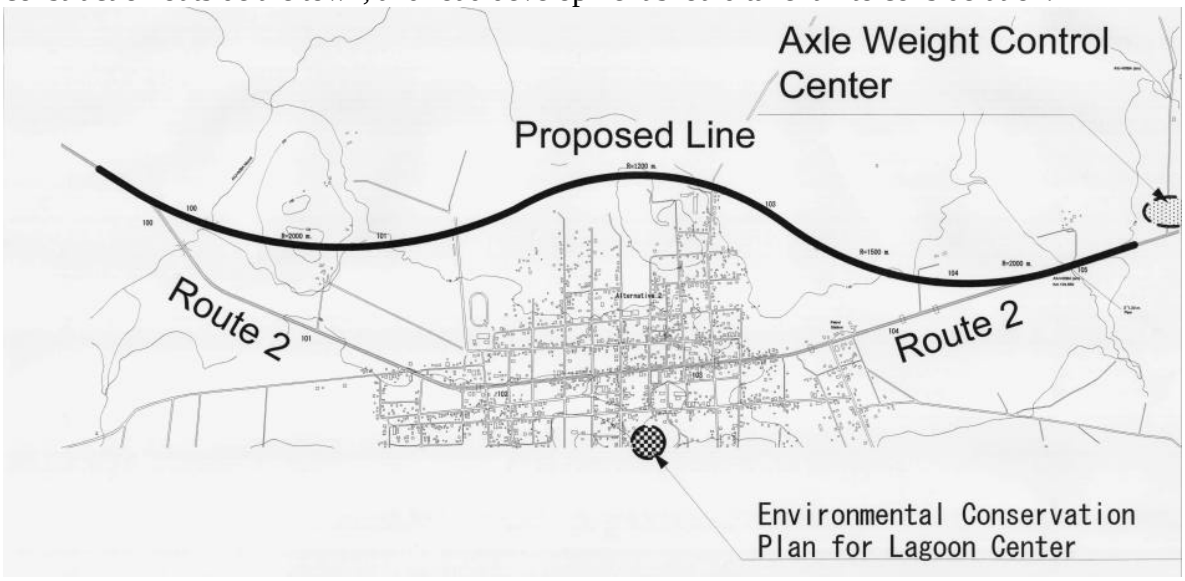


Figure 5.4 San Jose Truck Scale Gate

(5) Coronel Oviedo

The town develops in an area to the north of the intersection of Routes 2 and 7. Although there are plans for some access roads from the city connecting to the intersection of Routes 2 and 7, the importance of this intersection as a node for Coronel Oviedo remains unchanged. Thus, it is proposed that the intersection be improved so as to maintain the functionality of Routes 2 and 7 as an important artery road.

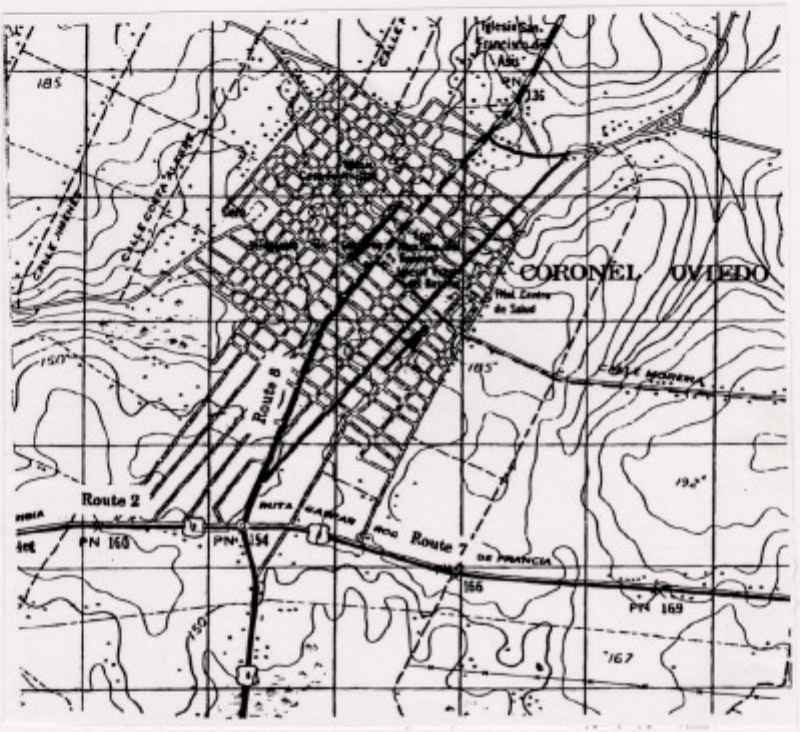


Figure 5.5 Road Plan of Coronel Oviedo

(6) Caaguazu

On both sides of Route 7, the town develops a grid structure of streets. The urban area in the south is larger than that in the north. Further urbanization is expected to spread outward. The right-of-way of Route 7 is reserved for 100m. The municipality of Caaguazu is planning the construction of a bus terminal at the center of the built-up area.

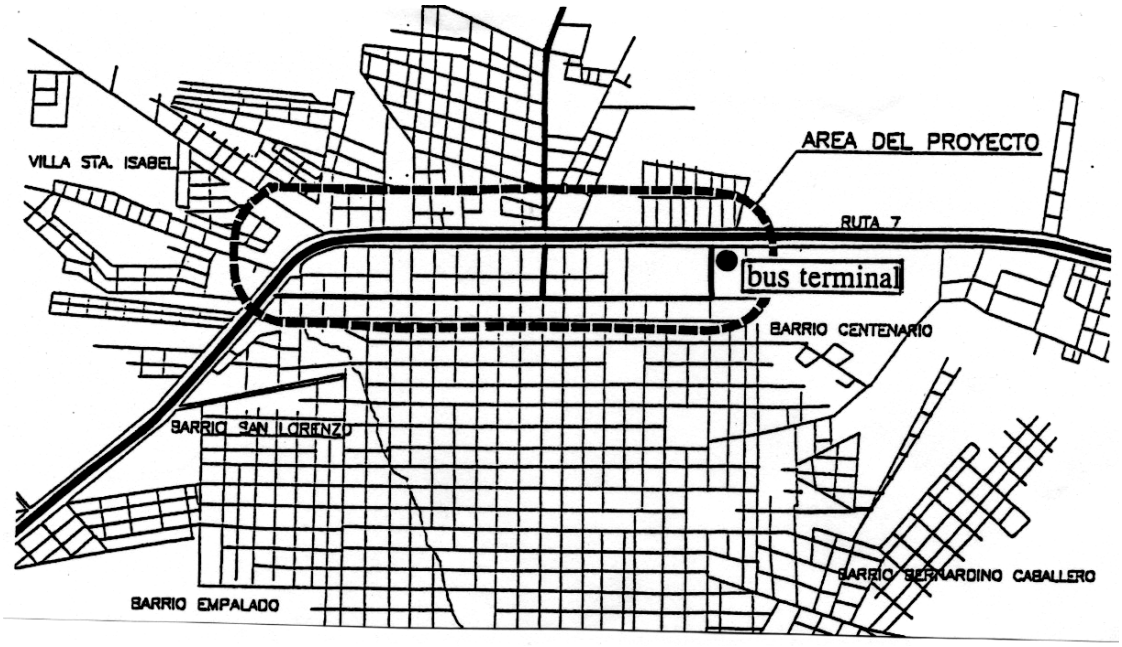


Figure 5.6 Project Area and Location of Bus Terminal in Caaguazu

6. EXISTING TRAFFIC CONDITIONS

(1) Traffic Survey

Traffic surveys have been conducted at eight locations for inter-city traffic and also at eight intersections. The result of the survey is described below.

- Roadside areas along the section between San Lorenzo and Ypacarai are highly urbanized, and the volume of commuter traffic is large and increasing. There are 38,000 vehicles per day.
- The number of vehicles counted at urban intersections is larger than that of inter-city traffic, and the ratio ranges from 1.2 to 1.75, which shows that intra-zone traffic is more significant.
- The truck ratio for inter-city traffic is significant, between 30 to 58%. Even in the section between San Lorenzo and Ypacarai, the ratio exceeds 30%.
- The peak ratio ranges from 6.0% to 7.7% at the urban survey points and 5.8% to 7.1% at the inter-city survey points, which indicate that traffic volume varies little with time of the day.
- Nighttime traffic volume of trucks is significant. 90% of daytime traffic volume of trucks is still observed during nighttime.

