6. DEMAND FORECAST

6. DEMAND FORECAST

6.1 Chronic Peculiarities of the Brazilian Economy and Irregular Allotment Among Means of Transport in Domestic Distribution

When the civil government assumed power in 1985, the economy was in a state of collapse due to a foreign investment crisis brought about by the former military government's excessive growth policies in disregard of international economic realities during its final stages. Price inflation, which the citizens had lived with until then, was also running rampant.

In order to solve these problems, the focus of economic policies since 1985 has shifted diametrically from development-oriented to stability-oriented, as each of the administrations to hold power--the Sarney Administration (1985-1989), the Collor Administration (1990-1992) and the interim administration of Acting President Franco (1992-Present)--have embarked on bold courses of comprehensive economic policies intended primarily to control inflation.

The measures implemented by these administrations in a process of trial and error include price policies, wage policies, issuing new denominations of currency as a banking and foreign exchange policy, administrative reforms and tax reforms. On some occasions they have even resorted to the drastic measure of freezing citizens' bank accounts in an effort to curb inflation and induce stable growth.

As shown in Table 6.1.1, economic plans were enacted at a bewildering pace. The plans provided some short-term symptomatic relief, but they fell short of accomplishing their intended results. As of mid 1994, the inability to attain monetary stability remains a chronic characteristic of the Brazilian economy, as Table 6.1.2 illustrates.

Table 6.1.1 Economic Stability Plans Since Civil Government was Established

Policy's Common Name	Date of Enactment
Sarney Administration	
(1) Cruzado Plan	February 28, 1986
Second Cruzado Plan (Moratorium Proclamation)	November 21, 1986 (February 20, 1987)
(2) Bressel Plan	June 12, 1987
(3) Summer Plan	December 4, 1988
Collor Administration	
(4) Collor Plan	March 16, 1990
Second Collor Plan	January 31, 1991
Franco Interim Administration	
(5) Real Plan	July 1, 1994

Source: Encyclopedia of Brazil's Economy

Table 6.1.2 The Brazilian Economy's Rate of Price Inflation

(%)

1988	1989	1990	1991	1992	1993
993	1,864	1,585	475	1,200*	2,700*

*Estimated Values

Although the extreme rates of price inflation shown above have come to be regarded as a matter of course, they still exert a significant influence on commerce. In other words, in setting the market price for a product, it becomes essential to consider the length of time until the product is sold in addition to such factors as production cost, distribution cost and profit margin. This gives rise to an abnormal situation in which the time element becomes the all-determining factor and disregard of the optimal value of distribution costs from the standpoint of transportation-economic theories becomes the general rule. This abnormal situation currently exists in Brazil and it is exerting a significant influence on the allocation of cargo among the means of transport in Brazil's domestic distribution system.

In addition to contradicting the economic theory that producers seek to maximize profit margin by minimizing distribution costs, this situation also results in a difficulty in determining theoretical values for the optimal allocation of cargo among the different means of transport in product distribution.

Consequently, under such economic conditions, using allotted rates (modal split) between road, rail and water transport and values calculated using transportation-economic theories to forecast the estimated volume of freight to be transported via the Parnaíba river is extremely unrealistic.

6.2 Scenario of the River Transport

Conceivable water transport scenarios are shown in Fig. 6.2.1 through 6.2.3.

Scenario 1 is a coherent water transport plan scenario from Santa Filomena, located in the upstream region, to the port of Luiz Correia, located at the river's mouth. This scenario contemplates shipping Piauí's agricultural products by boat from Luiz Correia to the port of Itaqui, for export to other states and countries. Imported goods can be brought to Luis Correia port by the reverse route and transported upstream on the river.

Scenario 2 contemplates water transport from Santa Filomena to Teresina. It presumes that agricultural and other products will be shipped via the river to Teresina, and then by existing rail or road networks to ports such as Itaqui and Fortaleza, where they will be shipped to other destinations in the same way as at present.

Scenario 3 contemplates water transport from Santa Filomena to Floriano, from where existing roads will be used to transport goods.

The feasibility of each scenario will be determined by future investigations of such factors as connectibility with existing transportation networks, investment costs, profitability and volume of demand. However, the areas upstream from Santa Filomena included in Scenario 3 currently lack water transport facilities and access to the area is extremely difficult. Resumption of water transport in this area is considered beyond doubt to be a prerequisite for the region's development.

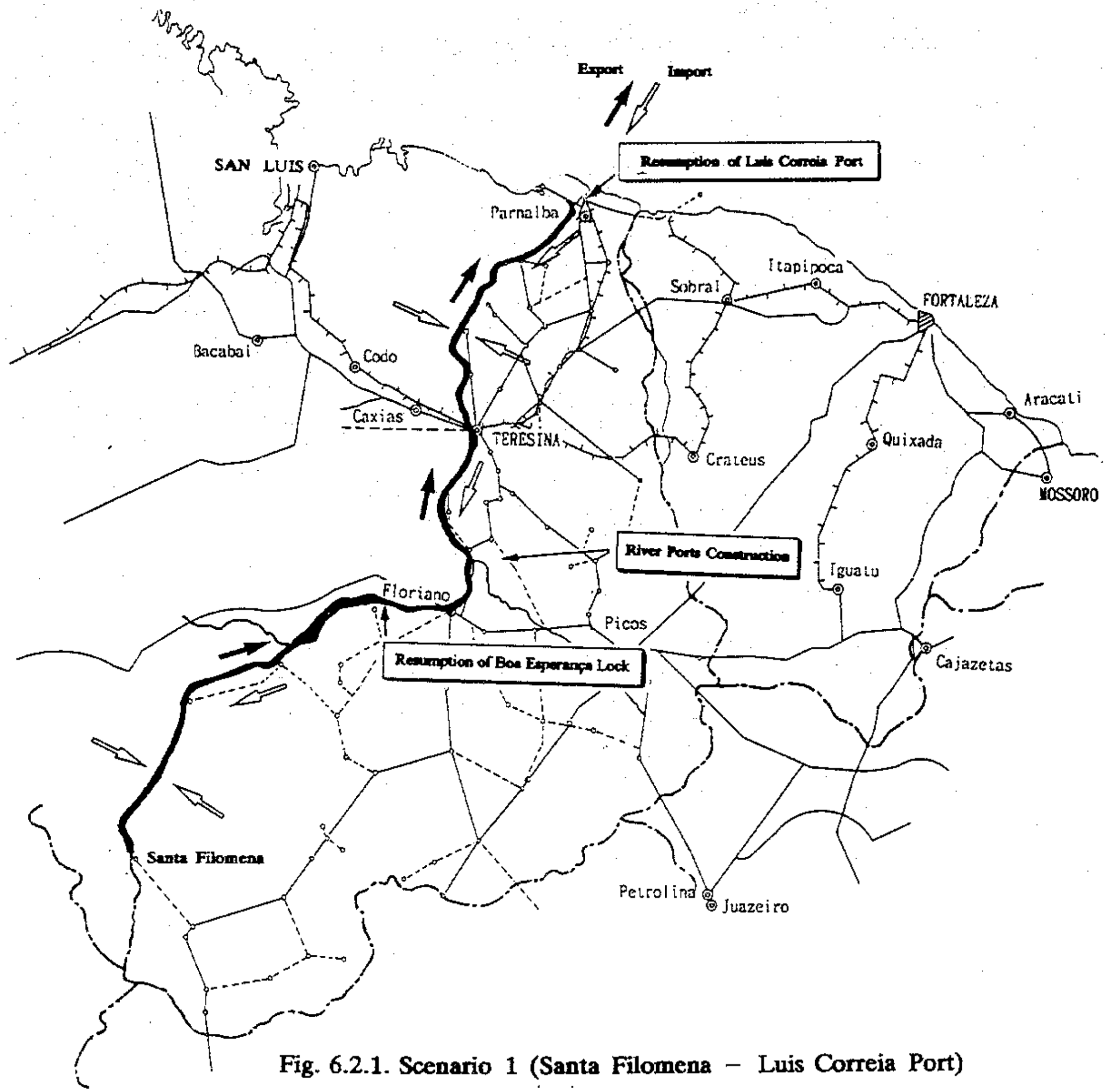

Fig. 6.2.1. Scenario 1 (Santa Filomena – Luis Correia Port)

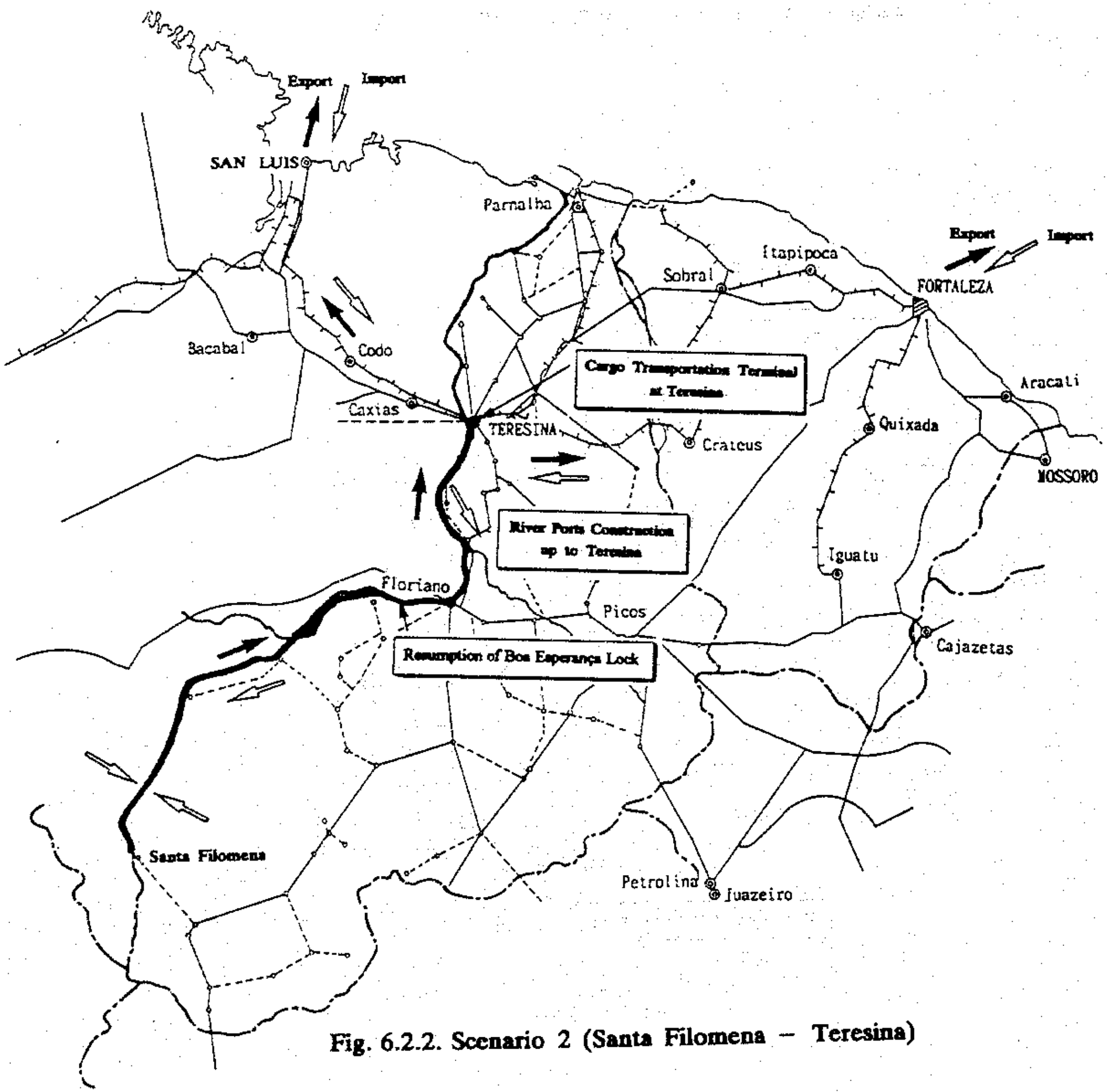

Fig. 6.2.2. Scenario 2 (Santa Filomena – Teresina)

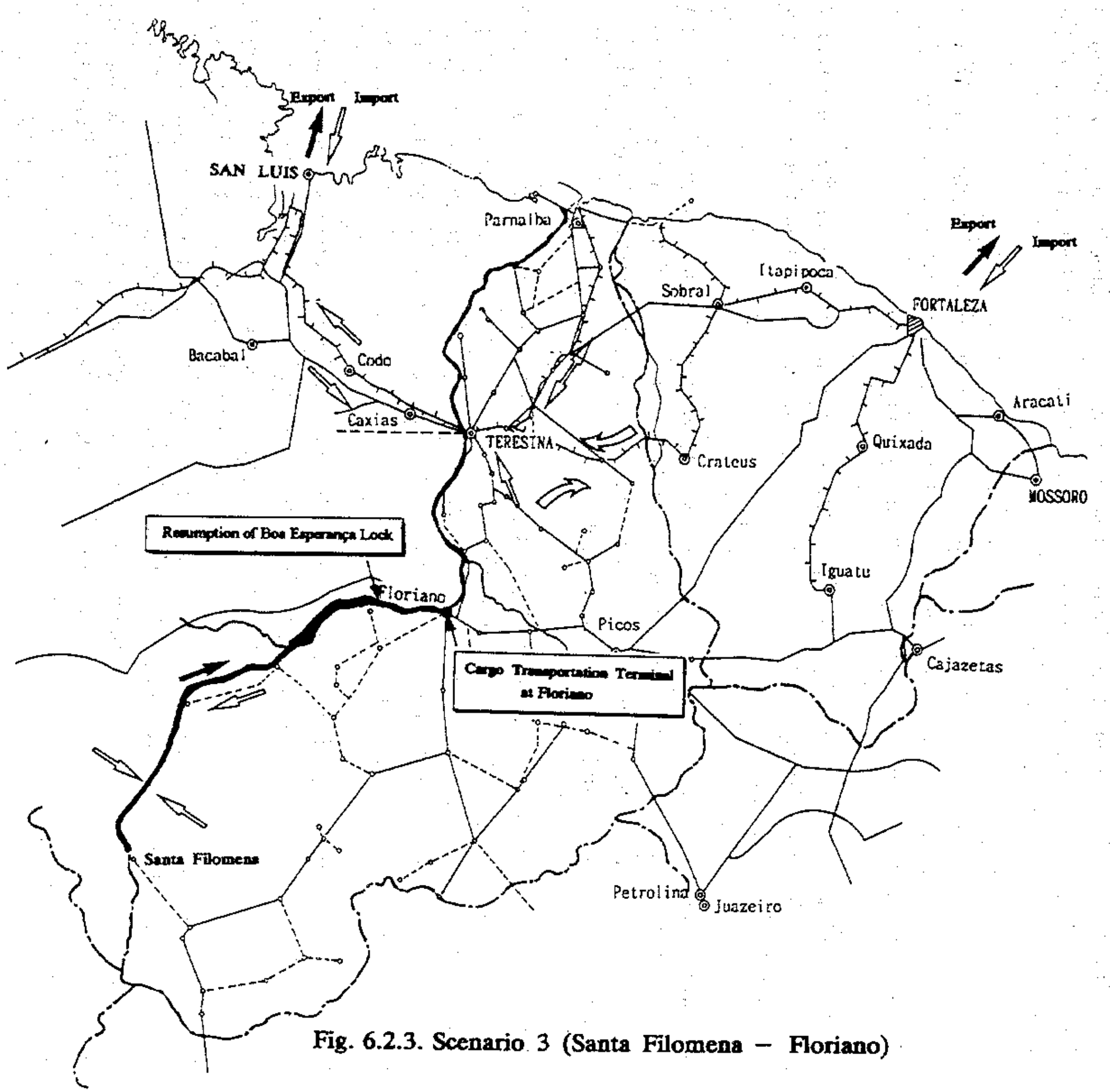

Fig. 6.2.3. Scenario 3 (Santa Filomena – Floriano)

6.3 Demand Forecast Method

6.3.1 General

As previously stated in 6.1, the peculiarities of cargo allocation among the modes of transport in the Brazilian domestic product distribution system makes it very difficult to generally adapt analysis methods based on transportation-economic theories to the forecast of demand for freight transport via the Parnaíba river.

Consequently, there was no alternative but to primarily use a cumulative forecasting method in an analytical approach based on present and future conditions for the transportation infrastructure of each section of the river and its surrounding coastal region.

Considering the fact that the possibility is slight that large quantities of the products mentioned below are those which, transported via the Parnaíba river, have the potential to be exported abroad on a long term basis.

Of course, some of these products do have export potential, such as Canobal wax and activated charcoal refined from Babacu. However, when the location of their primary points of production and the quantities involved are considered, exporting them from Sao Luiz in the Fortaleza port region would be more economical.

