coastal barrage at the outlet portion of the floodway to regulate the river flow especially in off-wet season. The relationship among distribution ratio of river discharge, sediment deposit condition in the Itajai river channel and river discharge to flush the deposited sediment by operation of the coastal barrage should be studied through a hydraulic model test to be performed in the detailed design stage.

3.5.3 Structural plan of floodway and related structures

(1) Structural plan of the floodway

The floodway design is carried out based on the topographical maps on a scale of 1:5,000 and at contour interval of 1 m, which have been produced through the topographical survey in this study period.

The length of the proposed floodway along its centerline totals around 9 km excluding the jetty portion and the required channel width for the provisional plan is estimated to be 50 m based on the results of the non-uniform flow calculation applying the natural diversion method.

The river bed slope is topographically set at 1:6,000, which is equivalent to two times that of the planned one for the Itajai main stream.

In order to determine the side slopes of the floodway channel, the stability analysis was made on the most critical condition that the river channel becomes empty immediately after completion of the excavation work. The representative geotechnical values applied to the stability analysis is derived to be 10° for an internal friction angle and 1.8 t/m^2 for cohesion. As a result of the stability analysis, the excavation slope was decided to be 1:2.0 for which the minimum safety factor for sliding comes to around 1.2 as shown in Fig. VI.3.19. The levee with a trapezoid shape of 5 m in crest width and side slope of 1:3 is provided at the place which is 5 m apart from the edge of the side slope of the floodway for the long term plan. The crest elevation is determined keeping 0.5 m of freeboard against the design flood water level. General plan and longitudinal profile including typical cross section of the floodway plan thus designed are shown in Figs. VI.3.20 and VI.3.5, respectively.

It is anticipated to occur the erosion of river bed at the branch point of the Itajai main stream due to variation of river bed slope by the floodway plan. To protect the variation of the design river bed and side slope from erosion, a ground sill supported by concrete pile and protected by concrete blocks in its up and downstream portions is applied as shown in Fig. VI.3.21. The revetment comprising foot protection and wet masonry is provided on the side slope in this ground sill structure portions.

Besides, ground sill consisting of concrete placement and wet masonry for the slope, is provided at 5 km point from the outlet for maintenance of riverbed slope of 1:6,000 as shown in Fig. VI.3.22.

(2) Structural plan of related structures

Three bridges are planned to be newly provided crossing the floodway. Out of these three new bridges, two bridges named No.1 and No.2 bridges are designed applying the design standard for the national road class bridge. The No.1 and No.2 bridges are located at just upstream of the jetty at the outlet site for connecting the coastal road and at 0.35 km downstream of the inlet site for relocation of national road BR-470, respectively as shown in Fig. VI.3.20. Design concepts of these bridges are as follows;

a) The proposed No. 1 bridge, located just upstream of the jetty, has to be designed to have a length required to span the cross section of the floodway for the long-term plan (50-year probable flood).
With regard to the No. 2 bridge, the construction is divided into two stages in order to reduce the cost overburden in the provisional plan, that is, the bridge length is designed to meet the floodway width in the provisional plan. In the stage of the successive flood control plan (the mid-term plan, otherwise long-term plan), the bridge length will be extended to span the cross section of floodway for long-term plan. The bridge is aligned to cross a centerline of the floodway at an angle of 65° in accordance with the proposed relocation route of BR-470.

b) Freeboard of 0.5 m is secured between the lowest elevation of girder and design high water level corresponding to 50 year probable flood for the both bridges.

c) Both bridges are designed to be of prestressed concrete (PC) type. The substructures of the bridges are supported by reinforced concrete (RC) piles of 40 cm in diameter, which are driven to the rock zone or firm layer.

d) The bridge width is determined to be 9.8 m applying the design standard for the road bridge in Brazil, which consists of 7.2 m for roadway, and 0.9 m for sidewalk and 0.4 m for curb in both sides.

The structural design of the bridges thus performed is shown in Figs. VI.3.23 and VI.3.24.

Besides, a new bridge with effective width of 4 m is planned to be constructed at about 3.2 km downstream of the inlet site in order to link the central area of Navegantes and the rural area on the left bank side of the floodway, which is isolated from the Navegantes due to its construction.

Due to the construction of the floodway, relocation of BR-470 road is needed at two portions. They are about 900 m near the inlet portion and about 1,200 m between 4.5 km and 5.7 km stretch upstream of outlet of the floodway. The road to be relocated was designed under the same design criteria as applied to the existing BR-470 road. Typical cross section of the relocation road is shown in Fig. VI.3.25.

(3) Land acquisition and compensation

The compensation for lands and houses was contemplated for the long-term plan. Their quantities are preliminarily estimated as follows based on the topographical map and the field reconnaissance.

Item of compensation	Unit	Quantity
Land	km^2	1.8
House	Nos	59

3.6 Widening of Floodway Channel in the Mid-Term and Long-Term Plans

The floodway channel with a riverbed width of 50 m, formulated for the provisional flood control plan, is planned to be widened to 85 m and 135 m in the mid-term and long-term plans, respectively as shown in Fig. VI.3.5, except for the upstream inlet portion and downstream outlet (jetty) portion. As well, such related structures on the floodway as ground sill, bridge and slope protection which are proposed in the provisional plan, have to be extended to the required widths for mid-term and long-term plans. Main work items and quantities for the mid-term and long-term plans are described in Chapter 4 of ANNEX VIII, CONSTRUCTION PLAN AND COST ESTIMATE.

4. DRAINAGE PLAN IN ITAJAI AND NAVEGANTES CITIES

4.1 General

It is intended by the flood control plan to protect the residential areas in the Itajai city in the right bank of the Itajai river and those of Navegantes city located in the left bank of the river by means of the construction of floodway and improvement works for the Itajai river and its tributaries. After the implementation of the proposed flood control plan, present drainage condition will be remarkably improved since the river water level is lowered by the river improvement works. However, depression areas along the Itajai river and Itajai Mirim river that are lower than the design high water level would be still in inundating conditions due to inland water caused by rainstorm as shown in Fig. VI.4.1.

In this study, the existing drainage system for these areas was investigated. Based on the investigation results, an internal water drainage plan including combinations of various drainage facilities such as regulating pond, pumping stations, gates, heightening of low elevation area and levee is studied based on the topographic map of 1 to 5,000.

4.2 Existing Urban Drainage System

4.2.1 Existing urban drainage system

The existing main drainage channels and drainpipes in the Itajai city which are led directly into the Itajai main stream, Itajai Mirim river and Murta river, and a small tributary of the Itajai river, are shown in Fig. VI.4.2. This Figure shows that the drainage system in the Itajai city is in well arranged condition.

The diameter of the drainage pipes ranges from 30 cm to 100 cm. The drainage system has been expanded in accordance with the development of the residential area, but it is found that a part of the drainage pipe is not connected with the Murta river.

There are no systematic urban drainage networks in Navegantes located on the left bank of the Itajai river.

On the basis of the field reconnaissance and data collected from the city authorities concerned, the locations of existing channels and drainpipes for the urban drainage in Itajai city were clarified as shown in Fig. VI.4.2.

4.2.2 Previous study on urban drainage system

The drainage plan in the Itajai city was prepared by DNOS. This plan is a revised plan of that prepared in 1963 (its details are unknown). In the revised plan, the central section of Itajai city was divided into 10 drainage basins referring to the basin division of the 1963's plan directed by the Itajai city office and the topographic conditions. It is contemplated in this plan to drain rainwater to the Itajai Mirim river or Itajai river directly or indirectly. No urban drainage plan has been prepared for Navegantes city.

4.3 Present Situation of the Envisaged Drainage Districts

The study area for the urban drainage plan covers a part of Itajai and Navegantes cities that are lower than the design high water level in the Itajai river even after the completion of the river improvement work and construction of the selected floodway.

The study area was divided into nineteen drainage districts taking into consideration the topographic condition and existing drainage network. The divided drainage districts are as shown in Fig. VI.4.3.

4.3.1 Drainage district along right bank of Itajai river

The internal water drainage plan for the area along the right bank of the Itajai river is divided into the following six districts as shown in Fig. VI.4.3. Present situation of the respective drainage districts is as follows;

(1) Drainage District IR-1

Drainage district IR-1 is located on both banks of the Schneider river, which flows into the Itajai river on the right bank close to the river mouth. A catchment area of the district is 4.65 km^2, out of which the mountainous area occupies 3.47 km^2. In this district, the drainage area lower than the design high water level of the Itajai river commands only around 9 ha, which spreads along the downstream reach of the Schneider river. The lowest ground elevation of the residential area is around 1.2 m against the design high water level of around El. 1.4 m for 10-year probable flood.

(2) Drainage district IR-2

Drainage district IR-2 is located upstream of the aforesaid IR-1. Its catchment area is around 1.8 km^2 and the lowest ground elevation is around 1.2 m. In this drainage district, most of the lands are utilized for the residential area. Rainwater in the district is being drained to the Itajai river through the existing three drainpipes.

(3) Drainage district IR-3

Drainage district IR-3 covering a catchment area of 0.74 km^2 is located upstream of the aforesaid IR-2. Of the catchment area, around 0.69 km^2 is developed as a city area. The ground elevation is in a range of 1.2 m to 3.5 m. Although the drainage work in this district is being conducted by the existing five drainpipes, the city authority has a plan to install a new drain channel to remedy insufficient capacity of the existing system.

(4) Drainage district IR-4

Drainage district IR-4 is located in the area immediately downstream of the confluence of the Itajai river and Itajai Mirim river. The drainage district is located in the low lying area inside a large curved section of the Itajai river. It is bounded by the river and Leodegario Pedro street. The drainage area lower than the design high water level of the Itajai river is approximately 1.13 km^2 of flat land. Its elevation is in a range of 1.0 to 3.0 m above sea level and the area is occupied by wasteland or woodland where the elevation is lower than 1.5 m. The remaining 0.95 km^2 of land is residential area. Rainwater in this district drains directly into the Itajai river through two small channels.

(5) Drainage district IR-5

Drainage district IR-5 is located at the confluence of the Itajai main stream and Itajai Mirim river, and the drainage area is as small as 0.12 km^2. The lowest ground elevation in this district is around 1.8 m, which is lower than the design high water level of the Itajai river. Rainwater in this district is drained into the Itajai main stream through the existing two drainpipes.

(6) Drainage District IR-6

Drainage district IR-6 consists of the low land area located along the Murta river, a small tributary of the Itajai river, which joins the Itajai river at a point approximately 9.2 km upstream from its mouth. This district occupies a catchment area of approximately 13.7 km^2 of which 11.41 km^2 is either wasteland or woodland, and the remaining 2.53 km^2 is residential area. There are some houses in this district, which were built on land of only 0.5 m above the sea level. This area suffers from flood damage most frequently. The drainage area lower than the design high water level of the Itajai river occupies approximately 4.32 km^2 which accounts for 31.5% of the drainage district. The Murta river has 10 m in width and 5 m in depth in the downstream reach, while 6 m in width and 3 m in depth in the neighborhood of the BR-101 national road. Its river slope is approximated to be 1:12,000, which is almost equal to that of the Itajai main stream.

The present land use in the area upstream of the Reinaldo Schimithusen street is largely classified into the city area, industrial area and undeveloped area. The outflow from the undeveloped area including a part of the industrial area is drained into the downstream reach through a drainpipe of 800 mm in diameter. However, because of insufficient capacity of the existing drainage system, the upstream undeveloped area has suffered from inundation even for a small amount of rainfall.

4.3.2 Drainage district along the left bank of Itajai river

The drainage area located on the left bank of the Itajai river is divided into three districts, namely IL-1, IL-2 and IL-3 as shown in Fig. VI.4.3. The districts are situated inside the large curved section of the meandered Itajai river. Most of the land in the district is utilized for pasture and paddy field and there are no houses in the low land area. It will be contemplated to fill up the low areas with the earth material to be produced from the excavation of the river channel.

4.3.3 Drainage basin along the Itajai Mirim river

The drainage basin along the Itajai Mirim river is divided into ten districts as stated in the followings;

(1) Drainage district IM-1

Drainage district IM-1 is located on the right bank close to the confluence with the Itajai main stream. It has a catchment area of 0.13 km^2 and is enclosed by a large meander of the Itajai Mirim river. The lowest ground elevation in this district is around 1.7 m, which is lower than the design high water level of the Itajai river by around 1.0 m. The drainage area lower than the design high water level occupies around 0.12 km^2, which is almost equal to the catchment area. Rainwater in this district is drained into the Itajai Mirim river by the existing drainpipe of 500 mm in diameter, which is laid along the David street in the center of the area.

(2) Drainage district IM-2

Drainage District IM-2 is situated on the right bank of the Itajai Mirim river close to the confluence with its short-cut channel. Its catchment area is 0.31 km^2, out of which the land area lower than the design high water level accounts for 0.22 km^2. A difference between the ground elevation and design high water level is approximately 0.5 m at the maximum. The city area occupies 0.17 km^2 or 75% of the drainage area. The remaining area consists of low land utilized for pasture and woodland. The internal rainstorm water in the district is drained into the Itajai Mirim river through the existing two drainpipes.

(3) Drainage district IM-3

A catchment area of drainage district IM-3 located upstream of the aforesaid IM-2 is as quite small as 0.13 km^2. Of the catchment area, the drainage area lower than the design high water level is only 0.06 km^2, which consists of a city area with the maximum difference of 0.6 m in elevation against the design high water level. Rainwater in this district is drained into the Itajai Mirim river through the existing three drainpipes of 300 mm in diameter.

(4) Drainage district IM-4

This district is located on the right bank of the river from the confluence point. A catchment area of the district is as small as approximately 0.1 km^2. The residential area is developed on the lands higher than 3.0 m above sea level. Areas along the river that are 1.5 to 3.0 m above sea level are utilized as pasture.

(5) Drainage district IM-5

This drainage district is located immediately upstream of IM-4. It has an area of approximately 0.77 km^2 of which about 0.68 km^2 is residential area and about 0.1 km^2 is unused area. The ground elevation of the river side residential area is around 2 m, which is lower than the design high water level of about 2.6 m. The drainage area lower than the design high water level is around 0.13 km^2. The drainage in this district is conducted using the existing two drainpipes of 1,000 mm in diameter, which is connected to the Itajai Mirim river at upstream of a bridge on the Adolfo Konder street.

(6) Drainage district IM-6

Drainage district IM-6 is located upstream of IM-5 along a tributary of the Itajai Mirim river. It has a catchment area of approximately 1.17 km^2 which is divided into residential area of about 0.52 km^2, hilly area of 0.32 km^2 and grassland of 0.33 km^2.

The drainage area lower than the design high water level of the Itajai Mirim river is 0.37 km^2. Residential areas occupy about 0.16 km^2 or about 42% of the drainage area. The rainwater in this district drains through a 5.5 m wide channel constructed in 1983. However, due to its insufficient capacity and the effects of the back water of the Itajai Mirim river, the district frequently suffers from flood damage. During 1984 flooding periods, most of the residential areas were inundated to a depth of 2 to 3 m from the ground.

(7) Drainage district IM-7

Drainage district IM-7 is located along the large curved section of the Itajai Mirim river. It has a drainage area of approximately 4.01 km^2. Most of the flood areas in the district are used for athletic grounds, such as soccer fields, or simply remain as pasture. Behind the district there is a hilly area. The rainwater in this district runs off into a small tributary of 5 m in width and 3 m in depth that connects with the Itajai Mirim river at a point 4.86 km upstream of the confluence with the Itajai river. In the upstream area of the small tributary, the residential areas are being developed. An artificial channel having a dimension of 5 m wide and 2 m deep has been provided to cope with requirement of the drainage in the upstream area including the hills. The channel is connected with two lanes drainpipes of 1,000 mm in diameter in the Ferra Antigo Leito street and then to the downstream channel.

(8) Drainage district IM-8

Drainage district IM-8 is located upstream of IM-7. The district is located at the place where the Itajai Mirim river runs closest to a hill. The catchment area is about 1.37 km^2 of which 0.70 km^2 is hilly and the remaining 0.67 km^2 is lowland consisting of a residential area and the flood prone area.

The area along the Ferrea Antigo Leito street passing through the district has been elevated by around 2 m through the recent road improvement. Consequently, there is no possibility of inundation due to the influence of back water of the Itajai Mirim river.

(9) Drainage district IM-9

Drainage district IM-9 is located on the left bank of the Itajai Mirim river. It is just opposite side of the river stretch for IM-5 and IM-6. The catchment area is 1.47 km^2 of which 0.51 km^2 is hilly area. The ground is low and flat and is about 1.0 to 2.5 m above sea level.

Most of the drainage district is lower than the design high water level of the Itajai Mirim river. The residential area occupies about 0.35 km^2 or about 24 % of the district catchment area.

(10) Drainage district IM-10

Drainage district IM-10 is located upstream of IM-9. The district is bounded by the BR-101 national road to the west. The district has an area of approximately 3.74 km^2, most of which is a flood prone area covered with grass and trees. The house yard that was recently developed in the central part of the district has an area of approximately 0.13 km^2 with an elevation of about 3.0 m above sea level.

4.4 Conceived Internal Storm Water Measures

Several internal storm water treatment methods to be applied to the study area are studied, and the proposed method for each drainage district are summarized in Table VI.4.1.

4.4.1 Principles of the internal storm water treatment measures

In order to set up an adequate internal storm water treatment plan, the topographic conditions of the drainage basin, the effective utilization of existing drainage systems and the problems relating to the existing drainage systems have to be taken into consideration.

The major principles of the planning considering the above-mentioned matters are as follows:

(1) Drainage method

A gravity flow type is applied for the drainage method from the internal storm water basins. Flap gates should be installed at each of end of the drainage channels to prevent back flow from the river. In areas where gravity flow drainage is impossible, mechanical drainage consisting of pumping should be adopted to solve the internal water problems.

(2) Installation of regulating ponds

In the areas where drainage pumping is adopted, regulating ponds having capacities as large as possible should be installed to reduce the peak runoff from the drainage basin. In order to achieve higher flood control effects, regulating ponds should be selected at locations as close as possible to drainage channel ends.

(3) Integration of drainage

Construction, operation and maintenance costs for the pump drainage method are generally costly. Therefore, neighboring drainage basins should be integrated into each other to reduce the number of pumping stations as well as to minimize the capacities of the pumps.

(4) Reformation of habitual flooding area

In such drainage districts as IL-1 to -3, IM-4 and IM-10 where they are low land and there are only a few houses, internal storm water problems will be solved by filling the low land areas with earth materials to be produced from excavation of the river channels. In the low lands where there are many houses, levees will be built to protect them from flooding.

(5) Planning scope

The drainage facilities contemplated in this internal storm water treatment plan will be regulating ponds, pumping station, culverts, gates and channels for connection to existing drainage channels. Improvement work of existing drainage channels will not be included in this plan.

