10. FORMULATION OF ROAD DEVELOPMENT PLANS

10.1 ESTABLISHMENT OF ROAD DESIGN STANDARDS

10.1.1 Characteristics of Roads Covered by the Plan

Roads covered by this plan can be generally categorized into two types. These are roads that form the framework of the targeted region and roads that provide access to port facilities.

There are two roads forming the framework of the targeted region, one is the Paraná River Coastal Road which runs parallel to the Paraná River and the other is extension of National Road Route 15, on the eastern side of Paraguay.

There are 9 access roads to the port facilities along the Paraná River coast. These roads are to access the ports for grain export from the Paraná River Coastal Road and from National Road Route 6.

(1) Importance of these roads in the context of the domestic road network

1) Paraná River Coastal Road

In Paraguay, Routes 1 through 12 are designated as national roads by law. However, this designation of a 12 national road network is inadequate. The definition of national roads in Paraguay is important roads straddling two or more provinces and those which connect to train stations or ports. However, there are many roads that actually meet these standards besides the 12 designated routes, and these roads are treated as byways. MOPC is in charge of the construction and maintenance of national roads, byways, and local roads, and byways are handled as national roads, for all practical purposes.

This road begins approximately 70 km north of Encarnación at the branch of Route 6, connects with Route 7 at Ciudad del Este, and continues northward to Salto del Guaira, the capital of Canindeyu. This road is a main highway connecting the province capitals of Canindeyu, Alto Paraná, and Itapúa located along the Paraná River in eastern Paraguay, and is regarded as a supporting road.

2) Road extending from Route 15

This road is part of a major road connecting Paraguari, Guairá, and Caazapá on the eastern side of Paraguay with Itapúa on the Paraná River. This road is also an important road as it provides access to an export gate and to Caazapá, an underdeveloped region in Paraguay. The road extending from Route 15, which is the road under this plan, is located between Route 6 and the Paraná River Coastal Road.

3) Port access roads

These roads provide access to the port facilities, which are important export gates for Paraguay, and are to be developed as roads that will allow safe use by large trucks as well as to be regional service roads.

(2) Importance in international road network

1) IIRSA

Many South American countries are located next to each other, and the IIRSA was proposed as a means to move from inefficient individual development on a country basis to more streamlined development. IIRSA classifies South America into 9 comprehensive hubs in order to enable comprehensive development of infrastructure across South America, and for each of these hubs, development plans are being considered in 7 fields.

The areas covered by this survey are the regions neighboring Brazil and Argentina, and are positioned in the IIRSA as the Capricorn Hub and the Paraguay-Paraná Waterway Hub. The road in this plan is an important transportation facility within these hubs.

2) Capricorn Hub

A major subject in transportation-related development in the regions that fall along the Tropic of Capricorn is the development of the Interoceánico transport facility in these regions.

A proposal is in the works for the development of a transport route, including a road and railroad, which would connect Chile (Antofagasta) on the Pacific Ocean side and Brazil (Paranágua) on the Atlantic side of this region. The road runs between Antofagasta, Paso de Jama, Jujuy, Resistencia (in Paraguay), Poz Iguazu, Curitiba, and Paranágua.

Within Paraguay, the Asunción route and Encarnación routes are considered, and these routes would form part of the Encarnación route.

Asunción route
The route connecting Ciudad del Este, Asunción, and Resistencia is the principal route connecting the capitol of Asunción and the second largest city of Ciudad del Este, and currently forms Routes 2 and 7 inside Paraguay. From Asunción it crosses the Paraguay River reaching the border with Argentina and connects to Resistencia via Formosa.

Encarnación route
This route connects Ciudad del Este, Encarnación (Posada), Pilar, and Resistencia, major cities along the Paraná River, and the port facilities. The road studied under this plan which runs along the Paraná River forms one part of this route.

3) Paraguay-Paraná Waterway Hub

Major proposed subjects of transportation-related development in the regions along the Paraná River and Paraguay River are the maintenance and operation of river transportation and improvements of the ports that are located along these rivers and the roads connect to them.

Roads providing access to the port facilities in this survey can be regarded as transportation-related infrastructure in the area of Paraguay-Paraná Waterway Hub within Paraguay.

10.1.2 Establishment of road design standards

(1) Road specifications and design speed

1) Paraná River Coastal Road

This road has the following characteristics.

- This road connects existing port facilities interspersed along the Paraná River, and enables efficient port management.
- It is a main road connecting the provinces of Canindeyu-Alto Paraná-Itapúa.
- It forms a link of the Interoceánico road in the IIRSA Capricorn Hub.

Given these characteristics, the road design standard is set at 100 km/h, equivalent to that for the national roads in Paraguay. However, for now the design speed will be set one corresponding to the current shape of the road, in the currently used sections.

2) Road extending from Route 15

Route 15 is a road that extends from the capital of Asunción to Paraguari, Guairá, Caazapá and finally to Itapúa. Parts of the road from Tavai in Caazapá to the Paraná River in Itapúa are developed, but the majority of this road is still undeveloped. The road under this plan is an important road connecting Caazapá, an underdeveloped province in eastern Paraguay, and the ports along the Paraná River.

Given the characteristics of this road, the design speed will be set at 80 km/h.

3) Port access roads

Most access roads are 20 km or less in length, and the impact of speed on reducing time would be minimal. It is also important that these roads function as safe passages for trucks carrying grain exports to reach the port facilities. Considering these factors, the design speed of access roads will be set at 50 km/h.

(2) Geometric structure standards

Geometric structure standards are generally based on AASHTO standards.

Table 10.1-1 Geometric structure standards

Item		Unit	Rio Parana coastal roads	Road extending from Route 15	Port access roads
Design speed		km/h	100	80	50
Minimum curve radius		m	460	260	90
Steepest longitudinal gradient	Flat	%	3	4	6
	Rolling	%	4	5	7
	Mountainous	%	6	7	9

10.2 INVESTIGATION OF NUMBER OF LANES, CROSS-SECTION STRUCTURE

10.2.1 Study on number of lanes

The general practice for determining the number of lanes is to obtain figures on the planned traffic volume for the particular road and compare those figures with the planned standard traffic volume. For the road in this plan, the number of lanes will be set to two, given the expected maximum volume of 3,500 vehicles/day.

Table 10.2-1 Number of lanes

Road name	Planned traffic volume (max.)	No. of lanes
Paraná River Coastal Road	2,930 cars/day	2
Road extending from Route 15	1,310 cars/day	2
Port access roads	3,530 cars/day	2

10.2.2 Study on road cross-section structure

In Paraguay, the following standard cross-section is proposed for national road-class roads based on previous examples of construction.

- Road: width 6.50 m, cross slope 2.0%
- Lane: width 3.25 m, cross slope 2.0%
- Shoulder: width 2.50 m, cross slope 4.0%
- Embankment cross slope: h<2m, v=1, h=3
  h>2m, v=2, h=3
- Cut earth cross slope:v=1, h=1
  Bridges: total width 10.0 m, road width 8.0 m, wheel guard width 1.0 m

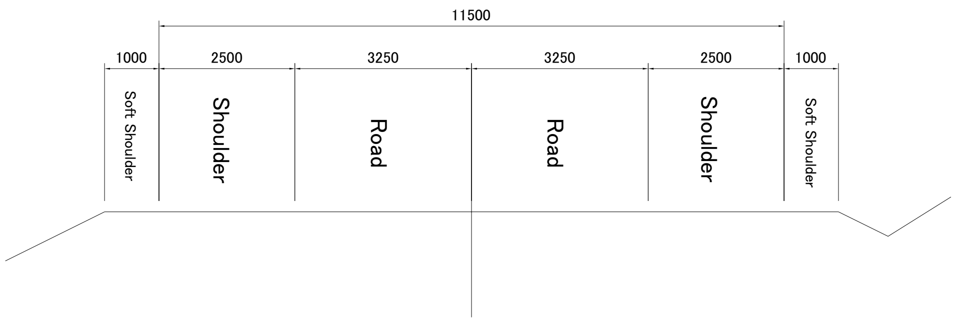
This cross-section configuration will also be the referenced standard for this plan.

1) Paraná River Coastal Road

・Earthwork

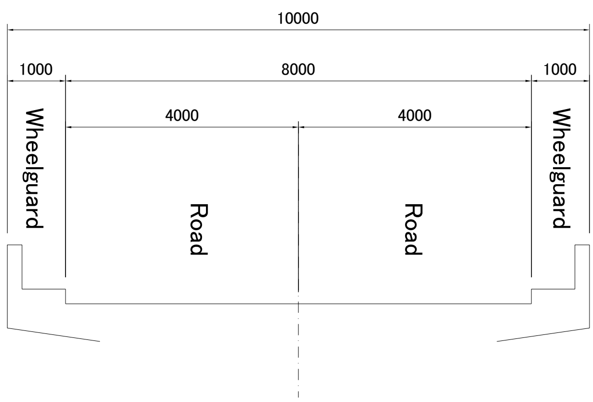
Road width:As mentioned earlier, the road running along the Paraná River is considered as both a link in the international road network and as a main road. Large trucks use it with great frequency and the design speed is fast, at V=100 km/h. Therefore, the road width of the road will be set at 3.25 m in accordance with the standards given above.

Shoulder width:Given the characteristics of this road and the possibility of large trucks stopping on the shoulder of the road, due to breakdowns or other trouble, the shoulder width is set at 2.50 m, in accordance with the standards given above.



・Bridges

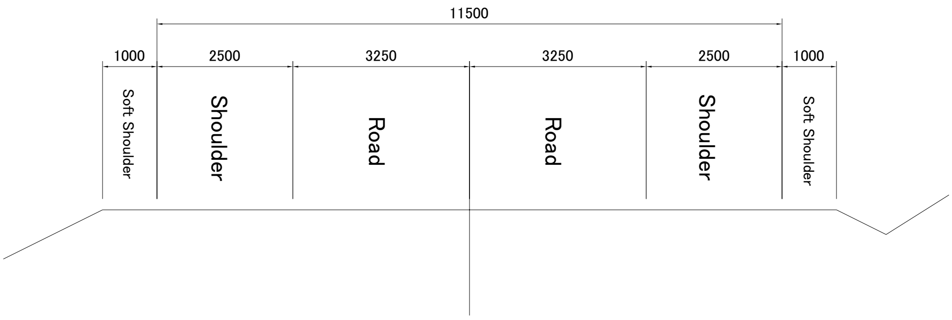
For the width of bridges, the standard is for a roadway width of 4.0 m including the shoulder. Looking at the breakdown of this figure, if the road width is set at 3.25 m, the shoulder width would be 0.75 m. This will allow sufficient width for a large truck. Therefore, the road width will be set in accordance with the standard.



2) Road extending from Route 15

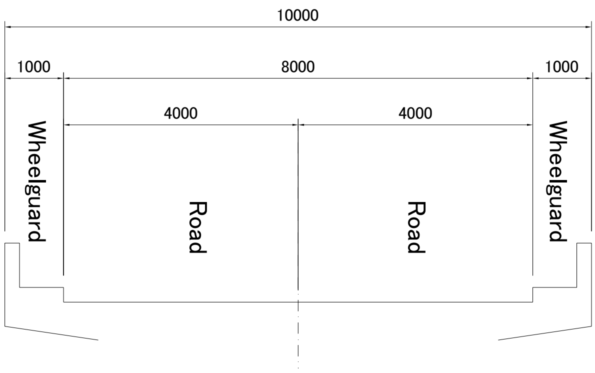
・Earthwork

This plan road will become Route15 in the future. The road width assumes it the road width same as Parana River Coastal Road. The cross-section is as shown below.



・Bridges

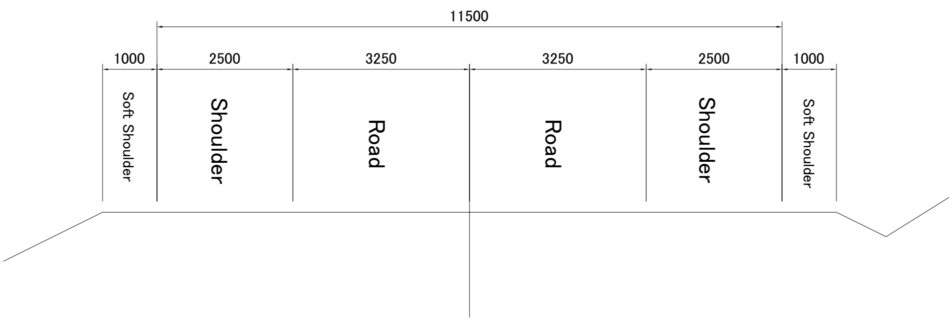
The width of bridges will be in accordance with standards, since, unlike earthwork, changing the existing width would be difficult.



3) Port access roads

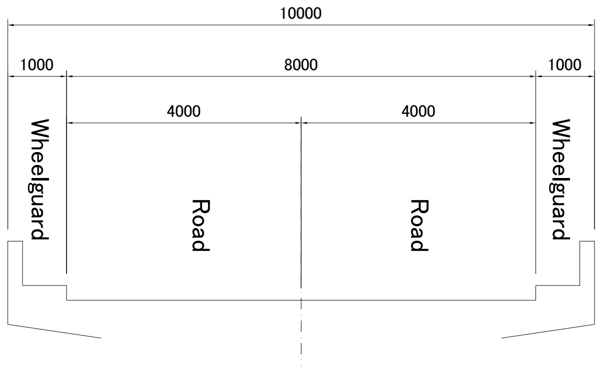
・Earthwork

Port access roads are regional main roads connecting main roads and port facilities, and as such, the goal is not to obtain ease of traveling or reduced travel time, but rather to ensure the safe transport of grain, even during rainy conditions. Therefore, the width of roads in the road configuration will be set at 3.25 m, a width allowing sufficient room for large trucks , as shown below. The shoulder width will be set at 2.5 m, in consideration for the possibility of large trucks stopping on the shoulder of the road due to breakdowns or other troubles.