There is also an economic advantage from the national point of view to use the port of Fortaleza to bring wheat and petroleum products, the main imports, into the state, when such factors as existing facilities and storage of the products for distribution are considered. Based on the relative advantages of these other ports, it was concluded that it is not economically feasible to construct a new port in Luiz Correia.

It was also concluded that it is very unlikely that the agricultural products which are expected to be produced in the future in the Balsas river basin region (the most notable among them is soya beans, which have the potential for export abroad) will be exported via the Balsas River. A more desirable route is to ship them to Carolina and Imperatriz by land routes (in the future the North-South Railway will be used) and then on to the port of San Luiz via the Carajas Railway. Establishment of this transport route will not only make the Carajas Railway, whose construction involved a massive investment of capital, more economically viable, it should also be economically beneficial from the national point of view. The above mentioned concept is shown in Fig. 6.3.1.

6.3.2 Products to be Transported via the Parnaíba River

The products of Piauí upon which great future expectations are placed are the agricultural products surveyed and analyzed in Chapter 5 "Agricultural Conditions in the State of Piauí.".

Large scale agricultural development is especially anticipated for the southwest part of the state, a coastal region of the Parnaíba river (see Table 5.5.1).

If this development actually occurs, the probability that a transport system will be established as a basic condition of the development's realization should increase.

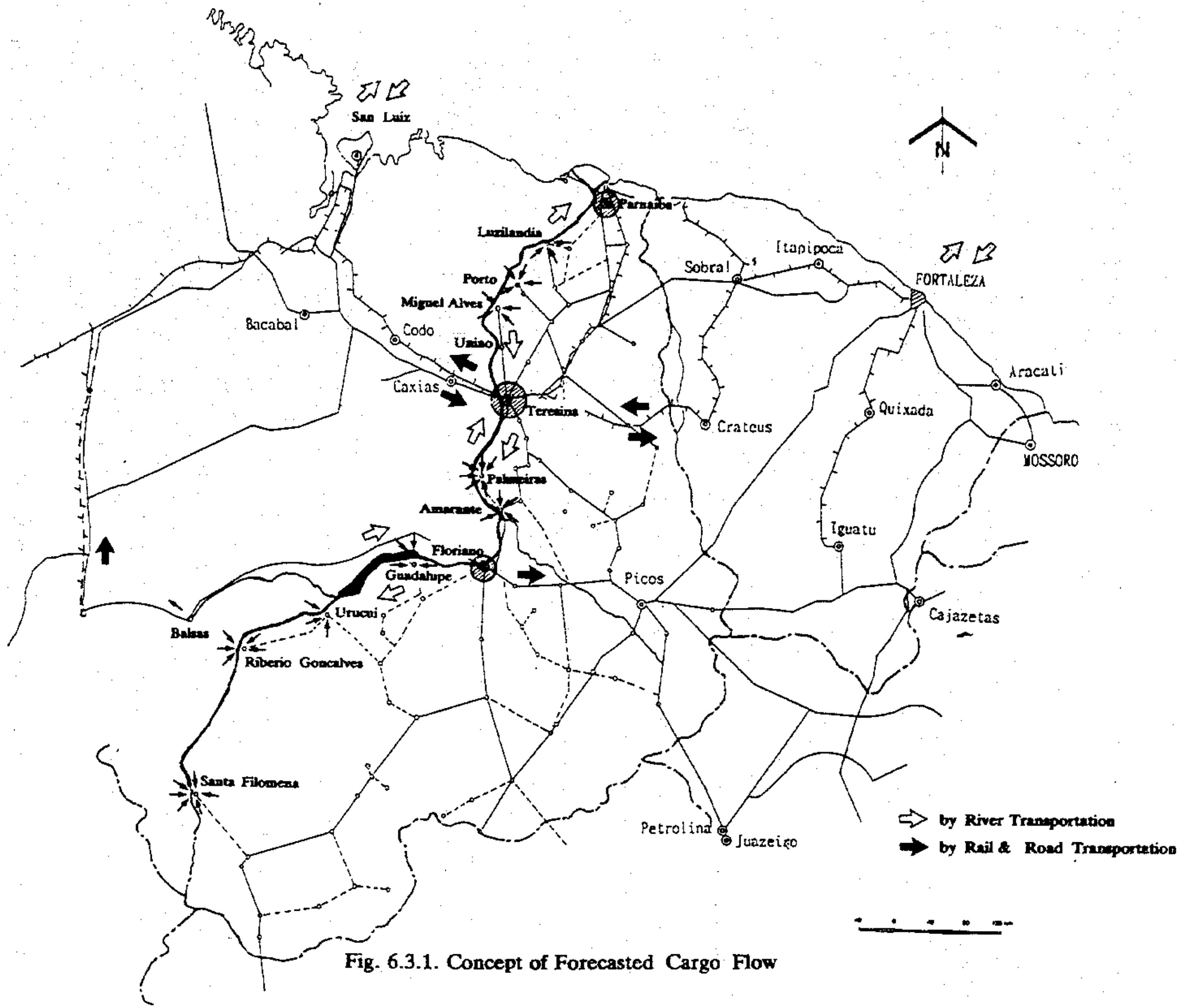

Fig. 6.3.1. Concept of Forecasted Cargo Flow

Currently, the region does not have a system of major roads. If this condition remains unchanged, there will be no alternative but to rely on the Parnaíba river as a means of transport for the region's products.

It will also become essential to transport into the region goods for the agricultural population's consumption as well as various goods necessary to increase the productivity of the development process (see Table 4.8.1).

Due to the above considerations and the peculiarities of cargo allocation among modes of transport in Brazil's domestic distribution system (as described in 6.1), it was decided to conduct the demand forecast for transport services on the Parnaíba river based on the products listed below for each of the three zones that the river was divided into in the water transport plan (6.2).

(1) The zone downstream from Teresina: agricultural products, salt

(2) The zone from Teresina to Floriano: agricultural products, products necessary for daily living and production for the upstream region, salt

(3) The zone upstream from Floriano: agricultural products, products necessary for daily living and production, salt

The economic modernization has brought productive and distributive merchandise various and high grade and economic activities to make much of validity of investment (for instance, reduction of financial expense, especially for the rate of interest and so on) following wide spreading and internationalization of financial organization will be indispensable to overtake a profit of each corporation. It means that the value of time for economic activities has increased.

From these points of views, we cannot deny the fact that the relative function of an inland navigable transportation system for cargo will generally deteriorate in the future.

Therefore, it should be considered that a transport by freight which has high marketing price for unit weight and variety will lose economy as a transport for inland navigation, only a transport which is varied cargo and has low marketing price for until weight has possibility on the very point that the economy is developing and contemporary condition of nature, that is economically as a transport for inland navigation in the State of Piauí, and also the relative predominance of a transport for inland navigation will deteriorate in the future as the economy is developing growth.

(Note: For the area downstream from Floriano, the effects of inflation on goods other than agricultural products are comparatively slight. Salt, whose transport costs make up a high percentage of its price, was the only of these products included in the forecast.)

6.3.3 Formulation of a Socio-Economic Frame

In estimating the growth rate to use in forecasting the future demand for transport services in the water transport plan, it is necessary to establish general socio-economic indicators for Piauí's future.

However, as Brazil's central government is in the process of implementing various reforms and its policies are currently in a state of flux, a long term development plan has yet to be determined. As would be expected in such circumstances, the various states of Brazil, including Piauí, do not have a future development plan either.

As a result, it is difficult to establish suitable future socio-economic indicators based on the State's policies to use in the demand forecast.

Nevertheless, in forecasting demand for transport services, it is essential to establish a growth rate to forecast future product distribution. It was thus decided to conduct the forecast based on the volume of the products to be transported by water transport (as described in 6.3.2) increasing in the manner described below.

(1) Agricultural Products:

The values forecast in 5.5 "Estimation of Agricultural Production Volume" (as found in Chapter 5, "Agricultural Conditions in the State of Piauí") are used as base values.

(2) Products Necessary for Daily Living and Production:

To estimate the quantities necessary to be shipped to the upstream region, the current transport volumes (analyzed in Chapter 4, "Traffic Conditions and Cargo Transportation in the State of Piauí") were used as base values (see Table 4.8.1).

The annual population growth rate of the region was assumed to be a constant 2.5%. Although Piauí's current annual population growth rate is 2.18%, the rate for the upstream region was estimated to be higher than the state's average, as the future advance of large scale agricultural development is expected to have a decentralizing effect on the trend of urban population concentration.

In concrete terms, population growth from the current level (1991's population is the base value) until the target year (2010) was estimated as follows:

$$(1.0 + 0.025)^{19} = 1.598.$$

It was assumed that the quantities of products to be shipped to each major river port in the upstream region would be distributed in proportion to each port's urban population.

6.3.4 Prior Conditions for the Demand Forecast

In order for the values forecast by this demand survey to be realized, the prior conditions listed below must be met. Be especially mindful that the forecasted values are unlikely to turn out to be accurate if these conditions are not maintained nor if there is a significant change in the basic volumes.

(1) Basic Conditions

a. A regular schedule of water transport will be maintained and vessels operated safely on the shipping routes.
b. There will be a consistent transport system from the upstream region to Teresina or Floriano.
c. Each river port that will be a key shipping point will have collection facilities and equipment for loading and unloading sufficient to accommodate the volume of cargo.
d. The network of trunk roads in the upstream region will not expand beyond its current state.

(2) Conditions for the Transport of Agricultural Products

a. The agricultural production forecast for the year 2010 (contained in 5.5) will be realized.
b. The plan to develop the agro-industry centers will be realized as per the state's policies.

In particular, rice processing complexes will operate in the downstream (in Parnaíba city as the central processing location) and the midstream (in Teresina city as the central location) regions.

Corn and soybean processing centers will be established in the upstream region (in Floriano city as the central location). Other currently operational agro-industry factories will be expanded.

It is recommended to establish a rice processing center at Floriano taking into account the present trend of increased rice production in the upstream regions. A realization of such a rice center at Floriano is a prerequisite of the demand forecast discussed in this chapter.

(3) Conditions for Distribution of Products Necessary for Daily Living and Production

a. No significant changes will occur that might affect the results of the analysis of the present state of product distribution (contained in 5.).
b. The commercial base in Floriano City will expand.

6.3.5 Projected Transport of Agricultural Products

(1) Rice, Corn, Fejon

Distribution of transport volume with regard to production volume of agricultural products such as rice, corn and fejon excluding consumption of the same at the production areas was forecasted to be shared by both land transport and water transport measured at the river ports, situated on the Parnaíba river taking into account of the conditions of existing roads around the production areas as well as the relative difficulties of approach to the Parnaíba river.

With regard to rice of which production volume for consumption is estimated to be approximately 200,000 tons, it is assumed that a considerable volume of the product where land transport is available at production area will be distributed to the southern and the central area of the country by roads and the balance of the produced volume will be transported by water transport to the rice processing centers at Floriano and Teresina first. Thereafter it will be distributed to the other surrounding regions (Northern and east-northern part of the country) by roads.

With regard to corn, it is forecasted that the assumed necessary volume of feed for livestock, made from corn as feed grain processed at the Agro-industry Center in Floriano, will be re-transported to the upstream regions.

(2) Soybean

The whole volume of soybean produced is assumed to be exported abroad. A part of the production volume both at Santa Filomena and its surroundings; and Ribeiro Goncaluves and Urucui Regions is assumed to be transported to the Maranhão Region by road and exported at Itaqui Port through the Carajas railway system. The remainder of the volume is assumed to be transported by water transport to Teresina and exported from both San Luiz and Itaqui Ports through the rail or road transport systems.

(3) Cotton

The volume of cotton production in 1994 at Guadalupe and its surroundings was 438 tons. Although the agriculture division forecasts that the production of cotton will continuously increase in the future, it is difficult to foresee the future volume of production. It is assumed that cotton will be transported and distributed by the road system taking into account both factors in addition to this unforeseenable production volume that the processing of cotton based products is concentrated in the southern area of which the center is São Paulo at present and the plan to establish an agro-industry center for cotton processing in the western part of the region (near Picos) is underway.

(4) Fruits

Fruit production in Piauí's southwest region (Alto Parnaíba, Bertolina and Floriano), where mango is the primary crop, is expected to increase. Production is predicted to double between 1992 and 2010, and the following transport schemes are projected (see Tables 6.3.1)

a. Approximately 80% of Alto Parnaíba's production will be collected in Ribeiro Goncalves and Urucui and shipped via the river to the agro-industry centers in Teresina and Floriano. The percentages of the total collected in Ribeiro Goncalves and Urucui are forecast to be 30% and 70% respectively, as are the percentages to be shipped to Floriano and Teresina.

b. Approximately 50% of Bertolina's production will be collected in Guadalupe and shipped via the river to the agro-industry centers in Floriano and Teresina, with half of the total going to each location. The remainder will be distributed to other states via land routes.

c. The entire production from other areas will be distributed via land routes within the state, as well as to other states.

Table 6.3.1 Fruit Production (Mango)

	1992 (1,000 pieces)	2010 (1,000 pieces)	2010 (ton)
Alto Parnaíba	2,900	5,800	2,900
Bertolina	2,340	4,600	2,300

Source : Producao Agricola Municipal 1992 - Piauí
Remarks : 2010 weight is projected by JICA with an average weight of 500 g per each pieces.

(5) Nuts

Nuts are another agricultural product whose production is expected to increase in the future. As the production of nuts, like fruit, is expected to double between 1992 and 2010, their transport scenario is projected below (see Table 6.3.2).

a. Approximately 80% of Alto Parnaíba's production will be collected in Ribeiro Goncalves and Urucui and shipped via the river to the agro-industry center in Teresina. The percentages of the total collected in Ribeiro Goncalves and Urucui are estimated to be 30% and 70%, respectively.

b. Approximately 50% of Bertolina's production will be collected in Guadalupa and shipped via the river to the agro-industry center in Teresina.

c. Approximately 30% of Floriano's production will be collected in Floriano and shipped via the river to Teresina.

d. The remainder of the nut production will be distributed via land routes within the state and to other states.

Table 6.3.2 Nut Production (Cashew)

	1992 (ton)	2010 (ton)
Alto Parnaíba	2,277	4,500
Bertolina	952	1,900
Floriano	2,671	5,300

Source : Producao Agricola Municipal 1992 - Piauí
2010 production is projected by JICA

(6) Babacu

The Babacu processing industry located in Teresina collects Babacu from as far away as 300 km upstream and 200 km downstream. It is estimated that in the future 30,000 tons per year will be shipped via the river from the upstream location of Amarante, as will 50,000 tons per year from the downstream location of Miguel Alves.

The results of the demand forecast for cargoes of agricultural products are shown in Table 6.3.3., 6.3.4 and 6.3.5.

6.3.6 Projected Transport of Commodities Necessary for Production and Daily Living

(1) Salt

a. Salt for the downstream region will be shipped via the river to the areas upstream of Luzilandia. This quantity will be meet 40% of the downstream region's demand for salt, and will be distributed in proportion to each area's population. The remainder of the salt for the downstream region will be distributed via land routes.

b. Salt for the upstream region will be collected in Teresina, shipped via the river, and distributed in proportion to each area's population.

c. All the salt to the central region will be shipped via land routes from Teresina.

(2) Fertilizer

a. Fertilizer will be distributed to the mid and downstream regions entirely by land routes.

b. Fertilizer will be shipped to the upstream region via the river, after being collected at Floriano and Teresina. The percentage shipped from each location will be 50%. Fertilizer will be distributed to the upstream region in proportion to the its cultivated farmland for the year 2010.

(3) Sugar

Approximately 80% of the quantity of sugar required by the upstream region will be collected in Floriano, shipped via the river, and distributed to the ports of Guadalupe, Urucui, Ribeiro Goncalves and Santa Filomena in proportion to the urban population. The remaining 20% will be supplied via land routes.

(4) Wheat Flour

Approximately 80% of the flour required by the upstream region will be collected in Floriano, shipped via the river, and distributed to each port in proportion to the urban population. The remaining 20% will be supplied via land routes.

(5) Oil and Liquefied Petroleum Gas (LPG)

Approximately 60% of the oil and LPG required by the upstream region will be collected in Floriano, shipped via the river, and distributed to each port in proportion to the urban population. The remaining 40% will be supplied via land routes.

(6) Cement

a. Approximately 80% of the cement required by the upstream region will be collected in Floriano and distributed via the river to each port in proportion to the urban population. The other 20% will be transported by land routes.

b. Approximately 30% of the cement required by the midstream region will be collected in Teresina, shipped via the river to Uniao, Miguel Alves and Porto, and distributed in proportion to the urban population. The other 70% will be transported by land routes.