Table 6.1 Traffic difference rate between urban and suburban areas

Area	Ratio
San Lorenzo	1.75
Itacurubi	1.21
Coronel Oviedo	1.39
Caaguazu	1.58

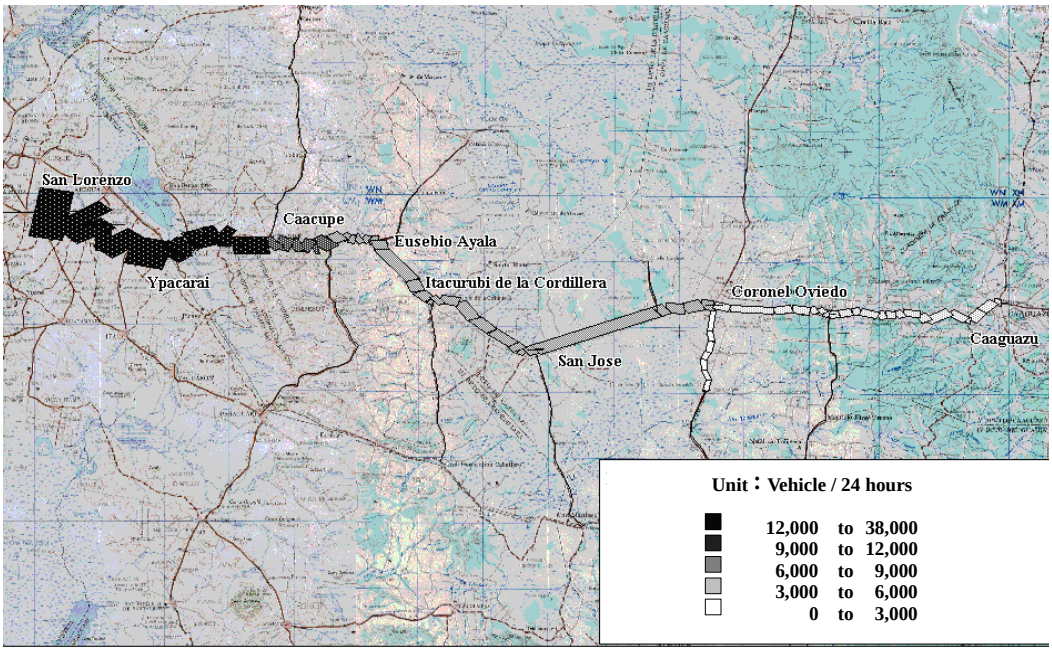


Figure 6.1 Existing Annual Traffic volumes (Vehicles/day)

Table 6.2 Roadside Traffic Volume in 1999

	Location Name	Traffic Volume (Vehicles/Day)	Truck Ratio (%)	Peak Ratio (%)	Directional Distribution
1	San Lorenzo –Capiatá Section	38,131	30.9	6.3	55/45
2	Capiatá – Itauguá Section	23,274	34.8	5.8	52/48
3	Ypacaraí – Caacupé Section	13,276	46.7	6.2	53/47
4	Eusebio Ayala – Itacurubí Section	10,279	48.1	5.8	56/44
5	Caacupé – Piribebuy Detour Section	7,086	49.6	5.9	53/47
6	San Jose – Cnel. Oviedo Section	8,271	50.9	6.6	61/39
7	Cnel. Oviedo – Caaguazú Section	5,638	57.9	6.7	52/48
8	Villarrica – Cnel. Oviedo Section	2,759	40.5	7.1	54/46

Table 6.3 Intersection Traffic Volume in 1999

	Location Name	Traffic Volume (Vehicles/Day)	Truck Ratio (%)	Peak ratio (%)
1	San Lorenzo-I/C de las Rutas 1 y 2	28,313	28.3	4.8
2	Capiata – Desvio a Aregua	28,400	36.9	4.9
3	Ypacaraí – Desvio a San Bernardino	8,717	44.5	5.0
4	Caacupé – Desvio a Oiribebuy	10,268	49.5	6.0
5	Eusebio Ayala- Entrada a la Ciudad	8,735	42.4	6.8
6	Itacurubi- Desvio a Valenzuela	7,045	46.7	5.5
7	Cnel. Oviedo – Ruranda de la Ruta 7	14,391	35.2	5.4
8	Caaguazu – I/C dela Ruta a Yhu	10,879	43.7	5.6

(2) Inventory of Existing Roads

Between San Lorenzo and Ypacarai, the national road has four lanes with a median strip of 1.5m, whereas in the rest of the study section has only two lanes. In Ypacarai and Caacupe, the old road is used for one-way traffic, and another two-lane road is provided for the other direction in the town. There are climbing lanes at two locations on the section between Ypacarai and Caacupe and six between Caacupe and Eusebio Ayala. Finally, most intersections do not have left-turning lanes.

The width of the existing right-of-way is described below:

- San Lorenzo – Ypacarai: 30.0m
- Ypacarai – Caacupe: 30.0m
- Caacupe – Itacurubi – San Jose: 20.0 – 16.0m
- Caacupe – Coronel Oviedo: 50.0m
- Coronel Oviedo – Caaguazu: 100.0m

The width of each lane is 3.25m, and that of a shoulder is 2.50m.

National Road Routes 2 and 7 have the largest traffic volume, and the number of accidents is also much larger than that on other roads. The road improvement plan has taken into account of this aspect.

Table 6.4 Number of Traffic Accidents

National Route	Extension (km)	1995		1996	
		Number	per km	Number	per km
1	370	509	1.37	506	1.37
2	134	1,474	11.00	1,457	10.87
3	452	29	0.06	50	0.11
4	206	5	0.02	4	0.02
5	215	22	0.10	25	0.12
6	250	159	0.64	105	0.42
7	193	254	0.32	419	2.17
8	202	24	0.12	16	0.08
9	776	67	0.09	66	0.08
10	396	13	0.03	34	0.09
11	88	-	-	-	-
12	162	6	0.04	-	-
Total	3,444	2,562	0.74	2,683	0.78

7. ROAD NETWORK

(1) Roads Competing with Route 2 and Route 7

- National Road Route 3 that originates in Asuncion and extends to the northeast This national road will improve the accessibility to a region to the northeast from Asuncion.
- Route Paraguari– Villarrica originating from Asuncion, roughly parallel to Route 2 The completion of this route will provide a better access to the central part of the Oriental region.

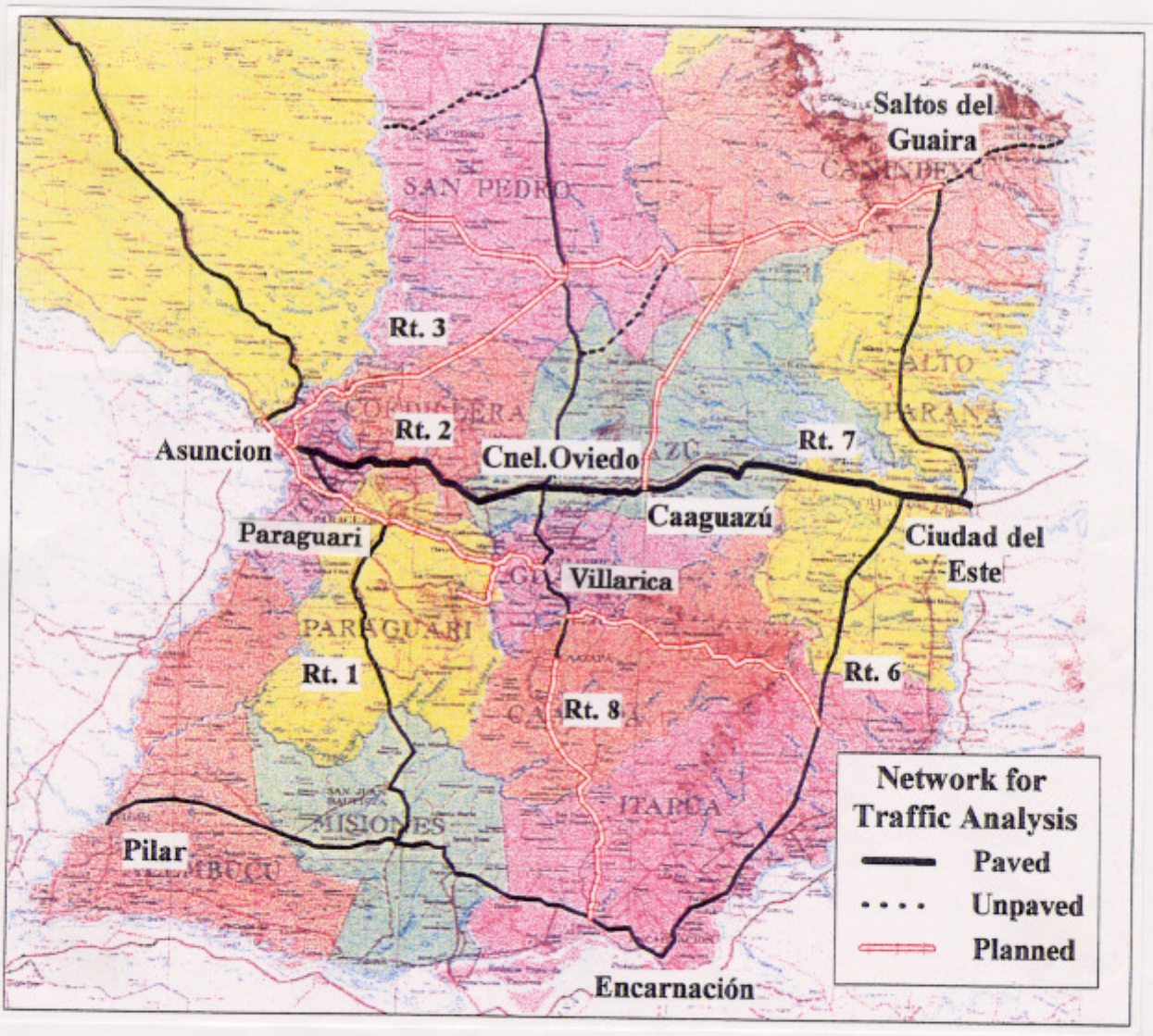


Figure 7.1 Road Network for Traffic Analysis

8. INITIAL ENVIRONMENTAL EXAMINATION

(1) Environmental Items

Environmental items to be examined in Environmental Impact Assessment (EIA) have been selected through Initial Environmental Examination (IEE). Environmental characteristics of the study area and Law No. 294 regarding EIA of Paraguay are considered. During the selection process, the study team has had discussions with officials of the Directorate of Environmental Control (*Dirección de Ordenamiento Ambiental*: DOA) of the Ministry of Agriculture and Stock Farming (*Ministerio de Agricultura y Ganaderia*: MAG), and the DMA (*Dirección de Medio Ambiente*, which formerly was known as *Unidad Ambiental*) of the MOPC. Selected items are shown in Table 8.1.