・**Bridges**

Since there is a great volume of large truck traffic, access roads should be a width that will allow for such traffic. Therefore, the width of bridges will be in accordance with the standards given in the section on roads along the Paraná River.



10.3 DISCUSSING ALTERNATIVE ROUTES

Possible alternative routes between the following seven districts are compared.

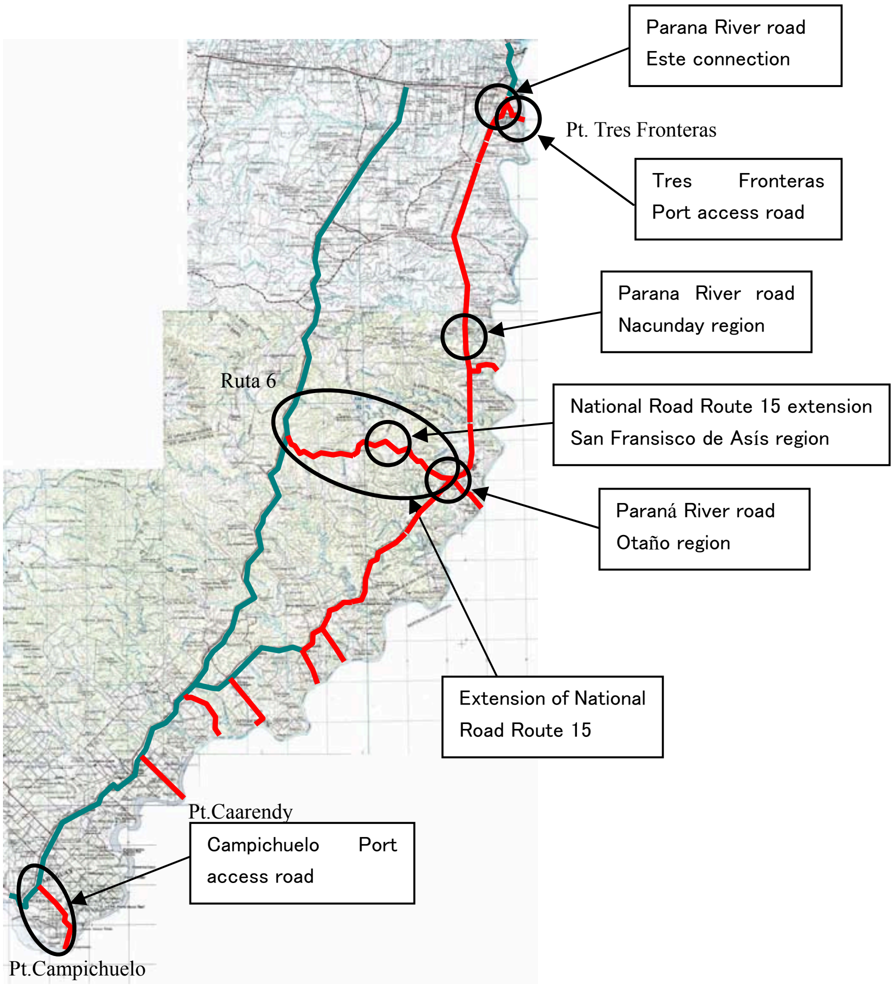


Figure 10.3-1 Area considered for route alternatives

10.3.1 Parana River Coastal Road

(1) Ciudad del Este region

1) Alternative Routes

Assuming the construction of the new Amistad Bridge as a prerequisite, the following five alternative routes were deemed possible given the relation of existing roads, and in consideration of this route as a national route within the national road system plan (Itapúa – Alto Paraná – Canindeyu).

Alternative 1: Upgrading existing roads

This proposal consists of upgrading existing roads, and while it would require the renovation of the bridge over the Monday River at some point in the future, the present bridge should be able to handle the traffic for the near term.

Alternative 2: Direct connection to the Alto Paraná – Canindeyu road (1)

A plan root is a plan to let the Alto Paraná – Canindeyu road connect directly.A route used an existing way from Prte.Franco to about 5.6km sections,.included Monday River of existing bridge.

Alternative 3: Direct connection to the Alto Paraná – Canindeyu road (2)

A plan root is a plan to let the Alto Paraná – Canindeyu road connect directly. On Monday River, I planned a bridge newly. One part of the plan roots assumed it a plan using section existing way.

Alternative 4: Direct connection to the Alto Paraná – Canindeyu road (3)

A plan root is a plan to let the Alto Paraná – Canindeyu road connect directly. On Monday River, I planned a bridge newly. I assumed it bypass plan without using an existing way.

Alternative 5: Direct connection with National Route 7

This alternative proposes using current high-tension power line rights-of-way to directly connect with National Route 7. High-tension power line rights-of-way currently do not have any roads running along them.

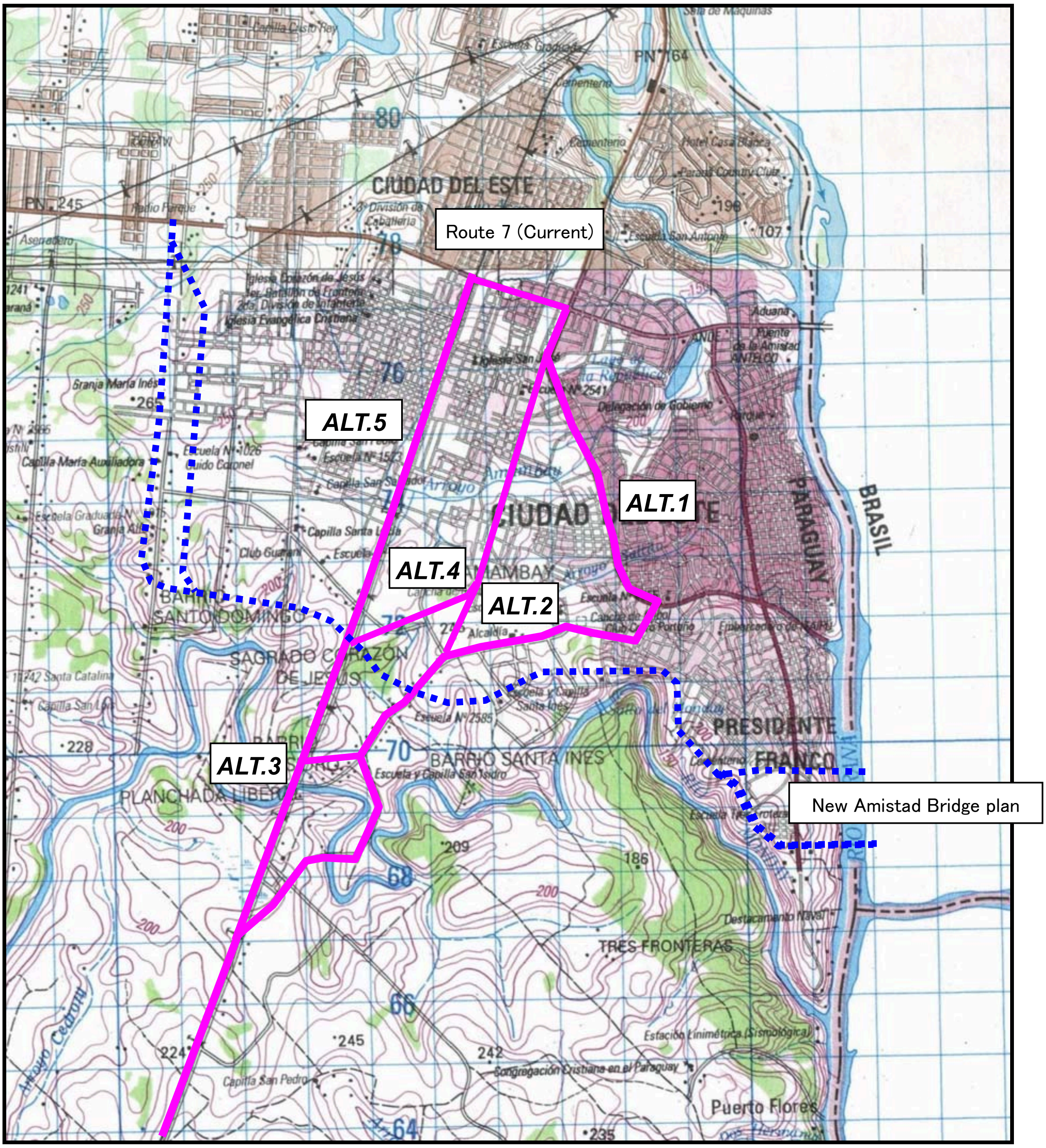


Figure 10.3-2 Ciudad del Este region alternative routes

2) Comparing alternative routes

Table 10.3-1 Alternatives comparison

Characteristics	Plan 1 Existing Route	Plan 2 Existing bridge	Plan 3 Existing road	Plan 4 New installation	Plan 5 High voltage cable
Total length	14.5	11.7	11.3	11.3	11.3
Horizontal alignment of the road	×	△	○	○	○
Vertical alignment of the road	△	△	○	○	○
Land acquisition (km)	0	1.0	2.0	2.2	0
Buildings	10	20	15	5	0
Construction cost	2.5	3.2	4.9	5.1	5.2
Road user and society costs millon$/ year	-1.7	-0.24	0	0	0
Length of the development section	0	4.9	8.6	10.2	10.7
Consistency with the urban development road	○	○	○	×	×
Request from the residents (*2)	○	△	△	×	×
Characteristics of the arterial road	×	△	○	○	△
Overall	×	△	○	○	△

*1 : Truck: 140,000 veh/year Passenger car: 4,000 veh/day

*2 : Opinions obtained in a residents meeting in Presidente Franco

Legend
○ Good
△ Normal
× Bad

Alternative Route Proposals:

Mainly five alternative plans were worked out on how to take the route through Presidente Franco City which is located next to Ciudad del Este, including a plan to use existing roads, a plan to use newly installed roads, and some combinations of the both. We compared and examined the characteristics of each route, and selected the Plan 3 from the following reasons:

a) It was superior to the Plan 1 and Plan 2 in addressing the issues of arterial road functions in terms of the total road length and road alignment.

b) Though the construction cost is higher than the Plan 1 and Plan 2 because of the installation of a new bridge, the road alignment is good, and the road length is short. Compared to the Plans 3, 4, and 5, the road user and society costs of the Plan 1 and Plan 2 is estimated to be 0.17 and 0.24

million US$ a year respectively. These costs and the construction cost taken into consideration, however, the difference will be negligible after 1.5 and 7 years of utilization of each road.

c) Since the section of a new road installation is long compared to the Plan 1 and Plan 2, it would make a large contribution to the urban development.

d) The Plan 4 and Plan 5 would decrease the convenience of the residents, because the routes are located away from the residential area.

e) Consistency with the urban development road of Presidente Franco City would be maintained.

f) Opinions of the residents are taken into account in this plan.

(2) Nacunday region

1) Alternative Routes

Two possible routes were considered given the current lay of the land.

Alternative 1: Upgrading existing roads

Current roads follow the ridges of the hills, and thus need almost no storm sewers. However, the route strays some 3.5km from the high-tension power line rights-of-way, taking a very major detour. Moreover, the current horizontal alignment of the road was designed to match the lay of the land, and thus it is a very curvy route. Consequently, the road must be improved to better meet design principles.

Alternative 2: Shortcut

This alternative would use the existing high-tension power line rights-of-way and cut across two valleys to make an almost straight route. Box culverts would be needed for the route to cut across the two valleys, and construction costs would also go up to account for the earthworks needed to build up or dig down to the roadbed. However, this would mean a shorter route, thus reducing automobile driving costs.

