V. ENVIRONMENTAL STUDY

5.1 General

The study area covers the lower Itajai river basin and the Picarras river basin located north of the Itajai basin, comprising urban areas of Itajai, Navegantes, Picarras and Penha.

The Itajai city is the second largest city in the whole Itajai basin. The population in the Itajai city is around 101,000 in 1989 and this city is known as a fishing port. The Picarras city located at about 15 km north of the Itajai city is famous as tourist spot for sea bathers during the summer season.

The environmental study in this stage was carried out to obtain the basis for comparison of the proposed three alternative floodway routes and also to make clear the matters to be taken into account in construction planning of the flood control project.

5.2 Prediction of Environmental Change and its Measures

5.2.1 Study on environmental aspect for floodway plan

The study on the environmental change caused by construction of floodway was made to obtain the basis for selection of optimum plan among three alternatives. The study items are recreation, fishery, landscape, area separation, inland navigation, coastal erosion and irrigation and drainage. Result of the study on these items is as follows, and the degree of the environmental impact for those items is summarized in Table 5.1.

(1) Recreation

Picarras has been developed as resort city for sea bathers, and 30,000 to 60,000 people visit the beach during the summer season from December to March. There are hotels, sanatoriums and restaurants along the Picarras coast. While it has been clarified that the water quality of the Itajai river is in a quite unfavourable condition since high value of fecal coliform as well as lead, mercury and cadmium indicating 10 to 100 times the standard value were detected in the low flow condition. Besides, the river water of Itajai is in the muddy condition. The river water of Picarras which flows into the Picarras coast is also polluted mainly by sewage. If the muddy Itajai river water with such a high concentration of heavy metal flows into the Picarras coast through Floodway-I, the sea water pollution in the Picarras coast is anticipated to be remarkably

accelerated. Consequently, it is considered that the Picarras will no longer be able to function as the resort.

While there are no hotel and other type of accommodation in the Navegantes coast. Although the beach is crowded with bathers during the summer season, impact in case of Floodways-II and III will not be so serious as compared with the case of Floodway-I.

(2) Fishery

It will be unavoidable that the water containing much mud spreads the coastal area to a large extent after the rainstorm due to the construction of the floodway. The shrimp fishery is performed along the coasts of Itajai, Navegantes, Penha and Picarras at water depth of 5 to 20 m. Among the fishery industries along the coast, shrimp fishery will be influenced seriously by muddy water from the floodway. However, degree of influence is unknown at this stage because it is not clear whether the mud water or particles attached to sand will exert any influence on diatomaceous and benthic organisms which the shrimp feeds on.

The study on diffusion of turbid water discharged from the Itajai river and the proposed floodway was made by numerical simulation method for the Navegantes coast. It is presumed that the acreage of diffusion of turbid water due to construction of the floodway is almost the same for both the Picarras and Navegantes coast. While the fishery activity is being carried out at the river mouth of the Itajai in spite of diffusion of turbid water discharged from the Itajai river. Considering this fact, it seems that there are no objection to the fishery activity for both the Picarras and Navegantes coasts even if the floodway is constructed.

(3) Landscape

Present landscape in the Picarras coast consists of beautiful beach and a small island which is located near shore. Due to the construction of a jetty structure at the outlet of the floodway, the present natural landscape will be remarkably damaged. On the Navegantes coast, landscape of the coastal line is not so excellent as compared with that in the Picarras coast. Besides, there are no hotels in this coast. Thus, the impact on landscape due to construction of the Floodway-II will not be so serious as compared with Floodway-I. The route of Floodway-III is almost the same as that of Floodway-II except its inlet portion where Machados town is located. The landscape of the Machados town area will drastically change due to separation by the floodway channel,

but its impact will not so serious as compared with Floodway-I since it does not rely on the tourism.

(4) Area separation

The environment impact in view of area separation for Floodways-I and III is predicted to be more serious as compared with that for Floodway-II due to separation of urban areas of Picarras and Machados.

(5) Inland navigation

The lower Itajai river is used as navigation for fishing boat and sand dredging ship at present. It is predicted that even after the river water of the Itajai is diverted to the floodway channel, the present navigation activity will not be affected since the water depth of the Itajai river after river diversion to the floodway channel is unchanged due to almost constant high tide level.

(6) Coastal erosion

The Picarras beaches are gradually diminishing due to coastal erosion. It is predicted that even after the construction of Floodway-I, the sand conveyed through the floodway channel will be insufficient for renourishing the beaches. While, after the construction of the floodway at the Navegantes coast, the erosion may take place in the left side of the jetty due to prevailing wave from SE direction but its extent will be relatively small.

(7) Irrigation and drainage facilities

It is planned that Floodway-I route passes through the sugarcane area and pasture land in about 5 km long stretch from its inlet portion. While, Floodways-II and III are aligned through pasture and forest/bush through whole stretch. The sugarcane along the Floodway-I is now cultivated by rain-fed culture.

Due to the construction of Floodway-I, drainage canal for the sugarcane will be cut in several places. To cope with this situation, culvert to be provided under the levee for floodway and connection canal will have to be planned. No environmental impact is predicted for Floodways-II and III.

5.2.2 Study on environmental aspect for construction planning

The environmental aspects which may take place during the construction of the flood control project were assessed to reflect its result to the construction planning. The conceivable environmental aspects will be water pollution, animal and vegetation, air pollution, noise and vibration, land and life. The result of the assessment is as follows;

(1) Water pollution, animal and vegetation

Due to the river dredging and excavation of the river channel, the pollution of the river channel and the pollution of water quality will temporarily increase and consequently seaweeds attached at stones of the river bed, by which the fish feeds on, may be extinguished.

The project area belongs to the coastal tropical forest zone, and the Itajai river with its riverside vegetation provides a breeding place and habit for aquatic life. The dredging and widening of river channel will affect the aquatic animal lives and they will be forced to search for another dwelling place.

Thus, it will be necessary to carry out a research of valuable animals and vegetation to grasp the degree of influence on them.

(2) Air pollution, noise and vibration

The air pollution caused by dust cloud of the vehicles and also noise and vibration will take place due to the implementation of the flood control works, but they can be reduced by cleaning and watering the street and by limiting the speed of the construction vehicles.

(3) Land (sliding)

The land slide will take place due to erosion caused by rainstorm in the course of construction of floodway and widening of river channel. To avoid such case, appropriate bank protection such as sodding will be needed.

(4) Life (housing)

For people residing along riverside, the widening of the river and construction of the floodway will mean the loss of their houses. Discussions with the residents will be necessary regarding their new place of residence and administrative measures will become necessary.

VI. CONSTRUCTION PLAN AND COST ESTIMATE

6.1 General

The construction plan and cost estimate for the provisional plan to protect the lower Itajai river basin from flood was carried out. The flood control project comprises the construction of about 10 km long floodway to Navegantes coast, river improvement works of the Itajai main stream, Itajai Mirim and existing short-cut channel and urban drainage works for Itajai and Navegantes cities. Since majority of the project works are occupied by earthmoving work, the construction plan was worked out with emphasis on the effective utilization of the excavated materials and minimization of a hauling distance.

6.2 Construction Plan

6.2.1 Work items and quantities

The construction works required for the project comprise three categories, namely, construction of the floodway, river improvement works for Itajai main stream, Itajai Mirim and existing short-cut channel and drainage works in Itajai city.

Major work items and their quantities are tabulated as follows;

	Work Items	Unit	Quantity
1.	Itajai river to be improved (23 km)		
	(1) Dredging of riverbed	cu.m	8,156,000
	(2) Levee embankment	cu.m	743,900
	(3) Parapet wall concrete	cu.m	19,700
2.	Construction of floodway (9 km)		
	(1) Excavation, common	cu.m	4,343,200
	(2) Excavation, rock	cu.m	150,000
	(3) Dredging	cu.m	3,006,800
	(4) Levee embankment	cu.m	140,000
	(5) Riverbed protection	sq.m	5,400
	(6) Relocation road	lin.m	2,100
	(7) Bridge construction	place	3
	(8) Jetty, dredging in seabed	cu.m	544,000
	(9) Jetty , embankment of core stone	cu.m	510,000

	Work Items	Unit	Quantity
(10)	Jetty, embankment of filter and armor stone	cu.m	795,000
(11)	Deformed concrete block, 16 tons	nos.	3,675
3.	Itajai Mirim river to be improved (8 km)		
(1)	River dredging	cu.m	151,400
(2)	Channel excavation	cu.m	180,400
(3)	Levee embankment	cu.m	725,400
(4)	Bridge heightening	place	4
4.	Itajai Mirim short-cut channel to be improved (4 km)		
(1)	River dredging	cu.m	227,100
(2)	Channel excavation	cu.m	53,200
(3)	Levee embankment	cu.m	137,900
(4)	Parapet wall concrete	cu.m	610
5.	Urban drainage works		
(1)	Excavation (channels, ponds and others)	cu.m	360,000
(2)	Embankment (Filling of low lands, channels and ponds)	cu.m	270,000
(3)	Pumping station, ($Q = 0.3\ m^3/s$)	place	2
(4)	Pumping station, ($Q = 0.5\ m^3/s$)	place	2
(5)	Drainage sluice	place	5
(6)	Flap gate	set	14

6.2.2 Conditions and assumptions for construction planning

The following conditions and assumptions were applied to the construction planning;

(1) Considering the extent of the project works, it is herein proposed to execute the project works by an international contract system. Taking into account the scale of the works and total amount of construction cost, the project works are divided into two packages. They are package-A which covers the river improvement works for Itajai, Itajai Mirim and existing short-cut channel and urban drainage works in Itajai city and package-B which involves construction of the floodway. The construction works will be administrated and supervised by DNOS in association with an international consulting firm.

(2) Based on the daily rainfall record at Itajai city, annual working day for construction works was set at 250 days in which rainfall intensity is less than 10 mm per day. The daily working hour is set at 8 hours.

(3) For excavation of the channel of the Itajai and Itajai Mirim rivers, existing short-cut channel and downstream stretch of the floodway, dredging method is applied considering soil condition of the materials to be excavated, economical aspect and so on. The workable day for dredging work is set at 300 days assuming that the minimum draft of dredger is 1.5 m.

6.2.3 River improvement works of Itajai main stream

The construction plan of major works for river improvement of the Itajai main stretch is as follows;

(1) River dredging

The river dredging of about 8.2 million m^3 is planned for 23 km long Itajai river stretch. To minimize the dredging cost, the dredging work is planned under the following principles;

a) Minimization of hauling distance from the dredging site to the spoil bank, and
b) Effective utilization of the dredged material for land reclamation in the depression area along the Itajai river.

Fig. 6.1 shows the proposed spoil banks of the dredged material. The dredging of the river channel is planned to be executed using three units of 1,100 PS class pump suction type dredger.

(2) Levee embankment

The levee embankment of about 0.75 million m^3 will be carried out in parallel with the dredging work using light class equipment. The embankment material will be obtained from the dredged material and/or borrow pits along the Itajai river.

6.2.4 Construction of floodway

The construction plan of major works for construction of the floodway is as follows;

(1) Excavation work

It is planned to construct about 10 km long floodway with a trapezoid shape of 50 m in bottom width and one km long jetty. The required excavation volume is estimated at about 7.5 million m^3. The excavated material is planned to be utilized for land reclamation in locally low land areas located in the left bank of the Itajai river as shown in Fig. 6.2. It is planned that about 6 km long upstream stretch of the floodway is excavated using 9 units of motor scraper with 23 m^3 class, and for about 4 km long downstream stretch, dredging work using one unit of pump suction dredger with 1,100 PS is employed considering the geological condition of the site and economical viewpoint. The excavation volume by working type is 4.5 million m^3 for dry work and 3 million m^3 for the dredging work.

(2) Levee embankment

The construction work of the levee embankment of about 140,000 m^3 will be executed using earth material to be obtained from excavation of the floodway in parallel with the excavation work. It is planned that the earth material is directly hauled to the embankment site and that compaction is performed by tire type roller after spreading.

(3) Relocation of the existing road and bridge construction

About 2,100 m long existing BR-470 road is planned to be relocated in the early stage of execution work of the floodway. The embankment materials of about 88,000 m^3 will be obtained from the channel excavation. The materials of subbase and base courses are planned to be procured by the local supplier. Tire type compaction equipment will be used for the embankment work.

Three new bridges are planned to be constructed crossing the floodway channel, out of which two bridges are designed as that of the national road class as explained in the foregoing Section 3.5. One is skew bridge with 3 spans by 40 m on the relocation route of BR-470 road. The other consists of 5 spans by 35 m at Navegantes coast. The remaining new bridge is provided to connect the rural road in the municipality of Navegantes and its effective width is 4 m. The bridge construction will be conducted in an early stage of the construction works of the floodway.

(4) Construction of jetty

A jetty structure is planned to be constructed at the outlet of the floodway. Feature of the jetty structure is as follows;

- Type of structure : Stone (core, filter and armor) and deformed concrete block levee
- Length, right : 1,158 m
  left : 898 m
- Crest elevation : +6.2 m
- Crest width : 10 m
- Side slope : 1:2

The jetty construction comprises the embankment of core, filter and armor stones, slope protection by deformed concrete block and dredging of the seabed as tabulated below.

- Embankment, core stone (1 to 80 kg/piece) : 510, 000 m^3
- Filter and armor stone (130 to 1, 600 kg/piece) : 795, 000 "
- Protection, deformed concrete block (16 tons/piece) : 3, 675 nos.
- Dredging (under and inside jetty) : 544, 000 m^3

The stone embankment materials for the jetty are planned to be obtained at Queimadas quarry site located between BR-101 and BR-470 with a hauling distance of about 4 km.

The dredging of seabed in the jetty will be conducted by two steps. First step is the dredging under portion of the jetty which will be carried out alternately with the embankment work. The dredging in the first step will be conducted using dragline or clamshell from the toe of partially completed jetty in consideration of the tidal conditions. Second step is the dredging inside the jetty that will be carried out using floating type of pump suction dredger having about 1,100 PS class capacity. The dredging in the second step will be conducted after the completion of the jetty embankment. The dredged materials are planned to be used for filling up the locally low land area selected by urban drainage plan located in the left bank of the Itajai river. Hauling distance is estimated at about 4 km.

6.2.5 River improvement works of Itajai Mirim river

The river improvement works in the Itajai Mirim river comprise excavation of river channel, levee embankment and heightening of the existing bridges. The construction plan of these works is as follows;

(1) Excavation of river channel

The excavation of river bed of about 150,000 m^3 will be carried out by floating and portable type pump dredger having 150 PS class capacity. The dredged material will be used for filling up the locally low land area along the Itajai Mirim river after drying up. The excavation of about 180,000 m^3 in the meandering river channel portion will be carried out by combination of bulldozer, crawler loader, dragline and dump truck. Swamp type equipment will be used due to trafficability of the site. The excavated materials will be utilized as the embankment material of the levee.

(2) Levee embankment

The embankment volume of the levee is estimated at about 730,000 m^3. The embankment material will be obtained from borrow pits located along the river and excavated material at the river channel. The excavated material is directly hauled to the embankment site. The compaction work will be carried out by tire type roller considering the soil properties.

(3) Heightening of existing bridges

Four existing bridges of which beam girder is lower than the design flood water level will be obliged to be heightened. The name of bridge to be heightened and extent of the heightening considering 0.5 m of freeboard are as follows;

Name of bridge	Dimension, existing (m)			Heightening (m)
	Length	Width	Span	
Nova Brasilia	45.9	7.85	3	1.6
Sao Vicente	52.0	11.1	3	1.2
Adolfo Konder	131.0	13.4	4	1.7
Jose Gall	45.0	9.0	3	2.4

The works will be conducted one by one to minimize traffic jam.

6.2.6 Improvement work of Itajai Mirim short-cut channel

The major works comprise dredging of riverbed, widening of channel and levee embankment. The improvement works of this channel will be carried out in later stage of construction period after completion of the Itajai Mirim river improvement.

(1) Channel dredging

About 230, 000 m^3 of channel dredging will be carried out using pump dredger of 150 PS class in capacity. The dredged materials will be used for levee embankment after drying up at temporary stock yards.

(2) Widening of channel

The widening work of the channel of about 60,000 m^3 will be carried out by the equipment shifted from improvement works of the Itajai Mirim river. The excavated material will also be utilized for the embankment of the levee.

(3) Levee embankment

The levee embankment of about 140,000 m^3 will be carried out using the same equipment as that used for levee construction works in the Itajai Mirim river.

6.2.7 Urban drainage works

The drainage works in the Itajai city consist of construction of regulating pond with sluice way and pumping station. The construction plan of these works is as follows;

(1) Regulating ponds

The regulating ponds are planned to be constructed at four places in the Itajai city as tabulated below.

Urban Drainage Area	Capacity of Pond (m^3)	Major Works	
		Excavation (m^3)	Embankment (m^3)
IR-4	13,000	9,100	2,500
IR-6	200,000	46,000	12,000
IM-7	130,000	130,000	-
IM-9	70,000	33,000	12,000
Total	413,000	218,100	26,500

Swamp and light class equipment will be used for the earthmoving works. Excavated materials at the ponds will be used as the embankment material after drying up.