Table 8.1 Environmental Items

1. Social Environment					
1.1	Resettlement	1.4	Split of Community	1.7	Public Health Condition
1.2	Economic Activities	1.5	Cultural Heritage & Properties	1.8	Waste
1.3	Traffic and Public Facilities	1.6	Water Rights and Common Rights	1.9	Disaster (Risks)
2. Natural Environment					
2.1	Topography and Geology	2.4	Hydrological Situation	2.7	Meteorology
2.2	Soil Erosion	2.5	Coastal Zone	2.8	Landscape
2.3	Ground Water	2.6	Fauna and Flora		
3. Pollution					
3.1	Air Pollution	3.3	Soil Contamination	3.5	Ground Subsidence
3.2	Water Pollution	3.4	Noise and Vibration	3.6	Offensive Odors

(2) Evaluation

Results of the above analysis are shown in Table 8.1. In case where the road improvements proposed in this Study have any positive impact, items are indicated with "P" in Table 8.2.

(3) Environmental Items Required for Further Study

As shown in Table 8.2, the items with "C" are required for further study in the areas where the proposed road improvements will be implemented.

Table 8.2 Findings of IEE

Environmental Items		Evaluation	Reasons	Remarks
Social Environment	Resettlement	B	Resettlement will be predicted by the construction of bypass and winding of the existing route	
	Economic Activities	C	Modification of the economic structures, and fluctuations of real estate price will be predicted by a bypass construction	P
	Traffic and Public Facilities	C	Public facilities such as religious and public utilities will be affected depending on the alternative bypass route.	
	Split of Communities	C	There is no indigenous community. However, administrative and cultural boundaries shall be identified in the bypass construction area.	
	Cultural Property	C	There are old buildings, Christian churches and so on in some cities.	
	Water Rights and Common Rights	C	Specific information shall be identified in the bypass construction area before execution	
	Public Health Condition	D	Roadside gutters for rain and domestic water shall be improved and covered.	
	Waste	D	Proper solid waste management shall be required during the bypass and widening construction stage.	
	Hazards (Risk)	C	There is a possibility flooding around Ypacarai Lake basin.	
Natural Environment	Topography and Geology	D	There will be no large excavation by the construction of bypass and widening	
	Soil Erosion	C	There will be no large excavation by the construction of bypass and widening	
	Groundwater	D	There will be no large excavation by the construction of bypass and widening	
	Hydrological Situation	D	There will be no large excavation by the construction of bypass and widening	
	Coastal Zone	D	No coastal zone in the study area	
	Fauna and Flora	C	Endangered rare species of fauna and flora have been identified in the departments in the study area. Study on the fauna and flora is necessary in the bypass construction area and widening section	
	Meteorology	D	There is no large scale construction and modification of the land configurations	
	Landscape	D	Bypass, widening and other improvement measures shall be constructed to harmonize with the surrounding landscape.	P
Pollution	Air Pollution	B	More or less, traffic volume will be increased after the improvement.	
	Water Pollution	D	No direct impact on the water will be expected by the execution of improvement.	
	Soil Contamination	D	More or less, traffic volume will be increased after the improvement.	
	Noise and Vibration	B	More or less, traffic volume will be increased after the improvement.	
	Land Subsidence	D	There is no excavation and construction that will affect ground water	
	Offensive Odor	D	More or less, traffic volume will be increased after the improvement.	

Note:
A : Serious impact will be expected
B : Some impact will be expected
C : Extent of impact is unknown (Further study will be required)
D : No impact will be expected
P : A positive impact will be expected

9. TRAFFIC DEMAND FORECAST

A trip generation model is developed based on population by zone, car ownership rate, and agricultural products. The numbers of trip generation and attraction are estimated by using the model. Trips are distributed according to the current pattern. Since Routes 2 and 7 receive direct impact of international freight, an O-D matrix is formulated by taking into account a future increase in freight transport induced by increase in external trades.

Table 9.1 OD Volume and Increase Ratio

Year	Item	P. Car	Bus	Truck	Total
1999	Vehicle/day	26,176	3,494	24,502	54,172
	% of 1999	100.0%	100.0%	100.0%	100.0%
2010	Vehicle/day	46,123	6,242	44,965	97,330
	% of 1999	176.2%	178.6%	183.5%	179.7%
2020	Vehicle/day	55,376	7,485	54,625	117,486
	% of 1999	211.6%	214.2%	222.9%	216.9%

With the future O-D matrix, trips are assigned to routes with the shortest travel time, and then the volume on each route is estimated.

Table 9.2 Daily Traffic Volume

Sections	2010	2020
San Lorenzo – Ypacarai	23,221	25,483
Ypacarai – Caacupe	16,836	18,930
Caacupe – Eusebio Ayala	17,765	20,907
Eusebio Ayala – Itacurubi	17,021	20,045
Itacurubi – San Jose	16,890	19,891
San Jose – Coronel Oviedo	16,892	19,888
Coronel Oviedo – Caaguazu	12,315	13,173

The following table shows sections with the level of service of the existing infrastructure exceeding D with the section daily traffic volume (PCU/day) modified upon considering local traffic of 2010.

Table 9.3 Daily Traffic Volume Converted into PCU

Locations	Road Capacity (C)	Est. Volume (V)	V/C
Intersection in Capiata built-up area	45,000	47,000	1.04
Intersection in Itaugua built-up area	45,000	47,000	1.04
Ypacarai downtown	32,000	42,220	1.31
Caacupe downtown	32,000	42,200	1.32
Sta. 68 point with steep gradient	24,000	35,000	1.45
Sta. 80 point with steep gradient	24,000	31,900	1.32
Itacurubi downtown	20,000	29,300	1.47
Sta. 92 point with steep gradient	24,000	31,500	1.31
San Jose downtown	20,000	30,600	1.50
Sta. 120 point with steep gradient	24,000	34,100	1.42
Intersection – Cnel. Oviedo	25,000	31,400	1.25
Sta. 146, 154, 162, 166 point with steep gradient	24,000	27,600	1.15
Intersection in Caaguazu built-up area	25,000	27,900	1.16

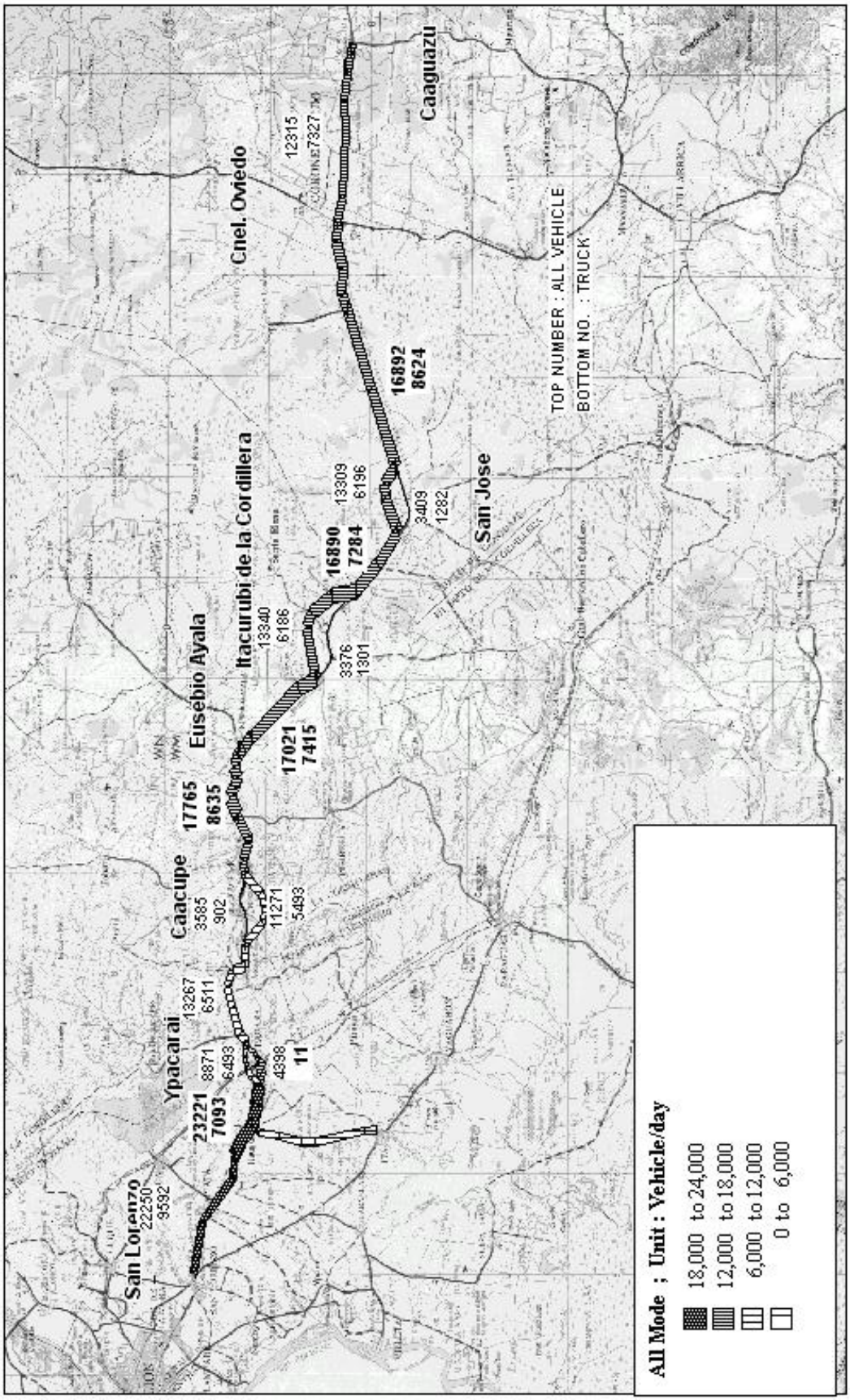


Figure 9.1 Future Traffic Volume in 2010

10. DESIGN STANDARD

(1) Geometric Design Standard

Paraguay has no geometric design standard. It is decided for each project and for each principal road. In this Study, the design standard is determined by taking into account the following conditions.

