ANNEX V. FLOOD DAMAGE STUDY

V. FLOOD DAMAGE STUDY

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

1. INTRODUCTION

Following the previous Flood Damage Study of Master Plan which covers the study area of whole Itajai river basin, the feasibility study of flood damage demonstrates more detailed analyses of study items required for understanding this component from the viewpoint of both existing records of past floods and probable flood damage based on hydrological simulation and estimation of damageable value in Blumenau-Gaspar river stretch.

The contents of flood damage study to be covered in this chapter are shown as follows;

- Existing Records of Past Large Scale of Floods,
- Estimation of Probable Inundation Area,
- Procedure of Estimating Damageable Value at present and in future condition, and
- Simulation of probable flood damage.

The flood damage survey was carried out with emphasis on the detailed analyses of area-depth-duration and damage conditions of various types of properties in Blumenau-Gaspar stretch. For these purposes, the reconnaissance survey of interviewing local people about inundation and of visiting municipal organs for collecting flood damage informations, and an additional collection of damage records were conducted. As far as an additional data collection is concerned, damage records of public sector in 1984 flood and the detailed damage records of private sector in 1983 and 1984 flood were newly collected.

Probable inundation area in Blumenau-Gaspar stretch is delineated on the topographic map with a scale of 1:10,000 which was newly surveyed this time. The delineation of probable inundation area is based on water level corresponding to past large scale of floods occurred in 1983 and 1984, and topographic conditions in Blumenau-Gaspar stretch.

Economic study of estimating damageable value in probable inundation area consists of the number or area of various types of properties, and unit value of them. Enumeration of properties and estimate of unit value by property are based on an administrative unit called Bairro and municipal level respectively in order to make the accurate estimation of damageable value.

2. EXISTING RECORDS OF PAST LARGE SCALE OF FLOODS

2.1 Data Collection

An additional collection of actual damage records of 1983 and 1984 floods was carried out in order to make the more detailed analyses of damage amount and conditions by various type of property in Blumenau-Gaspar stretch. A full list of records is arranged in the form of damage to public sector and private one. Damage records of public sector consisting of public buildings, utilities, and infrastructure belonging to municipal government in 1984 flood were collected from GAPLAN (Planning Department of Santa Catarina State Government), though a part of 1984's damage records of public facilities under state government's administration and damage records of the same category in 1983 flood do not exist in an original data and are not classified in detail respectively. Some of damage records of public facilities under state administration were further collected from other departments of state government which administers the corresponding facility.

Damage records of private sector consisting of manufacturing industry and commercial sector were collected from SIC (Association of Commerce and Industry). Damage records of 1983 flood differs from those of 1984 flood in data arrangement. Since the former is arranged in such detailed way that shows damage amount to individual establishment, the more detailed analyses of flood damage can be conducted than damage records of 1984 flood where data are arranged in an aggregate base by municipality.

Many staffs of these two institutions were specially organized in order to collect and compile both damage records of public and private sectors. In this respect, the data can be useful in terms of comparing actual damage to probable flood damage to be simulated by the study team.

Data collection and interview survey were furthermore conducted to municipal government and its related organs of Blumenau and Gaspar in order to clarify damage condition and its effect on socio-economic circumstances.

2.2 Area-Depth-Duration of Past Large Scale of Floods

Inundation due to 1983 and 1984 floods is identified in area along the Itajai river and its tributaries in Blumenau-Gaspar stretch, shown in Fig.V.2.1. Inundation area due to 1983 and 1984 floods is about 39 km^2 consisting of 13 km^2 in Blumenau and 26 km^2 in Gaspar administratively. Tributaries along which inundation area spreads are the Garcia, Salto do Norte, Rio do Teste, Itoupava do Norte, Fortaleza, Belchior, and Saltinho rivers in Blumenau and Gaspar Grande, Sertao, Poco Grande, and Arraial rivers in Gaspar.

Inundation area in Blumenau is mostly identified from the confluence of the Garcia river to the confluence of the Itoupava do Norte river., whereas BR 470 (Federal Road) on the right bank side and riparian area on the left bank along the main river in the downstream from the confluence of the Garcia river to the confluence of the Belchior river was not widely inundated by taking the shape of narrow corridor because topographic conditions on both banks side are steep. Inundation in Gaspar stretch is mostly identified in the low-lying area. In

particular, green field through which Agua Negra and the Gaspar Grande rivers penetrate was vastly inundated due to overflown water from the tributaries. Inundation along tributaries are considered to be caused by overflow from these rivers due to high water level of the main river at the flooding time.

Administratively, the most affected Bairro (city ward, administrative unit) in Blumenau by inundation due to both floods was Bairro Garcia along the Garcia river, da Velha along the Velha river, and Zona Central, Itoupava Seca on the right bank side and Itoupava Norte on the left side of the main river. According to the report concerning to 1983 flood published by municipal government of Blumenau, 678 streets in urban area which is about 30% of total number of streets was inundated. Bairro Itoupava Norte was the most seriously affected area in terms of the number of streets under inundation, followed by Bairro Garcia. In Gaspar, the most affected Bairro in terms of inundation area was Coloninha, Gaspar Grande, Centro and 7 de Setembro which are situated on the right bank side of the main river.

Blumenau has a long history of floods. At each flooding year water level has been measured at Adolfo Konder bridge which is located just in the upstream of the confluence of the Garcia river. As shown in Table V.2.1, the maximum water level was recorded at 17.10 m in 1880, followed by water level of 16.90 m recorded in 1911. Floods occurred in 1983 and 1984 are considered to be almost the same scale of big floods as those mentioned above since water level at the time of flooding in 1983 and 1984 reached at near to 16 m respectively.

Some of houses near or along the Itajai river are located at the elevation of around 8 m. When water level reaches at 8 m, these areas become critical and those houses locating at the elevation lower than 8 m are easily inundated. At present, water level of 6 m is set out as warning level which gives riparian people an allowance time to be ready for evacuating or bringing out their valuable properties.

As mentioned before, a special report concerning to 1983 flood published by municipal government of Blumenau informs total number of streets under inundation in urban area. These streets are classified into several groups by an elevation between 8 m and 16 m. In Zona Central having an elevation between 10.5 m and 13.5 m, water depth ranged from nearly 6 m to 3 m at the maximum water level. In the streets of riparian area of tributaries having an elevation between 12 m and 14 m, water depth was between 1 m and 3 m depending on the location of houses which were interviewed during reconnaissance survey. In general, since urban area in Blumenau is characterized by undulating streets, even the same street has different elevation. That's why there were some streets where water depth was quite different location by location.

As far as water depth in Gaspar is concerned, water depth in riparian area along the Itajai river was between 0.5 m and 1.0 m on the right bank side and part of left bank side in the downstream from the confluence of the Sertao river. This level of low water depth can be conceivable since overflown water from the main river or tributaries extended to the depression area with an elevation of around 8 m. Water depth in inundation area caused by overflown water from the Gaspar Grande river and in riparian area along the main river in the upstream from the confluence of the Gaspar Grande river was averagely 0.5 m and 1.5 m respectively.

Duration of inundation in 1983 and 1984 floods was averagely 10 days and 5 days as a result of interview survey to local people in Blumenau and Gaspar.

2.3 Actual Flood Damage Records and Effects of Flood Damage on Socio-economic Conditions

Both municipalities of Blumenau and Gaspar suffered from a tremendous amount of direct damage due to 1983 and 1984 floods. Direct flood losses shown in Table V.2.2 are observable in all their aspects, where some data are not collectable owing to difficulty of access to original data.

The magnitude of both floods was so large that population affected by inundation was estimated to be about 80,000 in Blumenau and 14,000 in Gaspar. Compared to the entire population of both municipalities in the Census year of 1980, inundation population in Blumenau and Gaspar turn out to be 52% and 54%.

The number of houses affected by 1983 and 1984 floods are categorized by damageability condition such as destruction, damaged, and just under inundation. According to an interview survey at municipal government of Blumenau, many destroyed houses locating in riparian area at low elevation were wooden made ones with block type of foundation made of brick which is vulnerable to inundated water. Most of houses categorized as "damaged" suffered from structural vulnerability to inundation having long duration characterized by 1983 flood. Most of damaged houses with their body and roof being completely spoiled had to be reconstructed. During inundation, lots of resident people had to be evacuated. More than a half of affected population mentioned before was inundation population having to abandon their houses. Most of affected houses shown in Table V.2.2 are categorized as just "inundation", though it goes without saying that inundated houses were partly spoiled with minor damage to wall, gate, and electrical wiring inside houses.

Damage to private sector is principally composed of direct loss in manufacturing industries and commerce & service sectors' establishment. The sector of manufacturing industry in Blumenau and Gaspar was the most seriously damaged field in terms of the amount of direct flood loss since industrial sector has been the major economic activity, especially in Blumenau. About a half of industrial establishments in Blumenau and 40% of total industries in Gaspar was damaged in 1983 flood, whereas the number of damaged industries caused by 1984 flood in both municipalities was smaller than those spoiled due to 1983 flood. The amount of direct damage due to 1983 flood in Blumenau and Gaspar was estimated to be about 3.3% and 8.5% of yearly value added respectively, on condition that value added in Census year of 1980 is revalued at 1983 price level without considering real growth. The corresponding percentage in 1984 flood was estimated to be 2% in Blumenau and 5% in Gaspar.

Table V.2.3 shows the more detailed breakdown of flood damage due to 1983 flood by sub-sector of manufacturing industry in Blumenau. Most of damaged industries are a small size of establishment having employees less than five persons or a middle size of one where the number of employees ranges from 10 to 30. Total number of affected industrial worker was reported to be 20,187 which corresponds to about a half of all economically active population engaged in industrial sector.The most seriously damaged sub-sector in terms of employees and damage amount was

a sector of clothes and textile where there was a textile company having their employees more than 2,000 persons. Foods and metals were also the severely damaged sub-sector whose direct damage amount is a noticeable figure. Since the major industry in Blumenau has been characterized by textile with respect to its large size of production, textile industry faced with the opportunity loss of selling textile goods for export. Total amount of finance required for compensating for damaged properties or facilities almost became twice as much as damage amount. Due to heavy damage to production facilities, it took 53 days averagely for industrial companies to get back to normal operation.

There are miscellaneous types of establishments in commercial sector in Blumenau and Gaspar. Compared to the registered number of establishments in the corresponding sector in the Census year of 1980, about 72% and 24% of them in Blumenau and Gaspar experienced flood damage in 1983, and the same percentages in 1984 flood turned out to be 78% in Blumenau and 48% in Gaspar. On condition that yearly value added of this sector in 1980 is revalued at 1983 and 1984 price level, the ratio of direct damage to revalued value added in Blumenau and Gaspar is equivalent to 3% and 4.6% in 1983, and the same ratio in 1984 is estimated to be 1.2% and 1.6% in Blumenau and Gaspar. Although the number of damaged establishments was larger in 1984 than in 1983, the size of damage amount was larger in 1983 than in 1984 since it was partly because damaged establishments in 1984 flood were mostly small size, and partly because discipline of bringing final good to safety places out of inundated water was well performed. Tremendous amount of flood damage incurred by private sector due to both floods made entrepreneur or individual owners consider it serious to take countermeasures against disaster. Some dozens of small size of industry already moved to places out of inundation area. Some large factories installed their generators and water tanks which are to be used at a state of emergency since blackout and stoppage of water supply in disastrous time of flooding gave a fatal blow to their operation. Some of small size of establishments still faces with financial constraint which means that financial soundness can not be realized owing to accumulating heavy debt which was borrowed for re-operation after disaster.

Flood damage to public sector consists of various types of public facility such as school, sanitary facility, public facility, utility and transportation infrastructure administered by municipal or state government. Damage amount of public sector shown in Table V.2.2 indicates public fund required for reconstruction of numerous damaged facilities in 1983 and 1984 floods. Of which infrastructure relating to transportation was the most seriously damaged facility. As shown in Table V.2.4, there is a marked contrast in damage conditions of road system caused by both floods. Long duration of inundation due to consecutive rainfall in the flooding time of 1983 caused the landslip of shoulders of urban and rural streets,whereas damage to road system due to the flooding occurred in 1984 was rather characterized by erosion of road foundation and destruction of drainage system in urban area than landslide. Most of destroyed drainage pipe were small size with 40 cm in diameter.

Table V.2.4 also shows list of damaged bridge due to 1984 flood which was 22 in total. Bridges damaged by flooding water in Gaspar are wooden-made ones locating in tributaries, while most of damaged bridges in Blumenau are made of concrete of which three bridges crossing over the Itajai river play the important role in connecting between left and

right bank sides. Damaged portion of wooden bridge extended to overall bridge structure including abutment and pier, but abutment was the major part of damage in case of concrete bridge. The bridge crossing over the Itajai river which is called Ireneu Bornhausen locating in the main stream between the confluence of the Itoupava and Fortaleza river, was severely spoiled. Since this bridge is located at the low elevation, it was completely covered by flood water with rapid velocity of flow, resulting in utter destruction of its abutment and structure as well. The cost of repairing this bridge amounted to 250 thousand Cr$ which is more than four times of cost required for repairing others.

Due to serious damage to entire road system, it took more ten days to get back to normal traffic system after roads were out of inundation. The disturbance of transportation indirectly affected economic activities of the secondary and tertiary sectors. Lots of establishments which were not directly damaged by inundation due to 1983 and 1984 floods, are reported to suffer from the opportunity loss of selling goods because intermediate material required for producing final goods could not be transported properly.

Damage to public utility such as water supply system, distribution networks of electricity and telephone system administered by SAMAE, CELESC, and TELESC respectively was critical problem to socio-economic activities. Blumenau experienced the complete stoppage of water supply for about 10 days in 1983 and for 2 days in 1984 since intake pump and treatment facility were damaged. Since treatment facility was contaminated by flooding water, an urgent action was taken by SAMAE to put liquid type of chemicals into treatment facility for preventing drinking water from spoiling health condition of resident people. Besides, water meters of individual buildings totaling in about 7,000 ones which corresponds to a quarter of total water meters in Blumenau were thoroughly replaced in 1983.

Blumenau also experienced the complete stoppage of electricity supply for about 10 days in 1983 and 4 days in 1984. A generator locating in the left bank of the Itajai river, many posts plus transformers, and distribution networks were thoroughly damaged by flooding water. According to interview survey conducted at CELESC of Blumenau, it took a whole month to recover damaged facilities. CELESC having two water gauging stations along the main river has been scheduled to take an emergency action when water level becomes critical point. In fact, they immediately stopped the operation of sub-station locating in Central area. Like water meters, about 9,000 of damaged electric meters corresponding to a third of total meters in Blumenau were completely replaced in 1983.

Flood damage to communication system led to serious social disturbance since about 80% of registered telephones in Blumenau had been out of order for about one month in 1983 due to damage to amplifiers which function to level up voltage of direct current flowing in telephone circuit. However, the duration required for recovering telephone system in 1984 turned out to be just 10 days because amplifiers were installed at electric posts after 1983 flood.

The rest of damage to public sector consists of schools, sanitary facilities such as hospitals, and community centers having simple-clinic type of services, and miscellaneous kinds of social infrastructure like park, public buildings administered by municipal or state government. Although damage amount of sanitary facilities in Blumenau was negligible

due to no serious damage to big public hospitals in 1983 and 1984, the welfare and health section of municipal government conducted extensive services like supply of food plus medicine and dispatch of physicians to local community centers where inundation population evacuated temporarily. Since these services were thoroughly carried out in cooperation with CEDEC which is organized by voluntary civilians aiming at leveling up social service or implementing an emergency action in disastrous time, it was not observable that resident or evacuated people suffered from contaminated water and infectious diseases.

3. ESTIMATION OF PROBABLE INUNDATION AREA

Having fully analysed actual damage records of recent large scale of floods occurred in 1983 and 1984, the primal concern of flood damage study is ultimately to calculate damage amount by different magnitude of flood from which damage amount to be mitigated by the proposed structural plan of flood control will be derived as an aggregate benefit. For this purpose, the initial requirement for damage calculation is estimation of probable inundation area on which simulation of probable flood damage puts the basis. The meaning of probable inundation area is defined as the area to be inundated by whatever scale of flood.

Since river stretch of the Itajai river to be covered by an engineering study of flood control plan is about 32 km between the confluence of Arraial river and the point in the upstream about 8 km from the confluence of the Itoupava river, the extent of probable inundation area along the main river is based on above river stretch at first. Secondly, the actual flood water level of Blumenau in 1983 and 1984, and simulated flood water level of Gaspar stretch in the corresponding scale of flood are taken into an account in order to estimate the dimension of inundation area due to the same scale of flood as those occurred in 1983 and 1984 while referring to actual inundation area in 1983 and 1984 flooding time. Thirdly, probable inundation area to be caused by whatever scale of flood is delineated on the map with a scale of 1:10,000 by considering topographic conditions in Blumenau-Gaspar stretch.

The extent of probable inundation area is about 69 km^2 in total. This area is divided into several blocks consisting of one block like narrow corridor along the Itajai river and others in areas of tributaries. The division of probable inundation area into blocks is based on two reasons. One is for the purpose of benefit calculation to be conducted in project evaluation. Unmitigated flood damage in drainage-problem blocks and area where is easy to remain inundated due to overflow from tributaries must be subtracted from an overall benefit. The other is for the purpose of easiness of being able to calculate the number of various types of properties by block. As a result, the number of blocks turned to be 17. Probable inundation area in Blumenau-Gaspar stretch is shown in Fig.V.2.2.

4 PROCEDURE OF ESTIMATING DAMAGEABLE VALUE

4.1 General

Since delineation of probable inundation area becomes clear, the objective of this sub-chapter is to count on the number or area of identifiable properties by item and estimate unit value of them in this inundation area. The procedure of estimating damageable value will be conducted in the following way;

- Method of mesh survey by which land use and elevation are read out by mesh.
- Identification of various types of properties in probable inundation area.
- Preliminary socio-economic study in Blumenau and Gaspar related to probable inundation area.
- Estimate of the number or area of identified properties and of unit value of them at present and in the future level.

The increase of damageable property value is assessed by the augment rate of unit value and of the number of damageable property items.

4.2 Method of Mesh Survey

The probable inundation area is divided by meshes having intervals with 200 m which is equivalent to 4 ha. The elevation of the ground surface is read out by using topographic map with a scale of 1:10,000 or 1:2,000 in case of city area with low elevation. Parts of meshes in which contours of high elevation more than 25 m exist are eliminated because these parts are basically not inundation area caused by whatever scale of flood. As far as land use in probable inundation area is concerned, a socio-economist fully surveyed present land use condition which are classified into several items, namely, building area consisting of residence, industry, and commerce, farm land consisting of paddy and other crops, and pasture land. This sort of classification in land use is slightly different from the criteria of categorizing land use in socio-economic study because the objective of land use study in flood damage study is to estimate the value of properties relating to each land use condition. As a result, other type of land use such as bush, river is taken off from the criteria of land use required for flood damage study, and this area is treated as non-use with respect to present land use.

Table V.4.1 shows land use categories by block into which probable inundation area is divided. A further classification of land use by Bairro in each block is also shown in order to conduct the reliable estimate for the number of property's items.

4.3 Identification of Various Types of Properties in Probable Inundation Area

Having confirmed land use of each mesh based on topographic map with a scale of 1:10,000 or 1:2,000, a reconnaissance survey was conducted for the purpose of clarifying present land use of some areas which could not be identified by the topographic map. The recent development of

residential area along some tributaries in Blumenau is also fully taken into account in order to reflect present land use in this area precisely.

Since buildings of multi-stories more than two floors exist in central area of Blumenau, and indoor movables existing in stories upper than the second floor inside this type of building are not considered to be inundated, a rough estimation in terms of the number of multi-stories' buildings was conducted during a reconnaissance survey. Furthermore, it was also identified through the field investigation whether the quality of buildings in central area of Blumenau corresponds to luxurious type of them or not, for the purpose of building costs' calculation.

A rough estimation of the average value of indoor movables per an ordinary house was tentatively conducted by interviewing staffs working at the section of Social Study in FURB university and researching present price of various types of consumer goods.

4.4 Preliminary Socio-economic Study in Blumenau and Gaspar Related to Probable Inundation Area

The basic statistics of population and the number of building by type of them in urban area of Blumenau and Gaspar are rearranged on the basis of Bairros consisting of 30 Bairros in Blumenau and 11 Bairros in Gaspar. The projection of the number of houses by Bairro in Blumenau at present time is referred to the number of them estimated by municipal government of Blumenau in 1986, while laborious works of enumerating houses by Bairro in Gaspar were done by a socio-economist based on aero-photo maps with a scale of 1:25,000 since there are no data on population or houses by Bairro in Gaspar. The results of manual works help to count on the correct number of houses by Bairro in Gaspar at present time. The number of buildings such as industrial and commercial establishments by Bairro in Blumenau and Gaspar are based on statistical data on them supplied from municipalities.

According to Fig.IV.2.1 of socio-economic study, peripheral boundaries of the existing urban area correspond to administrative boundaries of Bairros. In Blumenau, the extent of probable inundation area is almost inside the existing urban area, whereas probable inundation area in Gaspar extends to rural area outside urban area. The number of Birros relating to probable inundation area is 23 in Blumenau, and 11 in Gaspar. Table 4.2 shows densities of population and buildings by type of them in each Bairro relating to probable inundation area. These data shown by Bairro are basically important to rearrange the same data by block in probable inundation area. The density of residences per ha of residential area is estimated by the division of net population density into family size.

The statistics about production value and value added by economic sector which are necessary for estimation of indoor movable in each type of building are basically derived from Census Data of industry and commerce sectors published by IBGE in 1980. The current value of production and value added by economic sector is estimated by adjustment factor like price escalation between 1980 and June of 1987, and real growth rate of production and value added per annum up to 1987. The Real growth rate of them in Blumenau and Gaspar is assumed to be 5% annually

in all economic sectors, which is equal to an annual growth of GRDP of Santa Catarina in real term.

As shown in Tables V.4.3 to 4.5, the estimation of value added is arranged in the form of unit value added per establishment. The value of input costs or intermediate products, and of gross sales or production is estimated by using the ratios of respective value to value added by economic sector in the level of state economy of Santa Catarina since the said ratios can not be obtainable by municipality. The value of indoor properties, and raw materials in case of industrial establishment follow suits preceding estimation procedure by using the ratio of respective value to value added and intermediated value respectively.

Table V.4.6 shows basic statistics for present condition of socio-economy in probable inundation area. Data classified by block consist of population and its density, plus the number of buildings by type of them and their density. The largest number of population and maximum population density are identified in flood prone area around the Garcia river, followed by that around the Velha river. The noticeable point is that a substantial number of residences and commercial establishments are scattered in inundation area along the Itajai river in Blumenau. In Gaspar, the number of population in blocks of Belchior; Saltinho, and unknown rivers is negligibly small, while large number of population is identified in areas along the Itajai river, and Gaspar Grade river. Industrial and commercial establishments are mostly concentrated in area along the main river.