4.4.2 Design of drainage facilities

The design of urban drainage facilities such as regulating pond, pumping station, drainpipe connecting the existing one and the regulating pond is made under the following design conditions;

(1) Probable flood hydrograph and its volume to design the capacity of pump and regulating pond is simulated by the rational formula using the probable 4-day rainfall of

210 mm corresponding to 10-year probable rainfall at Itajai, and actual hourly rainfall distribution records on August 1984 flood.

(2) Probable flood peak discharges for design of drainage channel are estimated by the rational formula incorporating the following probable rainfall intensity-duration curve of 10-year probability, which was established in the feasibility study on the river improvement project in Blumenau-Gaspar stretch on the basis of the rainfall records for 22 years from 1935 to 1984 and Pearson III type distribution method.

A 10-year probable rainfall intensity-duration curve is derived as follows ;

$$I_{10\text{-year}} = 5.859/(t + 34)$$

where, $I_{10\text{-year}}$: 10-year probable rainfall intensity (mm/hour)

t : Duration (minute)

(3) In order to evaluate the increase in discharge due to the urbanization and development of Itajai city, runoff coefficient in future stage is estimated on the basis of the future land use map planned by the municipal government of Itajai city applying the following runoff coefficient classified by land use category in Japan;

- City area : 0.9
- Farm, pasture and unused lands : 0.6
- Forest area : 0.7

The runoff coefficient for the whole basin is estimated by weighted average method.

(4) Design high water level in the regulating pond is set to be the average ground elevation at the pond site and pump capacity is designed so as to keep the pond water level equal to or less than the design high water level assuming that water level of the main Itajai river is at the design high water level, since high flood water level in the Itajai river continues for around 4 days in normal condition.

(5) Connecting pipe to the pond is designed so as to flow the 10-year probable flood peak discharge from drainage district.

(6) Small drainage area subject to relatively shallow inundation depth is protected from the inflow of outer water by constructing levees with flap gates around them.

(7) The method of installing pump and regulating pond should be adopted for large drainage areas subject to inundation depth of more than one meter.

The capacity of the regulating pond and pump capacity are estimated by the procedure illustrated in Fig. VI.4.4. As seen in the Figure, the 10-year probable rainfall distribution derived based on actual one during flood in 1984 is converted into flood hydrograph by the rational formula using the estimated runoff coefficient and then mass curve is prepared from the simulated flood hydrograph. Based on the mass curve prepared, the required pump capacity is determined from the maximum pond volume determined from topographic and land use conditions.

Features of the regulating pond, pump and gates designed in accordance with the design condition and procedure are shown in Table VI.4.2. The proposed facilities comprise 4 regulating ponds, 4 pump stations and 18 flap gates. General plan of the drainage facilities and details of the ponds with the related facilities are given in Figs. VI.4.5 to VI.4.16. The drainage method in the respective drainage districts is presented as follows;

(1) Drainage district IR-1

Since majority of the area are occupied by unused area with low elevation along the Schneider river, filling up of the land is planned to prevent the flooding due to back water of the Itajai main stream.

(2) Drainage districts IR-2, IR-3, IR-5, IM-1, IM-2, IM-3 and IM-5

These districts have a remarkably small depression area of less than 0.2 km^2. A flap gate will be installed at the outlets of the existing drainage system.

(3) Drainage district IR-4

It has been planned that majority of the depression areas along the Itajai river in this district are developed as industrial area but it is still in unused conditions due to habitual inundation. The remaining area is occupied by the residential area with low elevation. It is planned to fill up this depression area up to the design high water level. Since the majority of the houses in the residential area are of high floor type with about 0.5 m in height, it is planned to fill up to about 0.5 m to avoid shifting of houses and to provide the regulating pond and pump station.

(4) Drainage district IR-6

It has been planned by Itajai municipality that the depression area along the Itajai river in this district is developed as residential and industrial areas. To meet this requirement, it is planned to fill up to more than design high water level. Since the remaining area is occupied by the residential area of about 0.5 m high floor type houses, it is planned to fill up to about 0.5 m and to provide the regulating pond and pump station.

(5) Drainage districts IL-1, IL-2, IL-3, IM-4 and IM-10

Since there are no houses in these districts, only the filling up of the land up to the design high water level is planned. However, earth filling for IM-10 should be carried out in the future stage when the area is developed, since the earth material to meet the requirement is not sufficiently available.

(6) Drainage districts IM-6 and IM-7

The hinterland of these districts forms mountainous areas. The rainwater from these mountainous areas is planned to be drained directly to the Itajai Mirim river by providing new drainage channel along the boundary zone between IM-7 and IM-8. The drainage in the remaining area is planned to be performed by providing the regulating pond and pump station.

(7) Drainage district IM-8

The low land in this district will be filled up since there are no houses. However, this earth filling will be performed in the future stage when the area is developed since earth material for filling up is not sufficiently available. The hinterland in this district is the mountainous area and rainwater from this area is planned to be drained directly to the Itajai Mirim river by providing new canal.

(8) Drainage district IM-9

This district will be topographically divided into two zones. Rainwater in the western part of this district is drained directly to the Itajai Mirim river by providing new canal. The drainage in the remaining area is planned to be made by providing the regulating pond and pumping station.

Tables

Table VI.2.1 EXISTING RIVER STRUCTURES AND RELATED STRUCTURES (1/2)

(1) Bridge

No.	Name	Location Distance from River Mouth/ Confluence (km)	Admini-strative Office	Classifi-cation	Features: Bridge Length (m)	Nos. of Span	Longest Span Length (m)	Width (m)	Lowest El. of Girder (m)	El. of Surface (m)	Type of Bridge	Water Supply Pipe Attached to Bridge
-	Itajai River											
1.	BR 101	18.50	DER	Road	472.00	25	19.00	8.00	4.00	5.50	Concrete	
-	Ribeirao da Murta											
2.	Eugenio Pezzini 1	0.10	Itajai city	Road	10.00	1	10.00	9.30	-	-	Composite	150 mm PVC
3.	Eugenio Pezzini 2	0.40	Itajai city	Road	10.00	1	10.00	3.90	-	2.90	Composite	140 mm PVC
-	Itajai Mirim River											
4.	Marcos Konder	0.22	Itajai city	Road	91.50	3	27.00	13.15	3.10	5.10	Concrete	450 mm DN & 250 mm PVC
5.	Nova Brasilia	1.06	Itajai city	Road	45.90	3	16.00	7.85	1.82	3.02	Concrete	180 mm PVC
6.	Sao Vicente	3.07	Itajai city	Road	52.00	3	28.00	11.10	2.30	3.80	Concrete	
7.	Adolfo Konder	4.55	Itajai city	Road	131.00	4	35.50	13.40	1.80	3.80	Concrete	300 mm DN
8.	Werner	9.61	Itajai city	Road	48.50	3	19.00	6.00	3.50	4.50	Concrete	250 mm PVC
9.	BR 101	11.04	DER	Road	70.00	3	20.00	10.04	4.35	6.40	Concrete	
-	Itajai Mirim Short-cut Channel											
10.	Tancredo Neves	1.48	Itajai city	Road	77.90	3	25.00	12.05	4.10	6.10	Composite	
11.	BR 101	4.00	DER	Road	147.23	4	36.85	9.70	4.30	6.40	Concrete	
-	Canhanduba River											
12.	Antiga Estrada de Brusque	0.10	Itajai city	Road		- missing -						
13.	Jose Gall	0.27	Itajai city	Road	45.00	3	15.00	9.00	-	2.20	Concrete	
14.	BR 101	0.60	DER	Road	83.00	3	20.00	10.04	4.30	6.40	Concrete	
-	Picarras River											
15.	Irineu Bohnhausen	0.40	Picarras city	Road	56.30	4	14.00	10.50	5.60	7.00	Concrete	300 mm PVC
-	Lagoa do Furado River											
16.	Ludgerio Caetano Vieira	0.50	Picarras city	Road	29.00	6	5.25	5.00	3.00	3.40	Concrete	
17.	BR 101	2.60	DER	Road	30.00	3	20.00	8.30	2.90	4.80	Concrete	

Note; Numbers in this table correspond to those in Fig. VI.2.5.

Table VI.2.1 EXISTING RIVER STRUCTURES AND RELATED STRUCTURES (2/2)

(2) Pump Station for Municipal Water Supply

No.	Location: Distance from River-Mouth/Confluence (km)	Left/Right Bank	Administrative Office	Nos. of Pump	Intake Discharge (l/s)
- Itajai Mirim Short-cut Channel					
1.	4.50	L	CASAN	2	560
- Canhanduba River					
2.	0.37	R	CASAN	2	150

(3) Irrigation Water Use

No.	Location: Distance from River Mouth/Confluence (km)	Left/Right Bank	Pump Capacity (l/sec)	Irrigation Area (ha)
-Itajai River				
1.	15.20	R	50	12.0
2.	15.51	L	50	12.0
3.	15.85	L	50	8.0
4.	16.30	L	50	13.0
5.	16.30	L	30	9.0
6.	16.30	L	30	9.0
7.	16.85	L	30	10.0
8.	17.13	R	30	10.0
9.	17.43	L	50	13.5
10.	17.43	L	40	10.0
11.	17.71	L	30	12.0
12.	17.71	L	50	6.0
13.	17.99	L	25	4.0

(4) River Crossing of Water Supply Pipe

No.	Location: Distance from River Mouth/Confluence (km)	Administrative Office	Diameter (mm)	Length (m)
- Itajai River				
1.	6.05	CASAN	250	250
2.	6.76	CASAN	200	300
-Itajai Mirim Short-cut Channel				
3.	3.11	CASAN	400	78

Note : Numbers in this table correspond to those in Fig. VI.2.5.

Table VI.3.1 REQUIRED WIDTH OF FLOODWAY CHANNEL AND WATER LEVEL AT BRANCHING POINT FOR ALTERNATIVE CASE

(1) Floodway-I

Design Discharge (cu.m/sec)		Required Riverbed Width (m)	Water Level at Branch Point (EL.m)	Flow Velocity (m/sec)	
Main Stream	Floodway			Main Stream	Floodway
1,000	5,030	900	1.27	0.1-0.6	0.5-0.6
2,000	4,030	315	2.09	0.6-1.0	1.2-1.4
3,000	3,030	140	3.29	1.0-1.6	1.8-1.9
4,000	2,030	60	4.54	1.3-2.1	2.1-2.4
5,000	1,030	15	5.75	1.6-2.6	2.0-2.7

(2) Floodway-II

Design Discharge (cu.m/sec)		Required Riverbed Width (m)	Water Level at Branch Point (EL.m)	Flow Velocity (m/sec)	
Main Stream	Floodway			Main Stream	Floodway
1,000	5,030	890	1.27	0.1-0.6	0.5-0.7
2,000	4,030	310	2.04	0.6-1.0	1.2-1.4
3,000	3,030	135	3.18	1.0-1.6	1.9-2.0
4,000	2,030	60	4.38	1.3-2.1	2.0-2.5
5,000	1,030	15	5.55	1.6-2.6	2.0-2.8

(3) Floodway-III

Design Discharge (cu.m/sec)		Required Riverbed Width (m)	Water Level at Branch Point (EL.m)	Flow Velocity (m/sec)		
Main Stream	Floodway			Main Stream Down /1	Main Stream Up /2	Floodway
1,000	5,030	15	4.52	0.1-0.6	2.1-2.7	0.6-0.7
2,000	4,030	60	3.59	0.6-1.0	2.1-2.5	1.2-1.4
3,000	3,030	130	2.68	1.0-1.6	2.0-2.3	1.9-2.0
4,000	2,030	280	1.86	1.3-2.1	1.9-2.1	2.2-2.5
5,000	1,030	800	1.27	1.6-2.6	1.8-1.9	2.1-2.7

Remark :
/1 : Downstream of the branching point of floodway
/2 : Upstream of the branching point of floodway

Table VI.3.2 RISE OF WATER LEVEL AT GASPAR AND ILHOTA DUE TO ENHANCEMENT OF PRESENT FLOW CAPACITY IN THE PREOJECT RIVER STRETCH

(1) Floodway-I

Design Discharge (cms)	Water Level (EL.m) at		
	Upstream end of Protection Area	Ilhota	Gaspar
1,000	1.65	6.50	9.20
2,000	2.33	6.50	9.20
3,000	3.50	6.56	9.20
4,000	4.75	7.00	9.34
5,000	6.12	7.50	9.55

(2) Floodway-II

Design Discharge (cms)	Water Level (EL.m) at		
	Upstream end of Protection Area	Ilhota	Gaspar
1,000	2.21	6.50	9.20
2,000	2.77	6.51	9.20
3,000	3.52	6.60	9.22
4,000	4.65	6.95	9.28
5,000	5.85	7.43	9.50

(3) Floodway-III

Design Discharge (cms)	Water Level (EL.m) at		
	Upstream end of Protection Area	Ilhota	Gaspar
1,000	3.90	6.63	9.24
2,000	4.10	6.75	9.27
3,000	4.52	6.87	9.29
4,000	5.10	7.08	9.40
5,000	5.80	7.43	9.50

Table VI.3.3 SUMMARY OF CONSTRUCTION COST
FOR ALTERNATIVE CASES OF FLOODWAYS-I AND II
(EXCLUDING COST FOR URBAN DRAINAGE WORK)

(Unit: US$ thousand)

Component	Design Flood Discharge (cms) *					
	Floodway I			Floodway II		
	1,000	2,000	3,000	1,000	2,000	3,000
1. Itajai River	20,119	21,762	26,431	20,062	21,622	25,458
2. Floodway	2,300,682	177,873	89,719	327,575	123,981	66,045
3. Itajai Mirim River	8,169	8,526	9,069	8,169	8,526	9,069
4. Itajai Mirim Short-cut Channel	2,253	2,348	2,584	2,253	2,348	2,584
5. Picarras River	1,211	1,286	1,437	-	-	-
Total	2,332,434	211,795	129,240	358,059	156,477	103,156

Note: * Design flood discharge in Itajai river downstream of confluence with Itajai Mirim river

Table VI.3.4 SUMMARY OF CONSTRUCTION COST
FOR FLOODWAY-III WITH SHORT-CUT CHANNEL

(Unit: US$ thousand)

Component	Design Flood Discharge (cms) * 3,000
1. Itajai River	26,476
2. Floodway	54,176
3. Itajai Mirim River	9,069
4. Itajai Mirim Short-cut Channel	2,584
5. Short-cut Channel	13,151
Total	105,456

Note : * Design flood discharge in Itajai river downstream of confluence with Itajai Mirim river

Table VI.3.5 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 portions 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 Bridge	2,100 m/3 New Bridge	Nil/3 New Bridge
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 m3/sec for every alternative Floodway route.
2. /1 ; excludes the cost for the urban drainage works.

Table VI.4.1 CONCEIVED INTERNAL WATER TREATMENT METHOD FOR DEPRESSION AREAS

District	Catchment Area (km^2)	Area Lower than R.D.H.W.L. (1) (km^2)	Residential of (1)		Conceived Internal Water Treatment Method
			Area (km^2)	Max. Inundation depth (m)	
IR-1	4.65	0.09	0.07	0.3	Levee construction along the Shneider river
IR-2	1.80	0.21	0.19	0.3	Installation of flap gate at outlet of drainpipe
IR-3	0.74	0.21	0.18	0.4	- do -
IR-4	1.13	0.73	0.21	1.2	Filling of low elevation area with excavated material/Installation of flap gate, regulating pond and pump
IR-5	0.12	0.07	0.04	1.6	Installation of flap gate at outlet of drainpipe
IR-6	13.70	4.32	0.98	2.8	Filling of low elevation area with excavated material/Installation of regulating pond and pump
IL-1	0.88	0.57	-	-	Filling of low elevation area with excavated material
IL-2	3.62	0.63	-	-	- do -
IL-3	4.04	2.67	-	-	- do -
IM-1	0.13	0.12	0.11	0.9	Installation of flap gate at outlet of drainpipe
IM-2	O.31	0.22	0.17	0.5	- do -
IM-3	0.13	0.06	0.05	0.6	- do -
IM-4	0.10	0.08	-	-	Filling of low elevation area with excavated material
IM-5	0.77	0.13	0.09	0.2	Installation of flap gate at outlet of drainpipe
IM-6	1.17	0.37	0.16	0.7	Diversion of excess water into IM-7 basin area
IM-7	4.01	0.78	0.25	0.7	Separation of outflow from hilly and that from urban area/Installation of regulating pond/Pump in short-cut portion of the Itajai Mirim
IM-8	1.37	0.5	0.06	1.0	Separation of outflow from hilly area and that from urban area/Filling of law-land with excavated materials
IM-9	1.47	0.51	0.18	1.0	Separation of outflow from area of ADOLFO KONDER STREET/Installation of regulating pond and pump
IM-10	3.74	0.56	-	-	Filling of low elevation area with excavated material

Note: R.D.H.W.L. means the river's design high water level.