- Routes 2 and 7 are the main principal roads that connect Asuncion and Ciudad del Este.
- Many feeder roads connect to the national Routes 2 and 7 and serve as development axes along the routes.
- Routes 2 and 7 make up an important export corridor to Brazil and Argentina, and constitute an international highway serving MERCOSUR trades.
- The volume of heavy vehicles is high.
- For the projected traffic volume in 2020, the principal roads need to be widened to four lanes.
- In roadside urban areas, road protection screens against noise and pollution need to be provided for houses.

Based on the above design concepts, this Study refers to the AASHTO design standard commonly employed in Paraguay and adopts the standard for regional arterial roads.

Table 10.1 Improvement Design Standard of National Road Routes 2 and 7

Terrain	Flat	Rolling	Mountainous
Design Speed (km/h)	60-80	60-80	50-60
Carriageway Width (lane/m)	3.65	3.65	3.65
Shoulder Width (m)	2.5	2.5	2.5
Right-of-way (m)	50.0	50.0	50.0
Radius (m)	200-400	200-400	150-200
Grade (%)	3-4	3-4	4-6
Passing Sight Distance (m)	350-550	350-550	250-550

(2) Typical Cross Section

The cross section of a road in this Study will follow the following rules:

- The cross section design should be able to serve for heavy freight transport and allow heavy vehicles to travel at a high speed.
- The cross section should be consistent with the road improvement plan for the target year, 2020.
- The cross section and the alignment should serve for preservation of a good living environment in response to future roadside urbanization.
- For easy maintenance, the cross-section should be standardized as far as possible.
- Right-of-way is set at 50m as adopted for arterial roads in Paraguay.

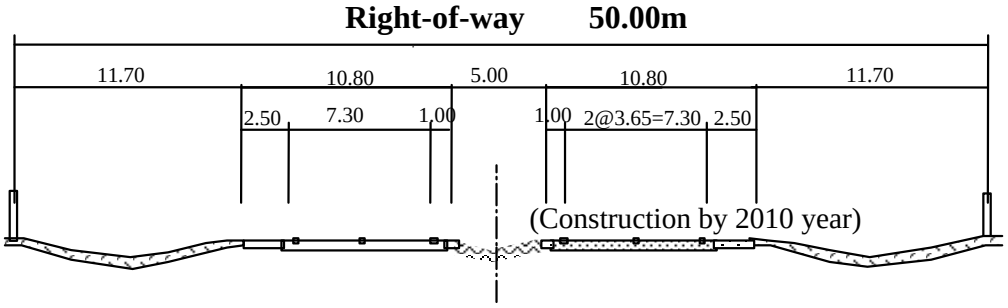


Figure 10.1 Typical cross section

11. PROPOSED IMPROVEMENT PLAN

(1) Mini-bypasses

The existing road passes through the built-up areas of Ypacarai, Caacupe, Itacurubi, and San Jose, where heavy vehicle often run in front of houses. The road width in these cities is narrower than that on the inter-city sections and often causes accidents resulting from mixed traffic of inter-city high-speed vehicles and local traffic. Since it is necessary to separate them to ensure safety, it is proposed that bypasses be constructed to circumvent the built-up areas.

Table 11.1 Mini-bypass Projects

Location	Improvements	Length (m)
Ypacarai	Four lanes	5,175
Caacupe	Four lanes	7,000
Itacurubi	Two lanes (to be widened into four in future)	6,120
San Jose	Two lanes (to be widened into four in future)	5,420

a. Ypacarai

A new bypass is designed to be a four-lane road crossing a northern part of the city where little development has taken place to date. The design also attempts to limit environmental impact on Lake Ypacarai to the minimum extent possible.

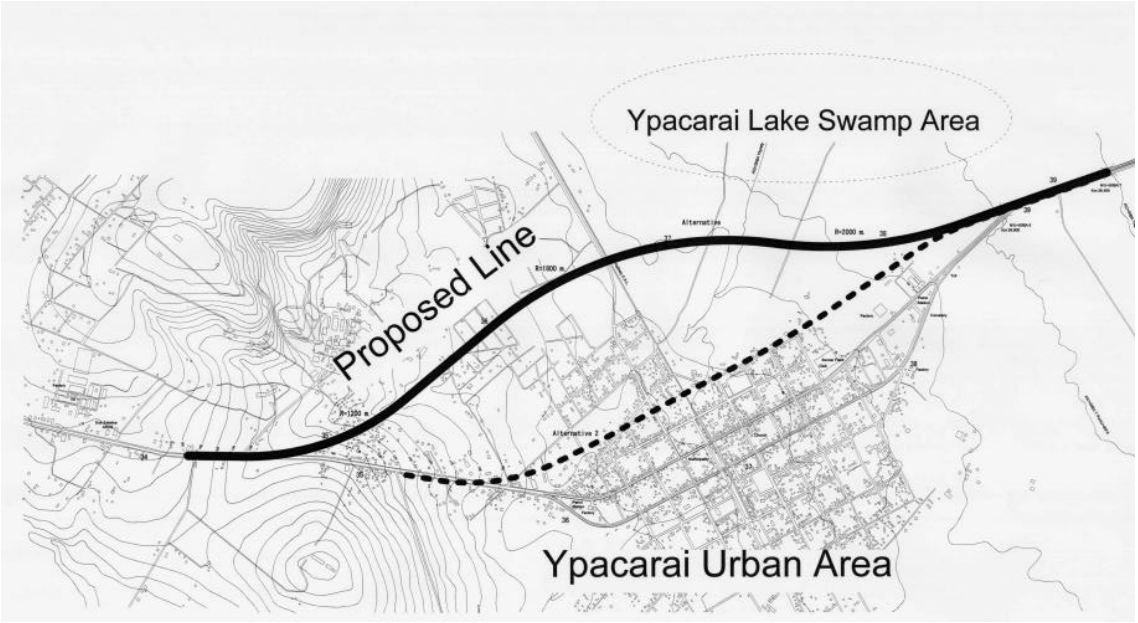


Figure 11.1 Ypacarai Mini-bypass

Table 11.2 Ypacarai Alternatives

Factors	Alternatives		
	Route 1	Route 2	Existing road
Length of Routes	3.5km	4.6km	——
1. Technical Evaluation			
Geometry	Good	Good	Bad
Accessibility to Existing road	Fair	Fair	Bad
Construction Difficulty	Fair	Fair	Fair
Construction Cost	Fair	Fair	high
2. Development Evaluation			
Compatibility with City Development Plan	Fair	Good	Bad
3. Environmental Evaluation			
Existing Natural Environment	Fair	Fair	Fair
Socio-Economic Environment	Good	Good	Bad
No. of Houses	45	33	——
Land Acquisition	15ha	17ha	
Total Evaluation	○	◎	△

b. Caacupe

A four-lane bypass will be provided in a southern area in order to avoid urbanization in the north.

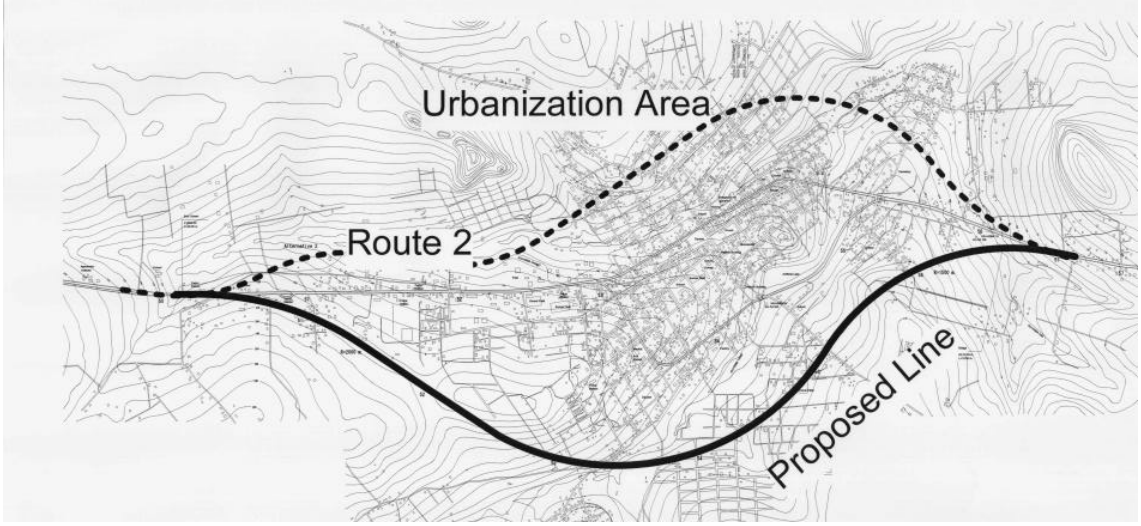


Figure 11.2 Caacupe Mini-bypass

Table 11.3 Caacupe Alternatives

Factors	Alternatives		
	Route 1	Route 2	Existing road
Length of Routes	7.2km	7.0km	——
1. Technical Evaluation			
Geometry	Fair	Good	Bad
Accessibility to Existing Road	Fair	Fair	Bad
Construction Difficulty	Fair	Fair	Fair
Construction Cost	Fair	Fair	high
2. Development Evaluation			
Compatibility with City Development Plan	Good	Fair	Bad
3. Environmental Evaluation			
Existing Natural Environment	Fair	Fair	Fair
Socio-Economic Environment	Good	Fair	Bad
No. of Houses	66	80	——
Land Acquisition	Fair	Difficult	——
Total Evaluation	◎	△	△

c. Itacurubi

A mini bypass is designed to avoid passing near the recreation areas in the north and circumvent the residential area in the south.