The construction of sluice way comprises excavation, piling, revetment by concrete blocks, riverbed protection and flap gate installation. These works will be conducted by combination of man-power and equipment.

(2) Pumping station

The following drainage pumping stations are planned to be provided in the Itajai city;

Urban Drainage Area	Discharge (m^3/s)	Pump Type	Unit (Nos.)	Diameter (mm)	Head (m)
IR-4	0.5	Submerged	2 (0.25 m^3/s)	400	2.3
IR-6	0.5	"	2 (0.25 m^3/s)	400	3.4
IM-7	0.5	"	2 (0.25 m^3/s)	400	2.6
IM-9	0.3	"	2 (0.15 m^3/s)	300	2.6

The civil works comprise excavation, piling, revetment and riverbed protection. The works will be conducted in dry condition of the site.

6.2.8 Construction time schedule

The construction works of the project are scheduled to be carried out during 10 years including prerequisite works such as the feasibility study, detailed design, financing and tendering as shown in Fig. 6.3. The construction time schedule of the project works excluding the prerequisite works is given in Fig. 6.4.

6.3 Construction Fund to be Required

6.3.1 Condition for cost estimate

The construction cost of the project is estimated by dividing into foreign and local currency portions. The conditions for cost estimate are as follows;

(1) The cost is estimated at price level of September 1989 for all of the project works.

(2) The official exchange rate of 1 US$ = NCz$3.78 = ¥140 is applied.

(3) The cost is estimated on unit cost basis, which consists of direct and indirect costs. The direct cost comprises the cost of labour, materials, equipment, etc. The conditions and assumptions applied to estimate of the direct cost are as follows;

(i) All of the required labour are assumed to be the local labour and its daily charge is estimated including the social charge.

(ii) It is assumed that all of the construction equipment are purchased by use of the foreign currency. The equipment cost comprises the hourly depreciation cost, management cost, repairing cost, cost of consumable good and maintenance cost and it is divided into following foreign and local components;

Foreign component	Local component
- Depreciation cost	- Maintenance and repair cost (labour)
- Cost of spare parts and consumables for maintenance and repair	- Other local incidental

(4) The indirect cost consisting of site expense and overhead and profit of contractor is assumed to be 30% of direct cost .

(5) Administration cost which is wholly covered by the local currency portion is estimated at 5% of total direct cost .

(6) Engineering service cost for detailed design and construction supervision is estimated at 9% of the total direct cost and it is divided into 80% of the foreign currency portion and 20% of the local currency portion.

(7) Price contingency is provided for implementation of the project. It is estimated at 3% per annum for both the foreign and local currency portions.

(8) Physical contingency is estimated at 15% of the total cost.

6.3.2 Financial cost and annual disbursement schedule

The financial cost for the proposed provisional plan was estimated as presented in Table 6.1 and summarized as follows;

(Unit: 10^3 US$)

Cost Items	F.C.	L.C.	Amounts
- Direct cost (Construction cost including preparatory works)	42,900	28,600	71,500
- Indirect cost (Land acquisition, administration and engineering service cost)	5,148	17,212	22,360
- Contingency (Physical and price contingency)	19,356	16,834	36,190
Total	67,404	62,646	130,050

The construction cost of each package is estimated at about US$ 48 million for Package-A, US$ 53 million for Package-B and US$ 29 million for cost of prerequisite works.

Based on the implementation schedule shown in Fig. 6.4, the annual disbursement schedule was prepared as given in Table 6.2. The annual investment cost ranges from about US$13 million to US$30 million.

VII. ECONOMIC EVALUATION

7.1 General

Economic evaluation of the proposed flood control project based on economic benefit and cost is a guideline of assessing its economic viability. Economic benefit is given as the effect of reduction in annual mean flood damage to assets in and around the flood protection area under present socio-economic conditions. Since design flood is determined to be 10 year probable flood at the stage of the provisional plan, the benefit corresponds to a reducible amount of annual mean flood damage after completion of the construction works against 10-year probable flood. In addition, other economic benefit including the future land enhancement expected in the flood protection area is also discussed as the conceivable effect of the project.

Economic cost differs from financial cost in the sense of value judgment since the former is valued at real resource cost and the latter is resource cost valued at market prices. Thus, to estimate the economic costs of the proposed project, the financial costs estimated in the previous chapter have to be converted by using conceivable adjustment factors.

Economic evaluation is carried out to ascertain the economic viability by comparing the economic cost and the economic benefit. As a method of project evaluation, economic internal rate of return (EIRR) is utilized as a tool of assessing economic viability on whether the proposed project is to be worth being invested. Then, the sensitivity test for EIRR of the proposed plan is made with respect to variations in the cost and benefit because of socio-economic changes in the future.

7.2 Conditions for Estimate of Economic Cost and Benefit

In estimating the economic cost and benefit, the economic values are estimated applying the following conditions and assumptions:

a) The economic life of the project is taken as 50 years after completion of the construction works.

b) The basic price level for cost and benefit estimates is set at the end of September, 1989.

c) Foreign exchange rate is set at NCz$3.78 to US$1.00 in obedience to the official exchange rate at the end of September 1989.

d) As for transfer payment such as tax and duty, it is assumed that goods and services procured locally would include the transfer payment of 10% of their market prices and that those imported from abroad would exclude any transfer payment.

e) Economic prices of unskilled labor hired locally are assumed to be 50% of the actual market wages in consideration of the social conditions of (a) the unemployment situation in the country in recent years and (b) social charge included in the wage, which consists of social security and fringe benefit and which accounts for almost 50% of the total wage payment.

f) Regarding compensation, the following matters to be sacrificed are considered as economic cost from the economic point of view: (a) in the case of farm land, annual production value of paddy (NCz$1,500/ha of net income in 1989) is taken as negative benefit and (b) in the case of residences and industrial facilities to be expropriated, prices to be newly built are applied as economic compensation costs.

g) Taking account of present land use and existing damageable assets distribution in the flood protection area, the following assets are considered as direct damage items: (a) residences, (b) industrial establishments and (c) commercial and service establishments.

h) In regard to other damage items such as infrastructure and indirect losses, the following rates to the total direct damage are applied: 30% for infrastructure damage; and 10% for indirect damage.

7.3 Economic Cost

The financial construction costs, as described in the foregoing Chapter VI, consist of the following items:

a) direct construction cost;
b) land acquisition and compensation cost;
c) government administration cost;
d) engineering service cost;
e) physical contingency; and
f) price contingency.

Among these costs, price contingency is not included in the economic construction costs. Other costs are given as the economic costs by making adjustments based on the aforesaid conditions and assumptions.

After going through this conversion procedure on the basis of the financial costs, the respective economic costs are obtained as presented in Table 7.1. The total economic capital cost is estimated at US$92.4 million comprising US$66.4 million for construction works, US$4.5 million for compensation, US$3.2 million for government administration, US$6.3 million for engineering service, and US$12.1 million for physical contingency.

The operation and maintenance (O&M) cost is annually required during the economic life of the project after completion of the project. The O&M cost is also given by making adjustment to economic prices. The O&M cost is estimated at US$0.33 million per annum, which is assumed to be equivalent to 0.5% of the total direct construction cost.

While the economic project life is assumed to be 50 years, some of facilities have shorter life than the civil works. Then, they are assumed to be 15 years for such mechanical equipment for the urban drainage system as pumps and gates. The replacement cost is considered to be 90% for investment value at the end of economic life, taking account of its salvage value of 10%. The economic investment value is estimated at US$1.06 million.

7.4 Economic Benefit

The flood damage was estimated by the "Mesh Method". A grid of 250 m interval squares was superimposed on the map of the flood protection area, each square representing 6.25 ha. The number of damageable properties was basically counted based on the latest topographic map on a scale of 1:5,000, prepared by JICA in 1989. The elevation of the ground surface is read also from the topographic map. The flood damage is calculated square by square. In every square, the damage is estimated as a product of the number of property by type, unit value of the property and a damage rate corresponding to the inundation depth.

In the flood protection area of 54.7 km^2, approximately 116 thousand people are living in 1989. Besides, the following damageable assets exist therein: 29,600 units of residence; 208 industrial establishments; and 1,329 commercial and service establishments. Provided that a 10-year probable flood hits the flood protection area, about 44 thousand inhabitants or 38% of the total people would be affected by the flood. In the same manner, the following assets would be inundated: 11 thousand residences or 38% of the total number of houses;

83 industrial establishments or 40%; and 301 service establishments or 23%. Table 7.2 shows these effects of the proposed project by return period of flood.

Converting these flood damages into monetary terms, the total flood damages are estimated at NCz$39.0 million for 2-year flood, NCz$61.3 million for 5-year flood and NCz$84.8 million for 10-year flood, as shown in this table. Subsequently, the annual flood damage to be reduced up to 10-year probable flood amounts to NCz$32.1 million or US$8.50 million equivalent. This is looked upon as the project benefit under present conditions, because the flood damage by 10-year probable flood will be completely eliminated by the proposed project in the flood protection area. In the same manner, the project benefit under future conditions is estimated at NCz$88.8 million or US$23.48 million in the year 2020, which is projected on the basis of trend of population and regional economic growth. Table 7.3 shows the benefit under future condition by return period.

7.5 Economic Evaluation

Based on the cost stream which is distributed in line with the construction schedule and the benefit stream where the annual benefit is generated after completion of the proposed project, EIRR is calculated at 7.1% in the case of implementation under present socio-economic conditions. In case that the proposed project is evaluated under future socio-economic conditions, EIRR is calculated at 11.9%. The cash flow streams of economic cost and benefit for the respective cases are indicated in Tables 7.4 and 7.5. The procedure to estimate EIRR is given in Table 7.4 and Fig. 7.1.

7.6 Sensitivity Analysis

The cost and benefit have been estimated based on a careful study, but they tend to deviate from original estimate since uncertain factors are still included in the conditions of estimating cost and benefit. Thus, the sensitivity analysis is conducted for the variations in cost and benefit under the following conceivable conditions:

a) Case 1; Construction period is extended from 5 years to 7 years.
b) Case 2; Construction work of the proposed floodway is executed after the completion of the river improvement work in the Itajai river, Itajai Mirim river and existing short-cut channel and the urban drainage work in Itajai and Navegantes cities to decrease annual investment cost. The construction period is extended from 5 years to 10 years due to this alteration.
c) Case 3; In the Case 2, the floodway construction is not executed. The river improvement and drainage works will mitigate flood damage up to 3-year

probable flood. The annual mean flood damage mitigated is estimated at Ncz$ 16.3 million or US$ 4.3 million under the present economic condition and at Ncz$ 45.4 million or US$ 12.0 million in the year 2020.

d) Case 4; Construction work of the proposed floodway is executed before the river improvement work in the Itajai river, Itajai Mirim river and existing short-cut channel and urban drainage work. The construction period is extended from 5 years to 10 years.

e) Case 5; In the Case 4, only construction work of the floodway is executed.

In these cases, EIRR is estimated as follows under both present and future economic conditions:

Case No. of Sensitivity Analysis	Present Condition	Future Condition
1.	6.4%	11.0%
2.	6.7%	11.7%
3.	6.4%	10.9%
4.	6.6%	11.5%
5.	5.9%	10.2%

In Cases 3 and 5, the annual financial burden is largely lightened compared with the proposed flood control project, and construction fund to be required is US$ 48 million for the Case 3 and US$ 53 million for the Case 5. The both cases will mitigate flood damage up to 3-year probable flood. However in the Case 5, the expected flood control effect cannot be acquired unless the floodway work is completed. While, even if a partial river improvement work is completed in the Case 3, the flood protection level in the envisaged flood prone area does not increase due to the flood flow from unimproved river stretch. Consequently similarly to the Case 5, the expected flood control effect will not be also obtained unless all the river improvement works are completed. The result of the sensitivity analysis in both cases shows that EIRR for the Case 3 is slightly higher than that for the Case 5 but EIRR for both cases is lower than that for the proposed flood control project.

VIII. ASSESSMENT OF SOCIO-ECONOMIC IMPACT

8.1 Stabilization of Livelihood in Riparian People

The latest two large scale floods in 1983 and 1984 were not so old that the scene of the flood menace is still fresh in people's memory in the flood protection area. People, suffered serious damages from the floods, still keep their damage records such as photographies in their albums and talk about difficulties and fearfulness of the flood disaster. It is clear that people in the flood protection area tremble in flood menace, whoever had fear experiences in the floods.

Two large scale floods caused the biggest inundations in the past in the flood protection area. At that time, however, there were not so many damageable assets in the lower elevation lands as those under the present conditions, since the central zone and old town areas are located at higher elevation than the newly developing residential areas. The population in the flood protection area in 1983 and 1984 were around 96,000 and 99,000, respectively. In 1989, the population increased to 116,000 or approximately 20% more than the respective population in the both years. Most of this incremental population might settle down in the low land on the outskirts of the central zone. Thus, once the same scale floods as those in 1983 and 1984 hit the flood protection area under the present socio-economic conditions, the inhabitants would suffer more serious damages from the inundation.

Due to the implementation of the flood control project, the riparian people can be relieved from menace of flood. This would result in the emergence and subsequent pervasion of positive mental climate among inhabitants, industrialists and businessmen in the Itajai city. This climate will bring the stabilization of livelihood in the riparian people and also be beneficial for prosperity of the development of regional economy.

8.2 Enhancement of Land Use in Flood Protection Area

There are many depression areas along the Itajai and Itajai Mirim rivers and they are unused due to habitual inundation at present. It is planned in this flood control project to elevate these depression areas by filling earth materials to be obtained from the construction of the proposed floodway and river dredging of the Itajai and Itajai Mirim. The land reclamation of these depression areas would foster more effective land use as residential or industrial zone because these areas are located at quite convenient place to the center areas of the Itajai city.

Majority of the depression areas along the lower Itajai river are utilized only as pasture excluding 125 ha of paddy field in the flood protection area. Although these areas are located

close to the center of the Itajai city and to the national highway, BR-101, they are habitually inundated due to low elevation area. After the implementation of the flood control project, these areas will be utilized for more effective activity.

8.3 Creation of Job Opportunity and Activation of Regional Economy

The implementation of the proposed project creates opportunities of temporal jobs during the construction period. These temporal workers and some construction materials will be supplied from inside and outside of the basin, and supporting services and other materials for these construction works are produced in the basin. These supporting business results in creating job opportunity, and it will contribute to activation of the regional economy.

Along the both banks of the Itajai and the Itajai Mirim rivers, there is some manufacturing industry such as shipyard of fishing boat and cannery of marine products. These factories are located at favorable place for supporting their production, because it is quite convenient for them to procure raw materials and to carry manufactured products through marine transportation as well as the national highways. Some of these factories have to be transferred to another places because of the implementation of river improvement works along both the Itajai river and the Itajai Mirim river. However, if the both banks of the proposed floodway are to be put into practical use for these transferred factories, the relocation of these factories to the planned both banks might activate their production by means of well-organized and appropriate locations. Of course, it would be prerequisite for this reconstruction project to prepare the necessary credits for the factories and co-operation of the local community in two municipalities. Besides the construction of the proposed projects, this redevelopment project of the industries would also activate the regional economy.

8.4 Stimulative Effect for Urbanization

Rapid urbanization in the flood protection area would be inevitable in the near future. The infrastructure still does not keep pace with the expansion of urban areas during the 70's and the 80's. The central built-up areas in the flood protection area have already revealed some typical urban problems such as traffic jam and environmental pollution. In the coming periods, new urban areas are predicted to expand to the hinterland of the existing urban areas. Once settlement of infrastructure is further behind the urbanization, urban areas would suffer from the following urban problems as seen in advanced big cities: urban squatter; security problems; urban disasters such as fire; inconvenience for commuting; lack of social infrastructure such as schools and hospitals; and environmental problems including landscape.

Countermeasures against urban problems must not be too late. To keep pace with the urbanization, the following countermeasures are taken into consideration in general: (a) amendment of taxation system for settlement of infrastructure; (b) compulsory development of necessary infrastructure to land settlers in urban areas; (c) intensification of regulation control; and(d) subsidy from the national and/or the state government for urban management. Implementation of flood control projects might give an impetus to urbanization in the probable inundation areas. Thus, urbanization problems might increase more seriously than before if active countermeasures are not introduced.

Besides these urbanization problems, the urban area of Navegantes municipality may have some new problems in the near future. It will be cut into two parts by the proposed floodway at the center of the urban area. At present, the inhabited areas are expanding along the seashore from both sides, i.e., Itajai side and Penha side, and the central part between the both urbanized areas is still left as grass and bush lands. Therefore, there might not be close communication between two urban parts at present. However, once the proposed floodway is constructed between the two urban areas, the people in the both sides would be difficult to get the cultural exchange between the two and administrative services by the local government. From this point of view, some appropriate countermeasures such as bridges would be inevitable for the local community, taking the regional development feature into consideration.

IX. STUDY ON FLOOD FORECASTING AND WARNING SYSTEM

9.1 General

The Itajai river basin has a long history of flooding and middle and downstream reaches of the basin have suffered from habitual inundation. To cope with such repeating inundation, DNAEE established a flood forecasting and warning system (herein called FFWS) in the Itajai river basin and started its preliminary operation in August 1984.