Table VI.4.2 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) Pump 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 VI.4.2 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

Figures

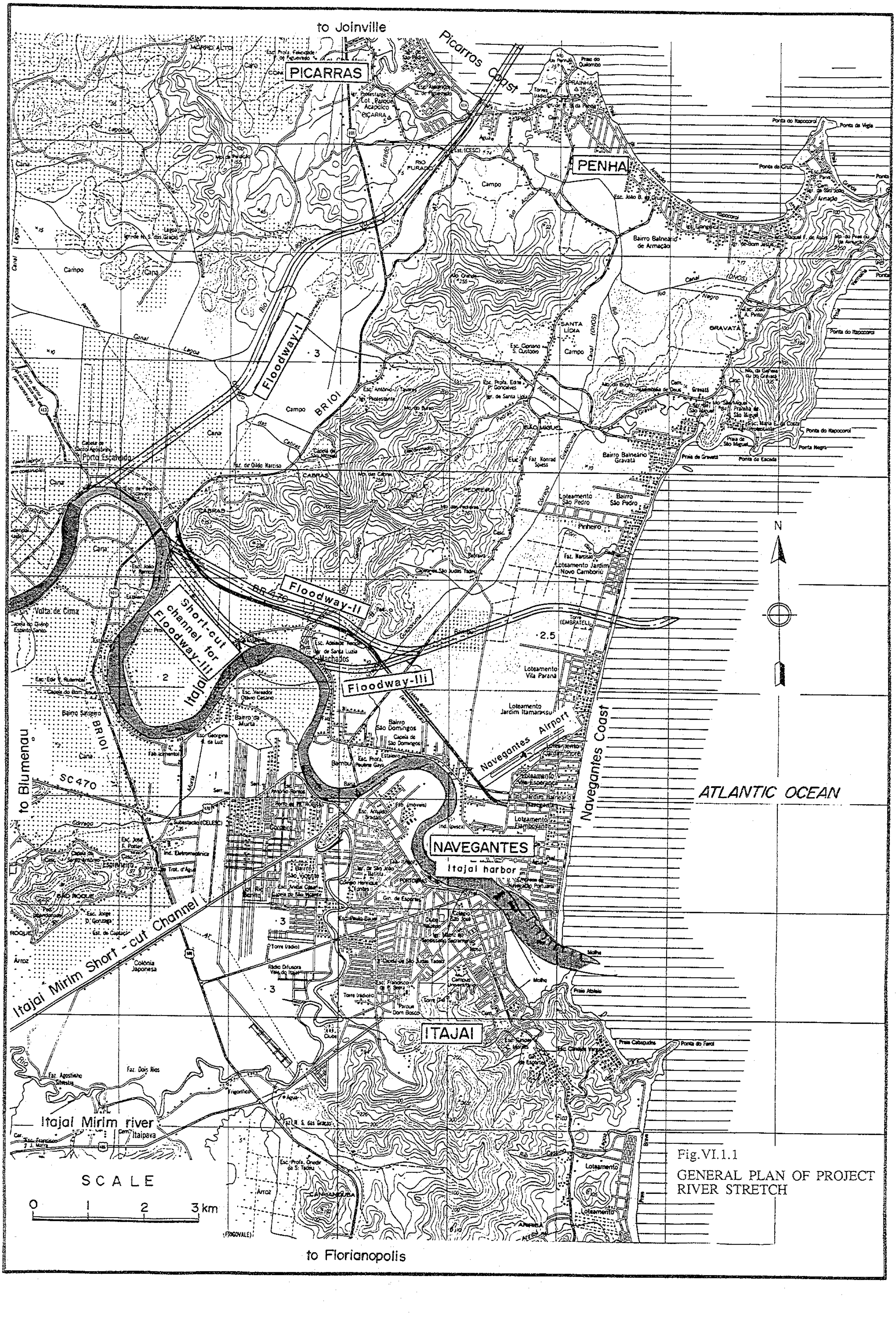


Fig.VI.1.1
GENERAL PLAN OF PROJECT RIVER STRETCH

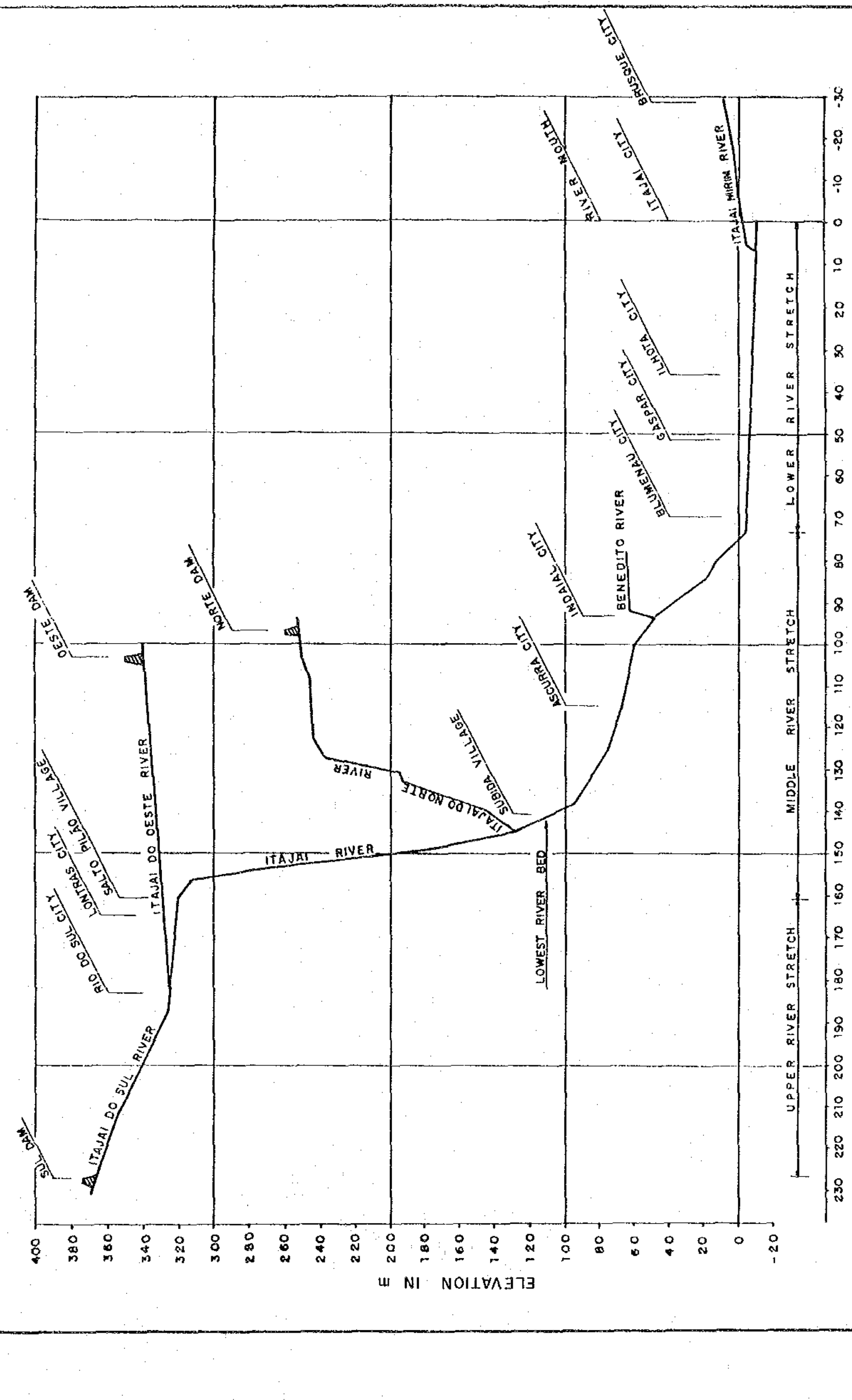


Fig.VI.2.1 LONGITUDINAL PROFILE OF ITAJAI RIVER AND ITS TRIBUTARIES

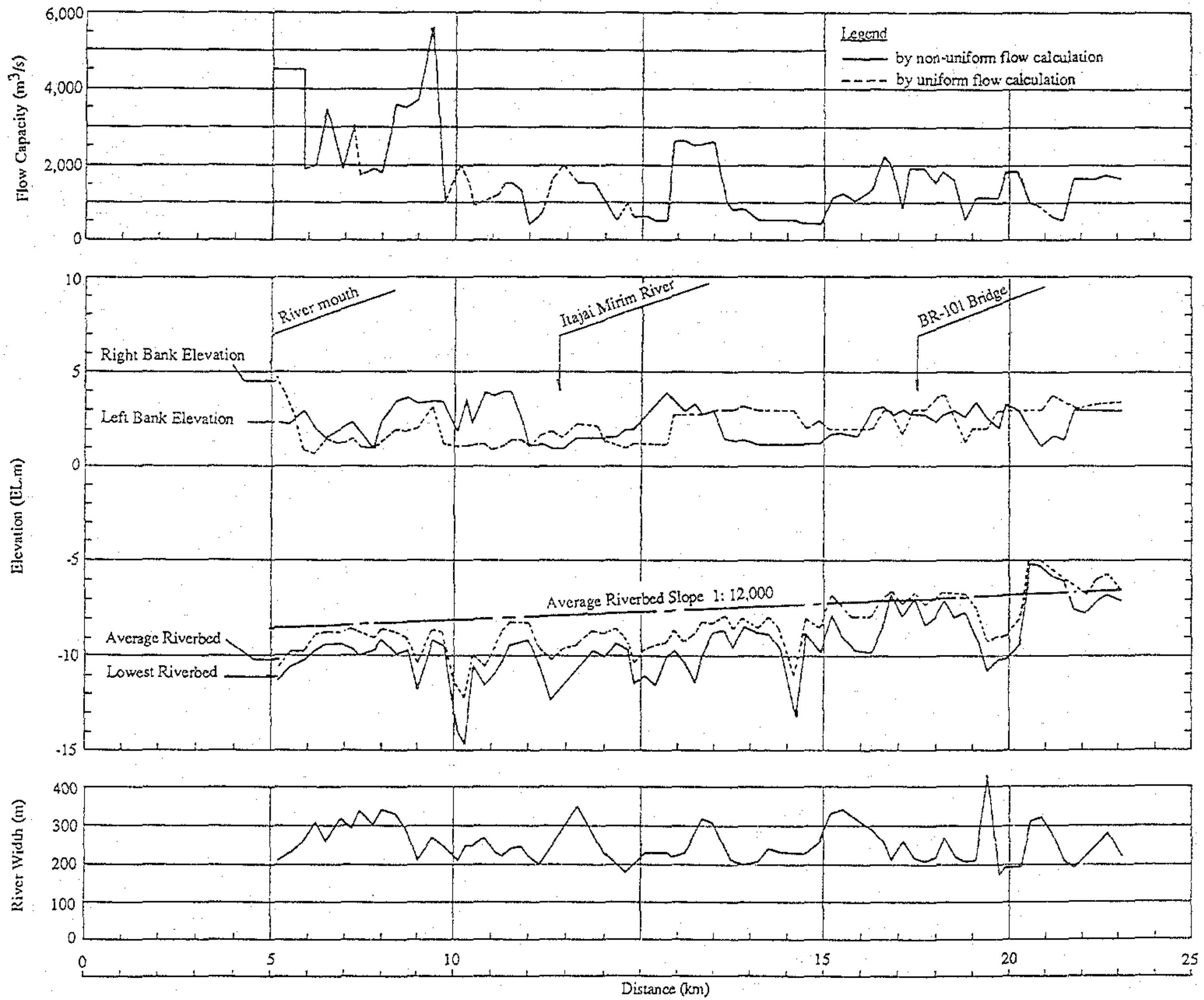


Fig.VI.2.2 CHARACTERISTICS OF PROJECT STRETCH OF THE ITAJAI RIVER

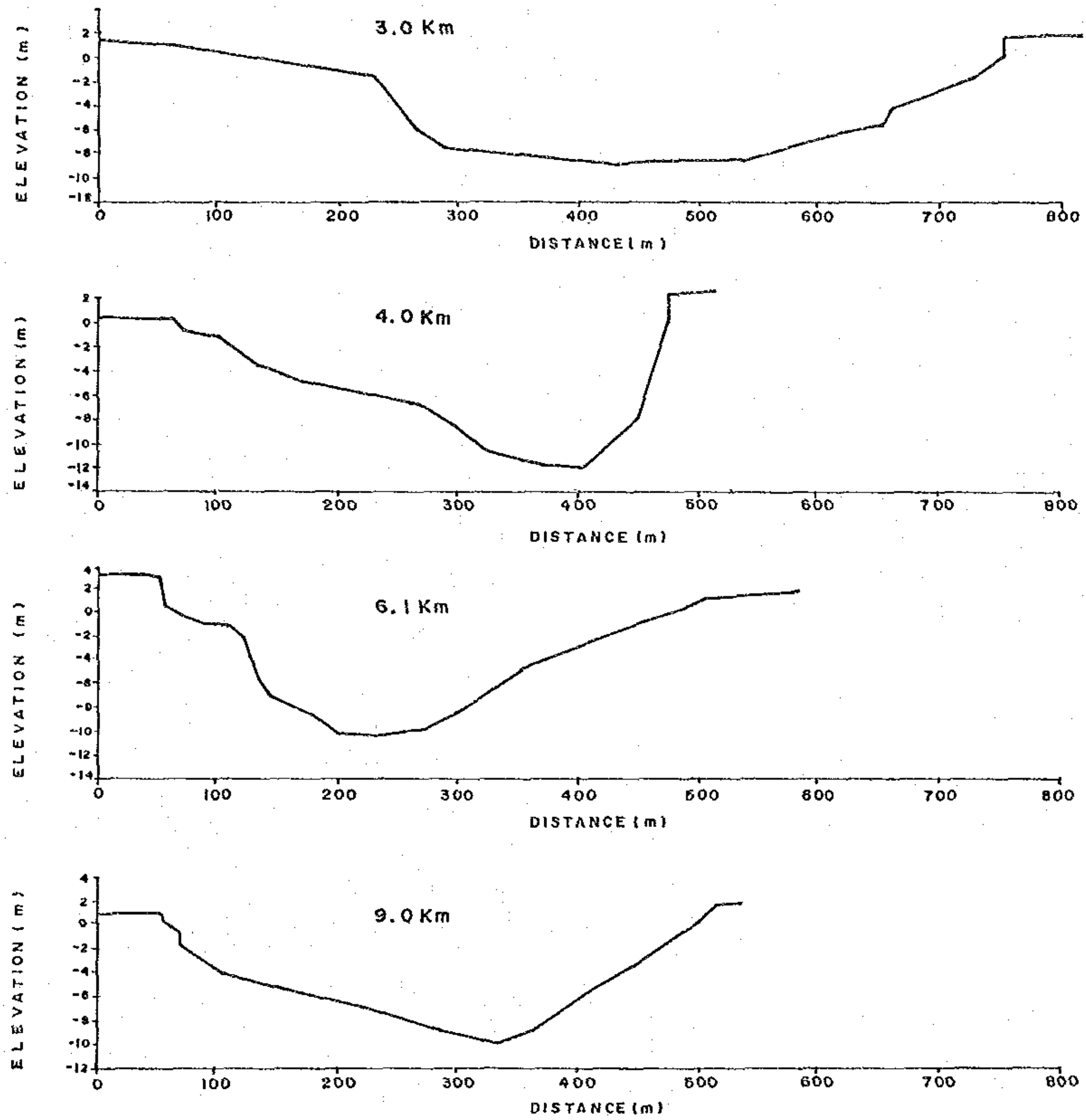


Fig.VI.2.3 CROSS SECTION OF ITAJAI RIVER (1/2)

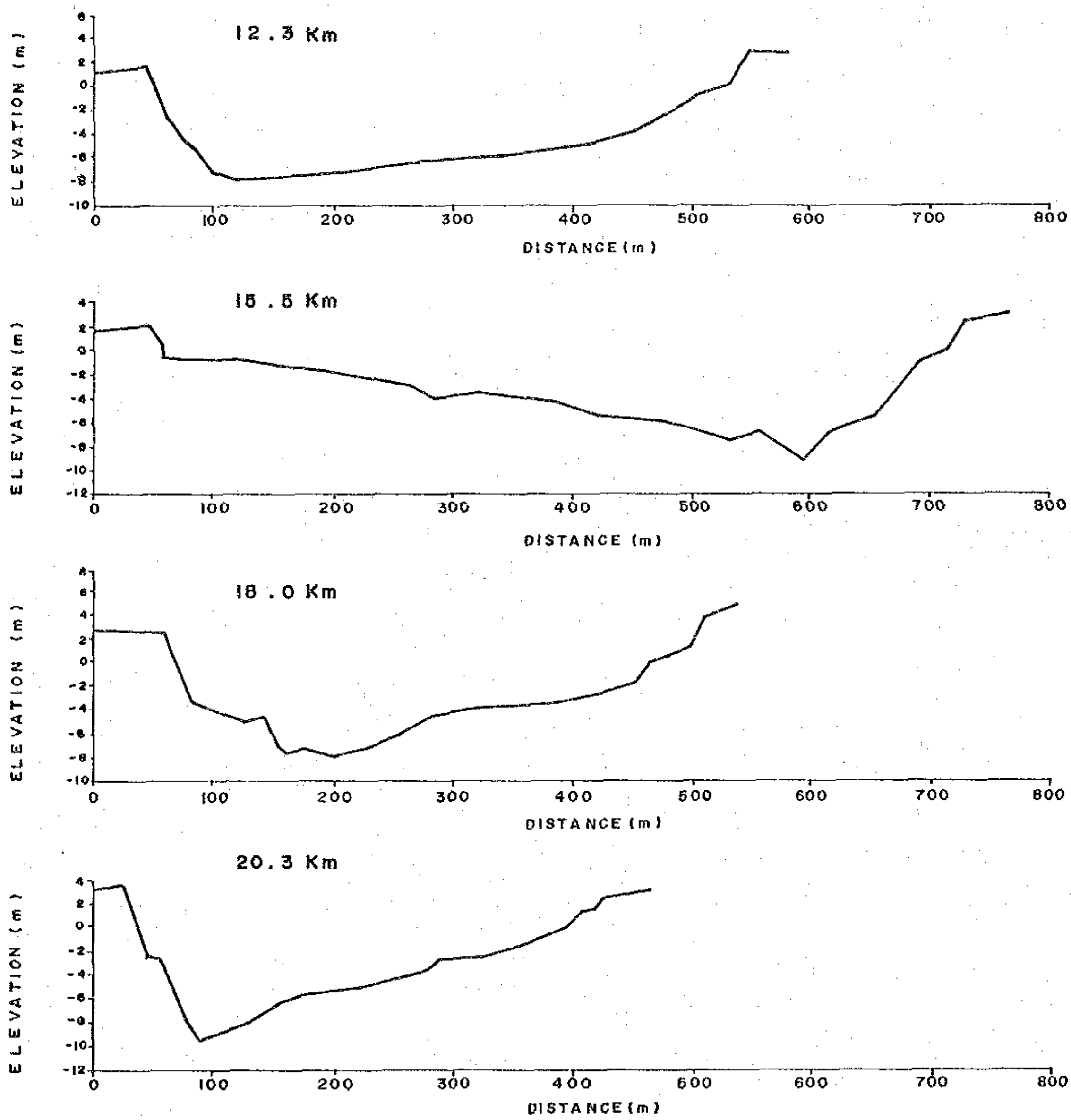


Fig.VI.2.4 CROSS SECTION OF ITAJAI RIVER (2/2)