Having clarified the present condition of socio-economy in probable inundation area, the requisite tool for estimating increase rate of buildings is forecast of population which is derived from land use plan supplied by a socio-economist. Land use plan in socio-economic study divides the existing urban rea into three zones, namely, 3 km, 5 km, 10-15 km zone centering Centro in Blumenau. Since a socio-economist determines the maximum population density in respective zone up to 2020, projection of population in the future is conducted by referring to the maximum residence density and residual capacity of residential area being able to absorb increase of population. Table V.4.7 illustrates projection of gross and net population density by Bairro. Population marked as "residual" indicates those being not able to be absorbed into the existing urban area. Eventually, those people will be obliged to settle down the area outside the said urban area.

Based on population forecast shown in Table V.4.7, an estimate of building density in selective year of 2000 and 2020 is illustrated in Table V.4.8. Residence density is calculated by division of net population density by family size. Commercial density is assumed to augment in proportion to the increase rate of residence density, but checked by considering the maximum density of commercial establishments per ha. In case of industrial establishments, the gross number of them is projected based on economically active population to be engaged in the secondary sector, and is then distributed into industrial area in each Bairro by considering the maximum density of industrial establishments.

4.5 Estimate of Unit Value of Properties and the Number of Them in Probable Inundation Area at Present and in the Future Level

4.5.1 Unit cost of building

Present unit cost per each type of building is estimated based on building cost per m^2, standard size of building and its salvage value. As shown in Table V.4.9, tax-based cost per m^2 in 1986 is multiplied by adjustment factors such as inflation and standard of difference between tax-based cost and market price in order to estimate the market value of buildings at current time.

4.5.2 Unit value of indoor movables by type of building

(1) Household effect

Unit value of household effect is estimated by referring to social statistics about household economy supplied from FURB university. The adjustment of original data to current value is based on price escalation up to June of 1987. Future unit value of household effect is assumed to increase in proportion to the augment rate of per Capita GRDP.

(2) Indoor movables of other type of buildings

Since basic calculation for estimating indoor movables per each type of establishment are shown in Tables V.4.3 to V.4.5, assumptions of stock period for different type of materials are necessary for estimating stock value by type of establishment.

In case of establishment in commercial sector, kinds of shops are classified into store for food, machine, and clothes, the percentage of each sales to total sales value was 15%, 30%, and 55% respectively. Then stock value of them can be estimated with different assumption of stock period by type of material.

As far as establishments in service sector are concerned, the components of indoor movables are classified into indoor properties and input cost. Input cost is furthermore divided into consumption plus merchant goods for service operation, and machine for activity. The percentage of respective input cost was 97% and 3% in 1980. Then, stock value of them can be estimated with different assumption of stock period by type of material.

In case of establishment in industrial sector, the contents of indoor movables are divided into indoor property, raw material, and final products to be sold. Since the respective ratio of three types of stock to production or value added in industrial sector are already estimated in Table V.4.3, stock value of them can be estimated with different assumption of stock period by type of material.

The result of present and future unit value of indoor movables in selective year of 2000 and 2020 are shown in Table V.4.10. Unit values of indoor movables in commercial and service sectors are combined into a single figure.

4.5.3 Unit value of crops and livestock

The damageable value of crops per ha is to be estimated as expected net income plus accumulated production cost spent at the time when a flood occurs. The damageable value calculated as the expected value is the sum of probable value of net income plus production cost through the year. Probability required for the calculation of expected value is based on seasonal frequency of floods.

Parameters to be required for estimating damageable value of paddy in paddy field and maize in upland are cropping pattern, planted area, seasonal frequency of flood and basic agro-economic indicators such as yield, farm gate price, and production cost. The results of damageable value of paddy and maize in Blumenau and Gaspar are shown in Fig.V.4.1 and 4.2. Livestock value per ha in Blumenau and Gaspar is estimated based on Agriculture Census of 1984, and is shown in Table V.4.11.

4.5.4 Present and future building density

As mentioned before in sub-chapter 3, probable inundation area is divided into blocks. Present and future building density by type of building and block is estimated based on Table V.4.1 showing land use, and Table V.4.8 indicating building density by Bairro. The results of them are shown in Table V.4.12. Furthermore, building cost and indoor movables per ha by type of establishment and block are also illustrated in Table V.4.13 for the purpose of comparing density of property's value by block.

5. PROBABLE FLOOD DAMAGE

5.1 Area-Depth-Duration Analysis

Area-depth-duration analysis is made using the following probable flood peak discharge flowing into Blumenau-Gaspar river stretch under present river condition estimated by flooding pattern on Dec.1978, Dec.1980, Jul.1983 and Aug.1984;

Return Period (year)	Probable Flood Peak Discharge							
	Blumenau				Gaspar			
	1978	1980	1983	1984	1978	1980	1983	1984
2	2,160	2,230	1,870	2,260	2,180	2,240	1,910	2,280
5	2,660	2,760	2,320	2,800	2,700	2,770	2,360	2,820
10	3,000	3,130	2,890	3,150	3,030	3,130	2,890	3,170
25	3,450	3,610	3,730	3,600	3,480	3,600	3,750	3,610
50	3,930	4,080	4,880	4,090	3,960	4,070	4,900	4,090
100	4,390	4,550	5,490	4,460	4,420	4,550	5,510	4,470

For converting the flood peak discharge to water level, water level-discharge curve based on topographic information from 1/10,000 or 1/2,000 and river cross section of average interval of 300 m was established by non-uniform flow calculation under the following roughness coefficient;

- Present river course ; 0.035 and
- Flooding area; 0.05.

Inundation area, depth and its duration in Blumenau-Gaspar river stretch are listed in Table V.5.1 against the above probable floods, and inundation map of 10-year probable flood, which is equivalent to design scale of provisional flood control plan, is illustrated in Fig.V.5.1.

Inundation area, depth and its duration due to 1980's flood pattern is almost the same as the equivalent results caused by 1984's flood since probable flood peak discharge represents the similar results by return period. Flood pattern in 1983 is characterized by long duration and an extensive size of inundation area where the magnitude of flooding reaches to return period more than 50 years.

5.2 Damage Rate

The damage rate of direct damage are assumed as follows;

- With respect to crops, buildings, and indoor movables standard rate developed by Ministry of Construction, Japan shown in Table V.5.2 is taken as the approximate damage rate conceivable in Brazil.

- Damage rate of livestock is assumed to be 100% if water depth is more than 2 m since lots of cattle were drowned in 1983 flooding with water depth more than 2 m.

- The damage rate of infrastructure to other direct damage is assumed to be 29% which is also referred to in Master Plan study.

Indirect flood losses are the net economic losses of goods and services to the nation due to interruption of industry, commerce, service, traffic, communication, and other activities. Indirect losses incurred in manufacturing and comercial sector are estimated based on multiplication of sales loss during operation stop by the number of effected companies. Operation loss of public utilities and emergency relief cost are derived from the Report issued by Special Secretariart for the Rebuilding of the State.

Although the amount of indirect damage was actually larger than direct damages in 1983 flood being equivalent to 50 years scale of flood, the damage rate of indirect damage to direct damages is assumed to be 10% in a conservative way.

5.3 Probable Flood Damage

Probable flood damage by different scale of flood is simulated at present and in the future level by different type of flood occurred in the past, namely, in 1978, 1980, 1983 and 1984 as shown in Tables V.5.3 to V.5.6. The annual mean flood damages in the above flood patterns are projected at 533 million Cz$, 611 million Cz$, 477 million Cz$ and 606 million Cz$, respectively. The maximum annual mean flood damage of 611 million Cz$ in 1980 flood pattern corresponds to 0.6% of projected GRDP (90,850 million Cz$) in Blumenau and Gaspar area in 1987.

Among probable flood damage simulated by different type of flood in 1978, 1980, 1983, and 1984, 1984 type of flood shows the maximum amount of probable flood damage in case of 10 year scale of flood which is the design flood to be applied to the provisional flood control plan. The direct flood damage at 1987 development level is projected to be about 1,220 million Cs$ which corresponds to 1.3% of projected GRDP in Blumenau-Gaspar area. Damage to buildings plus their indoor movables belonging to the secondary and tertiary sectors shares about 64% of total direct damage, while crop damage is utterly negligible. Areal characteristics of direct flood damage is explained in such that damage to commercial sector and residences are outstanding in area along the Garcia and Velha rivers. Damage to industrial establishments is mostly identified in area along the Itoupava river. Direct flood damage at 2000 development level is projected to be about 4,500 million Cz$ in Blumenau-Gaspar area. The increase of flood damage in future level is caused by the augment of properties' value.

Tables

Table V.2.1 PAST FLOOD WATER LEVEL AT ADOLFO KONDER BRIDGE IN BLUMENAU

Year	Date		Water Level (m)	Year	Date		Water Level (m)
1852	Oct.	29	16.30	1948	May	17	11.85
1855	Nov.	20	13.30	1950	Oct.	17	9.45
1862	Nov.	1	9.00	1953	Nov.	1	9.65
1864	Sep.	17	10.00	1954	May	8	9.56
1868	Nov.	27	13.30	1954	Nov.	22	12.53
1870	Oct.	11	10.00	1955	May	20	10.61
1880	Sep.	23	17.10	1957	Jul.	21	9.33
1891	Jun.	18	13.80	1957	Aug.	2	10.65
1898	May	1	12.80	1957	Aug.	18	13.07
1900	Jun.	1	12.80	1961	Sep.	12	10.35
1911	Oct.	2	16.90	1961	Sep.	30	9.63
1911	Oct.	29	9.86	1961	Nov.	1	12.49
1923	Jun.	2	9.00	1962	Sep.	21	9.29
1925	May	14	10.30	1963	Sep.	29	9.67
1926	Jan.	14	9.50	1966	Feb.	13	10.07
1927	Oct.	9	12.30	1969	Apr.	6	10.14
1928	Jun.	18	11.76	1971	Jun.	9	10.35
1928	Aug.	15	10.82	1972	Aug.	27	11.05
1931	May	2	11.05	1972	Aug.	29	11.35
1931	Sep.	11	10.50	1973	Jun.	25	11.30
1931	Sep.	14	11.25	1973	Jul.	28	9.35
1931	sep.	18	11.53	1973	Aug.	29	12.35
1932	May	25	9.75	1975	Oct.	4	12.63
1933	Oct.	4	11.85	1978	Dec.	26	11.50
1935	Sep.	24	11.65	1979	May	10	9.95
1936	Aug.	6	10.40	1979	Oct.	9	10.45
1939	Nov.	27	11.45	1980	Dec.	22	13.27
1943	Aug.	3	10.50	1983	Jul.	9	15.34
1946	Feb.	2	9.45	1984	Aug.	7	15.46

Source : FURB University Projeto Crise

Table V.2.2 ACTUAL FLOOD DAMAGE RECORDS IN BLUMENAU AND GASPAR

No	Item	Unit	1983		1984	
			Blumenau	Gaspar	Blumenau	Gaspar
1.	Affected population	person	50,000	12,400	80,000	14,000
2.	Affected houses	number				
	2.1 Destruction		220	102	-	54
	2.2 Damaged		300	217	-	325
	2.3 Inundation		20,000	2,450	-	2,900
3.	Damage to private sector	10^{6}Cr$				
	3.1 Industry		10,649	2,492	19,643	4,390
	3.2 Commerce & Service		7,551	308	8,882	348
4.	Damage to public sector	10^{6}Cr$				
	4.1 School					
	State		159	33	-	-
	Municipal		222	10	488	18
	4.2 Sanitary facility					
	State		4	6	-	-
	Municipal		80	10	50	18.2
	4.3 Municipal facility				1,207	49
	4.4 Public utility		588	120		
	Water supply (SAMAE)				300	16
	Electricity (CELESC)					
	4.5 Transportation					
	Road		1,943		9,164	679
	Bridge		20		551	101
	Machine		47		135	69

Source : Damage to public sector (GAPLAN, Municipal government)
Damage to private sector (SIC, Industryand Commerce Association)

Table V.2.3 ACTUAL DAMAGE OF INDUSTRY IN BLUMENAU DUE TO 1983 FLOOD

Kind of Industry	No. of Industry	No.of Employees (person)	Direct Damage (10⁶Cr$)	Loss of Export (10⁶Cr$)	Loss of Operation (day)	Required Finance (10⁶Cr$)
Mineral	5	184	39.6	0	42	84.3
Mineral products	25	202	241.2	0.3	58	257.2
Metal	37	1,651	368.2	0.07	50	1,644.8
Machine	20	276	185.2	0	68	420.0
Electrical goods	4	16	40.6	0.03	60	50.7
Transportation goods	4	83	70.7	0	45	94.5
Timber	15	185	316.7	0	44	250.1
Furniture	33	351	343.0	0.07	54	320.3
Paper	3	75	32.2	0	30	59.8
Leather	1	0	1.0	0	30	1.2
Chemical	3	20	22.1	0	30	26.6
Pharmaceutical	1	118	469.0	0	60	-
Perfume	1	9	0.9	0	30	-
Plastic goods	8	270	289.4	0.04	45	331.9
Textile	10	2,433	2,185.6	1.5	51	5,836.6
Clothes	44	8,504	3,663.4	0	47	4,929.2
Food	29	1,431	781.8	0	58	878.2
Beverage	2	189	158.2	0	45	1,053.1
Cigarrette	1	734	-	0	60	-
Printing	17	352	596.0	0	58	567.3
Others	19	3,104	844.2	0	55	4,616.4
Total	282	20,187	10,649.2	2.0	53	21,422.2

Source : SIC (Industry and commerce association)

Table V.2.4 DAMAGE RECORD OF ROAD SYSTEM

Damage of Road System in Blumenau unit 10⁶Cr$

	Land slide/ Rehabilitation	Foundation	Pavement	Drainage System	Bridge	Equipment	Total
1983	904	409	554	116	20	7	2,010
	(45)	(20)	(28)	(6)	(0.9)	(0.1)	(100)
1984	862	3,415	2,504	2,383	551	135	9,850
	(9)	(35)	(25)	(24)	(6)	(1.0)	(100)

Note: Parentheses indicates percentage

List of Damaged Bridge in 1984

Location	River/ Tributary	Material	Size (m)			Damage
			width	length	height	(10⁶Cr$)
Gaspar						
1. Margem Esquerda	Morro Grande	Concrete	5.0	8.0	4.5	9.5
2. Poco Grande	Arraial	Wood	5.0	8.0	5.0	26.0
3. Gaspar Grande	Gaspar Grande	Wood	4.0	9.0	3.0	12.0
4. Margem Esquerda	Sertao		8.0	-	6.0	17.0
5. Lagoa	Pocinho	Wood	4.0	4.0	-	6.0
6. Estrada Reinert	Souza	Wood	4.0	9.0	4.0	8.0
7. Travessa Lagoa	Pocinho	Mix	6.0	6.0	3.0	5.0
8. Sertao	Sertao	Wood	4.0	2.0	1.0	1.0
9. Estrada dos Poffo	Souza	Mix	5.0	10.0	3.0	7.5
10. Belchior Baixo	Belchior	Wood	4.0	12.0	6.0	9.0
Blumenau						
1. Santa Catarina	Itajai	Concrete	9.6	168.0	18.0	250.0
2. Johann Hadlich	Branco	Concrete	10.0	8.0	4.0	44.0
3. Fellpe Jensen	Itoupava	Concrete	10.0	10.0	4.0	53.0
4. Rudibert Krueger	Itoupava	Concrete	10.0	12.0	4.0	55.0
5. República Argentina	Itajai	Concrete	12.0	170.0	12.0	60.0
6. Antonio Zendron	Garcia	Concrete	12.0	35.0	6.0	12.0
7. Mariana Brunemann	Velha	Concrete	10.0	22.0	4.0	11.0
8. General Osorio	Velha	Concrete	10.0	25.0	4.0	10.0
9. Antonio Thesis	Itajai	Concrete	12.0	190.0	16.0	15.0
10. Sold Moacir Pinheiro	Garcia	Concrete	-	30.0	-	6.0
11. Manaus	Garcia		-	33.0	-	7.0
12. Itororo	Velha	Concrete	10.0	25.0	6.0	25.0

Source : Gaplan

Table V.4.1 LAND USE BY BAIRRO IN EACH BLOCK

Block	Bairro	Land Use (ha)								
		Building			Crop		Green	Pasture	No-use	Total
		R	I	C	P	O				
1. Blumenau										
IT 3	Centro	0	0	25	0	0	0	0	10	35
	Boa Vista	17	0	0	0	0	6	0	8	31
	Ponta Agua	181	0	36	0	0	6	0	72	295
	Vorstadt	100	0	53	0	0	16	0	50	219
IT 4	Do Salto	84	0	9	0	0	0	0	38	131
	Itoupava Seca	66	31	32	0	0	0	0	10	139
	Boa Vista	38	6	12	0	0	0	0	18	74
	Itoupava Norte	100	0	84	0	0	0	0	31	215
	Ponta Agua	8	0	10	0	0	0	0	5	23
	Salto do Norte	33	0	7	0	0	7	0	12	59
Velha	Centro	25	0	18	0	0	0	0	0	43
	Petropolis	10	0	1	0	0	0	0	0	11
	Da Velha	84	0	66	0	0	57	0	0	207
	Victor Konder	28	8	15	0	0	0	0	0	51
	Vila Nova	26	0	16	0	0	1	0	0	43
	Do Asilo	10	5	16	0	0	0	0	0	31
Fortaleza	Itoupava Norte	64	0	19	0	0	8	0	0	91
	Fortaleza	126	0	0	0	0	17	0	0	143
Salto do Norte	Salto do Norte	90	27	8	0	0	5	0	0	132
Itoupava	Itoupava Norte	39	0	3	0	0	0	0	0	42
	Fortaleza	30	2	0	0	0	0	0	0	32
	Salto do Norte	30	13	0	0	0	0	0	0	43
	Itoupavazinha	23	106	9	0	0	1	0	0	139
	Itoupava Cen	93	80	0	0	0	8	0	1	182
	Fidelis Vista	24	0	0	0	0	0	0	0	24
Garcia	Centro	9	2	11	0	0	0	0	0	22
	Jardin Blu	15	0	20	0	0	0	0	0	35
	Bom Retiro	17	3	0	0	0	10	0	0	30
	Riberao Fresco	48	0	10	0	0	12	0	0	70
	Do Garcia	144	20	52	0	0	3	0	0	219
	Villa Formosa	12	0	3	0	0	4	0	0	19
	Valparaiso	31	0	0	0	0	8	0	0	39
2. Gaspar										
IT 1	Centro	12	7	18	0	0	3	0	6	46
	Nova Espaeranca	2	2	0	0	0	0	0	0	4
	G. Grande	0	0	1	0	0	0	0	2	3
	Colninha	25	7	0	0	0	0	0	18	50
	M. Esqierda	78	0	5	0	0	10	0	42	135
	Rua Itajai	93	17	7	0	0	5	0	49	171
	Sete Setembro	23	0	4	0	0	0	0	0	27
	S. Ferezinha	1	0	2	0	0	0	0	0	3
	Rural	73	0	0	15	0	16	0	51	155
IT 2	G.Grande	0	0	0	0	0	4	0	0	4
	Fiqueira	14	10	0	0	0	1	0	18	43
	Bela Vista	108	14	3	0	0	16	0	74	215
	Rural	40	1	0	21	0	121	0	67	250
Belchior	Rural	8	0	0	179	5	88	0	0	280
Saltinho	Rural	8	0	0	0	48	44	0	0	100
U1	Rural	1	0	0	0	0	27	8	0	36
U2	Rural	5	0	0	0	0	39	0	0	44
G. Grande	Gasparinho	18	0	5	2	0	2	0	0	27
	G.Grande	40	0	7	0	0	0	0	0	47
	Colninha	54	3	2	0	13	0	10	0	82
	Figueira	54	0	0	0	0	19	45	0	118
	Rural	32	0	0	330	68	210	40	0	680
Do Sertao	M.Esqierda	72	0	0	19	0	8	87	0	186
	Rural	11	0	0	17	0	17	75	0	120
Arraial	Rural	44	0	0	266	5	31	0	2	348
P. Grande	Sete Setembro	46	0	0	0	0	10	0	0	56
	Rural	29	0	0	0	223	137	307	0	696
Total		2508	369	599	950	362	485	993	594	6860

Note : R-Residence I-Industry C-Commerce
P-Paddy O-Other crop

"Rural" shown in the column of Bairro in the above table indicates the area outside the existing urban area consisting of Bairro in Blumenau and Gaspar municipalities

"IT" shown in the column of Block means probable inundation area along the Itajai river.

Table V.4.2 POPULATION AND BUILDING DENSITY BY BAIRRO RELATING TO PROBABLE INUNDATION AREA AT PRESENT LEVEL

Bairro	Family Size (person/house)	Net Density (person/ha)	Residence Density (Est/ha)	Industry Density (Est/ha)	Commerce Density (Est/ha)
Blumenau					
Centro	4.4	145.5	33.1	12.2	30.9
Jardin Blu	4.3	77.3	18.0	-	2.9
Bom Retiro	4.4	54.6	12.4	0.2	6.7
Petropolis	4.3	57.2	13.3	-	27.0
Da Velha	3.9	29.9	7.7	3.7	6.0
Victor Konder	4.7	87.4	18.6	3.6	11.0
Vila Nova	3.7	66.6	18.0	5.5	4.8
Do Asilo	5.4	42.4	7.9	2.5	6.3
Do Salto	3.4	26.9	7.9	1.0	2.0
Itoupava Seca	3.1	36.5	11.8	1.8	8.1
Boa Vista	5.1	29.1	5.7	-	9.0
Itoupava Norte	3.2	25.9	8.1	5.7	2.7
Ponta Aguda	5.1	25.0	4.9	-	3.8
Vorstadt	4.8	28.0	5.8	-	2.9
Ribeirao Fresco	4.9	31.4	6.4	-	4.8
Do Garcia	4.5	46.5	10.3	4.7	7.0
Vila Formosa	3.8	24.7	6.5	-	3.1
Fortaleza	3.8	20.4	5.4	0.8	-
Salto do Norte	4.7	29.0	6.2	0.4	6.8
Itoupavazinha	3.5	9.3	2.7	0.2	-
Itoupava Central	5.0	6.5	1.3	0.4	-
Fidelis	4.0	6.4	1.6	-	-
Valparaiso	5.7	47.5	8.3	-	-
Gaspar					
Centro	4.4	29.5	6.7	5.0	8.4
Nova Esperanca	4.4	39.3	8.9	5.5	7.7
Gasparinho	4.4	22.4	5.1	4.5	6.0
G.Grande	4.4	20.3	4.6	4.8	7.5
Coloninha	4.4	12.9	2.9	1.2	5.6
M.Esquerda	4.4	17.2	3.9	1.4	5.6
Rua Itajai	4.4	12.1	2.8	0.5	2.6
sete Setembro	4.4	21.8	5.0	1.3	4.1
S.Terezinha	4.4	18.2	4.1	1.1	5.0
Figueira	4.4	15.8	3.6	1.3	4.8
Bela Vista	4.4	17.0	3.9	1.1	6.1
Rural	4.4	9.4	2.1	0.0	0.0

Note :
Net density - Population density per ha of residential area.
Residence density - The number of houses per ha of residential area.
Industry density - The number of industrial Est. per ha of industrial area.
Commerce density - The number of commercial Est. per ha of commercial area.