(7) Limestone

Limestone is about to be produced at Urucui and its surroundings. However, it is necessary to establish a plant to process limestone into calcium hydroxide for agriculture land improvement use. Taking into account this situation, it is assumed that limestone is transported from other regions located along the San Fransisco River basin by land transport for the time being and therefore the consequence of this item is excluded from the object of analysis.

The basic data of transport volume of commodities for production and daily consumption is from 1991. Future volumes for the years 2000, 2005, and 2010 are forecast by applying an annual average growth rate at 2.5% which is the same rate of population growth in the upstream regions as stated in the foregoing section of this report.

With regard to fertilizer, however, the forecasted volumes are 40% and 70% of the volume of year 2010 for the years 2000 and 2005 respectively in consideration of the increasing trend of farmland.

The result of the demand forecast cargo in commodities is shown in Tables 6.3.6, 6.3.7 and 6.3.8. Tables 6.3.9, 6.3.10 and 6.3.11 show the forecasted total cargo volume which will be expected for river navigation in the years 2000,2005 and 2010.

Table 6.3.3 Demand Forecast (Agricultural Products)

Year : 2000
Unit : t/year

		St. Filomena		Ribeiro Goncalves		Urucui		Guadalupe		Floriano		Amarante		Palmeiras		Teresina		Uniao		Miguel Alves		Porto		Luzilandia		Parnaiba
Rice	→	(18,400)	18,400	(78,000)	96,400	(45,800)	142,200	(23,300)	165,500	(-49,800)	115,700	(7,200)	122,900	(6,500)	129,400	(-129,400)				(3,500)	3,500	(6,000)	9,500	(4,800)	14,300	(-14,300)
	←																									
Corn	→	(4,400)	4,400	(5,500)	9,900	(7,300)	17,200	(9,100)	26,300	(-26,300)										(4,500)	4,500	(1,600)	6,100	(14,700)	20,800	(-20,800)
	←			(-800)	800	(-3,200)	4,000		4,000	(-21,400) (4,000	21,400	(7,000)	14,400	(1,600)	12,800	(10,800)	2,000	(2,000)								
Fejon	→	(300)	300	(1,100)	1,400	(800)	2,200	(2,000)	4,200	(-4,200)										(600)	600	(400)	1,000	(1,700)	2,700	(-2,700)
	←																									
Soy Been	→			(20,000)	20,000	(48,000)	68,000	(4,300)	72,300		72,300		72,300		72,300	(-72,300)										
	←																									
Fruits	→			(300)	300	(600)	900	(500)	1,400	(-500)	900		900		900	(-900)										
	←																									
Nuts	→			(400)	400	(1,000)	1,400	(400)	1,800	(600)	2,400		2,400		2,400	(-2,400)										
	←																									
Babacu	→											(6,000)	6,000	(6,000)	12,000	(-12,000)										
	←															(-20,000)	20,000	(10,000)	10,000	(10,000)						
Sub-Total	→		23,100		128,400		231,900		271,500		191,300		204,500		217,000		0		0		8,600		16,600		37,800	
	←		0		800		4,000		4,000		21,400		14,400		12,800		22,000		10,000		0		0		0	

Table 6.3.4 Demand Forecast (Agricultural Products)

Year : 2005
Unit : t/year

		St. Filomena		Ribeiro Goncalves		Urucui		Guadalupe		Floriano		Amarante		Palmeiras		Teresina		Uniao		Miguel Alves		Porto		Luzilandia		Parnaiba
Rice	→	(32,000)	32,000	(136,700)	168,700	(81,500)	250,200	(40,900)	291,100	(-87,400)	203,700	(12,550)	216,250	(11,700)	227,950	(-227,950)				(6,300)	6,300	(10,200)	16,500	(34,800)	51,300	(-51,300)
	←																									
Corn	→	(8,100)	8,100	(9,900)	18,000	(13,500)	31,500	(16,400)	47,900	(-47,900)										(8,200)	8,200	(3,100)	11,300	(29,600)	40,900	(-40,900)
	←			(-1,400)	1,400	(-5,600)	7,000		7,000	(-38,300) (7,000	38,300	(12,400)	25,900	(3,000)	22,900	(19,200)	3,700	(3,700)								
Fejon	→	(320)	320	(1,900)	2,220	(1,300)	3,520	(4,230)	7,750	(-7,750)										(1,100)	1,100	(760)	1,860	(3,300)	5,160	(-5,160)
	←																									
Soy Been	→			(49,000)	49,000	(118,600)	167,600	(10,700)	178,300		178,300		178,300		178,300	(-178,300)										
	←																									
Fruits	→			(500)	500	(1,100)	1,600	(800)	2,400	(-870)	1,530		1,530		1,530	(-1,530)										
	←																									
Nuts	→			(700)	700	(1,750)	2,450	(600)	3,050	(1,100)	4,150		4,150		4,150	(-4,150)										
	←																									
Babacu	→											(10,000)	10,000	(11,000)	21,000	(-21,000)										
	←															(-35,000)	35,000	(18,000)	17,000	(17,000)						
Sub-Total	→		40,420		239,120		456,870		530,500		387,680		410,230		432,930		0		0		15,600		29,660		97,360	
	←		0		1,400		7,000		7,000		38,300		25,900		22,900		38,700		17,000		0		0		0	

Table 6.3.5 Demand Forecast (Agricultural Products)

Year : 2010
Unit : t/year

		St. Filomena		Ribeiro Goncalves		Urucui		Guadalupe		Floriano		Amarante		Palmeiras		Teresina		Uniao		Miguel Alves		Porto		Luzilandia		Parnaiba
Rice	→	(55,700)	55,700	(239,000)	294,700	(140,800)	435,500	(71,200)	506,200	(-151,900)	354,800	(21,900)	376,700	(20,000)	396,700	(-396,700)				(10,900)	10,900	(18,000)	29,900	(60,400)	90,300	(-90,300)
	←																									
Corn	→	(16,800)	16,800	(18,000)	34,800	(24,200)	59,000	(29,200)	88,200	(-88,200)										(14,000)	14,000	(5,500)	19,500	(48,000)	67,500	(-67,500)
	←			(-2,000)	2,000	(-8,000)	10,000		10,000	(-67,700) (10,000)	67,700	(22,500)	45,200	(5,000)	40,200	(33,500)	6,700	(6,700)								
Fejon	→	(450)	450	(4,300)	4,750	(1,600)	6,350	(8,700)	15,050	(-15,050)										(2,000)	2,000	(1,300)	3,300	(5,900)	9,200	(-9,200)
	←																									
Soy Been	→			(100,000)	100,000	(240,000)	340,000	(21,500)	361,500		361,500		361,500		361,500	(-361,500)										
	←																									
Fruits	→			(700)	700	(1,600)	2,300	(1,150)	3,450	(-1,250)	2,200		2,200		2,200	(-2,200)										
	←																									
Nuts	→			(1,000)	1,000	(2,500)	3,500	(900)	4,400	(1,600)	6,000		6,000		6,000	(-6,000)										
	←																									
Babacu	→											(15,000)	15,000	(15,000)	30,000	(-30,000)										
	←															(-50,000)	50,000	(25,000)	25,000	(25,000)						
Sub-Total	→		72,950		435,950		846,650		978,800		724,500		761,400		796,400		0		0		26,900		52,700		167,000	
	←		0		2,000		10,000		10,000		67,700		45,200		40,200		56,700		25,000		0		0		0	

Table 6.3.6 Demand Forecast (Commodities)

Year : 2000
Unit : t/year

		St. Filomena		Ribeiro Goncalves		Urucui		Guadalupe		Floriano		Amarante		Palmeiras		Teresina		Uniao		Miguel Alves		Porto		Luzilandia		Parnaiba
Salt	→																									
	←	(-800)	800	(-1,600)	2,400	(-3,000)	5,400	(-900)	6,300	(-400)	6,700		6,700		6,700	(6,700)		(-1,200)	1,200	(-800)	2,000	(-400)	2,400		2,400	(2,400)
Fertilizer	→																									
	←	(-3,000)	3,000	(-17,000)	20,000	(-29,000)	49,000	(-11,000)	60,000	(30,000)	30,000		30,000		30,000	(30,000)										
Sugar	→																									
	←	(800)	800	(-1,900)	2,700	(-2,600)	5,300	(-1,300)	6,600	(6,600)																
Wheat Flour	→																									
	←	(-1,000)	1,000	(-2,000)	3,000	(-2,500)	5,500	(-1,400)	6,900	(6,900)																
Petroleum	→																									
	←	(-2,300)	2,300	(-4,500)	6,800	(-6,000)	12,800	(-3,200)	16,000	(16,000)																
Cemente	→																									
	←	(-500)	500	(-1,000)	1,500	(-1,300)	2,800	(-1,200)	4,000	(4,000)																
Limestone	→																									
	←																									
Sub-Total	→		0		0		0		0		0		0		0		0		0		0		0		0	
	←		8,400		36,400		80,800		99,800		36,700		36,700		36,700		0		1,200		2,000		2,400		2,400	

Table 6.3.7 Demand Forecast (Commodities)

Year : 2005
Unit : t/year

		St. Filomena		Ribeiro Goncalves		Urucui		Guadalupe		Floriano		Amarante		Palmeiras		Teresina		Uniao		Miguel Alves		Porto		Luzilandia		Parnaiba
Salt	→																									
	←	(-950)	950	(-1,800)	2,750	(-3,400)	6,150	(-1,000)	7,150	(-450)	7,600		7,600		7,600	(7,600)		(-1,250)	1,250	(-1,000)	2,250	(-450)	2,700		2,700	(2,700)
Fertilizer	→																									
	←	(-5,000)	5,000	(-30,000)	35,000	(-50,000)	85,000	(-19,000)	104,000	(52,000)	52,000		52,000		52,000	(52,000)										
Sugar	→																									
	←	(950)	950	(-2,100)	3,050	(-2,900)	5,950	(-1,450)	7,400	(7,400)																
Wheat Flour	→																									
	←	(-1,100)	1,100	(-2,300)	3,400	(-2,800)	6,200	(-1,600)	7,800	(7,800)																
Petroleum	→																									
	←	(-2,550)	2,550	(-5,050)	7,600	(-6,800)	14,400	(-3,600)	18,000	(18,000)																
Cemente	→																									
	←	(-500)	500	(-1,150)	1,650	(-1,500)	3,150	(-1,350)	4,500	(4,500)																
Limestone	→																									
	←																									
Sub-Total	→		0		0		0		0		0		0		0		0		0		0		0		0	
	←		11,050		53,450		120,850		148,850		59,600		59,600		59,600		0		1,250		2,250		2,700		2,700	

Table 6.3.8 Demand Forecast (Commodities)

Year : 2010
Unit : t/year

		St. Filomena		Ribeiro Goncalves		Urucui		Guadalupe		Floriano		Amarante		Palmeiras		Teresina		Uniao		Miguel Alves		Porto		Luzilandia		Parnaiba
Salt	→																									
	←	(-1,100)	1,100	(-2,000)	3,100	(-3,800)	6,900	(-1,200)	8,100	(-500)	8,600		8,600		8,600	(8,600)		(-1,500)	1,500	(-1,000)	2,500	(-500)	3,000		3,000	(3,000)
Fertilizer	→																									
	←	(-6,000)	6,000	(-42,000)	48,000	(-72,000)	120,000	(-28,000)	148,000	(74,000)	74,000		74,000		74,000	(74,000)										
Sugar	→																									
	←	(-1,100)	1,100	(-2,400)	3,500	(-3,300)	6,800	(-1,600)	8,400	(8,400)																
Wheat Flour	→																									
	←	(-1,200)	1,200	(-2,500)	3,700	(-3,300)	7,000	(-1,800)	8,800	(8,800)																
Petroleum	→																									
	←	(-2,700)	2,700	(-5,800)	8,500	(-7,800)	16,300	(-4,100)	20,400	(20,400)																
Cemente	→																									
	←	(-600)	600	(-1,300)	1,900	(-1,700)	3,600	(-1,500)	5,100	(5,100)																
Limestone	→																									
	←																									
Sub-Total	→		0		0		0		0		0		0		0		0		0		0		0		0	
	←		12,700		68,700		160,600		198,800		82,600		82,600		82,600		0		1,500		2,500		3,000		3,000	

Table 6.3.9 Demand Forecast (Total Cargo)

Year : 2000
Unit : t/year

St. Filomena — Ribeiro Goncalves — Urucui — Guadalupe — Floriano — Amarante — Palmeiras — Teresina — Uniao — Miguel Alves — Porto — Luzilandia — Parnaiba

		St. Filomena – Ribeiro Goncalves	Ribeiro Goncalves – Urucui	Urucui – Guadalupe	Guadalupe – Floriano	Floriano – Amarante	Amarante – Palmeiras	Palmeiras – Teresina	Teresina – Uniao	Uniao – Miguel Alves	Miguel Alves – Porto	Porto – Luzilandia	Luzilandia – Parnaiba
Agricultural Products	→	23,100	128,400	231,900	271,500	191,300	204,500	217,000	0	0	8,600	16,600	37,800
	←	0	800	4,000	4,000	21,400	14,400	12,800	22,000	10,000	0	0	0
Commodities	→	0	0	0	0	0	0	0	0	0	0	0	0
	←	8,400	36,400	80,800	99,800	36,700	36,700	36,700	0	1,200	2,000	2,400	2,400
All total	→	23,100	128,400	231,900	271,500	191,300	204,500	217,000	0	0	8,600	16,600	37,800
	←	8,400	37,200	84,800	103,800	58,100	51,100	49,500	22,000	11,200	2,000	2,400	2,400
Total		31,500	165,600	316,700	375,300	249,400	255,600	266,500	22,000	11,200	10,600	19,000	40,200

Table 6.3.10 Demand Forecast (Total Cargo)

Year : 2005
Unit : t/year

St. Filomena Ribeiro Goncalves Urucui Guadalupe Floriano Amarante Palmeiras Teresina Uniao Miguel Alves Porto Luzilandia Parnaiba

		St. Filomena – Ribeiro Goncalves	Ribeiro Goncalves – Urucui	Urucui – Guadalupe	Guadalupe – Floriano	Floriano – Amarante	Amarante – Palmeiras	Palmeiras – Teresina	Teresina – Uniao	Uniao – Miguel Alves	Miguel Alves – Porto	Porto – Luzilandia	Luzilandia – Parnaiba
Agricultural Products	→	40,420	239,120	456,870	530,500	387,680	410,230	432,930	0	0	15,600	29,660	97,360
	←	0	1,400	7,000	7,000	38,300	25,900	22,900	38,700	17,000	0	0	0
Commodities	→	0	0	0	0	0	0	0	0	0	0	0	0
	←	11,050	53,450	120,850	148,850	59,600	59,600	59,600	0	1,250	2,250	2,700	2,700
All total	→	40,420	239,120	456,870	530,500	387,680	410,230	432,930	0	0	15,600	29,660	97,360
	←	11,050	54,850	127,850	155,850	97,900	85,500	82,500	38,700	18,250	2,250	2,700	2,700
Total		51,470	293,970	584,720	686,350	485,580	495,730	515,430	38,700	18,250	17,850	32,360	100,060

Table 6.3.11 Demand Forecast (Total Cargo)

Year : 2010
Unit : t/year

Stations: St. Filomena, Ribeiro Goncalves, Urucui, Guadalupe, Floriano, Amarante, Palmeiras, Teresina, Uniao, Miguel Alves, Porto, Luzilandia, Parnaiba

		St. Filomena – Ribeiro Goncalves	Ribeiro Goncalves – Urucui	Urucui – Guadalupe	Guadalupe – Floriano	Floriano – Amarante	Amarante – Palmeiras	Palmeiras – Teresina	Teresina – Uniao	Uniao – Miguel Alves	Miguel Alves – Porto	Porto – Luzilandia	Luzilandia – Parnaiba
Agricultural Products	→	72,950	435,950	846,650	978,800	724,500	761,400	796,400	0	0	26,900	52,700	167,000
	←	0	2,000	10,000	10,000	67,700	45,200	40,200	56,700	25,000	0	0	0
Commodities	→	0	0	0	0	0	0	0	0	0	0	0	0
	←	12,700	68,700	160,600	198,800	82,600	82,600	82,600	0	1,500	2,500	3,000	3,000
All total	→	72,950	435,950	846,650	978,800	724,500	761,400	796,400	0	0	26,900	52,700	167,000
	←	12,700	70,700	170,600	208,800	150,300	127,800	122,800	56,700	26,500	2,500	3,000	3,000
Total		85,650	506,650	1,017,250	1,187,600	874,800	889,200	919,200	56,700	26,500	29,400	55,700	170,000

6.4 Demand Forecast In Volume (Potential Demand Volume)

Tables 6.4.1, 6.4.2 and 6.4.3 summarize and illustrate a demand forecast in volume between respective river ports obtained by means of an aggregation of each forecasted water transport demand by each commodities in volume estimated in accordance with the forecasting method mentioned in the previous chapter.

