i) Supporting small farmers, as well as improving their living conditions.

ii) Increase of agricultural productivity.

iii) Diversification of crops and improvement of product quality.

iv) Development of agro and food-processing industries.

It is advisable to design the road network so that it will enhance agricultural improvement, as discussed above.

(3) Improvement of Permanent Human Settlements

Farmland, spread throughout the entire region, generally corresponds to the area of human settlement, since farmers tend to live on the land they have cleared. After the period of colonization, serious attention must be paid to the human settlement aspects, rather than to the agricultural industrial aspects on farmlands. In this respect, the social or public services which permanent human settlements in the agricultural area require is of great concern for regional development. Therefore, it must be noted that besides agricultural development, the improvement of permanent human settlements must also be considered in the course of planning the road network.

In conclusion, the achievement of the goals described above, i.e., the development of an integrated agricultural zone, the promotion of agricultural improvement, and the improvement of permanent human settlements, will be supported by road network development in the region .

3-4-3 Regional Development Scenario

The regional development scenario, which will be enhanced by the improvement of the road network, can be summarized as follows:

(1) Regional Road Network for Developing an Integrated Agricultural Zone

The proposed regional road should be designed so that its effects spread broadly through the roads connecting with the proposed road, rather than being concentrated only in areas along the road. While national roads (R. 1, 2, 3, and 8) handling inter-regional traffic make up the basic frame of the proposed road network, the proposed Paraguarí - Villarrica road will be the regional backbone for collecting/distributing intra-regional traffic, as shown in Figure 3.4.4, ultimately leading to integration of the planning area.

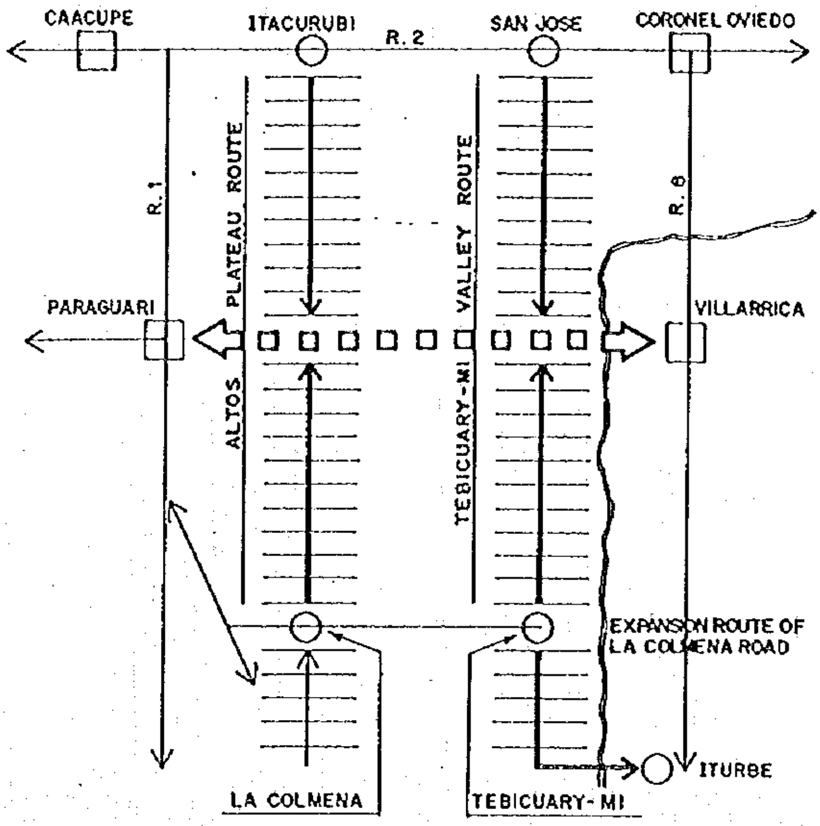


Figure 3.4.4 Proposed Road System for Regional Transport

Following the Paraguarí - Villarrica road, the Carapeguá-Tebicuary-mí - Iturbe - R. No.8 route stands as a regional road in the planning area. The access or connecting roads which are indispensable for forming a regional road network system are the following:

i) High plateau route (Itacurubí - Caballero - La Colmena and further south)

ii) Tebicuary-mí Valley route (San José Tebicuary - Tebicuary-mí)

(2) Agricultural Development

The agricultural area and products, which are expected to be favorably affected by the road improvement and hence be promoted in conjunction with improvement of the road, can be summarized as follows. (Figure 3.4.5)

i) Belt of urban-market-oriented farming and farming for food processing (fruit) in the existing intensive agricultural zone on the plateau stretching from Caacupé through Escobar, Sapucaí and Caballero up to La Colmena and Ybycuí.

ii) Belt of sugar cane farming and processing stretching from San José through Coronel Martínez (Tebicuary), Tebicuary-mí and Borja on the West side of the Río Tebicuary-mí up to Iturbe.

iii) Belt of agro-linkage-farming processing between La Colmena and Iturbe. The proposed 3 routes coupled with the Paraguarí - Villarrica road will hopefully promote the development belts indicated above.

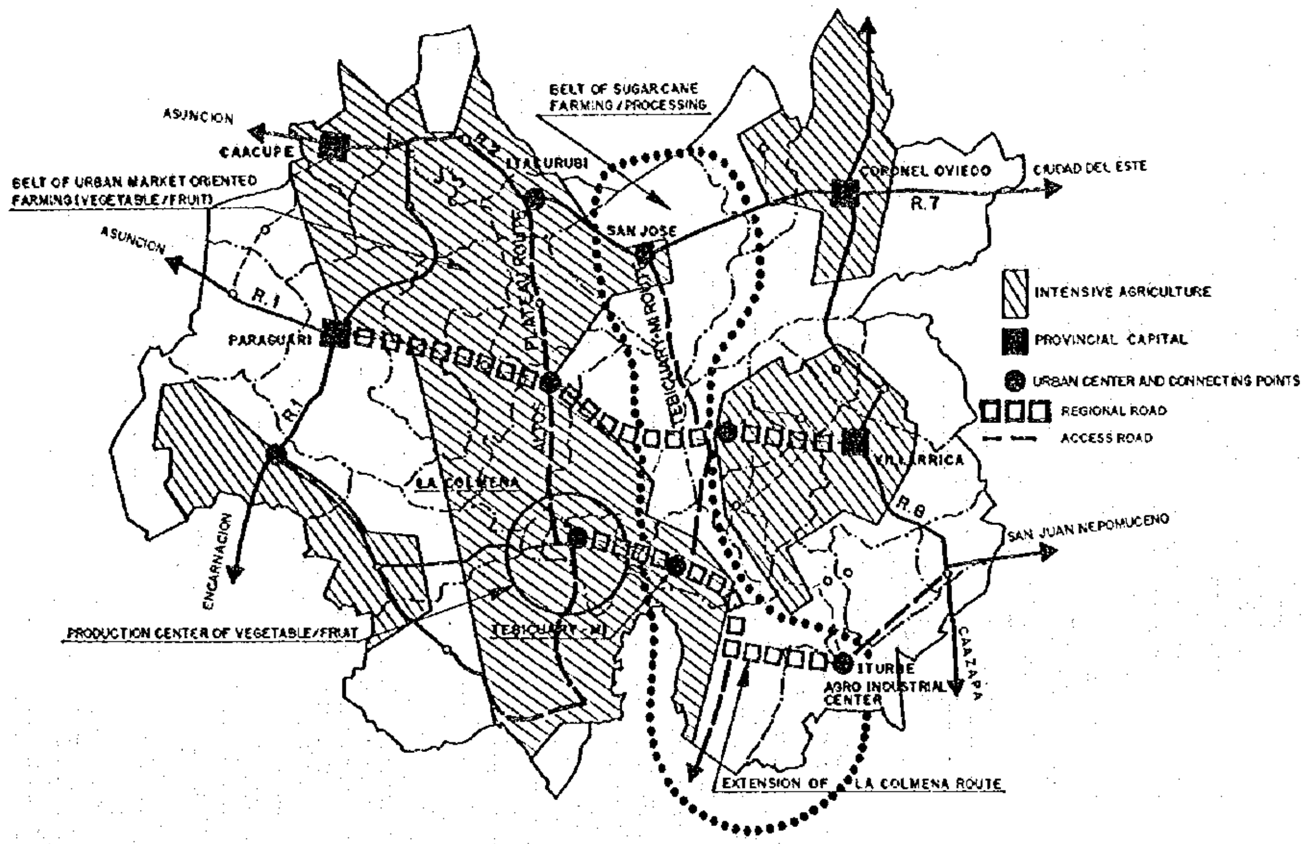


Figure 3.4.5 Proposed Road Network

The reason for selecting the strategic crops to be promoted listed above and the development scenario can be outlined as follows:

1) Urban-market-oriented farming and farming for food processing (vegetables and fruits)

i) Agricultural lands in the planning area are quite limited and large-scale farming is not possible. Therefore, intensive farming, focusing on valuable vegetables and fruits, should be promoted.

ii) A great market is foreseeable in the future because the urban population is expected to be as large as 2.9 million in Asunción and Central, and 1.5 million in Alto Paraná by 2010.

iii) It is reported that the rate of self-subsistence through the cultivation of vegetables and fruits in Paraguay is around 60% with the remaining 40% being obtained through importation. Therefore, domestic production can grow by 40% if quality is up-graded. Moreover, it seems that there seem some chance for Paraguay to export some agricultural products to Argentina, especially when crops are out of season there, but still in season in Paraguay.

iv) There is already an established model of vegetable and fruit production targeting the urban market, that is, La Colmena. It is recommended that this model should be applied and spread to all the urban-market-oriented farms along the plateau.

v) The most important factor for realizing this development scheme is the success of the belt of agro-linkage farming-processing between La Colmena and Iturbe, which is outlined later.

2) Sugar cane farming and processing

As shown in the chart on production volume, it is no doubt that sugar cane is the most important harvest in Guairá as well as in the planning area. In fact, it has been reported that many farmers have recently switched over to the cultivation of sugar, and the Iturbe sugar cane factory is planning to double its production capacity by 1999.

As shown in the geographical distribution, sugar cane products are widespread, especially in the eastern part of the planning area. However, the roads along which sugar cane is collected roads have not been properly improved to cover such widespread farming areas. It must be stressed that the industrial sugar cane products are quite time-sensitive.

The percentage of sugar content in the sugar cane tends to decrease rapidly, by 12%, 48 hours after cutting. The sugar content of the sugar cane planted reaches its maximum in the season between August and October. If the harvest is delayed after harvest time because the roads are flooded, for instance, the sugar content will be drastically decreased. In this regard the productivity and profitability of sugar-cane factories, just as the income of sugar-cane farmers are quite dependent on the condition of the roads.

It seems safe to conclude, therefore, that improving the road will remarkably increase agricultural production and productivity in the sugar cane industry, thus leading to economic growth in the planning area.

3) Agro-linkage farming-processing between La Colmena - Iturbe

Iturbe Sugar Company is strategically important for implementing the development scenario discussed above. Because that company guarantees the purchase of fruits and sugar cane from farmers, they are confident that their production will expand. Iturbe Sugar Company has an investment plan, already partially implemented, covering the following 3 fields.

Table 3.4.1 Iturbe Sugar Company's Investment Scheme

Field	Scheme
Agriculture	• Expansion of the company's cultivated land. • Improvement and expansion of farmers' cultivated land. • Diversification of farming. • Conservation of environment.
Manufacturing Industry	• Expansion of industrial production capacity-sugar and fruit processing. • Diversification of industrial products. • Increase of added value.
Marketing	• International association. • Regionalization. • New markets and new products.

The company's strategy is to become competitive in the Mercosur region, with the target of increasing its share of sugar and sugar-related products from 18% at present to 35% in that region. The company's development program will greatly affect the agricultural structure, especially of sugar cane and fruits in the planning area.

The company has proceeded with the development of its fruit-processing industry, especially the canning of fruit pulps and fruit juices, in expectation that materials (fruits) will be provided from La Colmena, which is a major producer of fruits in the planning area. It is said the canning industry is the industry with the greatest potential in Paraguay. This will also have a great effect on fruit production in the area.

La Colmena has already started fruit processing, for example, juice and wines, on a small scale. However, these efforts have not been fully developed and have not yet achieved a high level of industrialization. Accordingly, fruit production is nowhere near capacity. The fruit-processing factory in Iturbe will motivate the farmers of La Colmena to plant more fruit trees and expand fruit production.

The proposed 3 routes identified above are of great importance in promoting agricultural development in the planning area.

(3) Road System for Permanent Human Settlements

The urban centers provide all the social/public and commercial services in the rural areas. Therefore, permanent human settlements should be within a certain distance, in terms of travel time, from the nearest urban center. At present, the service areas of the urban centers (first biggest: Cnel. Oviedo, second: Caacupé, third: Paraguarí.) are supposed to cover the areas shown in Figure 3.4.6. The extent of the service area varies depending on access to the urban center and the attractiveness or size of the urban center. It is envisioned that service areas after road improvement will be as shown in Figure 3.4.7.

Since there is no urban center comparable to Villarrica except Caacupé, Cnel. Oviedo and access to Villarrica will be remarkably improved, especially from west of Villarrica, by the proposed road improvement, as will be noted from the improvement in travel time indicated in Figure 3.4.2. Moreover, Villarica's service area will expand to include La Colmena, Sapucaí, and so on.

In this respect, a permanent human settlement system with Villarrica as its urban center for social/public and commercial services should be established in the area. Under such a human settlement system (centering around Villarrica), it will be necessary to secure a reliable and comfortable road and public transportation system to facilitate shopping, education, social welfare, etc. Especially, the route of La Colmena - Tebicuary-mí - Tebicuary - Villarrica, and the route of La Colmena - Tebicuary-mí - Iturbe will be major social service roads providing transportation services to people residing along those routes.

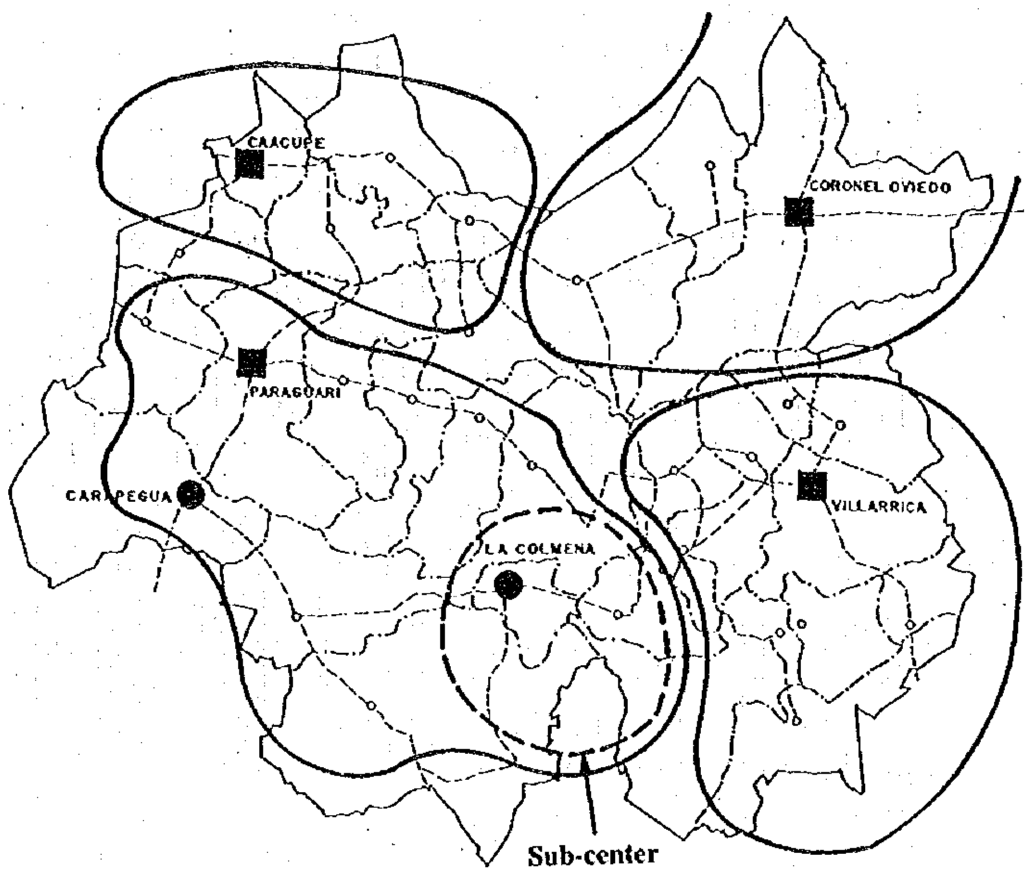


Figure 3.4.6 Existing Service Area of Urban Centers

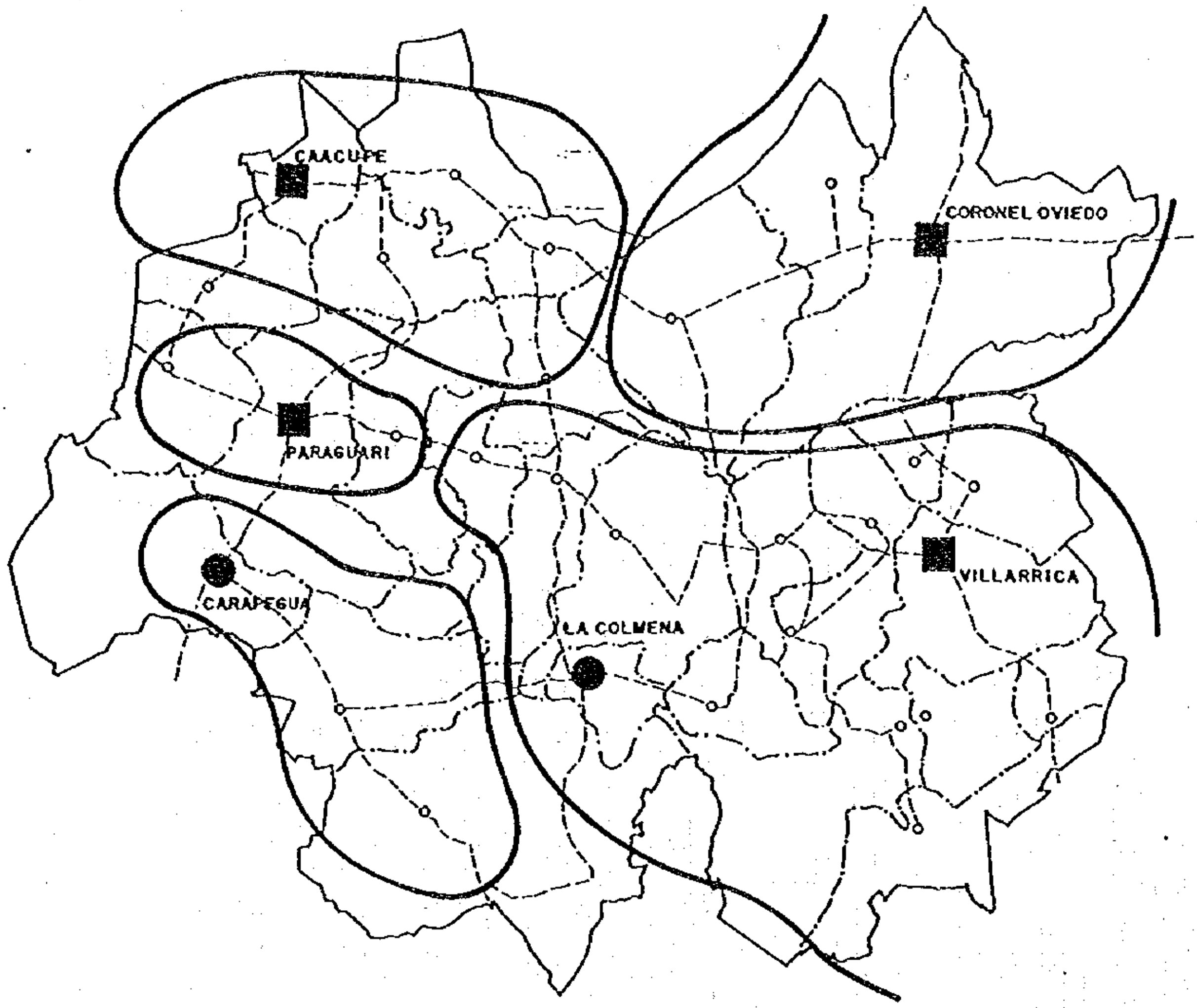


Figure 3.4.7 Service Area of Urban Centers After Road Improvement

3-4-4 MERCOSUR and the Planning Area

(1) General

MERCOSUR, as a regional free trade market and common trade tax league, consisting of Brazil, Argentine, Uruguay, and Paraguay, was formed at the beginning of 1995. MERCOSUR aims at completely eliminating import/export taxes among the league member countries, and applying a common tax rate to the member countries for trade between them and outside countries. However, from this viewpoint, the start made in 1995 can only be seen as partial. In other words, although it has already taken effect, some important agreements regarding constitutional items have been suspended, and considerably more goods have been listed for exemption from the above-described rules. The agreement has specified the elimination of exemptions between 2000 and 2006.

Some analysts said that it a partial start could not be avoided because of the scale and features of the macro economies of Brazil and Argentine, compared to those of Uruguay and Paraguay (the economic activity in Paraguay is said to be 1% that of Brazil). Hence, the necessary measures for preparation for MERCOSUR's start in some member countries had to be delayed.

Under such conditions, given the mono-cultural economic structure of Paraguay, it is considered that the influence of MERCOSUR on the agriculture sector and the establishment of appropriate counter-measures will be important and indispensable in Paraguay.

Although the Government of Paraguay has not yet publicized any new policy for the agriculture sector under the MERCOSUR system, some economists have pointed out the following findings and/or issues regarding Paraguay:

i) Including other sectors besides agriculture, the volume of transport or movement of goods in the region will increase greatly, and the infrastructure supporting it will gain in importance.

ii) Industrialization, especially in man-power oriented industries, electricity-consuming industries, the agro-industry, light industry and privatization will be promoted by receiving more foreign investment than at present.

iii) Production and price of cotton and soy bean, international commodities, will hardly be influenced by MERCOSUR.

iv) By promotion of the agro-industry, improvement of productivity, plant breeding, enlargement of production unit, diversification of crops, etc., the production of maize, fruits such as grapefruits, tobacco, cassava, meat and vegetables will be able to remain competitive.

v) The production of wheat, sugar-cane, potato, coffee and milk will be negatively influenced; however, sugar, is included in the exemption list, and hence it could become competitive, if some appropriate measures were taken utilizing the period until the expiration of the exemption, in order to increase productivity, efficiency in processing and marketing, and product quality.

vi) The following issues relevant to Paraguayan agriculture must be urgently improved under the MERCOSUR system:

- High concentration on the production of soy beans and cotton
- Complicated market system, such as the existence of many intermediate wholesalers

- Existence of many non-organized small scale farmers and lack of a supporting system for them
- Delay of farm reforms and of high utilization of farmland
- Increase of poverty in agricultural areas
- Poor infrastructure.

(2) Planning Area

Needless to say, the most important thing for Paraguay under the MERCOSUR system is to revitalize the Asunción market. Considering this goal, the location of the planning area is advantageous, and has the potential mentioned before. That is, taking advantage of the geography and based on the already developed agriculture, this planning area is considered to have a bright future even under the MERCOSUR system if it promotes, in a concentrated effort, suburban agriculture based on vegetables, and fruits, and dairy farming for the domestic market.

The regional development goals and scenario described in the previous sections, 3-4-2 and 3-4-3, is based on the idea described above of making this area one of the agricultural centers in Paraguay, so that it can maintain its position under MERCOSUR. The contents of the description in the previous section, such as integration of the area, diversification of crops, development of the agro-processing industry, and so on, coincide with some of the necessary measures, pointed out in the above sub-section (1), to strengthen the fundamental structure of Paraguayan agriculture under the MERCOSUR system.

Even sugar cane, the most predominant crop here, could be replaced in the long run. The strategic programs of the private sugar companies in Tebicuary and Iturbe, as described in 3-4-3 (see, Figure 3.4.1), seem to have been established aiming in that direction.

In other words, the planning area is considered to show great potential, and the development of the infrastructure, for example, road development in the area, is one of the most important measures for realizing the area's potential. In this sense, the development program of the objective road of this Study certainly represents an important and viable Project for the country not only for the present but also for the future under the MERCOSUR system.

CHAPTER 4

TRAFFIC SURVEYS

CHAPTER 4 TRAFFIC SURVEYS

Various traffic surveys were carried out during the beginning stage of the study, in order to analyze existing traffic condition in the study area.

4-1 Traffic Volume Counting Survey

(1) Location of Survey Stations

Existing traffic volume was counted at 32 locations in total and they were classified into two types; at 10 locations (same as the Origin-Destination Interview survey locations) over a 24-hour period on one weekday, and at 22 locations over 12-hour period for 3 weekdays and 1 Sunday. The survey locations are shown in Figures 4.1.1 and Figure 4.1.2.

(2) Hourly Traffic Volume Fluctuation

Hourly traffic volume fluctuations at the 24-hour survey locations are illustrated in Annex A-1, and the total average 24-hour traffic ratio, 24-hour traffic volume divided by 12-hour traffic volume (6:00 a.m. to 6:00 p.m.), is summarized below by type of vehicle. In these figures of Annex, no significant peak hours could be identified because traffic volume at survey locations in the Planning Area were fairly small and those on the national roads were considered to include much inter-department traffic with long-haul trips..

Table 4.1.1 Average Ratio of 24-hour/12-hour Traffic Volume

Vehicle Type	Passenger Car	Bus	Truck	Total
24 h/12 h Ratio	1.372	1.378	1.541	1.425

Traffic volume fluctuation of 3 weekdays average and of Sunday at the 12-hour survey locations are shown in Annexes A-2 and A-3, respectively. The traffic volume at location numbers 18 and 21 shown in Annex A-3 was huge, because surveys at these locations were carried out at the last day of 'Semana Santa', and many people were returning home from their vacations.

(3) Traffic Volume Composition

Traffic Volume Composition of 24-hour traffic volume, 12-hour traffic volume for the average of 3 weekdays and 12-hour traffic volume for Sunday are shown in Annexes A-4, A-5 and A-6, respectively. Table 4.1.2 summarizes the daily average ratio of heavy vehicles; 33 to 44% in weekdays and 14 to 28% in Sunday.