The system operates with data supplied by five rainfall and water level gauges located at upstream of Blumenau. The observed data at each gauge are transmitted by telephone and telex system to Central Operation Station (CEOPS) in Blumenau. Prediction of flood occurrence is made only for Blumenau based mainly on correlation and regression analyses between water level/water level and/or water level/rainfall at present.

The master plan recommended reinforcement of the current hydrological network and improvement of data collection system. This Chapter presents the outline of the proposed FFWS including the improved flood forecasting and warning procedures and method, required facilities and investment cost for this system on preliminary basis.

9.2 Basic Concept for FFWS

The basic concept for the proposed FFWS including target area, flood forecasting and warning method, system components and organization for system activity is established as follows.

9.2.1 Target Area

It is intended in this FFWS to issue the flood forecasting and warning to the following 18 municipalities widely spreading along the Itajai river and its tributaries in the basin;

	River Basin	Number of Target Municipalities	Municipality
1.	Itajai do Sul river	3	Ituporanga, Agronomica, Aurora
2.	Trombudo river	1	Trombudo Central
3.	Itajai do Oeste river	1	Taio
4.	Itajai do Norte river	1	Ibirama
5.	Benedito river	1	Timbo
6.	Itajai Mirim river	1	Brusque
7.	Along the Itajai river	10	Rio do Sul, Ascurra, Rodeio, Apiuna, Indaial, Blumenau, Gaspar, Ilhota, Itajai, Navegantes
	Total	18	

9.2.2 Flood forecasting method

There are two methods of flood forecasting, namely, mathematical flood simulation model method based on rainfall data and statistical model method established by correlation and regression analyses of meteo-hydrological data.

CEOPS established the forecasting model in the existing system for estimate of flood water level at Blumenau applying the latter method based on the water level data at Blumenau and Apiuna. But application of this method will be limited to a certain target area where there are no large tributaries between the envisaged target area and key gauging station and lag-time of flood flow is comparatively long to evacuate the inhabitant in the target area from the onrushing flood. To carry out flood forecasting with high accuracy and to derive a sufficient evacuation time, the mathematical flood simulation method based on rainfall data is proposed. Besides, to obtain the observation data at real time, it is proposed to convert the existing manual observation gauges into the telemetered gauges.

It is predicted that the population in the urban areas of the basin will increase at an annual growth rate of about 3%. It will be needed to obtain the flood forecasted result with higher accuracy and to derive longer evacuation time with an increase in flood damage potential due to increase in population and extension of urban area. Then, it will be necessary to detect directly the area rainfall in addition to the spot rainfall and change of rainy area. To meet this requirement, the flood forecasting system with a radar rain gauge system will be proposed. However, since the radar rain gauge requires a long-term and sufficient rainfall data to establish the model showing the relation between radar echo and rainfall, its installation will be made after the establishment of data base of rainfall and water level records to be obtained from the telemetered gauges.

In consideration of the foregoing situations, it is herein proposed to proceed with the flood forecasting method dividing into the following three stages;

(1) 1st stage

It is intended to improve the existing system for the purpose of;

a) Obtaining the meteo-hydrological data at the mountainous area and existing damsites on real time basis, and
b) Monitoring the flood water level in the target areas.

To meet these purposes, the existing observation stations will be improved by means of telemetering system and additional telemetered rainfall gauges at the mountainous areas upstream of the existing dams and telemetered water level gauges at up and downstream of the existing damsites and at the flood prone area will be installed. This system will be used not only for flood forecasting by means of statistical method by correlation of meteo-hydrological data but also for obtaining the fundamental data for establishment of mathematical simulation model based on the rainfall data.

(2) 2nd stage

The flood forecasting by means of mathematical flood simulation model method will be made for all the target areas in the basin. To meet this requirement, telemetered rainfall gauges will be additionally installed at the mountainous areas.

(3) 3rd stage

The radar rain gauge system to obtain area rainfall data in addition to the spot rainfall data will be installed not only to identify the movement of rain cloud timely but also to utilize this phenomenon for dam operation for flood regulation.

9.2.3 Flood warning method

Dissemination of flood warning has been made by newspaper, radio and television through Municipal Commission for Civil Defense (COMDEC) in the existing FFWS. It is considered in this dissemination manner that an immediate action may be difficult against flood which occurs suddenly and/or at night time.

To reinforce the existing dissemination manner, it is proposed to carry out flood warning by loud speaker in major cities and by patrol cars and motorcycles in other target areas.

9.2.4 System component

The proposed FFWS comprises the following five components;

1) Hydrological observation network consisting of telemetered 31 rain gauges, and 17 water level gauges.
2) Telemetering system required for sending data from gauging stations and receiving them for processing and analyzing.
3) Data processing system, mainly consisting of a computer system for processing and analyzing data transmitted by the telemetering system, and for forecasting flood based on these data.
4) Flood warning system to inform flood oncoming to the inhabitants along the Itajai river and tributaries in the target areas.
5) Communication system for communicating between the related agencies and offices so as to exchange information and manage FFWS.

9.2.5 Organization for FFWS

Fig. 9.1 shows the proposed organization for management, operation and maintenance of this system. In this FFWS, the following new offices and stations are organized;

a) FFWS Central Office (Florianopolis)
b) FFWS Control Center (Blumenau)
c) Master Station (Rio do Sul)
d) Monitor Station (Itajai)
e) Gauging stations (at 48 sites)
f) Warning stations (at 16 sites)
g) VHF repeater stations (at 7 sites)
h) UHF repeater stations (at 4 sites)

The systematic relation between these offices and stations is given in Fig. 9.2. The work flow in each office and stations is illustrated in Fig. 9.3. The data collected from Master Station is processed at Control Center to estimate the extent of oncoming flood and its arrival time. When the river water level at a warning point is forecasted to rise up to a certain warning level, warning is issued in accordance with the final instruction sent from the Central Office. The Control Center will send warning and flood information to the inhabitant in the target areas through warning station and by patrol cars.

9.3 System Design

The major equipment for the proposed FFWS including hydrological observation network, telemetering system, data processing system, flood warning system and communication system is designed on preliminary basis.

9.3.1 Hydrological observation network

It is planned to install the telemetered 31 rain gauges and telemetered 17 water level gauges in the basin. The telemetered rain gauges comprise 26 gauges to be set at or near the existing gauges of which 6 gauges are proposed to be shifted from outside of the basin area to inside of the basin, and 5 gauges to be additionally installed in the mountainous area in main tributaries. The telemetered water level gauges consist of 16 gauges to be installed at the existing gauges and one gauge to be additionally installed as tidal water level gauge. Breakdown of these rain and water level gauges is as follows;

River Basin	Number of Gauge	
	Rain	Water Level
Itajai do Sul river	5	3
Itajai do Oeste river	6	4
Itajai do Norte river	7	3
Benedito river	3	1
Testo river	1	-
Luis Alves river	1	-
Itajai Mirim river	4	1
Along the Itajai river	-	4
Along small tributaries	4	-
Tide water level gauge	-	1
Total	31	17

It is judged that the existing Fraiburgo radar located outside the basin is unsuitable for the proposed FFWS due to the topographic and operational conditions. Instead of this radar, a radar rain gauge having detecting range of 120 km is proposed to be installed in Rio do Sul which is located at almost the center of the basin.

9.3.2 Telemetering system

In order to receive data from the hydrological observation network at the Master Station and send them to the Control Center at real time, the telemetering system will be installed.

There are two kinds of data collection system; namely one is a "polling system" in which measured data at a gauging station are sent out in response to a calling signal from the Control Center; and the other is a "event recording system" in which measured data are sent out without any reference when a change of status takes place.

Among these two systems, the polling system is adopted in this FFWS to avoid the telemetering trouble due to many numbers of the gauges.

9.3.3 Data processing system

The data processing equipment aided by a computer is installed in the Control Center in Blumenau and Master Station in Rio do Sul for conducting the following functions;

a) Exchanging of data through the 800 MHz multiplex radio link at real time and non-real time
b) Processing the received gauging data at the Control Center for display on CRT screens and for starting flood analysis calculation
c) Flood forecasting analysis at the Control Center using the received gauging data, and
d) Processing the data received from the radar rain gauge at the Master Station for display on CRT screen.

9.3.4 Flood warning system

Flood warning system comprises the following equipment:

a) Warning control equipment consisting of a radio transmitter and receiver and operating console with necessary station selection switches, a microphone, indicators, etc. installed at Control Center in Blumenau.
b) Terminal equipment for receiving signals from the Control Center, amplifier and loud speaker for broadcasting and microphone to pick up the warning notice and retransmitting system installed at warning stations.
c) Mobile warning facilities such as patrol cars and motor cycles furnished with speakers and hand speaker sets, which are under control of Central Office in Blumenau and distributed to local authorities at Rio do Sul, Itajai and Brusque.

The required quantities of these the flood warning equipment are as follows:

Location	Warning Station	Patrol Car	Motorcycle
Blumenau	7	5	2
Rio do Sul	3	3	1
Itajai	5	3	1
Brusque	1	1	1
Total	16	12	6

9.3.5 Communication system

To inform the forecasted result and flood warning to the related agencies, the communication system by means of simplex and multiplex exclusive lines is designed to connect with the stations and offices. The telecommunication system proposed in this FFWS is illustrated in Figs. 9.4 and 9.5.

In this system, two exclusive lines, namely, 150 MHz VHF network and 800 MHz UHF network are proposed. The 150 MHz VHF network is adopted for sending and receiving signals between gauging stations. The 800 MHz UHF network is selected for the multi-channel communication network among the Control Center, Master Station, Central Office and Monitor Station. Since normal range of UHF network is about 50 km, two repeater stations are installed between the Control Center and Master Station and between the Control Center and Central Office, respectively.

9.4 Implementation Program

It has been proposed to level up the flood forecasting procedure in the proposed FFWS by dividing into three stages as shown in Fig. 9.6. The implementation program in three stages is as follows;

(1) 1st stage

(i) Improvement of the existing manual hydrological observation situation for rain and water level gauges by means of telemetering system,

(ii) Reinforcement of the existing hydrological gauge system by installing additionally the telemetered rain gauges at the mountainous area upstream of the existing dams and telemetered water level gauges at up and downstream of the existing dams and at the flood prone areas.

(iii) Construction of the Control Center in Blumenau and Master Station in Rio do Sul.

(2) 2nd stage

(i) Additional installation of telemetered rain gauges at the mountainous area
(ii) Installation of telemetered tide water level gauge at Itajai
(iii) Construction of Central Office in Florianopolis and Monitor Station in Itajai

(3) 3rd stage

Installation of the radar rain gauge equipment in Rio do Sul.

The system component in each stage is as follows;

Major Component	*Unit*	Stage		
		1st	2nd	3rd
Telemetered rain gauge	Nos	15	16	-
Telemetered water level gauge	Nos	16	1	-
Control Center in Blumenau	No	1	-	-
Master Station in Rio do Sul	Nos	1	-	-
UHF repeater station	Nos	2	2	-
VHF repeater station	Nos	7	-	-
Telemetering system between station and office	Set	1	-	-
Multiplex network	Set	1	-	-
Monitor Station in Itajai	No	-	1	-
Central Office in Florianopolis	No	-	1	-
Expansion of multiplex network	Set	-	1	-
Installation of warning equipment	Set	-	1	-
Installation of radar gauge system	Set	-	-	1

The implementation schedule of the proposed FFWS is shown in Fig. 9.7. The construction period is estimated to be 10 years comprising 4 years for such prerequisite works as feasibility study, financing, detailed design and tendering and 6 years for the stage construction including training works.

9.5 Required Cost

The cost required for establishment of the proposed FFWS is estimated based on the price level in September 1989 and expressed by US$ equivalent using the exchange rate of US$1 = ¥140 = NCz$3.78.

The project cost estimated by dividing into three stages is summarized as follows;

(Unit: US$ thousand)

	Cost Item	1st Stage		2nd Sage		3rd Sage		Total
		F/C	L/C	F/C	L/C	F/C	L/C	
(1)	Direct cost (Construction cost including preliminary works)	6,975	1,712	6,334	1,348	6,476	220	23,065
(2)	Indirect cost (Administration and engineering service costs)	1,395	776	1,267	654	1,295	379	5,766
(3)	Contingency (Physical contingency)	837	249	760	220	777	60	2,883
	Total	9,207 (11,944)	2,737	8,361 (10,563)	2,202	8,548 (9,207)	659	31,714

Note; F/C ; Foreign currency portion
L/C ; Local currency portion
Figures in bracket show total of F/C and L/C in each stage.

Tables

Table 3.1 COMPARISON OF ALTERNATIVE FLOODWAY ROUTES IN THE LONG-TERM PLAN (50-YEAR PROBABLE FLOOD)

Item	Alternative Floodway Route		
	Floodway - I to Picarras Coast	Floodway - II to Navegantes Coast	Floodway - III to Navegantes Coast (with a short-cut channel in meandering portion downstream of BR-101 bridge)
1. Dimension of Floodway			
a) Length (km)			
- Inland	10.20	8.80	5.80
- Jetty	1.89	1.03	1.03
Total	12.09	9.83	6.83
b) Riverbed Width (m)	140	135	130
c) Riverbed Slope	1/6,000	1/6,000	1/6,000
2. Land Acquisition/ Compensation			
a) Land (ha)	217	177	131
b) Houses (Nos.)	95	59	111
c) Relocation of Road/Bridge	2,600 m/4 Bridges	2,100 m/3 New Bridges	Nil/3 New Bridges
d) Other Main Compensation Item	- Sugarcane - Cemetery - Substation for Power Supply - Construction of Drainage Culverts	- Water Treatment Facilities	- Church - Cemetery
3. Construction Cost /1 (US$ Thousand)			
a) Floodway			
- Inland	74,057	47,852	37,015
- Jetty	11,088	14,044	14,028
- Land Acquisition/ Compensation	4,574	4,149	3,133
Sub-total	89,719	66,045	54,176
b) River Improvement Works	39,521	37,111	51,280
c) Total Cost	129,240	103,156	105,456
4. Environmental Impact Predicted	The impact will be the greatest among the three alternatives in view of influence on resort area, and land scape.	The impact will be the lowest among the three alternatives concerning every environmental factor.	The impact will be serious in terms of separation of town area of Machados in the municipality of Navegantes. Concerning other factors, the impact will be similar to that in Flooday-II.

Notes :
1. The features above show those in the case of the 50-year design flood of 3,030 m^3/sec for every alternative Floodway route.
2. /1 ; excludes the cost for the urban drainage works.

Table 4.1 MAIN FEATURE OF PROPOSED DRAINAGE FACILITIES (1/2)

(1) Regulating Pond

Drainage District	Catchment Area (km^2)	Available Pond Capacity (10^3 m^3)	Design Bottom Elevation (m)	Design H.W.L. (m)	Effective Depth (m)	Present Land Use
IR-4	0.550	13.0	0.50	1.50	1.0	Unutilized Area
IR-6	1.830	200.0	0.50	1.50	1.0	Pasture
IM-7 (6)	1.497	130.0	0.50	1.70	1.2	Pasture
IM-9	0.790	70.0	0.50	1.70	1.2	Pasture
Total	4.667	413.0				

(2) Pumping Station

Pumping Station	Design Discharge (m^3/s)	Type of Pump	Discharge per Unit (m^3/s)	Pump Diameter	Unit Number of Unit	Total Head Difference (m)
IR-4	0.5	Submerged	0.25	400	2	2.30
IR-6	0.5	Submerged	0.25	400	2	3.40
IM-7 (6)	0.5	Submerged	0.25	400	2	2.60
IM-9	0.3	Submerged	0.15	300	2	2.60

Table 4.1 MAIN FEATURE OF PROPOSED DRAINAGE FACILITIES (2/2)

(3) Flap Gate

Drainage District	Location: Distance from River Mouth/Confluence (km)	Left/Right Bank	Diameter of Flap Gate (mm)
Itajai River			
IR-2	I-01L + 300 m	R	800
	I-01L + 450 m	R	300
	I-02L	R	800
IR-3	I-02L + 200 m	R	1,000
	I-03R	R	600
	I-03R + 180 m	R	600
	I-04R	R	500
	I-05R + 60 m	R	500
IR-5	I-24R + 20 m	R	100
Itajai Mirim River			
IM-1	M-10R	R	500
IM-2	M-13L + 30 m	L	600
	M-13L + 80 m	L	600
IM-3	M-31L	L	300
	M-31L + 80	L	300
	M-32L + 70	L	300
IM-5	M-43R + 30	R	800
	M-43R + 170	R	600
IM-9	M-47L + 100	L	600

Table 5.1 COMPARISON OF ALTERNATIVE FLOODWAY ROUTES IN TERMS OF PREDICTED ENVIRONMENTAL CHANGE (1/2)