It should be noted that the forecasted transport demand in volume discussed in this chapter is the potential demand volume. It is necessary to conduct further analyses taking into account of the results of analyses on the maximum available annual transport volume among respective river ports discussed in following chapter so as to forecast the final water transport volume of the Parnaíba river.

6.5 Share of Water Transport for Agricultural Products in the Upper Stream Region

The share of the potential river transport demand volume for agricultural products in the upper stream region is around 43 % as shown in Table 6.5.1.

Table 6.5.1 Navigable Cargo Ratio (Potential Demand Volume)

Unit : ton

Products		2000	2003	2005	2010
Rice	Projected Product Volume	334,627	486,200	587,271	1,023,673
	Navigable Cargo Volume	165,500	240,860	291,100	506,700
Corn	Projected Product Volume	189,665	282,900	345,000	616,825
	Navigable Cargo Volume	26,300	39,260	47,900	88,200
Fejon Beans	Projected Product Volume	23,909	36,404	44,801	82,309
	Navigable Cargo Volume	4,200	6,330	7,750	15,050
Soy Beans	Projected Product Volume	94,226	178,300	234,434	471,516
	Navigable Cargo Volume	72,300	135,900	178,300	361,500
Total	Projected Product Volume	642,427	983,804	1,211,506	2,194,323
	Navigable Cargo Volume	268,300 (3,800)	422,350 (5,450)	525,050 (6,550)	971,450 (9,450)

Note : Numbers in ( ) shows Nuts and Fruits

Navigable cargo volumes in Table 6.5.1 are projected by the method of a gravity model which is commonly used in traffic analysis. The respective transport cargo volumes calculated from each agricultural production area to each river port along the Parnaíba river and to other major cities are based on the inverse proportion of the time distance factor for each route.

Table 6.4.1 Transition of Demand Volume (Agricultural Products)

Part of Up Stream Region(St.Filomena ~ Floriano)

Unit : t / year

		St.Filomena ~	R.Goncalves ~	Urcui ~	Gudalupe ~	Floriano
2000	→	23,100	119,400	231,900	271,500	
	←	0	800	4,000	4,000	
2005	→	40,420	239,120	456,870	530,500	
	←	0	1,400	7,000	7,000	
2010	→	72,950	435,950	846,650	978,800	
	←	0	2,000	10,000	10,000	

Part of Mid-Stream Region (Floriano ~ Uniao)

		Floriano ~	Amarante ~	Palmeiras ~	Teresina ~	Uniao
2000	→	191,300	204,500	217,000	0	
	←	21,400	14,400	12,800	20,000	
2005	→	287,680	410,230	432,930	0	
	←	38,300	25,900	22,900	35,000	
2010	→	724,500	761,400	796,400	0	
	←	67,700	45,200	40,200	56,700	

Part of Down Stream Region (Uniao ~ Luiz Correia)

		Uniao ~	Miguel Alves ~	Ponto ~	Lugiandia ~	Paranaiba ~	Luis Correia
2000	→	0	8,600	16,600	37,800		
	←	10,000	0	0	0		
2005	→	0	15,600	29,660	97,360		
	←	17,000	0	0	0		
2010	→	0	26,900	52,700	167,000		
	←	25,000	0	0	0		

Table 6.4.2 Transition of Demand Volume (Commodities)

Part of Up Stream Region (St.Filomena ~ Floriano)

Unit : t / year

		St.Filomena ~ R.Goncalves	R.Goncalves ~ Urcui	Urcui ~ Gudalupe	Gudalupe ~ Floriano
2000	→	0	0	0	0
	←	7,600	35,400	80,000	99,200
2005	→	0	0	0	0
	←	10,000	51,900	120,000	148,500
2010	→	0	0	0	0
	←	12,600	68,700	160,600	198,800

Part of Mid-Stream Region (Floriano ~ Uniao)

		Floriano ~ Amarante	Amarante ~ Palmeiras	Palmeiras ~ Teresina	Teresina ~ Uniao
2000	→	0	0	0	0
	←	36,300	36,300	36,300	0
2005	→	0	0	0	9,700
	←	59,400	59,400	0	0
2010	→	0	0	0	11,000
	←	82,600	82,600	0	0

Part of Down Stream Region(Uniao ~ Luiz Correia)

		Uniao ~ Miguel Alves	Miguel Alves ~ Ponto	Ponto ~ Lugiandia	Lugiandia ~ Paranaiba	Paranaiba ~ Luis Correia
2000	→	4,400	1,480	0	0	0
	←	1,200	1,940	2,350	2,350	0
2005	→	4,950	1,680	0	0	0
	←	1,300	2,190	2,650	2,650	0
2010	→	5,600	1,900	0	0	0
	←	1,480	2,480	3,000	3,000	0

Table 6.4.3 Transition of Demand Volume (All Cargo)

Part of Up Stream Region(St.Filomena ~ Floriano)

Unit : t / year

		St.Filomena ~ R.Goncalves	R.Goncalves ~ Urcui	Urcui ~ Gudalupe	Gudalupe ~ Floriano
2000	→	23,100	119,400	231,900	271,500
	←	8,400	37,200	84,800	103,800
2005	→	40,420	239,120	456,870	530,500
	←	11,050	53,450	127,850	155,850
2010	→	72,950	435,950	846,650	978,800
	←	12,700	70,700	170,600	208,800

Part of Mid-Stream Region (Floriano ~ Uniao)

		Floriano ~ Amarante	Amarante ~ Palmeiras	Palmeiras ~ Teresina	Teresina ~ Uniao
2000	→	191,300	204,500	217,000	0
	←	58,100	51,100	49,500	20,000
2005	→	387,680	410,230	432,930	0
	←	97,900	85,500	82,500	35,000
2010	→	724,500	761,400	796,400	0
	←	150,300	127,800	122,800	56,700

Part of Down Stream Region(Uniao ~ Luiz Correia)

		Uniao ~ Miguel Alves	Miguel Alves ~ Ponto	Ponto ~ Lugiandia	Lugiandia ~ Paranaiba	Paranaiba ~ Luis Correia
2000	→	0	8,600	16,600	37,800	
	←	11,200	2,000	2,400	2,400	
2005	→	0	15,600	29,660	97,360	
	←	18,250	2,250	2,700	2,700	
2010	→	0	26,500	52,700	167,000	
	←	26,500	2,500	3,000	3,000	

7. NAVIGABLE SHIP AND MAXIMUM TRANSPORT CAPACITY OF THE PARNAÍBA RIVER

7 NAVIGABLE SHIP AND MAXIMUM TRANSPORTATION CAPACITY OF THE PARNAÍBA RIVER

7.1 Navigable Ship Size of Parnaíba River

In Chapter 3 and Chapter 4, the Parnaíba river was investigated in the geographic and traffic fields respectively, and in those studies, the river is divided into three zones which show several different features.

According to the above investigations, the applicable and suitable ship size and type for the Parnaíba river navigation is studied to meet each zone especially from a view point of safe manoeuvring.

7.1.1 Conditions of Each Zone

Zone-1

In this zone, the river has sufficient width but several difficulties in river navigation are observed such as many sand bars, shallow depth in the dry season at Luzilandia and sharp curves in the Igaracu river. Though the river is wide enough, it is very difficult for the ship to find practically navigable water because of the opaque water of the river.

Therefore, adequate navigation aids are required for the ships safe navigation, especially in shallow water. The ship should have excellent manoeuvrability for the narrow and bending river. Furthermore, some improvements are necessary to the above mentioned sharp curve at the Igaracu river such as new bypass channel and tug boat assistance.

Zone-2

The river shows a relatively stable width and depth in this zone though it has some sharp curves, narrow channels and sand bars.

Suitable navigation aids are therefore essential for a ship's safe navigation, especially in the narrow and shallow areas. Some improvements are necessary for the extremely narrow points of the corrade.

Zone-3

The river in this zone has sufficient depth but some difficulties for ship navigation are found such as many narrow channels with rocky riverbanks, high velocity of flow and a few shallow areas near Santa Filomena. Boa Esperanca locks, construction of which has been interrupted will physically restrict passable ship's size.

Boa Esperanca Lock, as well as the waterway between the two locks should be repaired and completed (but lock dimensions should be kept at least as the original ones.) for the through process of navigation.

Adequate anchorage and mooring spaces should be provided at the gates of the locks, especially at the entrance to the Parnaíba river.

Suitable navigation aids are essential for a ship's safe navigation, especially at the narrow areas by the corrade.

In addition to the above, the following are commonly required for each zone.

- Fuel oil, fresh water and provision supply facilities shall be prepared at the calling ports.
- Mooring and anchorage spaces and necessary fittings shall be provided at the calling ports.
- Loading and unloading facilities shall be prepared at each port in the future.
- Basically the ships shall be in service only in daytime in view of safety.
- Some assistance and rescue systems shall be considered against accidents anticipated such as grounding, collision and engines trouble.

7.1.2 Dimensions of Navigable Ship

The following three systems are typical and applicable for the Parnaíba river navigation.

1. Self-propulsive cargo ship (lock passable type)
2. Larger sized self-propulsive cargo ship
3. Pusher and barge system (Pusher plus single or plural barges)

All ships or barge systems should have a navigation speed of around 8.0 knots which is required not only for an effective transportation but for as a suitable speed for such a size of ship with economical fuel consumption by propulsion. Lower speeds could not overcome the high velocity of the river upstream and excessive speed involves too much engine horse power.

The size of ships and barges must be within the dimensions of the Boa Esperanca Lock as follows.

Boa Esperanca Lock :	Length	50m
	Width	12m
	Height	8m (Lower gate of upper lock)
	Depth	2.5m (Upper lock)

For the safe passage of locks, the ship shall have a suitable allowance in dimensions which are generally advocated and recognized as 3-10 m longitudinally and 0.2-1.5 m at the sides. In this case, it is recommendable that the vessel shall have 3 m (1.5m each for fore and aft) and 1 m (0.5 m for each side) clearance respectively since excessive breadth will make manoeuvrability difficult for the crew. Thus the ship's overall length is not to exceed 47.0 m and breadth is not to exceed 11.0 m.

The above lock dimensions restrict the maximum ship size as follows.

Length o.a. : max. 47.0m

Breadth	max. 11.0m
Height	max. 5.0m above water line
Draft	max. 2.3m when passing

The maximum draft of ship is restricted to 2.3m by the water level of the Boa Esperanca Locks when passing and the ship height shall be adjusted by suitable ballasting if the draft is not enough.

In the case of a barge system, it is convenient to unify the size of barge as the module and the following dimensions are recommendable.

Barge size : L x B = 30m x 11m
Pusher size : L = 17m

(1) Dimension of Case 1 (Lock passable type)

Length over all	: 47.0m
Length p.p.	: 45.0m
Breadth	: 11.0m
Depth	: 3.5m
Draft(max.)	: 3.0m (0.5m for freeboard)
Speed	: 8.0knots

(2) Dimension of Case 2 (Large sized cargo ship)

	Type A	Type B
Length o.a.	63.0	85.0
Length p.p.	60.0	80.0
Breadth	15.0	20.0
Depth	4.0	4.5
Draft(max.)	3.5	4.0
Speed	8.0	8.0

(3) Dimension of Case 3 (Pusher and barge system)

For the barge system, the following four cases are applicable.

Case A : Pusher and one barge
Case B : Pusher and two barges (longitudinal)
Case C : Pusher and two barges (transverse)
Case D : Pusher and 4 barges (2 x 2)

Table 7.1.1 Dimension and Capacity of Barge System

	A	B	C	D
Length of system (m)	47.0	77.0	47.0	77.0
Breadth of system (m)	11.0	11.0	22.0	22.0
Depth (m)	3.0	3.0	3.0	3.0
Draft (max) (m)	2.5	2.5	2.5	2.5
Speed (knot)	8.0	7.0	6.0	4.0

See Fig.7.1.1 for the type and size of navigable ship.

In the case of D, the ship's speed will be much reduced and the ship can not overcome the river flow because of the large displacement when loaded. If a speed of 8 knots is to be maintained, the pusher must have a very large horse power for its main engines which will result in an excessive draft of the pusher itself.

In general, a vessel navigating a shallow depth area is influenced by shallow water effects such as change for the worse of turning performance by rudder and sinkage of the vessel which means an increase of draft etc.. Therefore operators are required to pay special attention to the manoeuvring during shallow water navigation.

Furthermore, the ship should navigate carefully when passing through very narrow channel because the effect of bank suction will make the ship's manoeubrability worse especially in course stability.

The applicability and suitability of ship type for each zone is studied as follows.

Zone-1

Basically all types of ship stipulated above are applicable in this zone.

Since this zone has sufficient width and very few sharp curves except at the Igaracu river, only depth is a factor which restricts the ship's dimension.

Near Luzilandia and Buriti Dos Lopes, there are 500m and 400m radius curves respectively which require a sufficient turning ability of a ship especially in the case of a barge system.

Even in the case of 3 (Barge system), the size of pusher and barge shall be within the limit of the Boa Esperanca lock for the possible future transportation as above mentioned.

Zone-2

This zone has a relatively stable waterway for navigation though there are some narrow points by the corrades. The ship, however, should have good performance and capacity for steering and turning because this zone also contains sharp curves of 300m and 400m radius and very shallow areas.

The above three systems are also applicable for this zone as in Zone-1. However, the width of the river is less than Zone-1 and the river has some projecting rocks and sharp curves so that only type A (63 m length) for large cargo ships and cases A and B for barge systems are to be recommendable in view of safe navigation.

Zone-3

A lock passable cargo ship and a barge system are both applicable though the size of ships for this zone is basically restricted by dimensions of the Boa Esperanca Locks.

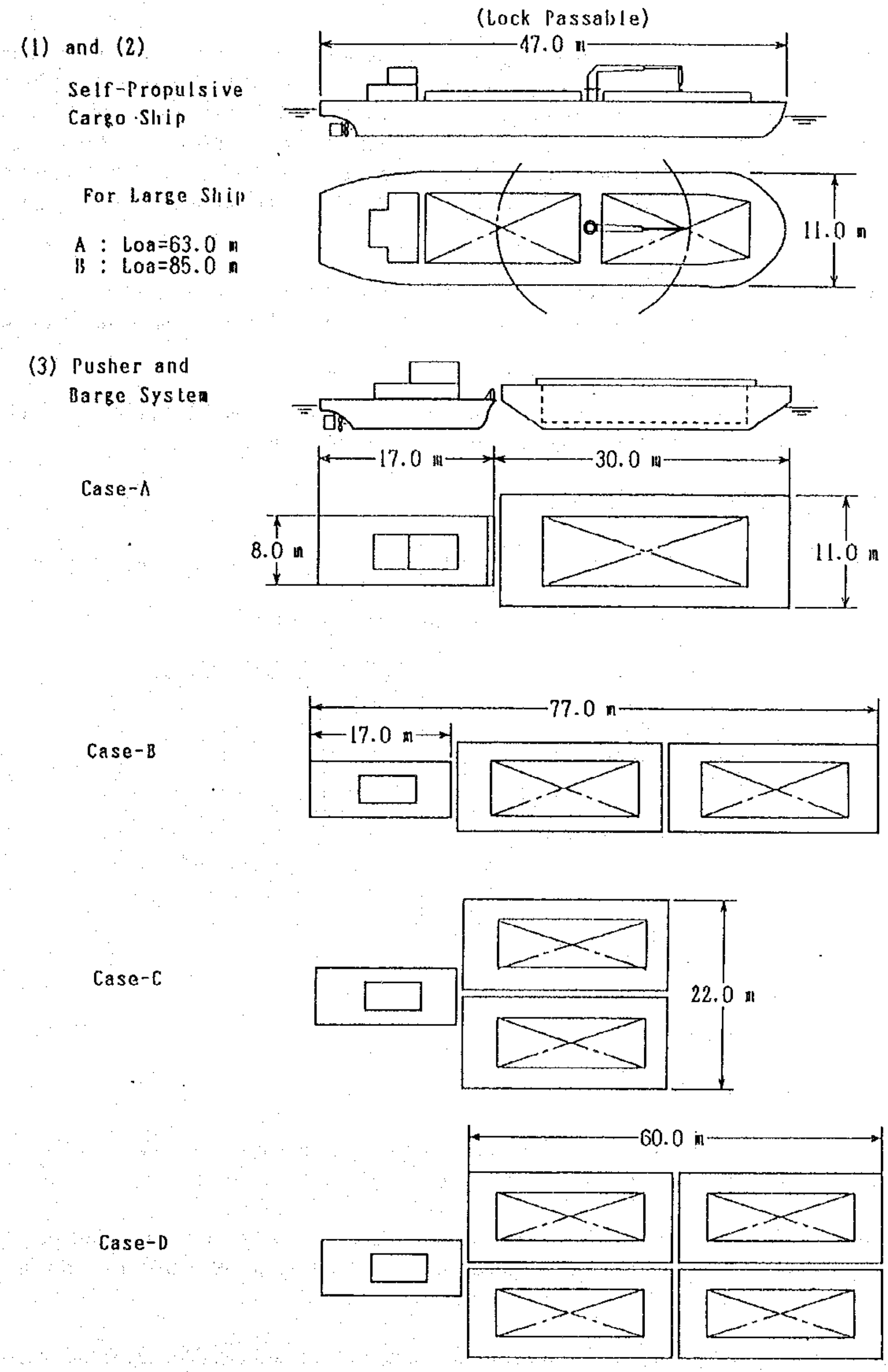

Fig. 7.1.1 Type of Navigable Ship

However, as there are several curves and areas where the flow velocity exceeds 3.5 knots upstream of Urucui, a barge system shall be accordingly restricted to 1-pusher and 1-barge only, and in that case the cargo carrying capacity would be less than for a cargo ship. Even in the case of a plural barge system, the barges must be reformed to a pusher and a single barge for lock transportation before and after the locks which means much time lost. This means that a barge system is not advantageous in this zone and therefore self propulsive cargo ships of 47m length are to be recommendable.