Table 4.1.2 Daily Average Heavy Vehicle Ratio

Location	Weekday/Holiday	Heavy Vehicle Ratio
All Locations	Weekday	42.8%
	Sunday	22.0%
Paraguarí-Villarrica	Weekday	33.2%
	Sunday	14.3%
Tebicuary-La Colmena	Weekday	43.7%
	Sunday	27.8%

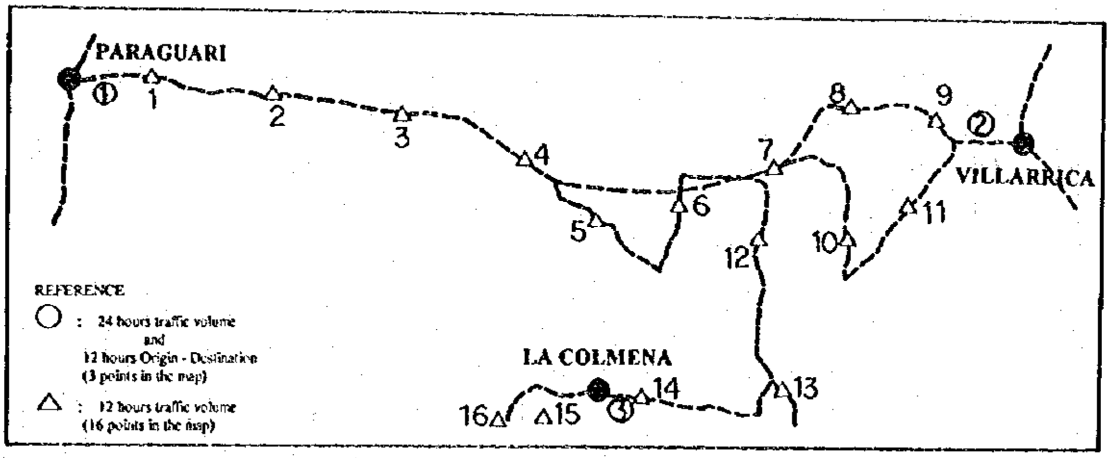


Figure 4.1.1 Traffic Volume Count and Origin-Destination Interview Locations in Other Area

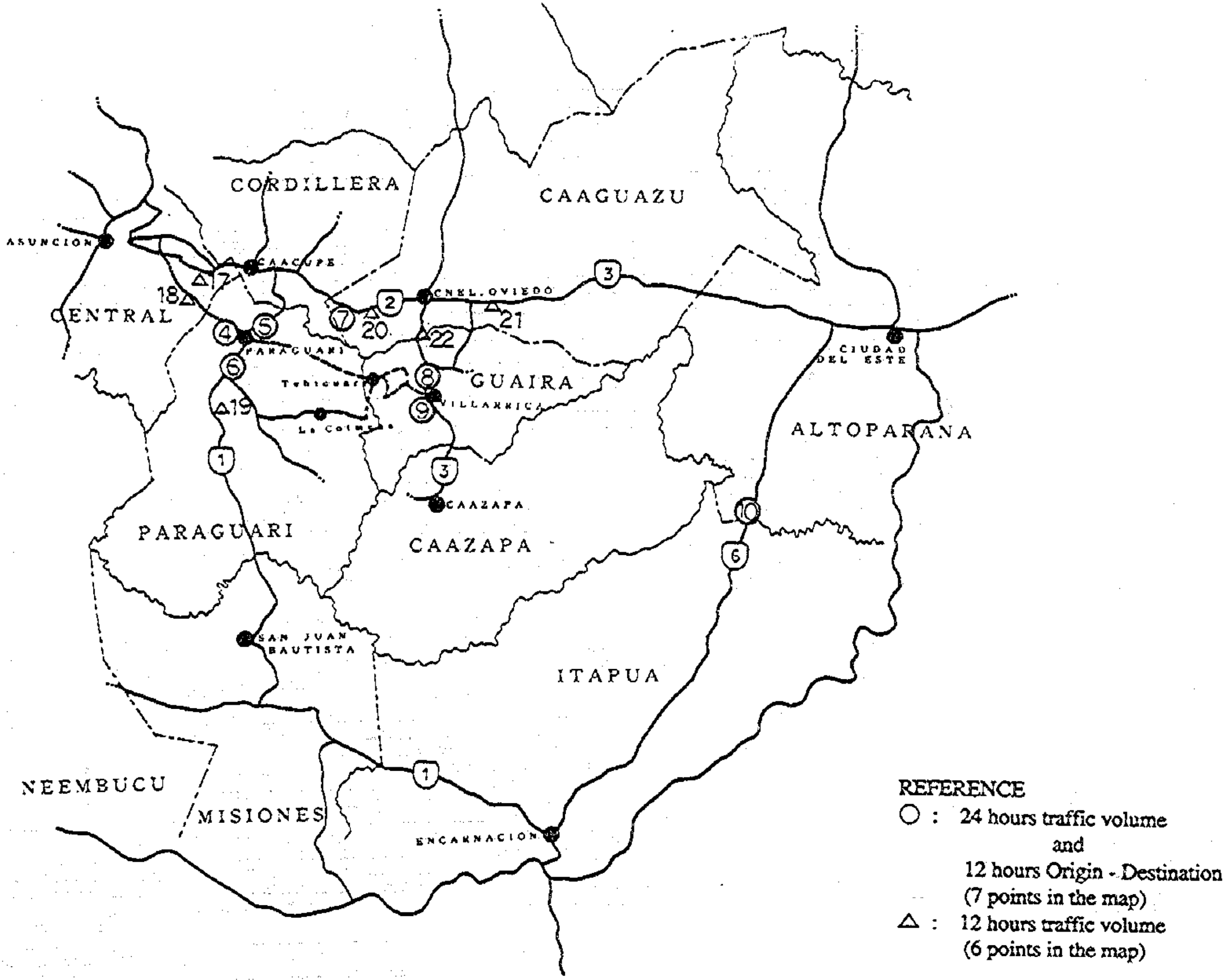


Figure 4.1.2 Traffic Volume Count and Origin-Destination Interview Locations

4-2 Road-side Origin-Destination Interview

(1) Survey Locations

A road-side Origin-Destination (O-D) Interview survey was conducted by interviewing drivers at 10 locations shown in Figures 4.1.1 and 4.1.2 over a 12-hour period from 6:00 a.m. to 6:00 p.m. for 3 days, that is, 2 weekdays and 1 Sunday. The number of samples checked is tabulated in Table 4.2.1. Vehicle movements by vehicle type obtained from the results of O-D interviews are summarized in the form of O-D tables in Annex A-8, and also illustrated under "Desired lines" in Figures 5.3.1 and 5.3.2.

Table 4.2.1 Sample Number of Road-side Origin-Destination Interview Results

(Unit : Vehicle)

Loc	24 hours count				Interview		Road-side Origin-Destination Interview Sample							
No.	P.Car	Bus	Truck	Total	No	Day	P.Car	Ratio	Bus	Ratio	Truck	Ratio	Total	Ratio
1	161	32	42	235	1	Weekday	137	85.1%	29	90.6%	42	100.0%	208	88.5%
					2	Weekday	159	98.8%	28	87.5%	46	109.5%	233	99.1%
					3	Sunday	50	31.1%	14	43.8%	11	26.2%	75	31.9%
2	302	43	98	443	1	Weekday	183	60.6%	24	55.8%	44	44.9%	251	56.7%
					2	Weekday	145	48.0%	11	25.6%	39	39.8%	195	44.0%
					3	Sunday	153	50.7%	16	37.2%	24	24.5%	193	43.6%
3	77	25	30	132	1	Weekday	28	36.4%	16	64.0%	18	60.0%	62	47.0%
					2	Weekday	35	45.5%	19	76.0%	14	46.7%	68	51.5%
					3	Sunday	63	81.8%	18	72.0%	9	30.0%	90	68.2%
4	1,928	470	900	3,298	1	Weekday	554	28.7%	141	30.0%	283	31.4%	978	29.7%
					2	Weekday	641	33.2%	114	24.3%	240	26.7%	995	30.2%
					3	Sunday	982	50.9%	111	23.6%	136	15.1%	1,229	37.3%
5	327	67	156	550	1	Weekday	283	86.5%	42	62.7%	70	44.9%	395	71.8%
					2	Weekday	157	48.0%	35	52.2%	88	56.4%	280	50.9%
					3	Sunday	220	67.3%	18	26.9%	30	19.2%	268	48.7%
6	1,770	389	786	2,945	1	Weekday	684	38.6%	127	32.6%	218	27.7%	1,029	34.9%
					2	Weekday	642	36.3%	113	29.0%	314	39.9%	1,069	36.3%
					3	Sunday	501	28.3%	139	35.7%	89	11.3%	729	24.8%
7	2,495	468	2,042	5,005	1	Weekday	416	16.7%	105	22.4%	381	18.7%	902	18.0%
					2	Weekday	350	14.0%	92	19.7%	275	13.5%	717	14.3%
					3	Sunday	236	9.5%	80	17.1%	155	7.6%	471	9.4%
8	1,773	272	672	2,717	1	Weekday	402	22.7%	68	25.0%	133	19.8%	603	22.2%
					2	Weekday	351	19.8%	52	19.1%	153	22.8%	556	20.5%
					3	Sunday	503	28.4%	74	27.2%	46	6.8%	623	22.9%
9	721	77	409	1,207	1	Weekday	154	21.4%	23	29.9%	103	25.2%	280	23.2%
					2	Weekday	154	21.4%	22	28.6%	87	21.3%	263	21.8%
					3	Sunday	164	22.7%	15	19.5%	24	5.9%	203	16.8%
10	1,601	105	1,427	3,133	1	Weekday	211	13.2%	55	52.4%	324	22.7%	590	18.8%
					2	Weekday	229	14.3%	50	47.6%	301	21.1%	580	18.5%
					3	Sunday	231	14.4%	48	45.7%	215	15.1%	494	15.8%

(2) Present Traffic Generation and Attraction by Vehicle Type

The present traffic generation/attraction (G/A) volume by traffic zone, which was developed both by the O-D interview survey results and an ENTA study (refer to Chapter 5), is tabulated in Table 4.2.2. The greatest G/A volumes were found at Coronel Oviedo, Villarrica, Caacupé and Paraguarí within in the 'Planning Area', which encompasses zones 1 to 30; meanwhile, outside of the 'Planning Area', huge volumes were also found at Central Norte (which includes San Lorenzo and other cities), Alto Paraná (including Ciudad del Este), Itapúa (including Encarnación), and Asunción.

Table 4.2.2 Traffic Generation and Attraction in 1996

(Unit : vehicle/day)

Zone No.	Name	Passenger Car		Bus		Truck		Total	
		Gen.	Att.	Gen.	Att.	Gen.	Att.	Gen.	Att.
1	Paraguarí	477	225	80	38	51	156	608	419
2	Escobar	28	61	3	11	11	60	42	132
3	Sapucái	44	54	3	9	9	35	56	98
4	Acahay	71	77	7	26	14	4	92	107
5	Carapeguá	233	179	28	61	59	42	320	282
6	Yaguarón	140	126	0	0	36	102	176	228
7	Pirayú	8	52	0	0	5	47	13	99
8	Caballero	14	49	13	9	7	14	34	72
9	Ybytimí	12	47	6	10	4	28	22	85
10	Tebicuary-mí	31	29	8	0	8	7	47	36
11	La Colmena	91	58	20	4	9	3	120	65
12	Ybycuí	87	112	29	47	20	6	136	165
13	Villarrica	754	410	158	95	239	433	1,151	938
14	Yataity	81	43	9	0	12	2	102	45
15	Mbocayaty	170	81	3	5	30	34	203	120
16	Ñumí	123	62	3	0	43	13	169	75
17	San Salvador	68	41	0	0	16	19	84	60
18	Iturbe	126	75	7	10	36	135	169	220
19	Borja	74	62	4	11	5	42	83	115
20	Itapé	62	44	11	4	14	1	87	49
21	Coronel Martínez	30	45	0	0	4	43	34	88
22	Felix Perez Cardozo	74	52	0	0	10	11	84	63
23	Caacupé	230	198	4	68	931	505	1,165	771
24	Eusebio Ayala	58	78	0	0	59	109	117	187
25	Piribebuy	165	121	21	28	36	49	222	198
26	Itacurubí de la Cordill	239	110	0	0	528	11	767	121
27	Valenzuela	15	31	0	0	68	0	83	31
28	Colonel Oviedo	505	463	35	163	1,155	2,165	1,695	2,791
29	Nueva Londres	0	0	0	0	10	0	10	0
30	San José de los Arroyos	206	144	0	0	149	149	355	293
31	Asunción	2,884	1,078	889	211	4,324	2,467	8,097	3,756
32	Concepción	87	407	54	82	1,288	1,100	1,429	1,589
33	San Pedro	204	790	95	160	1,604	2,204	1,903	3,154
34	Cordillera Oeste	50	146	0	0	87	255	137	401
35	Cordillera Este	58	135	0	26	142	286	200	447
36	Guairá	400	145	21	30	276	316	697	491
37	Caaguazú Oeste	34	169	6	36	447	605	487	810
38	Caaguazú Este	422	580	23	113	960	277	1,405	970
39	Caazapá Oeste	350	157	40	34	377	395	767	586
40	Caazapá Este	127	147	20	33	210	313	357	493
41	Itapúa	634	1,067	83	214	2,924	2,584	3,641	3,865
42	Misiones	345	216	40	42	338	567	723	825
43	Paraguarí Sur	232	139	74	30	223	338	529	507
44	Alto Paraná	1,809	1,755	218	334	2,847	2,248	4,874	4,337
45	Central Norte	683	2,644	0	0	886	6,385	1,569	9,029
46	Central Sur	238	238	20	47	1,585	547	1,843	832
47	Ñeembucú	59	189	9	39	199	487	267	715
48	Amambay	162	312	50	64	1,185	445	1,397	821
49	Canindeyu	109	339	33	65	1,231	1,026	1,373	1,430
50	Chaco	995	316	95	63	576	839	1,666	1,218
Total		14,098	14,098	2,222	2,222	25,287	27,909	41,607	44,229

4-3 Other Surveys

4-3-1 Travel Speed Survey

(1) Travel Speed Survey Route

Travel speed was examined by registering trip-distance and travel-time at major intersections along the 10 routes shown in Figure 4.3.1. One surveyor recorded the distance, by using the trip meter in his vehicle, and the time, by using his watch. This survey was carried out 6 times along each route.

(2) Travel Speed Survey Results

The travel speed survey results are shown in Annex A-7, and are summarized in Table 4.3.1. Travel time was checked in three categories; from 7:00 a.m. to 9:00 a.m. as the morning peak hours, from 5:00 p.m. to 7:00 p.m. as the evening peak hours, and from 9:00 a.m. to 5:00 p.m. as the off-peak hours.

The results of the travel speed surveys reveal two different average speeds; around 70 km/hr along national routes (survey routes 1 to 6), and 35 to 50 km/hr along the project routes. This shows the completely different running conditions of the two, even in dry weather. It is noteworthy that travel speed surveys could not carried out on several occasions because of the heavy mud following a rainstorm on sections between Ybytymí and Cnel.Martínez along survey routes 7 and 8, and between Tebicuary and Tebicuary-mí along routes 9 and 10.

Table 4.3.1 Average Velocity of Travel Speed Survey

Route No	Origin	Destination	Distance (km)	Ave. Velocity (km/h)
1	E. Ayala y Mme. Lynch	Acc. a Pte. France (Rotonda)	326.9	73.95
2	Acc Pte Franco (Rotonda)	Curva 90° Avda E.Ayala	321.0	72.86
3	Intersec. calle de Mcal. López	Rotonda	359.9	72.51
4	Rotonda (Route 6 and Pacú Cuá)	Curva 90° a Avda. E. Ayala	361.2	69.34
5	Rotonda (Route 6 and Pacú Cuá)	Intersection Route 7	252.2	71.18
6	Intersection Route 7	Rotonda (Route 1 and Pacú Cuá)	252.2	69.68
7	Inter. Route 1 (Paraguarí)	Inter. Route 2 (Rotonda Oviedo)	138.0	35.47
8	Inter. Route 2 (Rotonda Oviedo)	Inter. Route 1 (Paraguarí)	138.2	34.87
9	Intersection Route 1(Carapegua)	Intersection Route 2 (San José)	112.4	49.61
10	Intersection Route 2 (San José)	Intersection Route 1 (Carapegua)	112.4	50.22

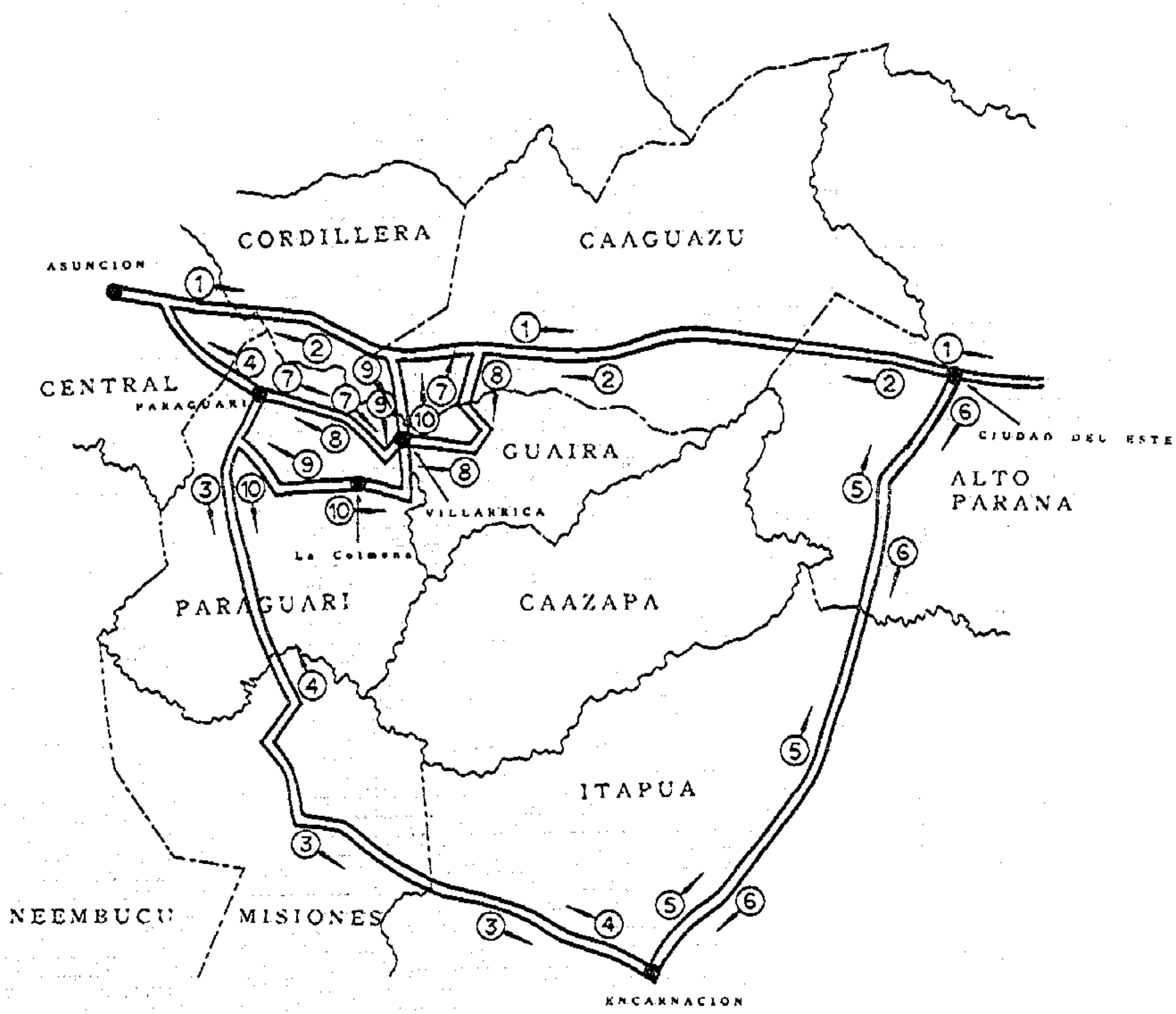


Figure 4.3.1 Travel Speed Survey Route

4-3-2 Interviews with Bus Companies

Bus companies were interviewed to get basic information about present passenger transport conditions. Seven major bus companies, which operate their services in the "Study Area", were interviewed. Major items of interview and number of answered companies are as follows;

- Company information : 7
- Bus route information in the "Planning Area" : 7
- Approximate trip time on Bus route in the "Planning Area" : 7
- Future route plan in the "Planning Area" : 6

Trip time between major locations by bus route are shown in Table 4.3.2.

Table 4.3.2 Trip Time between Major Location on Bus Route

From	To	Trip Time
Villarrica	Asunción	3:15 5:10
Villarrica	Ciudad del Este	4:00
Asunción	Ciudad del Este	4:30
Paraguarí	Asunción	1:40
Paraguarí	Ciudad del Este	5:00
Asunción	La Colmena	3:20
Asunción	Carapegua	1:50

4-3-3 Interview to Major Enterprises

Major enterprises were interviewed to get basic information about present cargo transport conditions in the area. The types of companies interviewed are shown in Table 4.3.3.

Table 4.3.3 Interviewed Major Enterprises

Category	No. of Companies Interviewed	Major Products
Transport	7	-
Processor	3	Sugar
Processor	1	Cotton
Processor	1	Wine
Processor	1	Silo (Wheat, Soybean, Maize)

Major items of interview and number of answered companies are as follows;

- Company information : 13
- Fleet indicators : 13
- Monthly major products volume of in/outflow : 13
- Annual major products volume by mode : 13

The annual volume of major products transported by interviewed transportation companies and processing companies are shown in Tables 4.3.4 and 4.3.5, respectively.

Table 4.3.4 Annual Volume of Major Products Transported by Interviewed Transportation Companies

Products	Annual Volume (ton)
Soybean	182,500
Wheat	5,000
Cotton	1,000
Lumber	3,980
Oil	300
Plastic	250
Tire	280
Chemical Products	400
Tube	200
Diesel Oil	2,400

Table 4.3.5 Annual Volume of Major Products Transported by Interviewed Processing Companies

Products	Annual Volume (ton)
Sugarcane	1,250,000
Sugar	126,120
Alcohol	10,800
Wine	40,240
Rum	20,000
Cotton	1,500
Cotton Fiber	610
Cotton Seed	890
Grape	300
Wheat	3,000
Maize	600
Soybean	6,400

CHAPTER 5

TRAFFIC DEMAND FORECAST

CHAPTER 5 TRAFFIC DEMAND FORECAST

This chapter describes the methodology, process, and results of a traffic demand forecast for the proposed road sections for the years 2005 and 2015.

5-1 Methodology

Since comprehensive information on transport in Paraguay, which covers all transportation mode movements both at present and in the future, can be obtained only from the results of the 1992 JICA ETNA Master Plan, a method that makes the Master Plan data as applicable as possible, is applied in the traffic demand forecast of this study. The overall flow of the traffic demand forecast work is illustrated in the following figure.

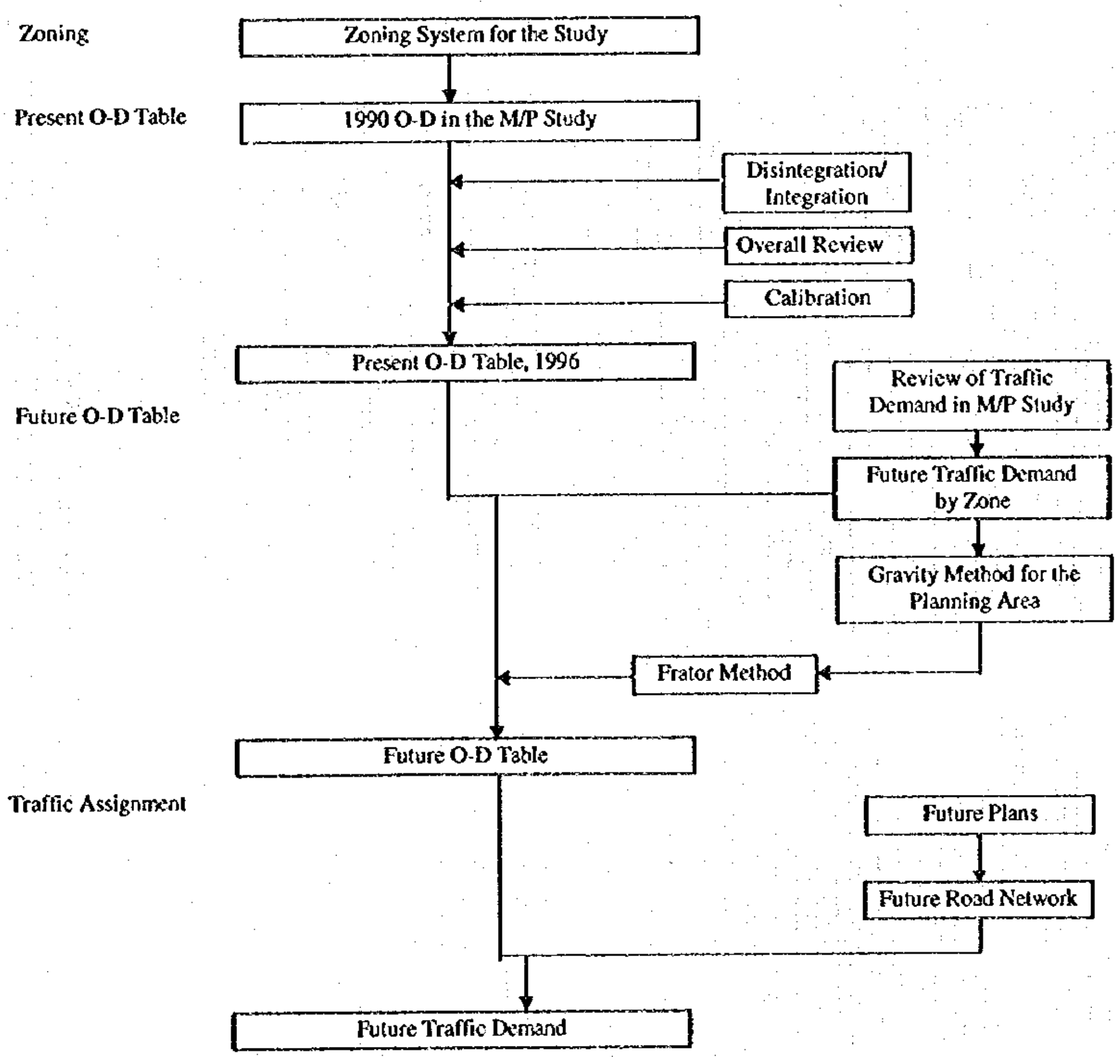


Figure 5.1.1 Overall Flowchart of Traffic Demand Forecast

5-1-1 Major Premises

The following premises were assumed.

i) Traffic demand is forecast in terms of vehicle volume in AADT (Average Annual Daily Traffic) by type of vehicle, that is, three (3) types: passenger car, bus, and truck.

ii) Detailed analyses are conducted mainly within the 'Planning Area', and the M/P results are adopted with a sufficient review for the other areas.

iii) Basic traffic movement in the M/P study, in the form of O-D tables, is also used with the necessary modifications, both at present and in the future.

iv) The expected road development up to 2005 is considered in the future road network for traffic assignment, and some possible plans/projects are also examined to provide additional cases for reference.

5-1-2 Zoning

As explained in Chapter 1, the proposed 'Planning Area' was selected for a detailed analysis and divided into 30 zones based on the smallest jurisdiction unit known as the 'Distrito'. The zoning for the surrounding area, the 'Overall Study Area' excluding the planning area, is based on 'Departamento', while the other regions are integrated into three (3) zones by direction. The total number of traffic zones considered in the study was 50 in total.

Destination \ Origin	2) Overall Study Area		3) Others	Total Generation
	1) Planning Area(1-30)	(31-47)	(48-50)	
1) 01 02 03 . . 30				---
2) 31 . . 47				--- - ---
3) 48 . 50				--- ---
Total Attraction				Total Trip Ends

Figure 5.1.2 O-D Table Structure

5-1-3 Present O-D Tables

To determine the present O-D tables in 1996, the following steps were required;

- Examination of O-D traffic in the planning area based on the results of O-D interview survey,
- Zone disintegration/integration in accordance with the proposed zoning system,
- Overall review/revision of O-D distributions, and
- Calibration based on the actual traffic count survey results.

(1) Zoning Arrangement

Since the O-D tables in the M/P study were basically prepared following a zoning system of Department-base, disintegration was necessary for the planning area, while integration was necessary for the other areas.

For disintegration, the available socioeconomic indicators on a departmental level were examined to clarify their correlation with traffic demand and to estimate the intra-zonal/intra-departmental traffic demands. And finally distribution factors were determined. These socioeconomic indicators are:

- Population and labor force in 1992,
- No. of vehicles registered in 1994,
- Land use,
- Agricultural production, 1981 and 1991, etc.

(2) Overall Review

An overall review of the present O-D tables was conducted to determine whether they reflect actual traffic movement, before calibration through traffic assignment was tested. This review consisted of:

- Comparison with the results of Road-side O-D Interviews.
- Verification based on the results of Bus Company Interviews.
- Seasonal traffic fluctuation by major agricultural products.
- Some significant traffic characteristics of the area, etc.

(3) Calibration through Traffic Assignment

The first traffic assignment of the present O-D tables was done for the present road network, and the results are compared with the results of traffic count surveys, which were conducted at 32 survey stations in the first beginning stage of the study. When the results were within a reasonable range, these O-D tables were confirmed as the 'Present O-D Tables in 1996'.

5.1.4 Future O-D Tables

Future O-D Tables for the years 2005 and 2015 were estimated by taking the following two steps.

(1) Future Traffic Generation/Attraction by Zone

The forecast of traffic demand (traffic generation & attraction) by zone was examined in accordance with correlation to the selected socioeconomic indices, such as future estimated population, probable car ownership, estimated agricultural production, etc. Most of these indices were forecast in advance for this purpose in the same zoning system that was applied in the present O-D tables.

(2) O-D Distribution

The distribution pattern of O-D traffic demand was forecast based on the premises outlined below.

1) Planning area

Since road traffic conditions will be drastically changed by the development of the proposed roads within the Planning Area, the 'Gravity model', in which the O-D distribution pattern was explained by trip generation/attraction of the zone and travel time between zones, was applied.

2) Other areas

- In 2005, the present O-D pattern would remain unchanged, because there would be no significant changes in the regional structure.
- In 2015, some specifically developed demands might be added to the present pattern in accordance with foreseeable regional development.

Therefore, both 'Gravity model' and 'Present pattern model' based on the present O-D data were applied to estimate future O-D distributions by vehicle type.

5-1-5 Future Road Network

Since the basic target year for traffic demand forecast is 2005, when the proposed roads will be completed and open to the public, the future road network for traffic assignment was assumed considering the 'present road network plus future plans'; such as on-going projects, committed projects up to 2005, and other future implementation plans.