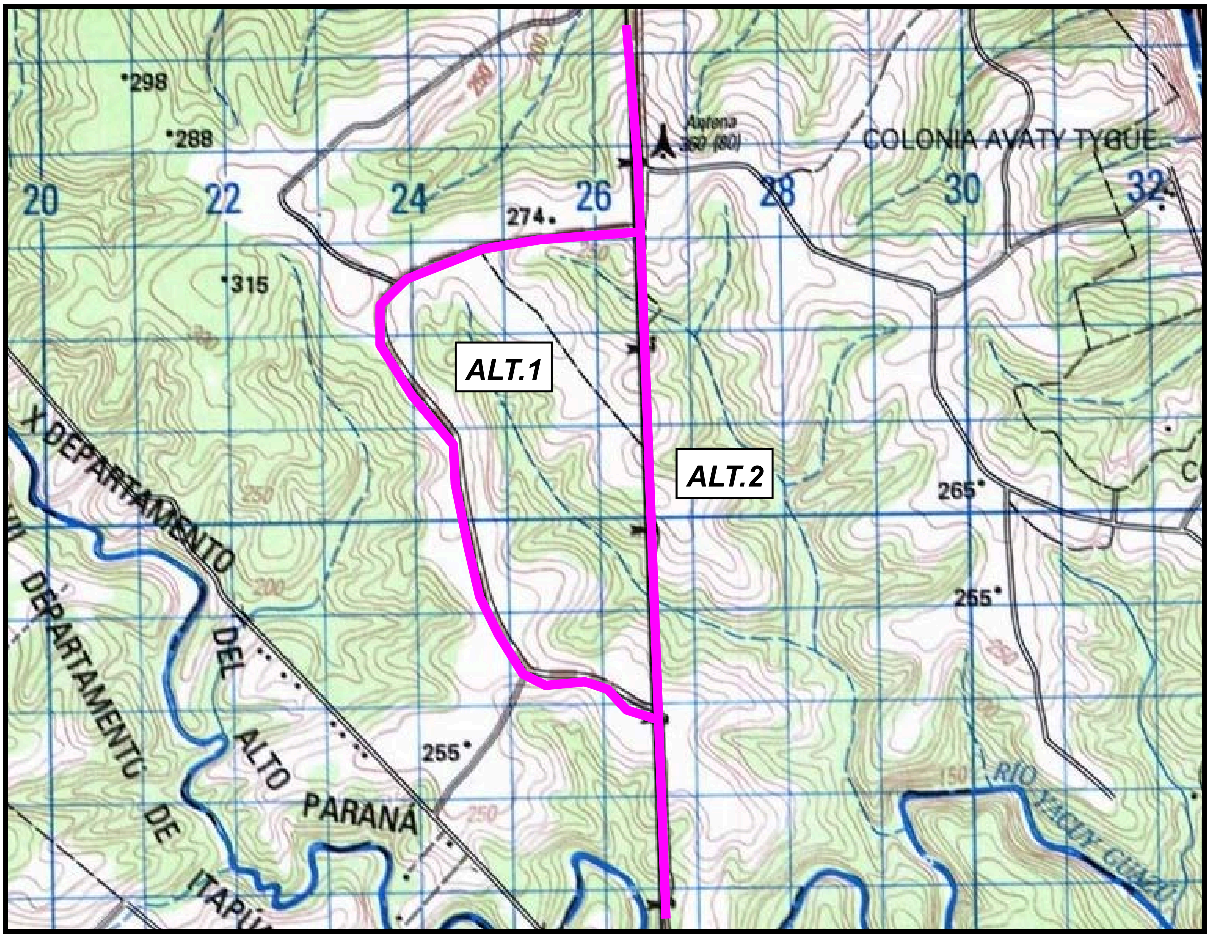


Figure 10.3-3 Nacunday region alternative routes

2) Comparing alternative routes

The routes were compared based on the three criteria of construction costs, environmental impact, and driving costs.

Table 10.3-2 Alternatives comparison

Comparison criteria		Unit	Alternative 1	Alternative 2
			Using present roads	Shortcut
Road extension		km	8.5	5.0
Construction cost	Earthworks	$1,000	303	1,400
	Paving	$1,000	1,241	730
	Structures (box culvert 2x2) 2places	$1,000	-	68
	Total construction costs	$1,000	1,544	2,198
Environment		—	Vicinity is agricultural land; no environmental problems or roadside environmental issues	Would involve cutting down forested valley areas. Otherwise, same as Alternative 1.
Driving costs	2,050 vehicles per year X 300 days X $0.43 per km	$1,000/yr	2,248	1,322
	Overall evaluation		△	○

Alternative 2 entails greater construction costs, but lesser maintenance and driving costs going forward, and given also that it involves no major environmental problems, it appears to be the optimal of the two.

(3) Otaño region

1) Alternative routes

Two alternative routes were considered in the vicinity of the Mayor Julio de Otaño and Carlos A. López villages, either the road following the high-tension power line rights-of-way, or a road branching off of that road.

Alternative 1: Use existing roads

The route would be some three to seven km away from the two villages of Mayor Julio de Otaño and Carlos A. López. Moreover, the route would also depart from the high-tension power line right-of-way to follow existing roads. This proposal would require new construction to link two roads in one area, which would require that land be purchased.

Alternative 2: Use the high-tension power line rights-of-way

This would use the current roads along the high-tension power line rights-of-way as much as possible to bring the route close to the urban areas along the rights-of-way. This proposal would require some land purchases to improve the route to meet design principles, and to connect with existing roads, and may also require that some residents be moved.

Figure 10.3-4 Otaño region alternative routes

2) Comparing alternative routes

Table 10.3-3 Alternatives comparison

Comparison criteria	Alternative 1	Alternative 2
	Using existing roads	Using high-tension power line rights-of-way
Road extension	14.0km	13.8km
Accessibility from roadside towns	Road would be 7.3km from Mayor Julio de Otaño and 5.4km from Carlos A. Lopez urban areas; low accessibility to planned road. Likewise low accessibility between the two towns.	Road would be 1km from Mayor Julio de Otaño and Carlos A. Lopez urban areas, improving accessibility to planned road, and accessibility between the two towns.
Land acquisition	Land acquisition required to change road's horizontal, vertical, and cross-sectional layout.	Some new road construction areas, requiring more land acquisition than Alternative 1.
Moving of current residents	No need to move residents.	A number of residents would need to be moved.
Other		Following hearings, roadside towns would like the road located as close to the urban areas as possible.
Overall evaluation	△	○

Though there would be some impact on the living environment along the road, this plan focuses on regional accessibility and promoting development, and from this standpoint, Alternative 2, the proposal to use the high-tension power line rights-of-way, was selected.

10.3.2 Extension of National Road Route 15

(1) Extension of National Road Route 15

1) Alternative Routes

National Road Route 15 is relatively developed from Villarrica in Guairá state through to Tavai in Caasapá state, but from Tavai until National Road Route 6, the specified road is missing as it has not yet been developed. The planned area for the National Road Route 15 extension in this survey goes from National Road Route 6 through to the presently planned road along the Paraná River, with the following two alternatives that use existing roadways.

Alternative 1: San Rafael del Paraná route

This route goes from the San Rafael intersection close to the border with the state of Alto Paraná, and goes through to the town of San Rafael de Paraná.

Alternative 2: Otaño route

Like Alternative 1, this route goes from the San Rafael intersection close to the border with the state of Alto Paraná, and goes through to the town of Mayor Julio D. Otoño.

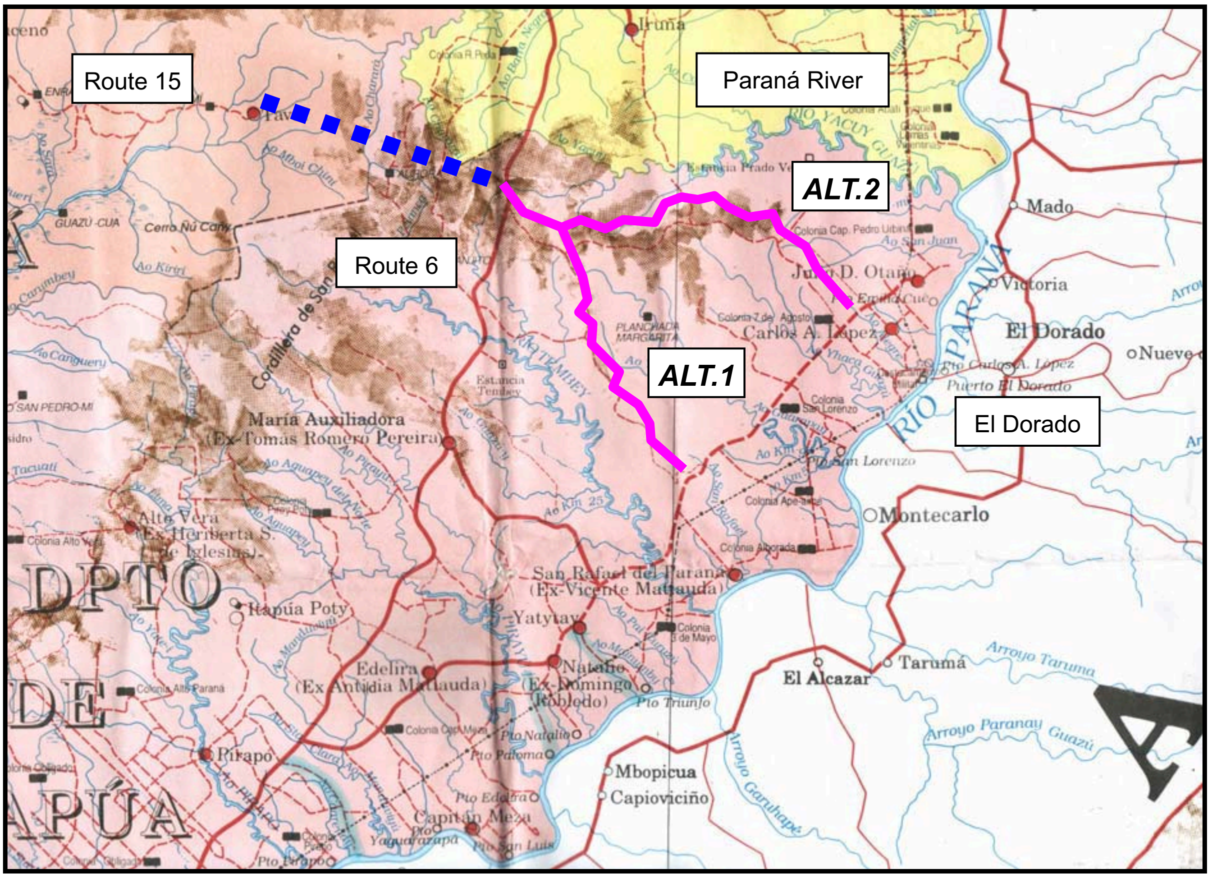


Figure 10.3-5 National Route 15 extension alternative routes

2) Alternative routes comparison

Table 10.3-4 Alternatives comparison

Item	Alternative 1 Paraná Route	Alternative 2 Otoño Route
Summary of plan	This route starts from San Rafael intersection close to the provincial border with Alto Paraná on Route 6 and reaches San Rafael de Paraná	This route starts from San Rafael Intersection on Route 6 which is close to the provincial border with Alto Paraná and reaches Mayor Julio D. Otoño
Length	45.0km	49.6km
Road network	Since Paraná is located near the starting point of the Export Corridor, this route is not so favorable as an access road to the Route 6 and the export corridor in terms of networking.	Since Otoño is located around the center of Export Corridor, this route is appropriate to access Route 6 and Export Corridor. In addition, faced with a major city of Argentina, El Drado across the river, the route is also advantageous for distribution of people and goods.
Accessibility to port facilities	This route is favorable access to such ports located on the side of the starting point of Export Corridor as Triunfo Port and Paloma Port.	With such ports as Dos Fronteras and Trocua located on the extension of this route and at the center of Export Corridor, it is an excellent access to ports and harbors.
Overall evaluation	△	○

Alternative 2 connects to Otaño Ferry Terminal at Paraná River and over the ferry terminal is a major city of northern Argentina, El Drado city across the river. This plan will adopt Alternative Plan 2 as an extension route over Route 15. in consideration of distribution of people and the form of network.

(2) San Francisco de Asís r*egion*

1) Alternative Routes

The road through this area branches in two, so this survey explored which of the two to take up for development.

Alternative 1: Lowlands route

Alternative 2: Ridgeline route

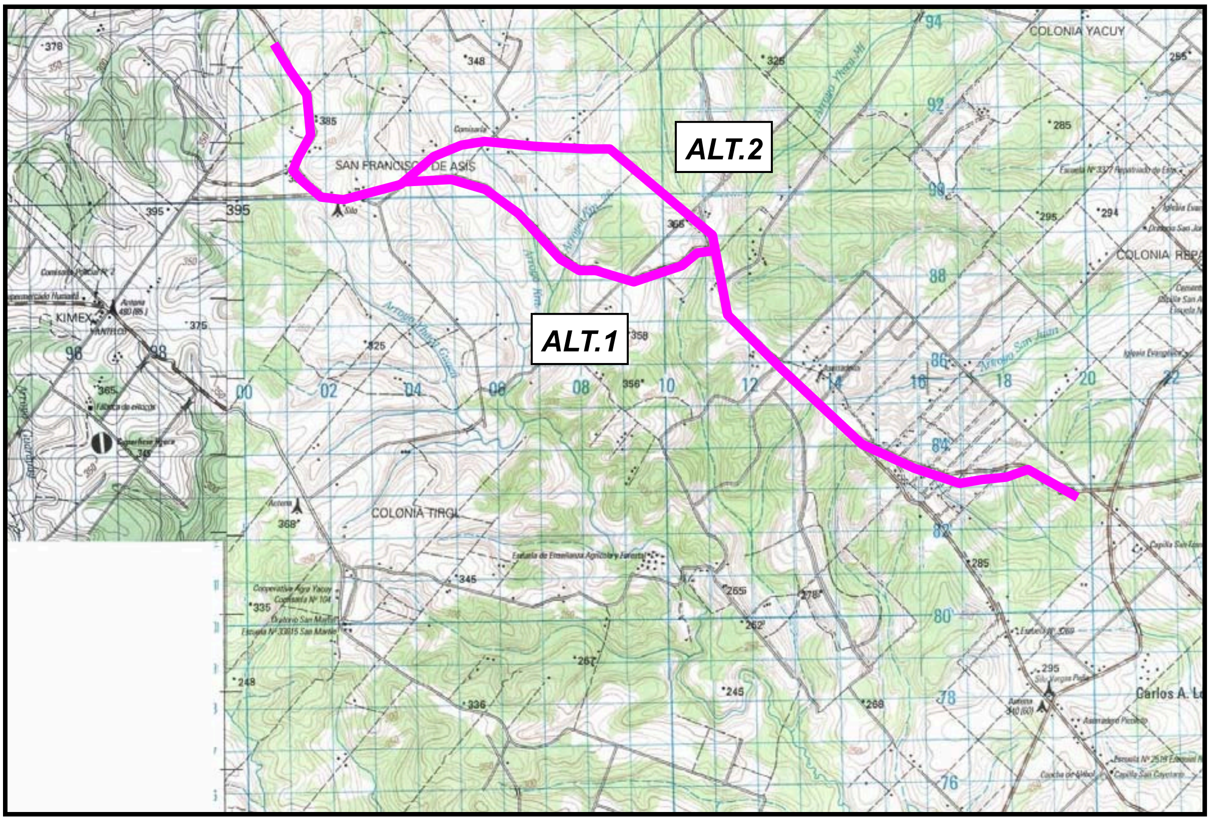


Figure 10.3-6 San Francisco de Asís region alternative routes

2) Alternative route comparison

Table 10.3-5 Alternatives comparison

Item	Alternative 1	Alternative 2
	Lowlands route	Ridgeline route
Overview	Using existing road along relatively lowland area. This route would involve a lot of up- and downhill as it passes through a number of valleys.	Using existing road along hill ridgeline. Almost no need for culverts, and up- and downhill sections not as steep as for Alternative 1.
Extension	8.4km	8.7km
Crossing structures	Route passes through lowlands, and crosses a number of small rivers, requiring bridges and B-boxes.	Follows ridgeline, so no river crossings and almost no need for any crossing structures.
Maintenance	Presence of many structures would mean more complicated maintenance than for Alternative 2.	Almost no structures, so maintenance would be simple.
Overall evaluation	△	○

Road extensions for either proposal would be about the same, with the main points of difference arising in road location. Alternative 1 follows the valleys, and so must cross several small streams and rivers, thus requiring culverts that cross the roadway. Meanwhile, Alternative 2 would follow the hill ridgeline, and so need little by way of culverts, resulting in easier road maintenance. This plan therefore takes up Alternative 2.