Item	Contents	Env.Impact	
		Floodway Route	Degree
Recre-ation	The Picarras coast, which has been developed as bathing resort, will be seriously damaged by polluted water from the Itajai river.	I	+++
	There are no hotel and other accomodation in the Navegantes coast. Then degree of impact will not be serious compared with the Picarras.	II	++
	As for the town of Machados in Floodway-III, an appropriate measure should be considered.	III	++
Fishery	The acreage of the diffusion of turbid water due to construction of the floodway is presumed to be almost the same for both the Picarras and Navegantes coasts. While the fishery activity is being carried out at the river mouth of the Itajai in spite of diffusion of turbid water discharged from the Itajai river. Considering this fact, it seems that there are no objection to the fishery activity for both the Picarras and Navegantes coasts even if the floodway is constructed.	I	++
		II	++
		III	++
Land scape	In Floodway-I, the landscape most likely to be influenced is the Picarras coast. Approximately 140 m wide and 1300 m long jetty will be seen protruding a right angle to the coast. The present landscape consists of a small island near shore therefore this new linear and artificial land scale will give unfavourable effect on the natural scenery.	I	+++
	In the Navegantes coast, the present view of beach is not so excellent and there is no tourist hotel along the beach. Thus, the impact on the view will be small as compared with Picarras.	II	+
	The jetty site in Floodway-III is almost same as Floodway-II. Although the landscape of the town of Machados will be split by about 140 m wide floodway creating a new view of the river, the town does not depend on the tourist industry, therefore it will not have the same effect as for Picarras in Floodway-I.	III	++

Remarks: Degree of Impact
+++ High; ++ Medium; + Low

Table 5.1 COMPARISON OF ALTERNATIVE FLOODWAY ROUTES IN TERMS OF PREDICTED ENVIRONMENTAL CHANGE (2/2)

Item	Contents	Env.Impact	
		Floodway Route	Degree
Area Separation	Floodway-I passes by the boundary between Picarras and Penha, however the coastal area is already separated by the Picarras river. By taking appropriate measures, such as constructing a bridge, the impact should be minimized.	I	++
	Floodway-II and III pass by the city of Navegantes. Although its route will not conflict with the present housing, Navegabtes city will be surrounded by water on all sides, so the replacement of road and construction of new bridge are needed.	II	++
	In Floodway-III, the community of Machados with a church and cemetery in the way will be split into two. An appropriate measures should be considered.	III	+++
Inland Navigation	As the natural flood diversion method will be adopted in all 3 Alternatives, the navigation of boats along the Itajai river will not be affected.	I	+
		II	+
		III	+
Coastal Erosion	The sand supplied by the floodway will mostly consist of suspended sand and it will not be adequate to renourish the beach. It is predicted that erosion takes place in the left side of jetty at the Navegantes coast but its extent is relatively small.	I	+
		II	+
		III	+
Irrigation and Drainage Facility	The major crop produced in the area for all 3 Alternatives is sugarcane except for the small paddy cultivation area in the downstream of the existing bridge of BR-101. The outstanding impact due to intrusion of sea water through floodway will not occur concerning the existing drainage system of sugarcane fields.	I	++
		II	+
		III	+

Remarks: Degree of Impact
+++ High; ++ Medium; + Low

Table 6.1 SUMMARY OF FINANCIAL COST

(Unit: US$ thousand)

	Cost Items	F.C.	L.C.	Amounts
I.	Package-A	28,703	19,134	47,837
	a) Direct construction cost	20,250	13,500	33,750
	b) Physical contingency	3,037	2,024	5,061
	c) Price contingency	5,416	3,610	9,026
II.	Package-B	31,805	21,202	53,007
	a) Direct construction cost	22,650	15,100	37,750
	b) Physical contingency	3,398	2,265	5,663
	c) Price contingency	5,757	3,837	9,594
III.	Prerequisite works	6,896	22,310	29,206
	a) Land acquisition and compensation cost	0	12,350	12,350
	b) Government administration	0	3,575	3,575
	c) Engineering service	5,148	1,287	6,435
	d) Physical contingency	773	2,582	3,355
	e) Price contingency	975	2,516	3,491
	Grand Total	67,404	62,646	130,050

Notes : (1) Construction work of Package-A and B is as follows:

Package-A : River improvement work in the Itajai river, Itajai Mirim river and existing short-cut channel and drainage work in Itajai and navegantes cities.

Package-B : Floodway construction work

: (2) Physical contingency is estimated as 15% of direct construction cost and price contingency is also estimated using price escalation rate of 3% for F.C. and L.C. per annum

Table 6.2 ANNUAL DISBURSEMENT SCHEDULE

(Unit : US$ thousand)

Work Item	Fiscal Year 1991 F.C.	1991 L.C.	1992 F.C.	1992 L.C.	1993 F.C.	1993 L.C.	1994 F.C.	1994 L.C.	1995 F.C.	1995 L.C.	1996 F.C.	1996 L.C.	1997 F.C.	1997 L.C.	1998 F.C.	1998 L.C.	Total F.C.	Total L.C.	Grand Total
I. Package-A																			
a) Direct construction cost	0	0	0	0	0	0	2,943	1,962	3,950	2,633	5,669	3,780	4,525	3,016	3,163	2,109	20,250	13,500	33,750
b) Physical contingency	0	0	0	0	0	0	441	294	593	395	850	567	679	452	474	316	3,037	2,024	5,061
Sub-total	0	0	0	0	0	0	3,384	2,256	4,543	3,028	6,519	4,347	5,204	3,468	3,637	2,425	23,287	15,524	38,811
c) Price contingency	0	0	0	0	0	0	539	359	882	588	1,499	999	1,388	925	1,108	739	5,416	3,610	9,026
Total of item I	0	0	0	0	0	0	3,923	2,615	5,425	3,616	8,018	5,346	6,592	4,393	4,745	3,164	28,703	19,134	47,837
II. Package-B																			
a) Direct construction cost	0	0	0	0	0	0	4,082	2,722	5,873	3,915	6,097	4,064	5,201	3,468	1,397	931	22,650	15,100	37,750
b) Physical contingency	0	0	0	0	0	0	612	408	881	587	915	610	780	520	210	140	3,398	2,265	5,663
Sub-total	0	0	0	0	0	0	4,694	3,130	6,754	4,502	7,012	4,674	5,981	3,988	1,607	1,071	26,048	17,365	43,413
c) Price contingency	0	0	0	0	0	0	748	499	1,311	874	1,612	1,074	1,596	1,064	490	326	5,757	3,837	9,594
Total of item II	0	0	0	0	0	0	5,442	3,629	8,065	5,376	8,624	5,748	7,577	5,052	2,097	1,397	31,805	21,202	53,007
III. Prerequisite works for construction																			
a) Land acquisition and compensation cost	0	0	0	6,175	0	6,175	0	0	0	0	0	0	0	0	0	0	0	12,350	12,350
i) River improvement and drainage works	0	0	0	4,100	0	4,100	0	0	0	0	0	0	0	0	0	0	0	8,200	8,200
ii) Floodway construction	0	0	0	2,075	0	2,075	0	0	0	0	0	0	0	0	0	0	0	4,150	4,150
b) Government administration	0	475	0	475	0	475	0	430	0	430	0	430	0	430	0	430	0	3,575	3,575
c) Engineering service	1,374	342	686	172	0	0	494	124	710	178	834	208	710	178	340	85	5,148	1,287	6,435
Sub-total	1,374	817	686	6,822	0	6,650	494	554	710	608	834	638	710	608	340	515	5,148	17,212	22,360
d) Physical contingency	206	123	103	1,023	0	998	74	83	107	91	125	96	107	91	51	77	773	2,582	3,355
Sub-total	1,580	940	789	7,845	0	7,648	568	637	817	699	959	734	817	699	391	592	5,921	19,794	25,715
e) Price contingency	96	57	73	727	0	960	90	101	159	136	220	169	218	186	119	180	975	2,516	3,491
Total of item III	1,676	997	862	8,572	0	8,608	658	738	976	835	1,179	903	1,035	885	510	772	6,896	22,310	29,206
Grand total	1,676	997	862	8,572	0	8,608	10,023	6,982	14,466	9,827	17,821	11,997	15,204	10,330	7,352	5,333	67,404	62,646	130,050
Total of F.C. and L.C.	2,673		9,434		8,608		17,005		24,293		29,818		25,534		12,685		130,050		

Remarks :
Construction work of Package-A and B is as follows:

Package-A : River improvement work in the Itajai river, Itajai Mirim river and existing short-cut channel and drainage work in Itajai and Navegantes cities

Package-B : Floodway construction work

Table 7.1 FINANCIAL COST AND ECONOMIC COST

(Unit : Thousand US Dollars)

	Item	Foreign Currency Portion	Local Currency Portion			Total
			Major Works	Unskilled Labor	Sub-Total	
I.	Financial Cost					
1.	Construction Works	42,900	22,880	5,720	28,600	71,500
2.	Land Aquisition & Compensation	0	12,350	0	12,350	12,350
3.	Government Administration	0	3,575	0	3,575	3,575
4.	Engineering Service	5,148	1,287	0	1,287	6,435
	Sub-total	48,048	-	-	45,812	93,860
5.	Physical Contingency	7,207	-	-	6,872	14,079
6.	Price Contingency	12,147	-	-	9,964	22,111
	Grand Total	67,402	-	-	62,648	130,050
II.	Economic Cost					
1.	Construction Works	42,900	20,592	2,860	23,452	66,352
2.	Land Aquisition and Compensation /1	0	4,460	0	4,460	4,460
2.	Government Administration	0	3,218	0	3,218	3,218
3.	Engineering Service	5,148	1,158	0	1,158	6,306
	Sub-total	48,048	-	-	32,288	80,336
4.	Physical Contingency	7,207	-	-	4,843	12,050
5.	Price Contingency	0	-	-	0	0
	Grand Total	55,255	-	-	37,131	92,386

Remark : /1 Economic land value is estimated as follows:

(1) Land aquisition cost is eliminated for both agricultural land and other lands such as residential and industrial use.

(2) Economic value of expropriated agricultural land is estimated as foregone value of agricutural production from lands concerned, which is expressed as negative benefit in the cash flow stream.

(3) Prices to be newly built are applied as economic compensation cost for residences and industrial facilities.

Table 7.2 ASSETS RELIEVED FROM FLOOD DAMAGE AND FLOOD CONTROL BENEFIT FOR SELECTED RETURN PERIOD IN FLOOD PROTECTION AREA UNDER PRESENT CONDITION

Item		Return Period (Year)		
		2	5	10
I.	Assets relieved from flood damage			
1	Victim (Persons)	20,144	27,908	40,208
2	Area Inundated (sq.km.)*1	20.6	25.6	30.4
3	Assets Inundated by Flood (Nos)			
	(1) Residence	5,036	6,977	10,052
	(2) Industrial Establishment	44	65	81
	(3) Service Establishment	134	243	301
II.	Benefit (reduction of flood damage : NCz$ Million)			
1	Residence	18.8	28.4	40.7
2	Industrial Establishment	6.5	10.8	13.8
3	Service Establishment	2.0	3.7	4.8
	Sub-total	27.3	42.9	59.3
4	Infrastructural Damage	8.2	12.9	17.8
5	Indirect Damage	3.5	5.6	7.7
	Annualized Value*2	9.8	24.8	32.1
	US$ Equivalent (US$ Million)			8.50

Remark: *1 Including the water surface for river.

*2 $Bn = \sum_{i=1}^{n} ([\{D(Q_{i-1}) + (Q_i)\}/2) \cdot [P(Q_{i-1}) - P(Q_i)]$

- Bn means the average annual benefit with the flood control project against (n)-year probable flood.
- $D(Q_{i-1})$ and $D(Q_i)$ mean damages by (i-1)th-flood with Q_{i-1} discharge and (i)th-flood with Q_i discharge, respectively.
- $P(Q_{i-1})$ and $P(Q_i)$ mean probabilities of occurrence off larger discharge than Q_{i-1} discharge and Q_i discharge, respectively.

Table 7.3 ASSETS RELIEVED FROM FLOOD DAMAGE AND FLOOD CONTROL BENEFIT FOR SELECTED RETURN PERIOD IN FLOOD PROTECTION AREA IN THE YEAR 2020

Item			Return Period (Year)		
			2	5	10
I.	Assets relieved from flood damage				
1	Victim (Persons)		36,040	48,884	67,660
2	Area Inundated (sq.km.)*1		20.6	25.6	30.4
3	Assets Inundated by Flood (Nos)				
	(1) Residence		9,010	12,221	16,915
	(2) Industrial Establishment		70	104	129
	(3) Service Establishment		213	387	479
II.	Benefit (reduction of flood damage : NCz$ Million)				
1	Residence	58.6	89.7	126.3	
2	Industrial Establishment	12.2	20.5	26.3	
3	Service Establishment	4.5	8.6	11.2	
	Sub-total	75.3	118.8	163.8	
4	Infrastructural Damage	22.6	35.6	49.1	
5	Indirect Damage	9.8	15.4	21.3	
	Total	107.7	169.9	234.2	
	Annualized Value	26.9	68.6	88.8	
	US$ Equivalent (US$ Million)			23.48	

Remark : *1 Including the water surface for river.

Table 7.4 CASH FLOW STREAM OF THE ECONOMIC PROJECT COST AND BENEFIT UNDER PRESENT ECONOMIC CONDITION

(Unit : US$ thousand)

n	Year	Economic Cost				Economic Benefit			Present Value for Selected Discount Rate							
		Const-ruction	Replace-ment	O/M	Total	Damage Reduction	Negative Benefit	Total	5 %		7.1 %		7.5 %		10 %	
									Benefit	Cost	Benefit	Cost	Benefit	Cost	Benefit	Cost
-8	1991	2,426			2,426			0	0	3,584	0	4,199	0	4,327	0	5,200
-7	1992	4,023			4,023		-10	-10	-14	5,661	-16	6,502	-17	6,674	-19	7,840
-6	1993	3,056			3,056		-10	-10	-13	4,095	-15	4,612	-15	4,716	-18	5,414
-5	1994	13,637			13,637		-10	-10	-13	17,405	-14	19,214	-14	19,578	-16	21,963
-4	1995	18,916			18,916		-10	-10	-12	22,993	-13	24,886	-13	25,262	-15	27,695
-3	1996	22,547			22,547		-10	-10	-12	26,101	-12	27,697	-12	28,010	-13	30,010
-2	1997	18,745			18,745		-10	-10	-11	20,666	-11	21,501	-12	21,662	-12	22,681
-1	1998	9,035			9,035		-10	-10	-11	9,487	-11	9,676	-11	9,713	-11	9,939
0	1999			332	332	8,492	-10	8,482	8,482	332	8,482	332	7,890	309	8,482	332
1	2000			332	332	8,492	-10	8,482	8,078	316	7,920	310	7,340	287	7,711	310
2	2001			332	332	8,492	-10	8,482	7,693	301	7,395	289	6,828	267	7,010	289
3	2002			332	332	8,492	-10	8,482	7,327	287	6,905	270	6,351	249	6,373	270
4	2003			332	332	8,492	-10	8,482	6,978	273	6,447	252	5,908	231	5,793	252
5	2004			332	332	8,492	-10	8,482	6,646	260	6,020	236	5,496	215	5,267	236
6	2005			332	332	8,492	-10	8,482	6,329	248	5,621	220	5,113	200	4,788	220
7	2006			332	332	8,492	-10	8,482	6,028	236	5,248	205	4,756	186	4,353	205
8	2007			332	332	8,492	-10	8,482	5,741	225	4,901	192	4,424	173	3,957	192
9	2008			332	332	8,492	-10	8,482	5,468	214	4,576	179	4,115	161	3,597	179
10	2009			332	332	8,492	-10	8,482	5,207	204	4,273	167	3,828	150	3,270	167
11	2010			332	332	8,492	-10	8,482	4,959	194	3,989	156	3,561	139	2,973	156
12	2011			332	332	8,492	-10	8,482	4,723	185	3,725	146	3,313	130	2,703	146
13	2012			332	332	8,492	-10	8,482	4,498	176	3,478	136	3,082	121	2,457	136
14	2013		1,060	332	1,392	8,492	-10	8,482	4,284	703	3,248	533	2,867	470	2,234	533
15	2014			332	332	8,492	-10	8,482	4,080	160	3,032	119	2,667	104	2,031	119
16	2015			332	332	8,492	-10	8,482	3,886	152	2,831	111	2,481	97	1,846	111
17	2016			332	332	8,492	-10	8,482	3,701	145	2,644	103	2,308	90	1,678	103
18	2017			332	332	8,492	-10	8,482	3,524	138	2,468	97	2,147	84	1,526	97
19	2018			332	332	8,492	-10	8,482	3,357	131	2,305	90	1,997	78	1,387	90
20	2019			332	332	8,492	-10	8,482	3,197	125	2,152	84	1,857	73	1,261	84
21	2020			332	332	8,492	-10	8,482	3,045	119	2,009	79	1,728	68	1,146	79
22	2021			332	332	8,492	-10	8,482	2,900	113	1,876	73	1,607	63	1,042	73
23	2022			332	332	8,492	-10	8,482	2,762	108	1,752	69	1,495	59	947	69
24	2023			332	332	8,492	-10	8,482	2,630	103	1,636	64	1,391	54	861	64
25	2024			332	332	8,492	-10	8,482	2,505	98	1,527	60	1,294	51	783	60
26	2025			332	332	8,492	-10	8,482	2,386	93	1,426	56	1,204	47	712	56
27	2026			332	332	8,492	-10	8,482	2,272	89	1,332	52	1,120	44	647	52
28	2027			332	332	8,492	-10	8,482	2,164	85	1,243	49	1,041	41	588	49
29	2028		1,060	332	1,392	8,492	-10	8,482	2,061	338	1,161	191	969	159	535	191
30	2029			332	332	8,492	-10	8,482	1,963	77	1,084	42	901	35	486	42
31	2030			332	332	8,492	-10	8,482	1,869	73	1,012	40	838	33	442	40
32	2031			332	332	8,492	-10	8,482	1,780	70	945	37	780	31	402	37
33	2032			332	332	8,492	-10	8,482	1,695	66	882	35	725	28	365	35
34	2033			332	332	8,492	-10	8,482	1,615	63	824	32	675	26	332	32
35	2034			332	332	8,492	-10	8,482	1,538	60	769	30	628	25	302	30
36	2035			332	332	8,492	-10	8,482	1,464	57	718	28	584	23	274	28
37	2036			332	332	8,492	-10	8,482	1,395	55	671	26	543	21	249	26
38	2037			332	332	8,492	-10	8,482	1,328	52	626	25	505	20	227	25
39	2038			332	332	8,492	-10	8,482	1,265	50	585	23	470	18	206	23
40	2039			332	332	8,492	-10	8,482	1,205	47	546	21	437	17	187	21
41	2040			332	332	8,492	-10	8,482	1,147	45	510	20	407	16	170	20
42	2041			332	332	8,492	-10	8,482	1,093	43	476	19	378	15	155	19
43	2042			332	332	8,492	-10	8,482	1,041	41	445	17	352	14	141	17
44	2043		1,060	332	1,392	8,492	-10	8,482	991	163	415	68	327	54	128	68
45	2044			332	332	8,492	-10	8,482	944	37	388	15	305	12	116	15
46	2045			332	332	8,492	-10	8,482	899	35	362	14	283	11	106	14
47	2046			332	332	8,492	-10	8,482	856	34	338	13	264	10	96	13
48	2047			332	332	8,492	-10	8,482	815	32	315	12	245	10	87	12
49	2048			332	332	8,492	-10	8,482	777	30	295	12	228	9	79	12
	Total								162,505	117,272	123,736	123,736	109,959	124,770	92,404	136,191

Remark:

(1) Present value (PV) is estimated by the following formula:
PV = (Benefit or Cost) / (1 + Discount Rate)^{n}

(2) An economic internal rate of return (EIRR) is estimated to be 7.1 %
which equalizes total of present value of benefit and cost in the above cash flow stream.