5-1-6 Traffic Assignment

Based on future O-D tables and the future road network, traffic demand was forecast by road section as a result of traffic assignment simulation. The following cases were examined;

O-D \ Net	1996 Network	2005 Network	2015 Net (A)	2015 Net (B)
1996 O-D	O	-	-	-
2005 O-D	O	O	-	-
2015 O-D	O	-	O	for reference

Note : (A) - only proposed roads will be completed
(B) - other roads will also be completed

5-2 Zoning

5-2-1 Zone Code

The traffic demand analysis was examined by 30 zone-system based on the 'District' in the 'Planning Area', while the total number of traffic zones considered in the study was 50. The zoning code for the whole area is tabulated in Table 5.2.1.

Table 5.2.1 Zone Code Table

Zone Code	Zone Name	Department	District
1	Paraguarí	Paraguarí	Paraguarí
2	Escobar	Paraguarí	Escobar
3	Sapucai	Paraguarí	Sapucai
4	Acahay	Paraguarí	Acahay
5	Carapeguá	Paraguarí	Carapeguá
6	Yaguarón	Paraguarí	Yaguarón
7	Pirayú	Paraguarí	Pirayú
8	Caballero	Paraguarí	Caballero
9	Ybytymí	Paraguarí	Ybytymí
10	Tebicuary-mí	Paraguarí	Tebicuary-mí
11	La Colmena	Paraguarí	La Colmena
12	Ybycui	Paraguarí	Ybycui
13	Villarrica	Guairá	Villarrica
14	Yataity	Guairá	Yataity
15	Mbocayaty	Guairá	Mbocayaty
16	Ñumí	Guairá	Ñumí
17	San Salvador	Guairá	San Salvador
18	Iturbe	Guairá	Iturbe
19	Borja	Guairá	Borja
20	Itapé	Guairá	Itapé
21	Colonel Martínez	Guairá	Colonel Martínez
22	Félix Pérez Cardozo	Guairá	Félix Pérez Cardozo
23	Caácupe	Cordillera	Caácupe
24	Eusbio Ayala	Cordillera	Eusbio Ayala
25	Piribebúy	Cordillera	Piribebúy
26	Itacurubí	Cordillera	Itacurubí
27	Valenzuela	Cordillera	Valenzuela
28	Colonel Oviedo	Caaguazú	Colonel Oviedo
29	Nueva Londres	Caaguazú	Nueva Londres
30	San José de Los Arroyos	Caaguazú	San José de Los Arroyos
31	Asunción	Central	Asunción
32	Concepción	Concepción	-
33	San Pedro	San Pedro	-
34	Cordillera Oeste	Cordillera	-
35	Cordillera Este	Cordillera	-
36	Guairá	Guairá	-
37	Caaguazú Oeste	Caaguazú	-
38	Caaguazú Este	Caaguazú	-
39	Caazapá Oeste	Caazapá	-
40	Caazapá Este	Caazapá	-
41	Itapúa	Itapúa	-
42	Misiones	Misiones	-
43	Paraguarí Sur	Paraguarí	-
44	Alto Paraná	Alto Paraná	-
45	Central Norte	Central	-
46	Central Sur	Central	-
47	Neembucú	Neembucú	-
48	Amambay	Amambay	-
49	Canindeyú	Canindeyú	-
50	Chaco	Pre. Hayes, Boquerón, Alto Paraguay	-

5-2-2 Zoning Map

A schematic zoning map for the 'Planning Area' is illustrated in Figure 5.2.1.

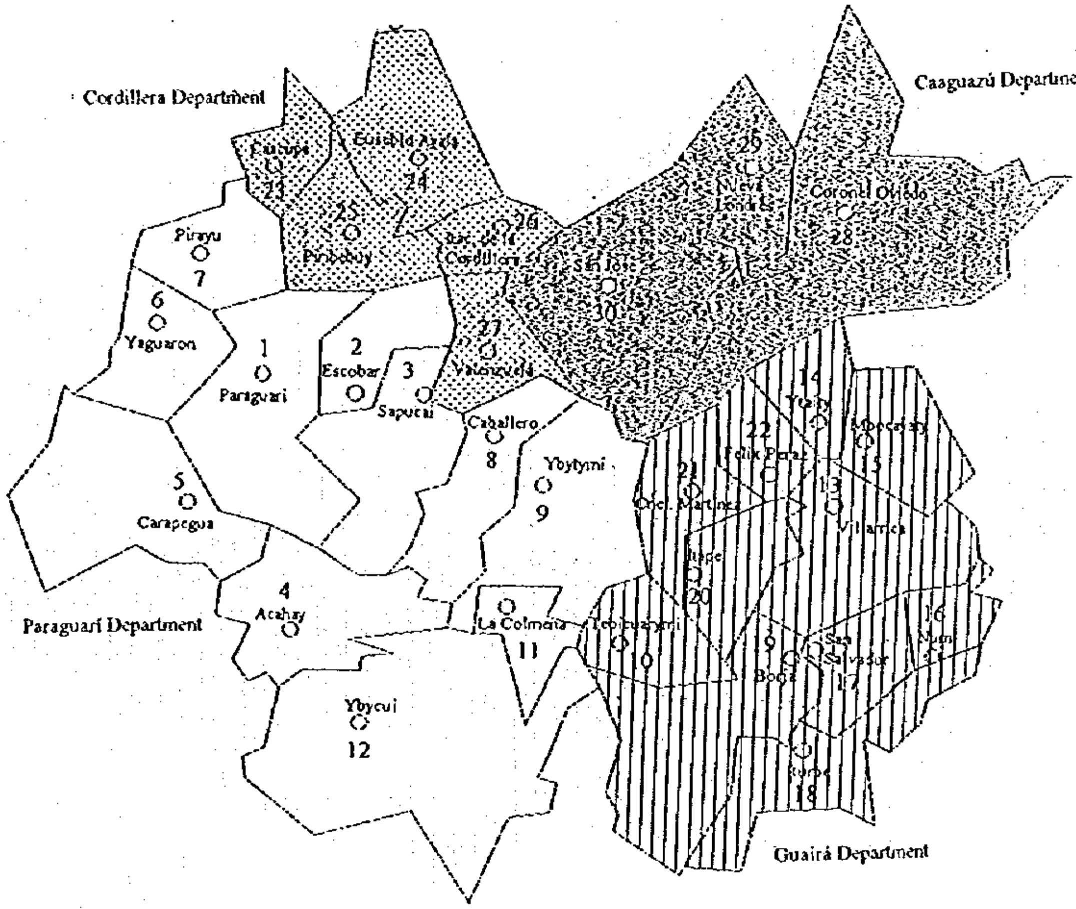


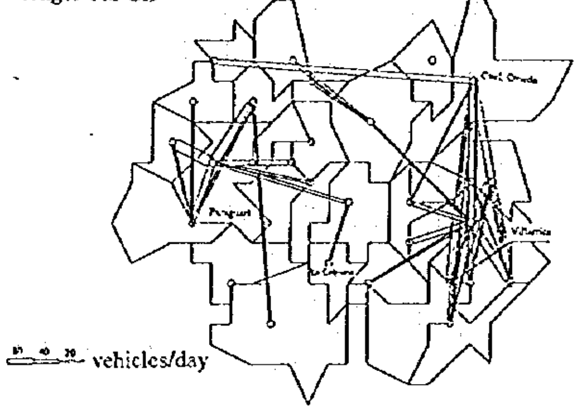
Figure 5.2.1 Zoning Map for the 'Planning Area'

5-3 Present O-D Tables and Desired Lines

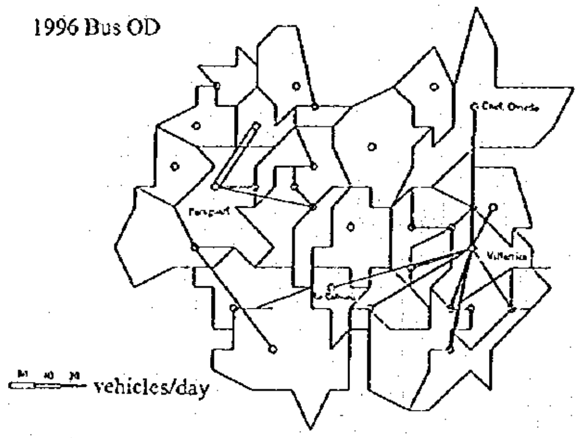
Present vehicle O-D movements are summarized in the form of O-D tables by type of vehicle. As these O-D tables are attached in Annex A, a visual flow is illustrated as 'Desired Lines' by vehicle type; O-D movements within the Planning Area in Figure 5.3.1 and in Figure 5.3.2, Desired Lines showing the principal flow between the Planning Area and other areas of Paraguay.

The total volume of vehicle movement within the Planning Area is relatively smaller than other areas, since there is no sufficient road network to promote regional activity in 1996. Moreover, only limited movements to and from regional centers such as Paraguarí, Villarrica, Cnel. Oviedo, and Caacupé are identified.

1996 Passenger Car OD



1996 Bus OD



1996 Truck OD

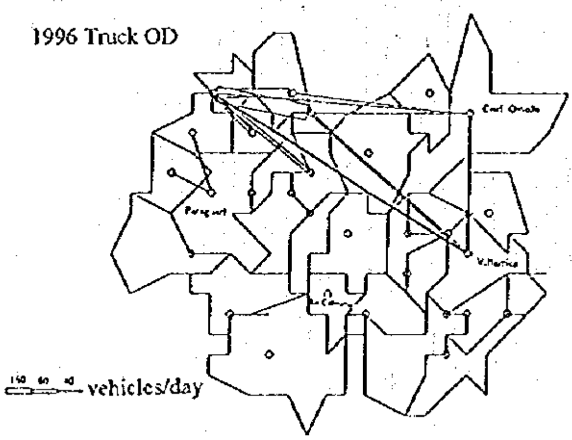


Figure 5.3.1 Vehicle Movement, within Planning Area (1996)

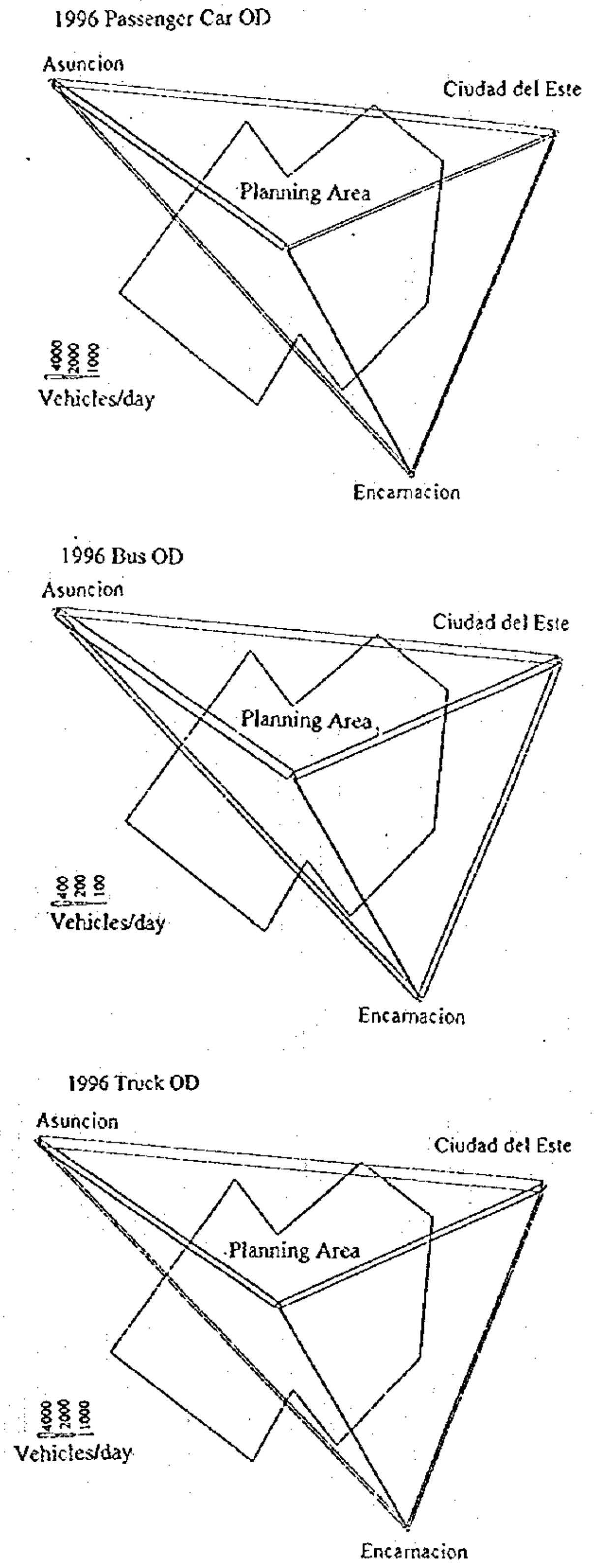


Figure 5.3.2 Vehicle Movement, Outside of Planning Area (1996)

5-4 Trip Generation/Attraction Analysis

5-4-1 Trip Generation/Attraction Model

Based on the present O-D tables, the correlation between traffic generation/attraction demand and some socioeconomic indices by zone was examined, and a significant correlation was found between these factors, as shown in Table 5.4.1.

Table 5.4.1 Correlated Parameters for the Generation/Attraction Model

	P. Car Generation	P. Car Attraction	Bus Generation	Bus Attraction	Truck Generation	Truck Attraction
Population	O	O	O	O	O	O
Car Registration	O	O	-	-	-	-
Bus Registration	-	-	O	O	-	-
Soybean	-	-	-	-	O	O
Cotton	-	-	-	-	O	O
Sugarcane	-	-	-	-	O	O
Cassava	-	-	-	-	O	O
Maize	-	-	-	-	O	O
Wheat	-	-	-	-	O	O

The major socioeconomic indicators used as explanatory factors in the G/A forecast model were independently assessed in chapter 3-3. The major socioeconomic indicators for the 'Planning Area' by zone are summarized in a time series in Figure 5.4.1.

Table 5.4.2 shows the parameters applied for the generation/attraction model. As the multiple correlation coefficients between generation/attraction and the socioeconomic factors show relatively high, each model was judged accurate enough for forecasts. The correlation between real values and estimated values obtained by the applied model is shown in Figure 5.4.2. Though livestock industry is one of the important ones in the study area, a meaningful correlation was not found between livestock production in the model.

Table 5.4.2 Parameters of the Generation/Attraction Model

Parameter	P. Car Generation	P. Car Attraction	Bus Generation	Bus Attraction	Truck Generation	Truck Attraction
Population	0.00228	0.00275	0.00018	0.00069	0.00387	0.00453
Car Registration	0.00427	0.00730	-	-	-	-
Bus Registration	-	-	0.28112	0.07361	-	-
Soybean	-	-	-	-	0.00229	0.00217
Cotton	-	-	-	-	0.01600	0.00830
Sugarcane	-	-	-	-	0.00014	0.00015
Cassava	-	-	-	-	0.00054	0.00009
Maize	-	-	-	-	0.00943	0.01194
Wheat	-	-	-	-	0.00427	0.00143
Constant	103.799	67.861	20.631	10.126	80.401	60.715
Multiple Correlation Coefficient	0.841	0.955	0.767	0.874	0.876	0.921

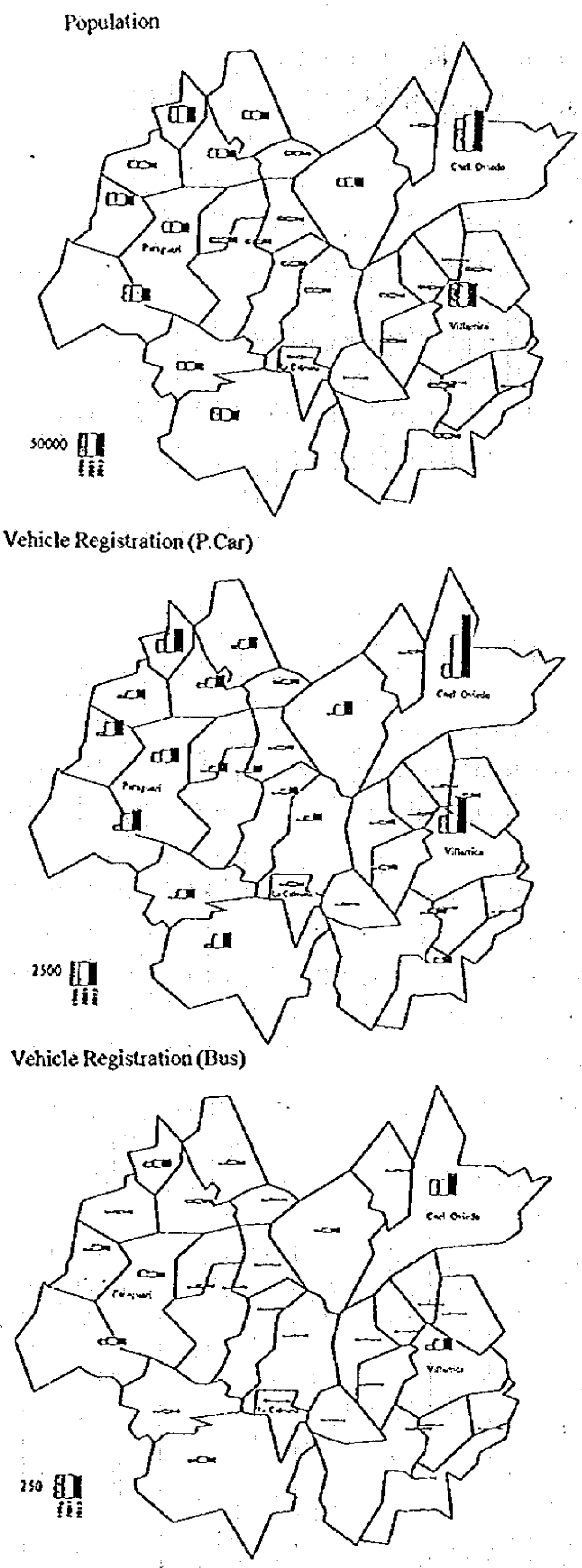


Figure 5.4.1 Socioeconomic Indicators by Zone (1)

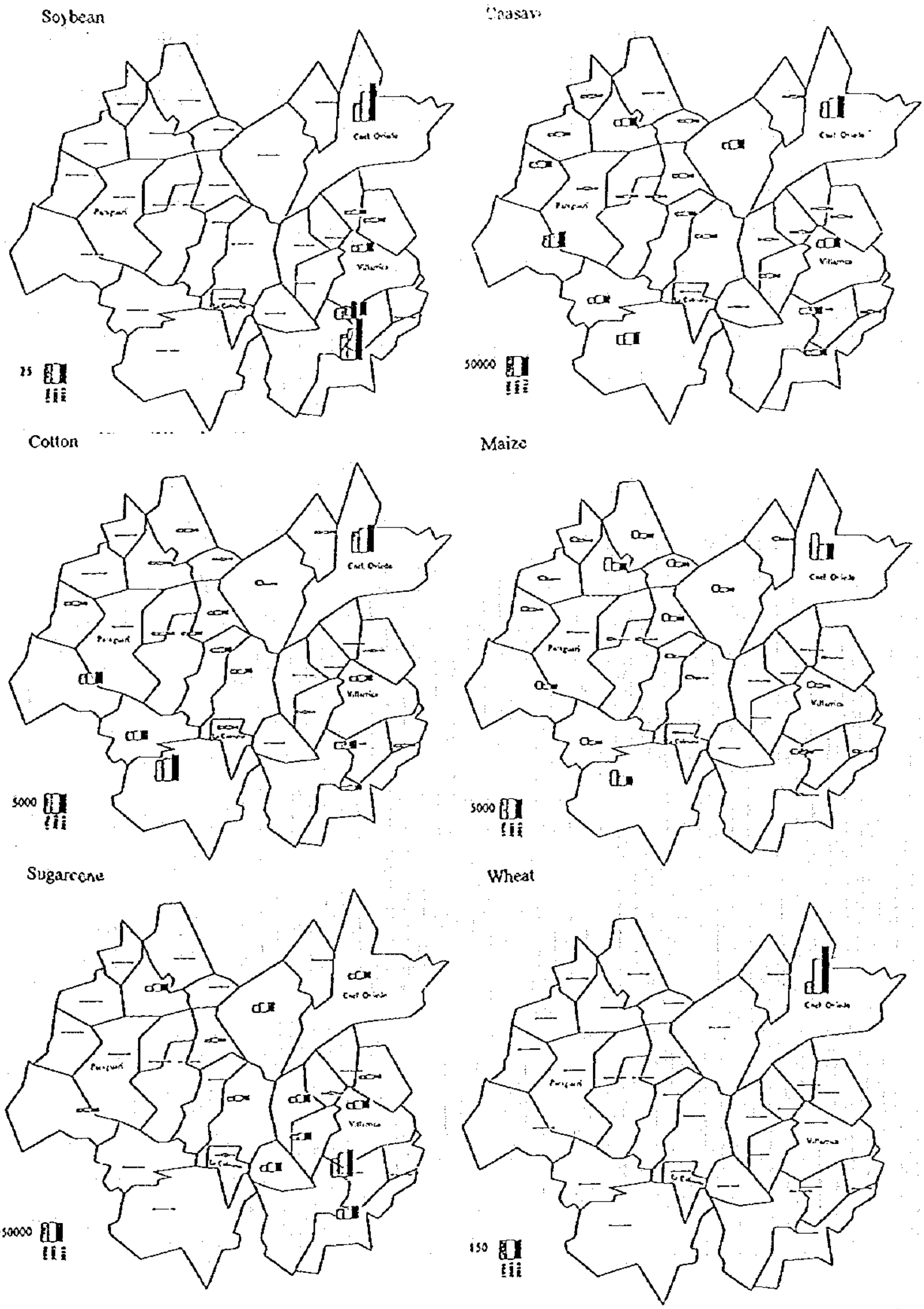


Figure 5.4.1 Socioeconomic Indicators by Zone (2)

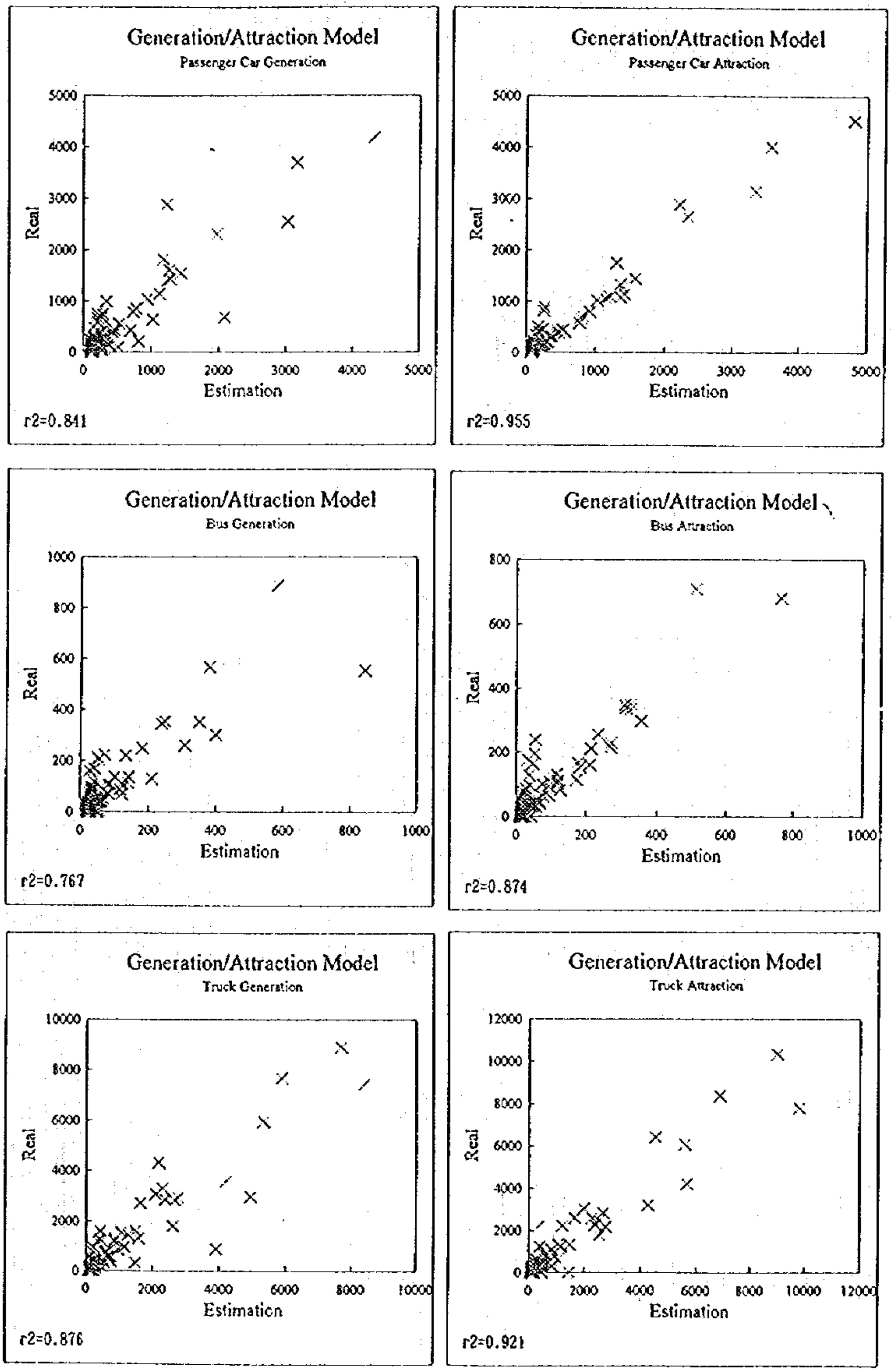


Figure 5.4.2 Accuracy of Generation/Attraction Model

5-4-2 Future Trip Generation/Attraction

Future trip generation/attraction by zone were estimated, applying the proposed model, as summarized both in Table 5.4.3 and Figure 5.4.3.

The major features are:

- Total trip volume in the study was 86 thousand in 1996, 112 thousand in 2005, and 130 thousand in 2015.
- Of these, G/A within the Planning area is 16 thousand, 18 thousand, 19 thousand, respectively, which means that its share is only 15 to 19 % of the total volume.
- Increase ratio of G/A volume within the Planning area is slightly low, compared to the whole area; 2005/1996 = 1.13 and 2015/1996 = 1.20 in the Planning area, while it is 1.31 and 1.51 in the whole area, respectively.
- By type of vehicle, in contrast with a high increase in bus trips, truck trip demand will remain almost stable in the future in the Planning area.
- By zone, there are very wide fluctuations as shown in Figure 5.4.3.