10.3.3 Port access roads

(1) Campichuelo port access road

1) Alternative Routes

Two possible routes were considered given current road usage patterns.

Alternative 1: Encarnación urban route

This route would go from the Encarnación urban area through Cambyreta to access the port area, representing an extension of roughly 19km.

Alternative 2: Encarnación urban area detour route

This route would avoid the Encarnación urban area, going instead from National Route 6 through Cambyreta to access the port area, representing an extension of roughly 21km.

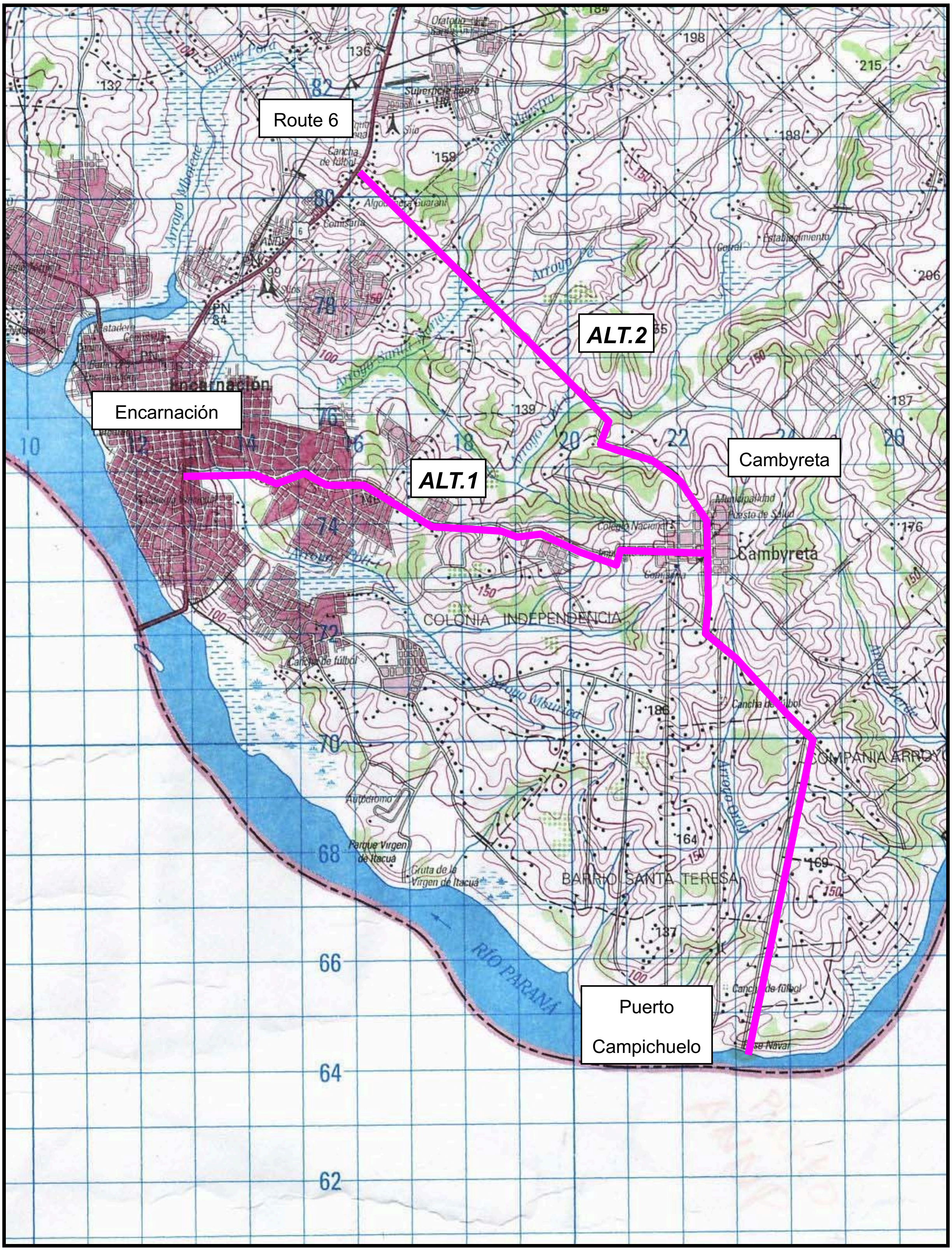


Figure 10.3-7 Puerto Campichuelo access road alternative routes

2) Comparing alternative routes

The road for the roughly 10km of the currently used Alternative 1 route from Encarnación through Cambyreta is rather narrow, and though the area is already built up, there are no pedestrian walkways, and roadside residents are demanding some measures to ameliorate the effects of large trucks passing through. Furthermore, work to widen the road in the urbanized area would raise many problems, including compensation for residents who would have to move.

Meanwhile, Alternative 2 would go through agricultural land, and thus large trucks passing through would entail no serious problems regarding the roadside environment. However, the current roadbed is undeveloped, and large trucks cannot presently use the route.

Table 10.3-6 Alternatives comparison

Item	Alternative 1	Alternative 2
	Urban area route	Urban area detour route
Extension	19.0km	21.0km
Roadside environment	Area roughly 10km around Encarnación is being built up, so road would require some environmental measures.	Area through to front line is all agricultural, so large trucks passing through poses no problems.
Land acquisition, moving of current residents	Road for above-mentioned section is narrow and roadside areas are being built up, so work to widen the road would raise many problems, including compensation for residents who would have to move.	Though some land would have to be purchased, almost no residents would have to be moved.
Structures	Road follows ridgeline, so almost no need for structures.	Route would cross Arroyo Santa María and tributaries, requiring C-boxes or bridges.
Overall evaluation	△	○

This plan selects Alternative 2, despite the higher project cost, as it avoids the urbanized area and thus does not raise environmental problems.

(2) Tres Fronteras port access road

1) Alternative Routes

Access to the Tres Fronteras port is currently via the four-lane road making up the city beltway (Alternative 1). The survey also explored the alternative possibility of upgrading existing roads to connect directly to the Paraná River coastal road. (Alternative 2)

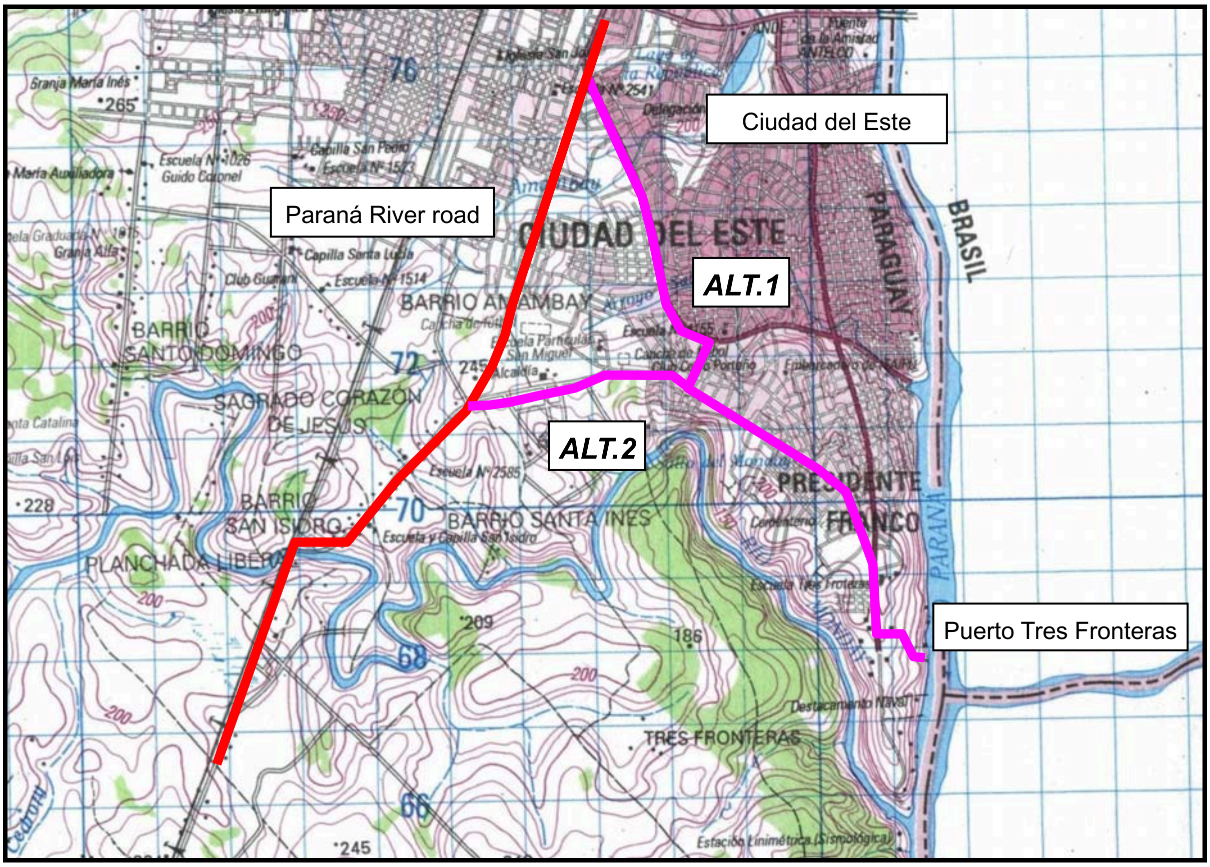


Figure 10.3-8 Puerto Tres Fronteras access road alternative routes

2) Alternative route comparison

Table 10.3-7 Alternatives comparison

Item	Alternative 1	Alternative 2
	Using present roads	Paraná River coast road connection
Extension	5.8km	10.2km
Roadside environment	This route is currently used for transport to the port, but it passes through heavily urbanized areas, and would entail both increased transportation costs for large trucks, and might lead to environmental problems along the roadway.	Would use existing roads, but areas along this route are also quite built up, and the road would likely have a impact.
Land acquisition, moving of current residents	Basically, upgrade of current road would allow large trucks to use it, so no land acquisition or resident moving would be needed.	Basically, upgrade of current road would allow large trucks to use it, so no land acquisition or resident moving would be needed.
Structures	Would use existing road, so no need for new structures.	Would use existing road, so no need for new structures.
Network	There is not construction of a new network to use an existing way.	Because an existing way is improved, an existing way accesses it with Parana coast road. Therefore a new network is built.
Overall evaluation	○	△

Alternative 1 uses existing roads, and as the existing roads are adequately developed, construction costs would be low. However, this route passes through heavily urbanized areas, and would entail both increased transportation costs for heavy freight vehicles, and might lead to environmental problems along the roadway. Meanwhile, Alternative 2 would access the port directly from the Paraná River coastal road, thus avoiding already built-up areas and likewise avoiding roadway environmental problems.

The choice plan assumes it Alternative 2. The reason is as follows.

- There is little influence for route environment.
- A new network is built.

10.4 PAVING PLAN REVIEW

10.4.1 Aligning Design Conditions

(1) Planned traffic volume

The traffic volume for the planned route is estimated as shown below.