Table V.4.3 BASIC CALCULATION FOR ESTIMATING INDOOR MOVABLES PER INDUSTRIAL ESTABLISHMENT.

(1) Estimation of Unit Value Added per Establishment

Unit : 10^3 Cr$

		Blumenau		Gaspar	
	Deflator	Current	Cons't /1	Current	Cons't /1
1980	100	54,783	54,783	20,359	20,359
1987	95,400 /2	73,539,090	77,085 /3	27,329,238	28,647

Note: /1 1980 constant price

/2 Estimation based on GAPLAN's publication for GRDP deflator and current inflation index.

/3 Real growth rate of unit value added is estimated to be 5% per annum.

The objective of this table is to project unit value added at 1987 price.

The average of unit value added of a manufacturing establishment in two cities is estimated to be 50.0 x 10^6Cz$

(2) Estimation of Intermediate value and Gross production

Unit: 10^6Cz$

Intermediate value	50.0 x 1.8 /1
Gross production value	50.0 x 2.8 /2

Note: /1, /2. These figures indicate the ratio of respective value to value added, which was estimated on the basis of GAPLAN's publication

(3) Estimation of Indoor Property, Raw Material, Gross Production per Establishmnet at 1987 price

Unit: 10^6Cz$

Indoor property	50.0 x 0.3/1
Raw material	50.0 x 1.8 x 0.8/2
Gross production	50.0 x 2.8

Note: /1 This figure means the average ratio of indoor property to value added.

/2 This figure means the average ratio of raw material to intermediate value.

Table V.4.4 BASIC CALCULATION FOR ESTIMATING INDOOR MOVABLES PER ESTABLISHMENT OF SERVICE SECTOR

(1) Estmimation of Unit Value Added per Establishment

Unit : 10^3 Cr$

		Blumenau		Gaspar	
	Deflator	Current	Cons't	Current	Cons't
1980	100	9,112	9,112/1	4,019	4,019/1
1987	95,400	12,230,250	12,820/2	5,394,870	5,655/2

Note : /1 Unit value added per establishment at 1980 constant price based on Censo dos Servicos (IBGE).

/2 Real growth rate of unit value added is estimated to be 5% per annum.

The objective of this table is to project unit value added per establishment at 1987 price.

The average of unit value added of a service establishment in two cities is estimated to be 9.2 x 106 Cz$.

(2) Estimation of Indoor Property, Input Costs per establishment at 1987 price

Unit:10^6Cz$

Indoor property	Unit value added x 0.06 /1=	0.55
Input costs	Unit value added x 0.06 /1=	0.55

Note: /1 These figures indicate the average ratio of respective value to total value added of service sector in 1980 based on Censo dos Servicos (IBGE).

Table V.4.5 BASIC CALCULATION FOR ESTIMATING INDOOR MOVABLES PER COMMERCIAL ESTABLISHMENT.

(1) Estimation of Unit Sales Value per Establishment

Unit : 10^3 Cr$

		Blumenau		Gaspar	
	Deflator	Current	Cons't /1	Current	Cons't /1
1980	100	20,959	20,959 /2	3,838	3,838 /2
1987	95,400	28,134,414	29,491 /3	5,151,600	5,400 /3

Note: /1 1980 constant price

/2 Unit Sales value per establishment at 1980 cons't price based on Censo Comercial (IBGE).

/3 Real growth rate of unit sales value is estimated to be 5% per annum.

The objective of this table is to project unit sales value per establishment at 1987 price.

The average of unit sales of a commercial establishment in two cities is estimated to 17.5 x 106Cz$.

(2) Estimation of Unit Value Added per Establishment

Unit:106Cz$

Unit value added	17.5 / 5.4 /1

Note: /1 This figure indicates the ratio of value added to sales value in 1980 based on census of commercial sector (IBGE).

(3) Estimation of Indoor Property, Gross value of Sales per Establishment at 1987 price.

Unit:106Cz$

Indoor property	Unit value added x 0.16 /1=0.51
Gross sales value	unit sales value=17.5

Note : /1 This figure indicates the average ratio of indoor property to unit value added in 1980 based on census of commercial sector (IBGE).

Table V.4.6 SOCIO-ECONOMIC DATA IN PROBABLE INUNDATION AREA

Block	Land use (ha)	Population		Residence		Industry		Commerce		Est. density		
		Number	Density (person/ha)	Number	Area (person/ha)	Number	Area (person/ha)	Number	Area (person/ha)	Residence per/ha	Industry per/ha	Commerce per/ha
Blumenau												
IT 3	584	7,840	13.4	1,571	298	0	0	1,083	115	5.2	0.0	9.3
IT 4	656	9,580	14.6	2,723	329	56	37	704	154	8.2	1.8	4.5
Velha	392	11,450	29.2	2,699	185	42	13	1,373	134	14.6	3.2	10.0
Fortaleza	236	4,250	18.0	1,199	190	0	0	51	19	6.3	0.0	2.7
Salto do Norte	132	2,630	19.9	560	90	10	27	57	8	6.2	0.4	6.8
Itoupava	468	3,480	7.4	887	240	65	203	15	13	3.7	0.3	2.7
Garcia	440	13,610	30.9	2,963	280	128	26	845	98	10.5	4.8	8.5
Gaspar												
IT 1	604	440	7.4	1,012	308	64	34	253	40	3.3	1.9	6.3
IT 2	516	2,440	4.7	553	162	28	25	19	3	3.4	1.2	6.1
Belchior	280	75	0.3	17	8	0	0	0	0	2.1	0.0	0.0
Saltinho	100	75	0.8	17	8	0	0	0	0	2.1	0.0	0.0
U1	36	10	0.3	2	1	0	0	0	0	2.1	0.0	0.0
U2	44	50	1.1	11	5	0	0	0	0	2.1	0.0	0.0
G.Grande	964	3,100	3.2	704	198	4	3	93	14	3.5	1.2	6.7
Do Sertao	308	1,360	4.4	308	83	0	0	0	0	3.7	0.0	0.0
Arraial	348	410	1.2	92	44	0	0	0	0	2.1	0.0	0.0
P.Grande	752	1,270	1.7	288	75	0	0	0	0	3.9	0.0	0.0

Table V.4.7 ESTIMATION OF POPULATION AND ITS DENSITY BY BAIRRO IN EXISTING URBAN AREA

Bairro	1987			2000			2020		
	P	G.D	N.P	P	G.D	N.P	P	G.D	N.P
(1) 3 km zone									
Blumenau									
Centro	4,221	46.9	145.5	4,802	53.4	165.6	5,510	61.2	190.0
Jardim Blumenau	927	30.9	77.3	1,365	45.5	113.8	1,899	63.3	158.0
Bom Retiro	1,850	7.4	54.6	4,326	17.3	127.2	7,340	29.4	215.9
Petropolis	1,715	34.3	57.2	2,492	49.8	83.1	3,439	68.8	114.6
Victor Konder	1,832	45.8	87.4	2,209	55.2	105.2	2,669	66.7	127.1
Boa Vista	2,562	18.3	29.1	5,799	41.4	65.9	9,740	69.6	110.7
Ponta Aguda	9,246	13.8	25.0	25,466	38.0	68.8	45,210	67.5	122.2
Vorstadt	5,304	13.6	28.0	14,470	37.1	76.2	25,629	65.7	134.9
Riberao Fresco	2,460	12.3	31.4	7,038	35.2	90.2	12,610	63.1	161.7
Do Garcial	16,592	24.4	46.5	29,575	43.5	82.8	45,379	66.7	127.1
Villa Formosa	1,189	4.1	24.7	5,330	18.4	111.0	10,370	35.8	216.0
Sub-total	47,898	16.9	38.1	102,872	36.4	81.8	169,795	60.0	135.1
(2) 3-5 km zone									
Blumenau									
Da Velha	24,833	11.3	29.9	27,133	12.4	32.7	29,932	13.7	36.1
Vila Nova	7,396	41.1	66.6	7,396	41.1	66.6	7,396	41.1	66.6
Do Asilo	15,972	23.8	42.4	15,972	23.8	42.4	15,972	23.8	42.4
Itoupava Seca	4,013	21.1	36.5	4,070	21.4	37.0	4,140	21.8	37.6
Itoupava Norte	13,407	18.4	25.9	15,560	21.3	30.0	18,180	24.9	35.1
Fortaleza	13,636	15.5	20.4	17,650	20.1	26.5	22,537	25.6	33.8
Valparaiso	5,697	21.9	47.5	5,697	21.9	47.5	5,697	21.9	47.5
Sub-total	84,954	16.7	31.1	93,478	18.3	34.2	103,854	20.4	38.0
(3) 10-15 km zone									
Blumenau									
Do Salta	3,665	16.7	26.9	3,883	17.7	28.6	4,148	18.9	30.5
Da Gloria	8,345	21.4	93.8	8,345	21.4	93.8	8,345	21.4	93.8
Prgresso	10,089	10.7	41.5	10,089	10.7	41.5	10,089	10.7	41.5
Salto do Norte	6,093	10.5	29.0	6,258	10.8	29.8	6,458	11.1	30.8
Salto Weisbach	1,894	4.7	11.5	3,166	7.9	19.2	4,715	11.8	28.6
Passo Manso	2,620	4.0	8.0	5,600	8.6	17.1	9,230	14.2	28.1
Bandenfult	2,116	5.2	11.1	3,619	8.8	18.9	5,448	13.3	28.5
Fidelis Vista	321	6.4	6.4	806	16.1	16.1	1,397	27.9	27.9
Itoupava Zinha	3,516	3.3	10.1	6,400	6.1	18.3	9,910	9.4	28.4
Itoupava Central	7,042	4.3	6.5	17,580	10.7	16.2	30,410	18.5	27.9
testa Salta	2,225	3.5	4.1	8,055	12.6	14.7	15,153	23.7	27.7
Sub-total	47,926	6.9	14.1	73,801	10.6	21.7	105,303	15.1	31.0
Residual /1				15,940			35,845		
Gaspar									
Coloninha	1,106	7.9	12.9	1,810	12.9	21.0	2,656	19.0	30.9
Figueira	1,529	8.5	15.8	2,195	12.2	22.6	2,996	16.6	30.9
Bela Vista	4,201	12.4	17.0	5,759	16.9	23.3	7,633	22.5	30.9
Centro	767	12.8	29.5	785	13.1	30.2	806	13.4	31.0
Nova Esperanca	471	23.6	39.3	471	23.6	39.3	471	23.6	39.3
Gasparinho	941	15.7	22.4	1,104	18.4	26.3	1,300	21.7	30.9
G.Grande	772	12.9	20.3	995	16.6	25.1	1,175	19.6	30.9
Mongem Esqierda	2,963	8.7	17.2	4,031	11.9	23.4	5,315	15.6	30.9
Rua Itajai	1,894	6.1	12.1	3,221	10.4	20.6	4,817	15.5	30.9
Sete Setembro	2,285	13.4	21.8	2,722	16.0	25.9	3,248	19.1	30.9
S.Ferezinha	1,979	13.2	18.2	2,616	17.4	23.9	3,369	22.5	30.9
Sub-total	18,908	10.3	17.3	25,709	14.0	23.5	33,786	18.5	31.0
Residual /1				4,765			11,505		

Note : P - Population
G.D - Gross density of population
N.D - Net density of population per ha of residential area

/1 Residual means population being not able to be absorbed into existing urban area.
/2 Figures shown in "Sub-total" indicates total population and an average gross and net density of population.

Table V.4.8 ESTIMATION OF BUILDING DENSITY PER HA BY BAIRRO RELATING TO PROBABLE INUNDATION AREA

Unit : Est./ha

Bairro	1987			2000			2020		
	R	I	C	R	I	C	R	I	C
(1) 3 km zone									
Blumenau									
Centro	33.1	12.2	30.9	36.8	12.2	34.4	42.2	12.2	39.4
Jardim Blumenau	18.0	-	2.9	25.2	-	4.1	35.2	-	5.7
Bom Retiro	12.4	0.2	6.7	28.3	0.7	15.3	48.0	1.2	25.9
Petropolis	13.3	-	27.0	18.5	-	37.6	25.5	-	48.0
Victor Konder	18.6	3.6	11.0	23.4	3.9	13.8	28.2	4.3	16.7
Boa Vista	5.7	-	9.0	14.6	-	23.1	24.6	-	38.8
Ponta Aguda	4.9	-	3.8	15.3	-	11.9	27.2	-	21.1
Vorstadt	5.8	-	2.9	16.9	-	8.5	30.0	-	15.0
Riberao Fresco	6.4	-	4.8	20.0	-	15.0	35.9	-	26.9
Do Garcial	10.3	4.8	7.0	18.4	5.0	12.5	28.2	5.4	19.2
Villa Formosa	6.5	-	3.1	24.7	-	11.8	48.0	-	22.9
(2) 3-5 km zone									
Blumenau									
Da Velha	7.7	3.7	6.0	8.4	4.1	6.5	9.3	4.6	7.2
Vila Nova	18.0	5.5	4.8	18.0	5.8	4.8	18.0	6.2	4.8
Do Asilo	7.9	2.5	6.3	7.9	2.9	6.3	7.9	3.4	6.3
Itoupava Seca	11.8	1.8	8.1	11.9	2.3	8.2	12.1	2.9	8.3
Itoupava Norte	8.1	5.7	2.7	9.4	5.9	3.1	11.0	6.3	3.7
Fortaleza	5.4	0.8	-	7.0	1.3	-	8.9	1.9	-
Valparaiso	8.3	-	-	8.3	-	-	8.3	-	-
(3) 10-15 km zone									
Blumenau									
Do Salta	7.9	1.0	2.0	8.4	1.4	2.1	9.0	2.1	2.3
Salto do Norte	6.2	0.4	6.8	6.3	0.9	6.9	6.5	1.6	7.1
Fidelis Vista	1.6	-	-	4.0	-	-	7.0	-	-
Itoupava Zinha	2.7	0.2	-	5.2	0.7	-	8.1	1.4	-
Itoupava Central	1.3	0.4	-	3.2	0.9	-	5.6	1.6	-
Gaspar									
Coloninha	2.9	1.2	5.6	4.8	2.7	9.3	7.0	4.8	13.5
Figueira	3.6	1.3	4.8	5.1	2.9	6.8	7.0	5.0	9.3
Bela Vista	3.9	1.1	6.1	5.3	2.7	8.3	7.0	4.9	10.9
Centro	6.7	5.0	8.4	6.9	6.0	8.7	7.0	7.5	8.8
Nova Esperanca	8.9	5.5	7.7	8.9	6.5	7.7	8.9	8.0	7.7
Gasparinho	5.1	4.5	6.0	6.0	5.5	7.1	7.0	6.5	8.2
G.Grande	4.6	4.8	7.5	5.7	5.8	9.3	7.0	7.0	11.4
Mongem Esqierda	3.9	1.4	5.6	5.3	3.0	7.6	7.0	5.0	10.1
Rua Itajai	2.8	0.5	2.6	4.7	2.2	4.4	7.0	4.5	6.5
Sete Setembro	5.0	1.3	4.1	5.9	2.8	4.8	7.0	4.9	5.7
S.Ferezinha	4.1	1.1	5.0	5.4	2.6	6.6	7.0	4.8	8.5
Rural /1	2.1	0.0	0.0	6.4	0.0	0.0	10.4	0.0	0.0

Note : R-Residence I-Industry C-Commerce

/1 Residential density in rural area is assumed to increase owing to residual population which can not be absorbed into the existing urban area. According to land use plan by a socio-economist, populatin density in ranging 10 to 15 km zone will expand to 31 per ha, which means that residential density will be around 7 houses per ha at maximum by considering family size of 4.4 per house. It is assumed that rsidual population in Gaspar shown in Table V.4.7 will be absorbed into 120 ha of non-use land between 2000 and 2020. Thus, houses in residential land of rural area in 2020 includes residences in non-use land.

Table V.4.9 PRESENT UNIT COST PER EACH TYPE OF BUILDING

Item	House	Industry	Commerce	
			Blumenau Central Zone	Other areas
Unit cost per m^2 (Cz$)/1	3,860 /2	5,800	11,630	8,400
Standard size of building (m^2)	125	500	350	125
Unit cost per building (10^3Cz$)	480	2,900	4,070	1,050
Salvage value /3	10% of unit cost per building			
Average unit cost per/4 building (10^3Cz$)	260	1,600	2,240	580

Source : Municipality government of Blumenau

Note : /1 Types of building shown above are categorized as middle class except commercial buildings in central zone of Blumenau where most of buildings are identified to be the first class or luxurious type. Tax-based unit cost per m^2 at price level of Dec, 1986 shown in original data is converted to show market value at current price level by adjusting inflation and difference between tax-based cost and market price.

/2 Unit cost of house is the average one between brick and wooden made.

/3 Salvage value of buildings is assumed to be 10% of purchasing price.

/4 Average unit cost indicates the mean cost between purchasing price and salvage value.

Table V.4.10 PRESENT AND FUTURE UNIT VALUE OF INDOOR MOVABLES

unit : Million Cz$

Item	1987	2000	2020
Study area			
Household effect	0.12	0.16	0.24
Commerce	1.67	3.48	7.63
Industry	26.80	55.10	126.73

Note : Household effect is assumed to increase in proportion to the augment rate of per capita GRDP in study area.

Unit value of commercial establishment is calculated as the average value per building belonging to both service and commercial sectors.

Future unit value of indoor movables in commerce and industrial establishment is estimated to increase in proportion to the growth rate of GRDP shared by tertiary and secondary sectors.

Table V.4.11 LIVESTOCK VALUE PER HA

Unit : Million Cz$

Municipality	1987	2000	2020
Blumenau	0.01	0.01	0.01
Gaspar	0.01	0.01	0.01
Average	0.01	0.01	0.01

Note : Original data on livestock is based on statistics of Agricultural Census in 1984. Livestock value at 1987 price is estimated by adjusting the difference of price index between 1984 and 1987.

Future livestock value is assumed to show no increase of its value since real growth rate of primary sector is estimated to be null.

Table V.4.12 ESTIMATION OF BUILDING DENSITY PER HA BY BLOCK

Unit : Est./ha

Block	1987			2000			2020		
	R	I	C	R	I	C	R	I	C
Blumenau									
IT 3	5.2	0.0	9.3	15.8	0.0	15.2	28.0	0.0	22.2
IT 4	8.2	1.8	4.5	10.1	2.3	6.4	12.2	2.9	8.6
Velha	14.6	3.2	10.0	16.5	3.5	11.1	18.7	4.0	12.6
Fortaleza	6.3	0.0	2.7	7.8	0.0	3.1	9.6	0.0	3.7
Salto do Norte	6.2	0.4	6.8	6.3	0.9	6.9	6.5	1.6	7.1
Itoupava	3.7	0.3	2.7	6.1	0.8	3.1	7.4	1.5	3.7
Garcia	10.5	4.8	8.5	19.3	5.1	13.5	30.2	5.4	19.6
Gaspar									
IT 1	3.3	1.9	6.3	5.5	3.4	7.2	7.8	5.4	8.3
IT 2	3.4	1.2	6.1	5.6	2.8	8.3	7.8	4.9	10.9
Belchior	2.1	0.0	0.0	6.4	0.0	0.0	10.4	0.0	0.0
Saltinho	2.1	0.0	0.0	6.4	0.0	0.0	10.4	0.0	0.0
U1	2.1	0.0	0.0	6.4	0.0	0.0	10.4	0.0	0.0
U2	2.1	0.0	0.0	6.4	0.0	0.0	10.4	0.0	0.0
G.Grande	3.5	1.2	6.7	5.4	2.7	8.5	7.5	4.8	10.6
Do Sertao	3.7	0.0	0.0	5.4	0.0	0.0	7.5	0.0	0.0
Arraial	2.1	0.0	0.0	6.4	0.0	0.0	10.4	0.0	0.0
P.Grande	3.9	0.0	0.0	6.1	0.0	0.0	8.3	0.0	0.0