The river in this zone has some very narrow points of about 30m in width caused by projecting rocks, but a ship of 11m breadth can pass through these areas with suitable navigation aids and also skillful operation by the crew.

No passing each other and no passing another ship at this narrow point should be done and it would be required to have proper steering ability against bank effects.

7.1.3 Navigable Ship Size and Type

After the investigations above, the navigable ship size for each zone are summarized below.

Table 7.1.2 Summary of Navigable Ship Size

SHIP SIZE, TYPE		Zone-1	Zone-2	Zone-3
(1) Self Propulsive Ship (Lock passable)		x	x	x
(2) Self Propulsive Ship (Large Sized)	Type A	x	x	-
	Type B	x	-	-
(3) Pusher and Barges	Case-A	x	x	-
	Case-B	x	x	-
	Case-C	x	-	-
	Case-D	x	-	-

x : Applicable
- : Not applicable

7.2 Vessel Types and Capacity

7.2.1 Suitable Ship Type and Size

According to the studies in 7.1, a pusher and barge system is applicable in Zone-1 and Zone-2. However a barge system is not recommendable for the reasons as follows:

1. Since the Parnaiba river has many sharp curves in each zone, a barge system is not suitable for river navigation because the manoeuvrabilty of a barge is not satisfactory for such curves in view of safety.

2. The river depth especially in the downstream region is not sufficient for ship's navigation even in the rainy season. This will affect the steering ability and speed of the barge system because of the shallow water effects caused by insufficient under keel clearance of the barge.

3. The river has narrow channels of approximately 30 m in width with rocks both sides in some places and where flow velocity of the river increases up to 4 - 5 knots. When a barge system contains plural barges, speed will be much reduced especially in the loaded condition, which means a barge system sometimes cannot overcome the river flow when going upstream.

4. In general, barges are not fitted with cargo gear because there are no power units on barges. Therefore it will take a lot of time for loading and unloading, and furthermore in the case of of plural barge system, it will also take time and expense for the releasing and fixing works of the barge, which has to be done in inadequate anchorage space and in the high flow velocity of the river.

On the other hand, large sized cargo ship are also applicable in Zone-1 and Zone-2 and these can be navigable in narrow channels and shallow water with proper steering and manoeuvring by crew. It is however not recommendable to apply large vessels for the river navigation because these are not lock passable size, which means every cargo would have to be changed to another passable ship before or after entering the Boa Esperanca Lock.

Another inconvenience of large sized ships is that the ship could not enjoy her large capacity under the full draft because of the shallow water depth especially in Zone-1.

From the investigation of traffic conditions in chapter-4 and demand forecast in chapter-6, the volume of cargo flow is basically concentrated in the area between Zone-2 and Zone-3. Size of ship should meet such cargo flows and locations and all ships in service in these zones should have the flexibility of navigating in that area. Thus lock passable sized cargo ships are much more suitable and convenient than the larger ones.

As a conclusion, it is recommendable that the ships to be in service in all zones of the Parnaíba river should be self-propulsive, lock passable sized cargo ships.

The ship should have a cargo hold capacity of 1,300 m^3 as above mentioned which would enable the ship to load cargoes of specific gravity approximately 0.7 (corresponding about 50 cubic feet/long ton in stowage factor) at the full draft of 3.0 m.

The dimensions of which are as follows.

Length o.a. = 47.0m
Length p.p. = 45.0m
Breadth = 11.0m
Depth= 3.5m
Draft(max.) = 3.0m
Cargo Hold Capacity = 1,300 M3
Speed = 8.0 knots

In addition to the above, the ship shall be provided with the following equipment and facilities:

1. Twin main engines and twin screw system which would enable the ship to keep a shallow draft. The main engines can be operated remotely from the navigation bridge deck.
2. Twin rudders for excellent turning performance.

3. A deck crane of 1.0 ton capacity for easy loading and unloading.
4. Very low height of navigation bridge and collapsible mast to pass Boa Esperanca locks.
5. Specially reinforced structure for the bow, bottom and side construction against the grounding or collisions anticipated.
6. Radio equipment for ship to ship and ship to shore communication for safe navigation and emergencies.

General Arrangement Plan is shown in Fig.7.2.1.

The plan shows the typical cargoes ship which is for grain cargo such as soybean, corn and rice. Cargo holds and capacity as well as hatch size are changeable to accommodate other cargoes without modification of ship's dimensions and propulsions.

7.2.2 Loadable Cargo Capacity at Each Ship's Draft

Based on the ship size recommended in 7.2.1, the ship's carrying capacity at each draft are estimated as the Table 7.2.1.

The ship can load the weight of cargo up to 930 tons at 3.0m draft but as the navigable draft is restricted by water depth of the river with suitable under keel clearance for safety, therefore the loadable cargo weight is limited accordingly.

Table 7.2.1 Loadable Cargo Volume by Ship's Draft

Draft (m)	0.9	1.0	1.1	1.2	1.3	1.4	1.5	1.6	1.7	1.8	1.9
Q'ty (ton)	50	90	120	160	200	240	290	330	370	410	450

Draft (m)	2.0	2.1	2.2	2.3	2.4	2.5	2.6	2.7	2.8	2.9	3.0
Q'ty (ton)	490	540	580	620	660	710	750	800	840	890	930

Source : JICA Study Team

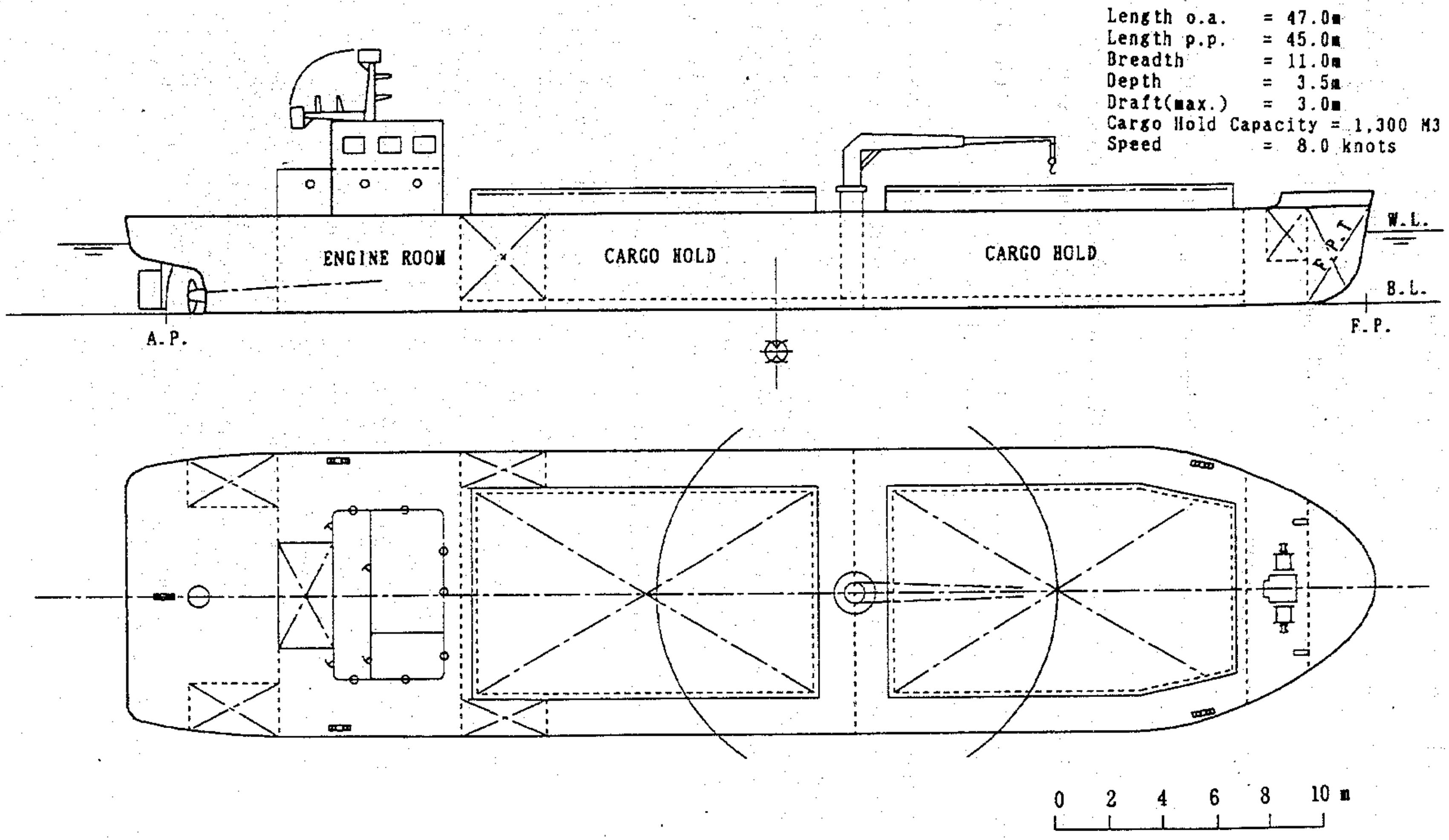

Fig. 7.2.1 General Arrangement

7.3 Maximum Transport Capacity of the Parnaiba River

In this section, the transport capacity of the Parnaiba river was estimated under the restricted conditions of the Boa Esperanca Locks and the depth of the river (see Fig.7.3.1 for the location of the locks, area restricted by water depth and major river ports).

7.3.1 Maximum Transport Capacity

The transportation capacity was obtained by multiplying the number of ships passing the locks by loadable cargo volume per ship.

The number of ships passing the locks will be affected by the operational hours of the locks, with the loadable cargo volume affected by the depth of the locks and the waterway.

The estimation was made shown as below in which was studied 3 cases of operational hours of the locks for the following 3 transportation models and the lock passage.

1) Transportation between Santa Filomena and Parnaiba - All the way throughout the river which is restricted by the depth of the locks, Fazenda Veneza and Luzilandia as shown in Table 7.3.5.
2) Transportation between Ribeiro Goncalves and Teresina - The most typical transportation which is restricted by the depth of the locks and Fazenda Veneza as shown in Table 7.3.6.
3) Transportation between Ribeiro Goncalves and Floriano - The second typical transportation which is restricted by the depth of the locks and Urucui as shown in Table 7.3.7.
4) The passage of the Boa Esperanca Locks which is restricted only by the depth of the locks.

Table 7.3.1 Transport Capacity of the Parnaiba River

Unit : ton

Lock Operation Hours		Case 1 12 hours	Case 2 18 hours	Case 3 24 hours
Passable Ships/day	Downward	5 ships	7 ships	10ships
	Upward	5 ships	7ships	10 ships
Santa Filomena	Downward	423,600	593,040	847,200
	Upward	423,600	593,040	847,200
Parnaiba	Total	847,200	1,186,080	1,694,400
Ribeiro Goncalves	Downward	526,800	737,520	1,053,600
	Upward	526,800	737,520	1,053,600
Teresina	Total	1,053,600	1,475,040	2,107,200
Ribeiro Goncalves	Downward	782,400	1,095,360	1,564,800
	Upward	782,400	1,095,360	1,564,800
Floriano	Total	1,564,800	2,190,720	3,129,600
	Downward	892,800	1,249,920	1,785,600
Locks	Upward	892,800	1,249,920	1,785,600
	Total	1,785,600	2,499,840	3,571,200

Source : JICA Study Team

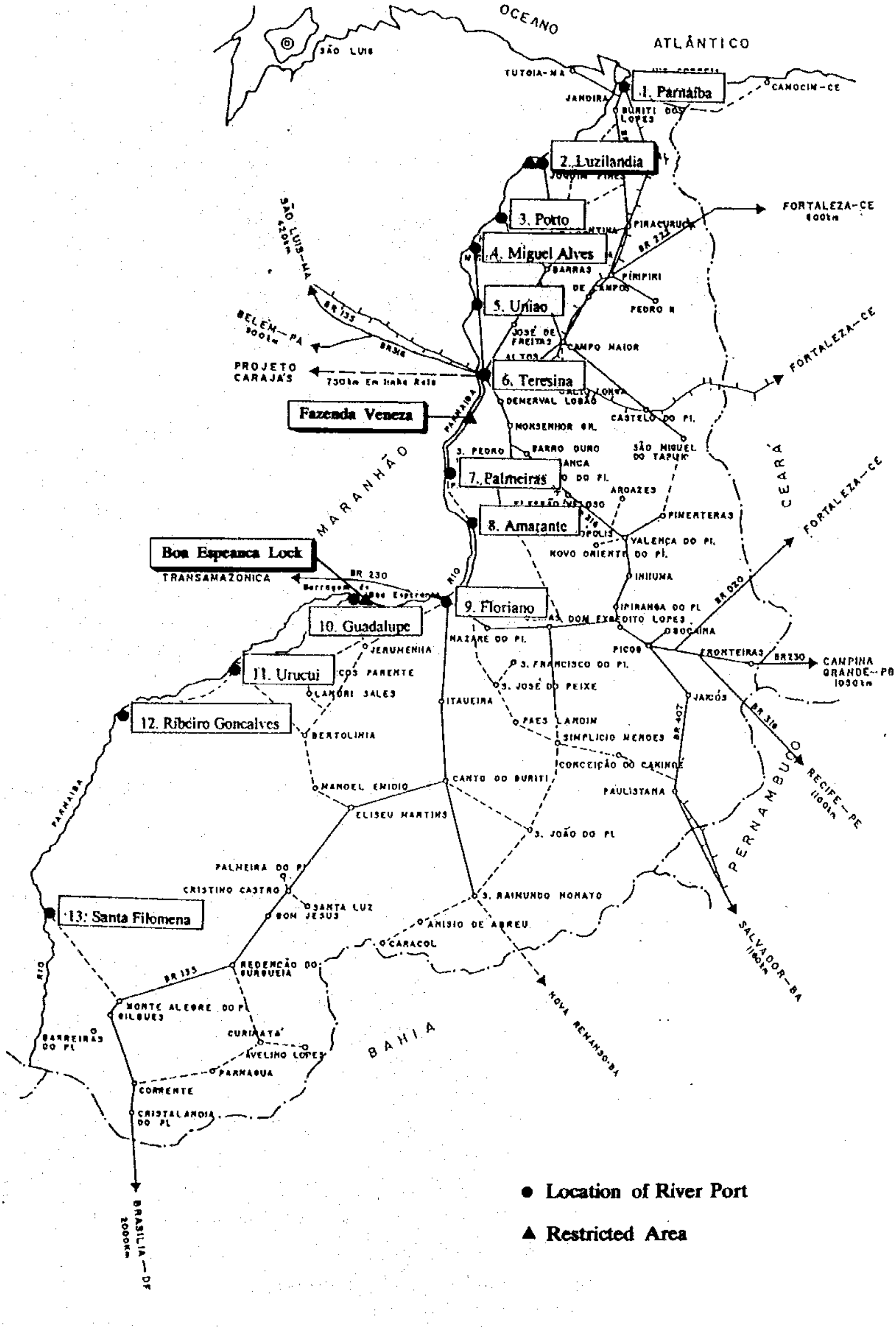

Fig. 7.3.1 Location of River Ports, Lock and Area Restricted by Water Depth

Unit : tons

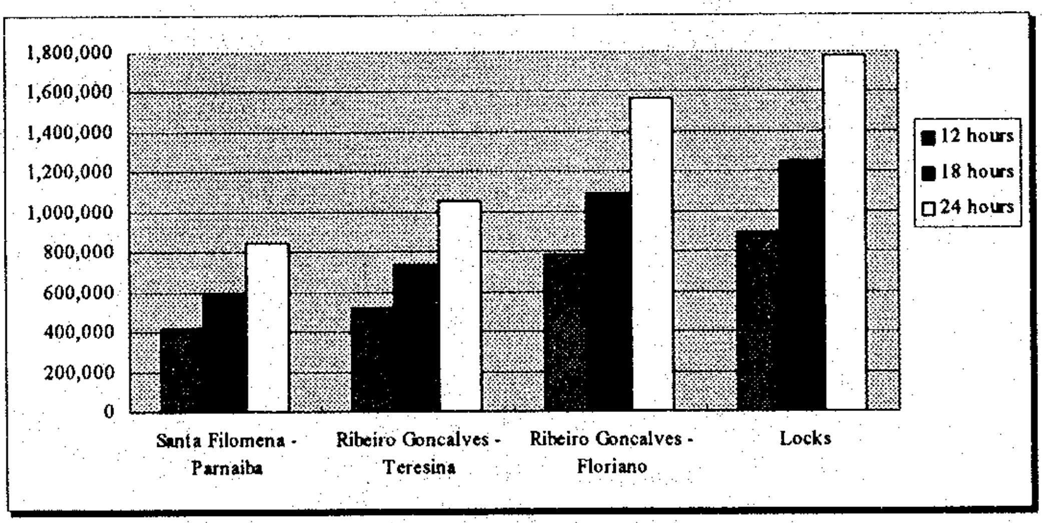

Fig. 7.3.2 Maximum Transport Capacity of the Parnaíba River

The most applicable operational period shall be 18 hours (case-2 above) considering the demand forecast and ship's congestion in the waiting area for daytime navigation etc.