Table 10.4-1 Future traffic volume estimate (March 2015)

Area	Volumen de tráfico de vehículos de carga relacionados con exportación	Carga de tráfico de residente a los lados de la ruta				Volumen de tráfico convertido				Total			
		Veh pequeños	Bus	Camion	Subtotal	Veh pequeños	Bus	Camion	Subtotal	Veh pequeños	Bus	Camion	Total
M-1(1)	130	870	40	160	1,070	130	40	40	210	1,000	80	330	1,410
M-1(2)	210	870	40	160	1,070	130	40	40	210	1,000	80	410	1,490
M-2	200	870	40	160	1,070	130	40	40	210	1,000	80	400	1,480
M-3	200	870	40	160	1,070	130	40	40	210	1,000	80	400	1,480
M-4	300	870	40	160	1,070	260	50	60	370	1,130	90	520	1,740
M-5(1)	290	870	40	160	1,070	260	50	60	370	1,130	90	510	1,730
M-5(2)	430	870	40	160	1,070	260	50	60	370	1,130	90	650	1,870
M-6	400	870	40	160	1,070	260	50	60	370	1,130	90	620	1,840
M-7	450	870	40	160	1,070	260	50	60	370	1,130	90	670	1,890
M-8(1)	450	2,320	630	220	3,170	260	50	60	370	2,580	680	730	3,990
M-8(2)	540	2,320	630	220	3,170	260	50	60	370	2,580	680	820	4,080
R15E-1	50	350	20	80	450	150	10	30	190	500	30	160	690
R15E-2	60	350	20	80	450	150	10	30	190	500	30	170	700
PAR-0	70	310	50	30	390	0	0	0	0	310	50	100	460
PAR-1	110	440	20	30	490	0	0	0	0	440	20	140	600
PAR-2	90	90	0	30	120	0	0	0	0	90	0	120	210
PAR-3	120	790	10	90	890	0	0	0	0	790	10	210	1,010
PAR-4	130	90	0	40	130	0	0	0	0	90	0	170	260
PAR-5	120	190	10	50	250	0	0	0	0	190	10	170	370
PAR-6	150	90	0	30	120	0	0	0	0	90	0	180	270
PAR-7	140	90	0	30	120	0	0	0	0	90	0	170	260
PAR-8	130	1,990	610	230	2,830	0	0	0	0	1,990	610	360	2,960

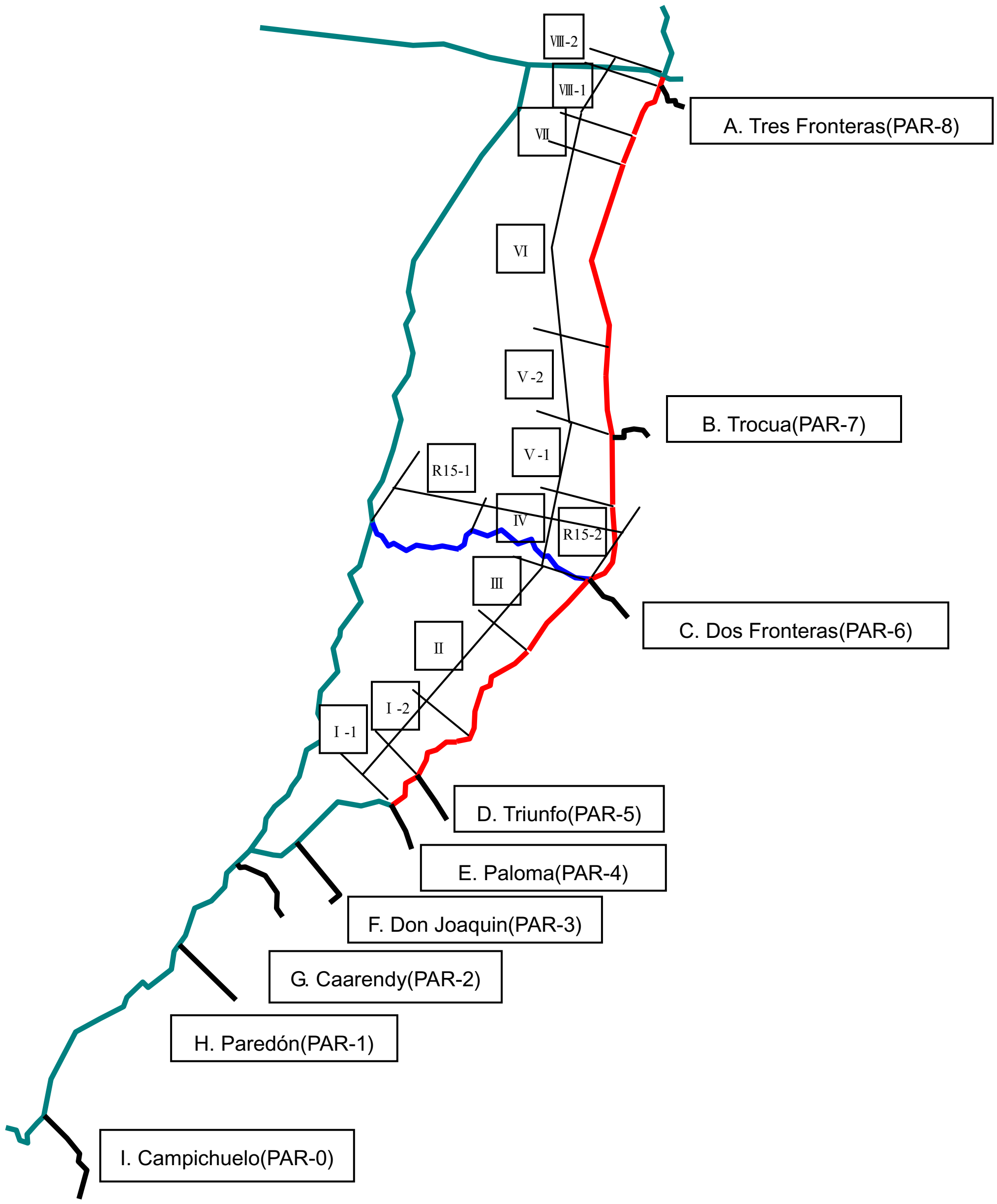


Figure 10.4-1 Traffic volume estimate area diagram

(2) Design traffic volume categories

The design traffic volume categories are defined according to the volume of large vehicle traffic. Breaking down the above areas by the categories shown in Table 10.4-2 gives us Table 10.4-3.

Table 10.4-2 Design traffic volume categories

Design traffic volume category	Large vehicle traffic volume (vehicles per day and direction)
L traffic	Under 99
A traffic	100 to 249
B traffic	250 to 999
C traffic	1,000 to 2,999
D traffic	3,000 or more

Table 10.4-3 Design traffic volume categories

Area	No. of large vehicles per day	No. of large vehicles per day and direction	Design traffic volume category
M-1(1)	410	205	Traffic A
M-1(2)	490	245	Traffic A
M-2	480	240	Traffic A
M-3	480	240	Traffic A
M-4	610	305	Traffic B
M-5(1)	600	300	Traffic B
M-5(2)	740	370	Traffic B
M-6	710	355	Traffic B
M-7	760	380	Traffic B
M-8(1)	1,410	705	Traffic B
M-8(2)	1,500	750	Traffic B
R15E-1	190	95	Traffic L
R15E-2	200	100	Traffic L

Table 10.4-4 Design traffic volume categories

Area	No. of large vehicles per day	No. of large vehicles per day and direction	Design traffic volume category
PAR-0	150	75	Traffic L
PAR-1	160	80	Traffic L
PAR-2	120	60	Traffic L
PAR-3	220	110	Traffic A
PAR-4	170	85	Traffic L
PAR-5	180	90	Traffic L
PAR-6	180	90	Traffic L
PAR-7	170	85	Traffic L
PAR-8	970	485	Traffic B

(3) Roadbed strength

As part of this survey, CBR testing was conducted at the following two sites at a total of four locations. The survey locations are shown in the figure below.

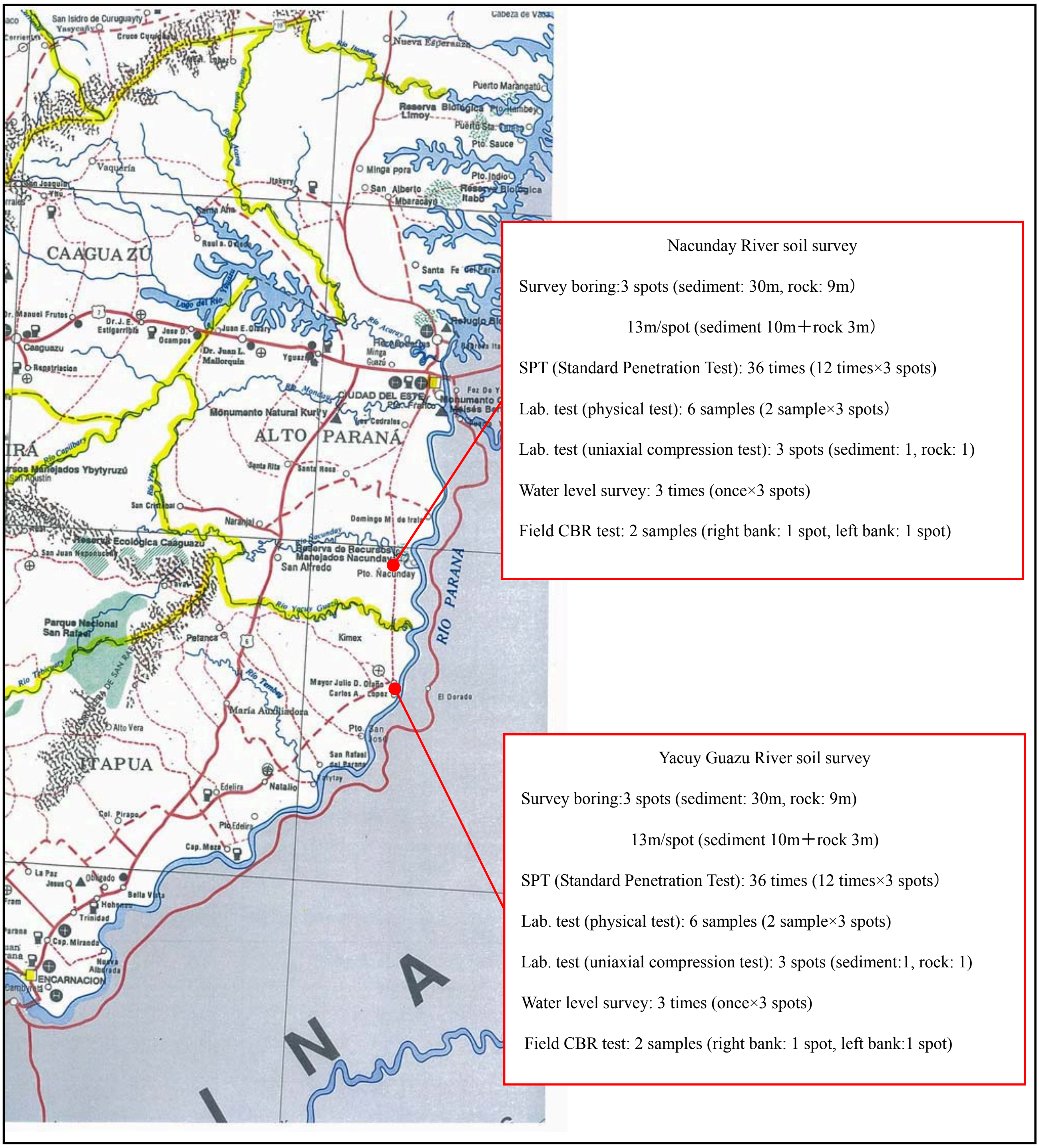


Figure 10.4-2 Soil survey locations

The survey results are as shown below.

- The CBR value for both banks of the Nacunday River was 4.9.
- The CBR value for both banks of the Yacuy Guazu River was 9.12.

For soil survey details, refer to the environmental conditions survey items.

The design CBR values are derived from the above CBR test results.

- Average CBR
  Average CBR = (4 + 9 + 9 + 12) / 4 = 8.5
- Standard deviation σ
  Σ = Sqrt (1 / (n-1) Σ (CBR – Avg CBR) * 2)
  = 3.3
- Design CBR
  Design CBR = Average value – Standard deviation
  = 5.2 → 5

(4) Materials used for each layer

The materials used are those materials generally in use in Paraguay as listed below.

- Surface and foundation: Asphalt mixture
- Upper roadbed: Size-graded crushed rock
- Lower roadbed: Crusher run

(5) Minimum thickness for each layer

Each layer's thickness is determined as shown in Table 10.4-5 for the surface and foundation, and in Table 10.4-6 for the roadbed.

Table 10.4-5 Surface and foundation minimum thickness

Design traffic volume category	Total sum thickness for surface and foundation (cm)
L, A traffic	5
B traffic	10
C traffic	15
D traffic	20

Table 10.4-6 Roadbed layer minimum thickness

Construction method, material	Minimum thickness for each layer
Bitumen stabilization process	Twice the gravel grain diameter, and 5cm
Other roadbed materials	Three times the gravel grain diameter, and 10cm

(6) Design specifications for pavement thickness

For the design specifications of the pavement thickness, the thickness of each pavement layer is determined as not less than T_A as shown in Table 10.4-7, correlated to the roadbed design CBR and the design traffic volume category. Moreover, the equivalence conversion factor for each material is shown in Table 10.4-8.

Table 10.4-7 Target T_A

Design CBR	L traffic	A traffic	B traffic	C traffic	D traffic
3	15	19	26	35	45
4	14	18	24	32	41
6	12	16	21	28	37
8	11	14	19	26	34
12	11	13	17	23	30
20	11	13	17	20	26

Table 10.4-8 Equivalence conversion factors

Location used	Construction method, material	Quality specification	Equivalence conversion factor α
Surface and foundation	Asphalt mixture		1.00
Upper roadbed	Size-graded crushed rock	Corrected CBR80 or higher	0.35
Lower roadbed	Crusher run	Corrected CBR30 or higher	0.25

(7) Axis Weight

The axis weight is considered around 10 tons each axis, and the total weight will be of 50 tons.