Table 7.5 CASH FLOW STREAM OF THE ECONOMIC PROJECT COST AND BENEFIT UNDER FUTURE ECONOMIC CONDITION

(Unit: Thousand US Dollars)

No.	Year	Economic Cost				Economic Benefit			Balance
		Construction Cost	Replacement Cost	O/M Cost	Total	Damage Reduction	Negative Benefit	Total	
-8	1991	2,426			2,426			0	-2,426
-7	1992	4,023			4,023		-10	-10	-4,033
-6	1993	3,056			3,056		-10	-10	-3,066
-5	1994	13,637			13,637		-10	-10	-13,647
-4	1995	18,916			18,916		-10	-10	-18,926
-3	1996	22,547			22,547		-10	-10	-22,557
-2	1997	18,745			18,745		-10	-10	-18,755
-1	1998	9,035			9,035		-10	-10	-9,045
1	1999			332	332	11,720	-10	11,710	11,378
2	2000			332	332	12,090	-10	12,080	11,748
3	2001			332	332	12,540	-10	12,530	12,198
4	2002			332	332	12,831	-10	12,821	12,489
5	2003			332	332	13,360	-10	13,350	13,018
6	2004			332	332	13,677	-10	13,667	13,335
7	2005			332	332	14,180	-10	14,170	13,838
8	2006			332	332	14,762	-10	14,752	14,420
9	2007			332	332	15,106	-10	15,096	14,764
10	2008			332	332	15,635	-10	15,625	15,293
11	2009			332	332	16,005	-10	15,995	15,663
12	2010			332	332	16,799	-10	16,789	16,457
13	2011			332	332	17,196	-10	17,186	16,854
14	2012			332	332	17,857	-10	17,847	17,515
15	2013		1,060	332	1,392	18,492	-10	18,482	17,090
16	2014			332	332	18,942	-10	18,932	18,600
17	2015			332	332	19,868	-10	19,858	19,526
18	2016			332	332	20,344	-10	20,334	20,002
19	2017			332	332	21,138	-10	21,128	20,796
20	2018			332	332	21,852	-10	21,842	21,510
21	2019			332	332	22,407	-10	22,397	22,065
22	2020			332	332	23,466	-10	23,456	23,124
23	2021			332	332	23,466	-10	23,456	23,124
24	2022			332	332	23,466	-10	23,456	23,124
25	2023			332	332	23,466	-10	23,456	23,124
26	2024			332	332	23,466	-10	23,456	23,124
27	2025			332	332	23,466	-10	23,456	23,124
28	2026			332	332	23,466	-10	23,456	23,124
29	2027			332	332	23,466	-10	23,456	23,124
30	2028		1,060	332	1,392	23,466	-10	23,456	22,064
31	2029			332	332	23,466	-10	23,456	23,124
32	2030			332	332	23,466	-10	23,456	23,124
33	2031			332	332	23,466	-10	23,456	23,124
34	2032			332	332	23,466	-10	23,456	23,124
35	2033			332	332	23,466	-10	23,456	23,124
36	2034			332	332	23,466	-10	23,456	23,124
37	2035			332	332	23,466	-10	23,456	23,124
38	2036			332	332	23,466	-10	23,456	23,124
39	2037			332	332	23,466	-10	23,456	23,124
40	2038			332	332	23,466	-10	23,456	23,124
41	2039			332	332	23,466	-10	23,456	23,124
42	2040			332	332	23,466	-10	23,456	23,124
43	2041			332	332	23,466	-10	23,456	23,124
44	2042			332	332	23,466	-10	23,456	23,124
45	2043		1,060	332	1,392	23,466	-10	23,456	22,064
46	2044			332	332	23,466	-10	23,456	23,124
47	2045			332	332	23,466	-10	23,456	23,124
48	2046			332	332	23,466	-10	23,456	23,124
49	2047			332	332	23,466	-10	23,456	23,124
50	2048			332	332	23,466	-10	23,456	23,124

Note : An EIRR is estimated to be 11.9% based on the above cash flow stream under future economic condition.