Table 5.4.3 Future Trip Generation and Attraction

Zone	Car Generation/Attraction					Bus Generation/Attraction					Truck Generation/Attraction					Total Generation/Attraction				
	1996	2005	(1)	2015	(2)	1996	2005	(1)	2015	(2)	1996	2005	(1)	2015	(2)	1996	2005	(1)	2015	(2)
1	702	455	0.65	479	0.68	116	101	0.86	136	1.15	207	386	1.86	468	2.26	1,027	942	0.92	1,083	1.05
2	89	240	2.70	244	2.74	14	71	5.07	100	7.14	71	181	2.55	242	3.41	174	492	2.83	586	3.37
3	98	232	2.37	230	2.35	12	49	4.08	83	6.92	44	111	2.52	155	3.52	154	392	2.55	468	3.04
4	148	287	1.94	279	1.89	33	82	2.48	127	3.85	18	5	0.28	9	0.50	199	374	1.88	415	2.09
5	412	532	1.29	565	1.37	89	189	2.12	233	2.62	101	105	1.04	39	0.39	602	826	1.37	837	1.39
6	266	371	1.39	380	1.43	0	0	0.00	0	0.00	138	233	1.69	343	2.49	404	604	1.50	723	1.79
7	60	203	3.38	209	3.48	0	0	0.00	0	0.00	52	113	2.17	240	4.62	112	316	2.82	449	4.01
8	63	216	3.43	228	3.62	22	63	2.86	104	4.73	21	63	3.00	33	1.57	106	342	3.23	365	3.44
9	59	218	3.69	227	3.85	16	59	3.69	110	6.88	32	98	3.06	102	3.19	107	375	3.50	439	4.10
10	60	135	2.25	124	2.07	8	6	0.75	69	8.63	15	17	1.13	7	0.47	83	158	1.90	200	2.41
11	149	170	1.14	162	1.09	24	19	0.79	57	2.38	12	8	0.67	11	0.92	185	197	1.06	230	1.24
12	199	408	2.05	411	2.07	76	165	2.17	215	2.83	26	7	0.27	9	0.35	301	580	1.93	635	2.11
13	1,164	855	0.73	965	0.83	253	281	1.11	311	1.23	672	1,019	1.52	1,188	1.77	2,089	2,155	1.03	2,464	1.18
14	124	158	1.27	138	1.11	9	4	0.44	61	6.78	14	12	0.86	124	8.86	147	174	1.18	323	2.20
15	251	209	0.83	237	0.94	8	32	4.00	80	10.00	64	103	1.61	194	3.03	323	344	1.07	511	1.58
16	185	150	0.81	136	0.74	3	0	0.00	37	12.33	56	19	0.34	43	0.77	244	169	0.69	216	0.89
17	109	107	0.98	99	0.91	0	0	0.00	22	0.00	35	51	1.46	87	2.49	144	158	1.10	208	1.44
18	201	186	0.93	171	0.85	17	45	2.65	85	5.00	171	337	1.97	427	2.50	389	568	1.46	683	1.76
19	136	158	1.16	157	1.15	15	53	3.53	85	5.67	47	108	2.30	10	0.21	198	319	1.61	252	1.27
20	106	165	1.56	152	1.43	15	36	2.40	80	5.33	15	9	0.60	26	1.73	136	210	1.54	258	1.90
21	75	178	2.37	183	2.44	0	0	0.00	0	0.00	47	129	2.74	181	3.85	122	307	2.52	364	2.98
22	126	180	1.43	185	1.47	0	0	0.00	0	0.00	21	36	1.71	105	5.00	147	216	1.47	290	1.97
23	428	598	1.40	568	1.33	72	182	2.53	224	3.11	1,436	805	0.56	1,007	0.70	1,936	1,585	0.82	1,799	0.93
24	136	303	2.23	289	2.13	0	0	0.00	0	0.00	168	279	1.66	531	3.16	304	582	1.91	820	2.70
25	286	367	1.28	357	1.25	49	90	1.84	119	2.43	85	138	1.62	564	6.64	420	595	1.42	1,040	2.48
26	349	277	0.79	245	0.70	0	0	0.00	0	0.00	539	29	0.05	318	0.59	888	306	0.34	563	0.63
27	46	143	3.11	131	2.85	0	0	0.00	0	0.00	68	0	0.00	140	2.06	114	143	1.25	271	2.38
28	968	1,273	1.32	1,400	1.45	198	401	2.03	481	2.43	3,320	2,506	0.75	193	0.06	4,486	4,180	0.93	2,074	0.46
29	0	0	0.00	0	0.00	0	0	0.00	0	0.00	10	0	0.00	51	5.10	10	0	0.00	51	5.10
30	350	436	1.25	390	1.11	0	0	0.00	0	0.00	298	189	0.63	431	1.45	648	625	0.96	821	1.27
31	3,962	2,505	0.63	2,787	0.70	1,100	630	0.57	612	0.56	6,791	6,094	0.90	4,993	0.74	11,853	9,229	0.78	8,392	0.71
32	494	975	1.97	1,015	2.05	136	244	1.79	236	1.74	2,388	2,870	1.20	1,707	0.71	3,018	4,089	1.35	2,958	0.98
33	994	2,036	2.05	2,219	2.23	255	504	1.98	487	1.91	3,808	6,111	1.60	3,535	0.93	5,057	8,651	1.71	6,241	1.23
34	196	323	1.65	308	1.57	0	0	0.00	0	0.00	342	382	1.12	411	1.20	538	705	1.31	719	1.34
35	193	313	1.62	311	1.61	26	29	1.12	29	1.12	428	647	1.51	375	0.88	647	989	1.53	715	1.11
36	545	314	0.58	322	0.59	51	65	1.27	63	1.24	592	611	1.03	345	0.58	1,188	990	0.83	730	0.61
37	203	423	2.08	411	2.02	42	90	2.14	88	2.10	1,052	959	0.91	667	0.63	1,297	1,472	1.13	1,166	0.90
38	1,002	1,431	1.43	1,546	1.54	136	277	2.04	248	1.82	1,237	321	0.26	5,265	4.26	2,375	2,029	0.85	7,059	2.97
39	507	352	0.69	352	0.69	74	74	1.00	74	1.00	772	981	1.27	598	0.77	1,353	1,407	1.04	1,024	0.76
40	274	334	1.22	340	1.24	53	95	1.79	93	1.75	523	672	1.28	841	1.61	850	1,101	1.30	1,274	1.50
41	1,701	2,711	1.59	2,950	1.73	297	685	2.31	599	2.02	5,508	6,761	1.23	12,031	2.18	7,506	10,157	1.35	15,580	2.08
42	561	508	0.91	504	0.90	82	105	1.28	108	1.32	905	1,380	1.52	1,032	1.14	1,548	1,993	1.29	1,644	1.06
43	371	301	0.81	285	0.77	104	78	0.75	79	0.76	561	768	1.37	500	0.89	1,036	1,147	1.11	864	0.83
44	3,564	5,138	1.44	5,637	1.58	552	1,205	2.18	1,153	2.09	5,095	7,192	1.41	19,184	3.77	9,211	13,535	1.47	25,974	2.82
45	3,327	7,480	2.25	8,484	2.55	0	0	0.00	0	0.00	7,271	15,947	2.19	15,103	2.08	10,598	23,427	2.21	23,587	2.23
46	476	632	1.33	671	1.41	67	153	2.28	167	2.49	2,132	1,618	0.76	1,143	0.54	2,675	2,403	0.90	1,981	0.74
47	248	442	1.78	434	1.75	48	95	1.98	92	1.92	686	1,163	1.70	781	1.14	982	1,700	1.73	1,307	1.33
48	474	786	1.66	808	1.70	114	197	1.73	192	1.68	1,630	1,110	0.68	1,787	1.10	2,218	2,093	0.94	2,787	1.26
49	448	864	1.93	904	2.02	98	200	2.04	210	2.14	2,257	2,681	1.19	2,625	1.16	2,803	3,745	1.34	3,739	1.33
50	1,311	778	0.59	805	0.61	158	168	1.06	153	0.97	1,415	2,232	1.58	1,575	1.11	2,884	3,178	1.10	2,533	0.88
Total	28,196	37,856	1.34	40,434	1.43	4,444	6,822	1.54	7,502	1.69	53,196	67,596	1.27	81,776	1.54	85,836	112,274	1.31	129,712	1.51
(3)	7,345	9,210	1.25	9,341	1.27	1,051	1,928	1.83	2,819	2.68	7,803	7,096	0.91	7,278	0.93	16,199	18,234	1.13	19,438	1.20
(4)	20,851	28,646	1.37	31,093	1.49	3,393	4,894	1.44	4,683	1.38	45,393	60,500	1.33	74,498	1.64	69,637	94,040	1.35	110,274	1.58

Note : (1) Growth rate of 2005/1996
(2) Growth rate of 2015/1996
(3) Sub total of Zones 1 to 30
(4) Sub total of Zones 31 to 50

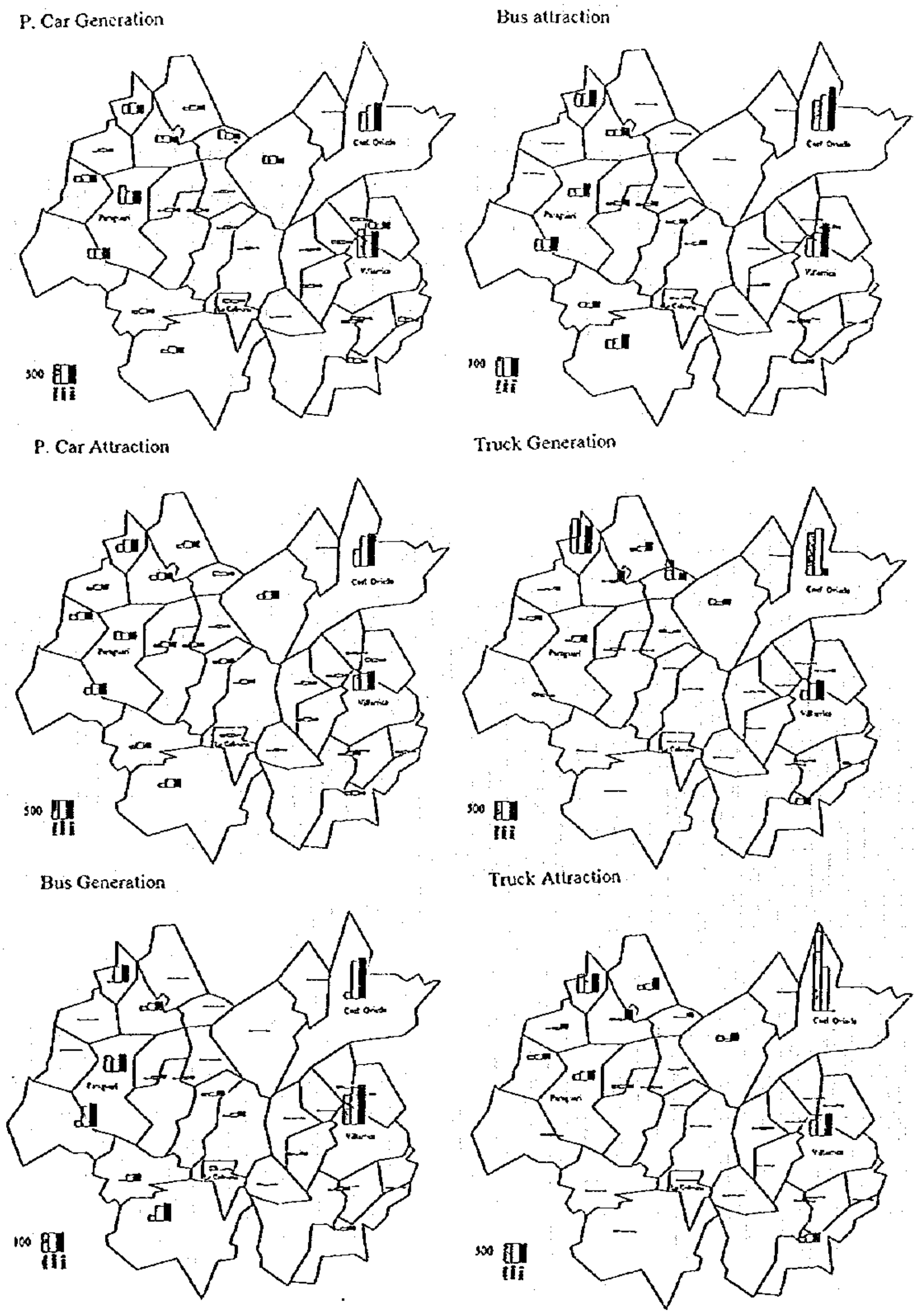


Figure 5.4.3 Future Trip Generation/Attraction by Zone

5-4-3 Future O-D Table

The future O-D tables were prepared by applying the 'Gravity model' to the Planning Area and applying the 'Present pattern method' to the other area, based on the future trip generation/attraction in Table 5.4.3 and the present O-D pattern.

O-D tables by type of vehicle both in 2005 and in 2015 are attached in Annex A. Since it is not easy to understand the origin - destination flow by only looking at the O-D tables, these O-D trip movements are summarized in the same manner as in the present O-D. Figure 5.4.4 shows the results of future vehicle movements within the Planning Area, while Figure 5.4.5 shows future vehicle movements between the Planning Area and outside areas.

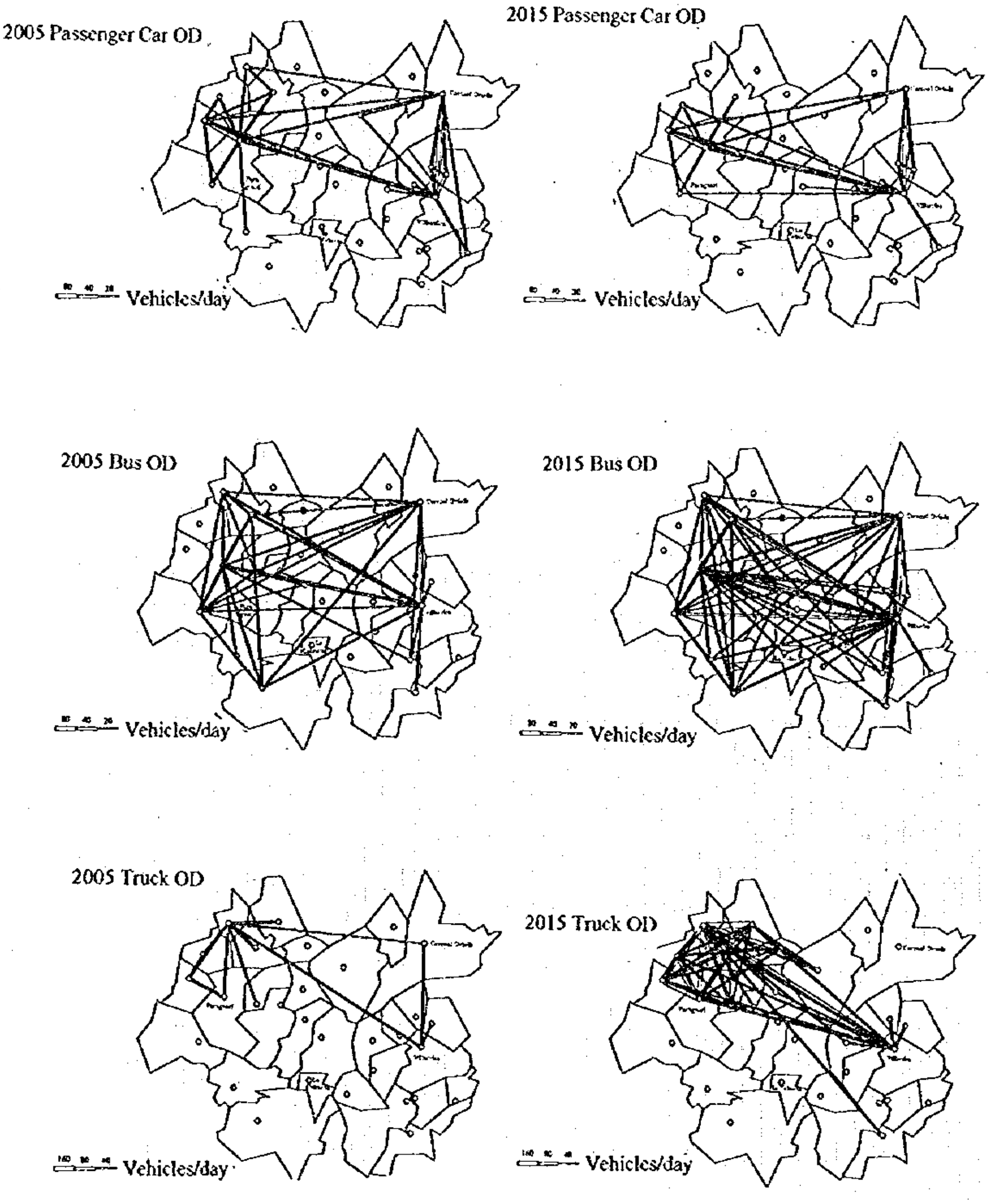


Figure 5.4.4 Future Vehicle Movement within the 'Planning Area'

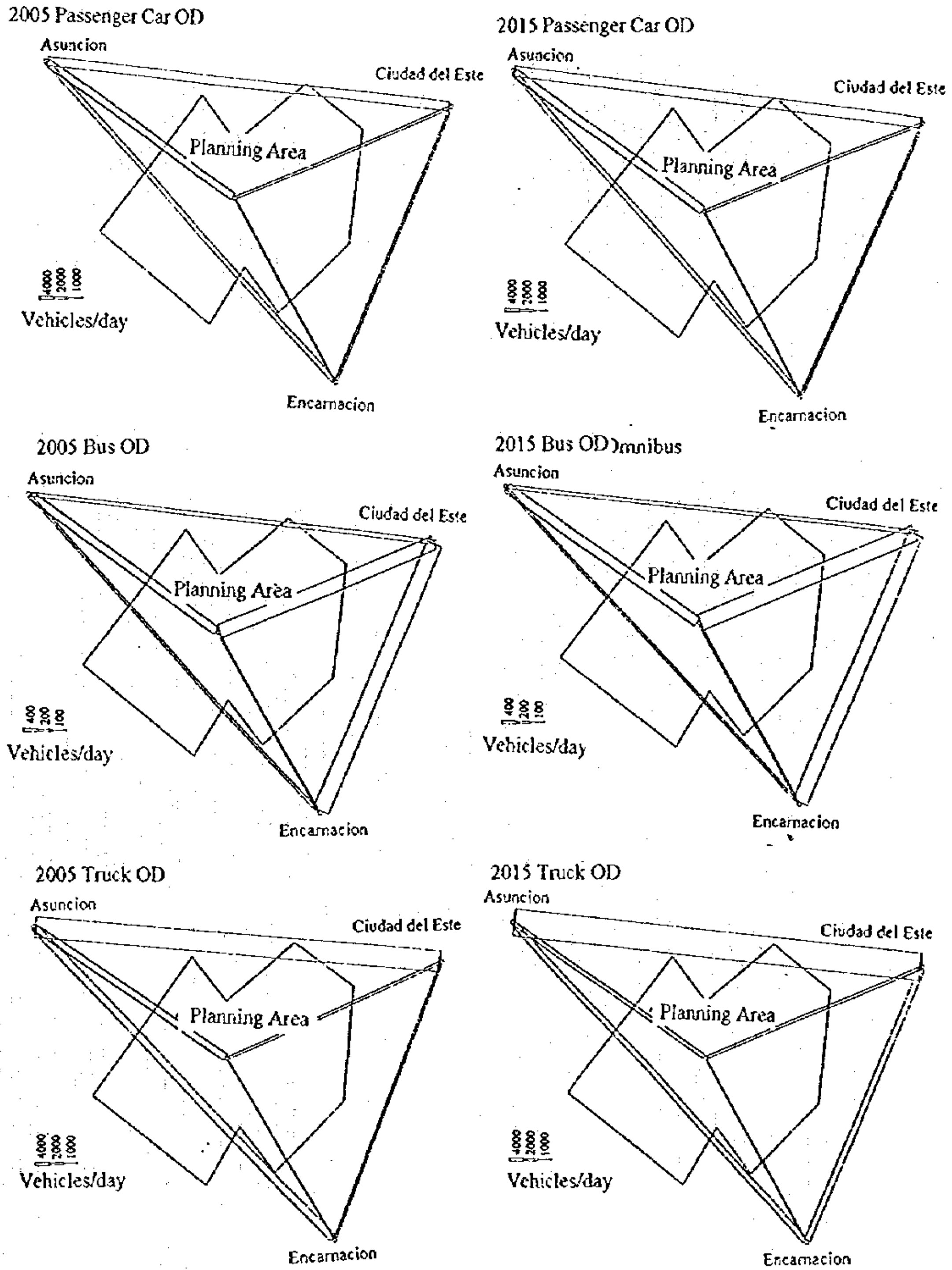


Figure 5.4.5 Future Vehicle Movements Outside of the 'Planning Area'

5-5 Future Traffic Demand along the Proposed Road

Future traffic volume along the proposed roads in 2005 and 2015 are estimated by the traffic assignment based on future O-D tables and future road networks. The future road network in 2005 is formulated based on the present road network adding the proposed road sections between Paraguarí and Villarrica, and an access route to/from La Colmena. Another future road network in 2015 is based on the ETNA Master Plan road network, which includes the proposed routes.

5.5.1 Traffic Volume by Section

The traffic assignment results are tabulated in Table 5.5.1 and Figures 5.5.1 & 5.5.2, which show traffic volume by section and type of vehicle. A certain high traffic demand along the proposed road sections is forecast both in 2005 and 2015, compared to the relatively low demand in 1996. In 2005, 1,400 to 2,400 vehicles/day are estimated between the Paraguarí and Villarrica section, while 250 vehicles/day are estimated between the Tebicuary and La Colmena section. The increased volume from 1996 is 1,100 to 1,900 vehicles/day between the Paraguarí - Villarrica section and 200 vehicles/day between the Tebicuary - La Colmena section. The composition by vehicle type, passenger car: bus: truck, is 45:15:40 in the Paraguarí - Villarrica section and 60:30:10 in the Tebicuary - La Colmena section.

Table 5.5.1 Assigned Traffic Volume by Section

(1) Traffic Volume by Vehicle Type (Unit : vehicle/day)

Route/Section	Length (km)	Passenger Car			Bus			Truck			Total		
		1996	2005	2015	1996	2005	2015	1996	2005	2015	1996	2005	2015
I. Paraguarí-Villarirca													
1) Paraguarí-Escobar	14.0	248	1,206	1,692	39	216	416	125	950	1,454	412	2,372	3,562
2) Escobar-Sapucai	9.0	159	1,104	1,638	25	209	436	64	843	1,362	248	2,156	3,436
3) Sapucai-Caballero	10.0	61	948	1,518	13	174	411	20	782	1,301	94	1,904	3,230
4) Caballero-Ybytymí	9.0	2	785	1,355	0	153	395	2	747	1,260	4	1,685	3,010
5) Ybytymí-Tebicuary	16.0	6	699	1,284	0	110	369	3	673	1,196	9	1,482	2,849
6) Tebicuary-Cnl.Martínez	4.0	43	830	1,231	7	193	462	30	693	1,033	80	1,716	2,726
7) Cnl.Martínez-Félix P.Cardozo	10.0	105	655	1,182	7	120	414	32	592	1,018	144	1,367	2,614
8) Félix P.Cardozo-Villarrica	11.0	231	661	1,169	7	120	414	53	608	1,029	291	1,389	2,612
II. Tebicuary - La Colmena													
9) Tebicuary-Tebicuary-mí	20.0	41	159	49	7	83	323	12	20	209	60	262	941
10) Tebicuary-mí-La Colmena	18.1	19	142	167	1	81	242	3	21	118	23	244	527

(2) Composition by Vehicle Type (Unit : %)

Route/Section	Passenger Car		Bus		Truck		Total	
	2005	2015	2005	2015	2005	2015	2005	2015
I. Paraguarí-Villarirca								
1) Paraguarí-Escobar	50.8	47.5	9.1	11.7	40.1	40.8	100	100
2) Escobar-Sapucai	51.2	47.7	9.7	12.7	39.1	39.6	100	100
3) Sapucai-Caballero	49.8	47.0	9.1	12.7	41.1	40.3	100	100
4) Caballero-Ybytymí	46.6	45.0	9.1	13.1	44.3	41.9	100	100
5) Ybytymí-Tebicuary	47.2	45.1	7.4	13.0	45.4	42.0	100	100
6) Tebicuary-Cnl.Martínez	48.4	45.2	11.2	16.9	40.4	37.9	100	100
7) Cnl.Martínez-Félix P.Cardozo	47.9	45.2	8.8	15.8	43.3	38.9	100	100
8) Félix P.Cardozo-Villarrica	47.6	44.8	8.6	15.8	43.8	39.4	100	100
II. Tebicuary - La Colmena								
9) Tebicuary-Tebicuary-mí	60.7	43.5	31.7	34.3	7.6	22.2	100	100
10) Tebicuary-mí-La Colmena	58.2	31.7	33.2	45.9	8.6	22.4	100	100

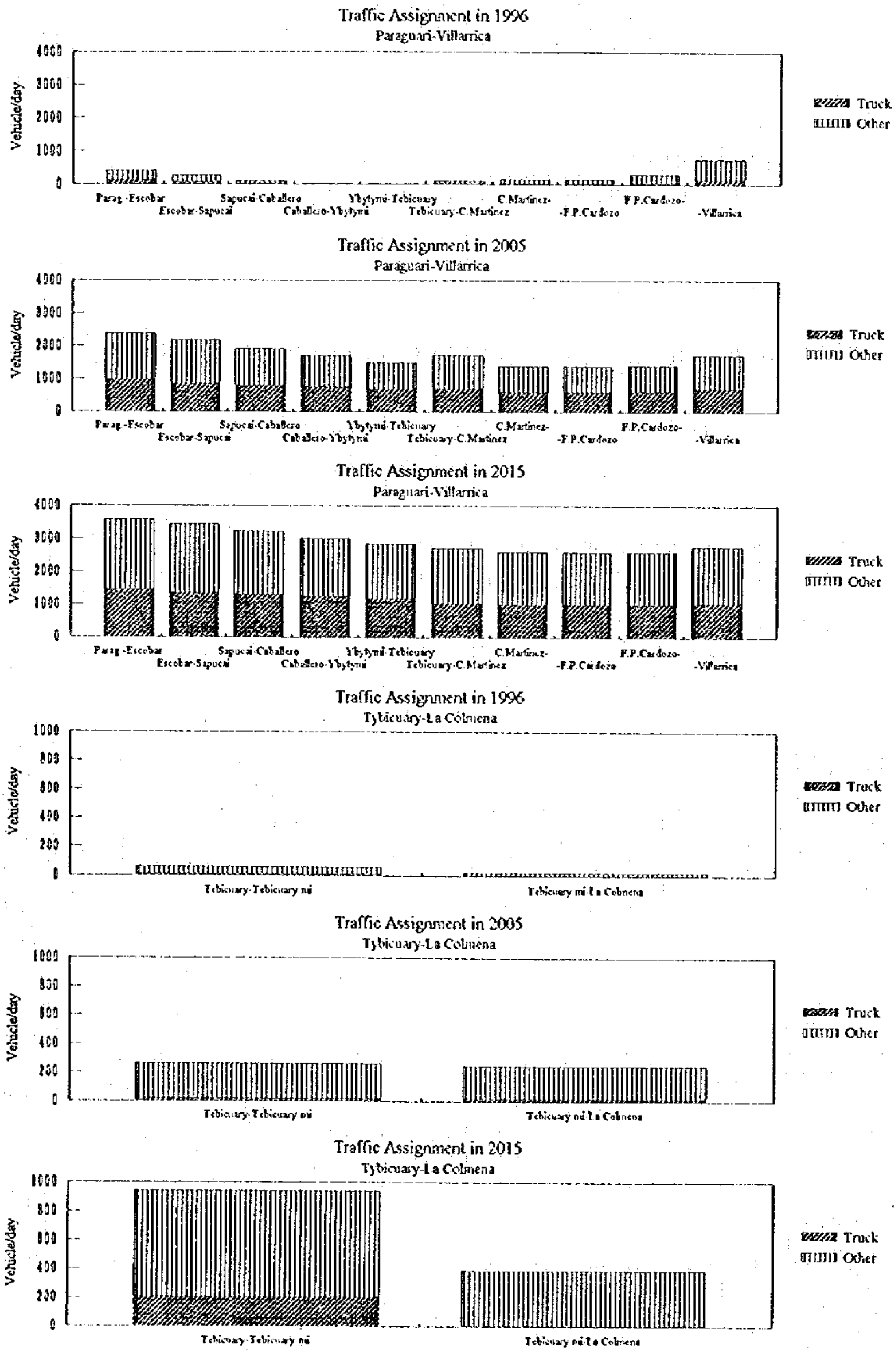


Figure 5.5.1 Summary of Traffic Assignment Results

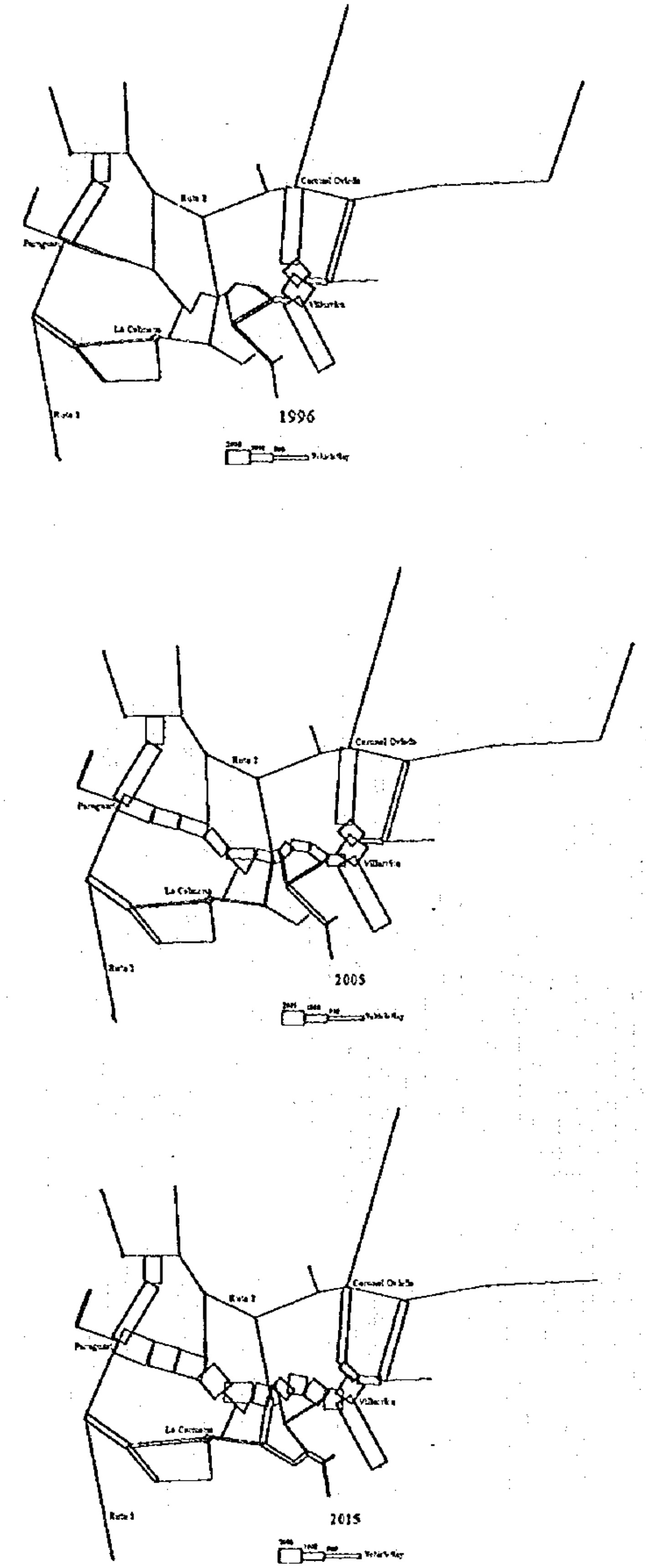


Figure 5.5.2 Forecast Traffic Volume by Section (All Vehicles)

5.5.2 Further Analysis of Assigned Traffic

A further analysis on the results of traffic assignment simulation reveal other characteristics of the assigned traffic along the proposed road.