10.4.2 Considerations for each type of pavement

(1) New construction areas

Under present circumstances, roads for areas of dirt roads and for areas where new roads must be constructed will be designed from the surface, foundation, upper, and lower roadbed, based on the surveyed CBR values.

(2) Stone-paved areas

Design for areas already paved in stone will focus only on surface layer construction. Surface paving will be designed in consideration of current stone pavement equivalence conversion factors and past experience with such pavement projects in Paraguay.

(3) Shoulder pavement

Road shoulder pavement will use the following materials as specified by MOPC.

- Asphalt mixture: 3cm
- Crusher run: 23cm

(4) Pedestrian walkway pavement

Pedestrian walkways will be paved to match the walkway pavement already in use in each town or village.

Pedestrian walkways will be designed according to the following policy.

Though the overall number of pedestrians is low, walkways will be constructed to allow various roadside activities in urban areas.

- Already developed areas will have pedestrian walkways along one side of the road of 1.5m in width.
- Commercial areas will have pedestrian walkways along both sides of the road of 1.5m in width.

10.4.3 Pavement design

(1) New construction areas

1) Type 1 pavement composition

- Design traffic volume category: L traffic
- Design CBR: 4
- Target T_A: 14

Based on these conditions, pavement composition will be as follows.

Construction type	Equivalence conversion factor	Thickness (cm)	T_A	
Surface	1	5	5	
Upper roadbed	0.35	15	5.25	
Lower roadbed	0.25	15	3.75	
Total		35	14	$\geq T_A' = 14$

2) Type 2 pavement composition

- Design traffic volume category: A traffic
- Design CBR: 4
- Target T_A: 18

Based on these conditions, pavement composition will be as follows.

Construction type	Equivalence conversion factor	Thickness (cm)	T_A
Surface	1	5	5
Upper roadbed	0.35	20	7
Lower roadbed	0.25	25	6.25
Total		50	18.25

$\geq T_A' = 18$

3) Type 3 pavement composition

- Design traffic volume category: B traffic
- Design CBR: 4
- Target T_A: 24

Based on these conditions, pavement composition will be as follows.

Construction type	Equivalence conversion factor	Thickness (cm)	T_A
Surface	1	10	10
Upper roadbed	0.35	15	5.25
Lower roadbed	0.25	35	8.75
Total		60	24

$\geq T_A' = 24$

4) Pavement type for each project section

The pavement type for each project section is given in Table 10.4-9.

Table 10.4-9 Pavement type for each section

Section	Beginning	Ending	Km	Pavement type
M-1	Natalio	Río Tembey	12.7	Type 2
M-2	Río Tembey (incl. Puente)	Ao. Gurapay	24.2	Type 2
M-3	Ao. Gurapay	Intersección con R15E	22.6	Type 2
M-4	Intersección con R15E	Río Yacuy Guazú	15.1	Type 3
M-5	Río Yacuy Guazú (inc. puente)	Río Ñacunday	29.8	Type 3
M-6	Río Nacunday (inc. Río)	Los Cedrales	43.4	Type 3
M-7	Los Cederales	Presidente Franco	7.6	Type 3
M-8	Presidente Franco	Super Carreterra	9.5	Type 3
PAR-0	Corredor Principal	Campichuelo	21.0	Type 1
PAR-1	Corredor Principal	Paredón	12.1	Type 1
PAR-2	Corredor Principal	Caarendy	15.5	Type 1
PAR-3	Corredor Principal	Don Joaquín	18.4	Type 2
PAR-4	Corredor Principal	Paloma	10.6	Type 1
PAR-5	Corredor Principal	Triunfo	11.0	Type 1
PAR-6	Corredor Principal	Dos Fronteras	15.9	Type 1
PAR-7	Corredor Principal	Trocua	8.8	Type 1
PAR-8	Corredor Principal	Tres Fronteras	5.4	Type 3
R15E-1	Ruta 6	Frutika	20.9	Type 1
R15E-2	Frutika	Corredor Principal	28.7	Type 1

10.5 EXAMINATION OF A DRAINAGE PLAN

10.5.1 Object Drainage system

A drainage system in this chapter decides to examine about a Lateral drainage system (pipe Culvert) and a Vertical drainage system (gutter on toe of slope). “Bridge” and “Box culvert” were designed in a road structure outline design.

10.5.2 Purpose of road drainage

The first purpose of road drainage is to facilitate good drainage for every section of a road, to prevent weakening of the road due rain on the road, surface water that flows off of adjacent areas onto sections of the road, groundwater that seeps in from adjacent areas, or from water that rises up from the water table, and to prevent scouring or degradation of the road gradient due to rainfall.

The second purpose is to prevent traffic delays or accidents due to water accumulation on the roadway.

10.5.3 Lateral drainage system

A lateral drainage system is classified into the following work items:

- Bridge
- Box culvert
- Pipe culvert

Of these items, “Bridge” and “Box culvert” were designed in a road structure outline design. This chapter shall deal with the design of a pipe culvert.

The road structure outline design usually defines a cross section of the pipe culvert based on a catchment area. This pipe culvert, however, covers a very small basin area, so it is difficult to determine the area from a floor plan used for the design.

Consequently, we basically followed a pipe diameter of an existing pipe culvert that was identified under a road inventory survey. Due to long extension of the pipe culvert, it is hard to maintain a shape of the cross section because of its reduction caused by sediment. This design employed a maximum pipe diameter of ϕ 1.0m currently used in consideration of an allowance of the section. It is natural that existing pipe culverts should be continuously utilized. Waterworks may be laid down at vertical and topographical sag points, so we decided to place new pipe culverts.

The number of pipe culverts in each section is shown in Table 10.5-1.

Table 10.5-1 List of pipe culverts

Project	Component			Station				Pipe diameter	Number of installments
Main Corridor	M-1	Beginning	Natalio	NO.	0	+	0	φ1.0	3
		End	Rio Tembey	NO.	12	+	93		
	M-2	Beginning	Rio Tembey (inc.bridge)	NO.	12	+	93	φ1.0	7
		End	Ao. Gurapay	NO.	35	+	989		
	M-3	Beginning	Ao. Gurapay	NO.	35	+	989	φ1.0	9
		End	Intersection with R15E	NO.	59	+	315		
	M-4	Beginning	Intersection with R15E	NO.	59	+	315	φ1.0	9
		End	Rio Yacuyguazu	NO.	72	+	285		
	M-5	Beginning	Rio Yacuyguazu(inc.bridge)	NO.	72	+	285	φ1.0	11
		End	Rio Nacunday	NO.	97	+	56		
	M-6	Beginning	Rio Nacunday (inc.Rio)	NO.	97	+	56	φ1.0	13
								φ1.0×2	1
		End	Los Cedrales	NO.	140	+	72	φ1.0×3	1
	M-7	Beginning	Los Cederales	NO.	140	+	72	φ1.0	0
		End	Prte. Franco	NO.	147	+	500		
	M-8	Beginning	Prte. Franco	NO.	147	+	500	φ1.0	4
		End	Super Carreterra	NO.	157	+	575		
Port Access Road	PAR-0	Beginning	Main Corridor	NO.	0	+	0	φ1.0	5
		End	Pt. Campichuelo	NO.	19	+	660	φ1.0×2	1
	PAR-1	Beginning	Main Corridor	NO.	0	+	0	φ1.0	9
		End	Pt. Paredon	NO.	11	+	0	φ1.0×2	1
	PAR-2	Beginning	Main Corridor	NO.	0	+	0	φ1.0	8
		End	Pt. Caarendy	NO.	15	+	600		
	PAR-3	Beginning	Main Corridor	NO.	0	+	0	φ1.0	10
		End	Pt. Don Joaquin	NO.	16	+	750		
	PAR-4	Beginning	Main Corridor	NO.	0	+	0	φ1.0	10
		End	Pt. Paloma	NO.	10	+	490		
	PAR-5	Beginning	Main Corridor	NO.	0	+	0	φ1.0	0
		End	Pt. Triunfo	NO.	11	+	800		
	PAR-6	Beginning	Main Corridor	NO.	0	+	0	φ1.0	3
		End	Pt. Dos Fronteras	NO.	5	+	650		
	PAR-7	Beginning	Main Corridor	NO.	0	+	0	φ1.0	5
		End	Pt. Torocua	NO.	8	+	720		
	PAR-8	Beginning	Main Corridor	NO.	0	+	0	φ1.0	0
		End	Pt. Tres Fronteras	NO.	7	+	900		
Route15 Extension	R15E-1	Beginning	Route6	NO.	0	+	0	φ1.0	0
		End	Frutika	NO.	24	+	800		
	R15E-2	Beginning	Frutika	NO.	24	+	800	φ1.0	19
		End	Main Corridor	NO.	54	+	430		

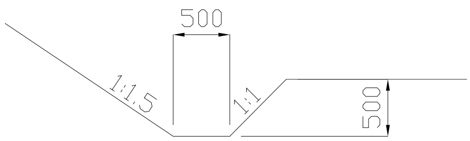
10.5.4 Vertical drainage system

A vertical drainage system is classified into the following work items:

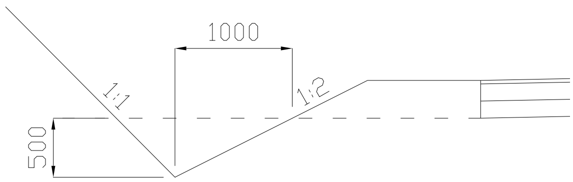
- Earth gutter on toe of slope (Filling and cut sections)
- Stone gutter on toe of slope (Point nearest to flow end)

The earth gutter on toe of slope shall have the following shape.

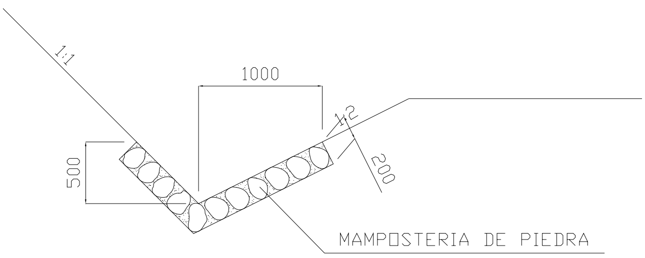
Filling section



Cut section



A point nearest to flow end may cause erosion due to an increasing flow rate and a faster flow velocity. Consequently, we decided to employ stone gutters, so that a drainage canal can be reinforced.



10.6 SETTLING ON BRIDGE MAINTENANCE PLAN

On the subject roads, constructs such as bridges (concrete, wooden, and steel bridges), box culverts and pipe culverts had been build up as many as listed in Table 10.6-1 and Table 10.6-2. Among these existing constructs, those on the road from the Natario to Otoño were built up around 1986 for the maintenance of these roads and are in relatively good conditions. In this Section, we consider the maintenance plan for the existing constructs including thriety-four existing bridges and other constructs that are equal to or larter than box culverts of 2 merter or longer. Constructs such as box culverts shorter than 2 meters as well as concrete pipes will be separately considered as the drainage plan.

Table 10.6-1 Number of Bridges Classified by Types

length	Main Corridor			Port Access Road			Total		
	Wooden Br.	Concrete Br.	Steel Br.	Wooden Br.	Concrete Br.	Steel Br.	Wooden Br.	Concrete Br.	Steel Br.
Less than15m	11	8	0	4	1	1	15	9	1
15m to less than 30m	2	2	0	0	0	0	2	2	0
30m to less than 50m	1	2	0	0	0	0	1	2	0
50m or longer	0	2	0	0	0	0	0	8	0
Total	14	14	0	4	1	1	18	15	1

Table 10.6-2 Number of Culverts Classified by Types

Types		Main Corridor	Port Access Road	Route 15 Extension	Total
Box Culverts		5	1	0	6
Pipe Culverts		12	42	6	60
	Simple	(10)	(40)	(3)	(53)
	Double	(1)	(2)	(0)	(3)
	Triple	(1)	(0)	(3)	(4)

10.6.1 Policy of Bridge Maintenance Plan

Considering that there are many sound constructs on the subject roads as mentioned above, our maintenance plan will be based on the following policy:

a) The sound existing bridges will be utilized to the full.

The sound existing bridges having a roadway of 7.0 meters or wider (3.25 x 2 + 0.25 x 2) will be utilized and those having less than 7.0 meters wide will be reconstructed. As to such bridges within the city and its vicinities that used to have a heavy traffic of pedestrians, sidewalk widening will be considered.

b) All the wooden bridges will be rebuilt.

c) The replacing structures will have the flow capacities that are equivalent to or higher than the existing structures to be replaced.

d) The scale (such as flow sections) of the structures will be determined based upon the hydrologic and hydraulic analyses.

e) Among other existing structures, the bridges that are recommended reconstruction from the comprehensive viewpoints including their locations and/or flows of the rivers will be rebuilt.

10.6.2 Setting Up Design Conditions

(1) Applicable Design Standard

The geometric design standard of the roads and the bridge design standard will comply with the standards by AASHTO (American Association of State Highways and Transportation Officials). This is because, in the Republic of Paraguay, the geometric design standard of roads applies correspondingly with "A Policy on Geometric Design of Highways and Streets" by AASHTO, and the bridge design standard applies with "Standard Specifications for Highway Bridges" by AASHTO. As to affects of earthquakes and other conditions such as temperature fluctuation, the loads and ranges that reflect the local conditions will be set up.