Figures

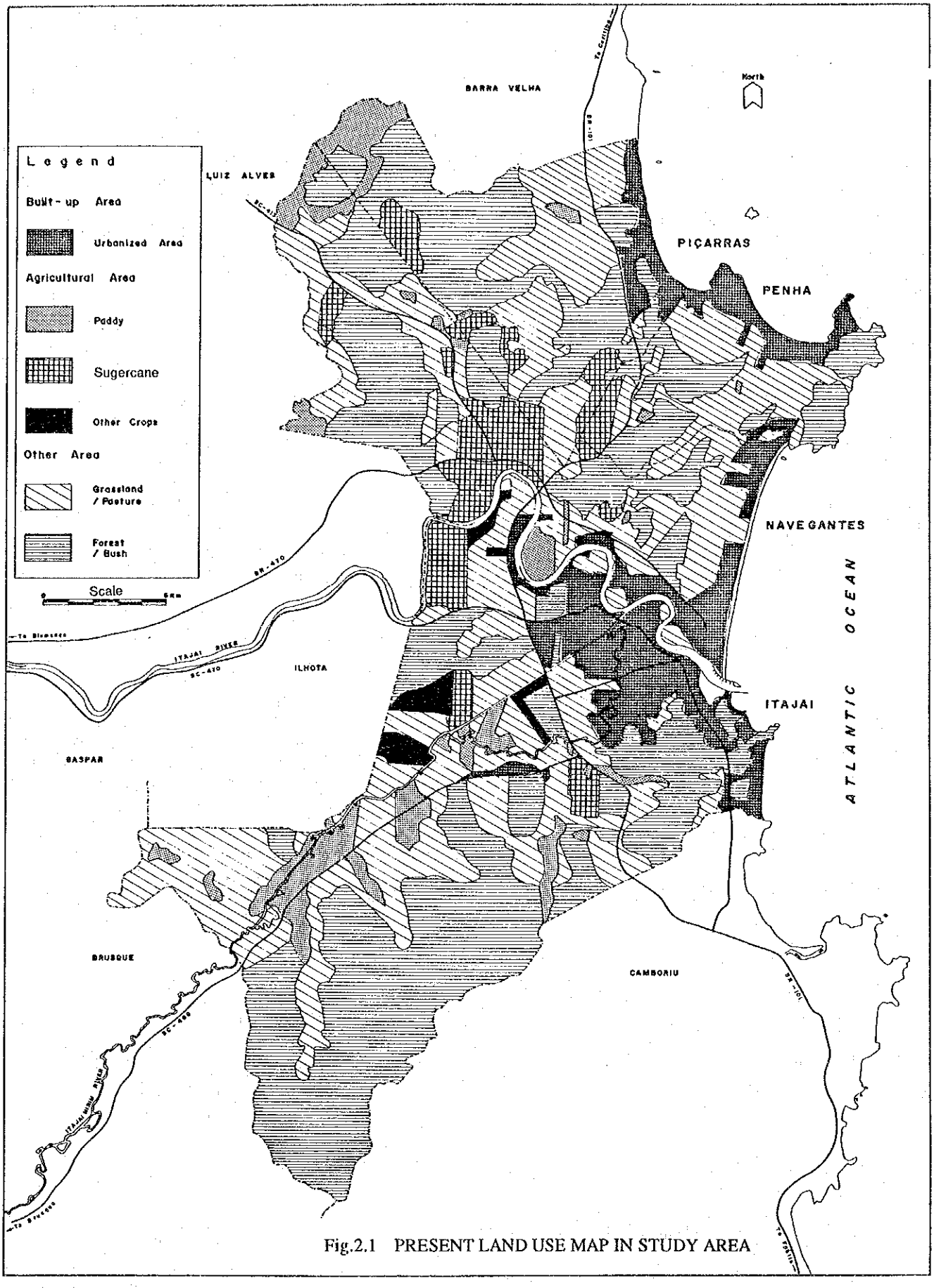


Fig.2.1 PRESENT LAND USE MAP IN STUDY AREA

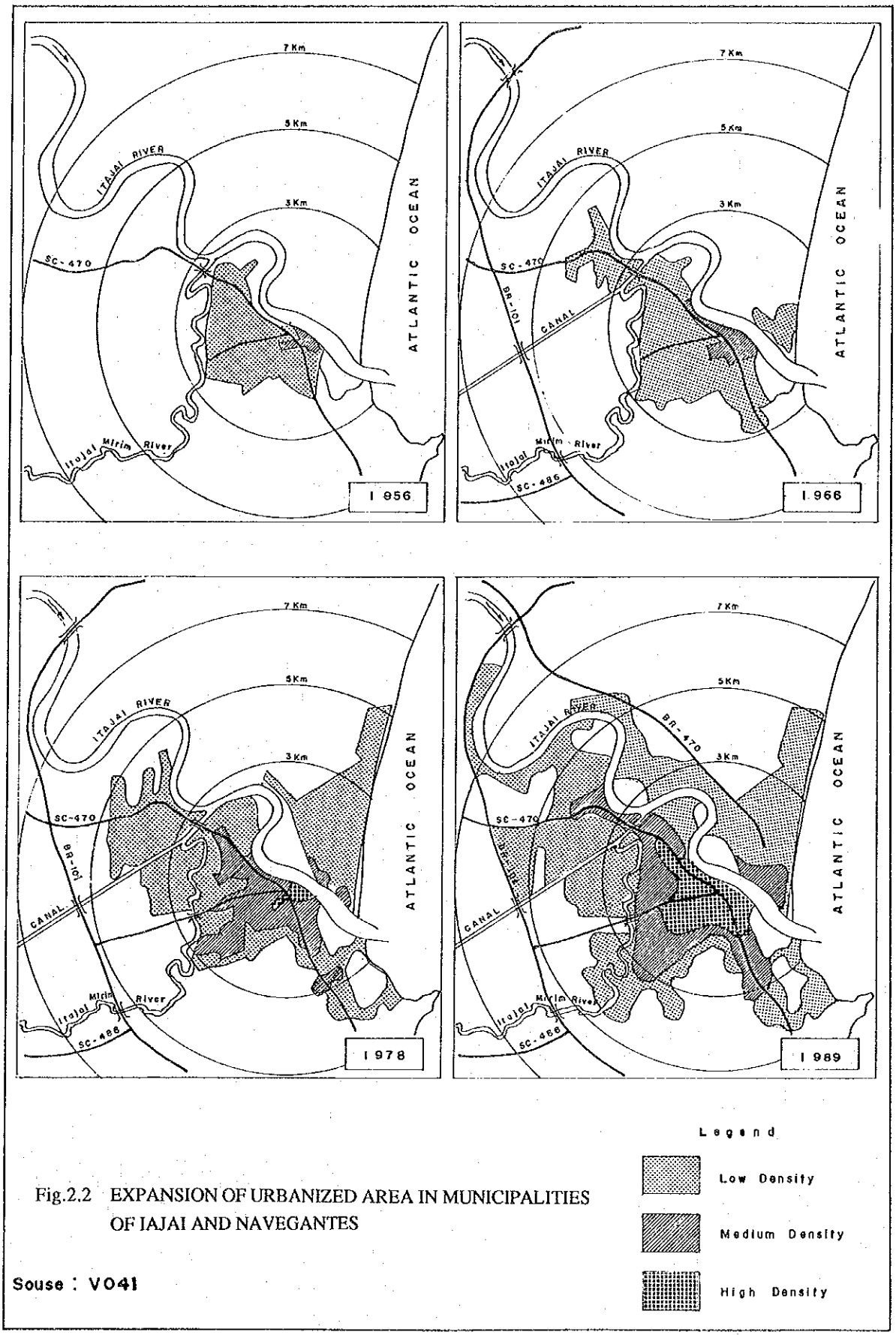


Fig.2.2 EXPANSION OF URBANIZED AREA IN MUNICIPALITIES OF IAJAI AND NAVEGANTES

Souse : V041

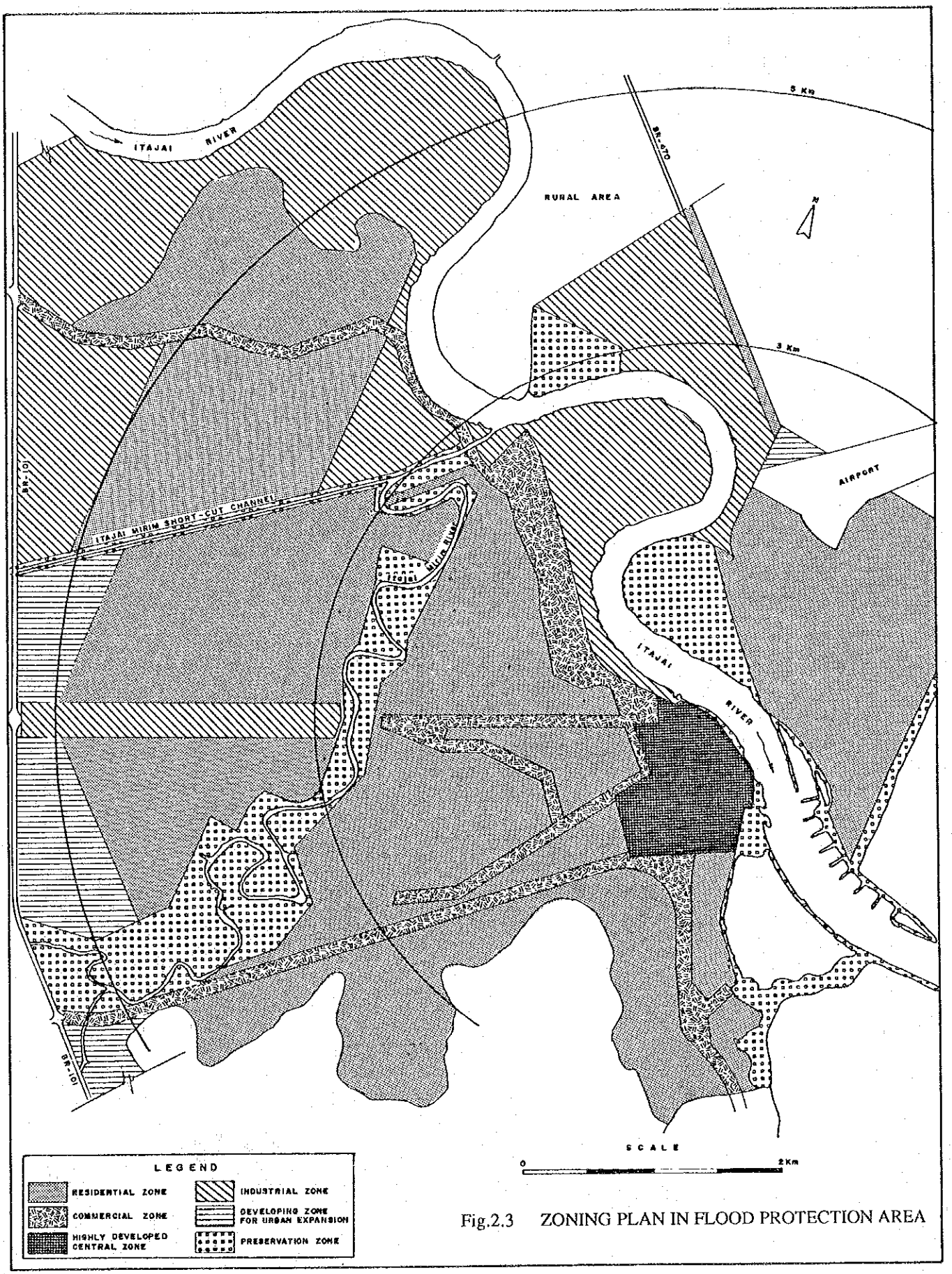


Fig.2.3 ZONING PLAN IN FLOOD PROTECTION AREA

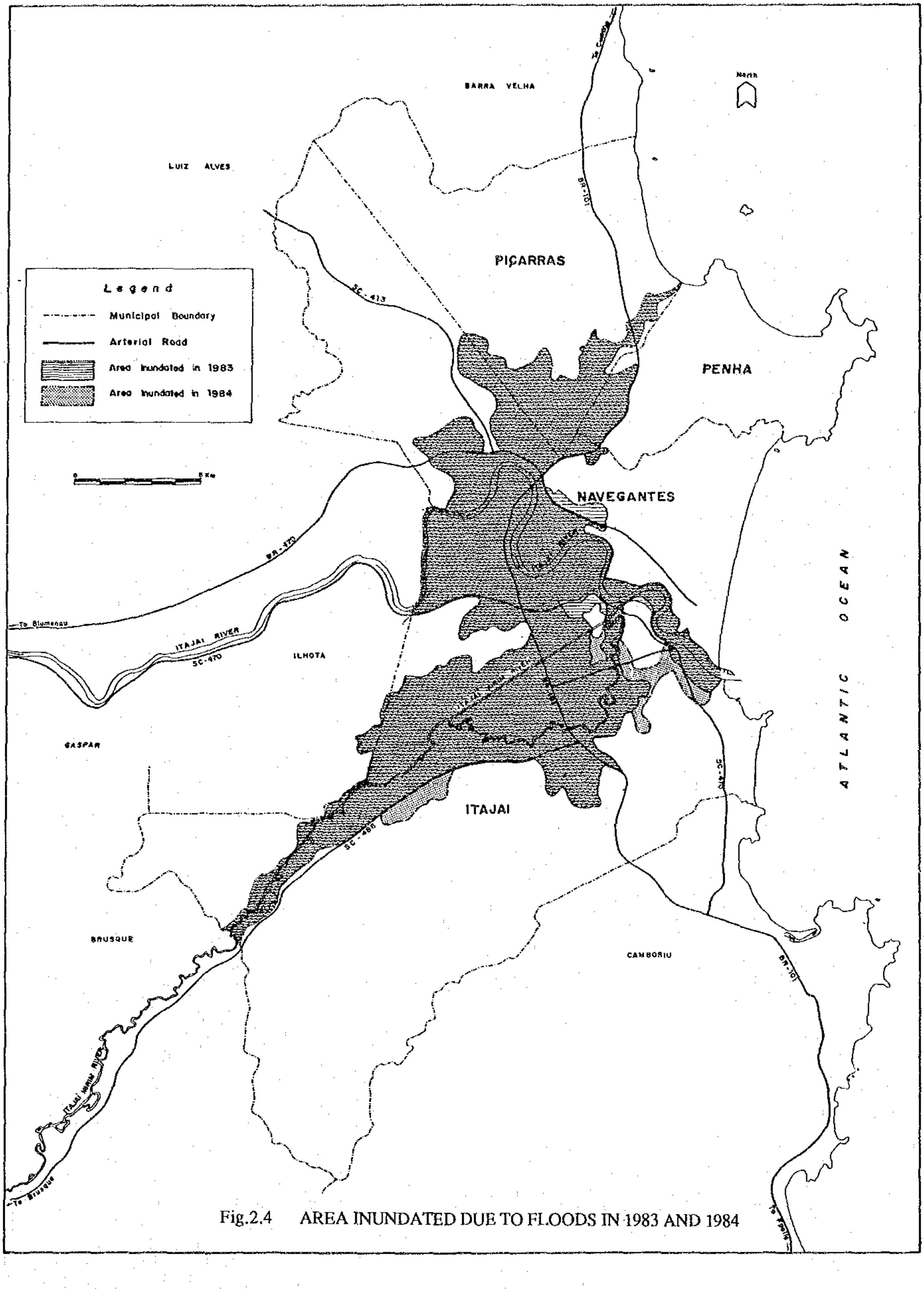


Fig.2.4 AREA INUNDATED DUE TO FLOODS IN 1983 AND 1984

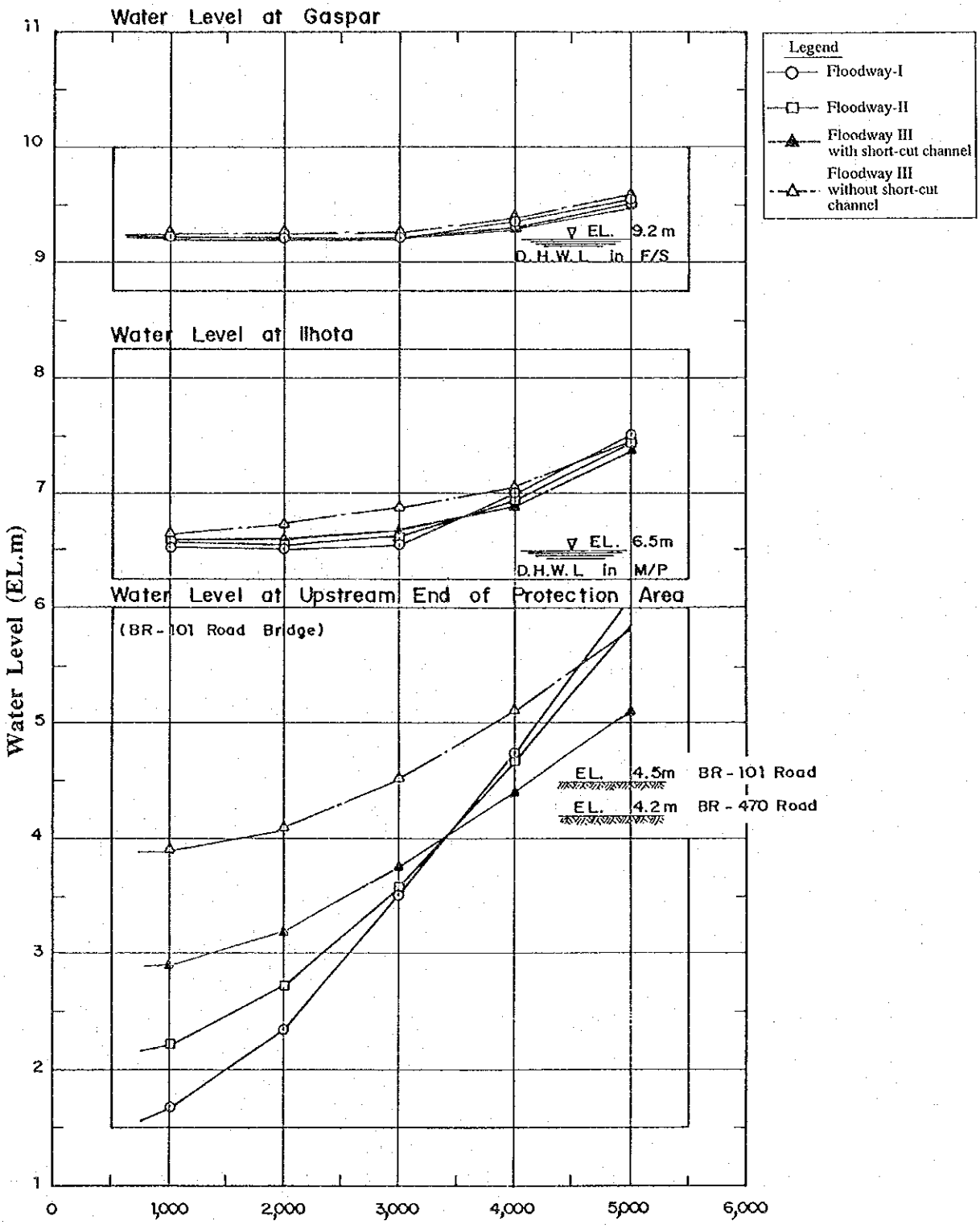
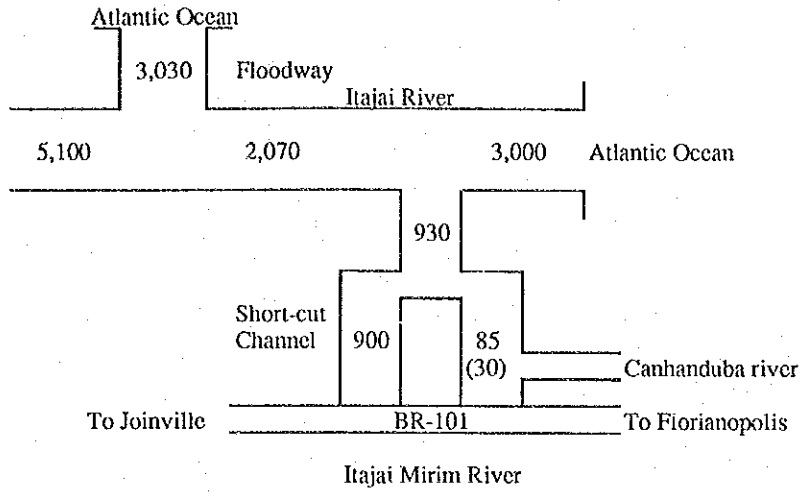
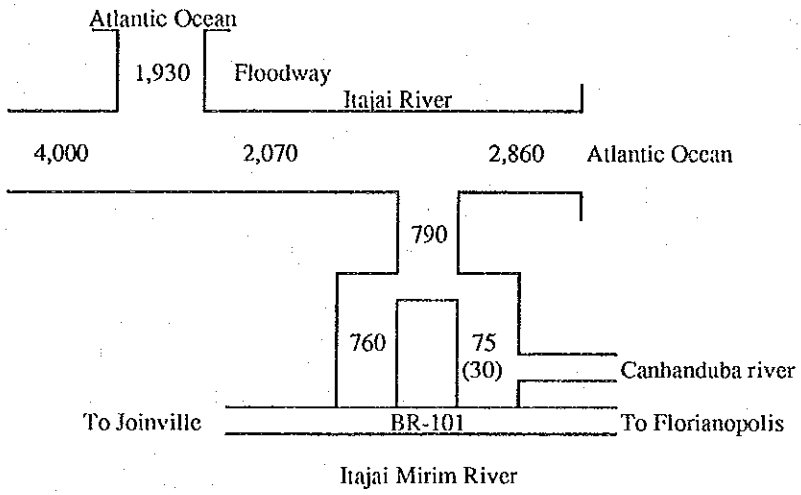


Fig.3.1 INFLUENCE TO UPSTREAM DUE TO ENHANCEMENT OF PRESENT FLOW CAPACITY OF THE PROJECT STRETCH

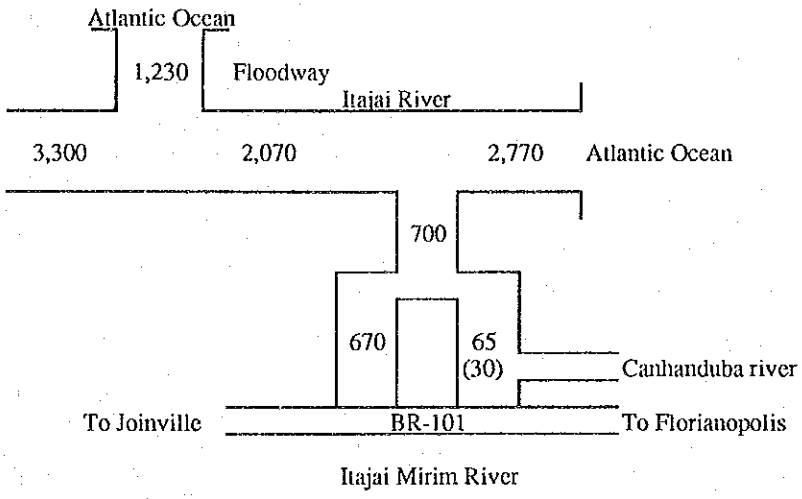
(1) Long-Term Plan (50-year)



(2) Mid-Term Plan (25-year)

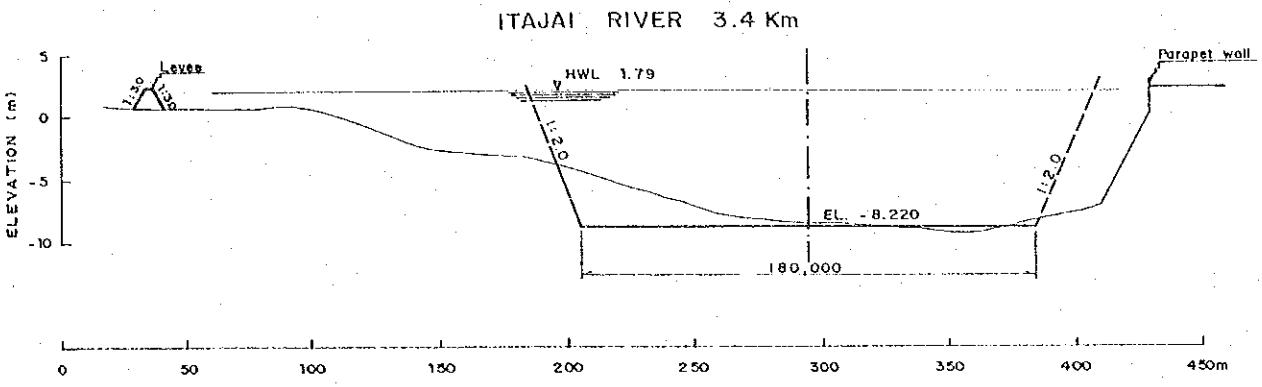


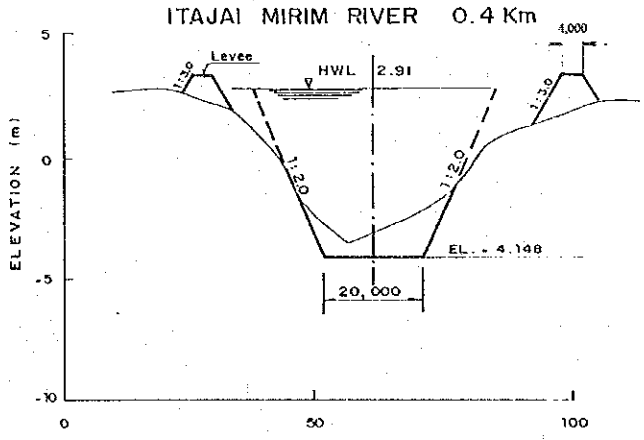
(3) Provisional Plan (10-year)

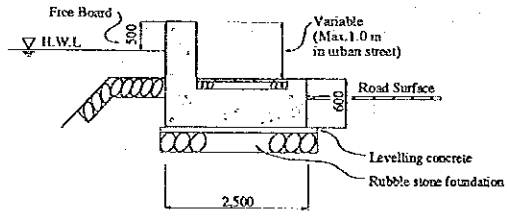


Remarks :
"( )" means the flood discharge in the Itajai Mirim river
at the time of flood peak occurrence in the short-cut channel.