(1) Traffic Flow at Major Points

The results of the analysis on traffic flow by direction at major intersections are summarized in Figure 5.5.3. This figure shows the outline of traffic flow at Paraguarí, Tebycuary and Villarrica in each case of traffic assignment. It is clearly indicated, showing a drastic change from the present (without project) traffic flow, that a certain volume of traffic will come into the proposed road at both points, Paraguarí and Villarrica; for instance, in 2005, proposed road to/from Asunción (1,700 vehicles/day), Carapeguá (250), and Piribebuy (250) at Paraguarí, and to/from Ñumí (500) at Villarrica. Though there is only little traffic at the Tebycuary intersection in 1996, 1,500 vehicles/day of traffic to/from Ybytymí and Cnel. Martínez, and 250 to/from Cnel. Martínez and Tebycuary-mí are also estimated for 2005.

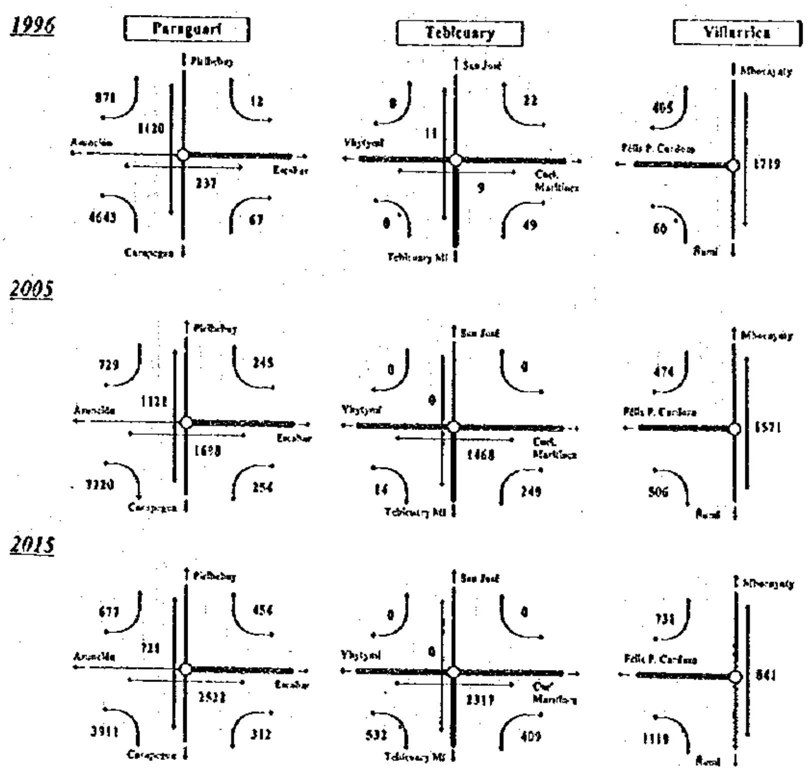


Figure 5.5.3 Traffic Flow by Direction at Major Points

(2) Through Traffic of Section

The assigned traffic is also analyzed by O-D pairs, based on the assumption that the traffic with its origin and/or destination outside of Paraguarí/Guairá department is categorized as 'through traffic' of the road-side area, while others are categorized as 'within traffic'. The results show that 70 to 80% of traffic demand between Paraguarí and Villarrica is 'through traffic', which means that the proposed road will serve as a regional trunk road. Meanwhile, the traffic between La Colmena and Tebicuary consists of 60% of 'within traffic' and 40% of 'through traffic'.

Table 5.5.2 Composition of 'through' and 'within' Traffic

Route/Section	2005				2015			
	within	through	Total	% of through	within	through	Total	% of through
I. Paraguarí - Villarrica								
1) Paraguarí-Escobar	515	1,857	2,372	78.3	681	2,881	3,562	80.9
2) Escobar-Sapucai	542	1,614	2,156	74.9	736	2,700	3,436	78.6
3) Sapucai-Caballero	527	1,377	1,904	72.3	736	2,494	3,230	77.2
4) Caballero-Ybytymí	517	1,168	1,685	69.3	748	2,262	3,010	75.1
5) Ybytymí-Tebicuary	487	995	1,482	67.1	774	2,075	2,849	72.8
6) Tebicuary-Cnl.Martínez	624	1,092	1,716	63.6	742	1,984	2,726	72.8
7) Cnl.Martínez-Félix P.Cardozo	388	979	1,367	71.6	639	1,975	2,614	75.6
8) Félix P.Cardozo-Villarrica	375	1,014	1,389	73.0	622	1,990	2,612	76.2
II. Tebicuary - La Colmena								
9) Tebicuary-Tebicuary-mí	161	101	262	38.5	400	541	941	57.5
10) Tebicuary-mí - La Colmena	141	103	244	42.2	364	163	527	30.9

CHAPTER 6

BASIC ENGINEERING STUDY

CHAPTER 6 BASIC ENGINEERING STUDY

6-1 Natural Conditions

6-1-1 Topography

The Republic of Paraguay is a land-locked country in the center of South America bordering on Brazil, Argentina and Bolivia. The area of the country is about 407 thousand km^2, which makes it a little bigger than Japan. From the topographical view, the country is divided into two zones, i.e., a flat Western region and a hilly Eastern region. The Eastern region of Paraguay is topographically divided into three zones; Mountainous Zone, Hilly Zone and Plain Zone.

(1) Mountainous Zone

From the north to the south of the region, the mountain ranges include two watersheds, which form the two major rivers of Paraguay; the Paraná River and the Paraguay River. The names of the major ranges are, from north to south, "Cordillera de Amamby", "Cordillera de Mbaraca Yu", "Cordillera de Ybytyruzu", and "Cordillera de San Rafael". These ranges have peaks of 500 m to 850 m above sea level, and the highest point is the San Rafael in the "Cordillera de Ybytyruzu".

(2) Hilly Zone

Apart from the above main mountain ranges, the lower mountain range called "Cordillera de Altos" is located in the center of southeastern part of the region. The mountain heights are around 400 m to 500 m, getting higher in the south. The surrounding area of the mountain range is hilly land about 100 m to 150 m above sea level. The project road passes beyond this area in Paraguarí and La Colmena, reaching the mountain range known as "Cordillera de Ybytyruzu" at Villarrica.

(3) Plain Zone

Along the Paraguay River and its Río Tebicuary branch, the lower plains average heights of 90 m to 100 m above sea level. These areas are swampy downstream, and the lower plains are prone to flooding in the upper stream of the river. The project road passes through these areas, formed by the Río Tebicuary-mí, a branch of the Paraguay River.

6-1-2 Geology

According to the "MAPA GEOLOGICO 1986", shown in Figure 6.1.1, the geological conditions of the central area of the Eastern Region of Paraguay can be summarized as follows:

i) The oldest formation can be seen in the southern part of "Cordillera de Altos", known as the Río Tebicuary Formation, which is from the Preterozoic era (600-2,500 million years ago), and consists mainly of granites.

ii) From the Paleozoic era, the Caapucu Formation in the Cambria (500-600 million years ago) forms western parts of the "Cordillera de Altos", and the Caacupe and the Itacurubi Formation Group in the Siluru (395-435 million years ago) forms the northern part of the same. It is also seen of the Independencia Formation Group, consisting of the San Miguel and Tacuary formations from the Permic age (225-280 million years ago) and other formations from the Calbonic age (280-345 million years ago) along the Mountainous Zone.

iii) From the Mesozoic era, the Misiones Formation of the Triasic age (195-225 million years ago) can be seen in the wider areas of mountain ranges in the center of the region, which consists of sandstone and many quarry sites for construction materials. Formations from the Cretacic age (65-141 million years ago) can also be seen in the wider areas of the western part of the region along the Paraná River. Formations from the same age can also be seen between the "Cordillera de Altos" and the Patino Formation around the town of La Colmena.

iv) From the Cenozoic era, the Nemby Formation of the Terciaric age (2-65 million years ago) can be found around Asunción and Paraguary. The remaining parts of the riverside's lower area were formed in the Quatronatic age (2 million years ago) by the sedimentation of the Tebicuary River.

The major formationss of the area surrounding the project road are as follows:

1) Siluric age (Caacupe Formation Group)

2) Permic age (Independencia Formation Group)

i) San Miguel Formation (Permic) : belongs to the independent group, and is made up of arcosica sandstone, generally solid, occasionally with poor stratification, friable, interpreted as the depositional facie of beach, followed by fine sandstone alternating with slate of fluvial origin, lacustrine, deltaic and plain marine.

Figure 6.1.1 Geological Conditions of the Central Area

ii) Tacuary Formation (Permic) : made up of a series of siltitas, lutites, sandstone of calcareous and fine grains, generally eolitic. They present a great variety of colors. The general characteristics of this formation make it a sedimentary environment near the sea shore, on a paleoline of emerged land coast, which is slightly raised and stable.

3) Cretacic age

i) Sapucai Formation (Jurasic - Cretacico) : its formation is connected to the Ybyturuzu intrusion. It is made up locally of esexitas, shonkinitas, nefelina-sienita, with the addition of crystalline fine-grain rocks, with extrusive parts, containing basalt alkaline, nefelitic, tefritas, traquitas, fonolitas, tufas of riolitica and intrusive graps (Palmieri, 1983).

ii) Patino Formation (Upper Cretaceous) : made up of conglomerated sediment on the bed and sandstone near the top, with a strong red color.

iii) Alto Parana Formation (Jurasic - Cretaceous) : made up of a vast basalt spread, predominately teoliticos. Volcano signs are related to the approach of a thermic domo of the layer associated with the Pangea, in the process of separation of the South American and African plates.

iv) Misiones Formation (Triasic - Jurasic) : the formation presents two sedimentary stages, one of a fluvial and the other of an eolic origin. The sedimentary stage of the fluvial environment makes up mainly a part of the basal formation, but may also cross the sandy deposits of an eolic origin. The basal part is made up of especially solid sandstone, having fine to average granulation and intercalated clayey plates. There are also conglomerated levels or graps with clay, siltita and slate clasto with little lateral continuity of sandy bodies. The basal part represents a face of alluvial plains associated with a fluvial environment. The eolic face is made up of fine or average sandstone, well-granulated on plates of a few millimeters thick, with crossed stratification.

v) Formation of Cnel. Oviedo (carbonaceous) : made up of diamictitas, lutites, sandstone and ritmitas of the "varvitas" type. This seems to be related to an environment of glacial sedimentation.

6-1-3 Soil Conditions

(1) General

According to the World Soil Map prepared by FAO-UNESCO, the soil conditions of Paraguay include the 10 categories proposed by the United States Agricultural Department. Soils surrounding the project area were found in the "Ultisol" area, which is defined as having a soil containing ironic or aluminumic materials with advanced weathering.

Because there are fewer organic processes in soil formation resulting from the hard climatic conditions found in Paraguay, areal soil conditions greatly depend on geological formations for their origin. According to the Brasilian Soil Reference System, the soil conditions in Paraguary and the Guairá Departments were summarized in "Atlas Ambiental de la Region Oriental del Paraguay, Universidad Nacional de Asunción".

1) Soils in the Paraguarí Department

Soils in mountain ranges are sandy with quartz and "Litosol" delivered by sandstone, and red and red yellow "Podosolicos" delivered by sandy feldspar rock. In hilly areas, those soils can be classified as "Planosol", "Litosol" and red yellow "Podosolicos". Soils in the plains are sand with water, "Planosol" and gley with slight humidity.

2) Soils in Guaira Department

The main soils in mountain ranges are "Litosol" and "Cambisol", which are derived from alcalic rocks of the Ybytyruzu mountains. In the hilly areas surrounding Villarrica, red yellow "Podosolicos" are derived from the geological formations of the Permic and Carbonific ages. Alluvial soils in low areas are "Planosol", "Plintosol", and Gley with slight humidity. Soil references are as follows:

- Litosol
- Podosolicos
- Planosol under translation
- Gley
- Cambisol
- Plintosol

(2) Boring Test

The geological survey performed by SERTECI.S.R.L of the main rivers and bridges of the alternative routes consisted of 10 boring tests.

Bearing layers are located at less than 7.0m depth below the ground except Río Tebicuary- mí (BST6/7) and its tributary (BST5), Ao Tebicuary-mí (BST8/9). At Río Tebicuary-mí and its tributary, bearing layers are found at approximately 16 meters below the ground and at Ao Tebicuary-mí, they are located approximately 17 meters below the ground. At Río Tebicuary-mí and its tributary, the bearing layer is clayey sand and silty sand/clay, while at Ao Tebicuary-mí, it is silty sand.

In order to obtain the N value, a Standard Penetration Test was conducted. The findings of this test indicate that it will be necessary to use pile foundations for bridge construction, given the soil conditions of Río Tebicuary-mí (BST6/7) and its tributary (BST5), Ao Tebicuary-mí (BST8/9). The boring results are shown in Table 6.1.1.

Table 6.1.1 Boring Results

Boring No.	Ground Elevation (m)	Depth of Bearing layer(m)	Bearing Layer Elevation (m)	Soil Classification
BST1	120.100	4.000	116.100	Clayey Sand
BST2	138.239	7.000	131.239	Silty Sand
BST3	140.050	7.000	133.050	Clayey Sand
BST4	142.658	3.000	139.658	Sandy Silt
BST5	118.057	15.000	103.057	Clayey Sand
BST6	104.043	15.000	89.043	Silty Sand
BST7	105.059	16.000	89.059	Sandy Silty Clay
BST8	103.971	17.000	86.971	Silty Sand
BST9	104.266	16.000	88.266	Silty Sand
BST10	119.568	5.000	114.568	Silty Sand

Source : JICA Study Team

(3) Test Pits

Soil taken from the Segment of Ybytimí - Punto Unido (Segment 5:TP1), Tebicuary - Cnel. Martínez (Segment 7; TP2/3) was examined in a laboratory. According to the soil test results, the soil of Ybytimí - Punto Unido (Segment 5; TP1) can be used as a subbase, however in the Segment of Tebicuary - Cnel. Martínez (Segment 7:TP2/3), it is recommended that other borrow pits be found near alternative routes due to the poor value of CBR, which is less than 4.3, the allowable limit for Transportation B. Traffic volume of Transportation B is 250~1,000 per day. Soil test results from test pits are shown in Table 6.1.2.

Table 6.1.2 Soil Test Results from Test Pits

Test Pit No.	Ground Surface Elevation (m)	Depth from Ground (m)	Soil Classification	Moisture Content (%)	CBR (%)	Allowable CBR for Transportation B (%)	Conclusion
TP1	122.531	0.5	Sandy Silt	16.4	16.5	4.3	Available for use as a subbase.
		1.0	Sandy Silt	24.2	12.5		
TP2	105.263	0.5	Sandy Silty Clay	28.1	2.4	4.3	Not available for use as a Subbase Finding other borrow pits is recommended
		1.0	Sandy Silty Clay	30.3	2.1		
TP3	104.985	0.5	Sandy Silty Clay	35.0	2.9	4.3	Not available for use as a subbase Finding other borrow pits is recommended
		1.0	Sandy Silty Clay	37.5	3.1		

Source : JICA Study Team

6-1-4 Hydrology

(1) Underground Water

According to the "Mapa Hidrogeológico 1986" (Hydrogeological Map), underground water levels around the project road are very high near the Paraguarí side up to Río Tebicuary-mí, that is, less than 1 m below ground level and even springing out in some wells. Near the Villarrica side, water levels are moderate, around 10 m to 15 m below the ground. The only area where springs can be found is on the east side of the "Cordellerra de los Altos" mountain range. Underground water flows north to south by the project road route, the same as the surface water flow.

(2) Surface Water (Rivers and Lakes)

The project area is included in the Río Tebicuary water basin, which has the largest area in the region. This basin can be divided into two major subbasins, that of the Río Tebicuary-mí in the east and that of the Ao Caanabe (Arroyo=branch river) at Sapucai.

The branch streams cross the project road routes at many points, where the larger streams are Río Tebicuari-mí at Tebicuary, Ao Paso Pypucu and Ao Pirayuvy between Caballero and Ybytymí and Arroyo Tebicuary-mí between Tebicuary and Tebicuary-mí.

Río Tebicuary-mí is the largest in the area, having a width of 80 m to 100 m. Its origin is found in the Ybyturuz mountain range. It is naturally meandering river with many horseshoe bends along its course. Low areas are found on both sides of Río Tebicury-mí, and these areas have flooded occasionally, that is, when rainfall exceeds 2,000 mm in a year. There are no lakes with a wide water surface area, but there are many small ponds along the project road route. The Río Tebicuary-mí flooded in 1983 and 1994, and the maximum water level in 1994 was recorded at the town of Tebicuary, where water reached the railway embankment.

(3) Water Quality

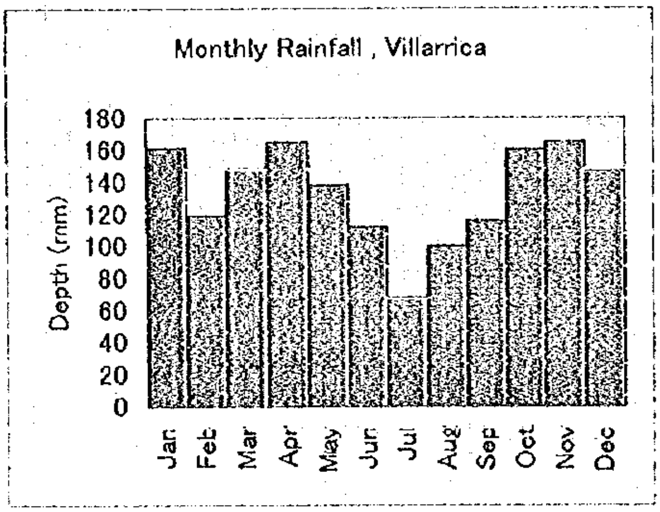
There is no available data about water quality in the project area. According to SENASA (Center for Public Health of Ministriy of Health), the water quality of the Río Tebicuary-mí can be described as follows. The river is very contaminated because of soil erosion and untreated drainage from factories along the river. In the summer season, once or twice a year fish killed by a lack of oxygen can be seen floating in the water. These fishes would seem to have been killed by organic materials discharged from food processing factories

6-1-5 Climate

The climate type in the Department of Paraguarí and Guairá can be classified as Cfa of Keoppen, that is, temperate and rainy. The average temperature in Paraguay becomes gradually lower from west to east, reaching about 22 degrees centigrade in the project area. The high temperature period (over 20 degrees on average) is from October to April, while the low temperature period (15-20 degrees on average) is from May to September (Figure 6.1.2).

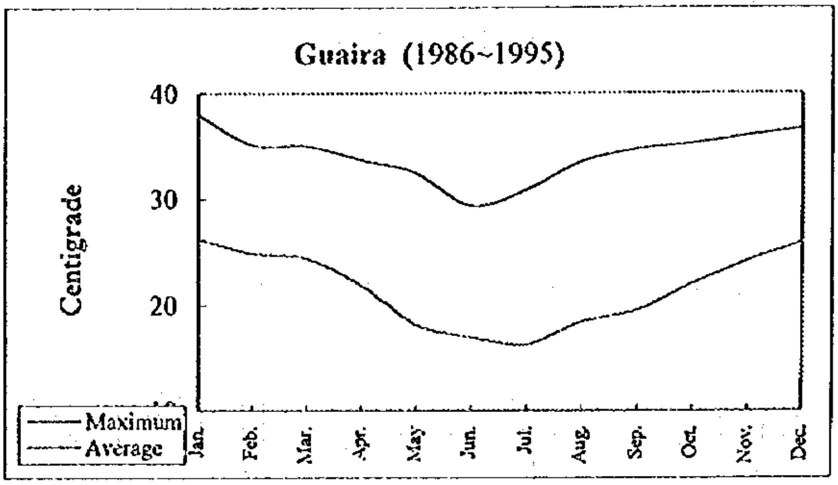
Meanwhile, the annual rainfall in Paraguay increases from west to east, averaging about 1,400 mm to 1,600 mm annually (Figure 6.1.3). The dry season in the area is from July to September, while other months are rainy. In the dry season, monthly rainfall averages around 100 mm. The pattern of monthly rainfall at Villarica is shown in Figure 6.1.4.

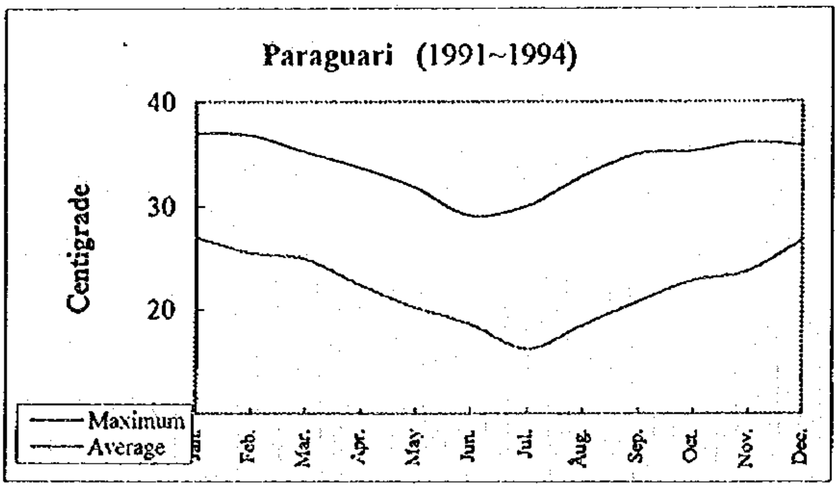
As for wind conditions, the average wind speed at Villarrica is 3.5m/sec, while the dominant wind directions are south, northeast, east, and southeast. Maximum velocity is 5 to 8 m/sec. The dominant wind directions at Caazapá are northeast, southeast, south, and southwest. At Paraguarí, the dominant wind directions were north and south from 1991 to 1994. Figure 6.1.5 indicates the wind direction frequency for each month at 3 sites. Figure 6.1.6 indicates the annual frequency of the wind direction.

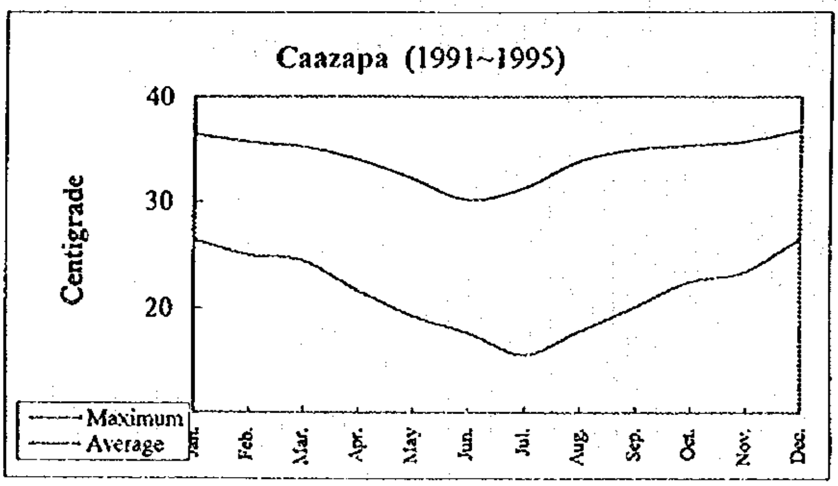


Source : Dirección de Meteorología y Hidrología

Figure 6.1.4 Pattern of Monthly Rainfall at Villarica

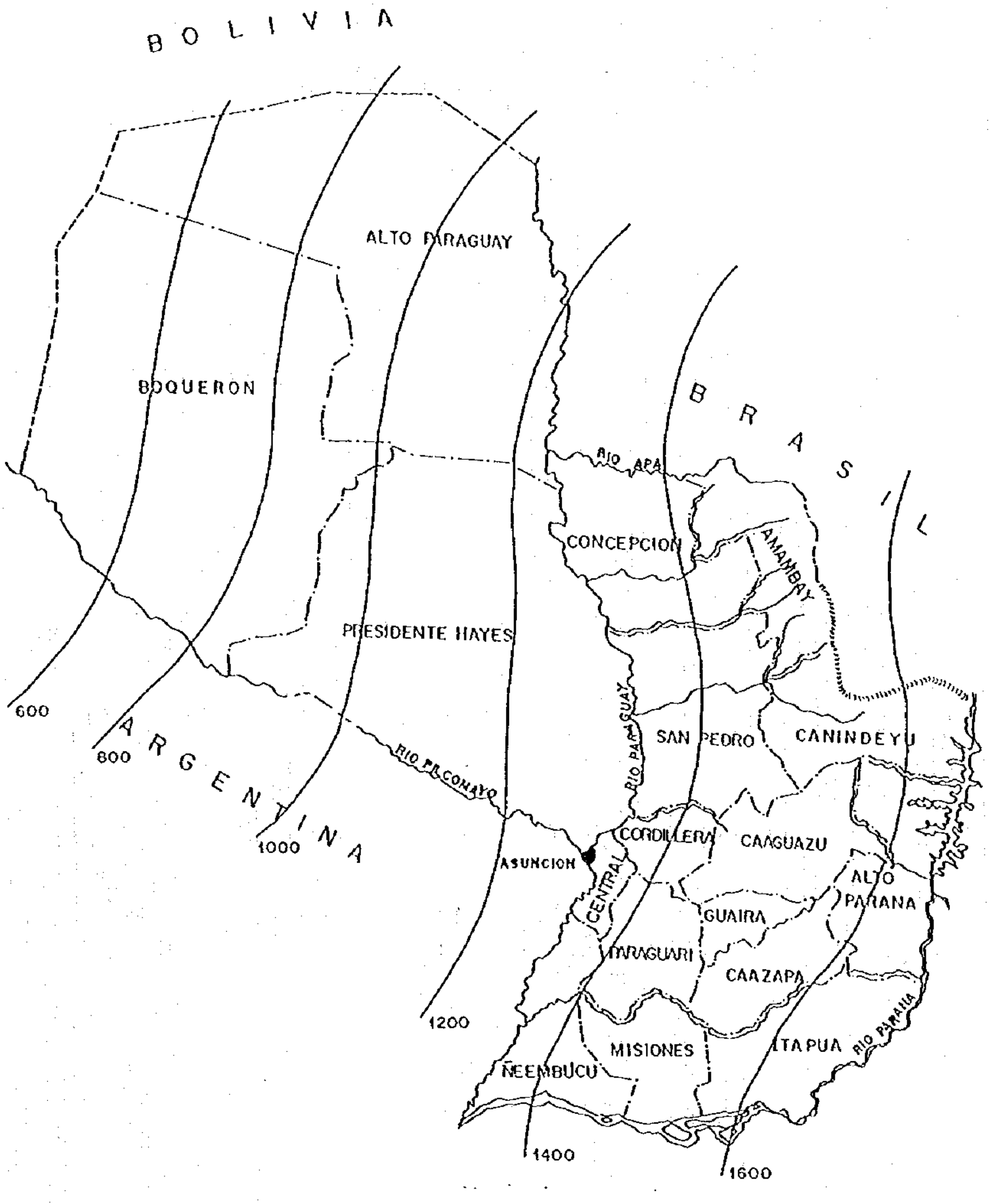






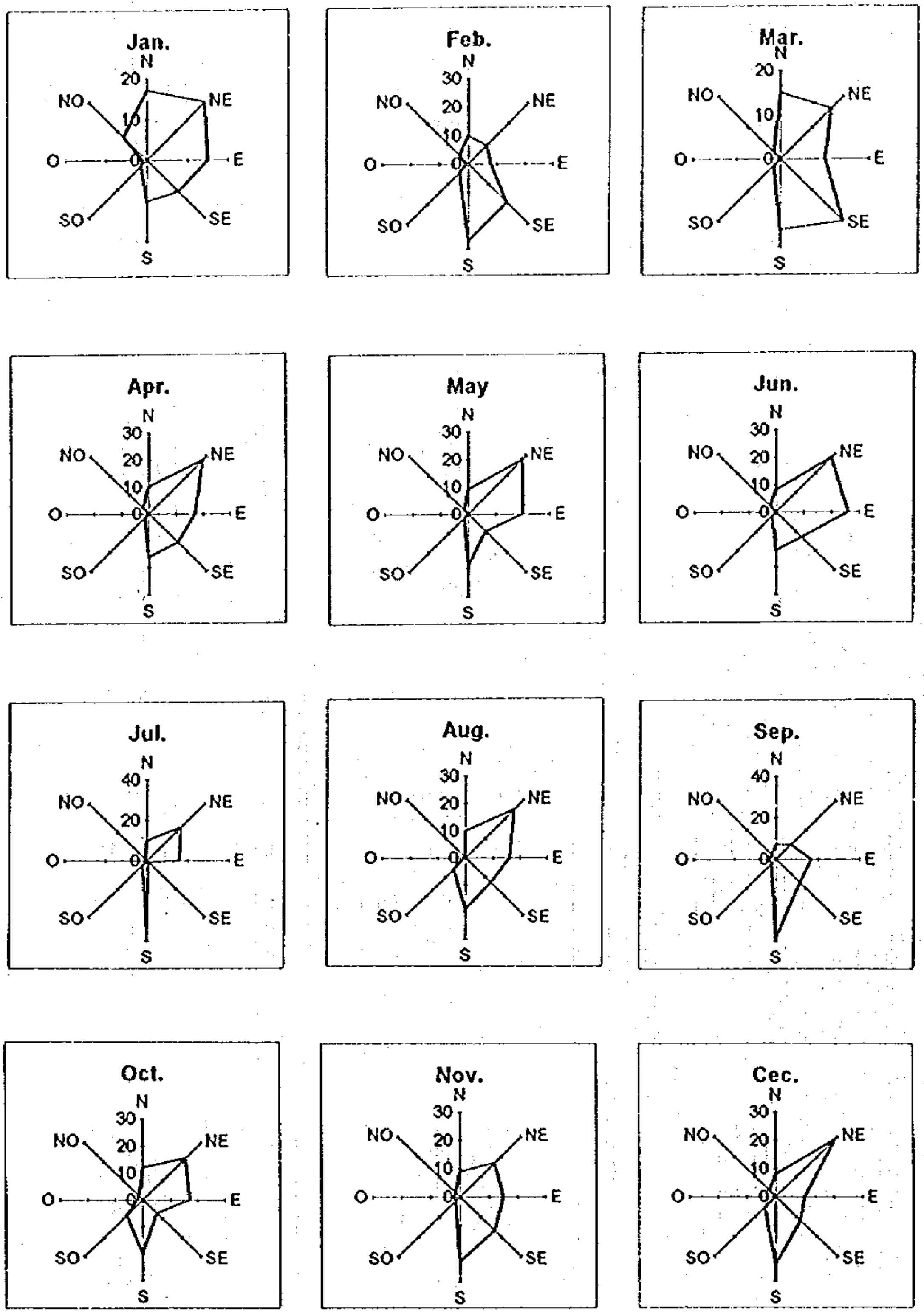
Source : Dirección de Meteorología y Hidrología