(2) Composition of Bridge Width

The width of the bridges will be composed as follows based upon the consultation with MOPC:

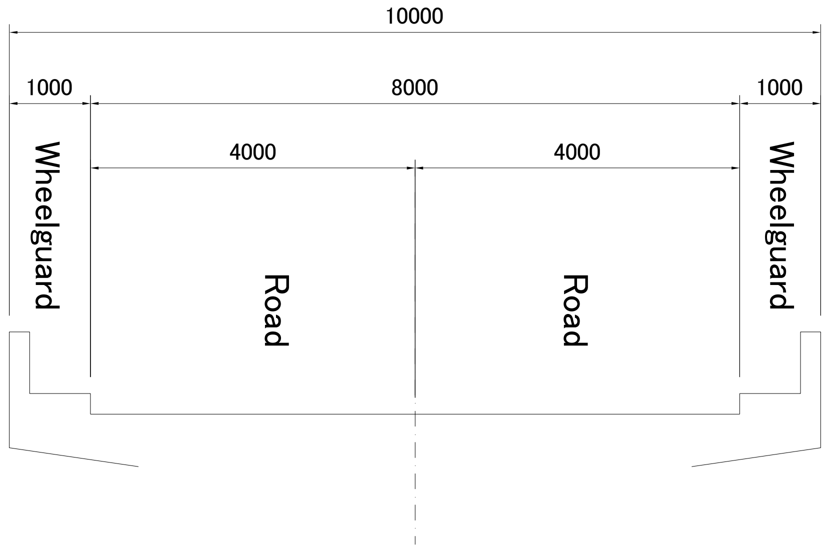


Figure 10.6-1 Standard Cross Section of Bridge

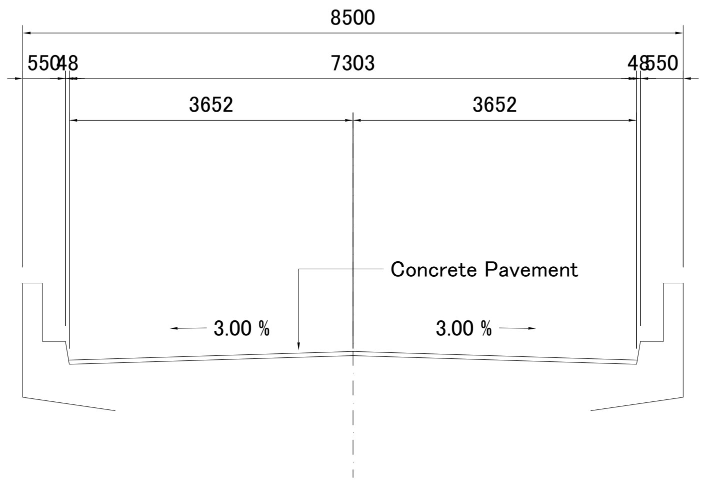


Figure 10.6-2 Width Composition of Reusable Bridge

(3) Design live loads

HS20-44 stipulated by AASHTO will be applied to the design live loads in this plan, as Paraguay employs this standard as their design live loads.

(4) Seismic load

There has been no record of earthquakes within Paraguay. There are some records of earthquakes centered in the neighboring countries but their scales were minimal. Therefore, our structural design will not consider seismic loads, conforming to the conventional design method.

(5) Temperature fluctuation

The temperature fluctuation to be considered in the design will be 0 ℃ to 40 ℃ (20℃±20℃) based upon the fact that the highest and lowest temperatures in the past five years at the observatories in Encarnación and Ciudad del Este were as shown in the table below:

Observatory	Lowest Temp.	Highest Temp.	Fluctuation
Encarnación	4.3 ℃	30.3 ℃	26.0 ℃
Ciudad del Este	7.3 ℃	31.5 ℃	24.2 ℃

10.6.3 Hydrology

(1) The Study of Catchments Areas

The catchments areas were identified in the study area. The catchments area for drainage facility is shown as the Table 10.6-3.

The areas are being drained by the rivers. These rivers are perennial rivers. During the rainy season these streams flow in full swing.

These rivers are braided rivers. The river banks height is variable from 2 to 3m throughout its course therefore the width of the channel depending upon the morphology, slope and nature of formation. The streams represent typical anatomizing pattern. The river channel meanders making numerous cut offs and bends. Most of catchments are farmland.

(2) Collection of Climatological and Hydrological Data

1) Rainfoll

The annual rainfall in Paraguay increases from west to east, averaging about 1,400 mm to 1,600 mm annually. The months of October to march are rainy while other months are dry. In the dry season, the average monthly rainfall is approximately 100 mm.

The average rainfall in the project area is 1,500mm to 1,600mm.

The monthly rainfall data was collected from two stations in the project area. Then the water level data which ANDE observed in the Nacunday River were collected for the period 1974 to 2005.

2) Hydraulic Analysis

a) Runoff Calculation

- Method

There are several methods to calculate runoff discharge. These include rational formula, the unit hydrology method, the triangular method, and storage function method. The rational formula can provide only peak discharge. However, the others provide flood hydrographs. It is the recommendation from MOPC to use the rational formula for small catchments less than 10 km^2, and the triangular method for catchments of more than 10 km^2.

- Rational Method

Q= C*I*A /6

Where,

Q = discharge (m3/sec)

C = runoff coefficient

i = rainfall intensity in concentration time (mm/min)

A = catchments area (ha)

- The Triangular Hydrograph Method (THM)

This method was developed and recommended by the US Soil Conservation Service.

MOPC recommends using this for the runoff calculation.

Formulas

qp = 2.08 x A /tp

Where,

qp = maximum peak of flow (for THM)

A = basin area in km2

tp = peak time

tp = At/2 + 0.6tc

tc = concentration time, in hours(*)

⊿t=tc/5 Unitary Time (hour)

tr = 1.67 tp = recess time (hour)

tb = 2.67tp = base time (hour)

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

$tc = 10 \times A^{0.3} \times L^{0.2} / K \times i^{0.4}$

Effective Rainfall

In order to establish the effective rainfall (Pe), the total rainfall (P) is used in accordance with the US Soil Conservation Service.

CN= 1000 / (10+S)

Where,

CN = curve number for the basin

S = retention and infiltration for the studied basin

Pe = (P'-0.2S)**2 /(P'+0.8S)

Where,

Pe = effective rainfall in inches

P ' = total rainfall in inches

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

P' = P x (1 – 0.1xlog A) /25

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

If A<25km^2 P=P'

The 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 proj~cted hydrograph are:

Qi= Pei.q1 + Pei-1.q2 + Pei -2.q3 + ...Pel.qi

- Rainfall intensity values

The rainfall intensity values at Ciudad del Este based on a long period (1967- 1991) are available.

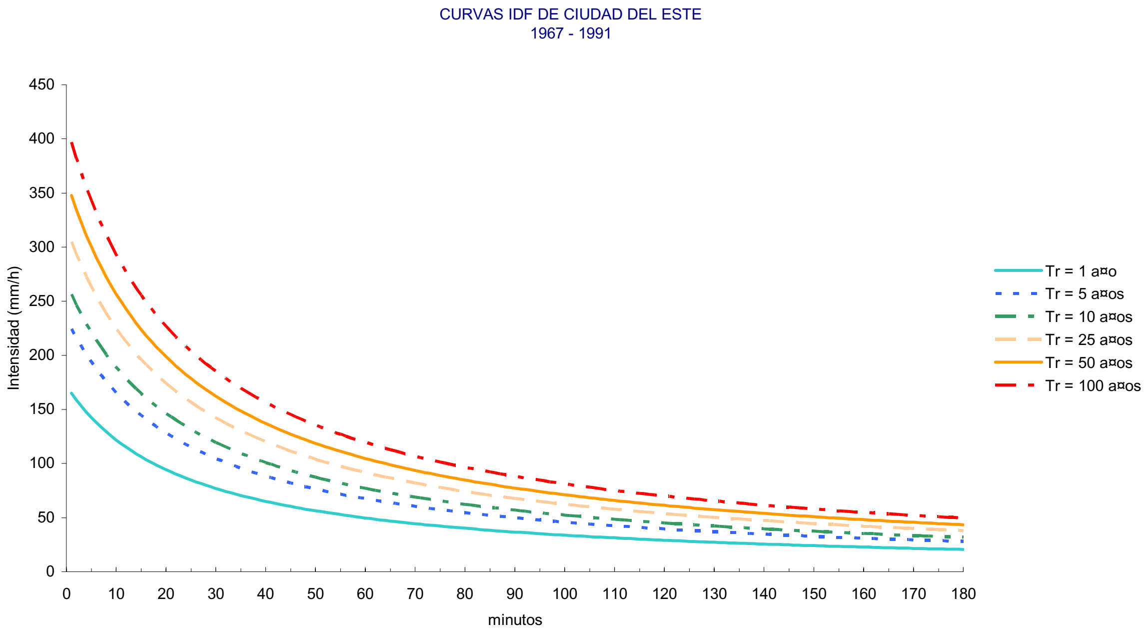


Figure 10.6-3 Indicates the values at various frequencies.(Source ; MOPC)

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

$$I\ (\text{mm/hr}) = \frac{4013 \times Tr^{0.19043}}{(t+24)^{0.99108}}$$

Where,

I : Rainfall intensity

Tr : Return Period

t : concentration time

- Calculation Result

The catchments area are measured based on the topographic map. Then probable discharge obtained by the rational method and the triangular hydrograph method are listed in Table 10.6-3.

Table 10.6-3 Probable Discharge at the Site

MAIN CORRIDOR

Compo-nent	Basin No.	No	River Name	Area (ha)	Length (m)	Peak Discharge(m3/s) 10years	25years	50years	T.H.M(m3/s) 10years	25years	50years	Remarks
M-1	1	3+250	Aro.Pai Curuzu(1)	1,310	5,300	42	50	57	35	46	59	
	2	5+553	Aro.Pai Curuzu(2)	850	4,300	28	33	17	23	30	39	
M-2	3	12+093	Rio Tembey	116,140	153,700	348	407	465	253	362	465	
	4	22+768	M-2-1									
	5	23+623	M-2-2									
	6	27+777	Aro. San Rafael	1,140	3,500	48	57	65	37	30	61	
M-3	7	35+989	Rio Guarapay	32,840	48,700	214	263	296	185	263	338	
	8	47+616	Aro.Yhaca Guazu	23,770	35,700	190	226	262	161	230	294	
	9	55+137	Aro.Alegre	2,240	7,900	65	78	89	55	74	99	
M-4	10	56+642	Aro.Cure-Ky	1,160	4,700	47	56	64	36	52	67	
	11	64+430	Aro.Emilia	2,466	8,250	70	84	95	59	84	107	
	12	64+562	Aro.San Juan	8,660	18,700	130	152	173	110	156	200	
	13	70+447	Aro.Yhaca-Mi	6,810	19,600	106	126	143	92	131	168	
M-5	14	72+250	Rio Yacuy Guazu	73,000	117,500	256	329	365	217	309	397	
	15	83+566	Aro.Diamante	2,250	6,300	75	90	102	62	88	112	
	16	88+291	Aro.Imperial	3,940	14,300	91	106	122	76	107	136	
	17	89+425	Aro.Imperial Afluen.1	1,750	8,300	55	66	74	46	65	83	
	18	90+000	Aro.Imperial Afluen.2	370	3,400	24	29	33	17	22	31	
	19	94+240	Aro.Carpincho	5,580	15,100	106	126	142	89	126	163	
M-6	20	97+048	Rio Nacunday	243,820	237,600	366	488	610	304	436	760	*1
	21	99+782	Rio Nacunday Afluen	490	3,400	28	33	38	20	29	37	
	22	111+462	Aro.Pira Pyta Afluen.	1,390	5,400	45	54	61	37	53	67	
	23	114+575	Aro.Pira Pyta	16,730	25,900	159	192	218	137	196	251	
	24	117+337	Aro.Pira Pyta Afluen.	3,550	9,800	76	91	103	65	92	118	
	25	126+177	Aro.Y-Tuti	9,310	14,200	112	135	154	100	142	182	
	26	134+683	Aro.Yta Coty	7,210	14,900	94	112	130	84	120	153	
M-7	27	146+413	M-7-1									
M-8	28	149+845	Rio Monday	701,300	241,100	–	–	–	–	–	2000	*2
	29	155+910	Aro.Amambay			–	–	–	–	–	—	

PORT ACCESS ROAD

Compo-nent	Basin No.	No	River Name	Area (ha)	Length (m)	Peak Discharge(m3/s) 10years	25years	50years	T.H.M(m3/s) 10years	25years	50years	Remarks
PAR-0	30	Par 0-2.7	Aro.Maestora	1,350	5,900	63	72	78	37	52	67	
	31	Par 0-3.2	Aro.Pe	920	3,400	43	49	53	31	43	57	
	32	Par 0-6.2	Aro.Curi-Y①	6,700	16,900	141	162	177	96	136	176	
PAR-3	33	Par 3-9.0	Aro.Pora	1,850	6,600	64	73	80	47	68	87	
PAR-6	34	Par6-11.7	Aro Cure-ky	860	102,000	13	15	16	9	13	17	

(Note) Area　Catchments Area
Length　River Length
*1 :　The flow discharge was determined based on data of ANDE.
Relation between Depth of water and Flow discharge is shown in Figure 9.6.4
*2 :　The flow discharge was determined based onRelation between Water level and Flow discharge
Relation between Depth of water and Flow discharge is shown in Figure 9.6.5