Consequently, the maximum transport capacity of the river is 593,040 tons per year for the downstream and upward stream transport between Santa Filonena and Parnaíba, 737,520 tons between Ribeiro Goncalves and Teresina, 1,095,360 tons between Ribeiro Goncalves and Floriano and 1,249,920 tons for lock passage.

7.3.2 Conditions

The following conditions were taken into account to estimate the maximum transport capacity.

(1) Lock Facility

Considering cargo movements and effective cargo transportation by ship throughout the Parnaiba river, reconstruction of the Boa Esperanca Lock is essential.

1) Lock - Ship Dimensions

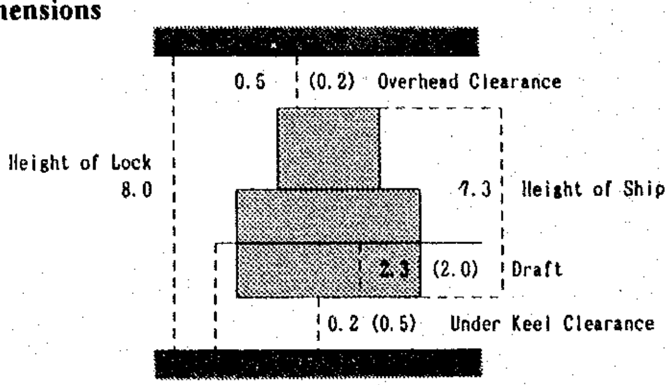

Fig.7.3.3 Lock - Ship Dimensions

2) Loadable Volume limited by the locks

Depth of the locks	: 2.5 m
Under keel clearance	: 0.2 m
Maximum draft	: 2.3 m
Loadable cargo volume	: 620 tons

3) Time required to pass the Boa Esperanca Locks

The following time will be required when passing the locks.

Procedure	Time(minutes)
a. Proceeding to upper lock and mooring	10
b. Closing upper gate of upper lock	7
c. Discharging water	16
d. Opening lower gate of upper lock	4
e. Relieving ship from mooring	10
f. Proceeding to lower lock (abt.1200m)	30
g. Mooring at lower lock	10
h. Closing upper gate of lower lock	2
i. Discharging water in lower lock	16
j. Opening lower gate of lower lock	10
k. Relieving ship from mooring	10
l. Proceeding to Parnaiba river	20
Sum	145
	(approx. 2.5 hrs)

The above is for a ship going down with almost the same time estimated for going up. About 2.5 hours is required for only one ship's passing but actually two ships can pass at the same time in upper and lower locks.

4) Number of Ships Passable the Boa Esperanca Locks

The number of ships passing the locks shall be affected by the operational hours of the locks.

The number of ships passing the locks per month was calculated as follows;

Number of ships/month = Number of ships/day x 30 days x 0.8

0.8 : Operation rate considering loss time for awaiting ships, repairs and maintenance etc.

Table 7.3.2 Number of Ships Passble the Locks

		Case 1	Case 2	Case 3
Lock Operation Hours (hr)		12	18	24
Number of Ships Passing the Locks per Day	Downward	5	7	10
	Upward	5	7	10
	Total	10	14	20
Number of Ships Passing the Locks per Month	Downward	120	168	240
	Upward	120	168	240
	Total	240	336	480

Source : JICA Study Team

(2)Depth of Waterway

Ship's draft shall be changed in accordance with the depth of the waterway. Table 7.3.3 shows the monthly water depth, maximum drafts of the vessel considering a 0.3 m of under keel clearance and a maximum loadable cargo volume in each zone (see Table 7.3.4 for the detailed estimation).

Table 7.3.3 Waterway Depth - Draft - Cargo Volume

	Zone 1			Zone 2			Zone 3		
	Depth (m)	Draft (m)	Cargo Volume (t)	Depth (m)	Draft (m)	Cargo Volume (t)	Depth (m)	Draft (m)	Cargo Volume (t)
Jan	2.7	2.4	660	2.8	2.5	710	1.9	1.6	330
Feb	2.8	2.5	710	3.1	2.8	840	2.1	1.8	410
Mar	3.3	3.0	930	3.2	2.9	890	2.0	1.7	370
Apr	3.1	2.8	840	2.7	2.4	660	1.9	1.6	330
May	2.1	1.8	410	1.8	1.5	290	1.6	1.3	200
Jun	1.6	1.3	200	1.5	1.2	160	1.5	1.2	160
Jul	1.3	1.0	90	1.5	1.2	160	1.5	1.2	160
Aug	1.2	0.9	50	1.5	1.2	160	1.5	1.2	160
Sep	1.2	0.9	50	1.5	1.2	160	1.4	1.1	120
Oct	1.3	1.0	90	1.6	1.3	200	1.5	1.2	160
Nov	1.4	1.1	120	2.0	1.7	370	1.6	1.3	200
Dec	1.6	1.3	200	2.1	1.8	410	1.7	1.4	240

(3) Daytime Navigation

Considering the difficulties involved with night navigation due to the nature of the river such as shallow water, narrow channels, rapid water flow and curved passages,daytime navigation shall be recommended.

7.3.3 Estimation of Maximum Transport Capacity

In this clause, the following three transportation models and the lock passage were studied.

1) Transportation between Santa Filomena and Parnaiba - All the length the river.
2) Transportation between Ribeiro Goncalves and Teresina - The most typical transportation.
3) Transportation between Ribeiro Goncalves and Floriano - The second most typical transportation.

Table 7.3.4 Water Depth - Draft - Loadable Cargo Quantity

		JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
SANTA FILOMENA	Depth(m)	1.9	2.1	2	1.9	1.6	1.5	1.5	1.5	1.4	1.5	1.6	1.7
	Draft(m)	1.6	1.8	1.7	1.6	1.3	1.2	1.2	1.2	1.1	1.2	1.3	1.4
	Cargo(t)	330	410	370	330	200	160	160	160	120	160	200	240
RIBEIRO GONCALVES	Depth(m)	3.4	3.6	3.6	3.4	3	2.9	2.8	2.7	2.7	2.7	3	3.2
	Draft(m)	3	3	3	3	2.7	2.6	2.5	2.4	2.4	2.4	2.7	2.9
	Cargo(t)	930	930	930	930	800	750	710	660	660	660	800	890
URUCUI	Depth(m)	3.5	3.7	3.7	3.5	2.6	2.4	2.2	2.1	2	2.1	2.6	2.9
	Draft(m)	3	3	3	3	2.3	2.1	1.9	1.8	1.7	1.8	2.3	2.6
	Cargo(t)	930	930	930	930	620	540	450	410	370	410	620	750
GUADALUPE	Depth(m)	8	7.1	7	7	7.1	7	7	7	7	7	7.1	7.1
	Draft(m)	3	3	3	3	3	3	3	3	3	3	3	3
	Cargo(t)	930	930	930	930	930	930	930	930	930	930	930	930
LOCK	Depth(m)	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5
	Draft(m)	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3
	Cargo(t)	620	620	620	620	620	620	620	620	620	620	620	620
FLORIANO	Depth(m)	4.5	4.6	4.3	3.4	3.1	3.1	3.1	3	3	3.2	3.4	3.7
	Draft(m)	3	3	3	3	2.8	2.8	2.8	2.7	2.7	2.9	3	3
	Cargo(t)	930	930	930	930	840	840	840	800	800	890	930	930
AMARANTE	Depth(m)	4.2	4.4	3.9	3.1	2.4	2	2	1.9	1.9	2.2	2.5	2.9
	Draft(m)	3	3	3	2.8	2.1	1.7	1.7	1.6	1.6	1.9	2.2	2.6
	Cargo(t)	930	930	930	840	540	370	370	330	330	450	580	750
PALMEIRAIS	Depth(m)	4.1	4.2	4	3.6	3	2.4	2.4	2.3	2.4	2.7	3.2	3.5
	Draft(m)	3	3	3	3	2.7	2.1	2.1	2	2.1	2.4	2.9	3
	Cargo(t)	930	930	930	930	800	540	540	490	540	660	890	930
FAZENDA VENEZA	Depth(m)	2.8	3.1	3.2	2.7	1.8	1.5	1.5	1.5	1.5	1.6	2	2.1
	Draft(m)	2.5	2.8	2.9	2.4	1.5	1.2	1.2	1.2	1.2	1.3	1.7	1.8
	Cargo(t)	710	840	890	660	290	160	160	160	160	200	370	410
TERESINA	Depth(m)	3.5	3.7	3.8	3.6	2.8	2.5	2.5	2.3	2.3	2.6	2.7	2.9
	Draft(m)	3	3	3	3	2.5	2.2	2.2	2	2	2.3	2.4	2.6
	Cargo(t)	930	930	930	930	710	580	580	490	490	620	660	750
UNIAO	Depth(m)	3.5	3.4	3.6	3.5	2.6	2.2	2.2	2.2	2.2	2.3	2.3	2.6
	Draft(m)	3	3	3	3	2.3	1.9	1.9	1.9	1.9	2	2	2.3
	Cargo(t)	930	930	930	930	620	450	450	450	450	490	490	620
MIGUEL ALVES	Depth(m)	3	3.2	3.4	3.1	2.1	1.9	1.8	1.7	1.7	1.8	2	2.2
	Draft(m)	2.7	2.9	3	2.8	1.8	1.6	1.5	1.4	1.4	1.5	1.7	1.9
	Cargo(t)	800	890	930	840	410	330	290	240	240	290	370	450
PORTO	Depth(m)	5	5.2	5.2	5	3.9	3.5	3.4	3.3	3.4	3.5	3.6	4
	Draft(m)	3	3	3	3	3	3	3	3	3	3	3	3
	Cargo(t)	930	930	930	930	930	930	930	930	930	930	930	930
LUZILANDIA	Depth(m)	2.7	2.8	3.3	3.9	2.4	1.6	1.3	1.2	1.2	1.3	1.4	1.6
	Draft(m)	2.4	2.5	3	3	2.1	1.3	1	0.9	0.9	1	1.1	1.3
	Cargo(t)	660	710	930	930	540	200	90	50	50	90	120	200
PARNAIBA	Depth(m)	Waterway Depth shall be changed by tide. Deeper than Luzilandia.											
	Draft(m)	2.4	2.5	3	3	2.1	1.3	1	0.9	0.9	1	1.1	1.3
	Cargo(t)	660	710	930	930	540	200	90	50	50	90	120	200

Remarks : Ship's Max. Draft : 3.0 m
Under Keel Clearance : 0.2 m for Lock
0.3 m for River Passage

Source : JICA Study Team

4) The passage of the Boa Esperanca Locks.

(1) Monthly and Annual Transport Capacity

The annual transport capacity was estimated in the three cases of the lock's operational hours by totalling the monthly capacity because the loadable cargo volume shall be changed monthly in accordance with the depth of the waterway.

1) Santa Filomena - Parnaíba

(The terminal of Santa Filomena shall be located at a place deeper than the minimum depth in the Table 7.3.5 below.)

Table 7.3.5 Monthly and Annual Transport Capacity
(Transportation between Santa Filomena and Parnaiba)

Month	Min. Water Depth (Point)	Draft (m)	Loadable Cargo Volume/ship (ton)	Montly Transport Capacity Lock Operation Hour 12 hr (120 ships)	18 hr (168 ships)	24 hr (240 ships)
Jan	2.5 m (Lock)	2.3	620	74,400	104,160	148,800
Feb	2.5 (lock)	2.3	620	74,400	104,160	148,800
Mar	2.5 (Lock)	2.3	620	74,400	104,160	148,800
Apr	2.5 (Lock)	2.3	620	74,400	104,160	148,800
May	1.8 (F. Veneza)	1.5	290	34,800	48,720	69,600
Jun	1.5 (F. Veneza)	1.2	160	19,200	26,880	38,400
Jul	1.3 (Luzilandia)	1.0	90	10,800	15,120	21,600
Aug	1.2 (Luzilandia)	0.9	50	6,000	8,400	12,000
Sep	1.2 (Luzilandia)	0.9	50	6,000	8,400	12,000
Oct	1.3 (Luzilandia)	1.0	90	10,800	15,120	21,600
Nov	1.4 (Luzilandia)	1.1	120	14,400	20,160	28,800
Dec	1.6 (Luzilandia)	1.3	200	24,000	33,600	48,000
Annual Transport Capacity		Downward		423,600	593,040	847,200
		Upward		423,600	593,040	847,200
		Total		847,200	1186,080	1,694,400

Source : JICA Study Team

2) Ribeiro Goncalves - Teresina

Table 7.3.6 Monthly and Annual Transport Capacity
(Transportation between Ribeiro Goncalves and Teresina)

Month	Min. Depth (Point)	Draft (m)	Loadable Cargo Volume/ship (ton)	Montly Transport Capacity Lock Operation Hour 12 hr (120 ships)	18 hr (168 ships)	24 hr (240 ships)
Jan	2.5 m (Lock)	2.3	620	74,400	104,160	148,800
Feb	2.5 (Lock)	2.3	620	74,400	104,160	148,800
Mar	2.5 (Lock)	2.3	620	74,400	104,160	148,800
Apr	2.5 (Lock)	2.3	620	74,400	104,160	148,800
May	1.8 (F. Veneza)	1.5	290	34,800	48,720	69,600
Jun	1.5 (F. Veneza)	1.2	160	19,200	26,880	38,400
Jul	1.5 (F. Veneza)	1.2	160	19,200	26,880	38,400
Aug	1.5 (F. Veneza)	1.2	160	19,200	26,880	38,400
Sep	1.5 (F. Veneza)	1.2	160	19,200	26,880	38,400
Oct	1.6 (F. Veneza)	1.3	200	24,000	33,600	48,000
Nov	2.0 (F. Veneza)	1.7	370	44,400	62,160	88,800
Dec	2.1 (F. Veneza)	1.8	410	49,200	68,880	98,400
Annual Transport Capacity		Downward		526,800	737,520	1,053,600
		Upward		526,800	737,520	1,053,600
		Total		1,053,600	1,475,040	2,107,200

Source : JICA Study Team

3) Ribeiro Goncalves - Floriano

Table 7.3.7 Monthly and Annual Transport Capacity
(Transportation between Ribeiro Goncalves and Floriano)

Month	Min. Depth (Point)	Draft (m)	Loadable Cargo Volume/ship (ton)	Montly Transport Capacity (ton) Lock Operation Hour 12 hr (120 ships)	18 hr (168 ships)	24 hr (240 ships)
Jan	2.5 m (Lock)	2.3	620	74,400	104,160	148,800
Feb	2.5 (Lock)	2.3	620	74,400	104,160	148,800
Mar	2.5 (Lock)	2.3	620	74,400	104,160	148,800
Apr	2.5 (Lock)	2.3	620	74,400	104,160	148,800
May	2.5 (Lock)	2.3	620	74,400	104,160	148,800
Jun	2.4 (Urucui)	2.1	540	64,800	90,720	129,600
Jul	2.2 (Urucui)	1.9	450	54,000	75,600	108,000
Aug	2.1 (Urucui)	1.8	410	49,200	68,880	98,400
Sep	2.0 (Urucui)	1.7	370	44,400	62,160	88,800
Oct	2.1 (Urucui)	1.8	410	49,200	68,880	98,400
Nov	2.5 (Lock)	2.3	620	74,400	104,160	148,800
Dec	2.5 (Lock)	2.3	620	74,400	104,160	148,800
Annual Transport Capacity		Downward		782,400	1,095,360	1,564,800
		Upward		782,400	1,095,360	1,564,800
		Total		1,564,800	2,190,720	3,129,600

Source : JICA Study Team

4) The Locks

Table 7.3.8 Monthly and Annual Transport Capacity
(Passage of the Locks)

Month	Min. Depth (Point)	Draft (m)	Loadable Cargo Volume/ship (ton)	Montly Transport Capacity (ton) Lock Operation Hour 12 hr (120 ships)	18 hr (168 ships)	24 hr (240 ships)
Jan - Dec	2.5 m (Lock)	2.3	620	74,400	104,160	148,800
Annual Transport Capacity		Downward		892,800	1,249,920	1,785,600
		Upward		892,800	1,249,920	1,785,600
		Total		1,785,600	2,499,840	3,571,200

Sorce : JICA Study Team

(2) Maximum Transport Capacity

The most applicable operational period of the lock seems to be 18 hours because of the following reasons.