Figure 6.1.2 Monthly Maximum and Average Temperature



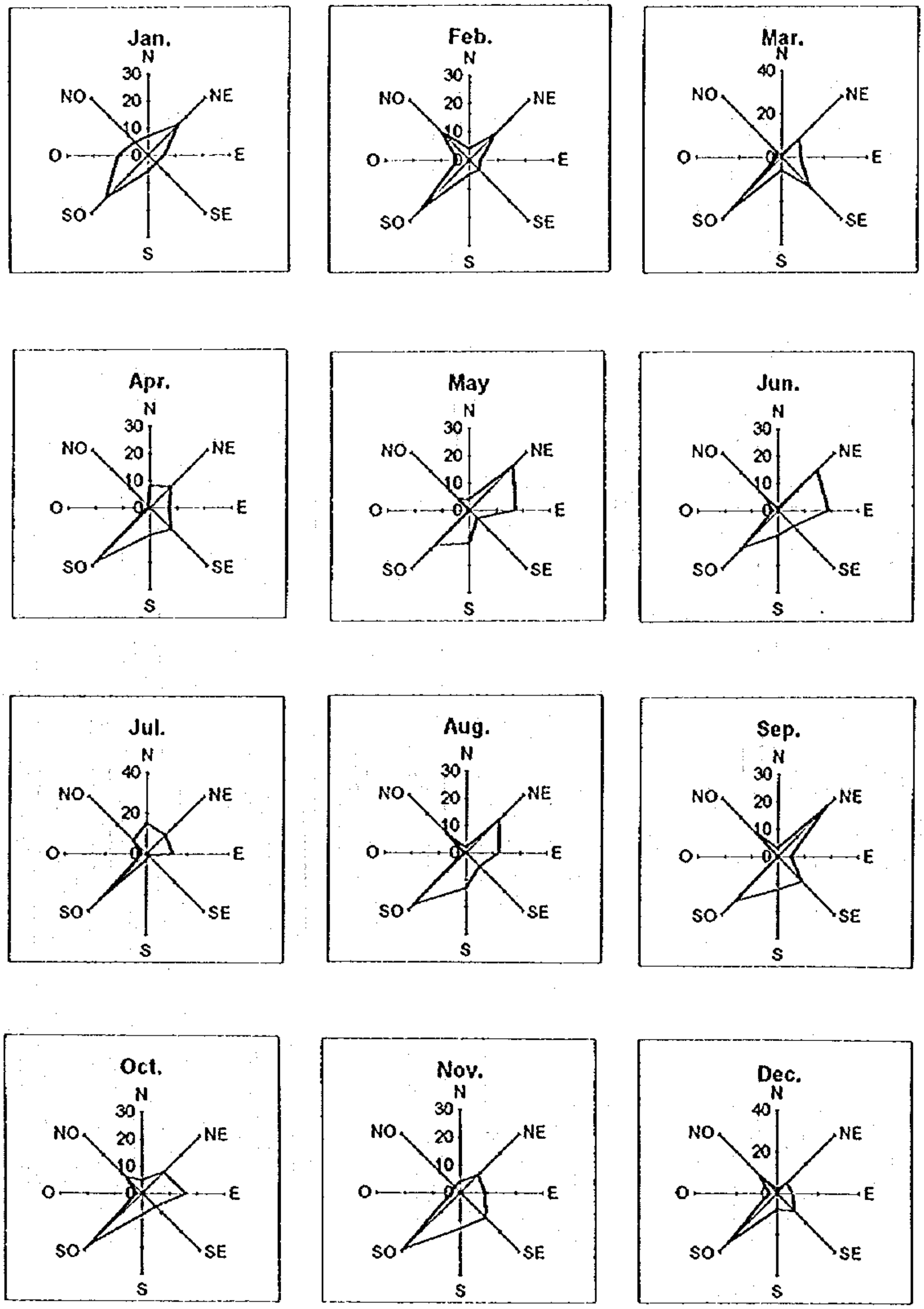
Source : Dirección de Meteorología y Hidrología

Figure 6.1.3 Annual Rainfall Isohyet in Paraguari



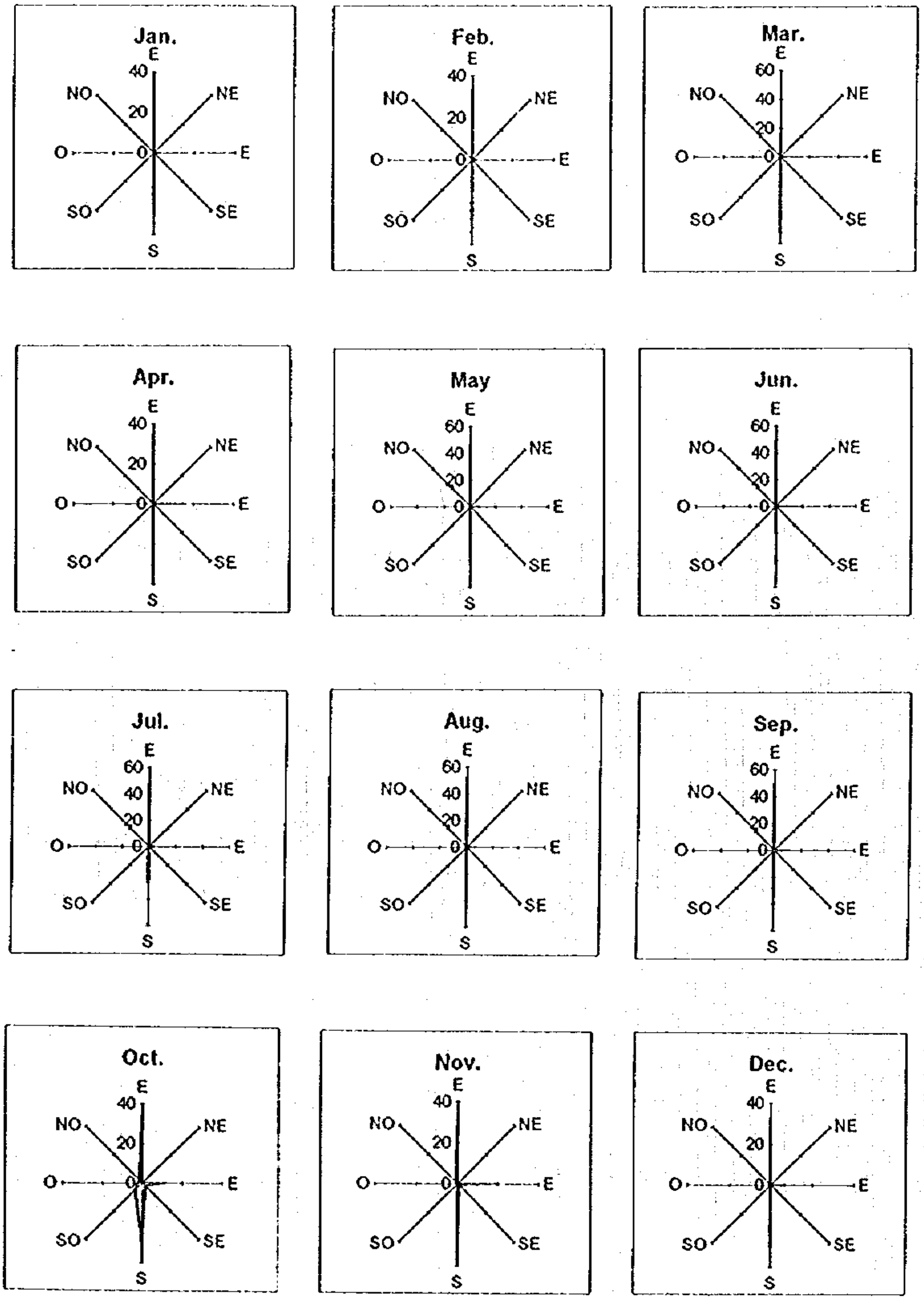
Source : Dirección de Meteorología y Hidrología

Figure 6.1.5 Monthly Wind Direction Frequency (1)



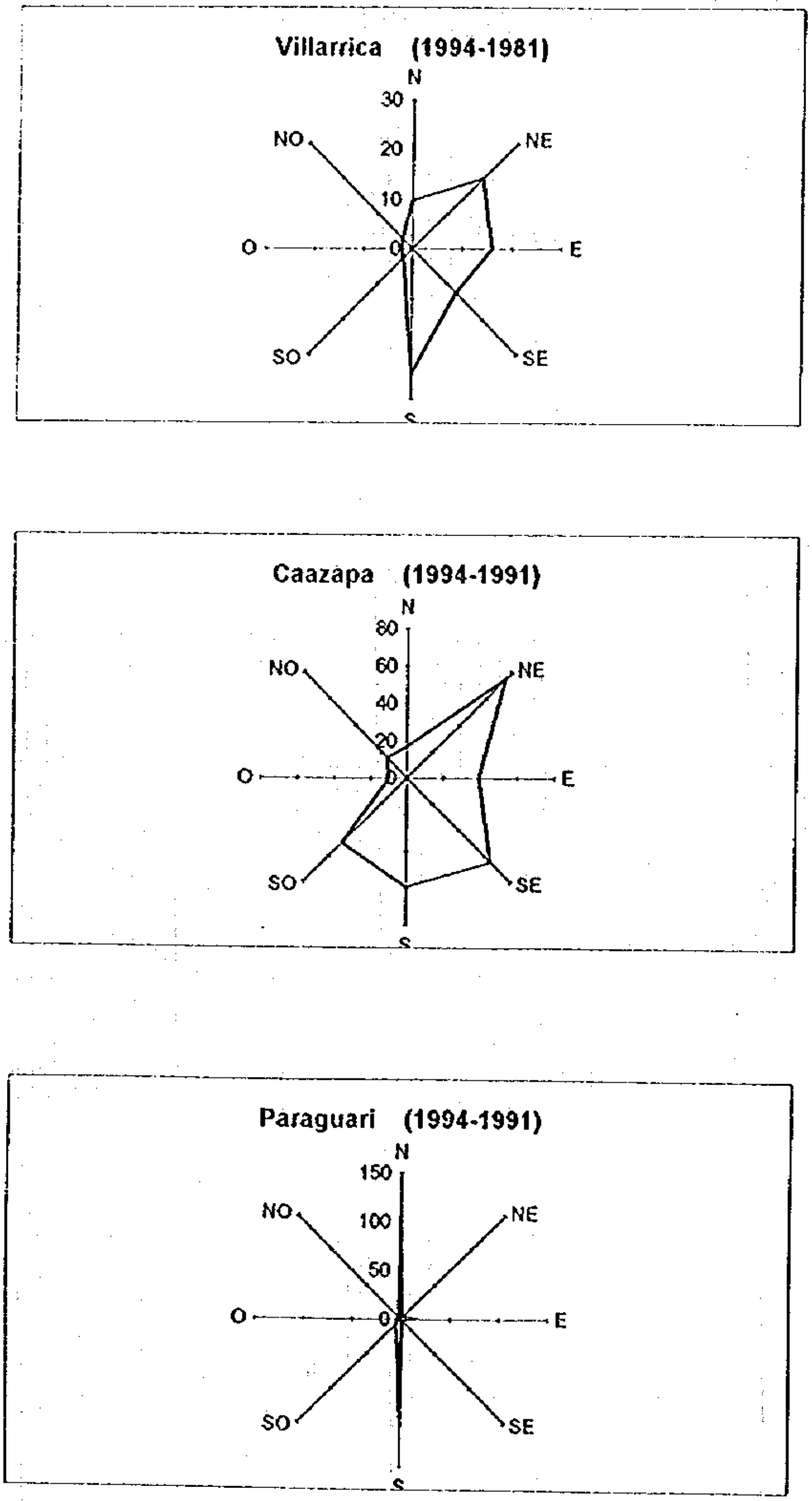
Source : Dirección de Meteorología y Hidrología

Figure 6.1.5 Monthly Wind Direction Frequency (2)



Source : Dirección de Meteorología y Hidrología

Figure 6.1.5 Monthly Wind Direction Frequency (3)



Source : Dirección de Meteorología y Hidrología

Figure 6.1.6 Annual Wind Direction Frequency

6-2 Design Standards for the Objective Roads

"The Standards for Road Geometric Design (Normas para el Diseño Geométrico de Carreteras) - 1985" have not yet been authorized by law or presidential decree. Therefore, the contents of these standards are understood in the MOPC to be only for references or recommendations. The design reports for several recently executed road construction projects show that these standards were referred to in part but not completely incorporated in the works.

Regarding other factors related to the geometric characteristics of the road, there are no standards or specifications for general use in road design work. The Environmental Unit Office (Unidad Ambiental) in the MOPC prepared "The General Environmental Technical Specifications for Road Works (Especificaciones Técnicas Ambientales Generales para Obras Viales)" in December, 1995, which cover items not only in the road design stage, but also in the construction stage. However, this also has not yet been authorized by any official administrative process in the government.

Therefore, the design criteria necessary for this Study were newly established, with reference to the above-mentioned "Geometric Standards" and "Environmental Specifications", and approved by the Steering Committee for the Study, which convened in March, 1996. The approved criteria for the Study are summarized in Table 6.2.1.

Adding to the criteria described in this table, the following matters in relation to the existing railway were also discussed and concluded by the said Steering Committee:

i) The right of way of the railway is 20 m on each side of the rail, even where there is no fence.
ii) The right of way of the study road must not overlap that of the rail.
iii) The road can cross the rail at any point and at any angle.

The Steering Committee also approved the typical cross section of the road shown in Figure 6.2.1 by referring to the criteria described in this table.

With respect to design of structures, it was confirmed that basically AASHTO's standards must be applied in the Study. The principal items to be adopted are as follows:

- Live Load : HS-20-44
- Bridge width (carriageway and shoulders): 12 m (see, Figure 6.2.1)
- Clearance between the bottom of the superstructure and the high water level : 1 m

Table 6.2.1 Geometric Design Criteria for the Study Road

Geometric Criterion	Value	
	Flat Land	Hilly Land
Road classification	I-b(2lanes,>1400v/day	
Design vehicle	SR (Semi-remolrue)*1	
Design speed	100km/h	80km/h *2
Stopping sight distance	>210 m	>140 m
Passing sight distance	>680 m	>560 m
Radius of horizontal alignment	>375 m	>230 m
Grade for vertical alignment	<3 %	<4.5 %
Superelevation rates	<8%	
Normal cross slope	2%	
Lane width	2×3.5 m=7.0 m	
Shoulder width	2×2.5 m	
Total width of the road cross section	>12.0 m	
Gradient of embankment slope	1:4 (h<2 m), 1:2(h>2 m)	
Gradient of cut slope	1:2 (soil), 1:1(rock)	
Standard Width of Right of Way	40 m (Paraguarí - Villarrica) 30 m (Branch to La Colmena) *3	

Note - *1 : "Norma" specifies 4 types of vehicles: passenger car, conventional truck, truck, and semi-trailer. The dimensions of the semi-trailer, which is the biggest and most important vehicle for road design are also defined as follows:
- total width = 2.6 m
- total length = 16.8 m
- min. radius of the outside front wheel when turning = 13.7 m
- min. radius of the inside back wheel when turning = 6.0 m

*2 : A design speed of 60km/h can be applied in some special and limited sections as exceptional cases.
*3 : The width of the "Right of Way" could be reduced in urban areas or in special limited areas.
*4 : When other criteria must be required to determine, the standards of the United States and Japan may be adopted.
*5 : In the branch section toward La Colmena, where the future traffic demand will be less than 1,400 vehicles per day, the geometric criteria described in this table should be adopted; however, this diminished traffic demand should be taken into account in the pavement structure determination.

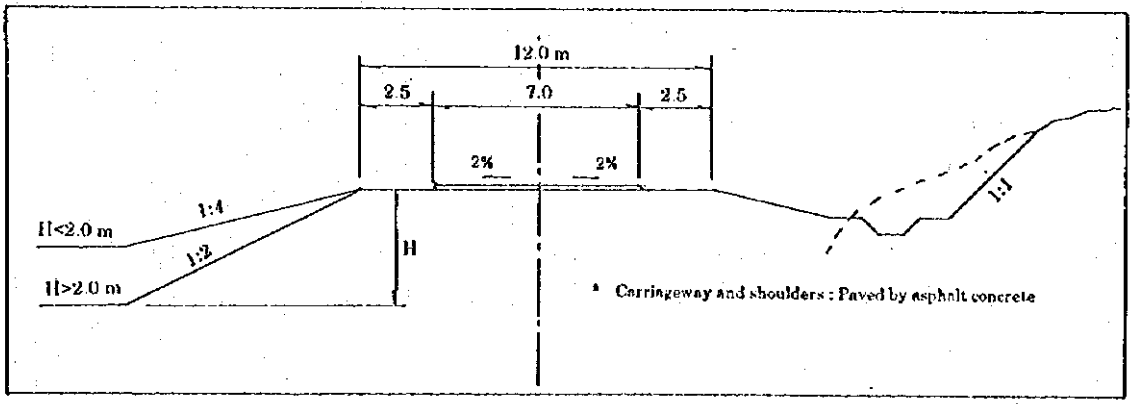


Figure 6.2.1 Typical Cross Section of the Study Road

6-3 Hydrography and Hydrology of the Road-side Area

6-3-1 General

(1) Objective

The objective of the hydrographic and hydrological study was to obtain a useful information on road alignment selection, road formation level, and bridge design.

(2) Study

The study consisted of the data collection, field inspection, and analysis described below.

1) Data Collection

To obtain basic information, all the available data on the following were collected from the related agencies of the Government.

- Topographic maps
- Geological maps and land use map
- Aerial photographs
- Meteorological data
- Hydrological data

2) Field Inspection

A field inspection was conducted to obtain a better understanding of the following:

- watershed identification along the road-side area
- experienced inundation water level through interviews with local residents
- wide flood plain along Río Tebicuary-mí, Ao Tebicuary-mí, and the López Railway
- the behavior of Río Tebicury-mí
- cross structures of the existing road, including alternatives.

3) Analysis

Analysis consisted primarily of the following:

- Runoff calculation
- Water level calculation

In addition, local consultants conducted various surveys.

6-3-2 Basic Data

(1) General

The following study information and data is available from the related government agencies.

- Dirección de Meteorología y Hidrología, PRESIDENCIA
- Administración Nacional de Navegación y Puertos (ANNP), MOPC
- Carlos Antonio López Railway, MOPC
- Dirección del Servicio Geográfico Militar
- Azucarera Paraguaya Tebicuary S.A.

The responsibility of ANNP, which observes the water level of Río Tebicuari-mí at Tebicuary is described below.

ANNP was created as a self-governing entity by Law number 1066, and in 1990 the administration of Navigation and Hydrography was created. These organizations are in charge of maintaining channels of fluvial navigation and port access in good condition to ensure normal navigation throughout the year, and to carry out topographic, geological, hydrological and hydrographical research in the rivers and streams of this country, to prepare, keep, and publish hydrological reference; to acquire, maintain and operate dredging and any others equipment necessary for regularization and river maintenance. There are divided in two departments:

- Hydrotopographic Research Department
- Dredging Department.

Water level observation in Río Tebicuary-mí at Tebicuary has been conducted since 1973 by ANNP.

(2) Data Conditions

Information and data were collected from the above-mentioned related agencies. The titles of these data are listed below.

1) Topographic Map :

- 1/100,000 Chart :No. 5469 (Paraguarí), 5569 (Sapucaí), 5669 (Villarrica)

2) Meteorological Data

- Wind velocity and direction frequency : Paraguarí , Villarrica , Caazapá
- Annual rainfall : Paraguarí, Villarrica, Caazapá
- Maximum and average temperature : Paraguarí, Villarrica, Caazapá

- Annual maximum rainfall depth : Paraguarí, Villarrica, Caazapá

3) López Railway
- Longitudinal profile
- Bridge dimensions

4) Hydrological Data
- Daily water levels of Río Tebicuary-mí at Tebicuary :

5) Topographic Survey
- Longitudinal leveling survey (Paraguarí - Villarrica, La Colmena - Tebicuary)
- Cross-section survey (Paraguarí - Villarrica, La Colmena - Tebicuary)
- Topographic survey (8 bridge sites)

6) Aerophotograph (Mosaoic)
- Photo-mosaic at 1:20,000 scale (Paraguarí - Villarrica, La Colmena - Tebicuary)
- Photo-mosaic at 1:50,000 scale (Paraguarí - Villarrica, La Colmena - Tebicuary)

6-3-3 Hydrography and Hydrological Conditions

(1) General

The hydrography and hydrological conditions of the existing and the proposed road-side area were surveyed through field inspections. In particular, the severe innundation area and the innundation depth of the bridge site were surveyed by the maintenance staff of Azucarera Paraguaya Tebicuary S.A. The conditions of segments, Rio Tebicuary-mí, and the 1994 November flood are described below.

(2) Local Conditions

The conditions of the segment are summarized below, and shown in Figure 6.3.1.

1) Paraguarí - Sapucaí

Four rivers (Ao Yacare, Ao Piraty, Ao Tulio, Ao Para) are found in this segment. All rivers originated in the Cordillera de Los Altos. The existing roadway is located upstream of the rivers leading to the López Railway. The ground level of the road is between El.147-113 m. The existing drainage structures are mainly box culverts. Roadway drainage is required. Severe inundation does not occur along the roadway area.

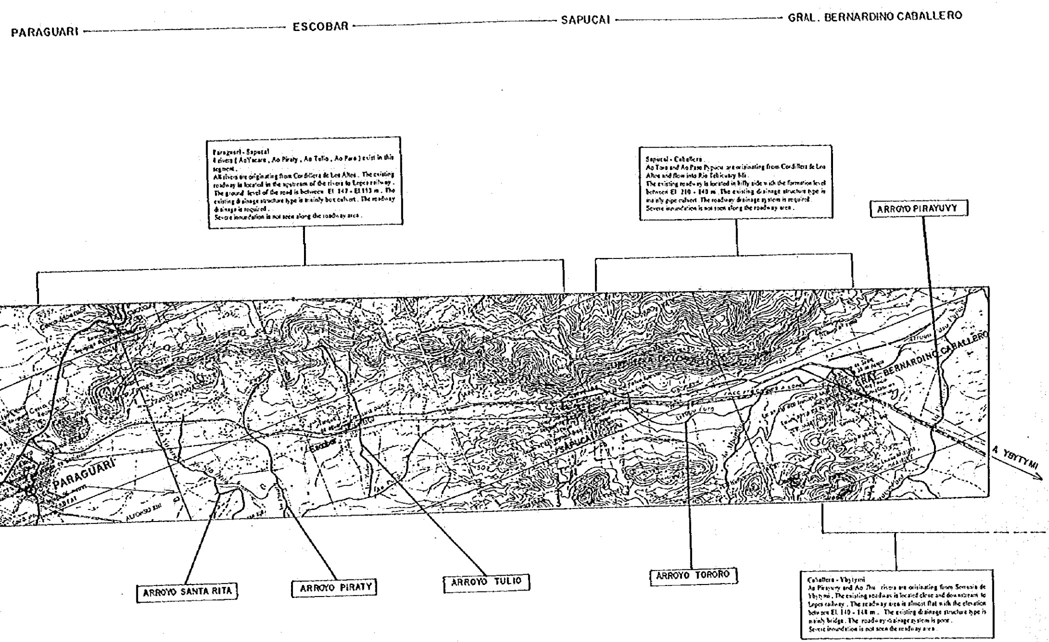


Figure 6.3.1 Hydrological Conditions of the Road Side Area (1)

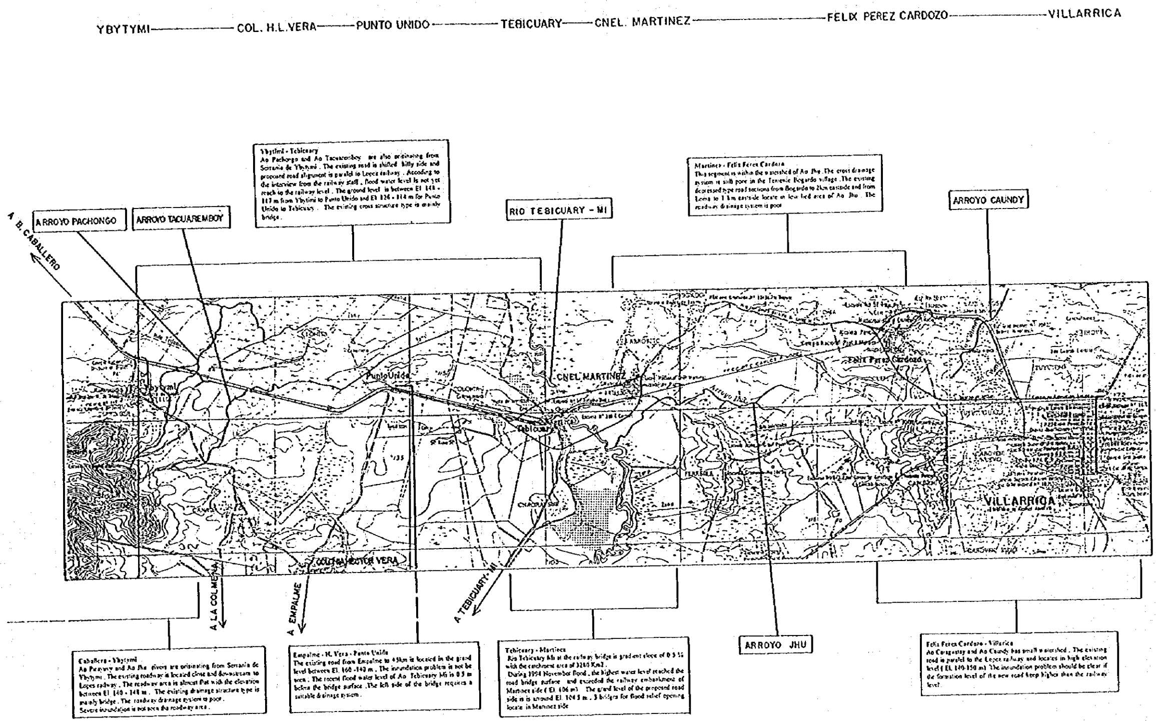


Figure 6.3.1 Hydrological Conditions of the Road Side Area (2)

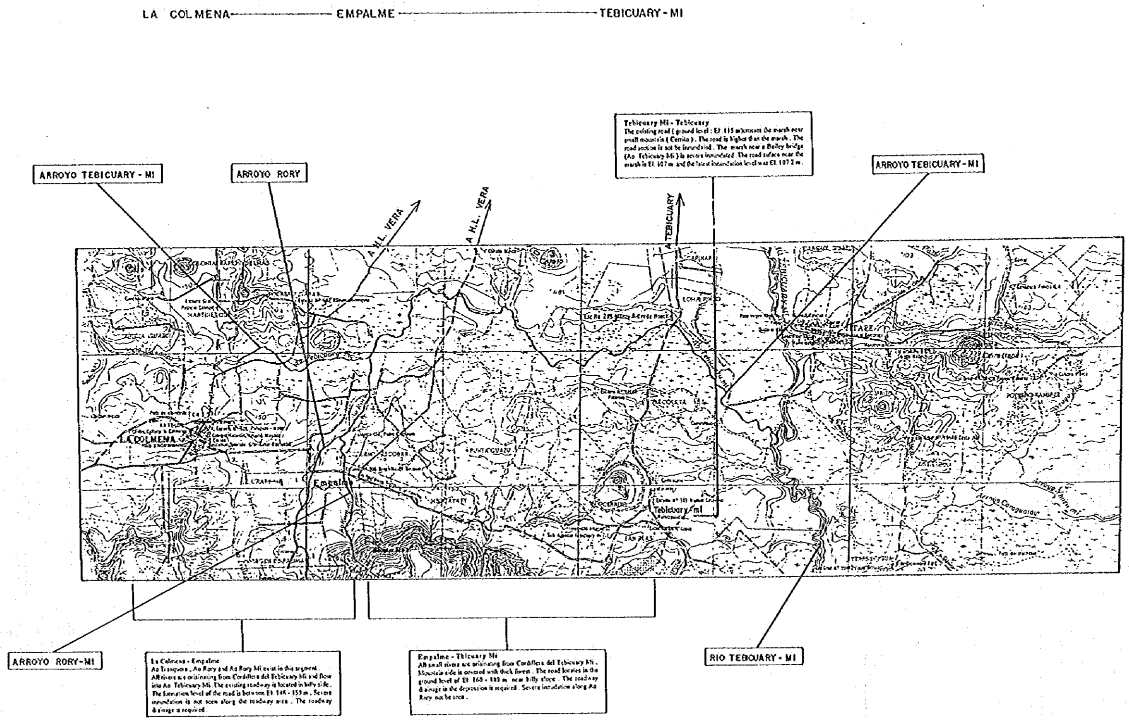


Figure 6.3.1 Hydrological Conditions of the Road Side Area (3)

2) Sapucai - Caballero

Ao Toro and Ao Paso Pypucu originate in the Cordillera de Los Altos, and flow into Río Tebicuary-mí. The existing roadway is located on the hilly side where the formation levels are between El.210-140 m. The existing drainage structures are mainly pipe culverts. As plans call for the construction of a new road with a new alignment in this section, an adequate roadway drainage system is required. Severe inundation does not occur along the roadway area.