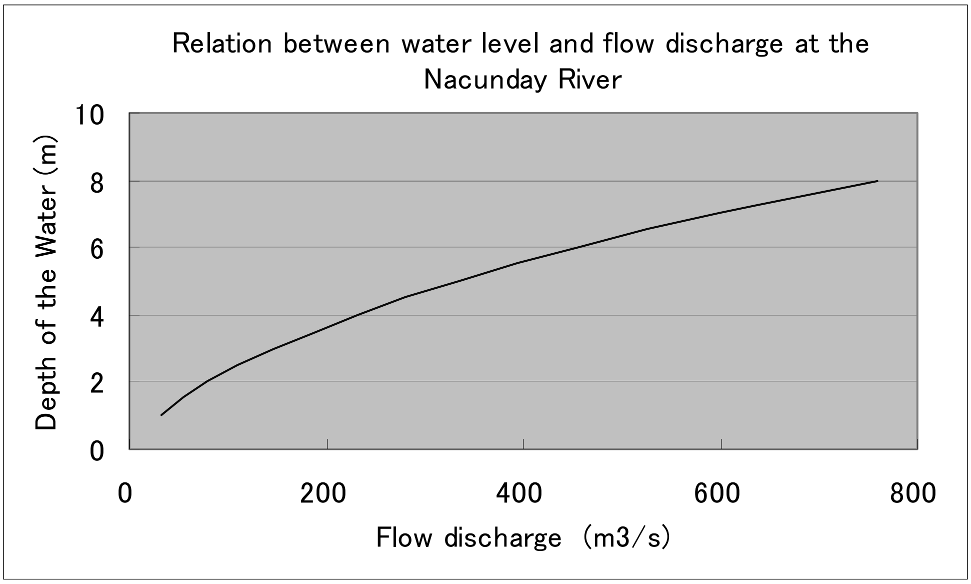


Figure 10.6-4 Relation between Depth of water and Flow discharge at the Nacunday River

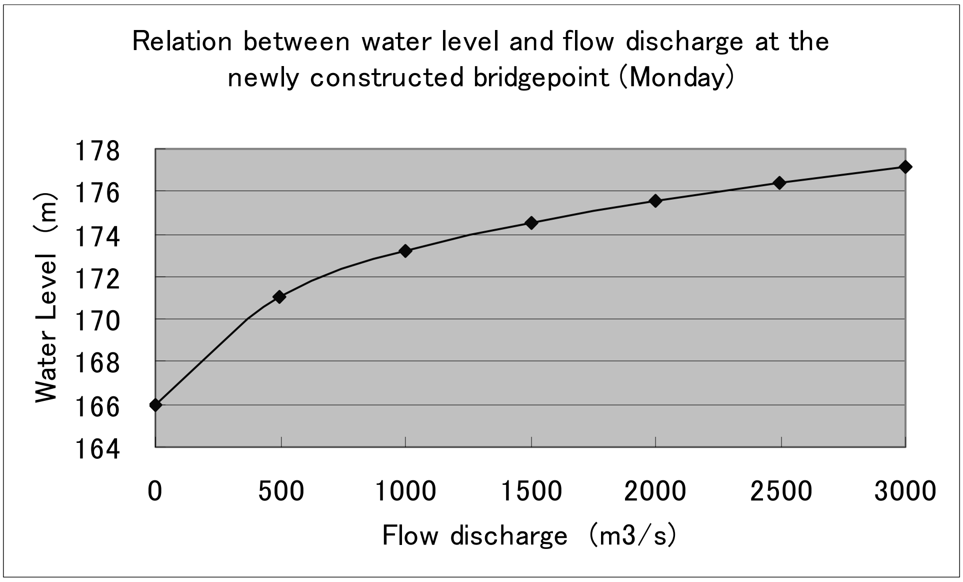


Figure 10.6-5 Relation between water level and flow discharge at the Monday River
(Refer to appendix, Hydraulic review of Monday River)

(3) Setting up flood frequencies

The scales of the road transected structures will be set up based upon the hydraulic and hydrologic analyses, and the flood frequencies will be estimated based upon the MOPC data as in the table below. As the allowances of the bridges against the high water level are not stipulated in Paraguay, Japanese River Structure Rules will be applied, and the allowances for the case of the maximum flood flow will be set up.

Table 10.6-4 Flood Frequencies by Structures

Structures	Frequency
Bridges	Once in 50 years
Box culverts	Once in 25 years
Pipe culverts	Once in 10 years
Banks	Once in 25 years
Road surfaces	Once in 5 years

Source: MOPC

Table 10.6-5 Bridge Allowances for Water Level

Classification	1	2	3	4	5	6
Estimated high water flow (m^3/sec)	Lower than 200	200 to less than 500	500 to less than 2,000	2,000 to less than 5,000	5,000 to less than 10,000	10,000 or higher
Allowance for water level (m)	0.6	0.8	1	1.2	1.5	2

Source: Japanese River Facilities Structure Rules. Section 20.

10.6.4 Bridge Maintenance Plan

The bridge maintenance plan, based upon the policy and design conditions mentioned above, will be as follows: For details, refer to Table 10.6-6 Detailed Bridge Maintenance Plan

Table 10.6-6 Detailed Bridge Maintenance Plan

Maintenance Method	No. of Bridges	Remarks
Reuse of existing structures	12	Detailed research will be required.
Rebuilding of existing bridges	20	
Building of new bridges	2	When no existing bridge is available or the route(s) are changed.

Rebuilding of existing bridges: Those that have apparently lower load capacity (wooden bridges, etc.), have shorter width, or have required to have smaller flow section as the result of hydrologic analysis, will be replaced with new bridges or culvers

Reuse of existing bridges: Those that have a roadway width of 7.0 meters or longer in a sound condition will be reused. Also, those having the roadway width of less than 7.0 meters but the width can be widened will be reused.

As to the Monnday River Bridge, it is reusable enough, but due to the route changed, the river crossing point is changed and a new bridge needs to be built.

Table 10.6-7 Detailed Bridge Maintenance Plan

Compo-nent	Basin No.	No	River Name	Area (ha)	Length (m)	Culvert Box n	b(m)	h(m)	Bridges L(m)	B(m)	H.W.L(m)	Remarks
M-1	1	3+250	Aro.Pai Curuzu(1)	1,310	5,300	2 -	4.500 ×	2.850		―		**Reuse**
	2	5+553	Aro.Pai Curuzu(2)	850	4,300	2 -	4.500 ×	2.850		―		**Reuse**
M-2	3	12+093	Rio Tembey	116,140	153,700		―		70.000	8.500	134.400	**Reuse**
	4	22+768	M-2-1			1 -	3.000 ×	3.000		―		**Reuse**
	5	23+623	M-2-2			1 -	3.000 ×	3.000		―		**Reuse**
	6	27+777	Aro. San Rafael	1,140	3,500	2 -	4.500 ×	2.800		―		**Reuse**
M-3	7	35+989	Rio Guarapay	32,840	48,700		―		48.000	8.500	166.200	**Reuse**
	8	47+616	Aro.Yhaca Guazu	23,770	35,700		―		48.000	8.500	173.200	**Reuse**
	9	55+137	Aro.Alegre	2,240	7,900	2 -	4.500 ×	2.800		―		**Reuse**
M-4	10	56+642	Aro.Cure-Ky	1,160	4,700	2 -	3.500 ×	3.000		―		Reconstruction
	11	64+430	Aro.Emilia	2,466	8,250	2 -	4.500 ×	3.000		―		Reconstruction
	12	64+562	Aro.San Juan	8,660	18,700		―		20.000	10.000	155.320 *1	Reconstruction
	13	70+447	Aro.Yhaca-Mi	6,810	19,600		―		20.000	10.000	164.689	Reconstruction
M-5	14	72+250	Rio Yacuy Guazu	73,000	117,500		―		75.000	10.000	173.200	Reconstruction
	15	83+566	Aro.Diamante	2,250	6,300	2 -	4.500 ×	3.000		―		Reconstruction
	16	88+291	Aro.Imperial	3,940	14,300		―		15.000	10.000	163.100 *1	Reconstruction
	17	89+425	Aro.Imperial Afluen.1	1,750	8,300	2 -	4.000 ×	3.000		―		Reconstruction
	18	90+000	Aro.Imperial Afluen.2	370	3,400	1 -	3.500 ×	3.000		―		Reconstruction
	19	94+240	Aro.Carpincho	5,580	15,100		―		20.000	10.000	147.800 *1	Reconstruction
M-6	20	97+048	Rio Nacunday	243,820	237,600		―		100.000	10.000	154.419	Construction
	21	99+782	Rio Nacunday Afluente	490	3,400	1 -	3.500 ×	3.000		―		Reconstruction
	22	111+462	Aro.Pira Pyta Afluen.2	1,390	5,400	2 -	3.500 ×	3.000		―		Reconstruction
	23	114+575	Aro.Pira Pyta	16,730	25,900		―		20.000	10.000	188.700 *1	Reuse of Existing Pier
	24	117+337	Aro.Pira Pyta Afluen.3	3,550	9,800		―		16.000	8.000	192.300 *1	**Reuse**、Widening of Wid
	25	126+177	Aro.Y-Tuti	9,310	14,200		―		25.700	8.000	199.400 *1	**Reuse**、Widening of Wid
	26	134+683	Aro.Yta Coty	7,210	14,900		―		15.000	10.000	199.000 *1	Reconstruction
M-7	27	146+413	M-7-1			2 -	2.000 ×	2.000		―		**Reuse**
M-8	28	149+845	Rio Monday	701,300	241,100		―		150.000	10.000	176.000	Construction
	29	155+910	Aro.Amambay			2 -	3.500 ×	3.000		―		Reconstruction
	PORT ACCESS ROAD											
PAR-0	30	Par 0-2.7	Aro.Maestora	1,350	5,900	2 -	4.000 ×	3.000		―		Reconstruction
	31	Par 0-3.2	Aro.Pe	920	3,400	2 -	3.000 ×	3.000		―		Reconstruction
	32	Par 0-6.2	Aro.Curi-Y①	6,700	16,900		―		15.000	10.000	124.000 *1	Reconstruction
PAR-3	33	Par 3-9.0	Aro.Pora	1,850	6,600	2 -	4.000 ×	3.000		―		Reconstruction
PAR-6	34	Par 6-11.7	Aro Cure-ky	860	102,000	1 -	2.500 ×	2.500		―		Reconstruction

(Note) Area : Catchments Area
Length: River Length
*1 is presumed height than topographical map.

10.7 EXAMINATION OF AN ASSOCIATED FACILITIES OF A ROAD

10.7.1 Safety Facilities

We decided to install the following items for safety facilities, referring to the results of current road research and the service status of existing national roads.

(1) Guardrail

Guardrails shall be installed to the following points:

- Section that may cause human damage to passengers when vehicles are off-road
- Section that may cause human damage to third persons when vehicles are off-road
- Section where a road is constructed near a high-voltage line steel tower (protection of the steel tower)

(2) Pavement markings

Pavement markings are intended to control traffic, guide or regulate. In this plan, the markings shall be provided to “center lane” and “curb lane”.

(3) Road signs

The following 4 types of road sings shall be placed.

- Signs that indicate directions and distances to destinations, prominent points, municipal boundaries, road classes and route numbers.
- Signs that indicate running dangerous points such as an intersection and a road corner
- Signs such as parking prohibition and maximum speed control signs that must be observed by road users
- Sings that indicate points necessary for traffic control such as a pedestrian crossing and a safety zone

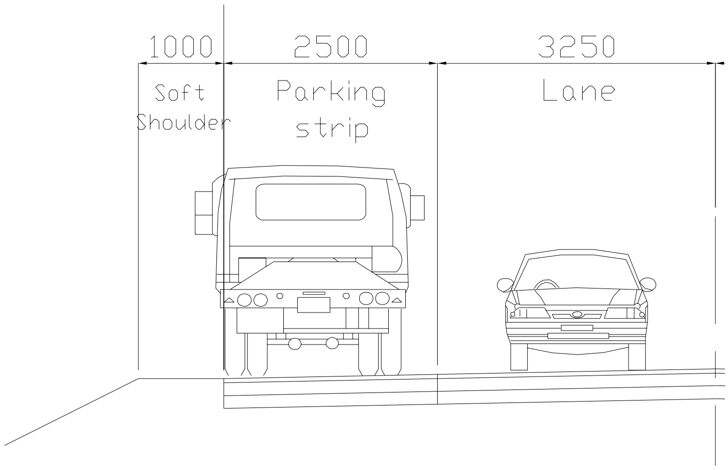
(4) Shoulder pavement

Shoulders shall be paved to serve as a side walk and draw a clear distinction between cars and pedestrians.

10.7.2 Other facilities

(1) Parking strip

Parking strips shall be provided in order to move a vehicle from a lane to a passing place when the car fails to operate and a driver wants to take a rest. A parking strip shall be placed every 1 km.



(2) Facilities for measuring vehicle specifications

The facilities shall be provided to measure a vehicle's weight and regulate illegal vehicles, with the aim of preserving road structure or preventing traffic dangers.

(3) Rest facilities

It is necessary to place rest facilities at reasonable spacing for safe and comfortable travels. These rest facilities are designed to answer a driver's call of nature, reduce his or her fatigue and tension from continuous running or meet the requirements of feed water and refueling for cars. It is recommended that individual municipalities or private organizations should place the facilities. One rest facility should be placed every about 50km.