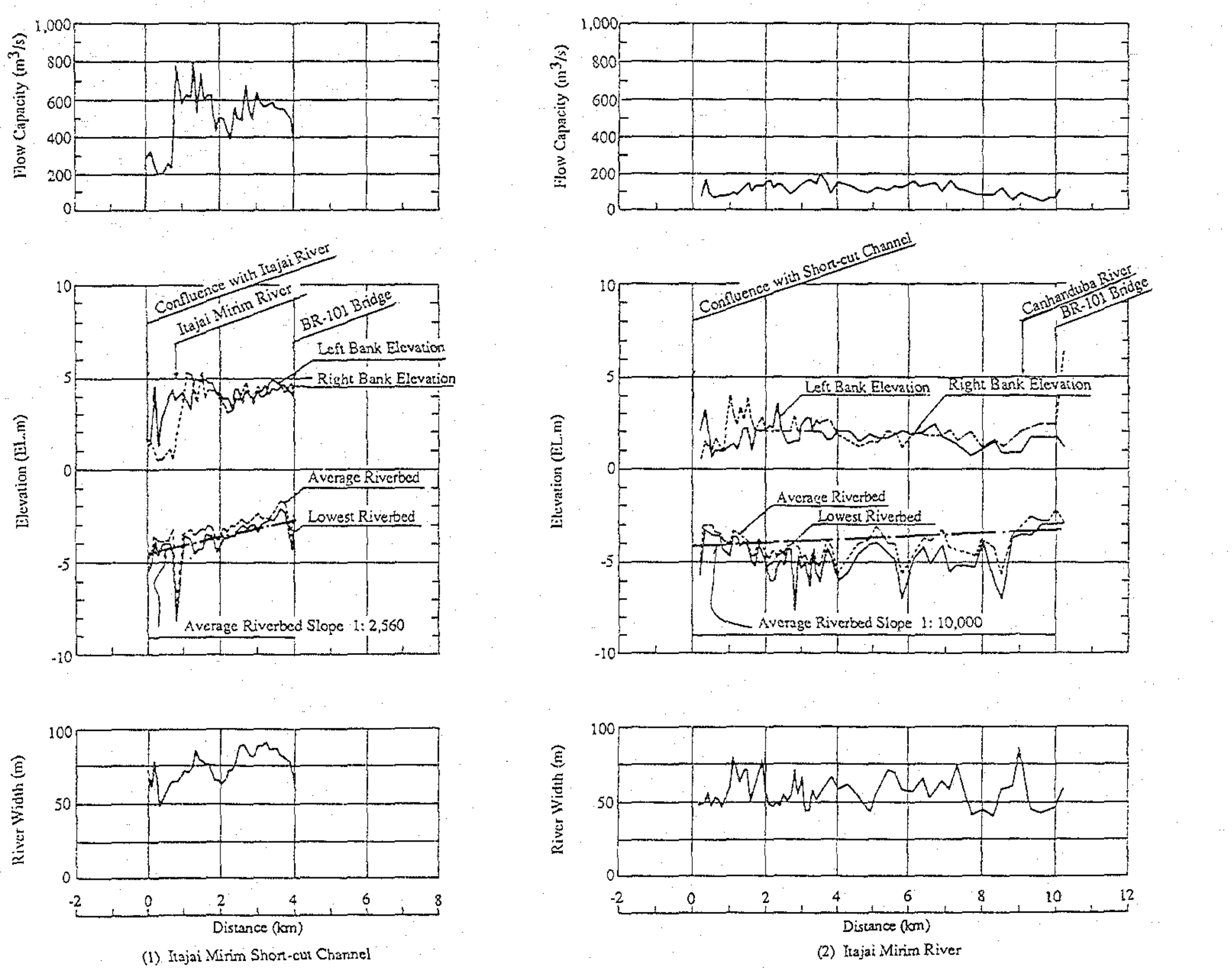


Fig.VI.2.4 RIVER CHANNEL CHARACTERISTICS OF THE ITAJAI MIRIM RIVER AND ITS SHORT-CUT CHANNEL

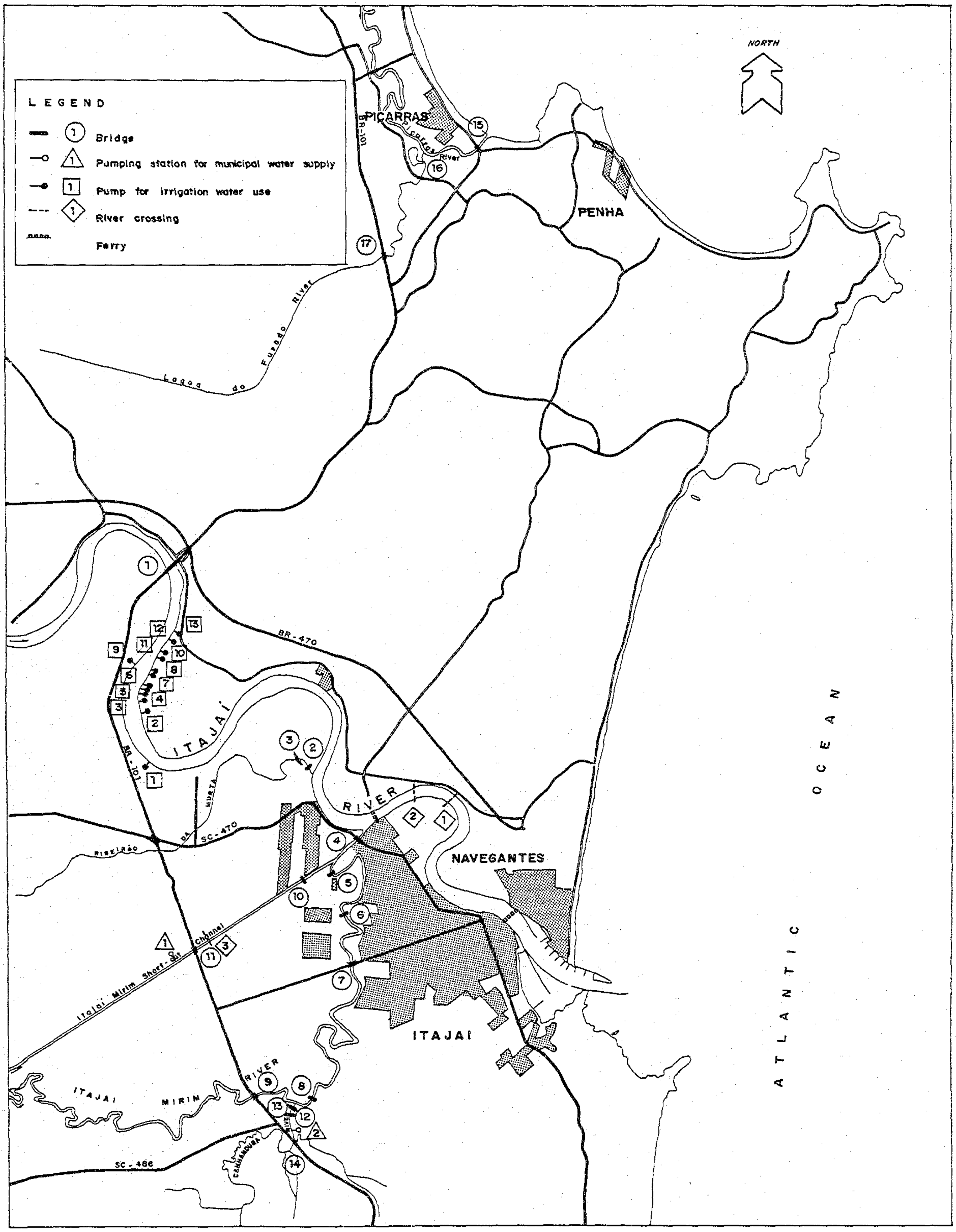


Fig.VI.2.5 LOCATION MAP OF RIVER STRUCTURES AND RELATED STRUCTURES

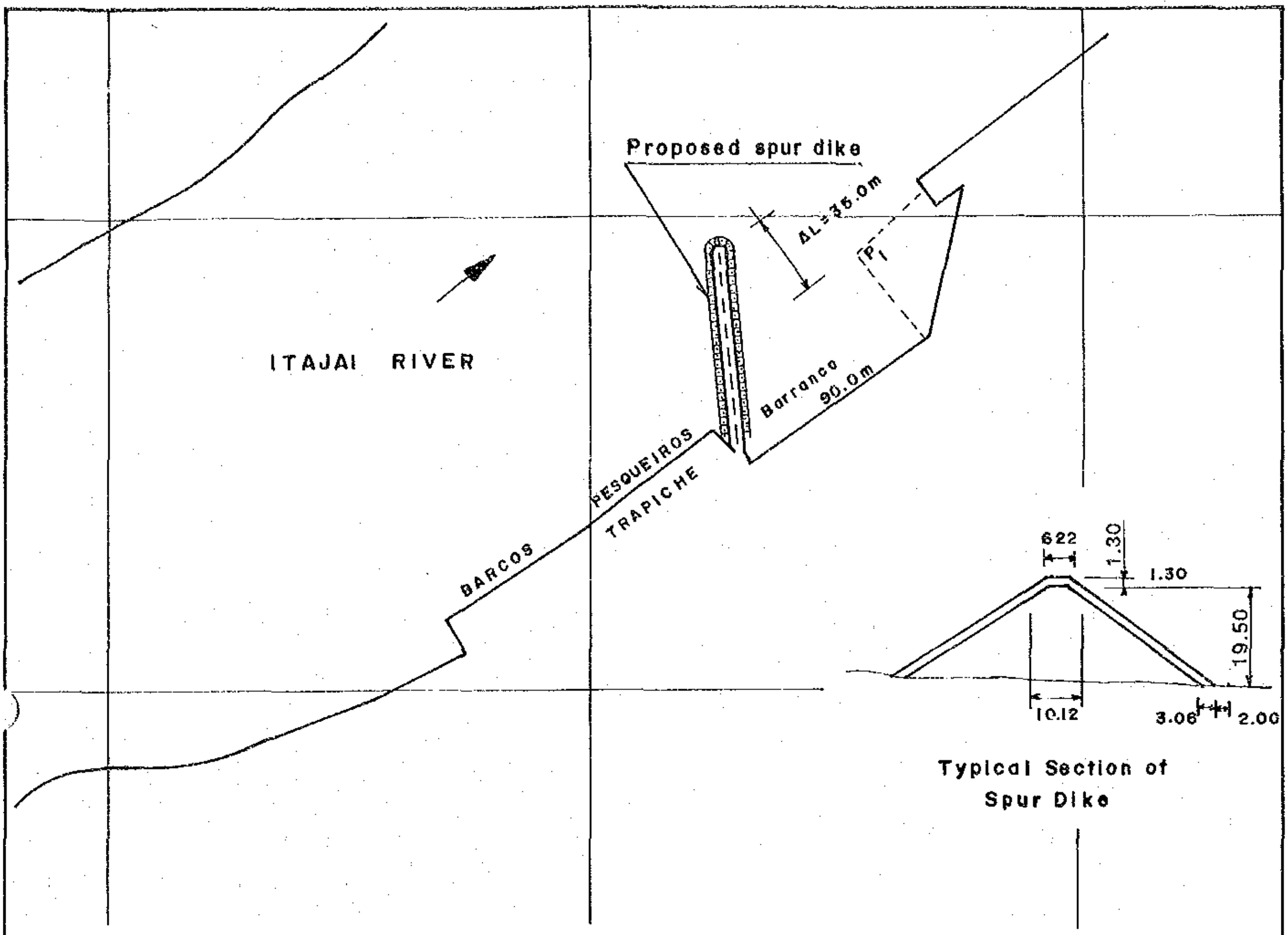


Fig.VI.2.6 GENERAL LAYOUT OF SPUR DIKE PLANNED BY PORTBRAS

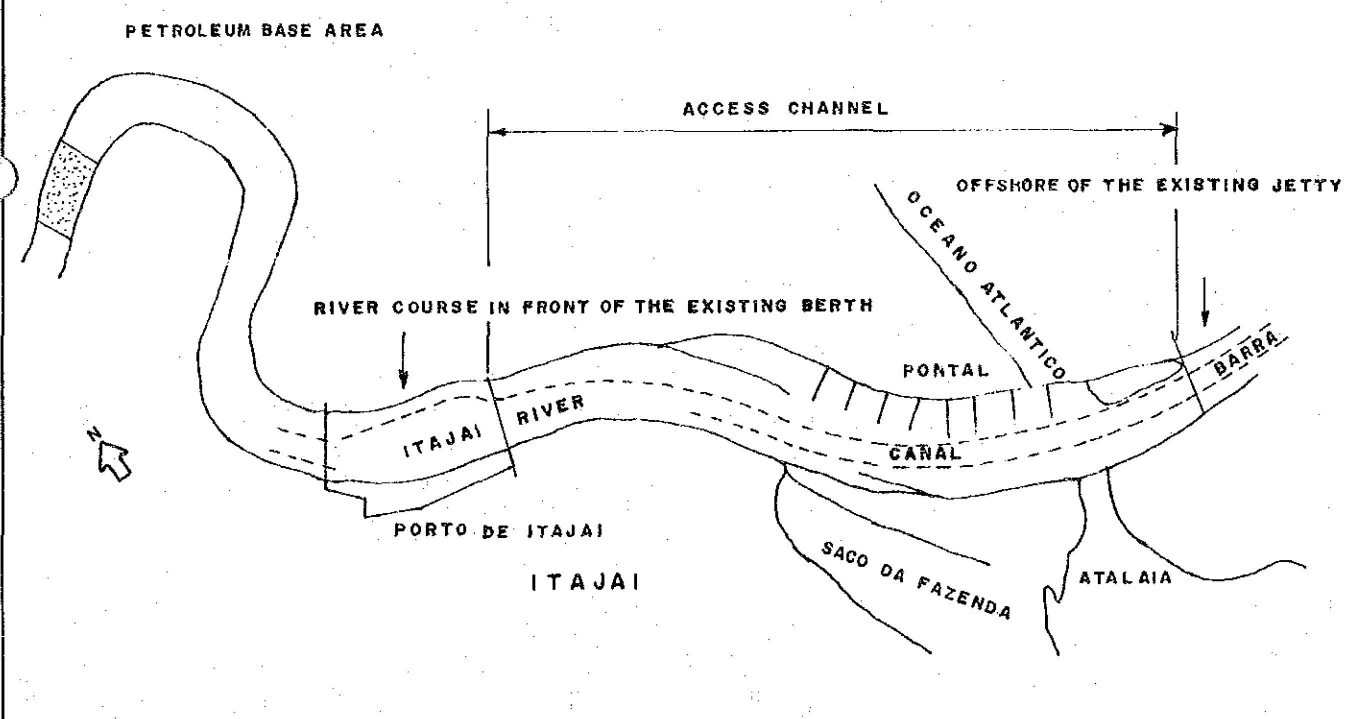
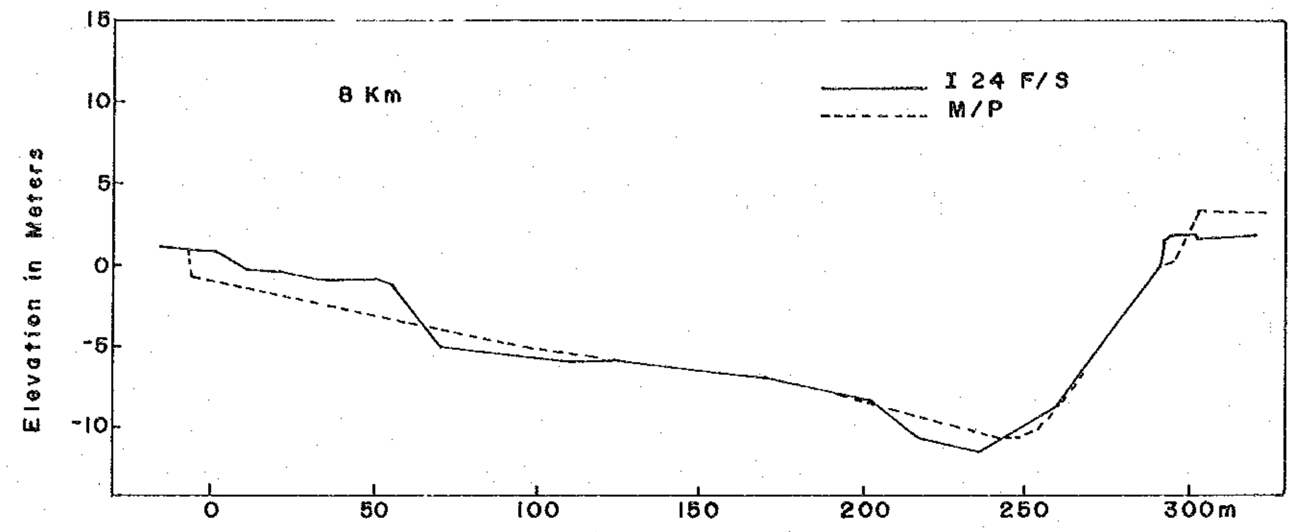
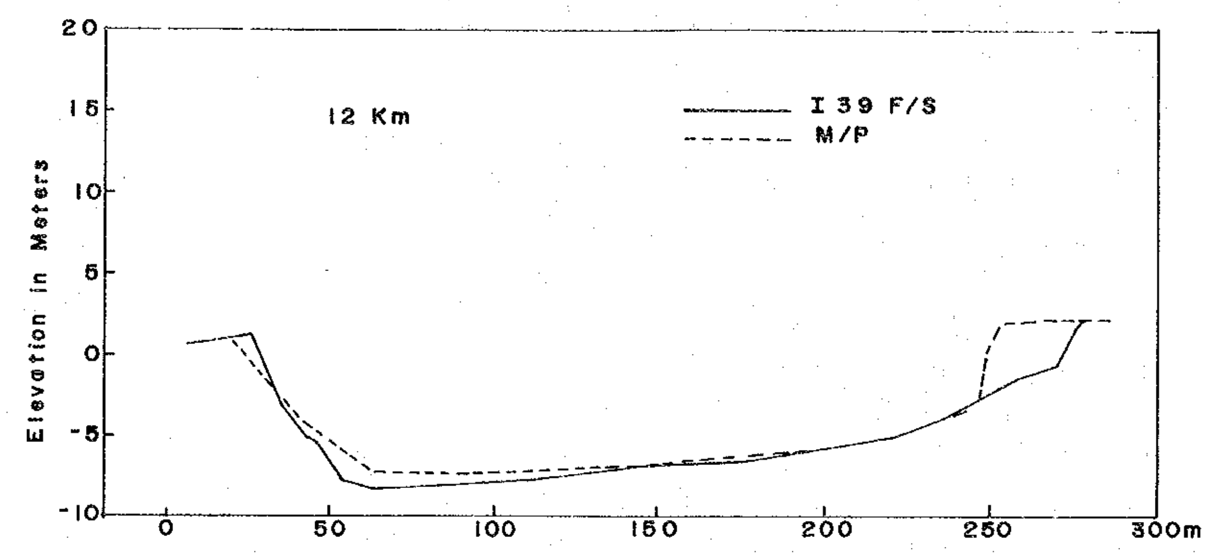
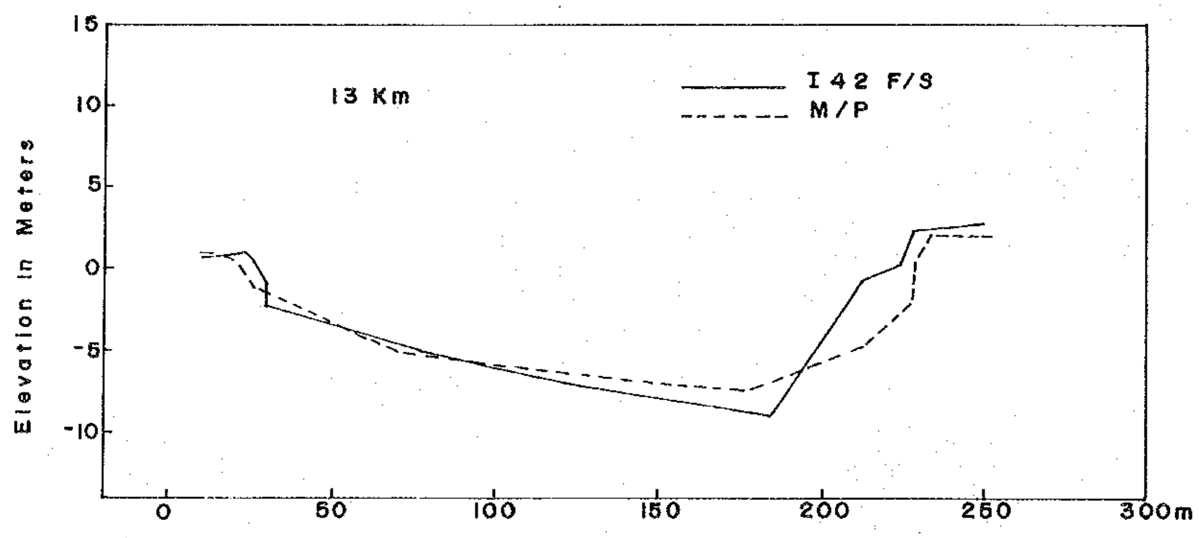