Note : R-Residence I-Industry C-Commerce

Table V.4.13 PRESENT AND FUTURE VALUE OF BUILDING AND INDOOR MOVABLES BY TYPE OF ESTABLISHMENT AND BLOCK

Unit : Million Cz$

Block		Building Cost			Indoor Movables		
		1987	2000	2020	1987	2000	2020
Blumenau							
IT 3	House	1.4 (12.5)	6.5 (5.0)	17.4	0.6 (11.6)	2.5 (5.1)	6.7
	Industry	0.0 (0.0)	0.0 (0.0)	0.0	0.0 (0.0)	0.0 (0.0)	0.0
	Commerce	5.2 (2.8)	7.4 (6.3)	25.3	7.1 (12.6)	33.4 (6.6)	120.5
IT 4	House	2.1 (5.3)	4.1 (3.1)	7.6	1.0 (3.8)	1.6 (3.0)	2.9
	Industry	2.9 (4.1)	4.9 (3.2)	9.3	48.2 (7.7)	126.7 (5.2)	350.1
	Commerce	2.6 (5.0)	4.9 (3.6)	10.0	7.5 (8.7)	22.3 (5.5)	65.6
Velha	House	3.8 (4.6)	6.8 (2.7)	11.6	1.8 (2.9)	2.6 (2.8)	4.5
	Industry	5.1 (3.0)	7.5 (2.7)	12.8	85.7 (6.4)	192.8 (4.7)	482.9
	Commerce	5.8 (2.3)	7.8 (3.1)	14.3	11.5 (6.6)	26.5 (4.6)	65.2
Fortaleza	House	1.6 (5.5)	3.2 (3.2)	6.0	0.8 (3.2)	1.2 (3.3)	2.3
	Industry	0.0 (0.0)	0.0 (0.0)	0.0	0.0 (0.0)	0.0 (0.0)	0.0
	Commerce	1.6 (3.2)	2.4 (3.0)	4.3	4.5 (7.0)	10.8 (4.9)	28.2
Salto do Norte	House	1.6 (3.8)	2.6 (2.2)	4.0	0.7 (2.8)	1.0 (2.4)	1.6
	Industry	0.6 (9.3)	1.9 (5.1)	5.1	10.7 (12.5)	49.6 (7.0)	193.2
	Commerce	3.9 (2.4)	5.3 (2.2)	8.2	11.3 (6.0)	24.0 (4.2)	54.2
Itoupava	House	1.0 (7.3)	2.5 (3.1)	4.6	0.4 (7.1)	1.0 (3.0)	1.8
	Industry	0.5 (9.8)	1.7 (5.3)	4.8	8.0 (14.0)	44.1 (7.3)	181.1
	Commerce	1.6 (3.1)	2.4 (2.9)	4.3	4.5 (7.0)	10.8 (4.9)	28.2
Garcia	House	2.7 (8.6)	7.9 (4.4)	18.7	1.3 (6.9)	3.1 (4.3)	7.2
	Industry	7.7 (2.7)	10.9 (2.3)	17.3	128.6 (6.2)	281.0 (4.3)	651.9
	Commerce	4.8 (5.9)	10.2 (3.9)	21.9	9.8 (10.7)	36.7 (6.3)	123.8
Gaspar							
IT 1	House	0.9 (7.5)	2.3 (3.7)	4.8	0.4 (6.4)	0.9 (3.8)	1.9
	Industry	3.0 (7.0)	7.3 (4.4)	17.3	50.9 (10.5)	187.3 (6.4)	651.9
	Commerce	3.7 (3.2)	5.6 (2.7)	9.6	10.5 (6.9)	25.1 (4.7)	63.3
IT 2	House	0.9 (7.5)	2.3 (3.7)	4.8	0.4 (6.4)	0.9 (3.8)	1.9
	Industry	1.9 (9.2)	6.0 (4.9)	15.7	32.2 (12.8)	154.3 (7.0)	591.6
	Commerce	3.5 (4.7)	6.4 (3.4)	12.6	10.2 (8.3)	28.9 (5.4)	83.2
Belchior, Saltinho, U1, U2 and Arraial							
	House	0.5 (13.5)	2.6 (4.6)	6.4	0.3 (9.7)	1.0 (4.7)	2.5
	Industry	0.0 (0.0)	0.0 (0.0)	0.0	0.0 (0.0)	0.0 (0.0)	0.0
	Commerce	0.0 (0.0)	0.0 (0.0)	0.0	0.0 (0.0)	0.0 (0.0)	0.0
G.Grande	House	0.9 (7.1)	2.2 (3.9)	4.7	0.4 (6.4)	0.9 (3.5)	1.8
	Industry	1.9 (8.8)	5.7 (5.1)	15.4	32.2 (12.5)	148.8 (7.0)	579.5
	Commerce	3.9 (4.1)	6.6 (9.5)	12.3	11.2 (7.8)	29.6 (5.2)	80.9
Do Sertao	House	1.0 (6.3)	2.2 (3.9)	4.7	0.4 (6.4)	0.9 (3.5)	1.8
	Industry	0.0 (0.0)	0.0 (0.0)	0.0	0.0 (0.0)	0.0 (0.0)	0.0
	Commerce	0.0 (0.0)	0.0 (0.0)	0.0	0.0 (0.0)	0.0 (0.0)	0.0
P.Grande	House	1.0 (7.3)	2.5 (3.6)	5.1	0.5 (5.5)	1.0 (3.5)	2.0
	Industry	0.0 (0.0)	0.0 (0.0)	0.0	0.0 (0.0)	0.0 (0.0)	0.0
	Commerce	0.0 (0.0)	0.0 (0.0)	0.0	0.0 (0.0)	0.0 (0.0)	0.0

Note : Parentheses indicates an annual increase rate(%) of respective value.
Value of Commercial building and its indoor movables in Blocks of IT 3, Velha and Garcia including Bairro of "Centro" in Blumenau is specially calculated since most of commercial buildings in "Centro" are multi-storied establishments and their building cost is higher than ordinary building. In this case, commercial buildings in Centro are assumed to have four stories.
Future unit cost of each type of building is assumed to increase in proportion to the augment rate of per capita GRDP.

Table V.5.1 INUNDATION AREA ,DEPTH AND DURATION DUE TO PROBABLE FLOOD (1/4)

(1) 1978's flood pattern — Unit : ha

Land Use	Depth/Duration	Returun period (year)					
		2	5	10	25	50	100
Residence	0.0 - 0.5 m	49	90	128	177	319	126
	0.5 - 1.0 m	26	47	70	126	224	351
	1.0 - 1.5 m	45	55	74	86	103	195
	1.5 - 2.5 m	30	67	94	127	194	215
	2.5 - 3.0 m	0	28	74	90	113	166
	over 3.0 m	11	11	27	73	145	217
	Sub-total	161	298	467	679	1,098	1,270
Industry	0.0 - 0.5 m	12	19	12	24	25	13
	0.5 - 1.0 m	7	8	12	26	23	34
	1.0 - 1.5 m	13	12	19	12	18	18
	1.5 - 2.5 m	15	20	20	27	42	45
	2.5 - 3.0 m	0	15	20	19	23	28
	over 3.0 m	0	0	15	28	47	70
	Sub-total	47	74	98	136	178	208
Commerce	0.0 - 0.5 m	12	31	16	28	59	69
	0.5 - 1.0 m	0	16	28	20	52	70
	1.0 - 1.5 m	4	12	27	28	22	56
	1.5 - 2.5 m	12	4	24	46	48	49
	2.5 - 3.0 m	0	12	4	12	46	49
	over 3.0 m	12	12	24	28	40	65
	Sub-total	40	87	123	162	267	358
Paddy	Less than 0.5 m						
	1-2 days	9	53	100	152	83	44
	3-4 days	0	0	0	0	0	0
	5-6 days	0	0	0	0	0	0
	over 7 days	0	0	0	0	0	0
	0.5 - 1.0 m						
	1-2 days	0	40	64	94	152	103
	3-4 days	0	0	0	0	0	0
	5-6 days	0	0	0	0	0	0
	over 7 days	0	0	0	0	0	0
	over 1.0 m						
	1-2 days	0	5	57	114	163	219
	3-4 days	0	0	0	0	45	114
	5-6 days	0	0	0	0	0	0
	over 7 days	0	0	0	0	0	0
	Sub-total	9	98	221	360	443	480
Upland crop	Less than 0.5 m						
	1-2 days	3	56	28	50	72	23
	3-4 days	0	0	0	0	0	0
	5-6 days	0	0	0	0	0	0
	over 7 days	0	0	0	0	0	0
	0.5 - 1.0 m						
	1-2 days	2	3	68	32	50	76
	3-4 days	0	0	0	0	0	0
	5-6 days	0	0	0	0	0	0
	over 7 days	0	0	0	0	0	0
	over 1.0 m						
	1-2 days	4	9	8	65	92	78
	3-4 days	0	0	4	6	12	72
	5-6 days	0	0	0	0	0	0
	over 7 days	0	0	0	0	0	0
	Sub-total	9	68	108	153	226	249
Pasture	0.0 - 2.0 m	1	182	242	311	322	266
	over 2.0 m	0	0	1	1	24	98
	Sub-total	1	182	243	312	346	364
Unutilized		76	155	272	367	521	564
Total		343	962	1,532	2,169	3,079	3,493

Table V.5.1 INUNDATION AREA ,DEPTH AND DURATION DUE TO PROBABLE FLOOD (2/4)

(2) 1980's flood pattern

Unit : ha

Land Use	Depth/Duration	Returun period (year)					
		2	5	10	25	50	100
Residence	0.0 - 0.5 m	47	74	130	269	324	209
	0.5 - 1.0 m	28	78	86	93	231	248
	1.0 - 1.5 m	46	42	91	102	145	303
	1.5 - 2.5 m	30	82	98	140	186	242
	2.5 - 3.0 m	0	53	71	110	122	171
	over 3.0 m	11	15	31	85	177	242
	Sub-total	162	344	507	799	1,185	1,415
Industry	0.0 - 0.5 m	12	12	26	20	28	15
	0.5 - 1.0 m	7	19	12	18	20	27
	1.0 - 1.5 m	13	8	19	26	18	26
	1.5 - 2.5 m	15	19	20	31	44	36
	2.5 - 3.0 m	0	24	20	20	27	42
	over 3.0 m	0	4	15	35	55	70
	Sub-total	47	86	112	150	192	216
Commerce	0.0 - 0.5 m	12	28	20	48	75	58
	0.5 - 1.0 m	0	30	28	18	58	75
	1.0 - 1.5 m	4	13	30	28	29	59
	1.5 - 2.5 m	12	12	29	54	48	60
	2.5 - 3.0 m	0	12	4	24	46	56
	over 3.0 m	12	12	24	28	40	79
	Sub-total	40	107	135	200	296	387
Paddy	Less than 0.5 m						
	1-2 days	17	67	104	175	60	36
	3-4 days	0	0	0	0	0	0
	5-6 days	0	0	0	0	0	0
	over 7 days	0	0	0	0	0	0
	0.5 - 1.0 m						
	1-2 days	4	38	67	104	87	56
	3-4 days	0	0	0	0	0	0
	5-6 days	0	0	0	0	0	0
	over 7 days	0	0	0	0	0	0
	over 1.0 m						
	1-2 days	0	21	59	126	312	294
	3-4 days	0	0	0	0	21	106
	5-6 days	0	0	0	0	0	0
	over 7 days	0	0	0	0	0	0
	Sub-total	21	126	230	405	480	492
Upland crop	Less than 0.5 m						
	1-2 days	6	68	36	101	72	19
	3-4 days	0	0	0	0	0	0
	5-6 days	0	0	0	0	0	0
	over 7 days	0	0	0	0	0	0
	0.5 - 1.0 m						
	1-2 days	2	0	72	36	54	76
	3-4 days	0	0	0	0	0	0
	5-6 days	0	0	0	0	0	0
	over 7 days	0	0	0	0	0	0
	over 1.0 m						
	1-2 days	4	12	12	77	104	134
	3-4 days	0	0	0	6	12	20
	5-6 days	0	0	0	0	0	0
	over 7 days	0	0	0	0	0	0
	Sub-total	12	80	120	220	242	249
Pasture	0.0 - 2.0 m	1	182	242	337	322	182
	over 2.0 m	0	0	1	1	26	198
	Sub-total	1	182	243	338	348	380
Unutilized		88	197	304	447	542	593
Total		371	1,122	1,651	2,559	3,285	3,732

Table V.5.1 INUNDATION AREA ,DEPTH AND DURATION DUE TO PROBABLE FLOOD (3/4)

(3) 1983's flood pattern — Unit : ha

Land Use	Depth/Duration	Returun period (year) 2	5	10	25	50	100
Residence	0.0 - 0.5 m	45	39	88	258	107	60
	0.5 - 1.0 m	21	44	93	134	264	109
	1.0 - 1.5 m	9	49	35	105	238	168
	1.5 - 2.5 m	0	30	91	166	407	523
	2.5 - 3.0 m	7	1	57	102	153	302
	over 3.0 m	4	11	16	118	34	460
	Sub-total	86	174	380	883	1,203	1,622
Industry	0.0 - 0.5 m	13	12	12	18	24	10
	0.5 - 1.0 m	11	7	19	19	21	25
	1.0 - 1.5 m	4	13	8	28	19	21
	1.5 - 2.5 m	0	15	19	28	46	38
	2.5 - 3.0 m	0	0	24	23	45	40
	over 3.0 m	0	0	4	47	94	130
	Sub-total	28	47	86	163	249	264
Commerce	0.0 - 0.5 m	4	13	28	55	38	32
	0.5 - 1.0 m	0	8	30	28	61	30
	1.0 - 1.5 m	12	4	17	20	60	35
	1.5 - 2.5 m	0	12	12	57	105	125
	2.5 - 3.0 m	8	0	4	29	46	87
	over 3.0 m	4	12	24	28	106	148
	Sub-total	28	49	115	217	416	457
Paddy	Less than 0.5 m						
	1-2 days	0	12	67	99	55	36
	3-4 days	0	0	0	0	0	0
	5-6 days	0	0	0	0	0	0
	over 7 days	0	0	0	0	0	0
	0.5 - 1.0 m						
	1-2 days	0	4	38	124	52	81
	3-4 days	0	0	0	0	0	0
	5-6 days	0	0	0	0	0	0
	over 7 days	0	0	0	0	0	0
	over 1.0 m						
	1-2 days	0	0	17	145	100	32
	3-4 days	0	0	4	26	207	115
	5-6 days	0	0	0	33	84	270
	over 7 days	0	0	0	4	37	63
	Sub-total	0	16	126	431	535	597
Upland crop	Less than 0.5 m						
	1-2 days	6	3	72	86	16	9
	3-4 days	0	0	0	0	0	12
	5-6 days	0	0	0	0	0	0
	over 7 days	0	0	0	0	0	0
	0.5 - 1.0 m						
	1-2 days	0	3	0	44	23	16
	3-4 days	0	0	0	0	0	0
	5-6 days	0	0	0	0	0	0
	over 7 days	0	0	0	0	0	0
	over 1.0 m						
	1-2 days	0	2	3	84	110	23
	3-4 days	0	4	3	0	32	76
	5-6 days	0	0	2	3	72	138
	over 7 days	0	0	4	9	12	12
	Sub-total	6	12	84	226	265	286
Pasture	0.0 - 2.0 m	0	8	194	316	174	94
	over 2.0 m	0	0	0	24	206	286
	Sub-total	0	8	194	340	380	380
Unutilized		32	92	202	501	653	685
Total		180	398	1,187	2,761	3,701	4,291

Table V.5.1 INUNDATION AREA ,DEPTH AND DURATION DUE TO PROBABLE FLOOD (4/4)

(4) 1984's flood pattern

Unit : ha

Land Use	Depth/Duration	Returun period (year)					
		2	5	10	25	50	100
Residence	0.0 - 0.5 m	51	76	125	271	318	140
	0.5 - 1.0 m	23	76	88	92	241	294
	1.0 - 1.5 m	50	46	92	102	148	235
	1.5 - 2.5 m	30	82	99	140	183	229
	2.5 - 3.0 m	0	53	72	110	126	170
	over 3.0 m	11	15	31	85	177	236
	Sub-total	165	348	507	800	1,193	1,304
Industry	0.0 - 0.5 m	12	12	26	20	32	13
	0.5 - 1.0 m	7	19	12	24	20	23
	1.0 - 1.5 m	13	8	19	16	18	28
	1.5 - 2.5 m	15	19	20	31	40	42
	2.5 - 3.0 m	0	24	20	20	31	32
	over 3.0 m	0	4	15	35	55	70
	Sub-total	47	86	112	146	196	208
Commerce	0.0 - 0.5 m	12	28	21	42	79	74
	0.5 - 1.0 m	0	27	28	20	58	58
	1.0 - 1.5 m	4	16	26	27	29	54
	1.5 - 2.5 m	12	12	33	54	48	52
	2.5 - 3.0 m	0	12	4	24	46	54
	over 3.0 m	12	12	24	28	40	79
	Sub-total	40	107	136	195	300	371
Paddy	Less than 0.5 m						
	1-2 days	17	67	104	175	59	36
	3-4 days	0	0	0	0	0	0
	5-6 days	0	0	0	0	0	0
	over 7 days	0	0	0	0	0	0
	0.5 - 1.0 m						
	1-2 days	4	38	67	104	88	95
	3-4 days	0	0	0	0	0	0
	5-6 days	0	0	0	0	0	0
	over 7 days	0	0	0	0	0	0
	over 1.0 m						
	1-2 days	0	21	59	122	274	140
	3-4 days	0	0	0	4	59	208
	5-6 days	0	0	0	0	0	0
	over 7 days	0	0	0	0	0	0
	Sub-total	21	126	230	405	480	479
Upland crop	Less than 0.5 m						
	1-2 days	6	72	36	101	68	23
	3-4 days	0	0	0	0	0	0
	5-6 days	0	0	0	0	0	0
	over 7 days	0	0	0	0	0	0
	0.5 - 1.0 m						
	1-2 days	2	0	72	36	55	76
	3-4 days	0	0	0	0	0	0
	5-6 days	0	0	0	0	0	0
	over 7 days	0	0	0	0	0	0
	over 1.0 m						
	1-2 days	4	12	8	74	108	50
	3-4 days	0	0	4	9	12	100
	5-6 days	0	0	0	0	0	0
	over 7 days	0	0	0	0	0	0
		0	0	0	0	0	0
	Sub-total	12	84	120	220	243	249
Pasture	0.0 - 2.0 m	1	182	242	337	322	226
	over 2.0 m	0	0	1	1	26	146
	Sub-total	1	182	243	338	348	372
Unutilized		88	197	304	447	542	565
Total		374	1,130	1,652	2,551	3,302	3,548

Table V.5.2 FLOOD DAMAGE RATE

(1) Building and Indoor movables

Item	Below Floor Level	0-0.5m	0.5-0.9m	1.0-1.99m	2.0-2.99m	Over 3.0m
1.Building ∠1	0.03	0.053	0.072	0.109	0.152	0.22
2.House hold effects	0.00	0.086	0.191	0.331	0.499	0.69
3.Properties	0.00	0.154	0.295	0.339	0.509	0.597

Note: ∠1 Sloop less than 1/1000

(2) Agriculutural Crops

Depth	Duration (days)	Paddy	Average of Damage Rate(Upland Crop)	Sugarcane
Less than 0.5m deep	1-2	0.21	0.27	0.00
	3-4	0.30	0.42	0.00
	5-6	0.36	0.54	0.00
	7-	0.50	0.67	0.03
0.5-1.0m	1-2	0.24	0.35	0.00
	3-4	0.44	0.48	0.00
	5-6	0.50	0.67	0.03
	7-	0.71	0.74	0.06
More than 1.0m	1-2	0.37	0.57	0.00
	3-4	0.54	0.67	0.03
	5-6	0.64	0.81	0.06
	7-	0.74	0.91	0.09

Source: Criteria for the Engineering of River and Sabo Project , Ministry of Construction,Japan

Table V.5.3 PROBABLE FLOOD DAMAGE IN BLUMENAU-GASPAR STRETCH DUE TO 1978 FLOOD PATTERN

(1) 1987 development level

Unit : Million Cz$

Damage Item	Return Period					
	2	5	10	25	50	100
Redidence						
Building	18.54	38.36	67.50	103.89	167.47	215.71
Indoor Movables	19.29	42.30	81.37	129.76	210.39	283.41
Industry						
Building	1.64	3.31	5.83	10.04	18.99	26.25
Indoor Movables	86.77	162.28	304.62	482.75	949.11	1,342.42
Commerce						
Building	19.55	34.74	60.26	82.82	131.85	174.55
Indoor Movables	116.04	197.91	377.96	523.37	808.00	1,077.88
Paddy	0.01	0.14	0.35	0.58	0.83	1.06
Sugarcane	0.00	0.00	0.00	0.00	0.00	0.00
Other Crop	0.00	0.00	0.00	0.00	0.00	0.00
Pasture	0.00	0.00	0.07	0.07	1.46	5.86
Infra-Structure	75.94	138.92	260.41	386.76	663.55	906.87
Indirect Damage	33.78	61.80	115.84	172.04	295.17	403.40
Total	371.56	679.76	1,274.21	1,892.08	3,246.82	4,437.41
Annualized Value	92.89	250.59	348.29	443.29	494.68	533.10 ∠1

(2) 2000 development level

Unit : Million Cz$

Damage Item	Return Period					
	2	5	10	25	50	100
Redidence						
Building	46.38	93.66	162.93	254.53	408.77	528.46
Indoor Movables	43.35	89.19	168.76	269.52	437.62	593.42
Industry						
Building	5.54	11.12	19.53	30.57	49.38	66.72
Indoor Movables	476.58	891.32	1,646.26	2,317.00	3,890.13	5,350.51
Commerce						
Building	39.21	66.14	108.90	146.53	223.92	292.91
Indoor Movables	420.64	673.80	1,209.18	1,655.64	2,481.19	3,292.13
Paddy	0.02	0.25	0.64	1.07	1.53	1.95
Sugarcane	0.00	0.00	0.00	0.00	0.00	0.00
Other Crop	0.00	0.00	0.00	0.00	0.00	0.00
Pasture	0.00	0.00	0.07	0.07	1.46	5.86
Infra-Structure	299.20	529.39	961.72	1,355.73	2,173.26	2,938.27
Indirect Damage	133.09	235.49	427.80	603.07	966.73	1,307.02
Total	1,464.01	2,590.36	4,705.79	6,633.73	10,633.99	14,377.25
Annualized Value	366.00	974.16	1,338.96	1,679.15	1,851.83	1,976.88 ∠1

Note : ∠1 Annual mean flood damage

Table V.5.4 PROBABLE FLOOD DAMAGE IN BLUMENAU-GASPAR STRETCH DUE TO 1980 FLOOD PATTERN

(1) 1987 development level

Unit : Million Cz$

Damage Item	Return Period					
	2	5	10	25	50	100
Redidence						
Building	18.57	49.72	73.73	117.64	179.68	239.63
Indoor Movables	19.38	58.51	87.92	146.01	225.49	315.19
Industry						
Building	1.64	4.56	7.05	12.94	20.41	29.96
Indoor Movables	86.77	234.28	304.62	659.69	1,028.73	1,519.86
Commerce						
Building	19.55	43.63	63.87	98.69	136.77	198.67
Indoor Movables	116.04	257.89	404.94	616.66	833.52	1,241.50
Paddy	0.03	0.19	0.36	0.65	0.96	1.12
Sugarcane	0.00	0.00	0.00	0.00	0.00	0.00
Other Crop	0.00	0.00	0.00	0.00	0.00	0.00
Pasture	0.00	0.00	0.07	0.07	1.54	11.86
Infra-Structure	75.98	188.14	273.34	479.18	703.86	1,031.76
Indirect Damage	33.80	83.69	121.59	213.15	313.10	458.96
Total	371.76	920.61	1,337.49	2,344.68	3,444.06	5,048.51
Annualized Value	92.94	286.79	399.70	510.16	568.05	610.51 /1

(2) 2000 development level

Unit : Million Cz$

Damage Item	Return Period					
	2	5	10	25	50	100
Redidence						
Building	46.54	119.39	180.16	286.41	440.27	578.52
Indoor Movables	43.59	120.56	183.92	301.68	472.61	649.45
Industry						
Building	5.54	15.29	21.58	36.57	54.11	73.82
Indoor Movables	476.58	1,272.78	1,646.26	2,930.63	4,304.92	5,872.30
Commerce						
Building	39.21	79.18	115.78	170.73	231.48	327.91
Indoor Movables	420.64	838.70	1,312.29	1,903.07	2,564.54	3,745.26
Paddy	0.05	0.34	0.66	1.20	1.77	2.06
Sugarcane	0.00	0.00	0.00	0.00	0.00	0.00
Other Crop	0.00	0.00	0.00	0.00	0.00	0.00
Pasture	0.00	0.00	0.07	0.07	1.54	11.86
Infra-Structure	299.32	709.41	1,003.61	1,632.81	2,340.66	3,265.74
Indirect Damage	133.15	315.56	446.43	726.32	1,041.19	1,452.69
Total	1,464.62	3,471.21	4,910.76	7,989.49	11,453.09	15,979.61
Annualized Value	366.16	1,106.53	1,525.63	1,912.63	2,107.06	2,244.22 /1