3) Caballero - Ybytymí

Ao Pirayuvy and Ao Jhu originate in Serraniá de Ybytymí. The existing roadway is located close to and downstream of the López Railway. The roadway area is almost flat, with an elevation between El.140-148 m. The existing drainage structures are mainly bridges. The roadway drainage system is poor. Severe inundation has not occurred in the roadway area.

4) Ybytimí - Tebicuary

Ao Pachongo and Ao Tacuaremboy also originate in Serranía de Ybytymí. The existing road is shifted to the hilly side and the proposed road alignment is parallel to the López Railway. Interviews with the railway staff reveal that the flood water level has never reached the railway. The ground level is between El.148-117 m from Ybytimí to Punto Unido and El.126-114 m for Punto Unido to Tebicuary. The existing cross structures are mainly bridges.

5) Tebicuary - Martínez

Río Tebicuary-mí at the railway bridge has a gradient slope of 0.5% with the catchment area of 3,280 km². During the flood in November 1994, the highest water level reached the road bridge surface and exceeded the railway embankment on the Martínez side (El.106 m). The grand level of the proposed road side is around El.104.5 m. Three bridges for flood relief are located on the Martínez side.

6) Martínez - Félix Pérez Cardozo

This segment is within the Ao. Jhu watershed. The cross drainage system is still poor in the Teniente Bogardo village. The existing depressed type road sections from Bogardo to 2 km east and from Loma to 1 km east are located in the low-lying area of Ao. Jhu. The roadway drainage system is poor.

7) Félix Pérez Cardozo - Villarrica

Ao Caraguatay and Ao Caundy have small watersheds. The existing road is parallel to the López Railway and has a high elevation level (El.140-150 m). There should be no danger of inundation if the new road is constructed at a higher elevation than the railway.

8) La Colmena - Empalme

Ao Tranquera , Ao Rory, and Ao Rory-mf are found in this segment. All rivers originate in the Cordillera del Tebicuary-mf and flow into Ao Tebicuary-mf. The existing roadway is located on the hilly side. The formation level of the road is between El.146-155 m. Severe inundation does not occur in the roadway area. Roadway drainage is required.

9) Empalme - H. Vera - Punto Unido

The existing road from Empalme to +5km is located on a ground level between El.160-140 m. There is no inundation problem. The recent flood water level of Ao Tebicuary-mf is 0.5 m below the bridge surface. The left side of the bridge requires a suitable drainage system.

10) Empalme - Tebicuary-mf

All small rivers originate in the Cordillera del Tebicuary-mf. The mountain side is covered with a thick forest. The road is located on a ground level of El.160-180 m near the hilly slope. Roadway drainage in the depression area is required. There is no problem with severe inundation along Ao Rory.

11) Tebicuary-mf - Tebicuary

The existing road (ground level : El.115 m) crosses the marsh near a small mountain (Cerrito). The road is higher than the marsh. The road section is not subject to inundation. The marsh near the Bailey bridge (Ao Tebicuary-mf) is severely inundated. The road surface near the marsh is El.107 m, and the latest inundation level was El.107.2 m.

(3) Río Tebicuary-mf

Information on the following topics has been collected through field inspections of Río Tebicuary-mf and available data.

1) River channel regime

Río Tebicuary-mf has wide flood plains upstream of Tebicuary town, and meandering channel segments. The catchment area at the bridge site is around 3,800 km^2 with a gradient of 0.15%.

2) River Channel stability

The river has reached a stage of development in which the force of the flowing water is insufficient to scour the bed and erode the banks. Río Tebicuary-mí is almost statically stable.

3) River channel flow pattern

The channel at the new bridge site is straight within 600 m. The forest on the lower right bank is dense, and is not eroded during flooding. Channel migration at the site is not active. At the existing railway bridge, erosion pockets and embayments are found on the left bank.

4) Range of water levels

The normal range of the water level was El.99.5-103.5 m from 1972 to 1994, based on records at the station belonging to ANNP. In November 1994, a high water level was observed reaching the road bridge surface and exceeding the embankment near Martínez. A leveling survey showed the water level to be El.106.5 m. The maximum high water level in 1983 was around El.106.5 m. The water level records for 1986 and 1987 are shown in Figure 6.3.2. (Appendix 1 includes all the record)

5) Range of discharge

The rating curve at the station is not available. The discharge capacity at the natural bank level of the left bank (El.104.5 m) was calculated to be about 600 m^3/s.

6) Width of flood plain

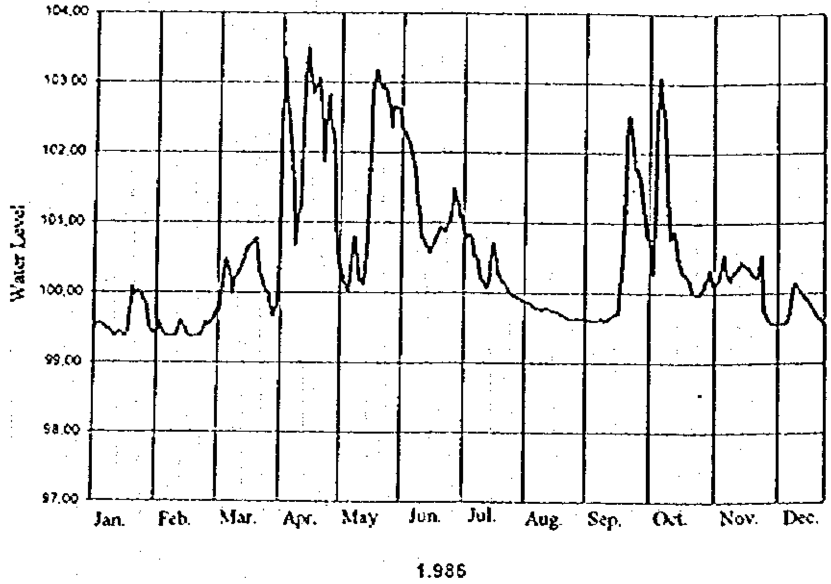
During the 1983 and 1994 November floods, the flood plain supposedly extended 10 km upstream of the railway bridge. Direct inundation area upstream of the embankment might be about 80 km^2 from the flood water level during the flood in November 1994. (Figure 6.3.3)

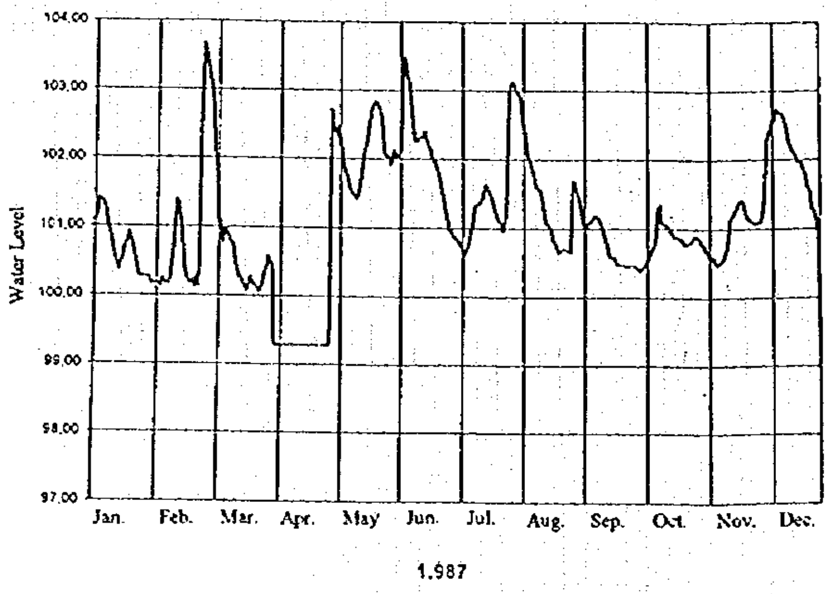
7) Bed material

Bed material is classified silt-clay, based on the boring data obtained at the bridge site.

8) Level of the railway truss bridge at Tebicuary

A leveling survey showed the sleeper level of the truss bridge to be between El.109.6-108.4 m. The flood water during the flood in November 1994 did not reach the soffit of the bridge.

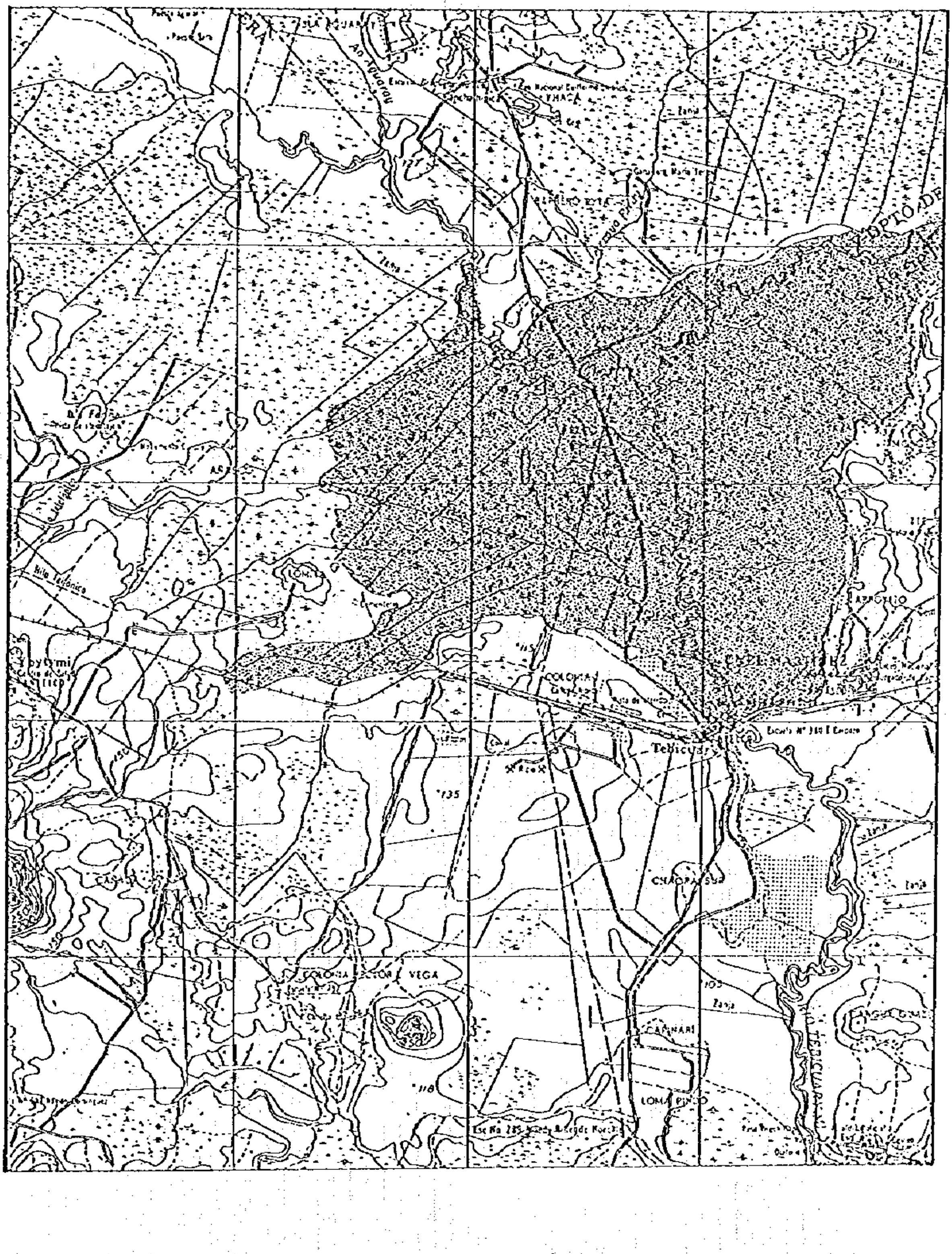




Zero gauge : EL 99.277(surveyed by JICA Team)

Source : Administración Nacional de Navigación y Puertos

Figure 6.3.2 Water Level at the ANNP Station, Río Tebicuary Mí (1986 and 1987)



Source : JICA Study Team

Figure 6.3.3 Direct Inundation Area During the Flood in November 1994

(4) Severe Flood in November 1994

1) Weather conditions in November 1994

A cold front with moderate intensity affected the north of the country, causing rainfall of some significance in the north and east.

- On the first day, the temperature was much lower than normal.
- On the following days, the weather was fine, with a pleasant temperature and a sky that was scantily cloudy.
- On the fourth day, there was a great increase in temperature and humidity.
- On the fifth day an unstable pre-front line caused rainfall of 85 mm in Asunción, 180 mm in Villarrica, and 117 mm in Caazapá.
- Instability later spread throughout the country and continued for many days, with heavy rainfall occurring on the seventh and eighth days: 104 mm in Asunción and 112 mm in Paraguarí.
- On the ninth day, there was a cold front with dry air that caused the weather to improve.
- On the eleventh day, there was a significant depression in the Argentine northeast and in the country also, causing some humid and unstable days, with variable rainfall throughout the country.
- The above-mentioned situation continued until a great instability happened. This effected the entire country between the sixteenth and seventeenth, and Caazapá registered 107 mm.
- From the eighteenth day, with the coming of dry and relatively fresh air, the country enjoyed good weather, which continued up to the 25th day. Then the region was subject to persistent high pressure.
- On the 26th day, the pressure dropped significantly and humid unsteady air swept across the north, causing rainfall in the Chaco, Mcal. Estigarribia: 50 mm, Pratts: Gill 81 mm.
- On the 28th day, an unstable front came into the area, causing general rainfall.
- On the 29th day the weather improved and the month ended with good weather, scantily cloudy skys with a temperature that was below normal.

2) Rainfall depth

The most remarkable positive changes occurred in the Guairá and Caazapá regions, the most outstanding being the one in Villarrica, where the pluviometric surplus was 368.5 mm and the one from Caazapá was 270.7 mm. The most remarkable negative changes were the ones in Pedro Juan Caballero and Adrián Jara, which registered 71.6 mm and 39.1 mm, respectively. The number of rainy days in the month were 5 in the western region and 12 in the eastern region.

Figure 6.3.4 shows the isohyetal map for November, and Figure 6.3.5 shows the isohyet for 5 days of the floods. The rainfall depth at Villarrica, Caazapá, and Paraguarí caused the flood is noted below.

Table 6.3.1 Rainfall Depth During the 1994 Flood

(unit : mm)

Day	Station		
	Villarrica	Caazapá	Paraguarí
1	0.0	0.0	0.0
2	0.0	0.0	0.0
3	0.0	0.0	0.0
4	0.0	0.0	0.0
5	180.0	87.0	116.6
6	71.0	18.0	31.5
7	70.0	112.0	28.0
8	45.0	109.0	55.3
9	0.0	0.0	0.0
10	0.0	0.0	0.0
Total	366.0	326.0	231.4

Source : Dirección de Meteorología y Hidrología

6-3-4 Hydraulic Analysis

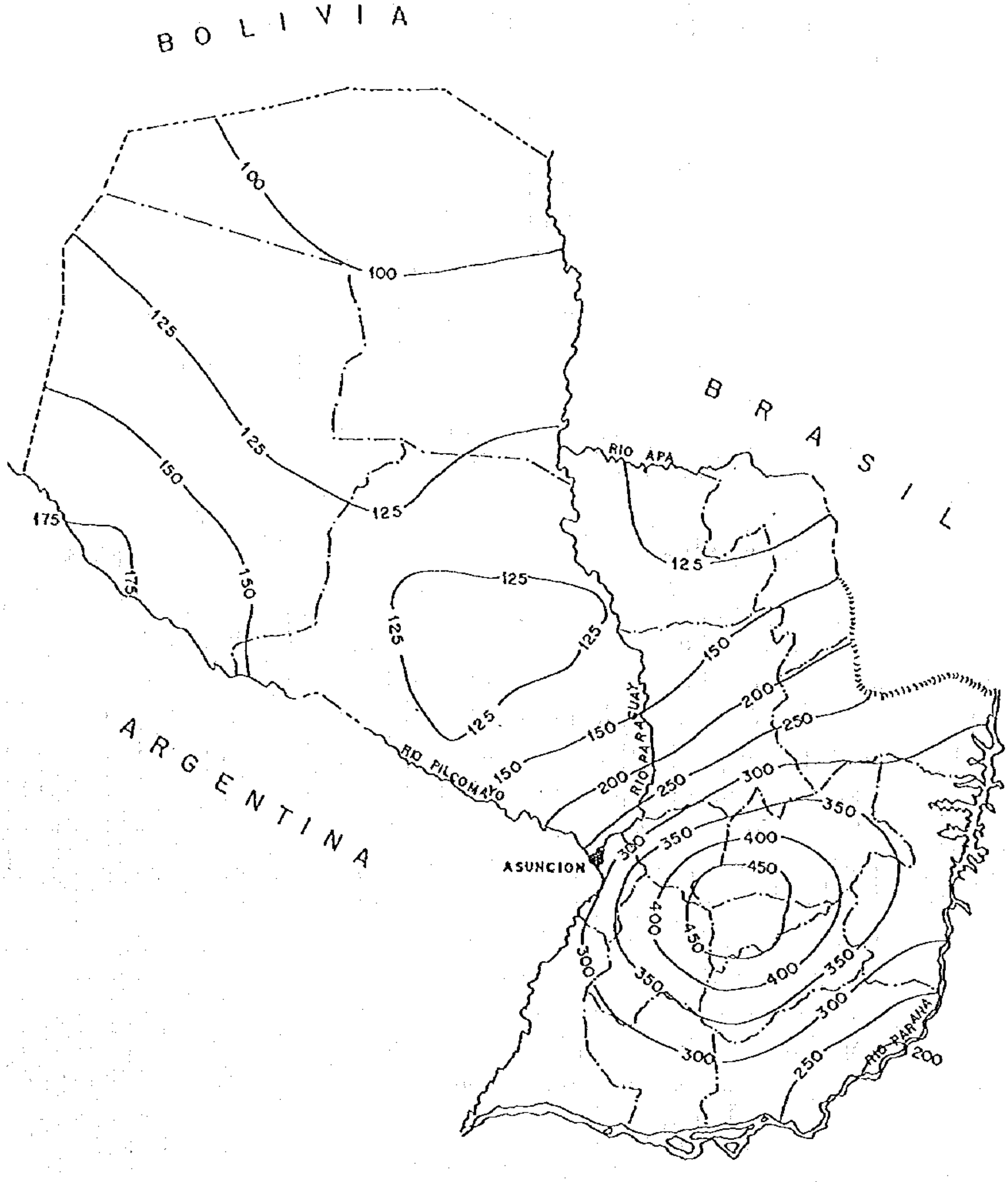
(1) General

A hydraulic analysis should be conducted to assess the flood discharge and water level at the bridge site. The design discharge should be selected, considering the frequency of discharge and the reliability of the data. Design criteria should be based on MOPC Standard (Normas para el Diseño Geométrico de Carreteras). The probable discharge and design high water level are calculated at the following bridge sites:

- Arroyo Tulio (Topographic survey site No. 1)
- Arroyo Tororo (Topographic survey site No. 2)
- Arroyo Pirayuby (Topographic survey site No. 3)
- Arroyo Pachóng (Topographic survey site No. 4)
- Arroyo Caundy (Topographic survey site No. 5)
- Río Tebicuary-mí (Topographic survey site No. 7)
- Arroyo Tebicuary-mí (Topographic survey site No. 6)
- Arroyo Tebicuary-mí (Topographic survey site No. 8)

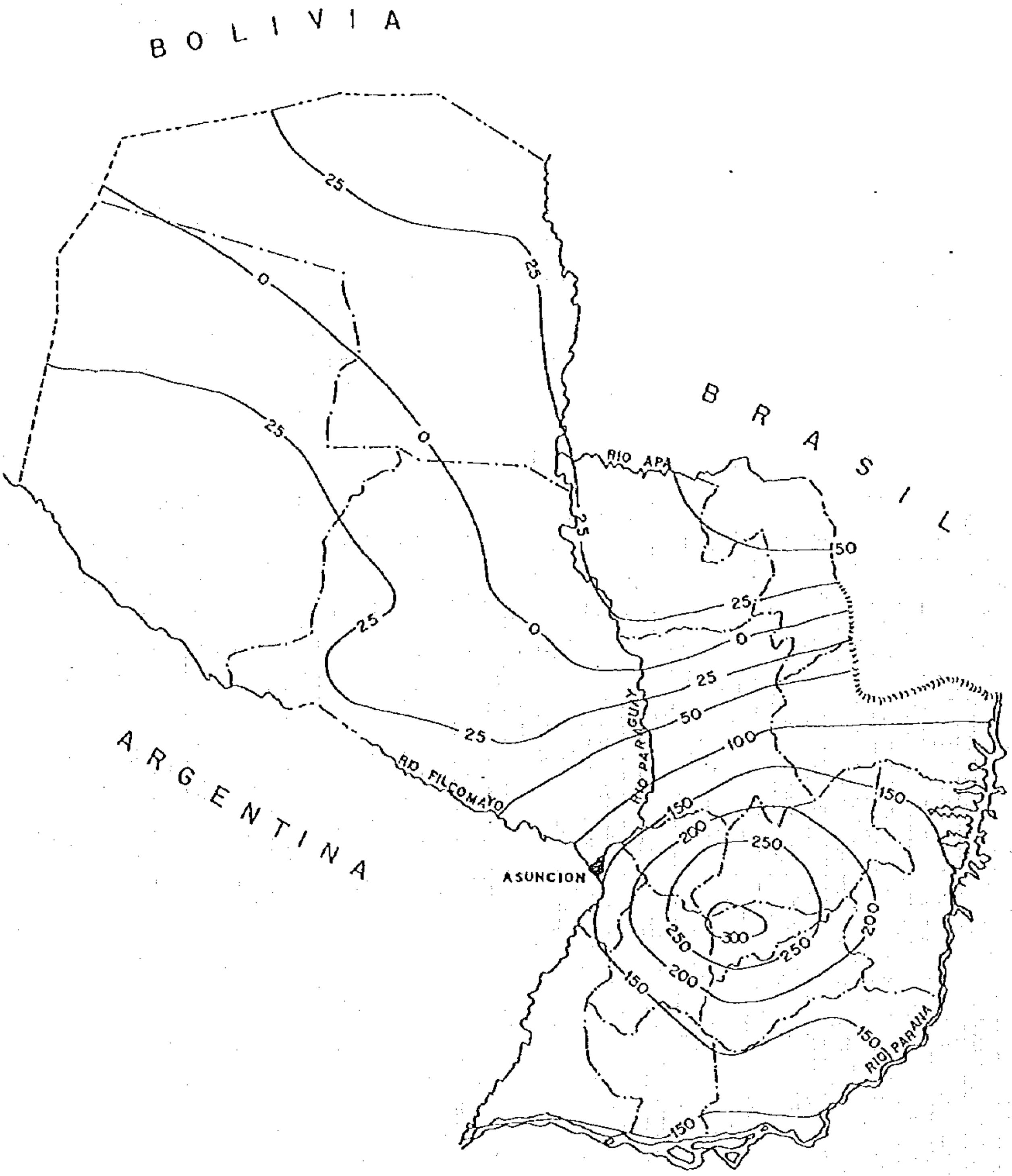
In addition, the probable discharges are calculated at the following 5 sites.

- Arroyo Santa Rita and Arroyo Piraty (Paraguarí - Escobar)
- Arroyo Tacuaremboy (Ybytimí - Punto Unido)
- Arroyo Jhu (Martínez - Félix Pérez Cardozo)
- Arroyo Rory and Rory-mí (La Colmena)



Source : Dirección de Meteorología y Hidrología

Figure 6.3.4 Monthly Isohyetal Map for November



Source : Dirección de Meteorología y Hidrología

Figure 6.3.5 Isohyetal Map for the 5 Days of Flooding

(2) Design Storm Frequency and Freeboard

For bridges the 1/50 years design storm frequency should accommodate a freeboard 1 m below the bridge soffit in rivers. For culverts, a freeboard 0.6 m below should be recommended by MOPC.

Table 6.3.2 Design Storm Frequency Period

Situation	Frequency
Bridges	1/50 years
Box Culverts	1/25
Pipe Culverts	1/10
Embankments	1/25
Road Surface	1/5
Roadside Drainage	1/5

(3) Runoff Calculation

1) Method

There are several methods to calculate runoff discharge. These include the rational formula, the unit hydrograph method, the triangular method, and the storage function method. The rational formula is generally used for small river basins. The rational formula can provide only peak discharge; however, the others provide flood hydrographs. MOPC recommends using the rational formula for small catchments of less than 10 km^2, and the triangular method for catchments of more than 10 km^2.

a) Rational Method

$$Q = \frac{CiA}{6}$$

where,
Q = discharge, m^3/s
C = runoff coeffcient
i = rainfall intensity in concentration time (mm/min)
A = catchment area (ha)

$$Tc = \frac{10 \times A^{0.3} \times L^{0.4}}{K \times I}$$

where,
Tc = concentration time (minutes)
L = river length (m)
K =coefficient of catchment (3.5 in common)
I =slope (%)

The dimensions of the catchment area, length, slope, rainfall intensity in concentration time, and K for the 14 watersheds are listed in Appendix B.

b) The Triangular Hydrograph Method (THM)

This method was developed and recommended by the U.S. Soil Conservation Service. MOPC recommends using this formula for the runoff calculation.