1) The maximum transport capacity in the case of 12 hours operation is too small considering the demand forecast.
2) In the case of 24 hours operation, congestion of ships will occur in the waiting area for the daytime navigation.
3) The halfnight operation has been carried out in the Tiete River.

Consequently, the maximum transport capacity of the river shall be as per Table 7.3.9.

Table 7.3.9 Maximum Transport Capacity

Unit : tons/year

Case	Downward	Upward	Total
Santa Filomena - Parnaíba	593,040	593,040	1,186,080
Ribeiro Goncalves - Teresina	737,520	737,520	1,475,040
Ribeiro Goncalves - Floriano	1,095,360	1,095,360	2,190,720
Lock Passage	1,249,920	1,249,920	2,499,840

Source : JICA Study Team

8. CARGO TRANSPORTATION PLANNING

8. CARGO TRANSPORTATION PLANNING

8.1 Maximum Navigable Water Transport Volume in the Parnaíba River and Potential Cargo Transport Demand Volume

The maximum navigable transport volume (permissible water transport volume by vessels) estimated in accordance with the result of the analyses of the natural conditions and various conditions related to water transport as discussed in Chapter 7 is as follows :

Up and mid-stream area (St. Filomena - Teresina) : 737,520 tons/year
Down-stream area (Miguel Alves - Parnaíba) : 593,040 tons/year

On the other hand, the maximum transport demand volume among ports in years 2005 and 2010 according to forecast and estimation on the potential cargo transport demand volume discussed in Chapter 6 is as follows. (see Table 6.3.10 and Table 6.3.11)

Year 2005

Up and mid-stream area (Guadalupe - Floriano) : 530,500 tons/year
Down stream area (Luzilandia - Parnaíba) : 97,360 tons/year

Year 2010

Up and mid-stream area (Guadalupe - Floriano) : 978,800 tons/year
Down stream area (Ludiandia - Parnaíba) : 167,000 tons/year

As shown above, the potential cargo traffic demand volume will be within the range of the navigable transport volume in year 2005, and therefore, water transport can be available. However, in the year 2010, the potential cargo transport demand volume will surpass the maximum navigable transport volume in the up and mid-stream areas.

It is estimated that the cargo transport demand volume will surpass the maximum navigable transport volume in the years 2007 - 2008 judging from the increasing rate of demand volume. In the down-stream area, the cargo transport demand volume will be still be within the range of the navigable transport volume in the year 2010. However, the demand volume will surpass navigable volume in the year 2011.

8.2 Maximum Navigable Cargo Volume

It is necessary to forecast transport volumes among ports in up and midstream areas concerning potential transport demand volume of water transport based on study results described in the previous chapter. The change of transport demands among ports is forecasted by transport items of the following taking into account associated characteristics of transport demand of respective items. The maximum navigable cargo volume of the Parnaíba river is estimated based on forecast of transport volume which is within the range of maximum permissible transport volume.

However, as the transport items which are required to be reviewed are agricultural products transported from up-stream to mid-stream area, it is not necessary to review the transport demand volume of materials for production and house hold goods from down and mid-stream areas to up-stream areas as these are within the range of permissible transport volume (Maximum transport volume among ports in year 2010 : 308,800 tons/year).

With regard to revision of the transport volume forecast, the following view points are adopted taking into account the relevant characteristics of transport demand of export items.

1. Soybeans are regarded as priority agricultural products since it requires a completion of transport within a limited season (February - May).

2. Fruits and nuts are also regarded as priority items for transport as these are items for export and require the necessity of preservation of quality.

3. As demand for rice within relevant regions is limited and it is an agricultural product which requires a distribution to other regions, it is assumed that an excessive production volume surpassing the navigable transport volume will be transported to the southern part of the country and navigable transport volume is adjusted mainly from the transport volume of rice.

4. As most corn and fejon are assumed to be distributed for demand within the region or for other regions after processing by the Agro-industry Center located in the region, an excessive volume of production surpassing its navigable transport volume is assumed to be distributed within the region (a part of it is assumed to be transported to other regions). As such, water transport volume is adjusted.

The maximum water transport cargo volume is determined by the adoption of the following method of estimations so as to adjust the transport volume to be within a range between potential demand volume and navigable transportation volume. The transport volume of agricultural products between, Guadalupe and Floriano in terms of volume is therefore adjusted and thus squeezed from 979,300 tons/year to 737,500 tons/year.

1. Soybean : Although it is assumed that all the production volume of soybean is to be exported principally, both 20,000 tons/year from Urucui and 1,500 tons/year from Guadalupe are assumed to be transported to the Agro-industry Center at Floriano and processed to soybean oil or cake and then to be distributed all over the country.

One hundred thousand tons/year from Ribeiro Goncaluves, 220,000 tons/year from Urucui, 20,000 tons/year from Guadalupe or 340,000 tons/year in total is assumed to be transported to Teresina by water transport for a period four months between February - May and transported further by railway to Sao Luiz or Itaqui ports from Teresina for export overseas. (The reason of assumption of export from Itaqui port by railways is discussed in details.)

2. Fruits and nuts : It is assumed that all potential transport demand volume for fruits and nuts is by water.

3. Rice : It is assumed that the potential transport demand volume of rice from St. Filomena and Ribeiro Goncalves is transported by water. However, 20,000 tons of its potential

transport volume 140,800 tons/year and 5,950 tons/year of the 71,200 tons/year from Guadalupe are transported by water. Transportable volume by water 120,800 tons/year from Urucui and its surroundings and 62,250 tons/year from Guadalupe and its surroundings are assumed to be distributed to various regions located in the southern part of the country by land transport. However, as the demand volume for rice within Piauí region is estimated around 200,000 tons/year and its is satisfied within the region, even if it is transferred to the mid-stream area by water transport it is needed to be re-transported to other regions by any means. Under such circumstances, the volume surpassing the navigable volume is assumed to be economical when it is transported by road directly to the southern regions where land access is thought to be available.

4. Corn : All potential transport demand volume from St. Filomena and Ribeiro Goncalves is assumed to be transported by water transport like in the case of rice. However, 15,200 tons/year of the 24,200 tons from Urucui and 19,000 tons/year of the 29,200 tons/year from Guadalupe are assumed to be transported by water : and the balance of 9,000 tons/year from Urucui and its surroundings and 5,200 tons/year from Guadalupe and its surrounding is assumed to be transported by land transport to the Agro-industry Center at Floriano.

5. Fejon : All potential transport demand volume from St. Filomena and Ribeiro Goncalves is assumed to be transported to Urucui by water transport and unloaded there. Subsequently, all potential transport demand volume including such volume from Urucui and its surroundings is assumed to be transported to various places within the region by land transport. It is assumed that the potential transport volume of Guadalupe and its surroundings is also assumed to be transported by land transport.

The maximum river transport volume of the Parnaíba river is the water transport volume which is revised to be within the limit of transport capacity of the Parnaíba river in each zone and is adjusted under the above mentioned assumptions in the following four navigation scenarios.

8.3 Alternative Plan for the Parnaíba River Water Transport

Four scenarios were examined based on the potential demand volume (maximum navigable water transport cargo volume) and transport capacity of the Parnaíba river analyzed in previous chapters taking into account the economic and financial evaluation being analyzed in Chapter 15. Four scenarios are as follows.

Scenario 1 : Plan to operate the whole section between Santa Filomena and Parnaíba.
Scenario 2 : Plan to operate the section between Santa Filomena and Teresina.
Scenario 3 : Plan to operate the section between Santa Filomena and Floriano.
Scenario 4 : Plan to operate the section between Santa Filomena and Teresina during the rainy season based on Scenario 3.

Figs. 8.3.1 to 8.3.4 show the respective cargo transport volume for river transportation of the above mentioned scenarios (see Tables A3.1.1 to A3.4.3 in Appendix 3 for transport cargo volume in 2010 in each scenario). Table 8.3.1 shows the outline of each scenario:

Table 8.3.1 Outline of Each Scenario

Particulars	Scenario 1	Scenario 2	Scenario 3	Scenario 4
Service Section (from St. Filomena to)	Parnaíba	Teresina	Floriano	Rainy Season : Teresina Dry Season : Floriano
Transport Character (Limiting Factors)	Lock and water depth at Fazenda Veneza Luzilandia	Lock and water depth at Fazenda Veneza	lock	Lock
Maximum Cargo Transport Volume (Lock operation : 18 hr)	593,040 t/yr.	737,520 t/yr.	1,095,360 t/yr.	1,095,360 t/yr.
Required Nos. of Vessels (in 2010)	53 units	46 units	31 units	40 units
Problem	Initial investment is too large for it's transport volume. Cost of O&M is too large.	As plan matches with existing infrastructures. Plan is desirable	There is a difficulty of land transport from Floriano.	Compromised plan supplementing a drawback of Scenario 3

Note : Required number of vessel in each scenario is estimated in Chapter 9.