Note : /1 Annual mean flood damage

Table V.5.5 PROBABLE FLOOD DAMAGE IN BLUMENAU-GASPAR STRETCH DUE TO 1983 FLOOD PATTERN

(1) 1987 development level

Unit : Million Cz$

Damage Item	Return Period					
	2	5	10	25	50	100
Redidence						
Building	7.85	21.75	55.28	132.91	288.24	362.36
Indoor Movables	8.13	22.83	65.26	166.47	390.46	513.38
Industry						
Building	0.63	1.64	4.56	15.39	37.39	51.08
Indoor Movables	22.75	86.77	234.28	747.93	1,912.57	2,623.98
Commerce						
Building	12.84	22.09	51.91	104.55	233.79	291.62
Indoor Movables	87.21	130.91	300.04	642.77	1,482.81	1,851.71
Paddy	0.00	0.03	0.19	0.86	1.52	1.94
Sugarcane	0.00	0.00	0.00	0.00	0.00	0.00
Other Crop	0.00	0.00	0.00	0.00	0.00	0.00
Pasture	0.00	0.00	0.00	1.46	12.34	17.14
Infra-Structure	40.43	82.95	206.34	525.58	1,264.15	1,656.83
Indirect Damage	17.98	36.90	91.79	233.79	562.33	737.00
Total	197.82	405.87	1,009.65	2,571.71	6,185.60	8,107.04
Annualized Value	49.45	140.01	210.78	318.22	405.80	477.26 /1

(2) 2000 development level

Unit : Million Cz$

Damage Item	Return Period					
	2	5	10	25	50	100
Redidence						
Building	20.70	52.76	134.47	328.03	701.03	879.35
Indoor Movables	18.58	48.89	135.44	349.50	806.66	1,053.29
Industry						
Building	2.12	5.54	15.29	43.29	90.72	117.37
Indoor Movables	124.93	476.58	1,272.78	3,394.25	7,144.68	9,243.39
Commerce						
Building	26.45	43.05	96.12	180.95	383.90	475.32
Indoor Movables	314.68	454.78	993.90	2,001.45	4,455.68	5,560.39
Paddy	0.00	0.06	0.35	1.57	2.80	3.57
Sugarcane	0.00	0.00	0.00	0.00	0.00	0.00
Other Crop	0.00	0.00	0.00	0.00	0.00	0.00
Pasture	0.00	0.00	0.00	1.46	12.34	17.14
Infra-Structure	147.16	313.68	768.02	1,827.14	3,943.36	5,031.45
Indirect Damage	65.46	139.53	341.64	812.76	1,754.12	2,238.13
Total	720.08	1,534.87	3,758.01	8,940.40	19,295.29	24,619.40
Annualized Value	180.02	518.26	782.91	1,163.86	1,446.21	1,665.79 /1

Note : /1 Annual mean flood damage

Table V.5.6 PROBABLE FLOOD DAMAGE IN BLUMENAU-GASPAR STRETCH DUE TO 1984 FLOOD PATTERN

(1) 1987 development level

Unit : Million Cz$

Damage Item	Return Period					
	2	5	10	25	50	100
Redidence						
Building	19.11	49.99	74.50	117.53	180.66	229.70
Indoor Movables	19.55	59.00	89.46	145.82	226.73	304.60
Industry						
Building	1.64	4.56	7.05	11.77	21.05	27.02
Indoor Movables	86.77	234.28	304.62	562.04	1,042.90	1,387.05
Commerce						
Building	19.55	43.88	64.67	97.83	137.08	192.03
Indoor Movables	116.04	261.76	409.02	614.97	833.52	1,178.71
Paddy	0.03	0.19	0.36	0.65	1.00	1.17
Sugarcane	0.00	0.00	0.00	0.00	0.00	0.00
Other Crop	0.00	0.00	0.00	0.00	0.00	0.00
Pasture	0.00	0.00	0.07	0.07	1.54	8.74
Infra-Structure	76.18	189.56	275.43	449.70	708.90	965.41
Indirect Damage	33.89	84.32	122.52	200.04	315.34	429.44
Total	372.76	927.54	1,347.70	2,200.42	3,468.72	4,723.87
Annualized Value	93.19	288.23	401.99	508.44	565.13	606.09 /1

(2) 2000 development level

Unit : Million Cz$

Damage Item	Return Period					
	2	5	10	25	50	100
Redidence						
Building	47.55	120.31	181.79	286.17	442.54	555.20
Indoor Movables	44.00	121.74	186.67	301.30	475.15	628.03
Industry						
Building	5.54	15.29	21.58	34.61	55.67	68.18
Indoor Movables	476.58	1,272.78	1,646.26	2,674.48	4,372.74	5,497.45
Commerce						
Building	39.21	79.71	117.41	169.40	232.07	317.57
Indoor Movables	420.64	853.20	1,327.57	1,898.07	2,564.54	3,542.05
Paddy	0.05	0.34	0.66	1.20	1.84	2.15
Sugarcane	0.00	0.00	0.00	0.00	0.00	0.00
Other Crop	0.00	0.00	0.00	0.00	0.00	0.00
Pasture	0.00	0.00	0.07	0.07	1.54	8.74
Infra-Structure	299.73	714.38	1,009.78	1,555.93	2,362.36	3,079.62
Indirect Damage	133.33	317.78	449.18	692.12	1,050.84	1,369.90
Total	1,466.63	3,495.53	4,940.97	7,613.35	11,559.29	15,068.89
Annualized Value	366.66	1,110.98	1,532.81	1,909.44	2,101.17	2,234.31 /1

Note : /1 Annual mean flood damage

Figures

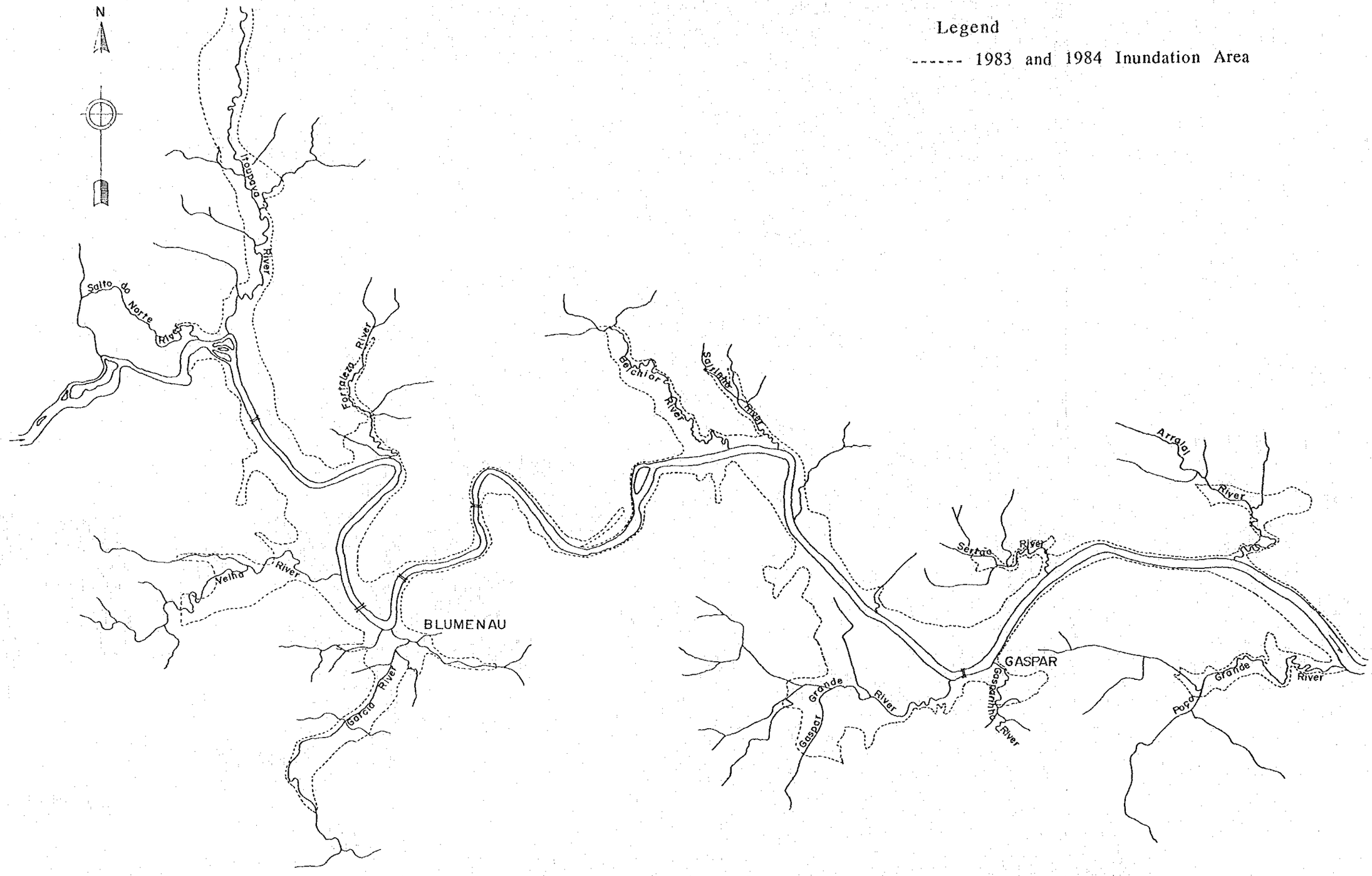


Fig.V.2.1 INUNDATION AREA DUE TO 1983 AND 1984 FLOODS

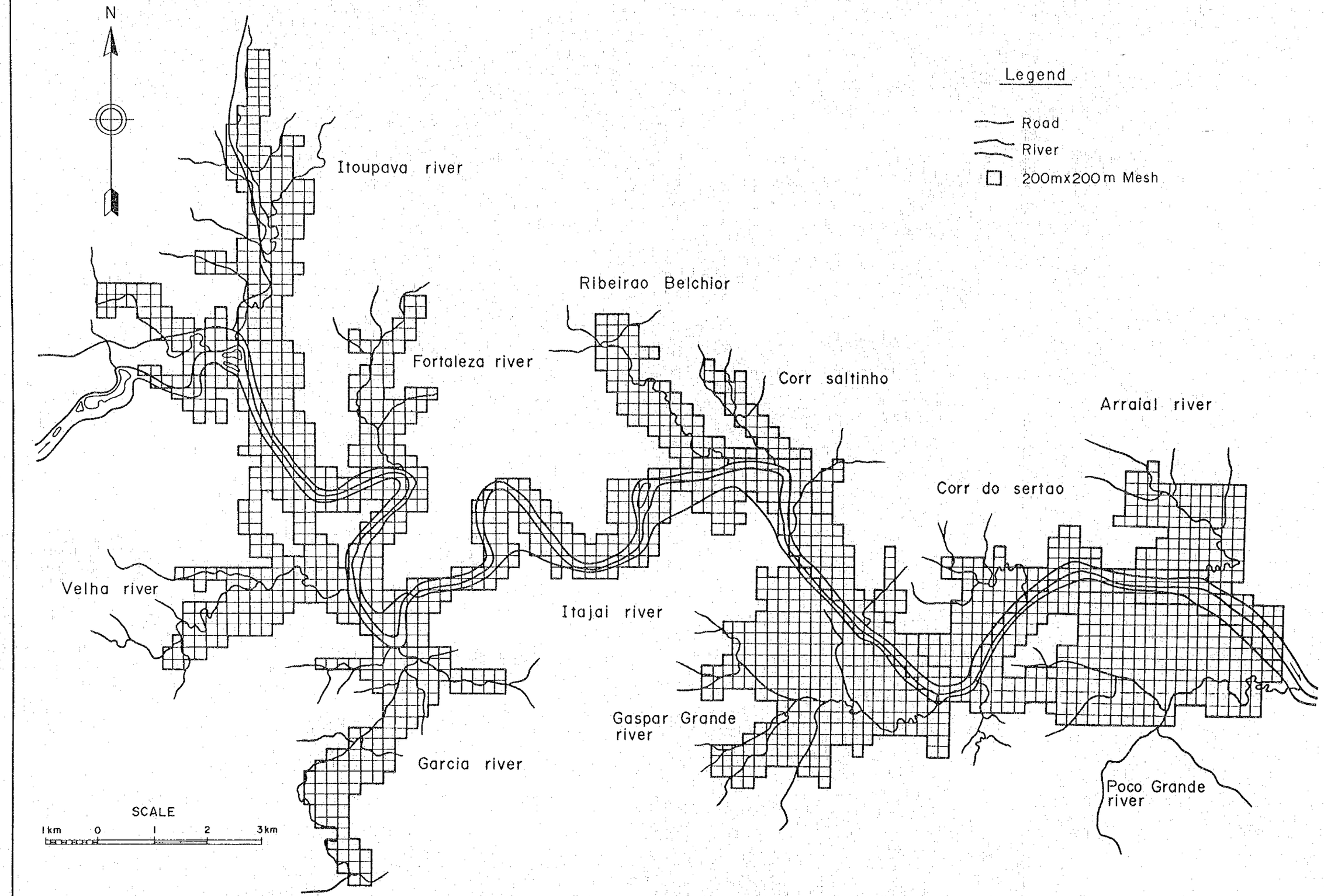


Fig. V. 2. 2 PROBABLE INUNDATION AREA

Fig. V. 4.1 DAMAGEABLE VALUE OF IRRIGATED PADDY

		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
(A)	Cropping Calender												
(B)	Planted Area (%)	100	100	75	25						25	75	100
(C)	Accumulated Cost (%)	65	75	85	98						20	40	55
(D)	Flood Frequency (%)	1.9	11.5	3.9	1.9	7.7	7.7	3.9	19.3	11.5	11.5	11.5	7.7

		1987	2000
(E)	Yield (ton / ha)	3.7	5.0
(F)	Price (CZ$ / ton)	7,450	9,110
(G)	Production Cost (CZ$ / ha)	18,160	25,040
(H)	Net Income (CZ$ / ha)	9,405	20,510
(I)	Damageable Cost (CZ$ / ha)	11,850	16,510
(J)	Damageable Value (CZ$ / ha)	5,885	10,860

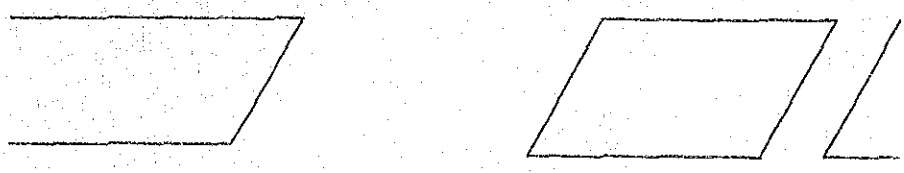
Note : $(J)=\sum_{JAN}^{DEC}(B \times C \times D \times I + B \times D \times H)$

(1) Damageable cost mean the remaining cost where labour cost for harvesting, transportation, and drying is subtracted from production cost.

(2) Production cost in the future year of 2,000 is assumed to increase in proportion to the augment rate of yield.

(3) Price is calculated as form gate price on condition that rice is imported.

Fig. V. 4.2 DAMAGEABLE VALUE OF MAIZE

		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
(A)	Cropping Calender												
(B)	Planted Area 1 st								50	100	100	50	
	2 nd	100	100	100	50								50
(C)	Accumulated Cost (%)	50	60	80	90				30	50	70	90	30
(D)	Flood Frequency (%)	1.9	11.5	3.9	1.9	7.7	7.7	3.9	19.3	11.5	11.5	11.5	7.7

		1987	2000
(E)	Yield (ton / ha)	1.8	3.0
(F)	Price (CZ$ / ton)	4,810	6,110
(G)	Production Cost (CZ$ / ha)	5,350	8,920
(H)	Net Income (CZ$ / ha)	3,310	9,410
(I)	Damageable Cost (CZ$ / ha)	4,150	6,920
(J)	Damageable Value (CZ$ / ha)	3,450	8,100

Note : $(J)=\sum_{JAN}^{DEC}(B \times C \times D \times I + B \times D \times H)$

(1) Price is calculated as form gate price on condition that maize is imported.

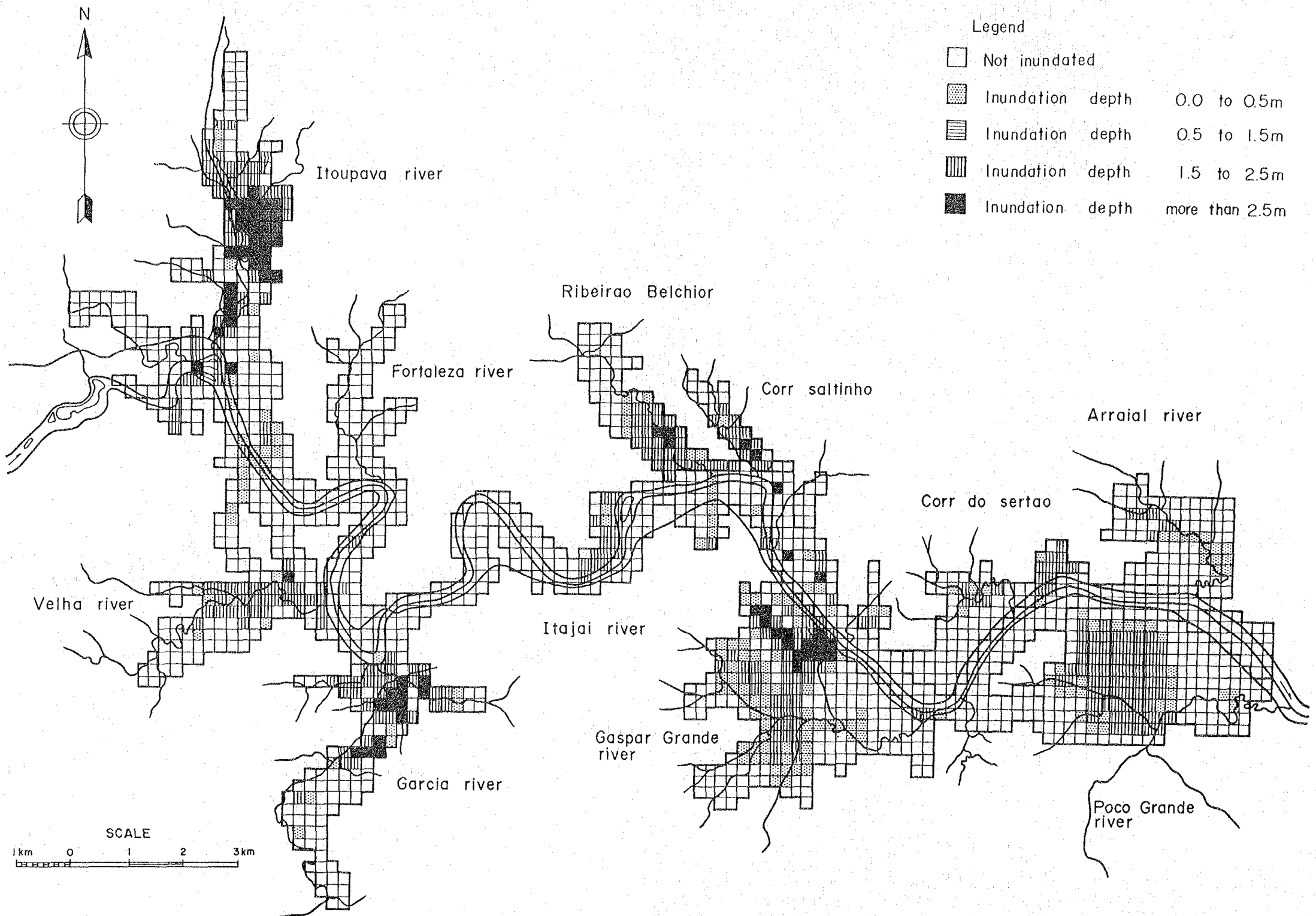


Fig. V. 5.1 INUNDATION MAP DUE TO 10-YEAR PROBABLE FLOOD

ANNEX VI. ENVIRONMENTAL ASSESMENT STUDY

VI. ENVIRONMENTAL ASSESMENT STUDY

TABLE OF CONTENTS

LIST OF TABLE

LIST OF FIGURES

1. General

1.1 Study area

The study area of Blumenau-Gaspar stretch is located in the downstream reach of the Itajai river. This stretch is composed of urban area of Blumenau, which is the biggest city in the basin and urban area of Gasper, and rural area between two cities.

The Itajai river flows down through the Blumenau city, meandering largely in the Blumenau stretch. The river stretch along the Blumenau city is characterized by excellent landscape which is in harmony with German style building, trees along the river and mountains behind the urban area. This landscape is a main sightseeing resource of this city.

The Gasper city also has a good landscape along the river stretch in up and downstream from the center of the city. In the Blumenau-Gasper stretch, there are rural landscape among the natural gentle slope riverside as well as valley landscape with mountains closing to riverine area.

Three tributaries, Garcia, Velha and Itoupava rivers flow into the Itajai river through the Blumenau city. The river water of these tributaries is being polluted due to drainage water from textile and crystal factories developed along the rivers as well as municipal drainage.

Although this pollution problem is not related to this river improvement plan, the data relevant to the pollution was collected. The results of water quality survey on this region carried out by Blumenau city are as shown on Table VI.1.1. Numbers of coliform groups are high compared with Japanese water quality standards shown on Table VI.1.2, which means human contamination is proceeding.

1.2 Purpose of study

In order to reflect the environmental effect to the planning of river improvement project in Blumenau-Gaspar stretch, the matters to be contemplated for river improvement planning and construction planning were studied.

2. Prediction of Environmental Change and Its Measure

2.1 Study on Environmental Aspect for River Improvement Planning

The impact on landscape in the riverine of the Blumenau city and area separation due to river improvement plan was studied.

(1) Landscape

(i) Present condition

The Blumenau city has developed at junction portion of hilly area and mountainous zone in the Itajai river basin. Three major tributaries, Garcia, Velha, and Itoupava rivers flow into the V-shaped meandering Blumenau river stretch. The landscape in the Blumenau river stretch is shown in Fig. VI.2.1.

A revetment has been provided in the right river bank along the meandering river stretch and the upper part of the river bank is covered with green lawn. Trees have been planted by the walkway along the right river bank. This right river bank side has a pleasant and relaxing function for the citizens and also provides a promenade for tourists.