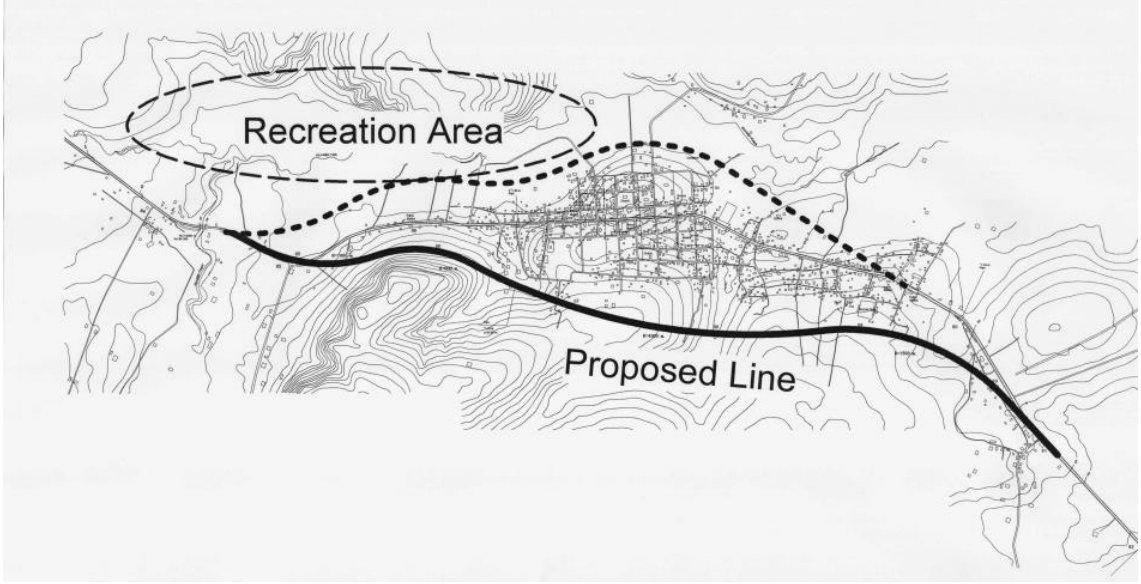


Figure 11.3 Itacurubi Mini-bypass

Table 11.4 Itacurubi Alternatives

Factors	Alternatives		
	Route 1	Route 2	Existing road
Length of Routes	5.5km	6.0km	——
1. Technical Evaluation			
Geometry	Good	Good	Bad
Accessibility to Existing Road	Fair	Fair	Bad
Construction Difficulty	Fair	Fair	Fair
Construction Cost	Fair	Fair	high
2. Development Evaluation			
Compatibility with City Development Plan	Bad	Good	Bad
3. Environmental Evaluation			
Existing Natural Environment	Bat	Fair	Fair
Socio-Economic Environment	Fair	Fair	Bad
No. of Houses	15	20	——
Land Acquisition	Difficult	Fair	——
Total Evaluation	△	◎	△

d. San Jose

Among the two alternative routes considered, a northern route has been selected because the project will affect fewer houses, and the route enables to utilize the existing weight control facility.

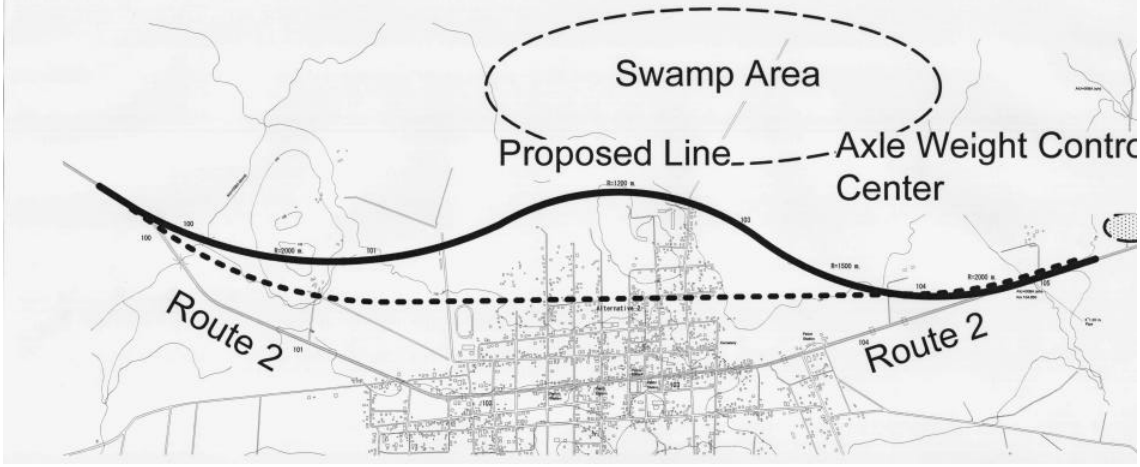


Figure 11.4 San Jose Mini-bypass

Table 11.5 San Jose Alternatives

Factors	Alternatives		
	Route 1	Route 2	Existing road
Length of Routes	4.1km	5.2km	——
1. Technical Evaluation			
Geometry	Good	Good	Bad
Accessibility to Existing Road	Fair	Fair	Bad
Construction Difficulty	Fair	Fair	Fair
Construction Cost	Fair	Fair	Bad
2. Development Evaluation			
Compatibility with City Development Plan	Fair	Good	Bad
3. Environmental Evaluation			
Existing Natural Environment	Fair	Fair	Fair
Socio-Economic Environment	Fair	Fair	Bad
No. of Houses	15	2	——
Land Acquisition	Fair	Fair	——
Total Evaluation	○	◎	△

(2) Provision of Climbing Lanes

Ascending sections with a long, steep gradient slow down the traveling speed of heavy vehicles and reduce the road capacity as a result. In such sections, many traffic accidents occur, involving those trying to overtake slow vehicles. Based on the AASHTO design standard, another lane will be provided for slow heavy vehicles to travel in sections with a gradient of over 3% continuing for more than 500m.

Table 11.6 Climbing Lane Projects

Location	Improvements to be made	Length (m)
Near STA 68	Extend the existing climbing lane	450
Near STA79	Climbing lane to Asuncion	1,000
STA91-93	Climbing lanes for both directions	1,400
STA119-123	Climbing lanes for both directions	1,900
STA146-150	Keep the existing road for Asuncion and build a new road for Caaguazu	3,985
STA154	Climbing lane to Asuncion	1,000
STA162	Climbing lane to Caaguazu	1,600
SAT166	Climbing lane to Caaguazu	2,000

In section near Coronel Oviedo (Sta. 147-150), a two-lane road is proposed for descending direction, whereas the existing two-lane road will be used for ascending direction.

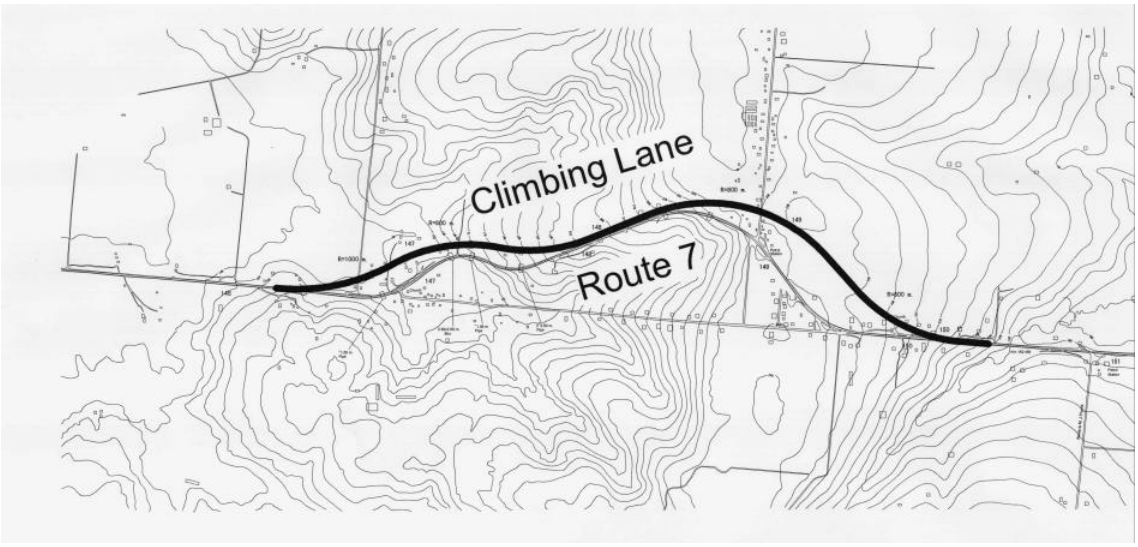


Figure 11.5 Coronel Oviedo Climbing Lane

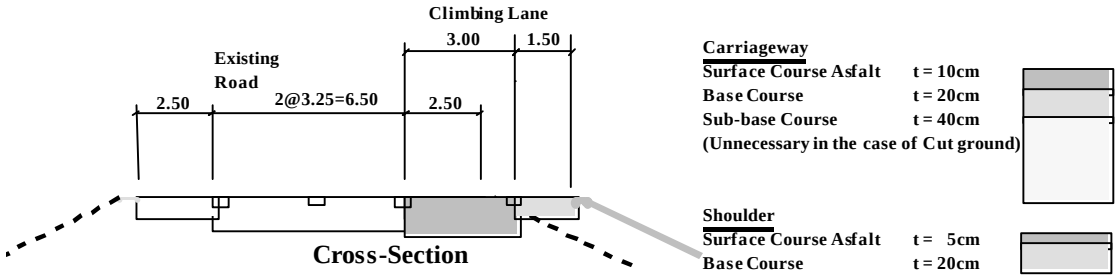
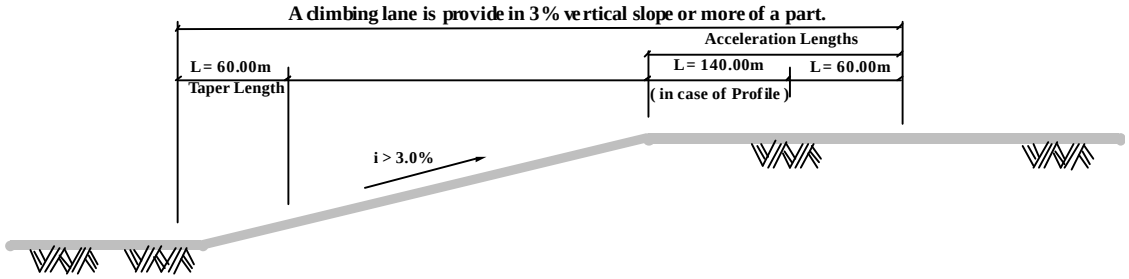