Fig.VI.2.7 DREDGING AREA AROUND ITAJAI PORT







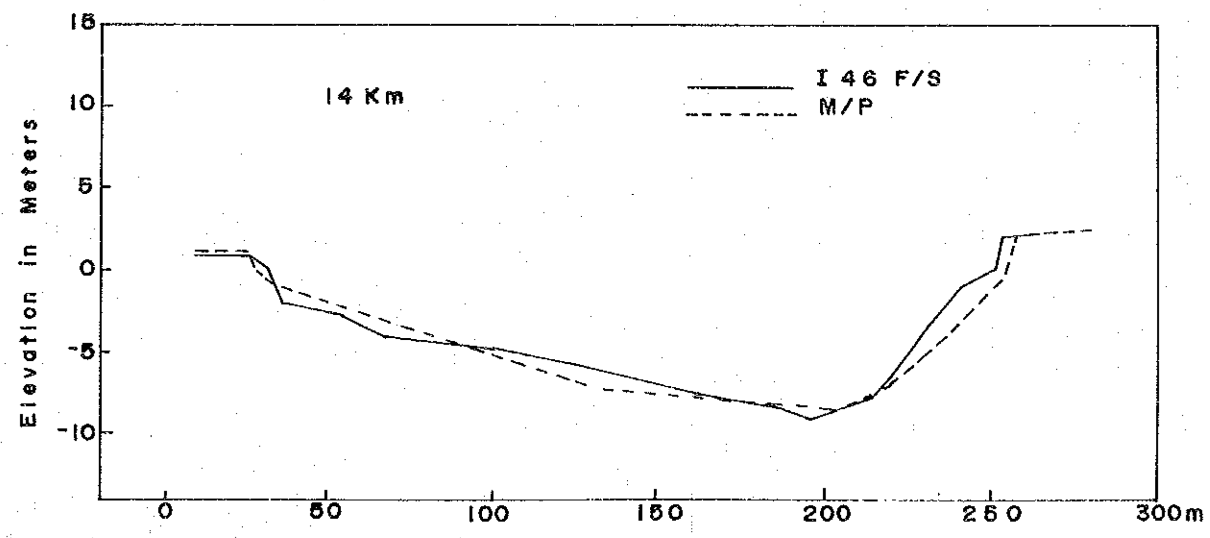
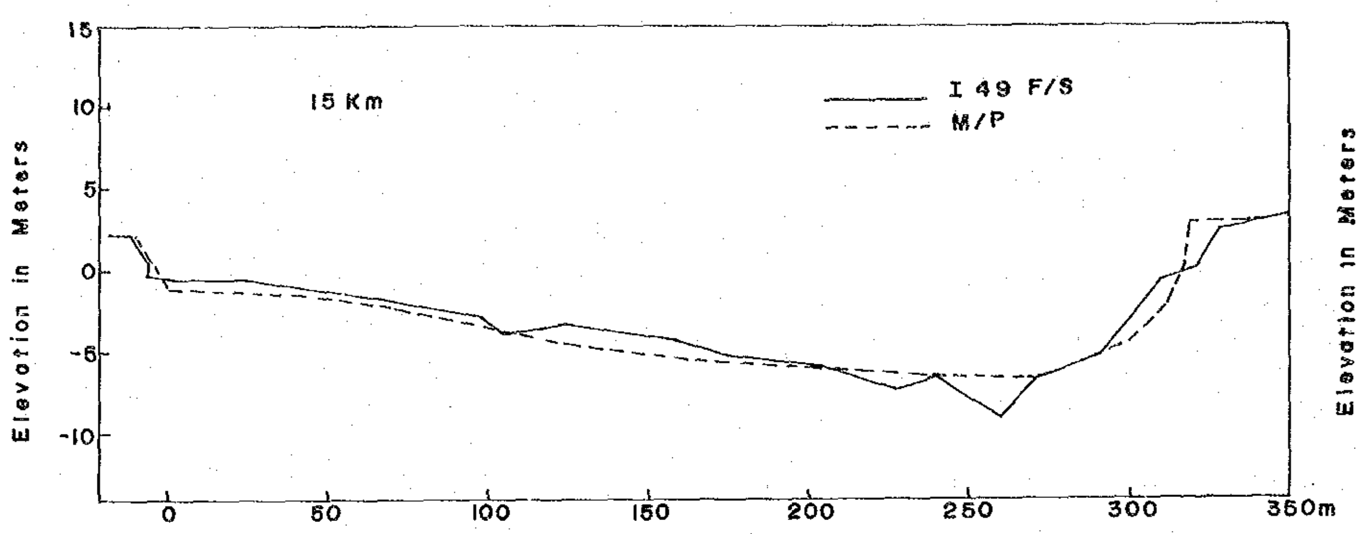
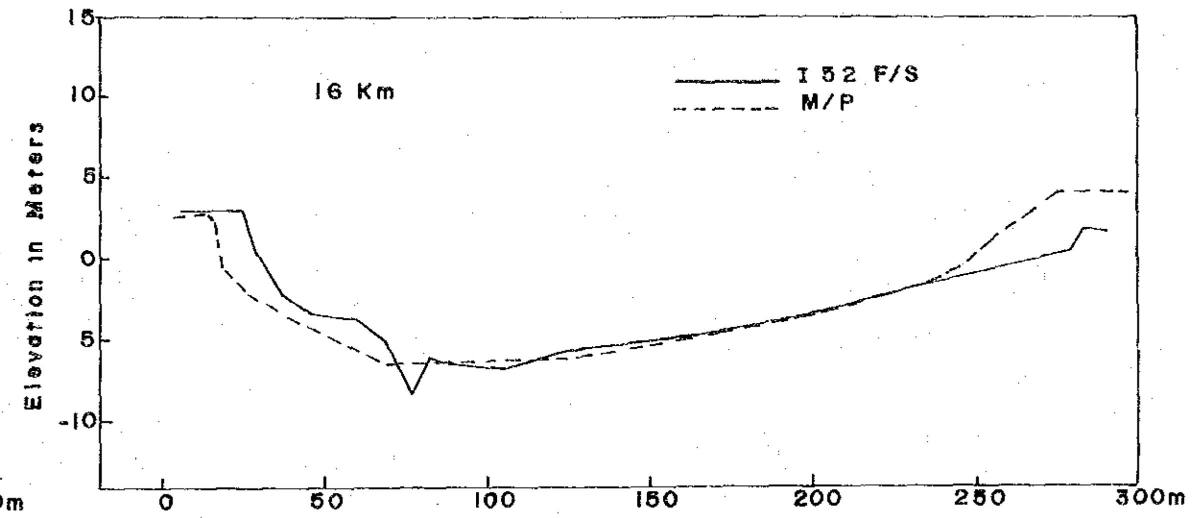
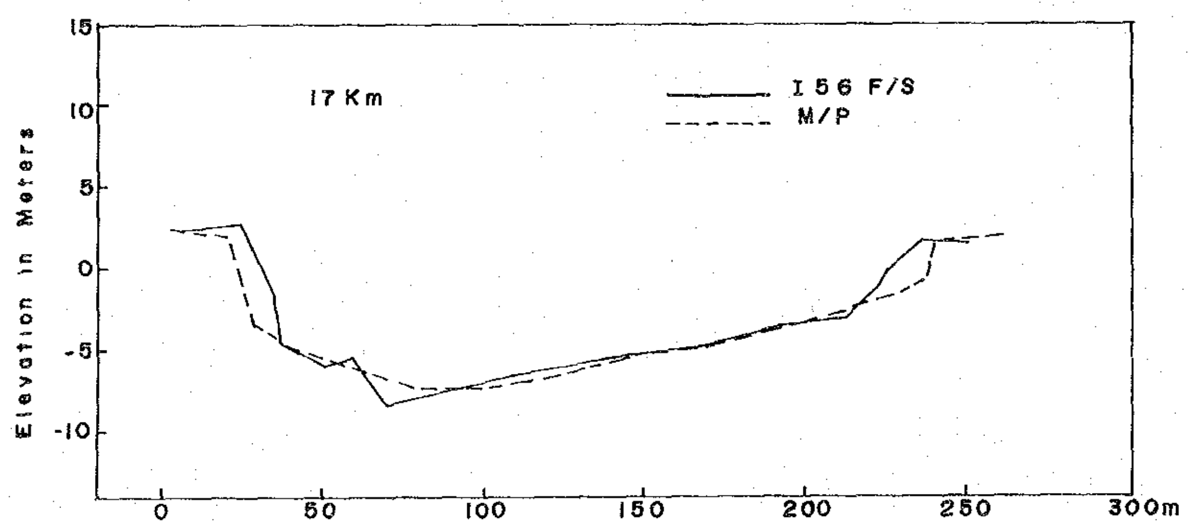


Fig.VI.2.8 COMPARISON OF RIVER CROSS SECTION SURVEYED IN 1983 AND 1989 (1/2)







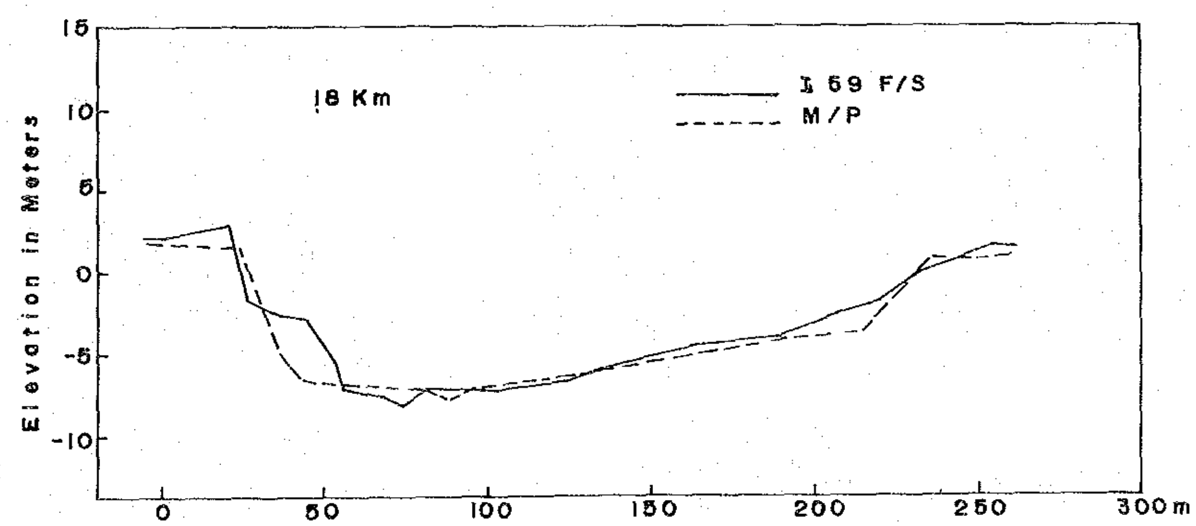


Fig.VI.2.8 COMPARISON OF RIVER CROSS SECTION SURVEYED IN 1983 AND 1989 (2/2)

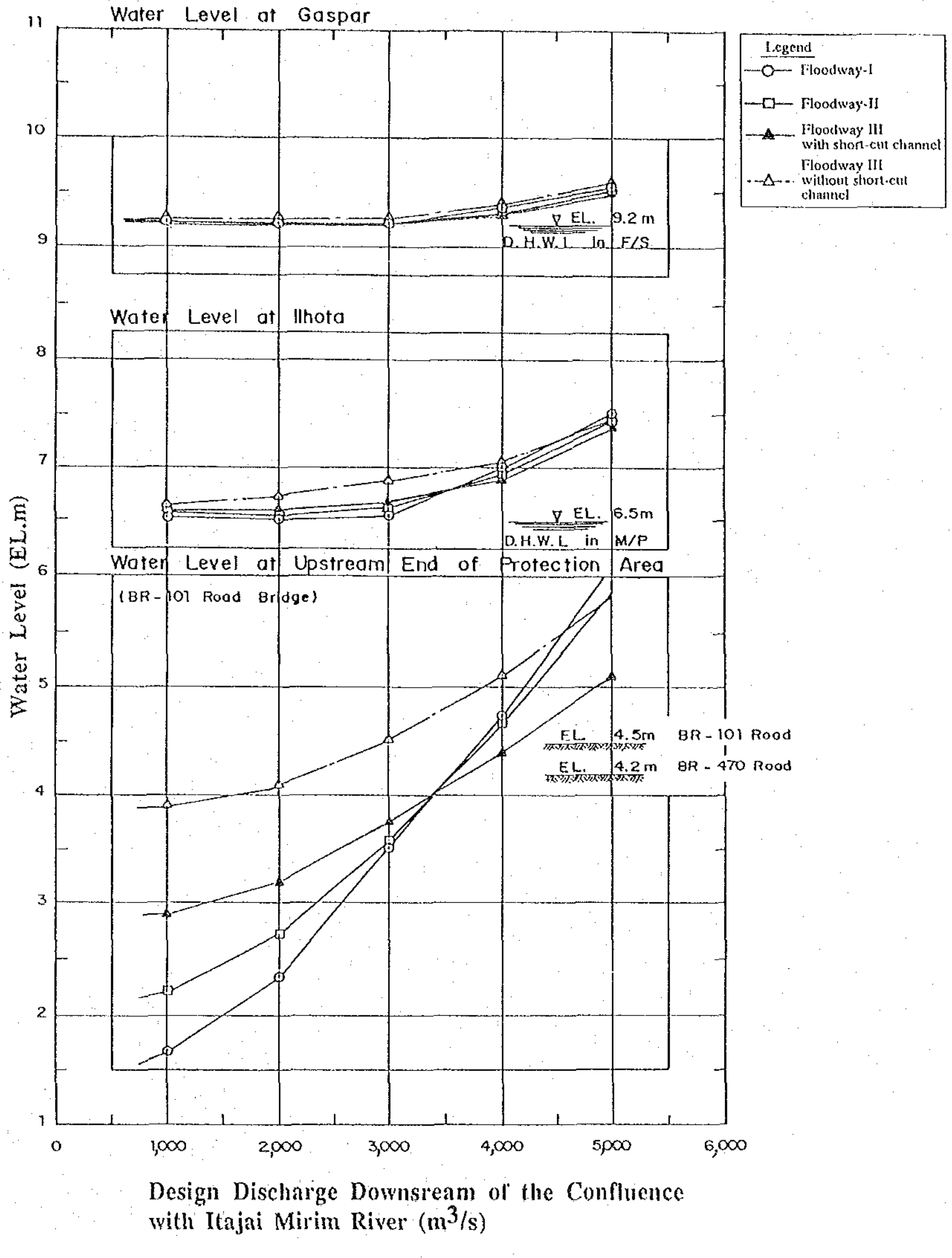
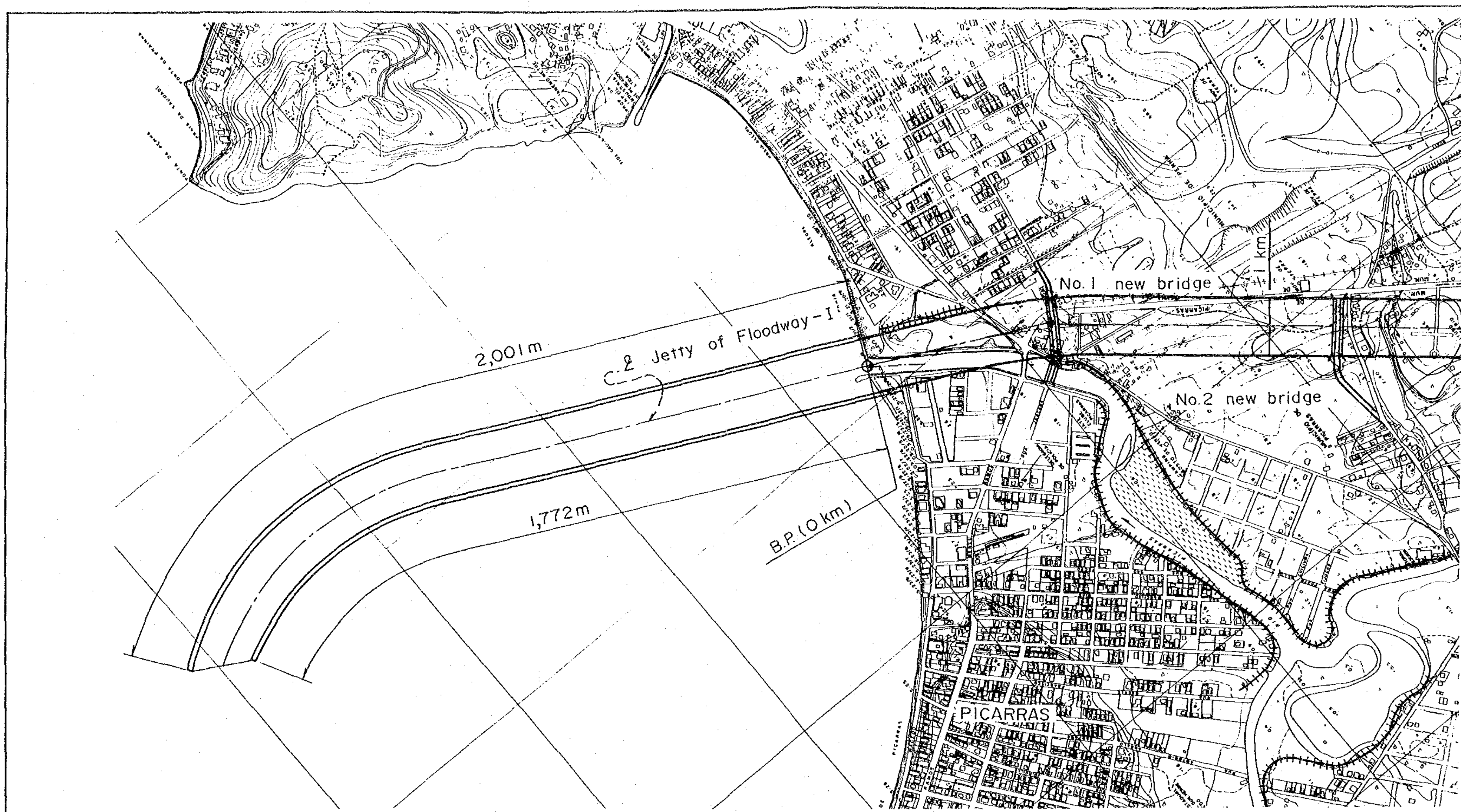