While, the Itajai river in this stretch has been used as a recreation area such as boating ,regatta, fishing and sightseeing by ship. The riverine area in this river stretch serves an excellent landscape with green space to the citizens of the Blumenau city.

The landscape in the Blumenau city will be categorized into three viewpoints, namely, a short distance landscape, medium distance landscape and long distance landscape.

As the short distance landscape, it provides a natural landscape with trees in the left bank and waterfront. In the medium distance landscape, it provides riverine landscape with an artificial revetment and Germany style building. As the long distance landscape, it provides view of mountains dotted with bared field showing underdeveloping area.

(ii) Change of landscape by river improvement

Three alternatives are conceivable for protecting the riverine area along the Blumenau stretch from flood. They are shown in Table VI.2.1. This table presents comparison of with and without project and examination of priority for utilization of the space around riverine area.

The function of flood control and the conservation of the environment, such as the landscape, is not in a "trade-off" relation and priority should be given, of course, mainly to the safety of the flood control. Therefore, these three plans should firstly guarantee the function of the control, which faces as the present problem.

Among the plans, plan C with a parapet wall as shown in Fig.VI.2.2 is considered to be the best plan from the viewpoint of utilization of space around river and landscape.

(2) Area separation

The separation of town and road which connects village to village owing to construction of the flood diversion channel at the Gaspar stretch will probably exert the influence to the way of living and communication, and it will be necessary to provide the compensation facility for them in the river improvement plan.

2.2 Study on Environmental Aspect for Construction Planning

Environmental impacts which may be caused by river improvement are shown in Table VI.2.2. It is presumed that influence to pollution of river water, air pollution, noises, vibration sliding, animal, vegetation and housing may take place due to widening of river channel, river dredging, levee embankment and treatment of the excavated material. Then the environmental impact study was performed concentrating to these problems.

(1) Water pollution, Animal and Vegetation

The pollution of water quality, especially concerning the river dredging and widening, causes temporary increase of artificial suspended solid (muddiness) load and consequently, seaweeds attached at stones of the riverbed, which affects the fish may be extinguished.

The change of the riverbed and the riverside deprives the animals of riverside vegetation and affects also the habitat of fish and they will be forced to search for another place to live.

Therefore, it is necessary to make a research of valuable animals and vegetation to grasp the degree of the influence on them, and depending on the results, an adequate measure must be taken.

(2) Air pollution, Noise, Vibration

When the construction is carried out, the air pollution caused by dust cloud of the vehicles and also, noises, vibrations, etc., will take place but they can be reduced by cleaning and watering the streets and by limiting the speed oh the vehicles. In this way, the influence on the environment can be diminished.

(3) Land(sliding)

At the riverside where widening of river channel is being executed, sliding caused by erosion takes place in several places, but this can be avoided by providing sodding.

(4) Life(housing)

As for residences which are essential for people who live near the river, the river widening will influence them and this demands an administrative measure for it.

Tables

Table VI.1.1 RESULT OF WATER QUALITY

Points	pH	COD (mg/l)	SS (mg/l)	DO (mg/l)	Number of Coliform groups MPN/100ml
Between Itoupava Norte and Santa Catarina Bridge	6.7	8.0	16.0	7.8	> 2400
Between the upstream of Sul Fabril and Cia. Schraeder	7.1	8.0	14.0	7.0	> 2400
Between the upstream of Testo and Prefeitura	7.1	4.0	21.0	7.5	> 2400

Note : COD : Chemical Oxigen Demand
(COD is reference data, because its analitical procedure is not clear.)
SS : Suspended Solid
DO : Dissolved Oxygen

Source : Blumenau municipal office

Table VI.1.2 STANDARDS RELATING TO LIVING ENVIRONMENT

Category	Purpose of Water Use	Standard Values /1 pH	Biochemical Oxygen Demand (BOD)	Suspended Solids (SS)	Dissolved Oxygen (DO)	Number of Coliform Groups
AA	Water supply, class 1; conservation of natural environment, and uses listed in A-E	6.5-8.5	1mg/l or less	25mg/l or less	7.5mg/l or more	50MPN/100ml or less
A	Water supply, class 2; fishery, class 1; bathing and uses listed in B-E	6.5-8.5	2mg/l or less	25mg/l or less	7.5mg/l or more	1,000MPN/100ml or less
B	Water supply, class 3; fishery, class 2, and	6.5-8.5	3mg/l or less	25mg/l or less	5mg/l or more	5,000MPN/100ml or less
C	Fishery, class 3; industrial water, class 1, and uses listed in D-E	6.5-8.5	5mg/l or less	50mg/l or less	5mg/l or more	-
D	Industrial water, class 2; agricultural water, and uses listed in E	6.5-8.5	8mg/l or less	100mg/l or less	2mg/l or more	-
E	Industrial water, class 3; conservation of environment	6.5-8.5	10mg/l or less	Floting matter such as garbage should not be observed.	2mg/l or more	-

Note: 1. The standard value is based on the daily average value. The same standard is applied to lakes and coastal waters.

2. At the intake for agriculture, value of pH shall be between 6.0 and 7.5 and dissolved oxygen shall not be less than 5 mg/l. The same standard is applied to the lakes.

3. Conservation of natural environment: Conservation of scenic spots and other natural resources.

4. Water supply
class 1-Water treated by simple cleaning operation, such as filtration.
class 2-Water treated by normal cleaning operation, such as sedimentation and filtration.
class 3-Water treated through a highly sophisticated cleaning operation including pretreatment.

5. Fishery
class 1-For aquatic life such as trout and bull trout inhabiting oligosaprobic water, and those of fishery class 2 and class 3.
clase 2-For aquatic life such as the salmon and sweetfish inhabiting oligosaprobic water and those of fishery class 3.
class 3-For aquatic life such as carp crucian inhabiting ß-mesoaprobic water.

6. Industrial water
class 1-Water given normal cleaning treatment such as sedimentation.
class 2-Water given sophisticated treatment by chemicals.
class 3-Water given special cleaning treatment.

7. Conservation of environment up to the limits at which no unpleasantness is caused to people in their daily life including a walk by the riverside, etc.

Source : ENVIRONMENT AGENCY GOVERNMENT OF JAPAN

Table VI.2.1 COMPARISON OF UTILIZATION OF RIVER SPACE AND LANDSCAPE IN RIVER IMPROVEMENT PLANS.
(in right river bank in Blumenau city with low elevation)

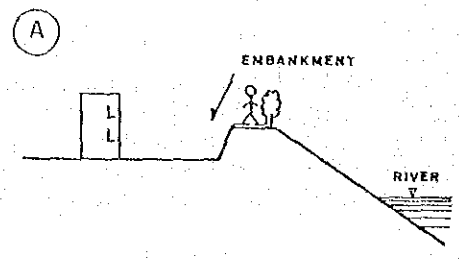
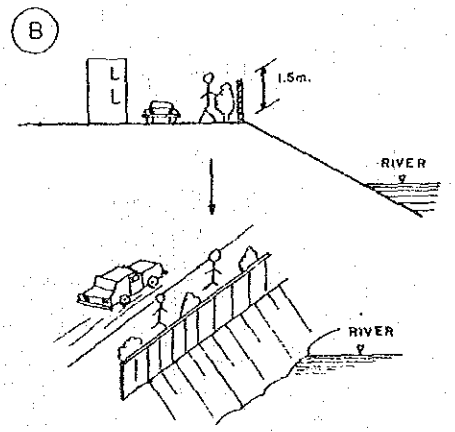
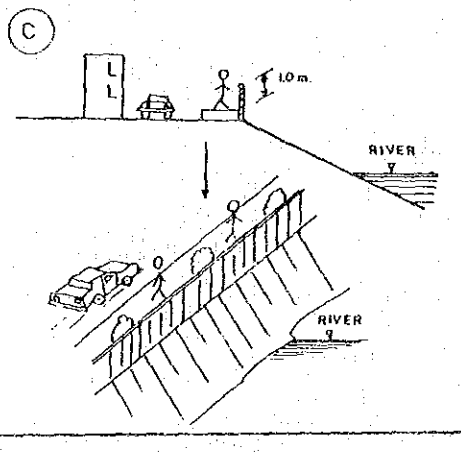
River improvement plan		
Without		The water space with a lot of nature cultivated by the citizen is still remained, but there is a problem at the function of flood control. Flood in 1983 and 1984 caused serious damage for the Blumenau city and reinforcement of the function of flood control and security is required.
With project		River landscapes will become invisible and less accessable because of the embankment. Therefore, interest and affection to the river space will be weakened and the function of park will be lost. Landscapes from footway will be still secured as it is.
		As well as A plan, river landscape from the urban area will become invisible because of the 1.5 m high wall, and also the sight of the river from footway becomes invisible. It will give a block-out feeling to the people. But it will be possible to soften at some extent this artificial landscape by planting trees along the wall.
		It will be possible to have a view of landscape from the urban area and footway. Besides, safety of footway will be secured by making step 0.5 m higher than roadway. Consequently, it is possible to preserve the present landscape and secure the access to waterfront even after the construction of a parapet wall, since Blumenau considers landscape as one of its tourist resources. (Refer to Fig.VI.2.2)

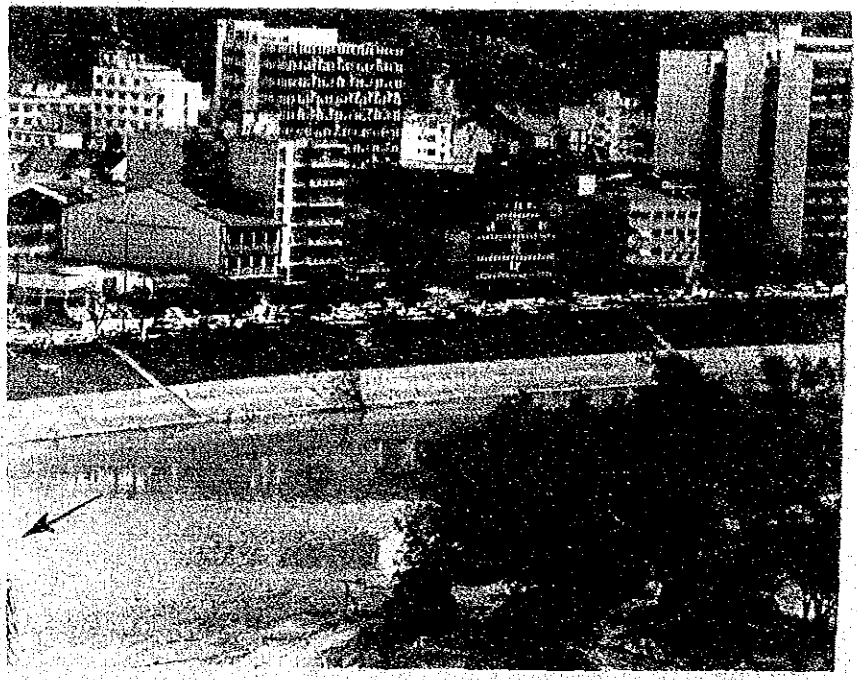
Table VI.2.2 MATRIX FOR THE IMPACTS ON THE ITAJAI RIVER IMPROVEMENT

ENVIRONMENTAL FACTORS / PROPOSED ACTIONS		HUMAN ENVIRONMENT				NATURAL ENVIRONMENT		SOCIAL ENVIRONMENT	
		WATER POLLUTION SUSPENDED SOLIDS	AIR POLLUTION DUST	NOISE VIBRATION	LAND BANK STABILITY	ANIMAL LIFE VEGETATION	LANDSCAPE	LIFE HOUSING	AREA SEPARATION
UNDER CONSTRUCTION	RIVER DREDGING	○	△	△		○			
	EMBANKMENT		△	△	△	○		△	
	RIVER WIDENING	○	△	△	△	○		○	
	DIVERSION CHANNEL	○	△	△	△	○		△	
	BRIDGE	△	△	△					
	REGULATION RESERVOIR		△	△	△	○		△	
	SURPLUS SOIL TREATMENT		△	△					
COMPLETED	PARAPET WALL SETTLEMENT						△		
	APPEARANCE OF IMPROVED SLOPE						△		
	APPEARANCE OF REGULATION RESERVOIR						△		△
	APPEARANCE OF DIVERSION CHANNEL						△		○

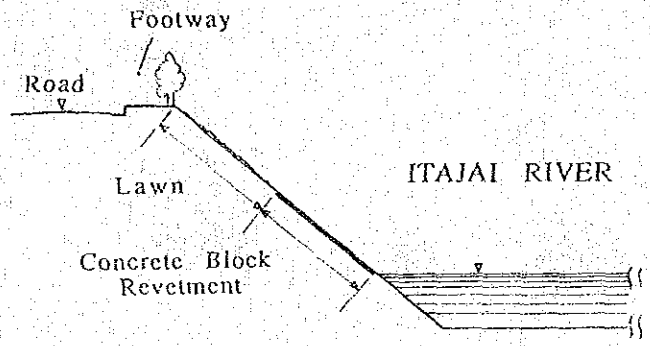
Remarks : ○ This mark indicates that the influence on environment is serious and an adequate survey to put the plan into practice is necessary.

△ This mark shows that environments impacts is slightly considered.

Figures



PRESENT LANDSCAPE OF CENTER STRETCH IN BLUMENAU



PRESENT CONDITION OF RIGHT BANK SIDE OF CENTER STRETCH

FUNCTION

- Footway : Promenade (pleasant space for citizen and tourist)
- Trees and lawn along the footway : Green space

Fig.VI.2.1 CENTER STRETCH IN BLUMENAU

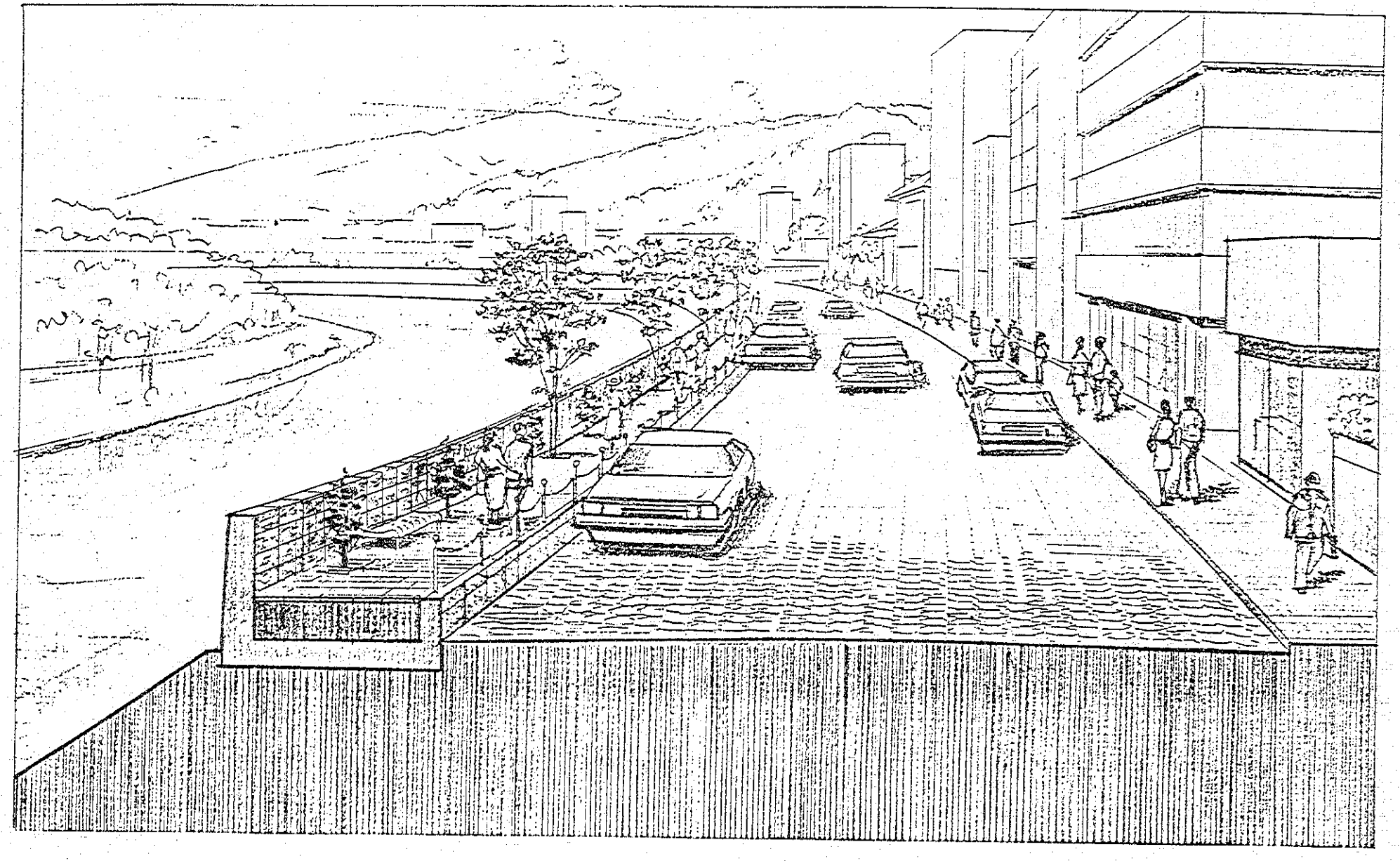


Fig.VI.2.2 PARAPET WALL PLAN

ANNEX VII. FLOOD CONTROL PLAN

VII. FLOOD CONTROL PLAN

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

1. INTRODUCTION

A master planning for flood control in the Itajai river basin with a catchment area of 15,220 km^2 was carried out during 10 months from beginning of April 1986 to the end of January 1987 including field works for 5 months and home works in Japan in 5 months. An Interim Report describing the result of the master planning of the basin and selection of the project for the feasibility study to be performed in the following stage was prepared and submitted to DNOS in the beginning of February 1987. Explanation meeting for this Interim Report was held on 9 to 10th February, 1987 in DNOS in Rio de Janeiro and it was decided to carry out the feasibility study on the river improvement in Blumenau-Gaspar stretch including drainage for the Blumenau city, which was selected among the several promising projects in the master plan in the Itajai river basin.

The Blumenau-Gaspar river stretch is located in the lower stretch of the Itajai river. River slope of the Itajai becomes gentle at just upstream of the Blumenau city. The Blumenau city is situated along V-shape meandering Itajai river stretch and houses densely develop up to both river banks. The Itajai river flows down through an alluvial flat plain and passes through also v-shaped river stretch along the Gaspar city at about 16 km downstream from the Blumenau city. Location of the project river stretch is shown in Fig.VII.1.1.

The geology of the project area in the Blumenau-Gaspar stretch consists mainly of an alluvial zone comprising clayey soil and fine sand, and rock zone distributes below the alluvial zone in the depth of 12 m in the upstream of the Blumenau river stretch and in the depth of 20 to 25 m in the downstream of the Gaspar stretch.

The Blumenau-Gaspar stretch is completely covered by both municipalities of Blumenau and Gaspar. The population in these municipalities within the Itajai river basin is 179 thousand on the basis of 1980 census, which is about 27% of the basin population. 159 thousand or 87% of them lives in urban areas, broken down as follows: 145 thousand in Blumenau; and 14 thousand in Gaspar.

The leading industry in these municipalities is the manufacturing industry from the point of view of production value. Receipts of this industry amount to Cz$ 69 billion at current prices according to 1980 industrial census, which accounts for 59% of the production in the basin. The commercial sector attains the sales amount to Cz$ 22 billion in 1980, which occupies 34% of the total sales in the basin. The agricultural production aggregates Cz$0.5 billion, which accounts for 3.5% of the basin's production. As a result of these production activity, GRDP in these municipalities is estimated to be Cz$47.7 billion in 1980 and the per capita GRDP comes into Cz$261 thousand. This per capita value corresponds to 2.4 times of both the state's and the national value.

Out of the municipal land area of 746 km^2 in the basin, the flood prone area occupies about 69 km^2 or 9% of municipal areas in the basin.42 km^2 or 60% of the flood prone area is already built up for residential use and for other urban activities. The rest areas are utilized for agricultural production. Thus, most of the flood prone areas have been urbanized along the Itajai river , as Blumenau is the center of urbanization.

The occurrence of two floodings in 1983 and 1984 was a vivid experience for both municipalities of Blumenau and Gaspar since they caused a tremendous flood damage of public and private properties in these areas. The extent of inundation in Blumenau-Gaspar stretch was approximately 40 km^2 in 1983 and a slightly larger than 40 km^2 in 1984. Inundation extended to the riparian area of the Itajai river as well as the tributaries such as Garcia, Velha and Itoupava rivers in Blumenau, and small rivers in Gaspar. Water depth in inundation area due to both floods depending on topographic condition reached to the ceiling of the first floor of buildings in height (more than 4m) in central area of Blumenau whereas inundation duration was averagely 10 days in 1983 and 5 days in 1984 respectively. Flood damages to residences, industrial properties plus facilities, and public infrastructure like road, bridge, utilities and others reached to a tremendous amount. In particular, damage caused by 1983 flood to manufacturing industries in Blumenau led to disturbance of their activities since long duration of inundation damaging production facilities took one or two months to return to normal operation.

To cope with such flooding, the river improvement work by means of widening of the river channel has been executed by DNOS under the local contract basis since 1985. The widening works of the river channel is being carried out at 4 places in the project river stretch using dredger with capacity of 95 to 280 m^3/hr and other construction equipment.

This Appendix VII presents the study on the river improvement in the Blumenau-Gaspar stretch, treatment of main tributaries flowing into the Itajai river through the Blumenau city and drainage plan in the urban areas along these tributaries in the Blumenau city. The study comprises the following items;

(1) Present river condition in Blumenau-Gaspar stretch including main three tributaries flowing into the Itajai river through Blumenau city.

(2) River improvement plan in Blumenau-Gaspar stretch

(3) River improvement plan in main tributaries.

(4) Drainage plan in urban areas along major tributaries in Blumenau.

2. PRESENT CONDITION IN BLUMENAU-GASPAR STRETCH

2.1 River Features

2.1.1 Blumenau-Gaspar stretch in Itajai river

The Itajai river is characterized by its irregular river bed slope. It will be widely classified into three stretches, namely, upstream stretch with gentle river bed slope in the upstream of Lontras city, middle stretch with remarkably steep river bed slope between downstream of Lontras city and Subida and rather steep river bed slope between Subida and upstream of Blumenau city and lower stretch with remarkably gentle river bed slope between Blumenau city and river mouth.

The river bed slope of the Itajai becomes remarkably gentle as being 1:10,000 to 1:15,000 at just upstream of the Blumenau city. The Blumenau city is located along V-shaped meandered Itajai river stretch and houses have been densely built up to both river banks. The river width is about 150 m and its depth is 15 m. Major tributaries, Itoupava, Velha and Garcia rivers flow into the the Itajai river in up and downstream of the V-shaped meandered river stretch.