Figure 11.6 Standard Cross Section of Climbing Lane

Table 11.7 Acceleration Length

Profile (%)	-0.5	0	0.5	1.0	1.5	2.0
Acceleration Length (m)	150	200	250	300	350	400



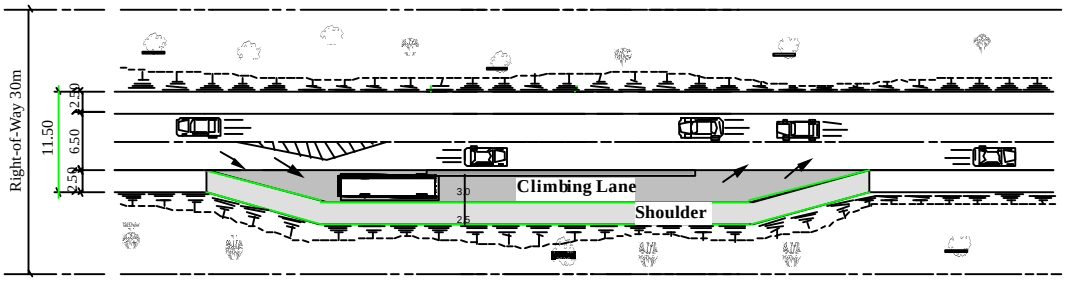


Figure 11.7 Climbing Lane

(3) Flyover Intersection in Coronel Oviedo

At the existing intersection near the town of Coronel Oviedo, many traffic accidents occur. In order to realize smooth traffic flows from Coronel Oviedo, where urbanization is taking place, and Routes 2 and 7, the rotary intersection will be grade separated, and a flyover will be constructed.

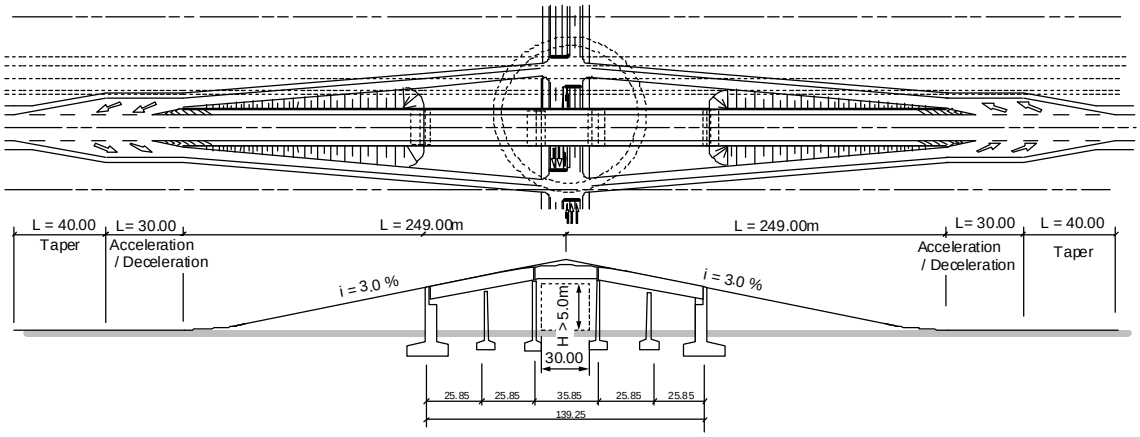


Figure 11.8 Plan for Grade Separation of the Intersection in Coronel Oviedo

(4) Urgent Maintenance

The road inventory survey identifies locations with frequent occurrence of traffic accidents, inadequate traffic facilities, and decreasing traffic capacity. Based on these findings, improvement schemes have been proposed to increase traffic capacity.

a. Improvement of At-grade Intersections

Many existing at-grade intersections on the study section do not have left-turning lanes and needs some improvements. The following intersections will be installed with left-turning lanes within their right-of-ways to increase the road capacity and reduce potential risks of traffic accidents.

- Built-up area between San Lorenzo-Ypacarai : 5 locations
- Caaguazu : 1 location

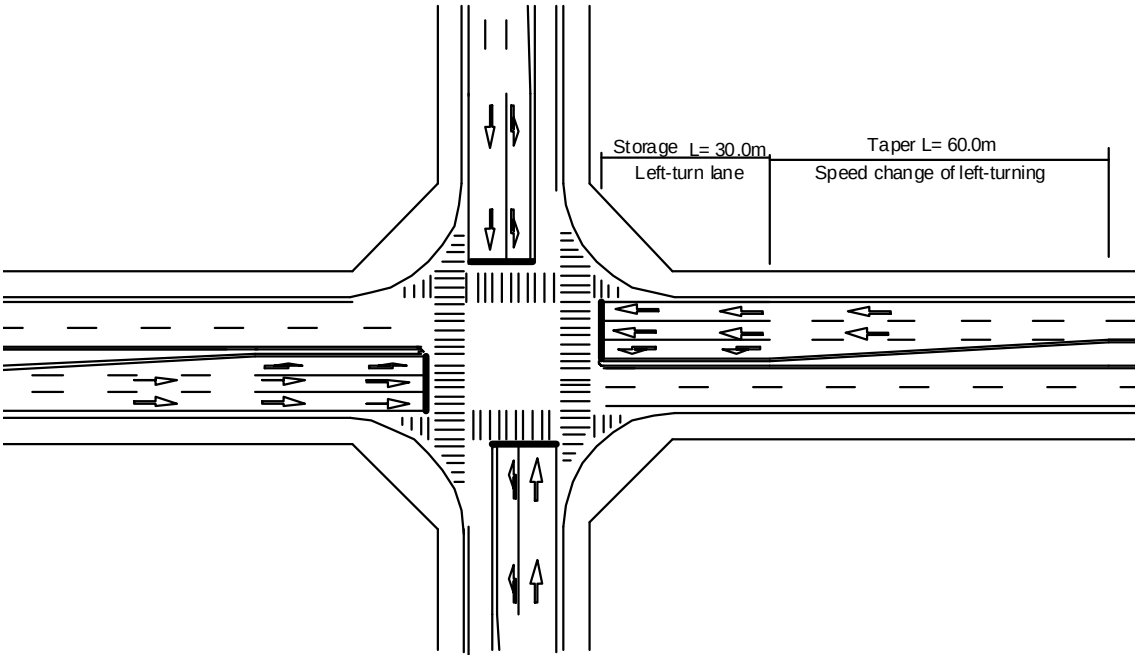


Figure 11.9 Improvement of At-grade Intersections in San Lorenzo, Capiata, and Itaugua

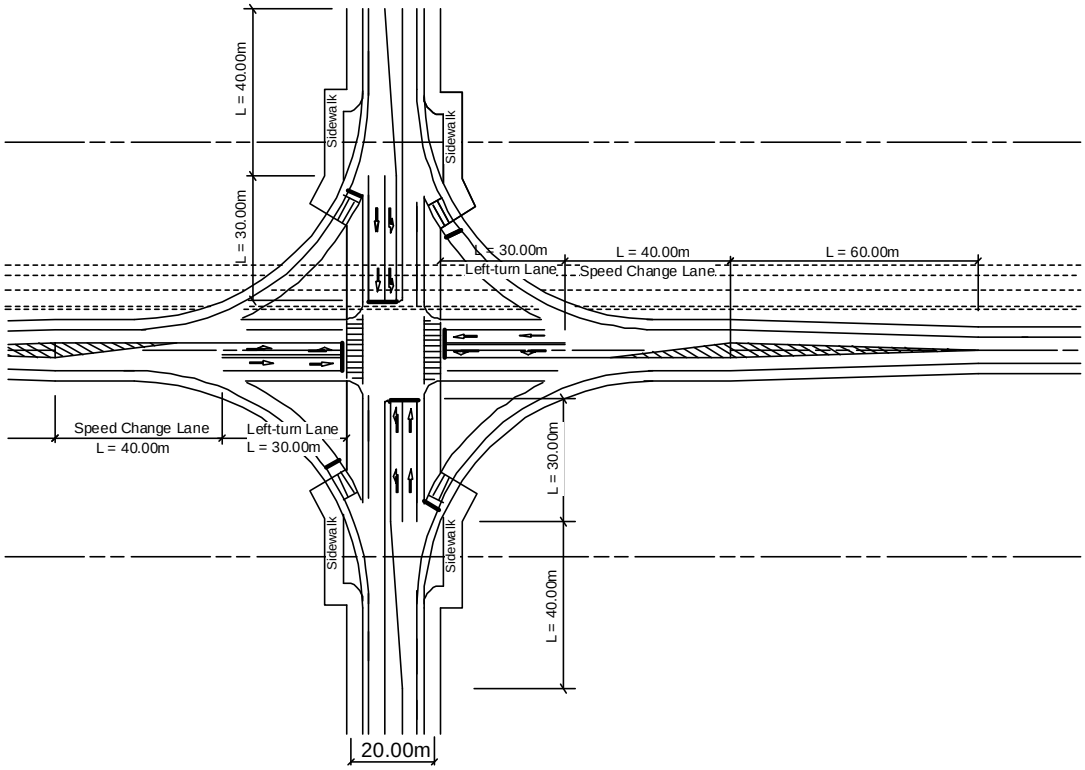


Figure 11.10 Improvement of At-grade Intersection in Caaguazu

(5) Installment of Traffic Safety Facilities

The reduction of shoulder widths just before crossing the bridge often leads to crashes against bridge structures. In addition, other sections that need to improve safety facilities include acute curves and intersections lacking in traffic safety signs.