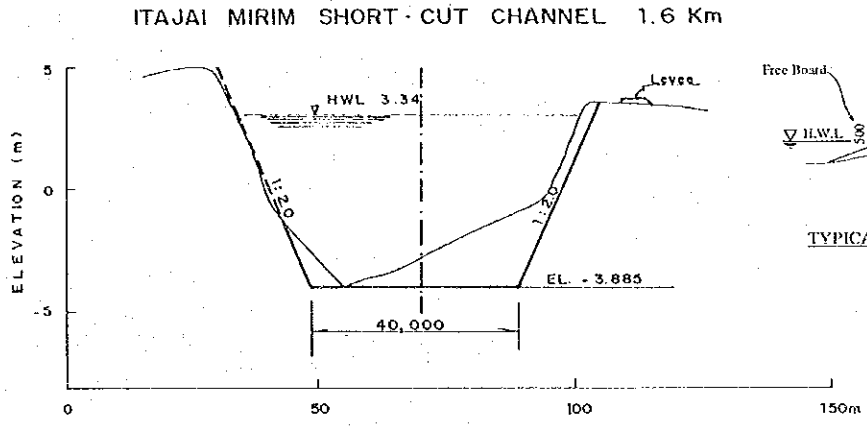
Fig. 3.2 PROPOSED FLOOD DISCHARGE DISTRIBUTION

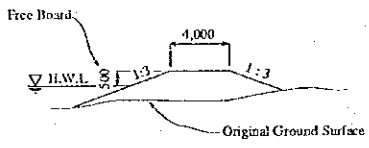






TYPICAL SECTION OF PARAPET WALL





TYPICAL CROSS SECTION OF LEVEE

Fig.3.3 TYPICAL CROSS SECTION OF RIVER IMPROVEMENT IN THE PROJECT STRETCH

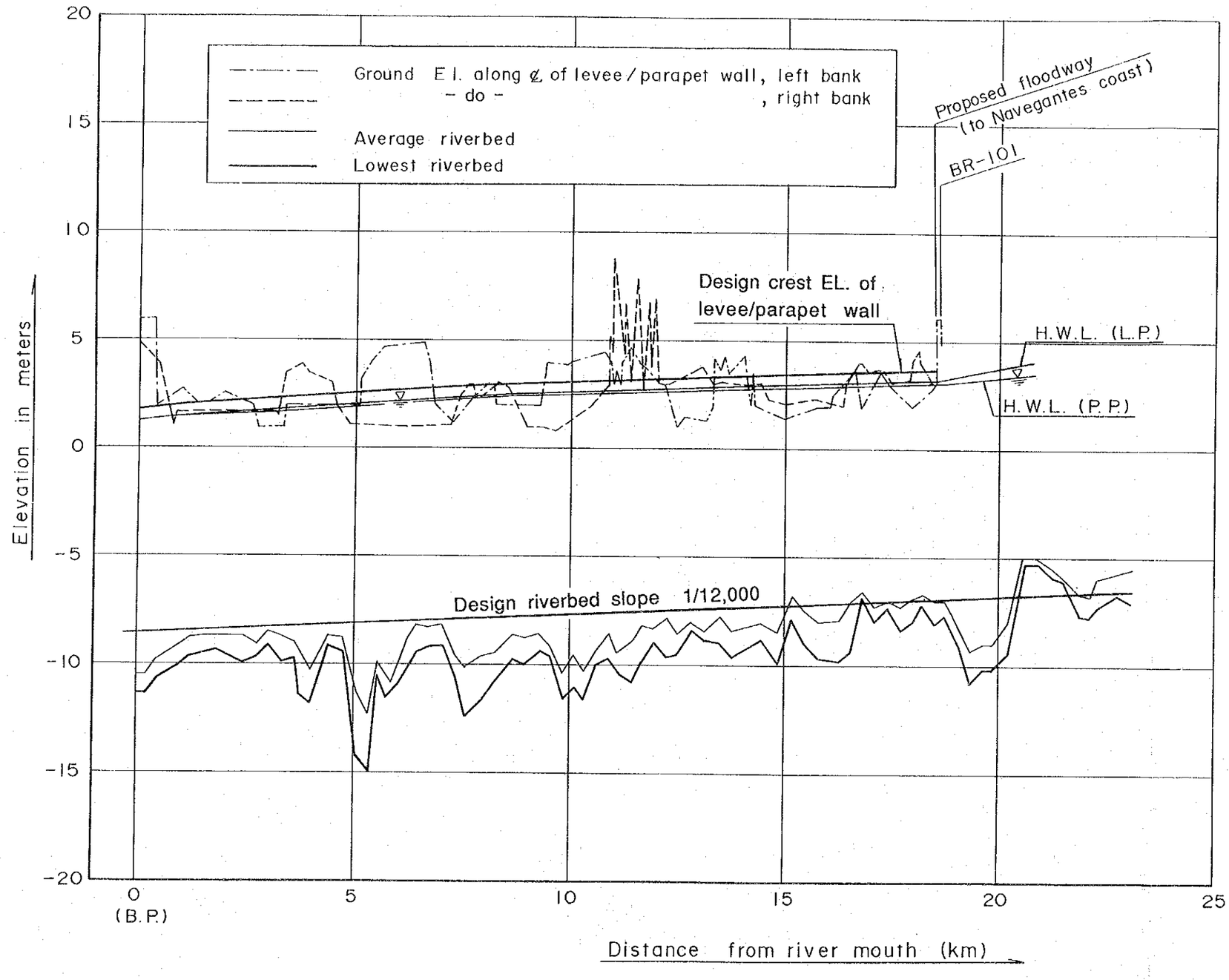


Fig.3.4 LONGITUDINAL PROFILE OF RIVER IMPROVEMENT WORK IN ITAJAI RIVER

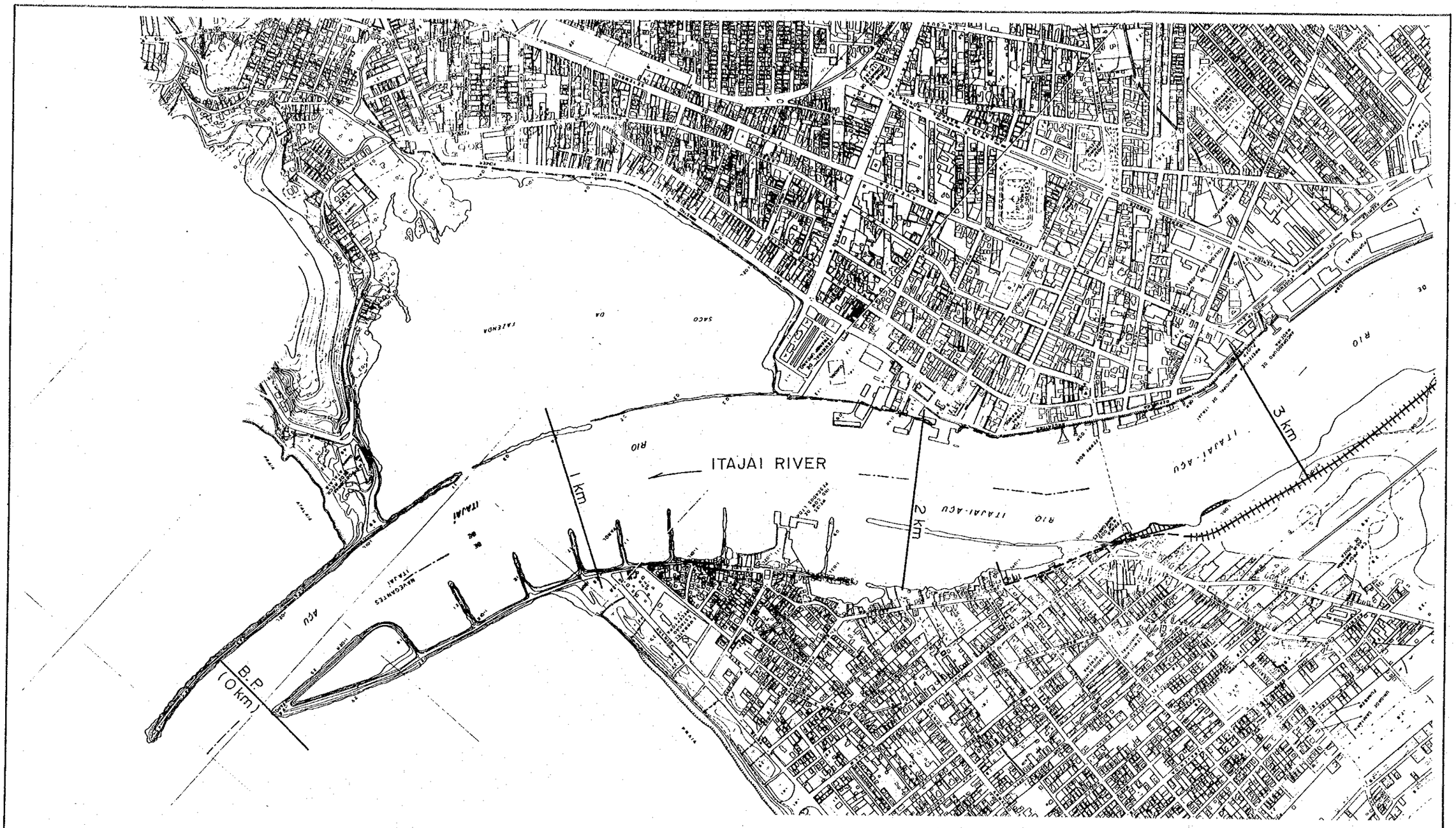


Fig. 3.5 GENERAL PLAN OF RIVER IMPROVEMENT WORK IN THE ITAJAI RIVER (1/5)

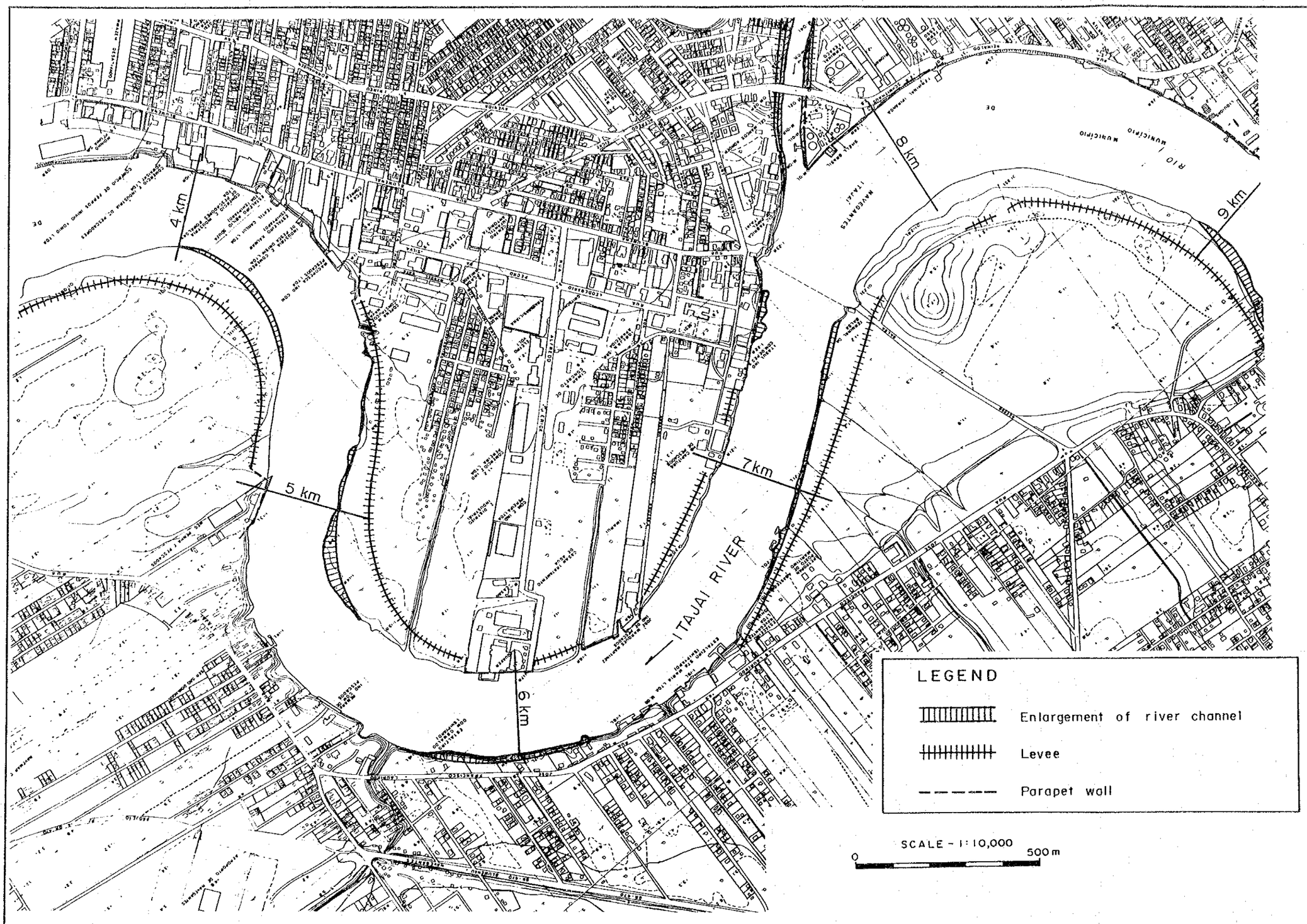


Fig. 3.5 GENERAL PLAN OF RIVER IMPROVEMENT WORK IN THE ITAJAI RIVER (2/5)

Fig. 3.5 GENERAL PLAN OF RIVER IMPROVEMENT WORK IN THE ITAJAI RIVER (3/5)

LEGEND

- Enlargement of river channel
- Levee
- Parapet wall

Fig. 3.5 GENERAL PLAN OF RIVER IMPROVEMENT WORK IN THE ITAJAI RIVER (4/5)

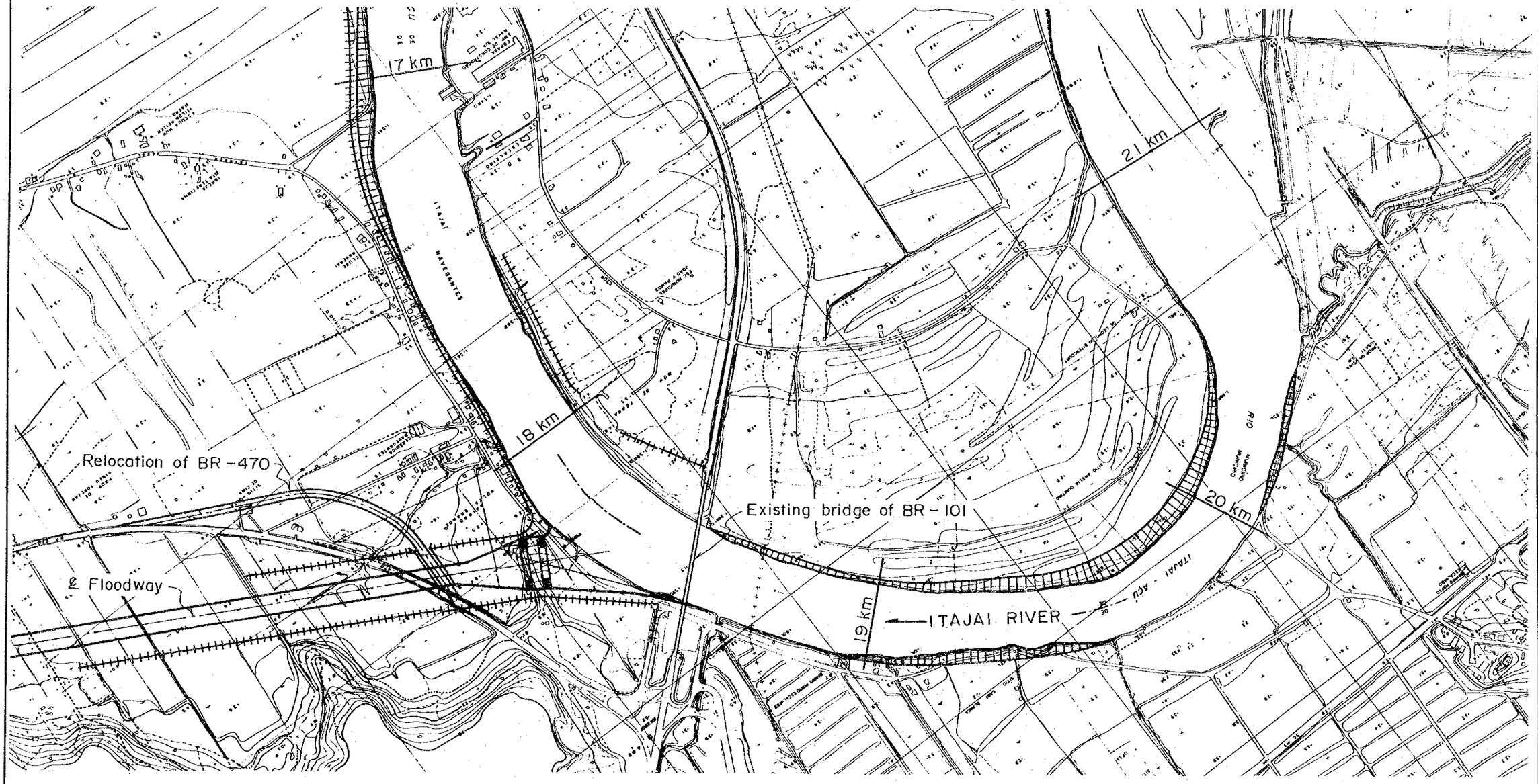
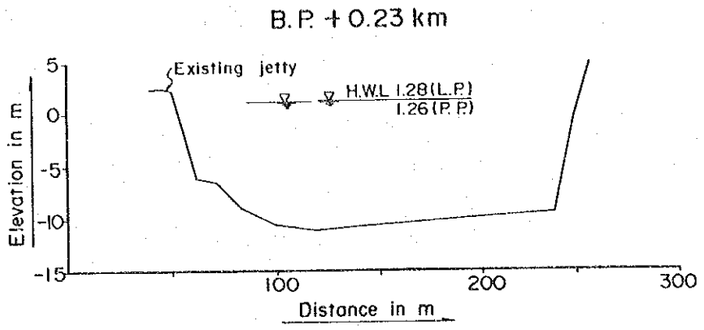
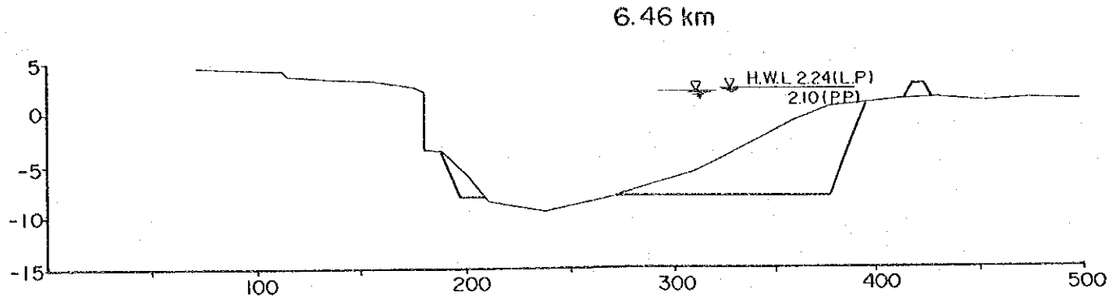
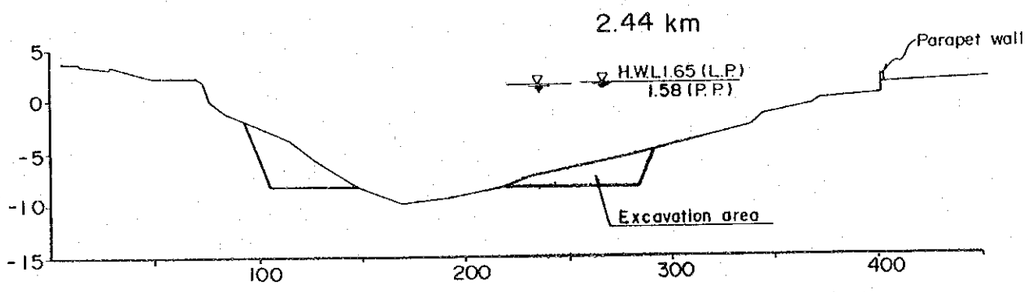
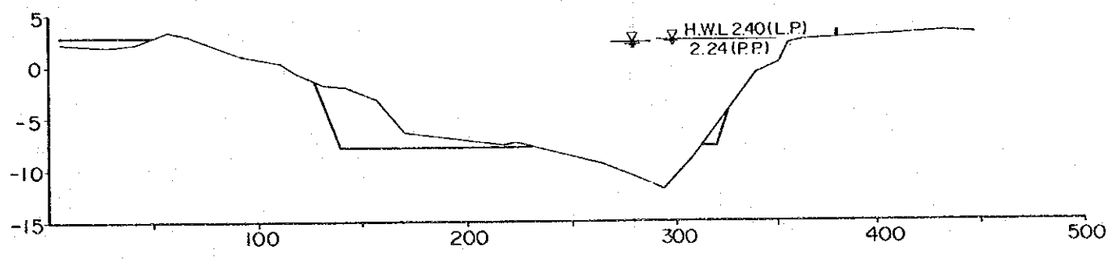