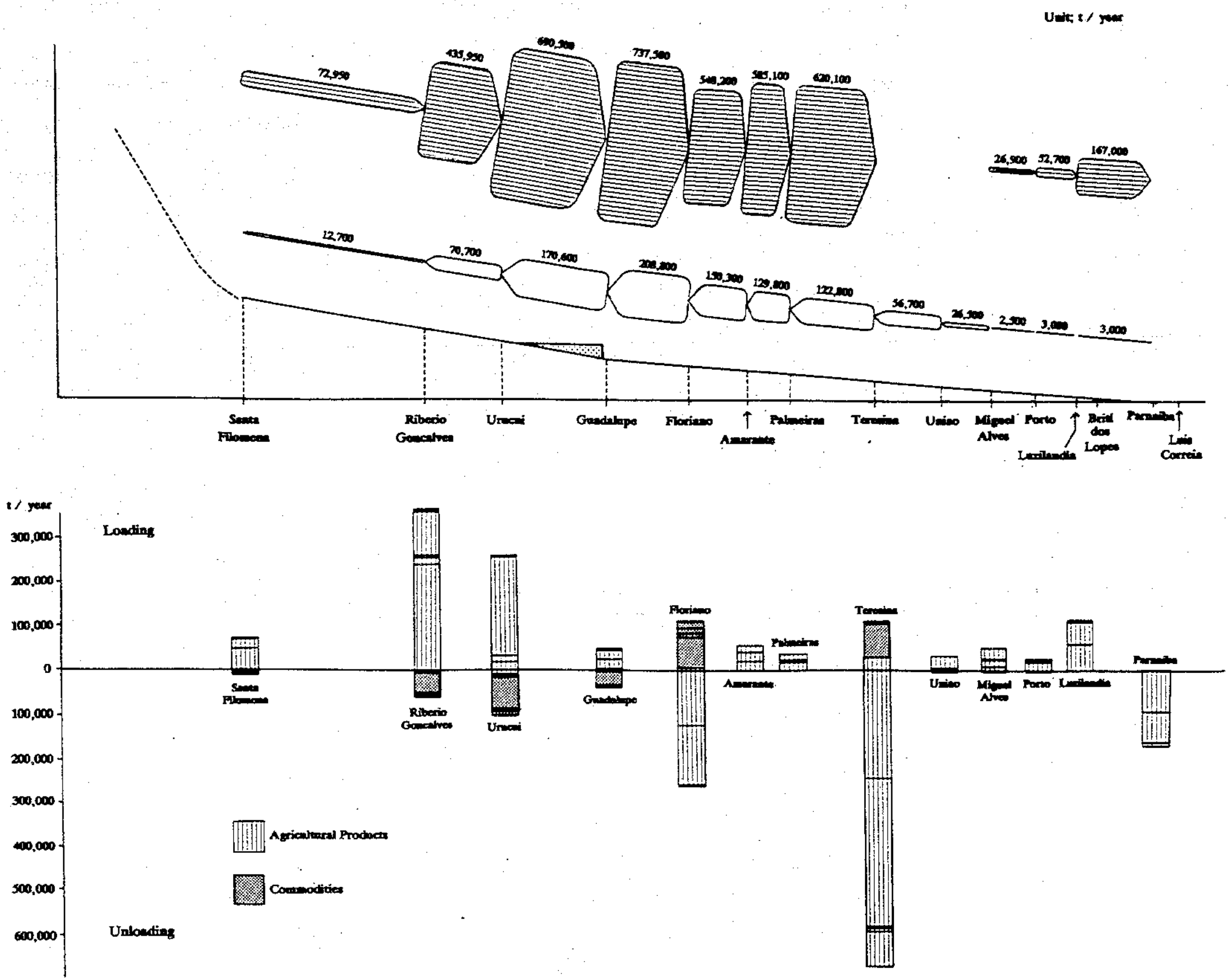

Fig. 8.3.1 Cargo Transport Volume in Scenario 1

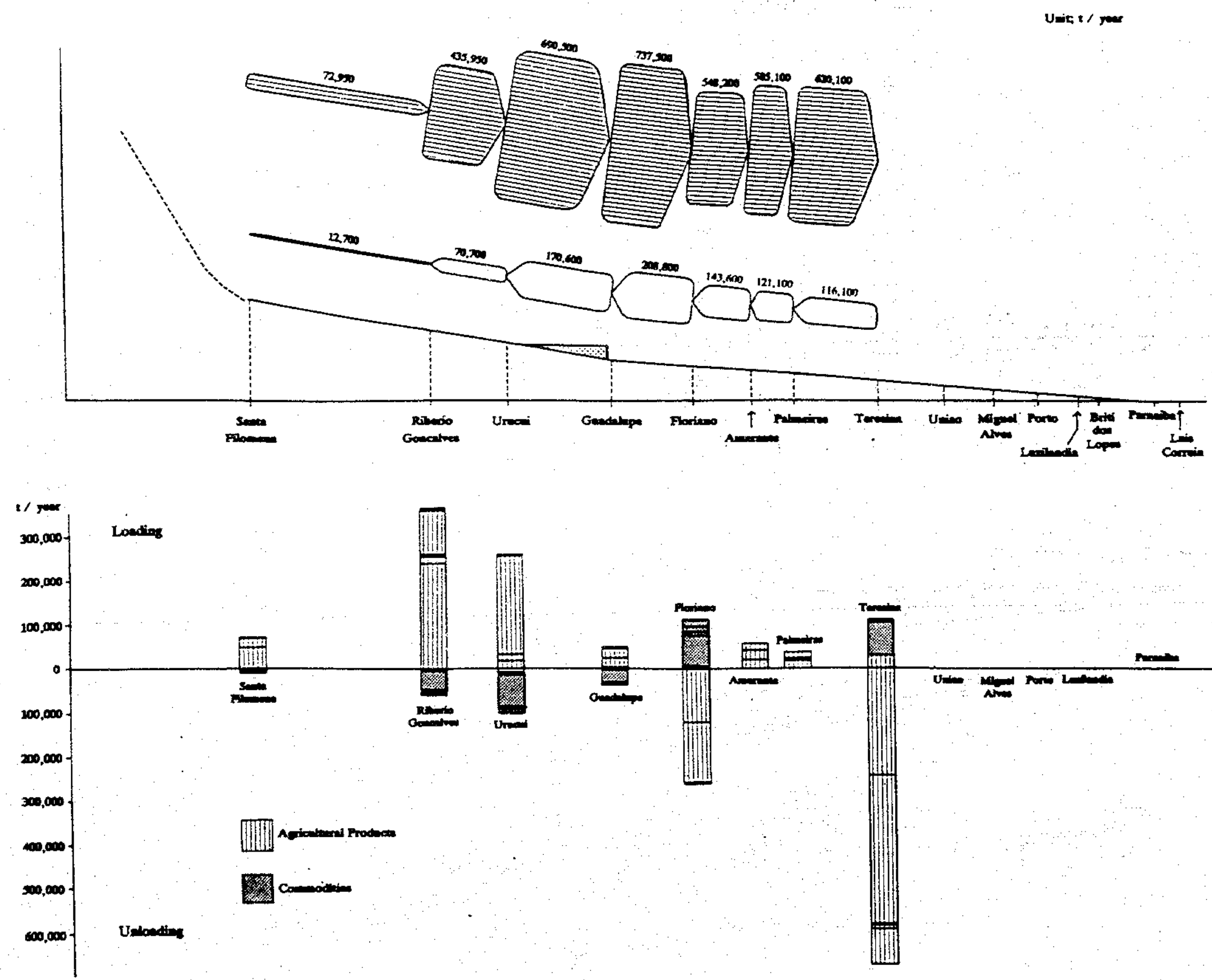

Fig. 8.3.2 Cargo Transport Volume in Scenario 2

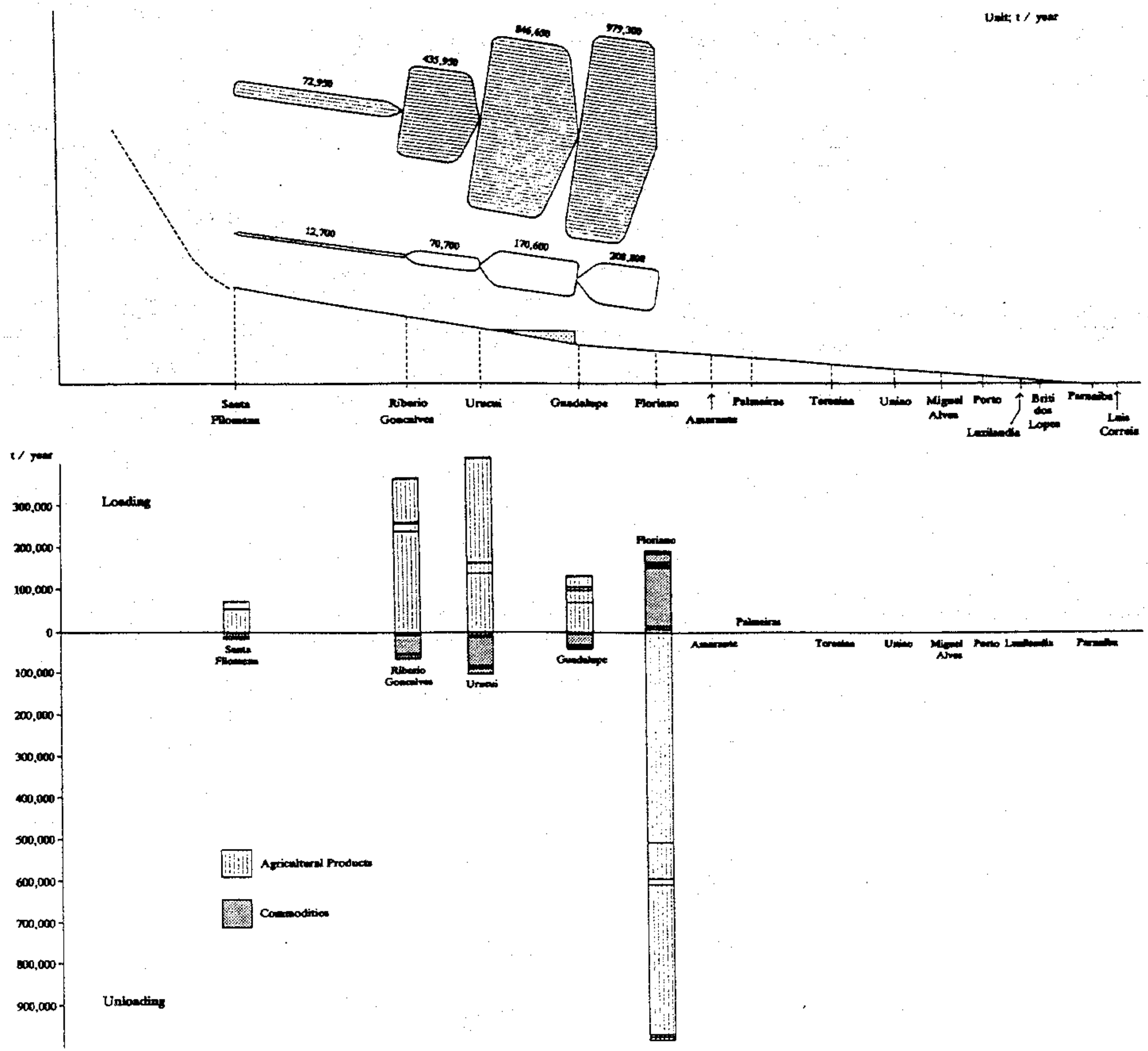

Fig. 8.3.3 Cargo Transport Volume in Scenario 3

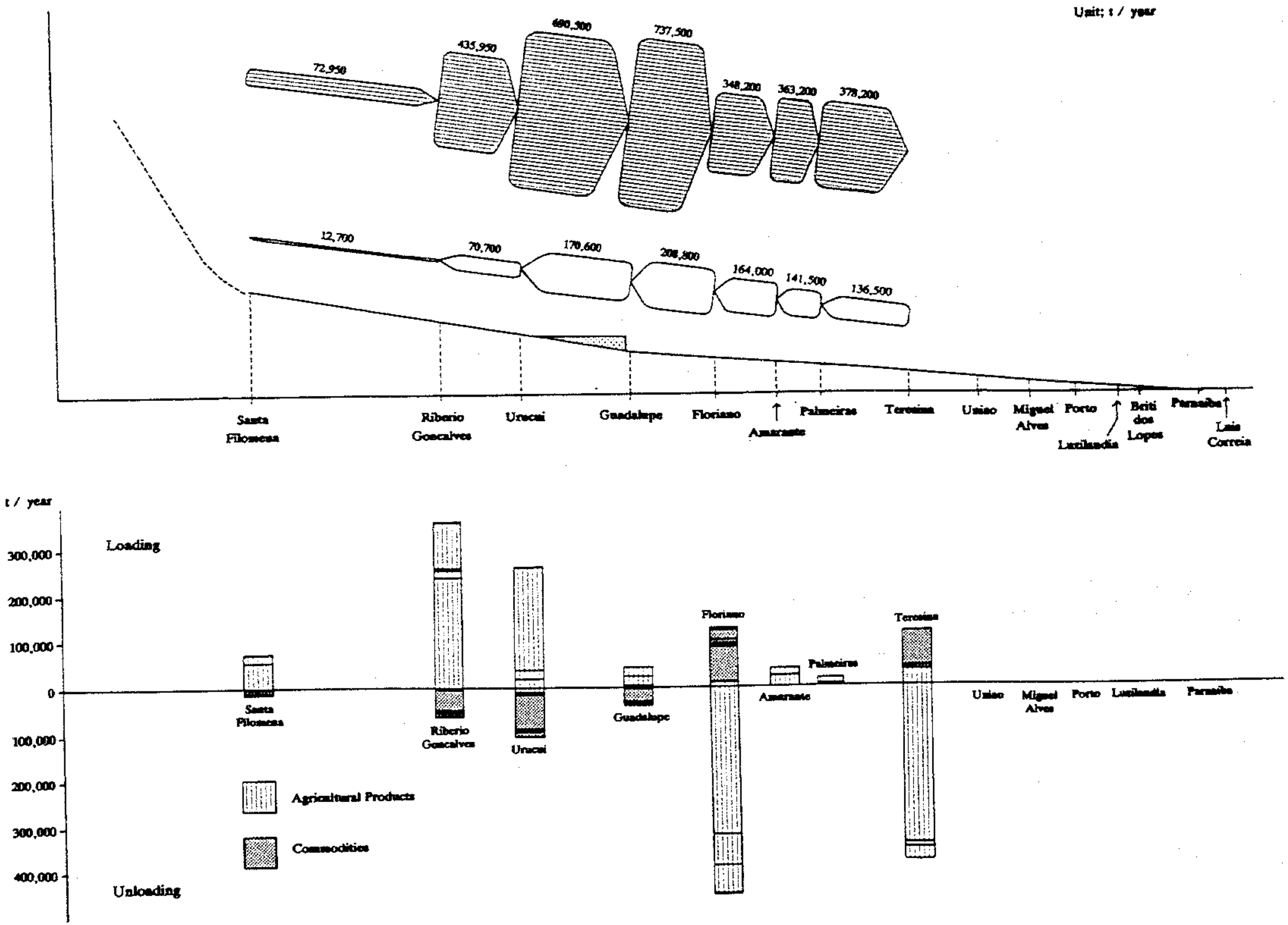

Fig. 8.3.4 Cargo Transport Volume in Scenario 4

9. PLANNING OF RIVER TRANSPORT

9. PLANNING OF RIVER TRANSPORTATION

9.1 Channel Planning

In this section, channel planning was studied to make a safe and effective navigation routing system for the Parnaíba river on the basis of ship's size and natural conditions of the river.

9.1.1 Ship's Size

The following ship's dimensions are applied to the study of a navigation routing system for the river.

Length Over All	: 47.00 m
Maximum Breadth	: 11.00 m
Maximum Draft	: 3.00 m
Maximum Height	: 4.30 m above water line
	7.30 m above keel
Maximum Speed	: 8.00 knots

9.1.2 Navigation Routing System

(1) Items to be Considered

The following items are taken into account when making a navigation routing system for the river.

a. Width of the Navigable Waters

As a minimum safety width of the navigable waters, the below mentioned widths are applied for straight channels ;

about 30m for one-way traffic.
about 50m for two-way traffic.

In addition, a greater channel width is required for curved channels in the river.

The reference standard is the US Army Corps of Engineers (1980) stated in the Interim Report (I) issued in September 1993.

b. Depth of the Navigable Waters

As a minimum safety depth for the navigable waters, the below mentioned depths were applied ;

Depth = Ship's Draft + UKC
UKC (Under Keel Clearance) : 0.20 m for locks
0.30 m for river passages

For example if a ship loads cargo up to 2.3 m of draft, the required depth is 2.60 m for a river passage.

c. River Flow

The river flow has a rate from 1.5 knots to 3.5 knots according to Table 3.3.2 Results of River Flow Observation.

Average flow speed is about 2.0 knots through the river. The strongest current of 3.50 knots was observed around Ribeiro Goncalves, 3.44 knots around Urucui, 3.15 knots around Uniao, 2.84 knots around Guadalupe and San Domingos.

When a ship navigates a passage in such a strong flow the ship's speed must be 3.0 to 4.0 knots over the river flow for safe maneuvering.

A ship of 8.00 knots can keep 4.5 knots against the strongest river flow of 3.5 knots which satisfies the above requirement.

According to the Port Regulations of Kanmon, Japan, the minimum required speed over the current is 3.0 knots.

d. Curves

There are several sharp curves along the river. A S-shaped curve is upstream of the Igaras river near the branch from the Parnaiba river. There are two sharp curves between Floriano and Amarante. Upstream between Santa Filomena and Ribeiro Goncalves, some sharp curves are observed. Careful maneuvering of engine and steering shall be required in such places.

e. Nature of the River Bed

Sand and/or mud are suitable as an anchorage for ships awaiting berth or awaiting another ship passing the lock or a one-way passage.

f. Obstructions

Removal of driftwood is to be recommended as circumstances may permit. Marking of underwater obstructions with buoys or other navigation aids shall be also recommended.

g. Safety Overhead Clearance

For the safe passage under a lock, a bridge or an electric cable, the following overhead clearances shall be required;

Lock	: about 0.2 m
Bridge	: about 1.0 m
Electric Cable	: about 2.0 m to 5.0 m Some authorities require a clearance of from 2.0 to 5.0 m depending on the possibility of a dangerous electrical discharge between the cable and a ship passing under it.

All bridges of the river can maintain a overhead clearance more than 1.0 m. The height of electric cables shall be adjusted if necessary.

(2) Measures

To establish a safe navigation routing system, the following measures were studied.

a. Separation Zone (Isolated Sand Bar)

A zone separating the traffic lanes in which ships are proceeding in opposite directions shall be recommended in following areas ;

Where a sand bar exists in the center of the river and navigable passages are available on both sides of the bar such as for the sand bars near Lago dos Porcos, Miguel Alves, Ribeiro Goncalves and etc., if practicable.

b. One-way Passage

A one-way passage system shall be recommended for the following narrow passages where a two-way navigation seems to be difficult ;

Where the width of the navigable waters is less than about 50 m such as the passage near Guadalupe.

c. Waiting Area for One-way Passage

Waiting areas for one-way passage shall be required down stream of the one-way passage where ship can wait for another ship's passage.

d. Signals on Passing a Curve

Some sound signals shall be required when a ship passes a curve where other ships may be obscured by intervening obstructions.

According to International Regulations for Preventing Collision at sea (1972), a ship nearing a curve where other ships may be obscured by intervening obstruction shall sound one prolonged blast. Such signal shall be answered with a prolonged blast by any approaching vessel that may be within hearing around the bend or behind the intervening obstructions.

e. Areas to be Dredged or Spur diked

To maintain enough depth for safe navigation, dredging or construction of a spur dike in the following areas shall be recommended if transportation of a lot of cargo in the dry season is required;

Where the depth of the river in dry season is less than 1.3 m such as the passage near Luzilandia and where the width of the river is less than 30 m, if exist.

f. Navigation Aids

Navigation Charts :

Judging from the history of navigation on the Parnaíba river, navigation charts do not seem to be necessarily essential for a navigator with local knowledge when navigating in daylight only. However the issue of navigation charts shall be considered if navigation in the night time becomes essential.

Navigation Aids :

Even if night navigation is not essential, navigation aids such as buoys or markers shall be required at about 1.5 km intervals along the waterway especially downstream of Teresina where many sand bars are observed.

Also a sufficient number of navigation aids shall be required which indicate an under water isolated danger, waiting areas for one-way passage, separation zone and other obstructions.

g. Daytime Navigation

Considering the difficulties involved with night navigation due to the nature of the river such as shallow waters, narrow channels, rapid water flow and curved passages, daytime navigation shall be recommended.

h. Local Knowledge

Even if a ship is to navigate in the daylight only, local knowledge shall be essential. Navigators are requested to be well trained especially about river navigation along sand bars and river bends of which the nature of the water way is generally said to be as follows;

1) The following sand bars are considered as stable.

- Sand bars observed at a curved waterway.
- Big sand bar like an island.
- Sand bars where some plants are observed

2) Nature of sand bars which exist alternately along the wide river.

There is a possibility that the down stream end of a sand bar will move down stream. However the sides of the bar shall be stable. Therefore the waterway shall be as shown below.

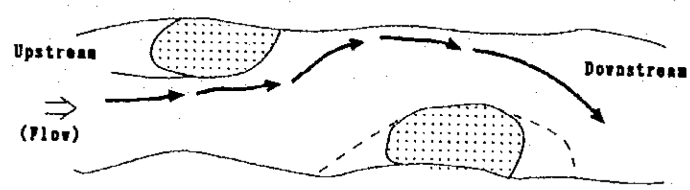

Fig. 9.1.1 Waterway along Alternate Sand Bar

3) Nature of sand bars which exist in the center of the river.

Up stream end of the sand bar is moving to the down stream end. Therefore it is recommended to give a wide berth to the down stream side of the sand bar as below.

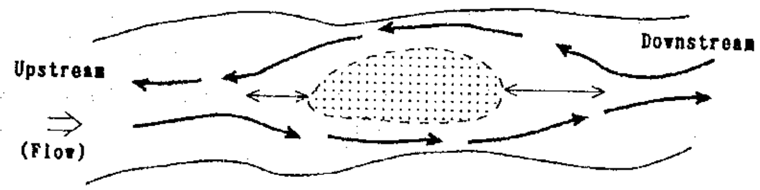

Fig. 9.1.2 Waterway along a Sand Bar in Center of the River

4) Curved Waterway

There is a deeper area in the concave part of the bend. Therefore the waterway is recommended as per the following illustration.

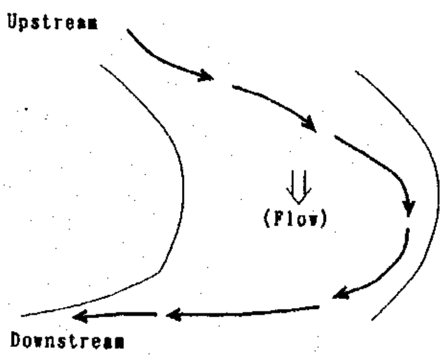

Fig. 9.1.3 Curved Waterway