It is necessary for MOPC to launch these proposed urgent projects immediately within a budgetary limit. Thus, this plan does not suggest large-scale improvements in the facilities posing impediments but warning devices for road users to foresee potential dangers. Such devices are as follows.

- Installment of studs on the road surface before and after bridges
- Installment of waning signs before acute curves
- Improvement of intersections of new bypasses and existing roads

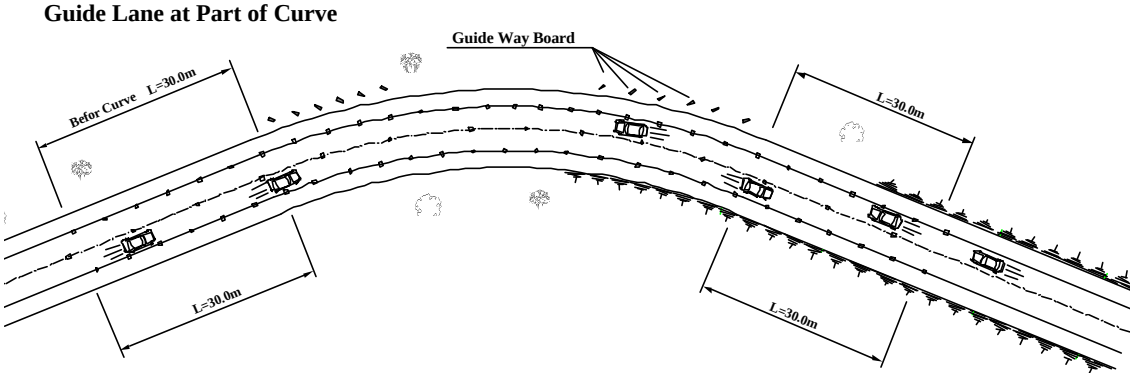


Figure 11.11 Installation of Traffic Safety Facilities

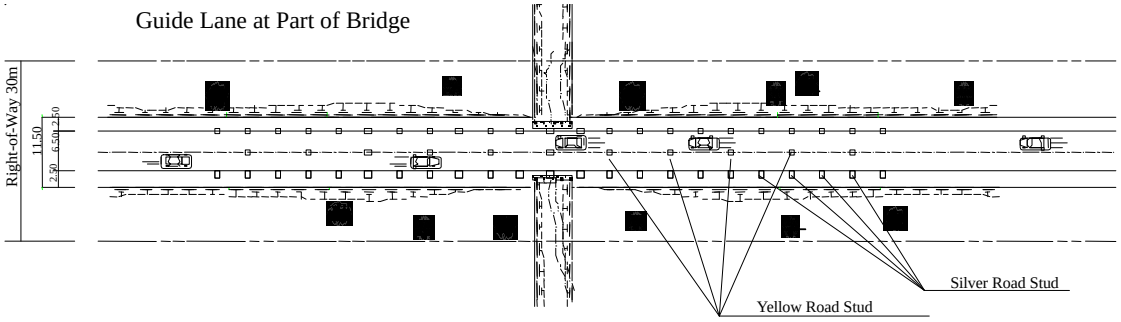


Figure 11.12 Vehicle Guiding Devices for Vehicles Approaching Bridge

(6) Maintenance and Repair

The road and bridge inventory survey shows those bridges that require urgent renovation. In particular, some bridges deserve urgent treatments because of its age and heavy weight repeatedly placed by the traffic. The improvement plan identifies these locations and renovation schemes. The following projects have been proposed:

- Repair of bridges
- Overlay

(7) Preliminary Design of Bridge

a. Design Codes and Standards

Design standards applied for bridge structures in this Study are Brazilian standards in principle, and the US and Japanese standards are applied supplementary. It is not necessary to consider a seismic coefficient for bridge design in Paraguay.

b. Plan for New Bridge

There are five new bridges for new bypasses and two bridges for reconstruction of existing road. The span length and type of bridge are determined based on conditions of road planning, crossing of the river, environmental requirements, and costs. Considerations are also made on experiences in construction and available techniques in Paraguay. The standard type is shown in Figure 11.4.

Table 11.8 Type of Proposed Bridges

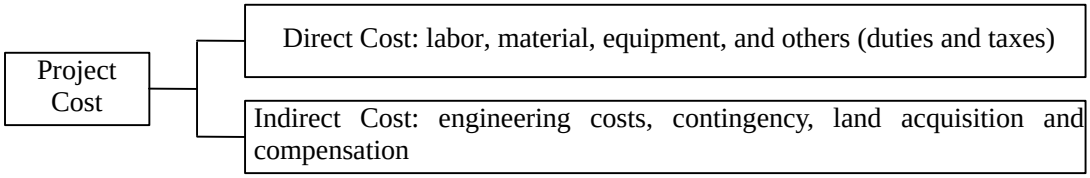
Bridge No.	Station	Width of Bridge (m)	Type of Superstructure	Length of Bridge (m)	Abutment Type	Foundation Type	Name of Bypass	Remarks
NB-1	38+600	11.80	PC-T Girder	25.80	Cantilever	Spread	Ypacarai	
NB-2	38+600	11.80	PC-T Girder	25.80	Cantilever	Spread	Ypacarai	
NB-3	53+400	11.80	PC-T Girder	30.80	Cantilever	Spread	Caacupe	
NB-4	53+400	11.80	PC-T Girder	30.80	Cantilever	Spread	Caacupe	
NB-5	100+200	11.30	PC-T Girder	30.80	Cantilever	Pile	San Jose	
NB-6	154+400	11.30	RC-T Girder	10.80	Cantilever	Spread	-	Reconstruction
NB-7	154+700	11.30	RC-T Girder	10.80	Cantilever	Spread	-	Reconstruction

Notes: PC-T Girder (Prestressed Concrete T- Girder)
RC-T Girder (Reinforced Concrete T-Girder)

12. COST ESTIMATION AND IMPLEMENTATION PLAN

(1) Cost Components

Overall project cost has been estimated at financial and economic prices and expressed in Gs. Economic prices do not include custom duties or value added tax.



Indirect Cost : Detailed design, supervision (engineering cost, 7% of direct cost)
Contingency : (10% of direct cost and detailed design and supervision)
Land acquisition : Gs25,000 per m^2
Compensation : Gs20 million per housing unit

Table 12.1 Project Cost

Items	Length (km)	Foreign	Local		Total		Remarks
			Financial	Economic	Financial	Economic	
		(US$×1000)	(mill Gs)	(mill Gs)	(mill Gs)	(mill Gs)	
A. Construction Cost							
(1) Road Improvement							
1.0 Coronel Oviedo Climbing Lane	4.00	2,807	7,833	6,105	17,096	15,368	W=5.15m
1.1 Other Climbing Lane & Urgent Maintenance	10	11,111	24,208	16,685	60,874	52,783	W=5.15m
1.2 Coronel Oviedo Flyover	0.57	1,198	3,104	2,250	7,057	6,203	W=12.3m enbank W=10.4m flyover
Sub Total (1)		15,116	35,145	25,040	85,027	74,355	W=5.15m
(2) Bypass							
2.1 Ypacarai Bypass	4.60	4,395	8,865	8,239	25,681	22,742	W=2×10.8m
2.2 Caacupe Bypass	7.20	9,761	26,121	19,935	58,330	52,144	W=2×10.8m
2.3 Itacurubi Bypass	6.02	3,378	9,069	6,950	20,217	18,098	W=12.3m
2.4 San Jose Bypass	5.15	2,898	7,490	5,596	17,052	15,158	W=12.3m
Sub Total (2)		20,432	51,545	40,720	121,280	108,143	
Total of A = (1) + (2)		35,548	86,690	65,760	206,307	182,498	
B. Engineering Cost 7% of Total A.	**lump**	**2,488**	**6,068**	**4,603**	**14,442**	**12,775**	
C. Total Construction Cost (A) + (B)		**38,036**	**92,758**	**70,363**	**220,749**	**195,272**	
D. Contingency 10% of C.		**3,804**	**9,276**	**7,036**	**22,075**	**19,527**	
E. Total Construction Cost (C)+(D)		**41,840**	**102,034**	**77,400**	**242,824**	**214,800**	
F. Land Acquisition Cost	**lump**				**24,570**	**11,940**	
G. Compensation Cost	**lump**				**3080**	**3,080**	
H. Project Cost	**lump**				**270,474**	**229,820**	
Equivalent million US$					82.0		Ius$=Gs3300

(2) Project Implementation

The project is divided into two periods that one is urgent maintenance and other are bypass constructions. The construction starts in 2002, and the first period finishes in 2005, and the second in 2009.

-Pakage-1: For urgent project are constructed to renovate overage facilities and provided traffic safety devices mainly at a place of traffic accident to be implemented by 2005 year. (Climbing lane, guard rail, improvement of interchange etc.)

-Pakage-2: The mini-bypasses project are constructed for increasing traffic capacity as well as traffic safety to be implemented by 2010 year. (Bypasses in Ypacarai, Caacupe, Itacurubi, and San Jose)

The urgent maintenance works include the overlay of the entire study section (169km) and replacement of two existing bridges.

Table 12.2 Project Implementation Schedule

Works	Unit	Quan-tity	2002	2003	2004	2005	2006	2007	2008	2009	Construction Cost Financial (Gs. million)	Construction Cost Economic (Gs. million)
1 Preparation of Project		lump	■									
2 Survey and Design		lump		■	■						15,886	14,052
3 Construction												
A Package-1 Road Improvement,												
1 Coronel Oviedo Climbing Lane	km	4			■	■					18,805	16,905
2 Others Climbing Lane & Urgent Maintenance	km	10			■	■					66,961	58,062
3 Coronel Oviedo Flyover	km	0.6				■					7,763	6,824
B Package-2 Bypass Construction												
1 Ypacarai	km	4.6				■	■				28,249	25,016
2 Caacupe	km	7.2					■	■			64,163	57,359
3 Itacurubi	km	6.1						■	■		22,239	19,908
4 San Jose	km	5.2							■	■	18,758	16,674
C Financial Cost			0	7,943	50,826	64,771	46,206	43,201	20,498	9,379	242,824	
D Economic Cost			0	7,026	44,510	56,815	41,187	38,633	18,291	8,337		214,800

13. ENVIRONMENTAL IMPACT ASSESSMENT (EIA)

In accordance with the environmental items summarized in Initial Environmental Examination (IEE), related surveys and an environmental impact assessment for the improvement projects have been carried out as follows.