① Formulas

$$q_p = \frac{2.08 \times A}{tp}$$

where,

q_p = maximum peak of flow (for THM)

A = basin area in km^2

t_p = peak time

$$t_p = \frac{\Delta_t}{2} + 0.6\, t_c$$

t_c = concentration time, in hours (*)

$$\Delta_t = \frac{t_c}{5} \text{ unitary time in hours}$$

t_r = 1,67 t_p = recess time in hours

t_b = 2,67 t_p = base time in hours

* The concentration time was calculated by the same formula used for the rational formula.

$$t_c = \frac{10 \times A^{0.3} \times L^{0.2}}{K \times i^{0.4}}$$

②Effective Rainfall

To establish the effective rainfall (Pe), the total rainfall (P) is used according to the U.S. Soil Conservation Service.

$$CN = \frac{1000}{10 + S}$$

where,

CN = curve-number for the basin

S = retention and infiltration for the studied basin

$$Pe = \frac{(P' - 0.2S)^2}{P' + 0.8S}$$

where,

P_e = efective rainfall in inches

P' = total rainfall in inches

* The total rainfall (P) was obtained using the formula h= a ln t + b and P'

$$P' = \frac{P \times (1 - 0.1 \times \log A)}{25}$$

P' is used only for areas larger than 25 km^2

If A < 25 km^2 P = P'

③The hydrograph

Outside the effective rainfall for each ΔT, the discharge is calculated for intervals by multiplying the order of the THM by the ΔPe(cm). These values for the projected hydrograph are:

$$Q_i = Pe_i \cdot q1 + Pe_{i-1} \cdot q2 + Pe_{i-2} \cdot q3 + \ldots Pe_1 \cdot qi$$

2) Rainfall Intensity values

The rainfall intensity values at Villarrica - Guairá based on a long period (1960-1994) is available. Figure 6.3.6 indicates the curve at various frequencies.

Table 6.3.3 Rainfall Intensity Values at Various Frequencies

Years	t = 6 min	t = 60 min	24 hours
5	1.60	5.99	14.25
10	1.82	6.75	16.22
25	2.09	7.69	18.70
50	2.30	8.36	20.55

Source : MOPC

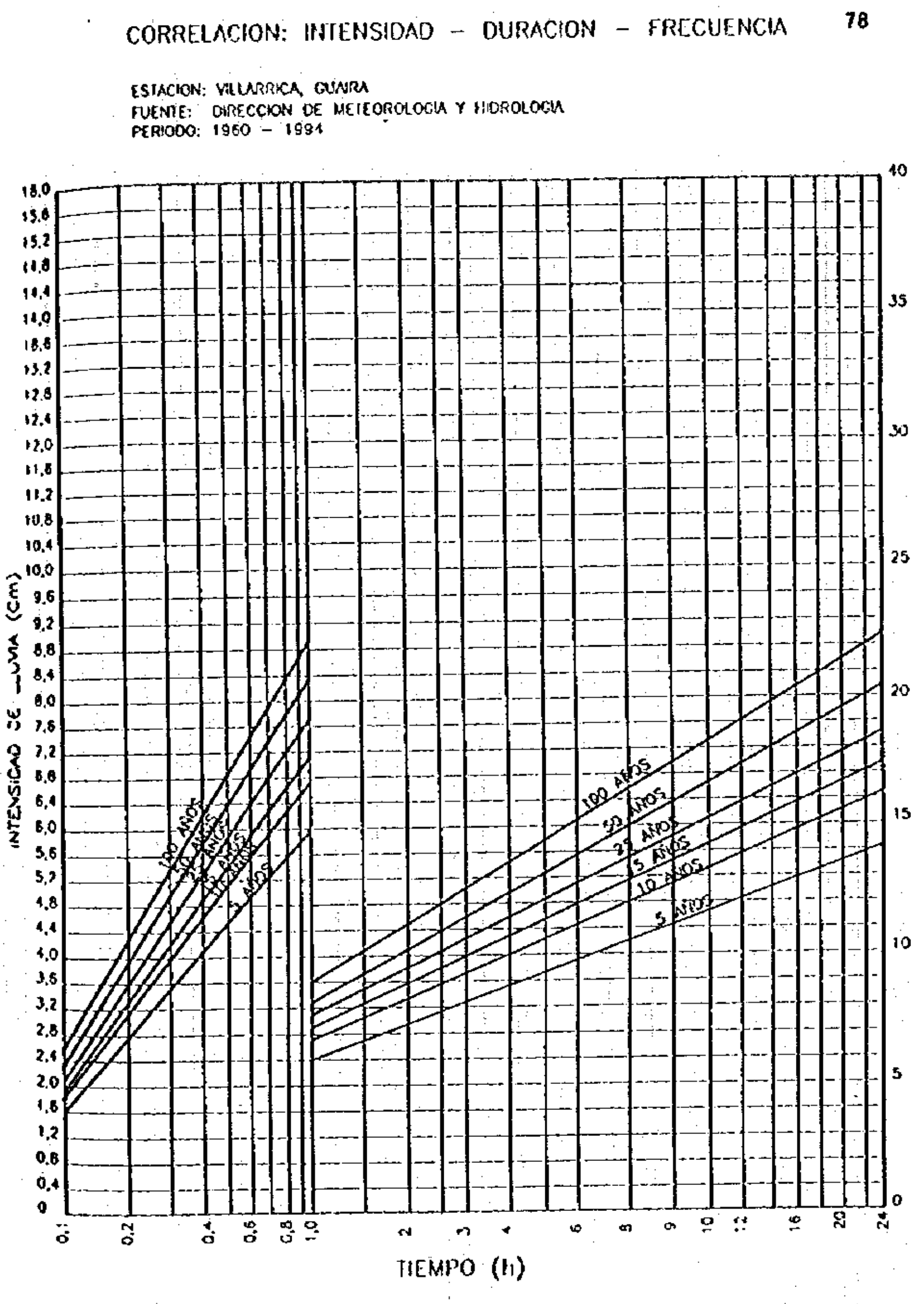
The intensity of the concentration time is calculated based on the following formula.

$$Q = \frac{a}{T^n}$$

where,
Rd : Rainfall intensity
a : Constant
n : Constant
T : concentration time

3) Calculation results

The catchment areas and river gradient slopes for bridge sites are measured based on the topographic map. Then, the probable discharges obtained by the rational method and the triangular hydrograph method are listed in Table 6.3.4. (Appendix B shows the calculation tables obtained with the triangular hydrograph method for various return periods.)



Year	T<1 a	n	1<T a	n
10	67.5	0.431	67.5	0.724
25	76.9	0.434	76.9	0.720
50	83.6	0.440	83.6	0.717

Figure 6.3.6 Rainfall Intensity Curves

Table 6.3.4 Probable Discharges at the Sites

Peak Discharge by Rational Formula

Basin No.	River Name	Area (ha)	Peak Discharge (m^3/s) 10	25	50
1	Arroyo. Santa Rita	307	18	21	22
2	Arroyo. Piraty	962	39	45	49
3	Arroyo. Tulio	1,345	43	49	53
4	Arroyo. Tororo	6,838	85	97	106
5	Arroyo Pirayuby	3,910	86	99	108
6	Arroyo. Pachongo	954	33	38	42
7	Arroyo. Tacuaremboy	1,298	35	40	44
8	Arroyo. Caundy	2,013	36	41	45
9	Rio Tebicuary-mí	380,000	1,296	1,500	1,649
10	Arroyo. Jhy	2,338	47	54	58
11	Arroyo. Rory	1,760	57	65	71
12	Arroyo. Rory-mí	922	42	48	52
13	Arroyo. Tebicuary-mí	23,177	214	246	269
14	Arroyo. Tebicuary-mí	30,000	222	256	280

Peak Discharge by Triangular Hydrograph Method

Basin No.	River Name	Area (ha)	Peak Discharge (m^3/s) 10	25	50
1	Arroyo. Santa Rita	307	15	21	23
2	Arroyo. Piraty	962	36	47	56
3	Arroyo. Tulio	1,345	42	55	66
4	Arroyo. Tororo	6,838	98	126	148
5	Arroyo Pirayuby	3,910	90	117	138
6	Arroyo. Pachongo	954	33	43	51
7	Arroyo. Tacuaremboy	1,298	37	49	58
8	Arroyo. Caundy	2,013	42	54	64
9	Río Tebicuary-mí	380,000	1,211	1,549	1,821
10	Arroyo. Jhy	2,338	52	68	80
11	Arroyo. Rory	1,760	55	72	86
12	Arroyo. Rory-mí	922	36	48	57
13	Arroyo. Tebicuary-mí	23,177	234	301	354
14	Arroyo. Tebicuary-mí	30,000	245	312	366

Source : JICA Study Team

(4) Water Level Calculation

1) Method

The Manning Formula is recommended to calculate the water level and velocity for open channels, culverts, conduits, side ditches, etc.

The Manning Formula

$$V=1/n\ R^{2/3}\ S^{1/2}$$

$$Q=AV$$

where,
n = is the roughness coefficient
R = hydraulic radius
S = hydraulic gradient
a = cross-section area

In streams with irregular cross sections, it is necessary to divide the water area into smaller but more or less regular subsections, assigning an appropriate roughness coefficient to each, then computing the discharge for each subsection separately.

2) Flood reservoir calculation for Río Tebicuary-mí

For Río Tebicuary-mí, another method is used, considering flood storage in the direct flood plain. This procedure is used to calculate the outflow hydrograph from a reservoir, given its inflow hydrograph and the characteristics of the outflow discharge-storage volume. The direct inundation area in the flood plain upstream of Tebicuray is assumed based on the water level reached during the flood in November 1994. (see Figure 6.3.3)

- Inflow hydrograph : Triangular Hydrograph Method (THM)
- Outflow discharge : Uniform calculation by the Manning formula (at the bridge site)
- Storage volume : Storage volume in the direct inundation area (supposed)

Table 6.3.5 shows the inflow discharge , water level , outflow discharge, and storage volume of the flood calculations for Río Tebicuray-mí .

- Inflow discharge : Inflow into the direct inundation area (by THM)
- Water level : Water level at the bridge site
- Outflow discharge : Discharge at the bridge site
- Storage volume : Storage volume by flooding

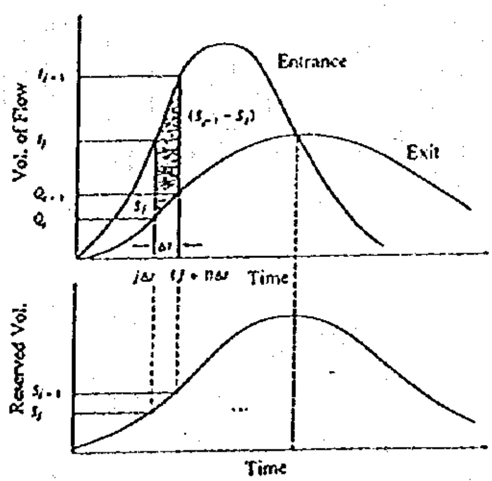


Figure 6.3.7 Relation to Flood Reservoir Calculations

3) Calculation result

Table 6.3.6 provides the design high water level at the bridge sites.

Table 6.3.5 Flooding Calculations Río Tebicuary-mí (1)

Day	Time	Inflow (m^3/s)	W.L (El.m)	Outflow (m^3/s)	Storage Volume (m^3)
1	0	40	99.83	3.6	65,528
1	1	80	99.93	8.5	259,816
1	2	121	100.09	16.4	576,900
1	3	161	100.30	27.1	1,006,200
1	4	202	100.57	40.4	1,538,032
1	5	242	100.85	57.9	2,160,354
1	6	282	101.08	83.4	2,849,363
1	7	323	101.33	110.7	3,588,998
1	8	363	101.59	139.7	4,372,974
1	9	404	101.83	167.2	5,201,049
1	10	456	101.96	186.9	6,111,692
1	11	507	102.10	208.9	7,132,777
1	12	560	102.27	233.1	8,257,785
1	13	611	102.44	259.5	9,478,795
1	14	663	102.63	287.8	10,786,885
1	15	714	102.81	316.3	12,178,130
1	16	766	102.92	336.8	13,666,442
1	17	818	103.04	358.8	15,265,448
1	18	870	103.17	382.3	16,969,768
1	19	922	103.30	407.2	18,774,302
1	20	987	103.44	433.7	20,697,038
1	21	1,052	103.60	462.1	22,754,920
1	22	1,117	103.76	492.2	24,941,398
1	23	1,182	103.88	518.2	27,260,810
2	0	1,248	104.00	544.0	29,722,772
2	1	1,313	104.12	571.2	32,325,130
2	2	1,378	104.24	599.9	35,060,964
2	3	1,443	104.38	629.8	37,925,344
2	4	1,509	104.52	661.1	40,915,276
2	5	1,540	104.66	693.0	43,966,044
2	6	1,571	104.80	725.0	47,013,440
2	7	1,602	104.89	751.9	50,066,392
2	8	1,634	104.99	779.1	53,135,332
2	9	1,665	105.08	806.4	56,219,672
2	10	1,696	105.17	833.8	59,317,152
2	11	1,727	105.27	861.3	62,427,360
2	12	1,758	105.36	890.4	65,547,292
2	13	1,789	105.46	920.3	68,672,608
2	14	1,821	105.55	950.3	71,803,496
2	15	1,814	105.64	979.7	74,872,512
2	16	1,807	105.73	1,007.9	77,812,728
2	17	1,800	105.81	1,030.8	80,635,816
2	18	1,793	105.84	1,039.0	83,377,744
2	19	1,786	105.88	1,047.0	86,065,304
2	20	1,779	105.91	1,054.8	88,699,088
2	21	1,772	105.94	1,062.5	91,279,672
2	22	1,765	105.97	1,069.9	93,807,840
2	23	1,758	106.00	1,077.3	96,284,152
3	0	1,740	106.03	1,084.5	98,689,248
3	1	1,722	106.06	1,091.4	101,004,176
3	2	1,705	106.09	1,098.1	103,231,696
3	3	1,687	106.12	1,104.5	105,372,736
3	4	1,670	106.14	1,110.6	107,428,216
3	5	1,652	106.17	1,116.5	109,399,056
3	6	1,634	106.19	1,122.1	111,284,368
3	7	1,617	106.21	1,127.5	113,086,856

Table 6.3.5 Flooding Calculation, Río Tebicuary-mí (2)

Day	Time	Inflow (m^3/s)	W.L (El.m)	Outflow (m^3/s)	Storage Volume (m^3)
3	8	1,600	106.24	1,132.6	114,809,200
3	9	1,582	106.26	1,137.6	116,450,456
3	10	1,557	106.28	1,142.2	117,997,168
3	11	1,533	106.29	1,146.5	119,439,600
3	12	1,509	106.32	1,152.7	120,776,624
3	13	1,484	106.35	1,160.0	122,001,120
3	14	1,460	106.38	1,166.6	123,112,368
3	15	1,436	106.40	1,172.6	124,114,456
3	16	1,412	106.43	1,178.0	125,009,704
3	17	1,387	106.45	1,182.7	125,798,600
3	18	1,363	106.46	1,186.8	126,483,400
3	19	1,339	106.48	1,190.2	127,068,304
3	20	1,306	106.49	1,193.1	127,539,368
3	21	1,274	106.50	1,195.2	127,884,520
3	22	1,242	106.50	1,197.3	128,106,928
3	23	1,210	106.51	1,198.9	128,207,488
4	0	1,178	106.50	1,198.9	128,189,968
4	1	1,145	106.50	1,197.4	128,058,072
4	2	1,113	106.50	1,195.1	127,815,968
4	3	1,081	106.49	1,193.0	127,466,672
4	4	1,049	106.48	1,190.3	127,010,856
4	5	1,016	106.46	1,187.0	126,448,832
4	6	984	106.44	1,182.9	125,783,080
4	7	951	106.43	1,178.3	125,015,840
4	8	919	106.40	1,173.2	124,149,072
4	9	887	106.38	1,167.5	123,186,680
4	10	854	106.35	1,161.2	122,128,920
4	11	821	106.32	1,154.3	120,976,016
4	12	789	106.30	1,147.7	119,730,400

6-3-5 Hydraulic Structures Inventory

(1) General

For the proposed road alignment, the proposed hydraulic structures type and sizes such as the bridges, culverts and pipe drains on the Interim stage are checked while considering the following:

- Size and type of the hydraulic structures of the existing road and the López Railway
- Waterways width and discharge capacity at the structure site
- Inundation water level determined through interviews
- Bridge design

Especially, the structure type and size of the López Railway is referred to for the segment over which the railway and the proposed road run parallel. Table 6.3.7 shows the position, structure type, and size of the López Railway.

Table 6.3.6 Design High Water Level at the Sites

River Name	Design H.W.L	Discharge Capacity	Dischrge(Q) by		Hydraulic Conditions and Remarks
			Rational	T.H.M.	
Arroyo Tulio	El. 121.5	55	49	55	
Arroyo Tororo	El. 138.2	150	106	148	
Arroyo Pirayuvy	El. 138.5	142	108	138	
Arroyo Pachóng	El. 141.9	52	38	51	The discharge capacity of railway structure is checked.
Arroyo Caundy	El. 118.5	64	45	64	
Rio Tebicuary Mí	El. 106.5	1,190 (**)	1,500	1,821	The water level is regulated by the flood plain storage. The experienced maximum water level was El. 106.5 m on the flood of 1983 and 1994.
Arroyo Tebicuary Mí (upstream)	El. 119.3 (*)	102 (***)	269	354 (*)	The flood plain exists in the upstream 2.5 km of the bridge site. Inundation W.L by the interview was 0.2 m below the bridge surface during the flood in November 1994.
Arroyo Tebicuary Mí (Existing Bailey bridge site)	El. 107.2 (*)	328 (***)	280	358 (*)	The dischage is regulated by 2 flood plains in the upstream of the bridge site. The water level rises up by back water of Río Tebicuary -mí. Based on the interview, the flood water level during the flood in 1994 was El. 107.2 m below the Bailey bridge.

Note : * El. 119.3 and El.107.2 of experienced maximum W.L are adopted as D.H.W.L
** reduced by flood plain
*** Q will be more reduced by flood plain

Table 6.3.7 Cross Structures of the López Railway

No.	Location*	Type of Structure	Section	Length (m)	Station
183	101.820	Pipe Culvert		0.70	Caballero
184	102.320	Timber Bridge	2	6.50	
185	103.445	Pipe Culvert		1.00	
186	105.035	Timber Bridge	3	15.05	
187	105.150	Timber Bridge	2	9.35	
188	105.905	Timber Bridge		4.55	
189	107.235	Timber Bridge		10.00	
190	109.025	Wooden Culvert		3.53	
191	109.490	Concrete Pipe Culvert		1.00	
192	109.815	Wooden Box Culvert		0.35	
193	111.570	Covered Culvert		4.00	Ybytimí
194	112.270	Timber Bridge		13.80	
195	112.550	Pipe Culvert		0.70	
196	115.012	Timber Bridge	2	9.50	
197	115.280	Timber Bridge	2	8.50	
198	115.675	Timber Bridge		4.96	
199	117.470	Timber Bridge	4	15.20	
200	117.535	Timber Bridge	3	13.70	
201	118.680	Timber Bridge		5.35	
202	119.835	Wooden Box Culvert		0.57	
203	121.455	Timber Bridge		6.30	
204	121.870	Timber Bridge		4.85	
205	125.350	Concrete Culvert		2.20	
206	125.715	Covered Culvert		5.00	
207	126.500	Masonry Bridge	10	213.30	Tebicuary
208	126.790	Timber Bridge	4	21.90	
209	127.712	Timber Bridge	5	27.55	
210	128.000	Timber Bridge	7	33.95	Martínez

Source : Carlos Antonio López Railway
Note : Location of stations - Caballero (101.4 km), Ybytimí (109.9 km), Tebicuary (125.8 km)

(2) Inventory

An inventory of hydraulic structures such as bridges, box culverts, and pipe drains is provided in Table 6.3.8. The inventory contains the distance based on the longitudinal section survey, structure type, size, etc. The size of box culvert is set at 3m×3m. The size of the pipe drain is set as ϕ 1,200 mm. The inventory should on the next stage be revised.

Table 6.3.8 Hydraulic Structures Inventory (1)

No.	Distance	Ground Elevation	Structure Type	Length(m)	Remark
Section : Paraguarí to Villarrica					
Segment 1 : Paraguarí - Escobar - Sapucaí					
1	3,193,000	115.455	Culvert		
2	3,709,000	122.443	Culvert		
3	3,888,000	123.051	Culvert		
4	4,309,300	126.649	Culvert		
5	4,526,500	128.558	Culvert		
6	5,455,200	132.819	Culvert		
7	5,688,000	134.072	Culvert		
8	5,929,300	134.917	Culvert		
9	6,779,300	133.270	Culvert		
10	7,745,400	134.686	Culvert		
11	8,186,200	134.435	Culvert		
12	9,652,500	130.496	Culvert		
13	10,195,000	123.445	Culvert		
14	10,609,300	121.646	Culvert		
15	10,874,500	120.904	Culvert		
16	11,088,300	119.545	Culvert		
17	11,470,500	120.559	Culvert		
18	11,609,000	119.911	Culvert		
19	11,754,000	120.551	Culvert		
20	11,978,000	120.854	Culvert		
21	12,212,000	119.809	Culvert		
22	12,718,000	121.661	Culvert		
23	12,984,000	121.416	Culvert		
24	13,322,000	121.209	Culvert		
25	13,456,000	121.253	Culvert		
26	13,987,500	122.933	Culvert		
27	14,102,600	121.791	Bridge	10	BST 1
28	15,507,000	129.515	Culvert		
29	16,525,000	123.451	Culvert		
30	16,762,000	122.758	Culvert		
31	17,055,000	125.081	Culvert		
32	17,609,000	127.769	Culvert		
33	17,933,000	126.552	Culvert		
34	18,136,500	125.690	Culvert		
35	18,540,500	127.525	Culvert		
36	19,180,000	127.901	Culvert		
37	19,222,200	127.827	Culvert		
38	19,720,500	131.221	Culvert		
39	20,063,400	133.365	Culvert		
40	20,432,000	143.528	Culvert		
41	20,510,000	138.954	Culvert		
42	20,735,500	139.254	Culvert		
43	21,860,000	177.134	Culvert		
Segment 2 Sapucaí - Caballero					
44	27,734,000	158.092	Drain (P)		
45	28,016,000	154.863	Drain (P)		
46	28,139,000	155.274	Drain (P)		
47	29,228,000	145.766	Drain (P)		
48	29,600,000	145.103	Drain (P)		
49	33,584,000	138.450	Bridge	25	BST 2
Segment 3 Caballero - Ybytimí					
50	34,020,000		Drain (P)		
51	34,200,000		Drain (P)		
52	35,260,000		Drain (P)		
53	37,040,500	139.437	Bridge	20	BST 3
54	38,120,000		Culvert	5	
55	39,238,500	141.510	Bridge	15	
56	40,530,000		Culvert	5	
57	41,440,000		Drain (P)		
58	41,750,000		Drain (P)		

Table 6.3.8 Hydraulic Structures Inventory (2)

No.	Distance	Ground Elevation	Structure Type	Length(m)	Remark
Segment 4 Ybytimí - Punto Unido					
59	47,014,500	129.794	Culvert	30	BST4
60	47,288,500	128.477	Bridge	10	
61	47,682,000	127.832	Bridge	10	
62	49,465,200	119.266	Bridge	5	
63	49,544,520	119.152	Bridge	15	BST5
64	50,679,000	120.040	Bridge	15	
65	50,979,000	120.671	Bridge	10	
Segment 5 Punto Unido - Tebicuary					
66	53,456,000	116.480	Culvert		
67	53,867,000	117.950	Culvert		
68	54,334,000	118.892	Culvert		
69	54,674,500	120.539	Culvert		
70	55,355,000	120.635	Culvert		
Segment 6 Tebicuary - Cnel. Martínez					
71	58,549,000	105.168	Bridge	215	Río Tebicuary-mí
72	59,500,000		Bridge	30	New Location
73	60,100,000		Bridge	30	New Location
74	60,500,000		Bridge	30	New Location
Segment 7 Cnel. Martínez - Cardozo					
75	64,542,000	112.114	Culvert		
76	64,933,200	113.186	Culvert		
77	65,810,000	113.235	Culvert		
78	66,117,000	113.312	Bridge	5	
79	70,620,000	131.113	Culvert		
Segment 8 Cardozo - Villarrica					
80	75,222,700	149.188	Drain (P)		
81	75,875,000	147.955	Drain (P)		
82	76,574,000	141.454	Drain (P)		
83	76,731,600	140.744	Bridge	5	
84	77,174,000	141.031	Drain (P)		
85	77,352,300	141.840	Drain (P)		
86	77,735,000	142.670	Drain (P)		
87	78,112,200	144.442	Bridge	5	
88	78,765,000	146.471	Drain (P)		
89	79,850,000	146.270	Culvert		
90	80,049,000	145.885	Drain (P)		
91	80,849,000	158.694	Drain (P)		
92	81,249,000	156.918	Culvert		
93	82,249,000	161.942	Drain (P)		
Section : La Colmena to Tebicuary					
Segment 1 Empalme - No 253+00					
1	925,000	175.990	Drain (P)		
2	3,327,500	166.773	Culvert		
3	3,462,000	167.773	Drain (P)		
4	4,972,000	152.139	Drain (P)		
5	5,330,000	146.128	Drain (P)		
6	7,968,000	144.416	Drain (P)		
7	9,422,300	141.206	Drain (P)		
8	9,635,000	138.725	Drain (P)		
9	10,089,000	137.763	Drain (P)		
10	10,534,500	138.382	Drain (P)		
11	10,707,300	134.299	Drain (P)		
12	11,742,000	126.905	Drain (P)		
13	12,030,800	125.195	Drain (P)		
14	12,300,000	123.229	Drain (P)		
15	13,192,500	117.740	Bridge	10	
16	14,352,000	115.776	Culvert	5	
17	14,948,200	115.924	Bridge	10	

Table 6.3.8 Hydraulic Structures Inventory (3)

No.	Distance	Ground Elevation	Structure Type	Length(m)	Remark
Segment 2 No 253+00 - No 277+00					
18	17,756,000	106.847	Bridge	15	
19	18,190,000	106.738	Bridge	10	
20	18,502,500	106.821	Bridge	15	
Segment 3 No 277+00 - Tebicuary					
21	19,535,500	109.066	Bridge	50	Ao Tebicuary-mf
22	22,390,000	108.935	Bridge	10	
23	22,690,800	108.935	Bridge	10	
24	24,352,000	107.591	Bridge	5	
25	24,682,000	107.700	Culvert		
26	25,966,500	114.529	Bridge	5	
Section : La Colmena - Empalme - Punto Unido					
Segment 1 La Colmena - Empalme - No 162					
1	2,105,300	151.077	Bridge	15	Ao Tranqera
2	4,484,000	156.841	Culvert		
3	6,396,500	147.221	Bridge	10	Ao Rory
4	6,448,500	146.647	Drain (P)		
5	6,597,000	146.496	Drain (P)		
6	7,428,000	146.997	Drain (P)		
7	9,733,700	159.772	Drain (P)		
8	10,200,000		Drain (P)		
9	11,262,500	143.366	Drain (P)		
10	11,326,500	142.826	Drain (P)		
11	12,207,500	137.687	Drain (P)		
12	12,424,500	136.366	Drain (P)		
13	13,067,000	132.455	Drain (P)		
14	14,542,000	127.922	Drain (P)		
15	15,432,000	124.204	Drain (P)		
16	16,112,000	119.488	Drain (P)		
Segment 2 No 162 - No 178					
17	16,421,000	119.799	Bridge	15	Ao Tebicuary-mf
18	16,934,000	119.260	Culvert		
19	17,197,000	119.121	Drain (P)		
20	17,312,000	119.205	Drain (P)		
Segment 3 No 178 - Punto Unido					
21	21,555,000	135.733	Drain (P)		
22	22,759,700	142.325	Drain (P)		
23	23,360,700	141.144	Drain (P)		
24	23,530,000	140.016	Drain (P)		
25	23,772,000	139.441	Drain (P)		
26	24,010,000	138.153	Drain (P)		
27	24,241,200	138.731	Drain (P)		
28	26,109,000	126.823	Drain (P)		
29	26,600,000	122.910	Drain (P)		

Source : JICA Study Team