Fig.VI.3.1 INFLUENCE TO UPSTREAM DUE TO ENHANCEMENT OF PRESENT FLOW CAPACITY OF THE PROJECT STRETCH



Legend

- Floodway Route
- New bridge
- Levee
- Jetty
- Enlargement of river channel (Itajai River)

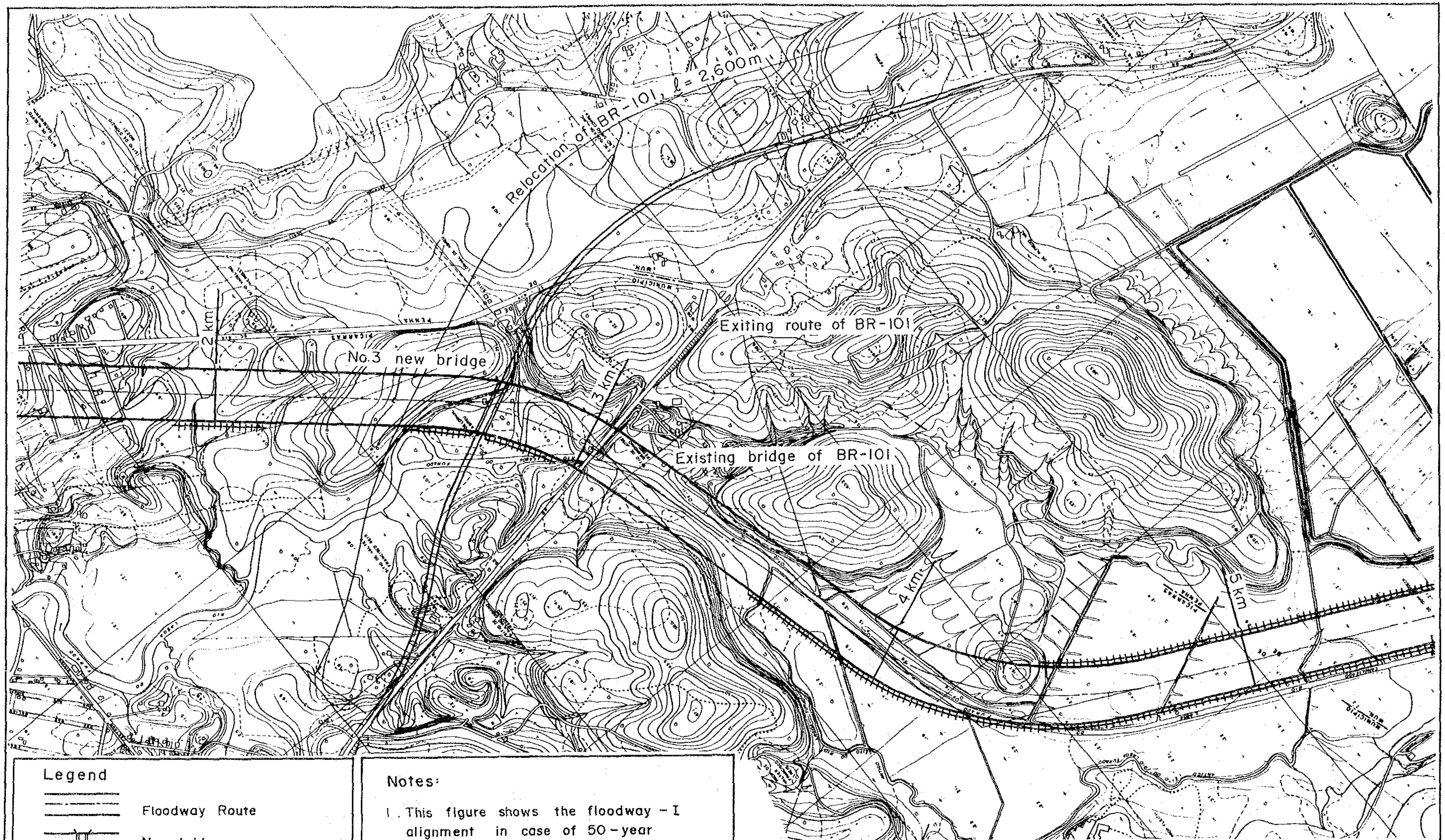
Notes:

1. This figure shows the floodway - I alignment in case of 50 - year probable flood of 3,030 m³ / sec.

2. Required river bed width
   - Floodway - II : 135 m
   - Floodway - III : 130 m

SCALE - 1 : 10,000
0 500 m

Fig.VI.3.2 LAYOUT PLAN OF ALTERNATIVE FLOODWAY-I (1/4)



Legend

- Floodway Route
- New bridge
- Levee
- Jetty
- Enlargement of river channel (Itajai River)

Notes:

1. This figure shows the floodway - I alignment in case of 50-year probable flood of 3,030 m³ /sec.

2. Required river bed width
   - Floodway - I 140 m

SCALE - 1:10,000
0 500m

Fig.VI.3.2 LAYOUT PLAN OF ALTERNATIVE FLOODWAY-I (2/4)

Legend

Floodway Route

New bridge

Levee

Jetty

Enlargement of river channel (Itajai River)

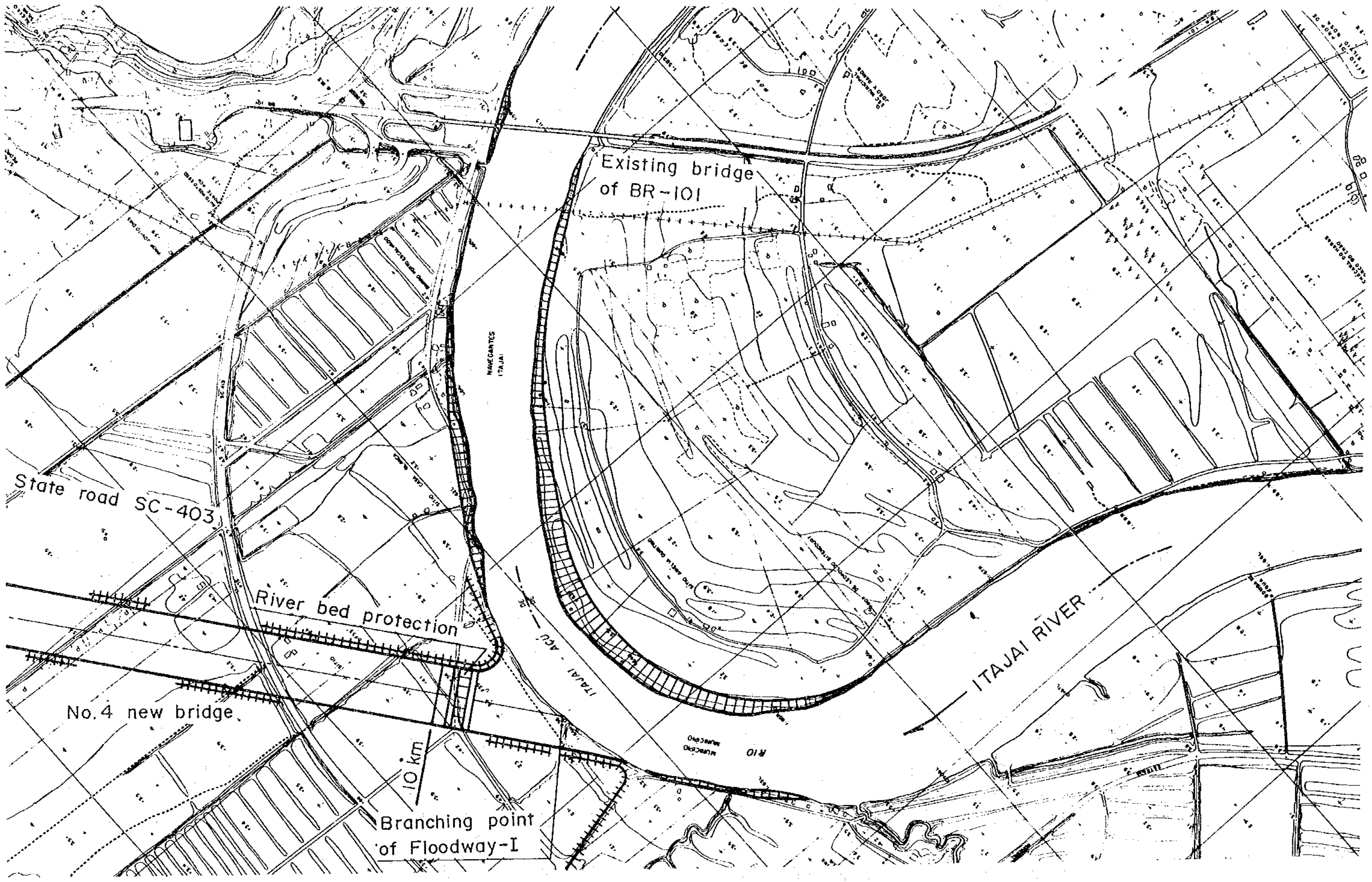
Notes:

1. This figure shows the floodway - I alignment in case of 50 - year probable flood of 3,030 m³ /sec.

2. Required river bed width
 - Floodway - I 140 m

SCALE - 1:10,000
0 500 m

Fig.VI.3.2 LAYOUT PLAN OF ALTERNATIVE FLOODWAY-I (3/4)



Legend

- Floodway Route
- New bridge
- Levee
- Jetty
- Enlargement of river channel (Itajai River)

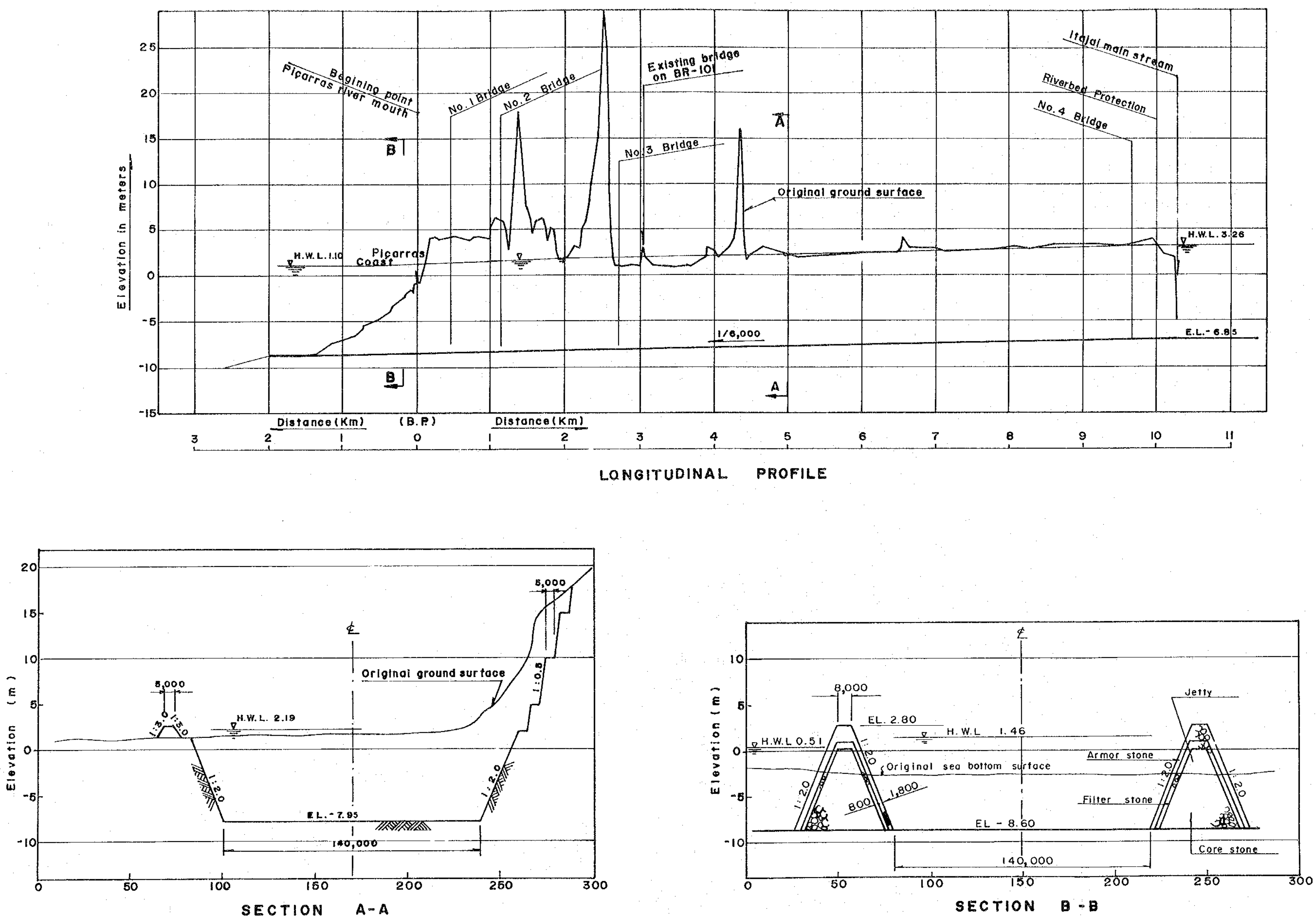
Notes:

1. This figure shows the floodway - I alignment in case of 50-year probable flood of 3,030 m³ /sec.

2. Required river bed width
 - Floodway - I 140 m

SCALE - 1:10,000
0 500m

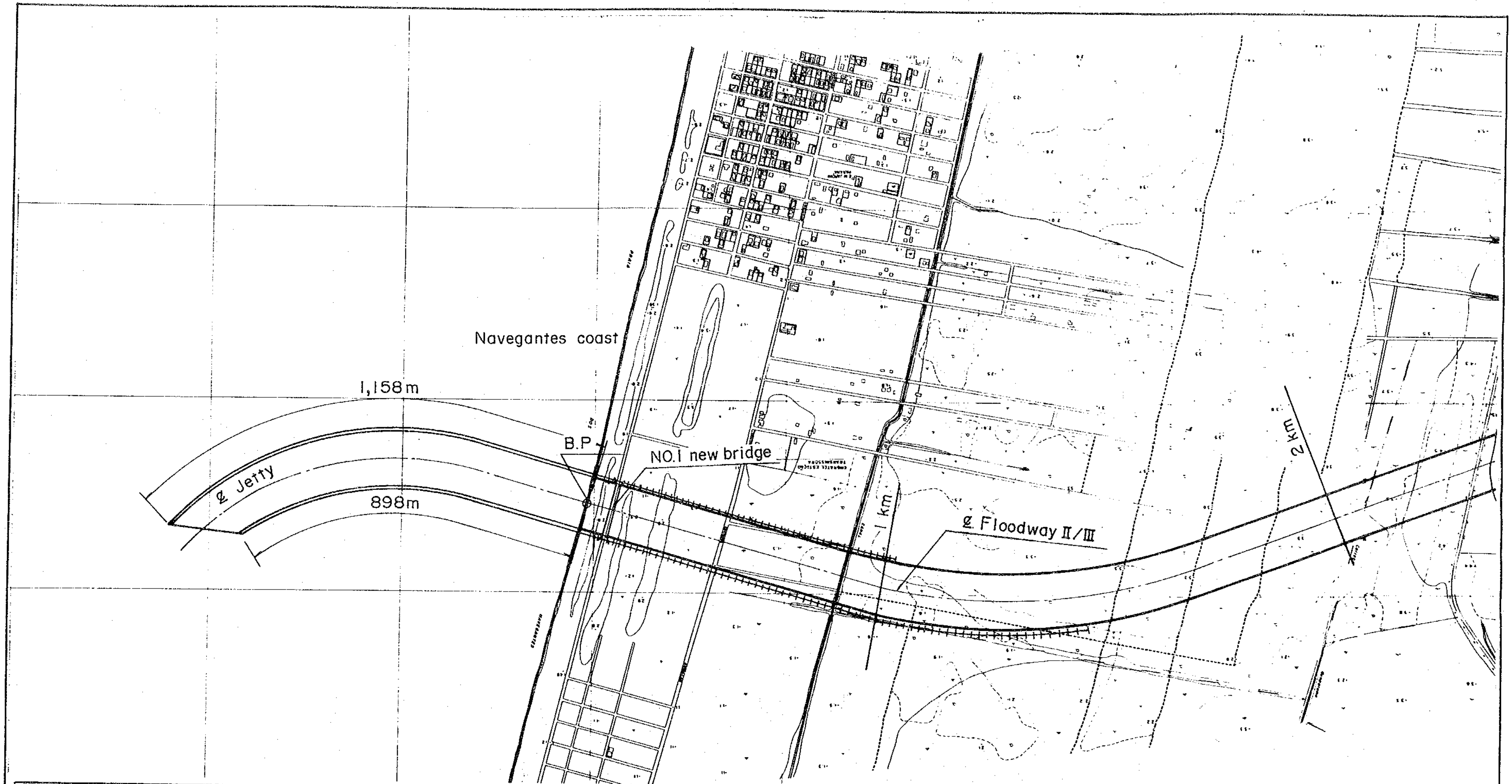
Fig.VI.3.2 LAYOUT PLAN OF ALTERNATIVE FLOODWAY-I (4/4)