The Itajai river flows down to eastward meandering gently and passes through the Gaspar city which has been developed closely to the river banks along also V-shaped river stretch and located at about 16 km downstream of the Blumenau city. River width in this stretch is 200 to 300.m and its depth is around 15 to 20 m.

The total length of the project river stretch between about 10 km upstream of the Blumenau city and about 6 km downstream of the Gaspar city is 32 km. The longitudinal profile of the river channel including its width and depth is shown in Fig.VII.2.1. The river cross sections at major points are given in Fig.VII.2.2. Present bankful flow capacity in the project river stretch calculated by non-uniform steady flow using the river cross sections with an interval of 300 m is shown in Fig.VII.2.3. This figure shows that bankful flow capacity in the project stretch varies from 2,000 to 5,000 m^3/sec . The river channel at the Gaspar and Blumenau stretches is so small as being 2,000 to 3,000 m^3/sec which corresponds only to 2 to 5 year probable flood.

2.1.2 Main tributaries flowing into Itajai river through Blumenau city

It has been anticipated that even after the river improvement work in the Itajai river along the Blumenau city is performed, inundation in the urban areas along the tributaries flowing into the Itajai river through the Blumenau city, which are Itoupava, Velha and Garcia rivers, will be still remained due to the flood from the Itajai river.

The Itoupava river with a catchment area of 93 km^2 originates in the mountainous area in the left side of the Itajai river, flows north to south passing through the flat plain area, and joins with the Itajai river at about 8 km upstream of the center of Blumenau city. The both banks along the Itoupava river have been utilized as a farm land and pasture and there is no residential area except at the confluence part with the Itajai river. The both banks along 9 km long stretch upstream from Itajai confluence was inundated at flood time in 1983.

The Velha with a catchment area of 56 km^2 originates in the mountainous area in the right side of the Itajai river, flows from north

to northeastward and joins with the Itajai river in the center of the Blumenau city. The riparian area along the both river banks in about 2 km long stretch upstream from the Itajai confluence is occupied by residential and commercial zones of the Blumenau city. The riparian area along 4.4 km long stretch upstream from Itajai confluence was inundated at flood time in 1983.

The Garcia river with a catchment area of 157 km^2 originates also in the mountainous area in the right side of the Itajai river, flows to northward and joins with the Itajai river at the center of the Blumenau city. The riparian area along the both river banks in about 3 km upstream from the Itajai confluence is occupied by residential and commercial zones of the Blumenau city. The riparian area along about 5.2 km long stretch upstream from Itajai confluence was inundated at flood time in 1983.

These three tributaries consist of the single river cross section. Their river width is around 20 to 50 m and river depth is 5 to 10 m and it is gradually increasing toward downstream stretch. The longitudinal profile of the river stretch which is affected by the flood water level of the Itajai river is shown in Fig.VII.2.4. It was reported that urban area along these tributaries are not inundated by flood coming from their upstream reaches.

2.2 River Improvement Work

Since occurrence of a large magnitude of flood in 1983, river improvement plan in the Itajai river to supplement the flood control effect by the existing Sul and Oeste dams was carried out. It was intended by this river improvement plan to lower flood water level by 3 m at the upstream end of the project river stretch by means of mainly widening of the existing river channel and river dredging to arrange the river width. Major features of the river improvement plan are as follows:

(1) Project river stretch; 22 km from about 6 km downstream of Gaspar city to Blumenau city.

(2) Design flood; 6,000 m^3/sec (assumed peak flood discharge at Blumenau in July, 1983).

(3) Design river channel; river channel with 220 m in width by widening the existing river channel by about 100 m.

(4) Total excavation volume; 27.5 million m^3.

In line with this plan, the river improvement work in the Blumenau-Gaspar stretch has been implemented since January 1985. The work is now executed by a local contract basis at the river stretch at about 5 km downstream and 5 km to 9 km upstream from Gaspar city respectively, where the detailed design and compensation of lands and houses were completed.

The equipment used for this work are 3 units of dredger with a capacity of 95 to 280 m^3/hr, 2 nos of drugline, 1 no of backhoe and 8 nos of dump truck. The excavated earth volume by July, 1987 is about 3.5 million m^3 in total which is 13% of the planned volume.

2.3 Existing River Structure and Related Structures

There are no river structures in the project river stretch except a revetment at the right river bank along V-shaped meandered stretch of the Blumenau city. This revetment is provided along about 1.4 km long river bank between confluence of Garcia river and also confluence of Velha river. Its height is about 6 m and side slope is around 1:1.7. The revetment is now in a good condition though a part of the revetment was damaged at flood time in 1983.

The related structures such as bridge, drainage gate, pumping station and hydro electric power station have been located in the project area as shown in Fig.VII.2.5.

In the project area, 33 bridges cross over the Itajai river and its tributaries. Most of them are roadway bridges connecting the national road to local road and local roads themselves. Majority of the bridges are concrete type with concrete pile foundation.

The pumping stations to supply the municipal water have been provided along the river stretch in the Blumenau and Gaspar cities. Their capacity is 130 l/s and 60 l/s respectively.

The drainage gate to drain the inner water is provided at three sites along the Blumenau river stretch. Out of them, two gate facilities were recently constructed to drain the inner water from urban areas in the left bank at about 7 km upstream of the center of the Blumenau city.

There is a hydro electric power station in the project Itajai stretch at about 10 km upstream of the Blumenau city. Its installed capacity is small scale such as 6,300 kw. This power station has been used as an emergency purpose to supply deficit of the electric power supply network.

The features of these related structures are summarized in Table VII.2.1.

3. RIVER IMPROVEMENT PLAN IN BLUMENAU-GASPAR STRETCH

3.1 General

Several flood control plans to protect the project area from flood were studied in the master plan stage and flood control method by means of river improvement was employed. In order to realize the flood control plan as earlier as possible and to meet with social urgent requirement, stage wise river improvement plan comprising provisional plan, mid-term plan and long-term plan was worked out. In this study, the river improvement plan in the Blumenau-Gaspar stretch for the provisional plan was discussed.

3.2 Principle of River Improvement Plan

3.2.1 Proposed flood discharge distribution

The proposed flood discharge distribution for river improvement plan for provisional plan was established against 10-year probable flood under the following conditions and assumptions;

(1) Flood peak discharge in the upstream reaches is regulated by the existing Sul and Oeste dams and under constructing Norte dam. In this case, present operation method is applied.

(2) The river stretches along urban areas in the upstream from the Blumenau city are improved against 10-year probable flood.

(3) Flood peak discharge with 10-year probable flood from the tributaries flowing through the Blumenau city flows into the Itajai river.

The proposed flood discharge distribution established in accordance with the foregoing conditions and assumptions is illustrated in Fig.VII.3.1.

3.2.2 River improvement method

It was worked out the river improvement plan in the project stretch by applying the following method;

(1) Since it is practically impossible to widen the river channel along the Blumenau city, it was contemplated to increase the flow capacity of the river channel by steepening hydraulic gradient of flood water level and by minimizing rise of flood water level as far as possible. To achieve these purposes, the followings were planned;

   (i) To lower the flood water level at the downstream end of the Blumenau river stretch by means of widening of the river channel in the project stretch. This widening method of the river channel accords with that being performed by DNOS at present.

   (ii) To widen the left river bank along the Blumenau city as far as possible.

   (iii) To reduce roughness coefficient of the river channel along the Blumenau city by arranging the river bank slope and providing river bank slope protection by means of sodding.

(2) Large scale floods occurred in 1983 and 1984 correspond to 50-year probable flood. To protect the Blumenau city against the same scale floods as those in 1983 and 1984, a concrete parapet wall is provided at the right river bank along the Blumenau city for about 420 m long stretch in the upstream from the confluence with Garcia river, which is locally low elevation. In view of the landscape of the Blumenau city, height of the concrete parapet will be limited to 1 m.

(3) It is also practically impossible to widen the river channel and to construct high levee in the river stretch along the Gaspar city because many houses have been built up close to the river banks. To protect the Gaspar city from flood and to lower the flood water level in the upstream stretch, a flood diversion channel is provided by connecting with the upstream and downstream ends of the V-shaped meandering Gaspar river stretch.

(4) Levee or filling of the excavated earth material from river channel is provided only at the river bank which is locally low elevation in the project river stretch.

3.3. River Improvement Structural Plan

3.3.1 Design of river improvement structural plan

The river improvement structural plan in the project stretch in the Itajai river was designed under the following design conditions;

(1) Design work of the river improvement plan is carried out based on the topographic map with a scale of 1:10,000 and contour interval of 1 m and river cross sectional maps with an interval of 300 m, which were surveyed in this year.

(2) Alignment of the design river channel is set along the existing river channel and widening side of the river channel is determined taking into account the topographic condition and compensation of houses.

(3) Design flood water level is set lower than the elevation of river bank considering especially the elevation of urban river stretch along the Blumenau city.

(4) Design river bed slope is set almost the same as the existing average river bed slope.

(5) Single cross section is applied as the design cross section. The width of the low water channel is decided at 155 m for the downstream of the Gaspar stretch and 140 m for the upstream of the Gaspar stretch.

(6) The flood diversion channel at the Gaspar stretch was designed under the follow-up conditions:

   (i) The design flood water level at the Gaspar stretch is lower than the existing river bank, and

   (ii) The design flood water level at the existing bridge site at the Gaspar city does not exceed the lowest elevation of the bridge girder.

The designed discharge to be flown down through the flood diversion channel determined under the above conditions is 600 m^3/sec for the provisional plan and 1600 m^3/sec for the long term plan. The width of this low under channel in the provisional plan is 10m. It was clarified that soft alluvial deposits mainly consisting of clayey soil and fine sand are developing along the proposed flood diversion channel route. Considering this geological situation, a berm with 2 m in width is provided for the flood diversion channel. Side slope of the excavated river channel is 1:2.

(7) Levee or filling of the excavated material from river channel is provided only at the river bank which is locally low elevation. Criteria for these works are as follows;

(i) The levee is provided to the river bank where houses are densely located.

(ii) Location of the levee in river bank is decided considering the river cross section which is able to flow down 50-year probable flood. The clearance between toe of the levee and edge of the excavated river slope is 5 m.

(iii) Height of levee is decided based on the water level corresponding to 50-year probable flood. Freeboard of the levee is 0.5 m.

(iv) The shape of levee is a trapezoid type with crest width of 4 m and side slope of 1:2 on both sides.

(v) The embankment material for levee is obtained from residual soil widely distributed superficially on most of hills in the project area.

(vi) The filling of excavated material from the river channel is adopted to the river bank where house is only partly located. No freeboard is provided for this filling.

(8) The compensation for lands and houses at the levee embankment site is carried out for the river width necessary for a long term plan.The existing road to be shifted should be reconstructed considering the river width for the long term plan.

Based on the above design conditions, design of river improvement structural plan was carried out. Fig.VII.3.2 shows the general plan of the designed river channel alignment. The longitudinal profile of the design river bed and design flood water level is shown in Fig.VII.3.3. Standard river cross sections for the protective river stretches are given in Fig.VII.3.4. Proposed concrete parapet wall along Blumenau stretch is shown in Fig.VII.3.5.

3.3.2 Design of related structure

It was planned to construct a new bridge on the proposed flood diversion channel and to heighten the existing bridge on the Itajai main stream if necessary. The established design conditions are as follows:

(1) For design of the bridge to be newly constructed on the proposed flood diversion channel, the following design conditions should be applied;

(i) Length of bridge is determined considering the cross section against 50-year probable flood. Freeboard of 0.5 m is provided between the lowest elevation of bridge girder and flood water level corresponding to 50-year probable flood.

(ii) Bridge width of 7.2m for roadway and 0.9 m for sidewalk in both sides is applied. Design standard which is applied to the bridge design for national road in Brazil is employed in this study.

(2) The existing bridge should be heightened if the lowest elevation of the existing bridge girder is lower than the design flood water level corresponding to 50-year probable flood in the Itajai river. In this case, freeboard is 0.5 m. The existing Ireneu Bornhausen bridge which crosses over the Itajai river at about 7 km upstream of the Blumenau city is lower than the flood water level corresponding to 50-year probable flood. However since new bridge plan at just downstream of the existing bridge is now worked out by the Blumenau municipality, this existing bridge was planned to be heightened after the new bridge is constructed and all of the traffic volume is shifted to the new bridge.

Fig.VII.3.6 shows the general plan and profile of the bridge to be newly constructed on the proposed flood diversion channel.

4. RIVER IMPROVEMENT IN TRIBUTARIES FLOWING INTO ITAJAI RIVER THROUGH BLUMENAU CITY

4.1 General

The urban areas in the Blumenau city along the tributaries, Garcia, Velha and Itoupava rivers at their endmost stretch have been inundated by the flood from the Itajai river at the time of a large scale flood. In order to protect these urban areas from flood, river improvement plan was worked out for these three tributaries to the extent that will be affected due to flood water level corresponding to 10-year probable flood in the Itajai river.

4.2 Principle of River Improvement Plan

The following principle was established for the river improvement plan of the Garcia, Velha and Itoupava rivers to the extent that is affected by the flood water level corresponding to 10-year probable flood in the Itajai river;

(1) Design flood in the tributaries is 10-year probable flood.

(2) To prevent the flood water in the Itajai river from flowing into the urban area of the Blumenau city, levee and/or filling of the excavated material is provided along the affected stretch of the Garcia and Velha rivers. For the Itoupava river, the levee and/or filling of the excavated material is provided only at its endmost river stretch where houses are densely located. Since riparian area along further upstream stretch is occupied mainly by pasture and non-use lowland areas, these areas are elevated by filling the excavated earth material from the river channel.

(3) Location of levee at river side is determined considering the alignment of the existing river channel.

(4) Height of levee is decided against the flood water level corresponding to 50-year probable flood in the Itajai river. Freeboard of the levee is 0.5 m.

(5) A short cut channel is provided for extremely meandered river stretch and the area to be surrounded between the existing river channel and short cut channel is utilized as the regulating pond for inner drainage plan for Blumenau city.

4.3 River Improvement Structural Plan

4.3.1 Design of river improvement structural plan

The river improvement plan for the endmost stretch of the Garcia, Velha, and Itoupava rivers was designed based on the topographic maps with a scale of 1:10,000 and 1:2,000 and contour interval of 1 m , and river cross sectional maps with an interval of 300 m. The applied design conditions are as follows;

(1) It is assumed that the design flood water level in the affected stretch in three tributaries is the same as that corresponding to 10-year probable flood in the Itajai river.

(2) Design river bed slope is set almost the same as the existing

average river bed slope.

(3) Height of levee is determined against the flood water level corresponding to 50-year probable flood in the Itajai river. Freeboard of the levee is 0.5 m.

(4) The shape of levee is a trapezoid type with crest width of 3 m and side slope of 1:2 for both sides.

(5) The residual soil widely distributed on most of hills in the project area is used as the levee embankment material.

Figs.VII.4.1 to VII.4.3 show the general plan of the river channel alignment. Longitudinal profile of the design river bed and design flood water level is shown in Fig.VII.4.4. Standard river cross sections are given in Figs.VII.4.5 to VII.4.7.

4.3.2 Design of related structure

More than 30 bridges cross over the tributaries, Garcia, Velha and Itoupava rivers flowing into the Itajai river through the Blumenau city and the tributaries, Gaspar Grande and Gasparinho rivers flowing through the Gaspar city. Among them 11 bridges were planned to be heightened or reconstructed under the following conditions;

(1) The existing bridge should be heightened if the lowest elevation of the bridge girder is lower than the design flood water level corresponding to 50-year probable flood in the Itajai river. In this case, freeboard is 0.5 m.

(2) In case that the existing substructure and superstructure are constructed separately, the substructure is only heightened. In case that the substructure and superstructure are constructed as one unit structure, the substructure is heightened after they are separated.

(3) The existing road connecting with the bridge to be modified is also reconstructed to the extent of the stretch that the longitudinal slope is 4 %.

The name of bridge to be heightened in accordance with the above design conditions are as follows;

Garcia river

PONTE DA RUA 7 DE SETEMERO

Velha river

PONTE DA RUA SAO PAULO

PONTE DA RUA PARAIBA

PONTE DA RUA 7 DE SETEMBRO

PONTE DA RUA MARIANA BRONNEMANN

PONTE DA RUA ALBERTO STEIN

RUA DA MARECHAL DEODORO

Gaspar grande river

PONTE DA RUA GEL. ARISTILIANO RAMOS (BR470)

PONTE DA AVENIDA DAS COMUNIDADES

Gasparinho river

PONTE DA RODOVIA JORGE LA CERDA

PONTE DA ROCOVIA GASPAR-BRUSQUE

5. DRAINAGE PLAN IN BLUMENAU CITY

5.1 General

The riparian area along the Blumenau river stretch will be relieved from flood from Itajai river by implementations of river improvement plan in the Itajai main stream and also in the endmost stretch of the tributaries, Garcia, Velha and Itoupava rivers. However, some parts of the urban area in the Blumenau city which are lower elevation than the design flood water level in the Itajai river will be still remained as depression area as shown in Fig.VII.5.1.

In this study, drainage plan for these areas including their catchment area was worked out by combining several drainage facilities such as regulating pond,pump and gate.

5.2 Existing Urban Drainage System

5.2.1 Existing urban drainage facilities

Any detailed map showing the existing drainage network does not exist in the Blumenau municipality. Fig.VII.5.2 shows the existing drainage network prepared based on the interview from the staff of the municipal office concerned.

The present drainage system is gradually expanded in keeping pace with the development of urbanization of the Blumenau district. Consequently the existing capacity of the network in the downstream area is insufficient condition to drain safety outflow from the basin area. Majority of outflow from the basin is drained to the tributaries of the Itajai river. Due to this drainage condition, drainage water in some depression areas flows reversely at the high water time of the tributaries.

5.2.2 Existing studies on drainage plan

Two kinds of study on the drainage plan in the Blumenau city were made in the past by the Blumenau municipality. One is the urban drainage plan including sanitary sewage. This plan was prepared in 1975, and design rainfall with 10-year probability was adopted. However, influence of the water level of the Itajai river is not taken into account in this study. This plan is not valid now, but expansion plan of the drainage system is made referring to this plan.

The other is inner water treatment plan for the urbanized area of the Blumenau city. This plan was prepared by DNOS in 1985. Several alternatives as stated in the following were contemplated;

Plan A : Construction of polders surrounding the inner water area and installation of pumping station.

Plan B.: Closure at the confluence of the tributary and installation of pumping station.

Plan C : Closure at the confluence of the tributary and construction of flood control dam at the upper reaches of the tributary or diversion channel/tunnel.

As a result, the plan A was selected as the most economical one.This

plan is, however, very costly because it is planned to drain directly inner water without providing regulating pond and consequently large scale pump capacity is needed.

5.3 Present Situation of Envisaged Drainage Districts

The envisaged drainage areas along the Garcia, Velha and Itoupava rivers are classified into 13 divisions as shown in Fig.VII.5.3 considering the existing drainage network as illustrated in Fig.VII.5.2. The present situation of divided drainage basins is stated hereinafter.

5.3.1 Drainage basin along Garcia river

The drainage basin along the Garcia river is divided into 4 districts;

(1) Drainage district; G-1

A Fresco river, a small stream joins with the Garcia river from right bank at just upstream of the Itajai confluence. The drainage district G-1 belongs to the drainage area of the Fresco river. The drainage area is 3.94 km^2 comprising 3.37 km^2 of undeveloped mountainous area, 0.5 km^2 of residential area and 0.07 km^2 of fields. The residential area has been developed in the valley surrounded by the mountains with an altitude of 100 to 200 m. Majority of flat plain along the valley has been already developed as the residential area. The ground elevation of the residential area is EL 10.0 m to EL 15.0 m and all of the area was inundated in the flood time in 1983 and 1984.

The Fresco river has been utilized as the drainage canal for the residential area, and a part of it was canalized with culvert. Due to insufficient capacity of the canal, habitual inundation takes place when it rains locally even when the water level in the Itajai river is low.

(2) Drainage district; G-2

This district is located at the upstream side of G-1. G-2 is further classified into two zones, namely, G-2-1 and G-2-2. G-2-1 is the drainage area along the main road (Amazonas Street) which is located in the right bank of the Garcia river.G-2-2 is the mountainous zone in the southeast of G-2-1.

Majority of G-2-1 is the residential area developed along the Garcia river and almost area is inundated at the flood time in the Itajai river. Main drainage pipe with diameter of 600 mm is located along the Amazonas street.

The drainage area of G-2-2 is 2.18 km^2 and about 92% of it is occupied by mountainous area with an altitude of 150 to 200 m. It is urbanized up to the area with the altitude of about 130 m. Habitual inundation takes place only at the downstream zone. Main drainage pipe with the diameter of 600 to 800 mm is installed along the Ararangua street which crosses with the Amazonas street but since there are no pipe lines to be connected in the downstream area, habitual inundation takes place in the downstream area. Drainage to

the Garcia river is made by 2.5 m wide and 2.5 m high culvert under the Amazonas street.

(3) Drainage district; G-3

This drainage area is located at the upstream of G-2 in the right bank along the Garcia river. The drainage area is 1.13 km^2 comprising 0.31 km^2 of the residential area, 0.68 km^2 of the mountainous area and 0.14 km^2 of fields. The drainage pipe with a diameter of 600 to 1,500 mm is installed along the Amazonas street but due to its insufficient capacity, the inundation takes place in the right side area along the Amazonas street. The low land area along the Garcia river is utilized as pasture or in undeveloped condition.

(4) Drainage district; G-4

This drainage area is situated in the left bank of the Garcia river and it is further divided into two districts from the viewpoint of the existing drainage network. They are G-4-1 which is a drainage area of 0.67 km^2 along the Garcia river and G-4-2 which is the drainage area of 4.50 km^2 and consists of hinterland of G-4-1.

G-4-1 is occupied by the residential and commercial areas of the Blumenau city. The existing drainage pipe with the diameter of 600 to 1,500 mm is installed along the center of the divided area and after joining with the main drainage pipe from G-4-2, it drains directly to the Itajai river.

G-4-2 comprises a center of commercial area in its downstream area, residential and industrial areas in flat plain along the valley and mountainous area in its upstream basin. The drainage in this district is made by a small stream in the upstream area and main drainage pipe with the diameter of 1,600 mm in the downstream area. However, due to insufficient capacity of the drainage system, an inundation takes place when heavy local rainfall occurs in the basin. Besides, the center of the downstream commercial area is topographically depression and drainage is always in the worst condition.

Majority of the urban area in G-4 is inundated due to the flood water from the Itajai river at the large scale flood time.

5.3.2 Drainage basin along Velha river

The drainage basin along the Velha river is divided into 7 districts.