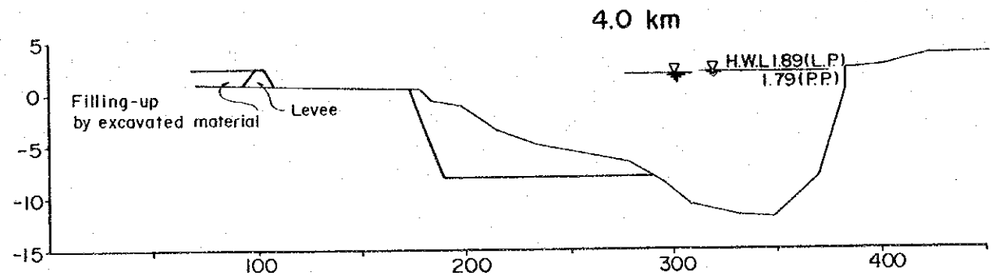
Fig. 3.5 GENERAL PLAN OF RIVER IMPROVEMENT WORK IN THE ITAJAI RIVER (5/5)

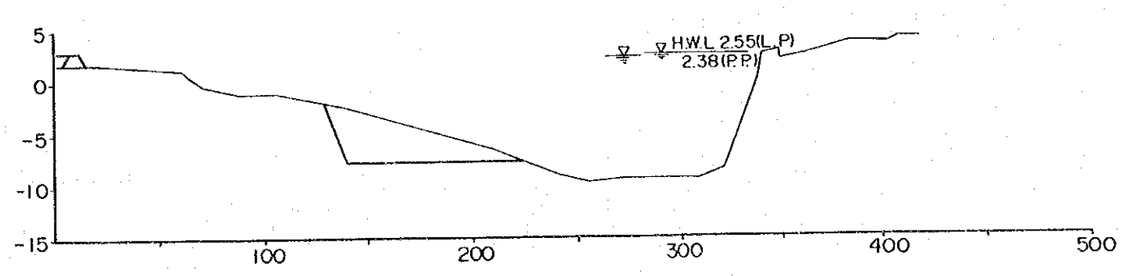


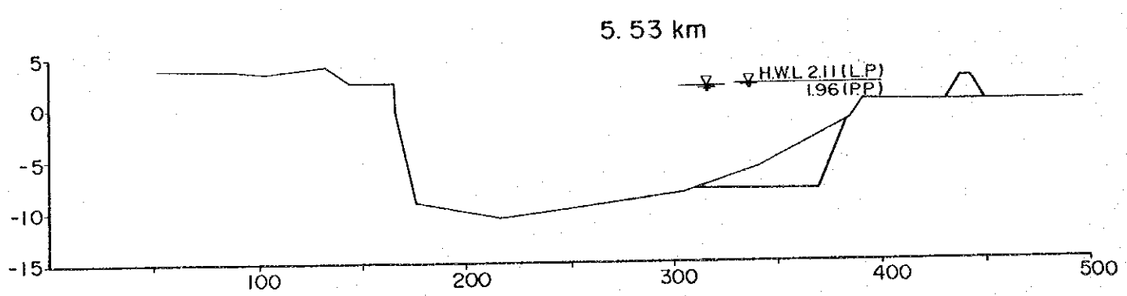






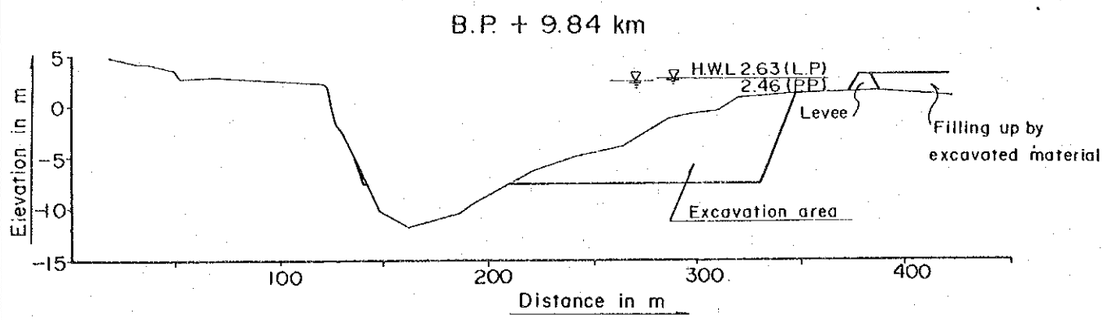


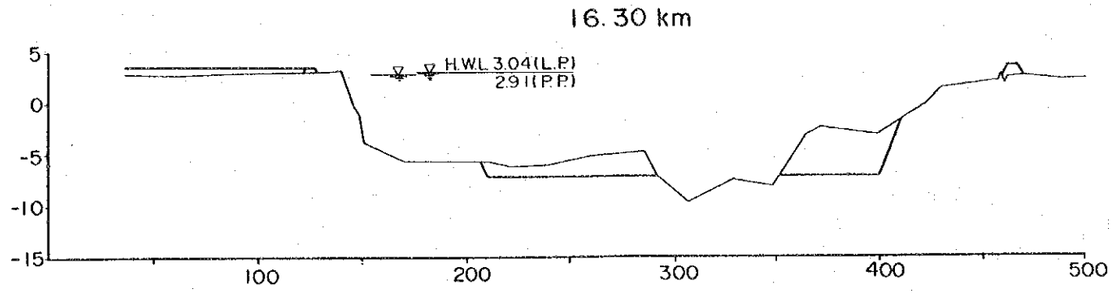


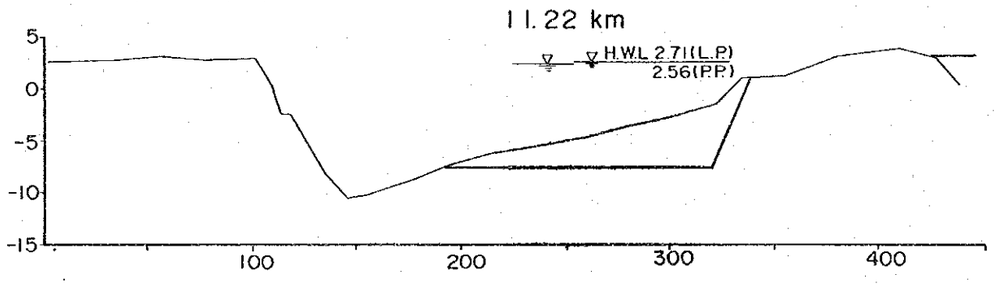


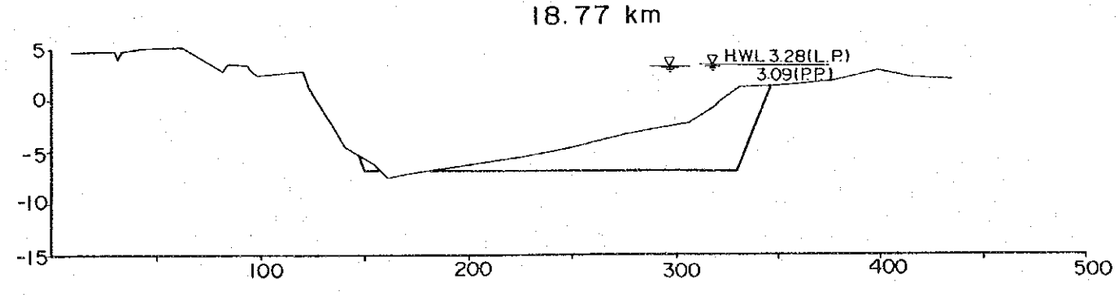
Remarks, L.P : Long-term Plan
P.P : Provisional Plan

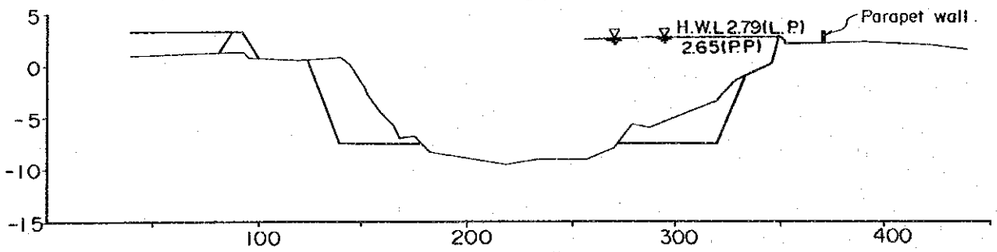
Fig. 3.6 RIVER CROSS SECTION OF ITAJAI RIVER (1/2)

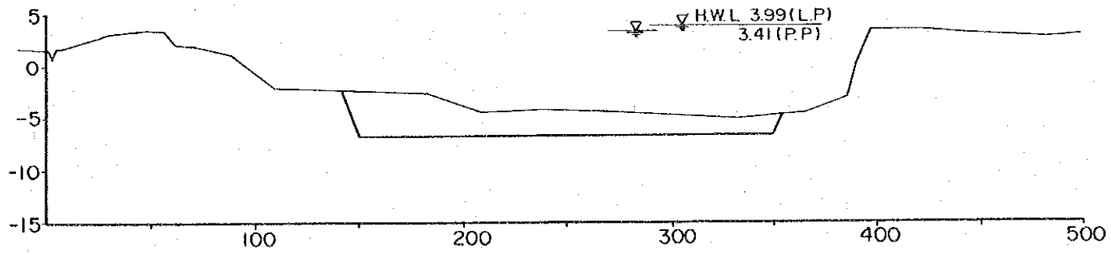


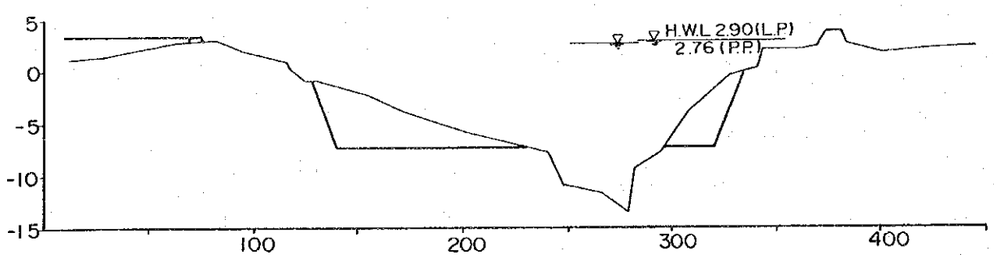












Remarks, L.P : Long-term Plan
P.P : Provisional Plan

Fig. 3.6 RIVER CROSS SECTION OF ITAJAI RIVER (2/2)

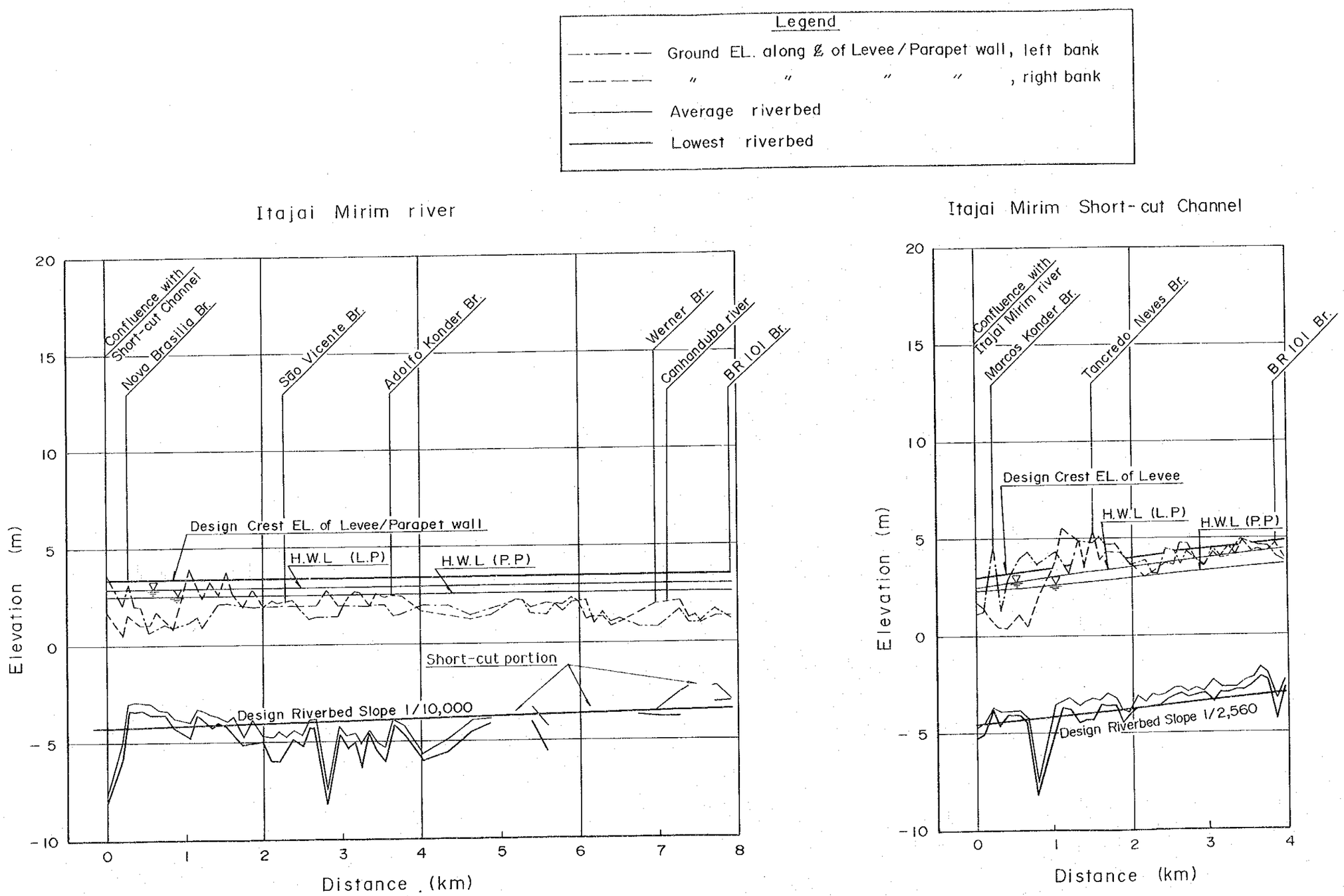


Fig.3.7 LONGITUDINAL PROFILE OF IMPROVEMENT WORK IN ITAJAI MIRIM RIVER AND ITS SHORT-CUT CHANNEL