Note

Required width of Floodway - I ; for 50-year probable flood: 140m

Fig.VI.3.3 LONGITUDINAL PROFILE AND TYPICAL CROSS SECTION OF FLOODWAY-I



Legend

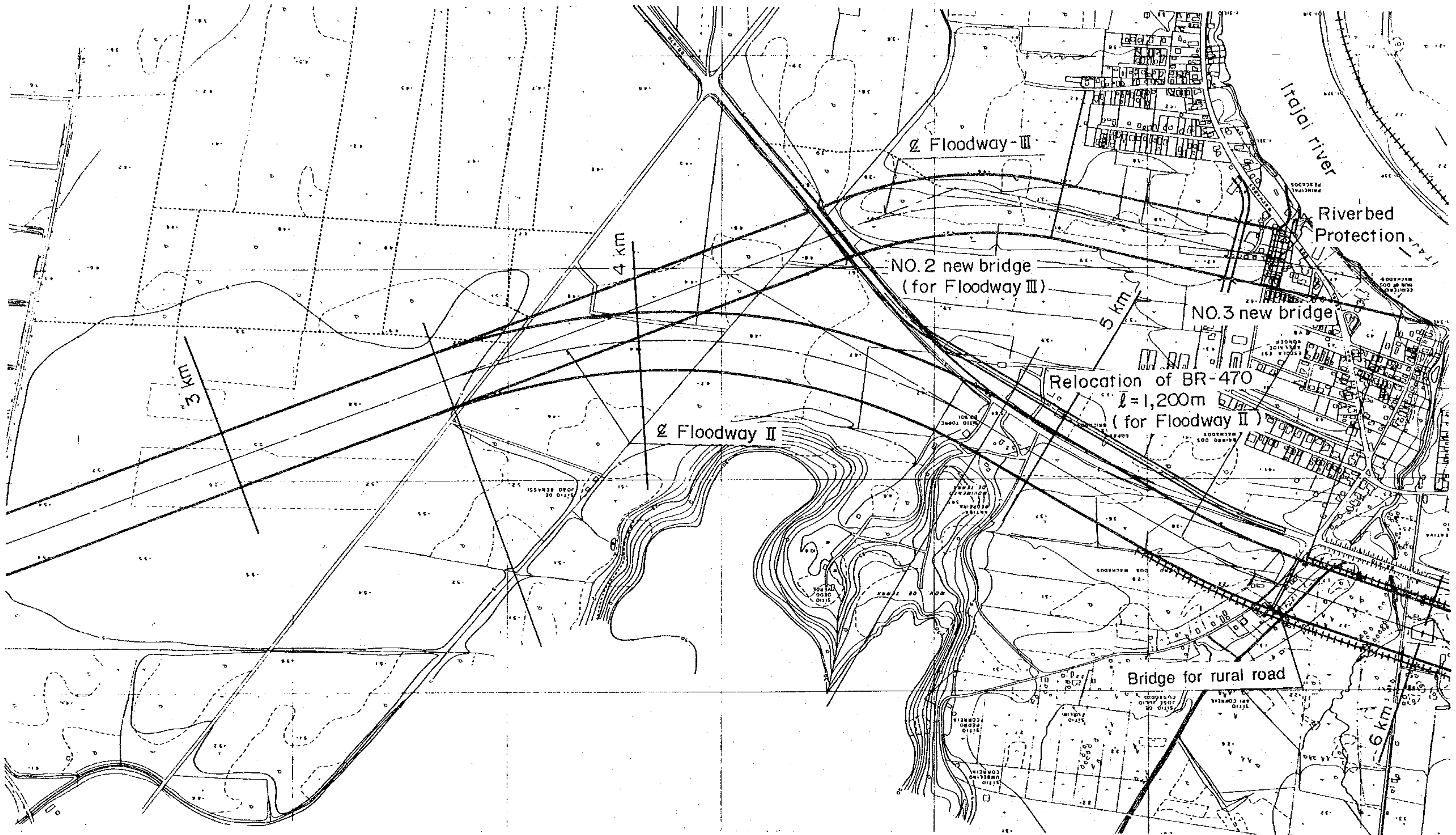
- Floodway Route
- New bridge
- Levee
- Jetty
- Enlargement of river channel (Itajai River)

Notes:

1. This figure shows the floodway - II/III alignment in case of 50-year probable flood of 3,030 m^3/sec.
2. Required river bed width
   - Floodway - II : 135m
   - Floodway - III : 130m

SCALE - 1:10,000 (0 – 500m)

Fig.VI.3.4 LAYOUT PLAN OF ALTERNATIVE FLOODWAY-II / III (1/3)



Legend

- Floodway Route
- New bridge
- Levee
- Jetty
- Enlargement of river channel (Itajai River)

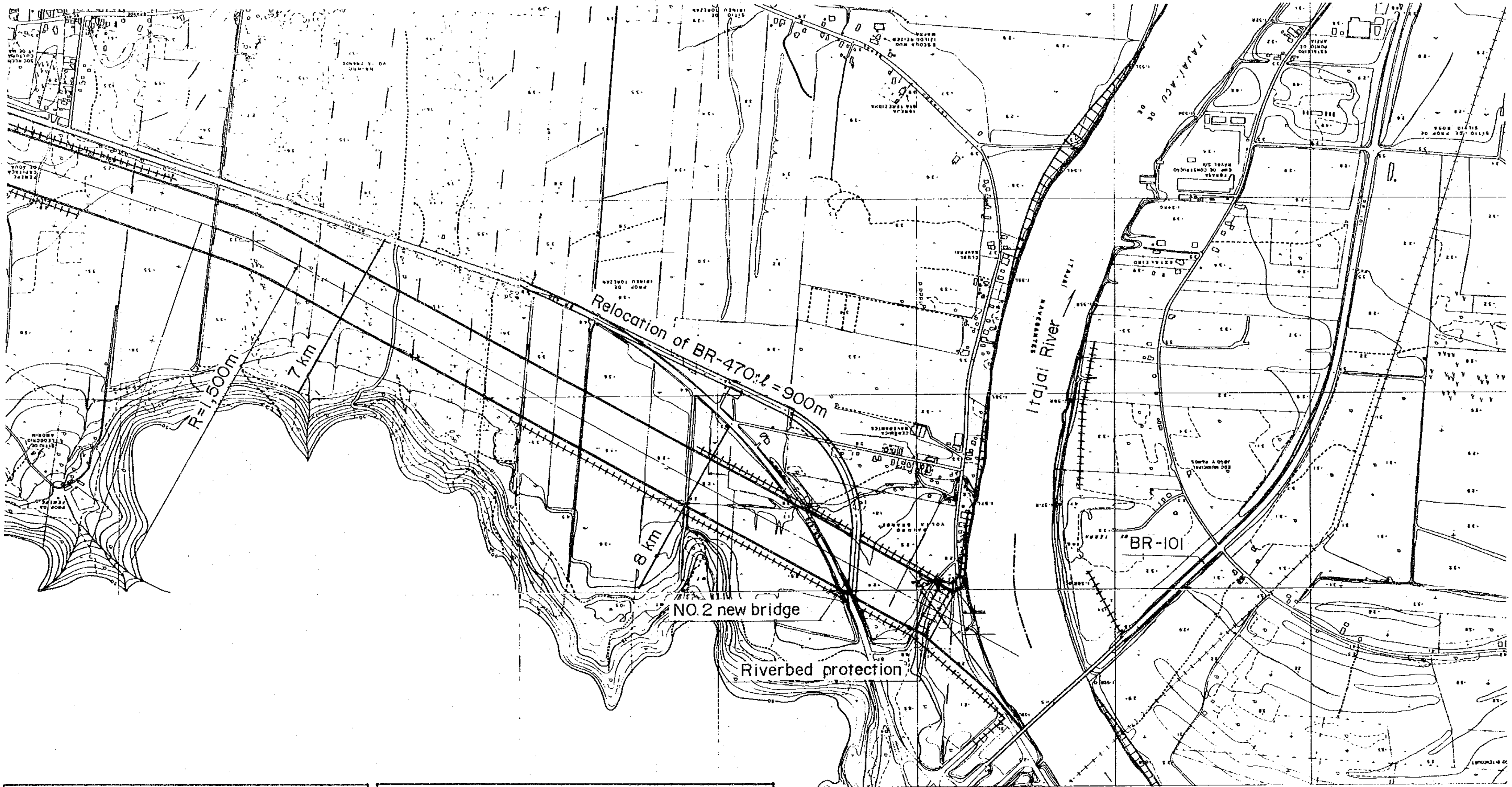
Notes:

1. This figure shows the floodway - Ⅱ/Ⅲ alignment in case of 50-year probable flood of 3,030 m³/sec.
2. Required river bed width
   - Floodway - Ⅱ : 135m
   - Floodway - Ⅲ : 130m

SCALE - 1:10,000

0 500m

Fig.VI.3.4 LAYOUT PLAN OF ALTERNATIVE FLOODWAY-II / III (2/3)



Legend

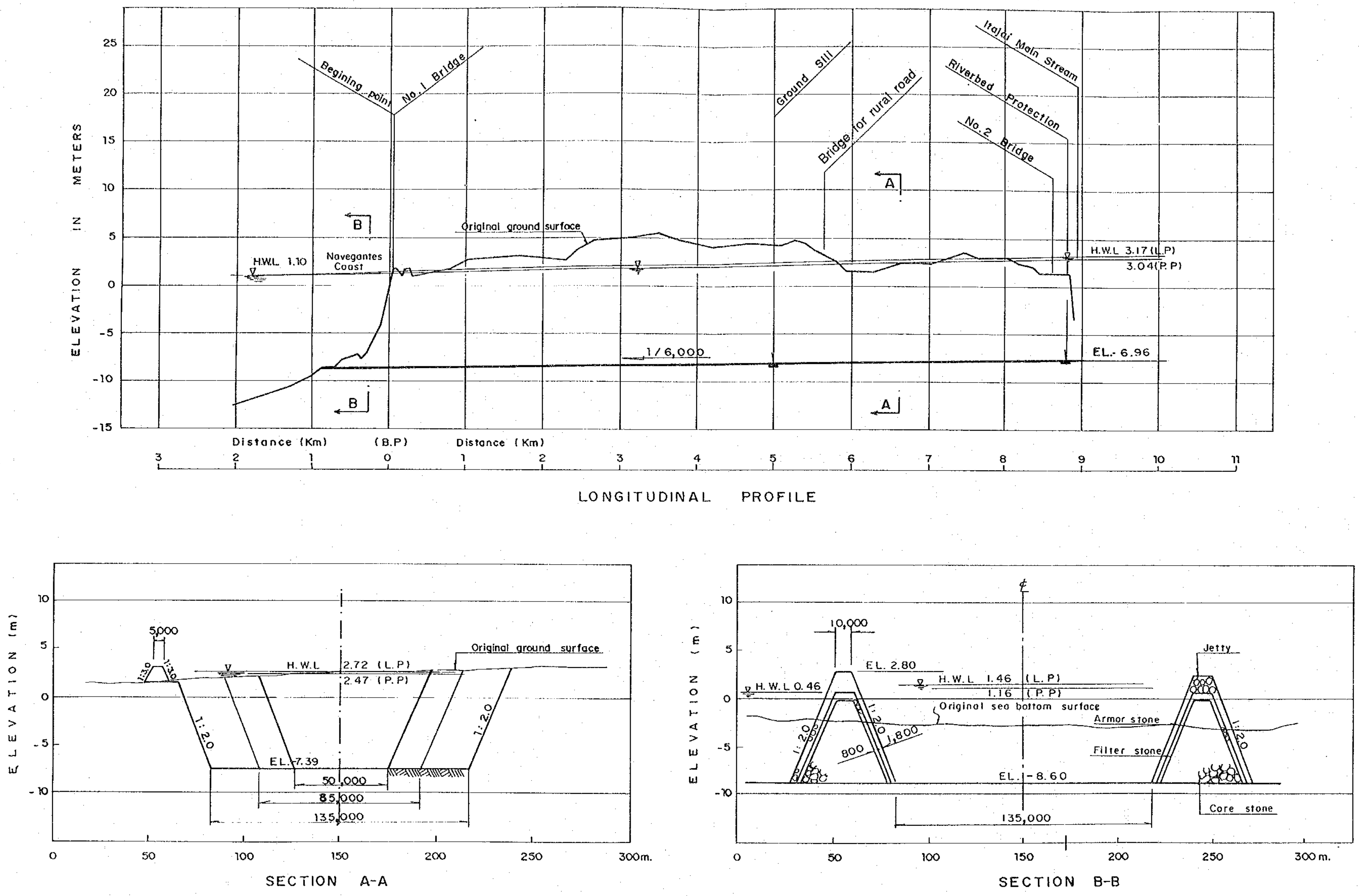
- Floodway Route
- New bridge
- Levee
- Jetty
- Enlargement of river channel (Itajai River)

Notes:

1. This figure shows the floodway - I alignment in case of 50 - year probable flood of 3,030 m³ /sec.

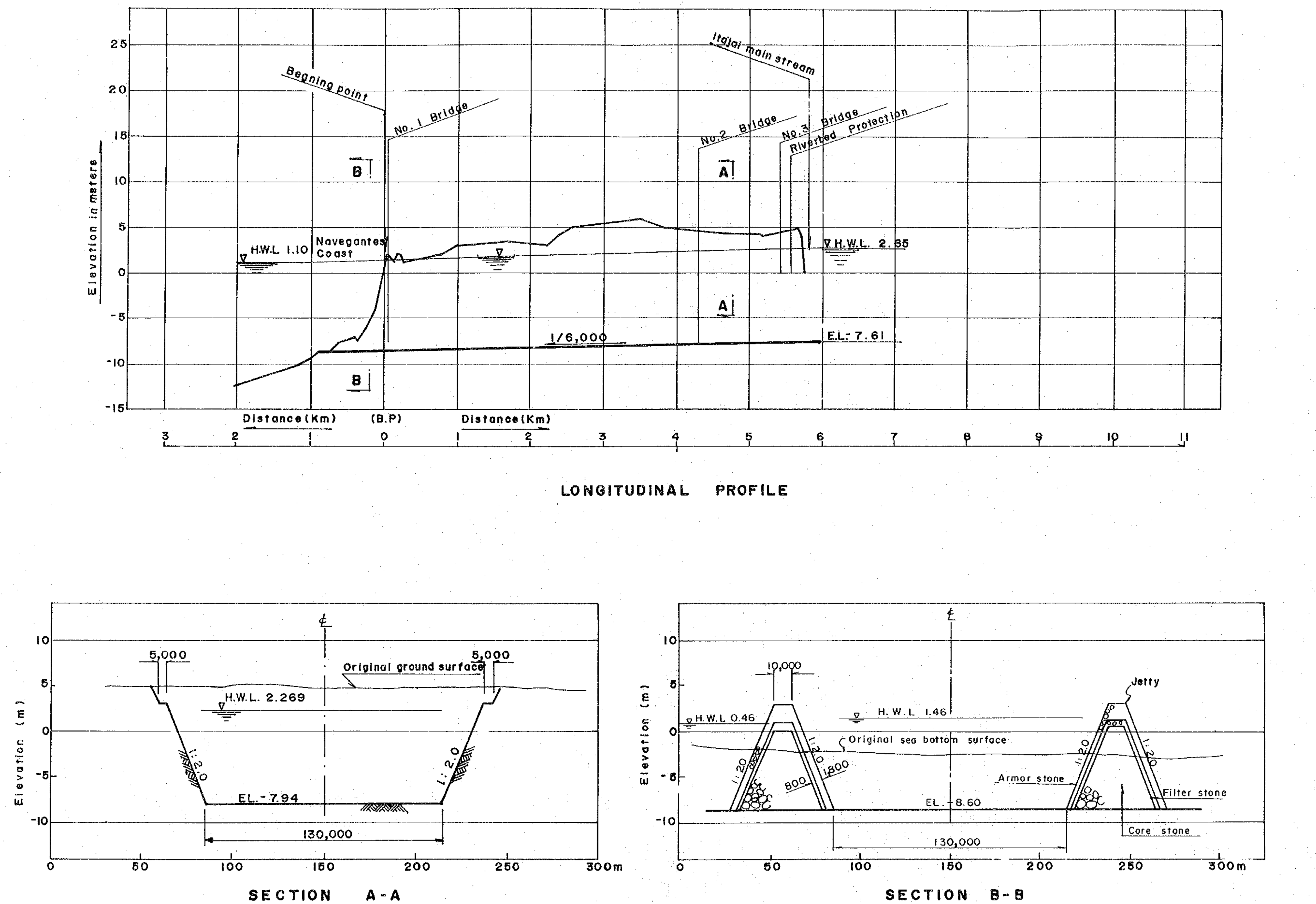
2. Required river bed width
   - Floodway - I 140 m

Fig.VI.3.4 LAYOUT PLAN OF ALTERNATIVE FLOODWAY-II / III (3/3)



Note : Required width of Floodway-II ; for 50-year probable flood : 135 m
for 25-year probable flood : 85 m
for 10-year probable flood : 50 m