Table 13.1 ENVIRONMENTAL IMPACT ASSESSMENT

Surveys	Environmental Items requiring EIA	Other Environmental Items requiring Further Study
Social Environmental Survey	- Resettlements	- Economic Activities - Traffic and Public Facilities - Split of Communities - Cultural Property - Water Rights and Common Rights - Hazards (Risk)
Natural Environmental Survey	-	- Soil erosion - Fauna and Flora
Air Pollution and Noise	- Air Pollution (Prediction of NO_x and CO_2) - Prediction of Noise level	-
Household Opinion Survey	To follow up social environmental survey, household opinion survey was carried out each bypass project areas	

(1) Social Environment

a. Resettlement

Resettlements will be necessary for construction of mini-bypasses in Ypacarai, Caacupe, Itacurubi, and San Jose. However, each alignment is designed to mitigate environmental impacts. Special consideration at later stage should continued to minimize the number of resettlement in each mini-bypass area. The result of the household opinion survey, which sampled 266 households in total among seven cities along Routes 2 and 7, indicates that among all households interviewed in the mini-bypass areas, only one household expressed an objection to implementing the project. Other households interviewed approve the implementation of the project. As for the compensation for the resettlements, many people have expressed their opinions that indemnity shall be made in the form of money equivalent to the actual price of their property. Since all the climbing lane projects will be executed in the existing right-of-ways (ROWs), they will not require any resettlements.

b. Traffic and Public Facilities

It is considered that there are no negative impacts on the existing traffic and public facilities by the implementation of the projects. However, a lot of monuments called "*Nicho*" which are built by the families or relatives of the victims of traffic accidents to mourn their deaths. Most *Nicho* are built at the edge of the ROW, therefore no impact will be expected by the projects. However, special consideration should be paid to these monuments during the construction of bypasses and widening of the existing road. If necessary, these monuments need to be moved to appropriate places in accordance with local religious practice during the preparation and construction stage.

c. Hazards (Risk)

Apparently, there will be no negative impacts of traffic accidents by the construction of the bypasses because each bypass route is designed to circumvent the existing urban area. However, in consideration of a future expansion of each urban area, it is recommendable to construct traffic facilities to reduce traffic accidents, such as pedestrian crossing, guard fence, and traffic signs. There are past records of flooding in the bypass construction areas around Ypacarai Lake and San Jose. Therefore, it is necessary to take adequate countermeasures such as an embankment structure and culvert construction in order to mitigate flooding

(2) Natural Environment

a. Fauna and Flora

No rare, endangered fauna and flora have been identified in the project area. However, Ypacarai Reservoir of Resource Management has been set up around Ypacarai Lake. Especially, it is necessary to pay an attention to the swampy area between the south of Ypacarai Lake and Route 2. Since the bypass is designed to run through a part of this swamp area, it is important to provide for a design that can minimize the impact and also take measures for better drainage such as culvert. In addition, these areas are protected by a local NGO (Non-governmental Organization). Therefore, negotiation and communication shall be required to form a good relationship with them at an early stage of the project implementation.

(3) Air Pollution and Noise

a. Air pollution

By the implementation of the improvement projects (“with projects”), an average travel speed will increase in the sections of mini-bypass and climbing lane projects in the target year of 2010, compared to a “without project.” Therefore, it is expected that the emission of NO_x and CO_2 from the vehicles will decrease in accordance with an increase of an average travel speed by the implementation of the projects, and environmental benefit will increase as well.

b. Noise

An increase in noise level from vehicles is expected in accordance with an increase of an average travel speed brought about by the implementation of projects. However, each bypass route is designed to pass around the existing urban area. Therefore, it is considered that there will be less direct impact of the increasing of noise level on the urban area. However, in consideration of future expansion of each urban area, facilities to mitigate future noise level issue such as planting area, green belt, and so on are expected to construct on the urban side of each bypass.

14. ECONOMIC AND FINANCIAL EVALUATION

(1) Economic Evaluation

a. Methodology

Economic evaluation only takes into account the proposed improvements and maintenance for those works. Improvement of the National Road Routes 2 and 7 will generate various types of benefits. Among them, the following direct benefits are counted in this analysis.

- Saving in Vehicle Operating Cost (VOC)
- Saving in Travel Time Cost (TTC)

In addition to the benefits taken into account conventionally, the following analysis are also included.

- Reduction in Traffic Accident Cost
- Environmental Improvement

In Paraguay, Oficina de Palnificación Integral del Transporte (OPIT) in MOPC has been periodically updating VOC and TTC data in order to use an input to the HDM Model Estimation of unit VOC and TTC was carried out with the data provided by OPIT. However, the speed factor is taken into account in VOC estimation referring to an IBRD report.

b. Results of the Evaluation

Economic indicators, such as IRR, B/C and NPV of the proposed projects are shown in Table 17.1. Although there are some sections with low IRRs, the whole project is fairly feasible in economic terms.

Table 14.1 Results of Economic Evaluation

	EIRR	NPV (Gs. Million)	B/C
Whole Project	25%	87,069	2.3
Bypass	28%	73,585	2.5
Climbing Lane (Coronel Oviedo)	20% (8%)	14,137 (- 2,835)	1.8 (0.7)
Flyover	9%	- 652	0.8

An economic analysis with consideration to the reduction of accident cost is made for the Coronel Oviedo climbing lane and the Coronel Oviedo Flyover. The results of analysis are shown in table below.

Table 14.2 Results of Economic Analysis Considering Accident Costs

	EIRR	NPV	B/C
Coronel Oviedo Climbing Lane	9.1%	-2,294	0.76
Flyover	11.7%	-79	0.98

Counting benefits of environmental improvements makes little change in economic indicators.

Sensitivity tests are conducted in cases for a 10% decrease in traffic volume and a 10% increase in costs. Economic indicators in case of the 10% decrease in traffic volume are calculated as shown in the table below. The whole project still remains economically feasible.

Table 14.3 Economic Indicators in Case of 10% Decrease in Traffic Volume

	EIRR	NPV (Gs. million)	B/C
Whole Project	18%	39,202	1.5
Bypass	22%	42,496	1.7
Climbing Lane	10%	-2,132	0.9
Flyover	6%	-1,161	0.7

The decrease in costs by 10%, including construction and operation and maintenance costs, will result in around a 10%-decrease of EIRRs. Sensitivity to costs is relatively low, compared to that of traffic volume.

(2) Financial Analysis

Financial analysis is conducted to examine financial viability of improvement, maintenance of the study area (National Road Routes 2 and 7), including the urgent maintenance projects, and the overlay and maintenance of the entire section, through toll collection. Other assumptions for a financial analysis are also described below.

In estimating toll revenues, two cases with different toll rates are examined, Case-1 for the Ypacarai scheme and Case-2 for the Ciudad del Este system, as shown in Table 14.4.

Table 14.4 Applied Toll Rates for Financial Analysis

	Passenger Car	Bus	Truck
Case-1	5,000	10,000	15,000
Case-2	6,000	12,000	18,000

- Tolls are to be collected at two gates, near the current toll plazas.
- At each gate, tolls are supposed to be charged for one direction only.
- The toll collection for improvement and maintenance is assumed to start in 2006.
- Annual traffic volume at toll plaza is assumed to be 300 times of the daily traffic volume estimated for the section near the plaza.
- The revenues and costs are estimated in the 1999 price, and inflation is not taken into account.
- Costs for land acquisition and compensation are not included in the project cost.

The FIRR is 15% (Case-1), and 20% (Case-2), respectively. In case of a 10%-decrease in traffic volume at both plazas, a 10%-decrease in toll revenue will reduce FIRR by 3% in both Case-1 and Case-2. The results show that a full cost recovery, including that for investment and financing costs, from the toll collection will be possible.

In the current financial market of Paraguay, interest rates of the national currency, Guarani, from commercial banks to a good private company are 22% to 24%. Assuming 5% of annual inflation, the commercial interest rate in real term might be 17% to 19%, and thus the FIRR of the Case-1 might not be so attractive to the private sector.

15. CONCLUSIONS AND RECOMMENDATIONS

1. A rapid increase in traffic demand on National Road Route 2 and Route 7 and its growing importance in MERCOSUR will require the provision of four lanes for the entire section before 2020. For the target year, 2010, various road improvements have been proposed in this Study on the basis of this assumption of a complete four-lane road.
2. The construction of mini-bypasses is proposed for the second project period. They are critical for increasing traffic capacity as well as for traffic safety to keep heavy trucks away from the built-up areas.
3. Urgent projects are proposed to renovate overage facilities and provide traffic safety devices to be implemented by 2005. Risks associated with overage facilities are fatal. Such accidents as bridge collapses produce tremendous damages such as direct damages and economic and social costs of blocking the traffic on this important national highway.
4. It is also highly recommended to establish an operation and maintenance system to preserve road functionality and provide reliable road service. It is imperative to survey current conditions of road facilities as well as structures, utilize such data, and construct an efficient operation and maintenance system. The importance of operation and maintenance is to provide reliable service to road users and prevent economic negativity resulting from decreasing the transport capacity.

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Mr. Masashi BESSHO	Structural Design
Mr. Yoshinori TANAKA	Implementation Plan/Cost Estimates
Mr. Sanggyoon LEE	Natural Condition Survey
Mr. Kenji IGARASHI	Environmental Impact Assessment
Mr. Naoki HARA	Economic/Financial Analysis
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