Fig.VI.3.5 LONGITUDINAL PROFILE AND TYPICAL CROSS SECTION OF FLOODWAY-II



Note
Required width of Floodway-III for 50-year probable flood: 130m

Fig.VI.3.6 LONGITUDINAL PROFILE AND TYPICAL CROSS SECTION OF FLOODWAY-III

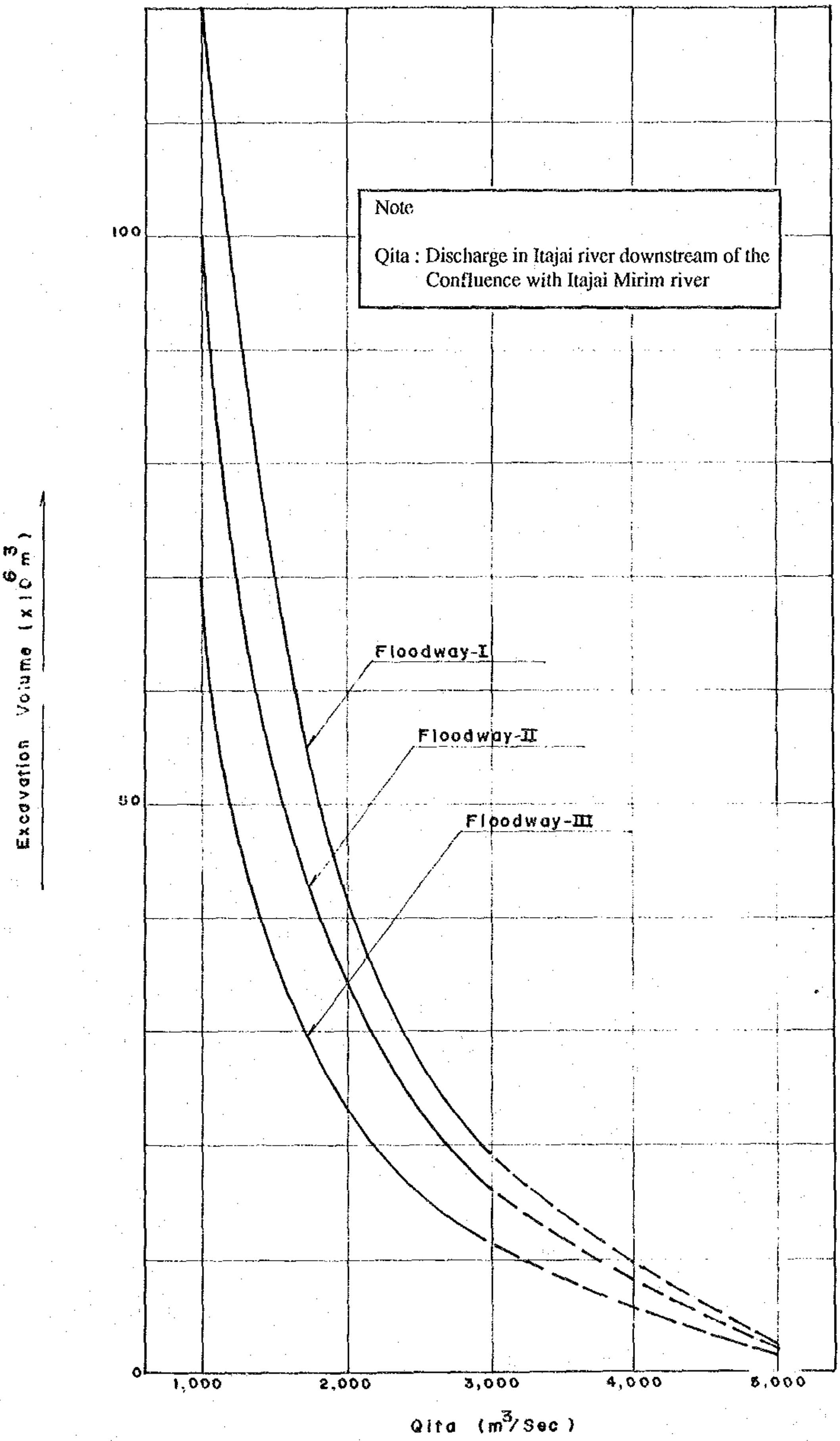
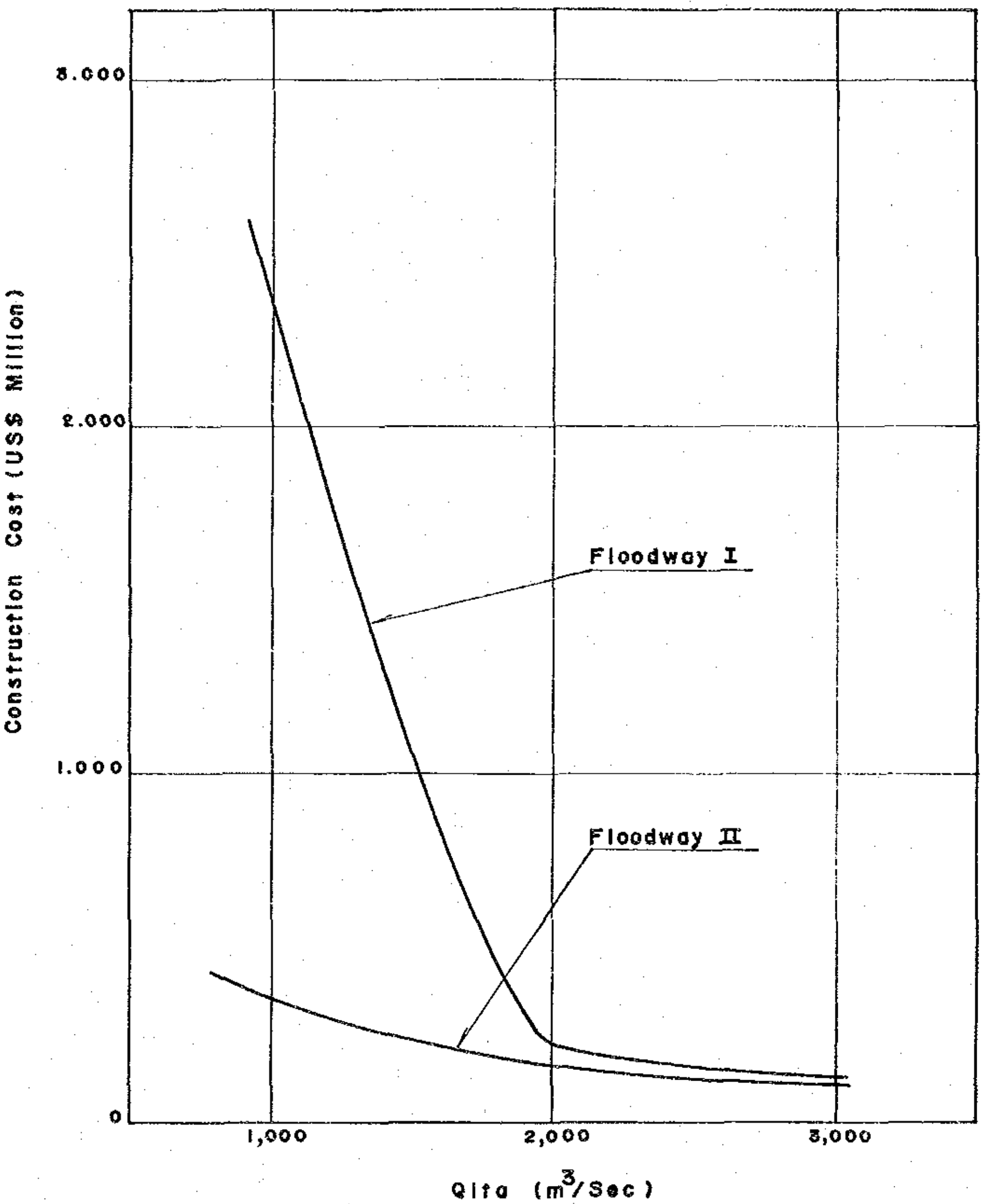


Fig.VI.3.7 VOLUME CURVE OF FLOODWAY EXCAVATION



Qita : design flood discharge in Itajai river downstream of confluence with Itajai Mirim river

Fig.VI.3.8 RELATIONSHIP BETWEEN CONSTRUCTION COST AND DESIGN FLOOD DISCHARGE FOR ALTERNATIVE CASES OF FLOODWAYS-I AND II

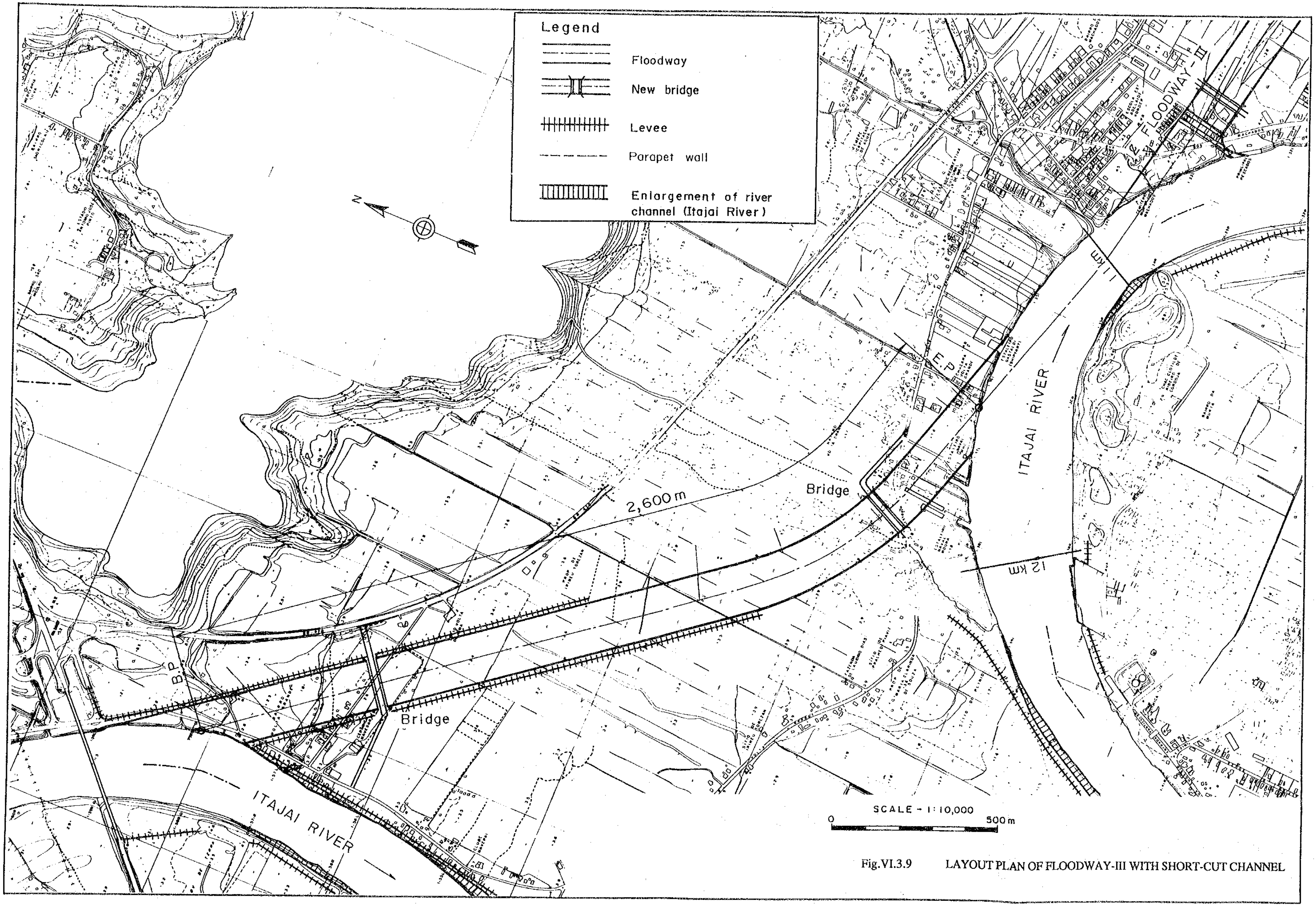
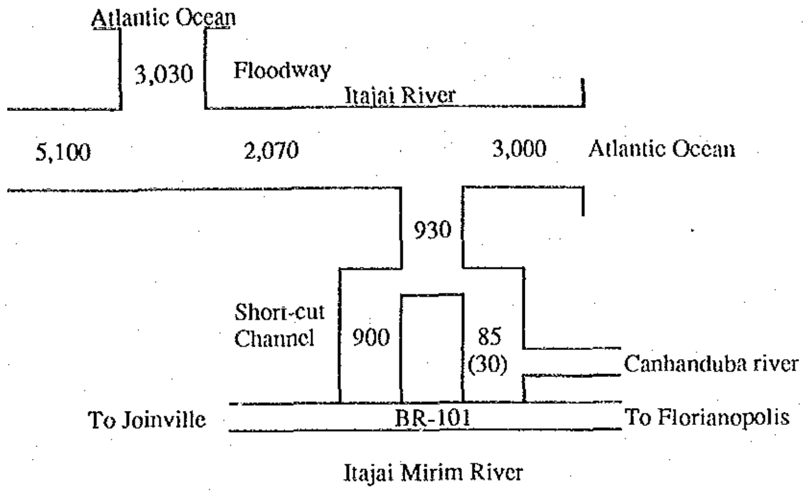
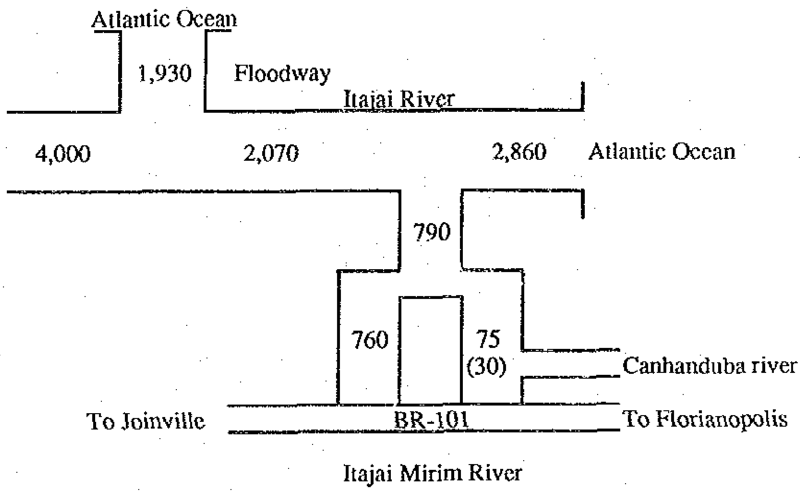


Fig.VI.3.9 LAYOUT PLAN OF FLOODWAY-III WITH SHORT-CUT CHANNEL

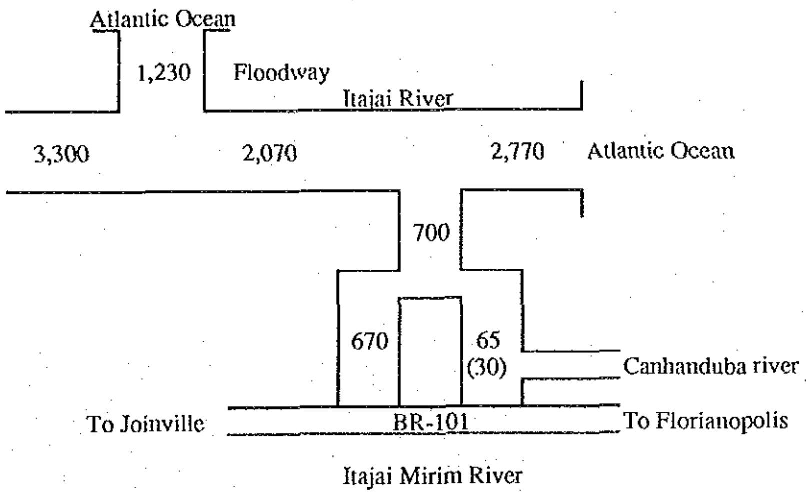
(1) Long-Term Plan (50-year)



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



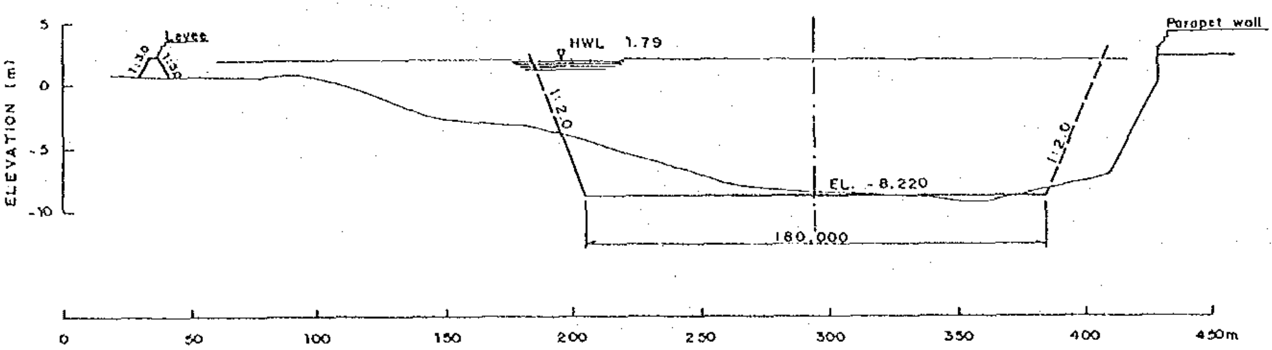
(3) Provisional Plan (10-year)



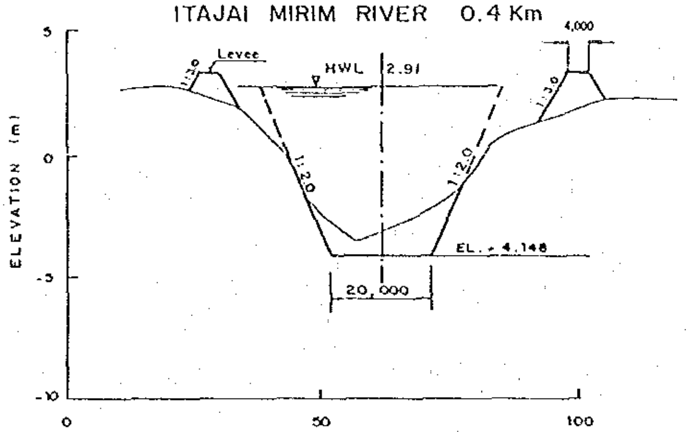
Remarks :
"( )" means the discharge in the Itajai Mirim river
at the time of flood peak occurrence in the short-cut channel.

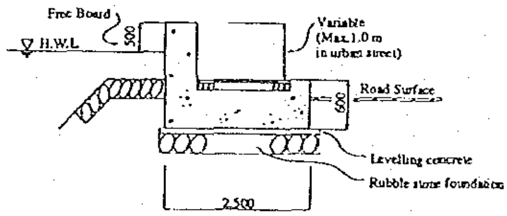
Fig.VI.3.10 PROPOSED FLOOD DISCHARGE DISTRIBUTION

ITAJAI RIVER 3.4 Km



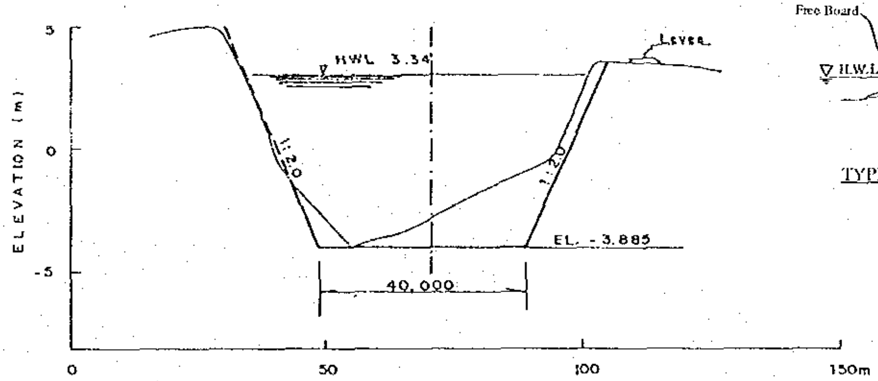
ITAJAI MIRIM RIVER 0.4 Km

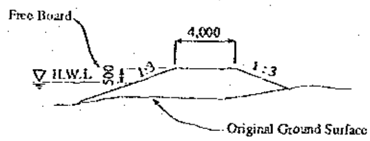




TYPICAL SECTION OF PARAPET WALL

ITAJAI MIRIM SHORT - CUT CHANNEL 1.6 Km





TYPICAL CROSS SECTION OF LEVEE

Fig.VI.3.11 TYPICAL CROSS SECTION OF RIVER IMPROVEMENT IN THE PROJECT STRETCH