(1) Drainage district, V-1

This drainage area is located in the right side of the Velha river in its endmost stretch. The drainage area is 0.43 km^2 comprising center part of the commercial area and mountainous area. The drainage pipe with the diameter of 1,000 mm is installed in the center of the commercial area and drained to the Velha river. However due to insufficient capacity of the drainage pipe and depression zone in the center of the commercial area, an inundation

always takes place.

(2) Drainage district; V-2

This drainage district with a catchment area of 0.62 km^2 is situated in the upstream of V-1 area. Majority of the area is occupied by the flat plain, and inundated at the large scale flood time.

The drainage pipe with a diameter of 1,500 mm is installed in the center of the area. However, this center part is the depression area and inundation often takes place due to insufficient drainage.

(3) Drainage district; V-3

The drainage area, V-3 which has an acreage of 0.67 km^2 is situated at upstream of V-2 and occupied by 55% of plain area and 45% of mountainous area. Majority of the plain area has been developed as the residential and commercial areas and development is being progressing to the mountain slope. Two units of drainage pipe with a diameter of 1,500 mm is installed in the area.

(4) Drainage district; V-4

This drainage area having an acreage of 0.68 km^2 is located at upstream of V-3 and topographic and social conditions are almost same as those for V-3. The drainage pipe with a diameter of 600 to 1,500 mm is installed to the Velha river through the center area but its capacity is insufficient. Since main trunk line is installed under the existing residential area, repairing work is in difficult condition.

(5) Drainage district; V-5

The drainage district, V-5 having an acreage of 0.59 km^2 is located in the left side of the Velha river. The area is fully occupied by the urban area except only a part of the mountainous area. Two units of the drainage pipe with a diameter of 1,000 mm is installed but its capacity is insufficient comparing with the acreage of this drainage basin. An inundation acreage due to past large scale flood in the Itajai river was about 0.29 km^2.

(6) Drainage district; V-6

This drainage district with an acreage of 1.17 km^2 is located in the upstream of V-5. More than 50% of the area has been utilized as the urban area. Two units of drainage pipe with the diameter of 1,500 and 2,000 mm is installed in this district.

(7) Drainage district; V-7

This drainage area is located along Jararaca river, a stream flowing into the Velha river and its acreage is 2.34 km^2. Majority of the area is utilized as the residential area and its development is progressing to the mountain slope in the upstream area. The drainage from this district is made using the Jararaca river at present.

5.3.3 Drainage basin along Itoupava river

The drainage basin along the Itoupava river is divided into two districts in the downstream reaches of the Itoupava river. Since there are no houses in its further upstream flat plain area, it is planned to utilize it as residential and industrial areas by elevating this area by means of filling the excavated material from river channel.

(1) Drainage district; I-1

This drainage district with an acreage of 0.51 km^2 is located in the left side of the Itoupava river. Majority of this area is occupied by residential area. In order to drain water from further upstream of I-1, a drainage system, comprising 120 m long earthfill dam, pumping station with 3 units of pump having the capacity of 0.25 m/sec and 280 m long drainage pipe with a diameter of 1,000 mm to 1,500 mm to the Itoupava river was recently constructed.

(2) Drainage district; I-2

This drainage district having an acreage of 1.93 km^2 is situated in the right side of the Itoupava river. The area is occupied by 52% of flat plain area and 48% of the mountain area. The national road which has been recently constructed passes through the center of this district. There are no residential areas except only at the downstream area of the district.

5.4 Plan of Inner Water Treatment

5.4.1 Principle of inner water treatment measure

In order to work out an adequate inner water treatment plan, topographic condition of the drainage basin, effective utilization of the existing drainage system and problem of the existing drainage system should be considered for planning. Major principles for the planning are as follows;

(1) In order to reduce peak discharge from the drainage basin, regulating pond as large scale as possible should be provided. Location of the regulating pond should be selected at the endmost area of the drainage basin considering flood regulation effect.

(2) Drainage using a pump is generally costly and much cost is necessary for its operation and maintenance. Thus, number of pumping station should be minimized and pump capacity should be reduced considering its spare part supply.

(3) In order to drain the inner water by gravity flow when water level of the tributaries or Itajai river is lower than that of the inner water level, flap type gate should be installed.

(4) The flag gate should be also installed at the outlet of the existing drainage network to prevent river water from flowing reversely to the urban area.

(5) Since only the downstream area in the Itoupava river is developed as

the residential area, it should be protected by polder.

(6) The drainage facilities to be contemplated in this plan involve regulating pond, pumping station, gate facilities and extension of drainage pipe from the existing main drainage pipe to the proposed regulating pond. The improvement of the existing drainage pipe line network is not included in this plan.

5.4.2 Design of urban drainage facilities

The design of urban drainage facilities such as regulating pond, pumping station, drainage pipe connecting the existing drainage pipe to the regulating pond was made under the following design conditions;

(1) Probable flood hydrograph and its volume to design capacity of pump and regulating pond are simulated by the rational formula using the probable 4-day rainfall with 10-year probability at Blumenau and actual rainfall distribution records on July 1983 and August 1984 taking into account the availability of hourly rainfall records during large scale flood.

(2) Probable flood peak discharges for design of connecting pipe is estimated by the rational formula method incorporating the probable rainfall intensity-duration curve with 10-year probability established by hydrological study.

(3) In order to evaluate the increase of discharge due to the urbanization and development of Blumenau city, runoff coefficient in future stage is estimated on the basis of the future land use map planned by the municipal government of Blumenau city in 1985 and the following runoff coefficient classification by land use category in Japan was adopted;

- City area ; 0.9,
- Farm, pasture and no-use lands ; 0.6 and
- Forest area ; 0.7.

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

(4) Design high water level in the regulating pond is set at the ground elevation at the pond side 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 set at 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 10-year probable flood peak discharge from drainage district.

Main features of the regulating pond, pump and gate designed in accordance with these design conditions are shown in Table VII.5.1. The proposed facilities comprise 10 sites of the pond, 5 sites of the pumping station and 20 nos. of the flap type gate with dimension of 2 m in height and 2 m in width. General plan of the drainage facilities and details of the pond with related facilities are given in Figs.VII.5.4 to VII.5.25 respectively. The drainage method in the respective drainage

districts is stated as follows;

(1) Drainage district; G-1

The regulating pond will be provided at the junction portion of the Garcia river and Fresco river by connecting straightly the meandered river stretch of the Garcia river. The estimated storage volume of the pond space surrounded by the existing river channel and short cut channel is 204,000 m3. This regulating pond will be connected with the pond to be provided in riverine area in G-2 district by means of pipe. The inner water stored in this pond will be drained by pump to the Garcia river when water level in the Garcia river is higher than that in the pond and also by flap type gate when the water level in the Garcia river is lower than that in the pond.

(2) Drainage districts; G-2-1, G-2-2

An unused area in the right side of the Garcia river will be utilized as the regulation pond. The obtainable pond capacity is 137,000 m3.

(3) Drainage District; G-3

Two portions of the unused area will be utilized as the regulating pond. Since total storage capacity is so much as being 409,000 m3, water volume for design 4-day continuous rainfall with 10-year probability can be fully stored. Thus the pump will not be needed and only the flap type gate will be provided.

(4) Drainage district; G-4-1, G-4-2

The inner water from G-4-1 and G-4-2 is now drained directly to the Itajai river. However, due to the depression in the center part of G-4-1, drainage becomes impossible in case of higher water level in the Itajai river. There is no space for providing the regulating pond in these districts. Then new drainage route is provided from existing drainage pipe and inner water diverted to new line is stored in the regulating pond for G-2 in the opposite river bank by conveying the inner water through a siphon to be newly provided crossing under the Garcia river.

(5) Drainage district; V-1 and V-5

The regulating pond will be provided at the left bank along the Velha river at about 0.3 km upstream of the Itajai confluence by utilizing the space to be obtained by short cutting of the existing river channel. The storage capacity of the pond is 50,000 m3. The inner water collected in the downstream of V-1 area will be diverted to the pond in V-5 area by means of a siphon to be provided crossing under the Velha river, and the inner water thus stored in the regulating pond in V-5 area will be drained to the Velha river using the pump and flap type gate. In this case, about 350 m long additional pipe from the existing main drainage pipe to the proposed pond site is needed.

(6) Drainage districts, V-2 and V-6

The regulating pond will be provided at both river banks along the Velha river at about 1.8 km upstream of the Itajai confluence by

utilizing the unused areas. The storage capacity of the pond is 57,000 m3 for V-2 area and 101,000 m3 for V-6 area. The inner water stored in the regulating pond in V-2 area will be diverted to the pond in V-6 area by means of a siphon to be provided crossing under the Velha river, and the inner water stored in the regulating pond in the V-6 area will be drained to the Velha river using the pump and flap type gate. It will be necessary to install about 450 m long additional drainage pipe for V-2 area and 200 m long drainage pipe for V-6 area to connect with the existing main drainage pipe and the proposed pond.

(7) Drainage district; V-3, V-4

The regulating pond will be provided by lowering the ground elevation of the existing sporting ground. The pump and flap type gate will be provided to drain the inner water stored in the pond. About 150 m long additional drainage pipe for V-3 area and 500 m long drainage pipe for V-4 area will have to be provided to connect with the existing main drainage pipe and the proposed pond.

(8) Drainage district; V-7

Since there is no space to provide the pond along Jararaca river, the required pond will be provided at unused area in the left river bank of the Velha river. The inner water coming through the Jararaca river will be diverted to new channel to be provided connecting with the Jararaca river to the pond by closing the Jararaca confluence by the flap type gate, and drained to the Velha river by pump.

(9) Drainage district; I-1, I-2

The residential area in the endmost area in I-1 will be protected by polder and a flap gate is provided to drain inner water. A part of the endmost area in I-2 is protected by filling up the excavated material from river channel.

Tables

Table VII.2.1 EXISTING RIVER STRUCTURES AND RELATED STRUCTURES (1/4)

(1) Weir

/1 No.	Name	Purpose	Location: Distance from River-Mouth/ Confluence (km)	Location: Administrative Office	Features: Length (m)	Features: Height (m)	Features: Crest Elevation (m)	Remark
Itajai river								
1.	SALTO WEISBACH	Hydroelectric power, municipal water supply	78.65	CELESC and SAMAE	400	3.5	18.3	Intake discharge for Municipal water supply
Garcia river								
	ARTEX	Industrial water supply	6.90	32.5	1.9	17.3		Enterprise

(2) Pumping Station for Municipal Water Supply

/1 NO.	Location: Distance from River-Mouth/ Confluence(km)	Left/Right Bank	Administrative Office	Features: Nos. of Pump	Features: Intake Discharge (l/s)
Itajai river					
1.	52.07	L	SAMAE	2	60.0
2.	69.90	R	SAMAE	3	133.0

(3) Hydroelectric Power Station

/1 NO.	Name	Location: Distance from River-mouth/ Confluence(km)	Location: Administrative Office	Features: Turbine Discharge (m3/s) Max	Features: Turbine Discharge (m3/s) Normal	Features: Effective Head (m)	Features: Output (kw) Max	Features: Output (kw) Normal
Itajai river								
1.	SALTO WEISBACH	78.6	CELESC	89	-	-	6,300	-

Source : SAMAE and CELESC
Note : /1 Numbers corresponds to those in Fig.VII.2.5

Table VII.2.1 EXISTING RIVER STRUCTURES AND RELATED STRUCTURES (2/4)

(4) Drainage Pipe

/1 NO.	Location: Distance from River-mouth/ Confluence(km)	Left/Right Bank	Administrative Office	Diameter (m)	Remarks
Itajai river					
1.	62.7	R	Blumenau city	1.5	Corrugate Pipe Gate (1.40x0.90)
2.	68.2	R	- do -	2.02x2.68	Box culvert
3.	68.9	R	- do -	0.92x1.27	- do -
4.	74.5	L	- do -	2.4	Corrugate Pipe Gate (2.80x2.50)
5.	75.3	L	- do -	1.8	Corrugate Pipe Gate (2.30x2.00)
Velha river					
1.	0.22	L	Blumenau city	1.0	RC Pipe
2.	0.45	R	- do -	1.0	- do -
3.	0.80	L	- do -	1.0	- do -
4.	1.45	L	- do -	2.0	- do -
5.	1.86	L	- do -	1.5x2.0	- do -
6.	2.10	R	- do -	1.5	- do -
7.	2.54	R	- do -	1.5	- do -
8.	2.70	R	- do -	1.5	- do -
9.	2.76	R	- do -	0.6	- do -
10.	3.31	R	- do -	1.0	- do -

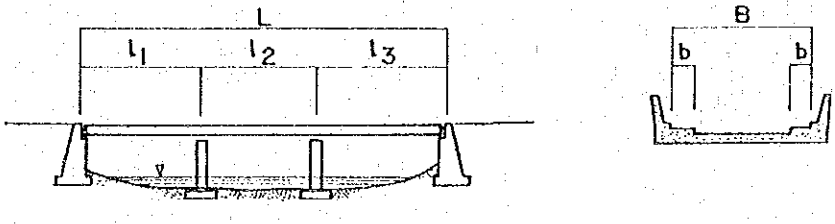
Source : DNOS and Blumenau city
Note : /1 Numbers correspond to those in Fig.VII.2.5

Table VII.2.1 EXISTING RIVER STRUCTURES AND RELATED STRUCTURES (3/4)

(5) Bridge

/1 No.	Name	Location: Distance from River-Mouth/ Confluence (km)	Administrative Office	Classification	Features: Bridge Length L (m)	Nos. of Span	Span Length l (m)	Width (m): B	Width (m): b	Lowest Elevation of Girder (m)	Elevation of Sidewalk Surface (lowest Point)	Remark
Itajal river												
1.	Hercilio Deeke	51.73	DER	Road	154.7	11	33.00	9.60	1.20	10.40	11.30	RC
2.	Jose da Silva	64.81	Blumenau city	- do -	185.6	6	31.50	15.80	1.20	15.00	17.10	- do -
3.	Ponte em Arco	67.15	RFFSA	- do -	180.2	8	41.60	13.10	0.75	19.80	20.80	- do -
4.	Adolfo Konder	68.71	Blumenau city	- do -	126.8	5	25.60	10.60	1.70	13.20	15.30	RC
5.	Ponte Ferroviaria	69.36	RFFSA	- do -	200.0	3	80.00	6.80	2.30	17.80	18.30	Steel
6.	Irineu Bornhausen	74.89	Blumenau city	- do -	161.5	10	17.45	10.40	1.60	13.00	14.60	RC
7.	Ponte do Slato	77.93	- do -	- do -	177.2	4	51.60	6.60	0.85	26.20	27.60	Steel
Garcia river												
1.	Desembargador Pedro Silva	0.07	Blumenau city	Road	38.1	-	-	14.30	2.00	12.30	13.48	RC
2.	Ponte da rua 7 de Setembro	0.78	- do -	- do -	52.0	3	38.30	19.00	2.50	8.81	11.56	- do -
3.	Ponte da Rua Manaus	1.57	- do -	Footpath	33.0	3	19.00	-	0.90	7.50	-	Wooden
4.	Ponte da Rua Sold Moacir Pinheiro	4.03	- do -	- do -	41.1	5	24.10	-	1.00	12.80	-	- do -
5.	Ponte da Rua Antonio Zendron	4.96	- do -	Road	20.9	1	20.90	9.35	1.10	15.35	16.75	RC
6.	Ponte da Rua Capinzal	5.39	- do -	- do -	27.8	3	11.35	7.80	0.90	16.84	18.49	- do -
7.	Ponte da Rua Mario Schmidt	6.07	- do -	- do -	31.5	3	23.90	10.55	1.40	18.14	19.34	- do -
Velha river												
1.	Ponte da Rua Sao Perimetral	0.09	Blumenau city	Road	42.0	3	16.35	13.80	1.85	14.63	15.88	RC
2.	Ponte da Rua Paulo	0.25	- do -	- do -	45.1	5	15.20	14.70	2.35	10.32	11.66	- do -
3.	Ponte da Rua Paraiba	0.70	- do -	- do -	42.0	3	16.00	5.30	-	8.91	9.72	- do -
4.	Ponte da Rua 7 de Setembro	1.84	- do -	- do -	30.2	3	12.10	18.00	2.10	9.33	11.55	- do -
5.	Ponte da Rua Mariana Bronnemann	2.47	- do -	- do -	20.0	3	11.45	7.30	0.60	9.78	11.18	- do -
6.	Ponte da Rua Alberto Stein	2.54	- do -	- do -	14.4	1	14.40	19.60	2.80	8.71	10.38	- do -
7.	Rua da Marechal Deodoro	3.11	- do -	- do -	20.0	3	9.55	10.20	1.10	11.49	12.74	- do -
8.	Rua Gustavo Budag	3.81	- do -	- do -	20.0	2	9.16	9.80	1.40	14.89	15.30	- do -
9.	Rua General Osorio	5.41	- do -	- do -	17.3	1	17.30	8.40	0.90	19.85	20.19	- do -

Source : DNER, RFFSA, DER, and DNOS
Note : /1 Numbers in this table correspond to those in Fig.VII.2.5.
Blank column of the name of bridge shows that bridge is not named.



L : Bridge length
l : Span length (longest portion)
B : Effective width including sidewalk
b : Width of sidewalk

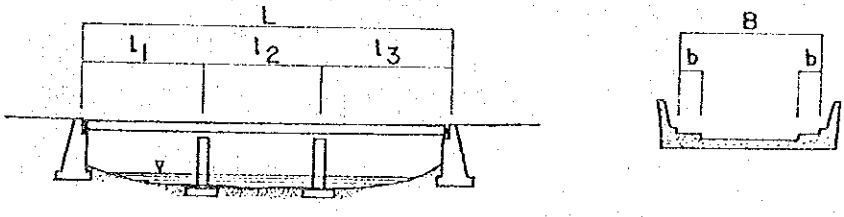
Table VII.2.1 EXISTING RIVER STRUCTURES AND RELATED STRUCTURES (4/4)

Bridge

No.	Name	Location: Distance from River-Mouth/ Confluence (km)	Administrative Office	Classification	Features: Bridge Length L (m)	Nos. of Span	Span Length l (m)	Width (m): B	Width (m): b	Lowest Elevation of Girder (m)	Elevation of Sidewalk Surface (lowest Point)	Remark
Itoupava river												
1.		0.19	Blumenau city	Footpath	23.2	1	23.20	-	0.90	12.60	-	Wooden
2.	Rua 2 de Setembro	0.23	DER	Road	107.7	7	19.90	8.30	0.50	15.71	17.56	RC
3.	BR 470	2.28	DER	- do -	60.0	4	24.10	12.30	-	15.40	17.70	- do -
4.	Ponte da Rua Guilherme Scharf	4.95	Blumenau city	- do -	20.0	1	20.00	10.10	1.30	11.28	13.38	- do -
5.	Ponte da Rua Carlos Pagel	9.53	- do -	- do -	8.3	1	8.30	5.20	0.50	15.99	16.49	- do -
6.	Ponte da Rua Felipe Jensen	11.75	- do -	- do -	8.2	1	8.20	5.10	0.50	18.25	18.65	- do -
Gaspar Grande river												
1.	Ponte da Rua Gel. Aristiliano Ramos (BR470)	0.21	DNER	Road	39.0	5	10.60	7.50	1.65	8.74	10.69	RC
2.	Ponte da Avenida das Comunidades	0.26	Gaspar city	- do -	45.0	4	10.80	10.85	1.00	9.36	10.36	- do -
3.	Ponte da Vicao Ferrea	0.30	- do -	- do -	55.5	3	24.20	2.90	-	10.60	12.10	- do -
4.		1.25	- do -	Footpath	42.4	1	42.40	-	1.40	11.58	-	Wooden
5.	Ponte da Rua Leopoldo Schramm	1.80	- do -	Road	16.0	3	8.30	10.80	0.90	7.70	9.05	RC
6.	Ponte da Rua Estrada para Garuva	5.20	- do -	- do -	7.7	1	7.70	9.85	0.75	11.36	12.98	- do -
Gasparinho river												
1.	Ponte da Rodovia Jorge Lacerda (BR470)	0.05	DNER	Road	47.6	3	16.10	5.80	-	9.20	10.75	RC
2.	Ponte da Rodovia Gaspar Brusque (SC411)	0.50	DER	- do -	34.7	3	12.00	7.10	0.70	8.53	9.90	- do -
3.	Ponte da Rua Duque de Caxias	0.90	Gaspar city	- do -	30.7	3	19.80	11.50	1.20	8.25	10.58	- do -
4.	Ponta da Estrada de Ferro	1.10	- do -	- do -	30.8	2	15.03	2.70	-	10.30	12.14	- do -
5.		1.35	- do -	Footpath	9.8	1	9.80	-	1.00	6.18	-	RC, Slab (t=0.2m)
6.		1.95	- do -	Road	6.0	1	6.00	4.00	-	7.11	-	- do - (t=0.3m)
7.		2.30	- do -	Footpath	7.0	1	7.00	-	0.45	6.68	-	- do - (t=0.15m)

Source : DNER, RFFSA, DER, and DNOS

Note : ⓛ Numbers in this table correspond to those in Fig.VII.2.5.
Blank column of the name of bridge shows that bridge is not named.



L : Bridge length

l : Span length (longest portion)

B : Effective width including sidewalk

b : Width of sidewalk

Table VII.5.1 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
Garcia River Basin						
G-1	3.94	204	2.6	9.5	6.9	Residential area
G-2	2.50	137	2.6	9.5	6.9	Unutilized area
G-3	1.13	240	3.5	10.5	7.0	Pasture
	-	169	4.1	10.5	6.4	Pasture
G-4	5.17	26	2.6	9.5	6.9	Unutilized area
Velha River Basin						
V-1	0.43	-	-	-	-	-
V-2	0.62	57	4.9	10.0	5.1	Unutilized area
V-3	0.67	57	7.5	10.5	3.0	Sports ground
V-4	0.68	-	-	-	-	-
V-5	0.59	50	3.6	10.1	6.5	Unutilized area
V-6	1.17	101	4.9	10.0	5.1	Unutilized area
V-7	2.34	15	6.7	10.0	3.3	Pasture
Total	19.24	1,056	-	-	-	

(2) Pumping station

Pumping Station	Design Discharge (m^3/sec)	Pump Unit					
		Type	Discharge per Unit (m^3/sec)	Diameter (mm)	Number of Unit	Total Head Difference (m)	Motor Output (PS.)
Garcia River Basin							
G-1,G-2 and G-4	7.8	VMF	2.60	1,350	3	9.5	460
Velha River Basin							
V-1 and V-5	0.7	I	0.35	500	2	8.9	65
V-2 and V-6	0.7	I	0.35	500	2	7.6	55
V-3 and V-4	1.0	HMF	0.50	600	2	5.0	55
V-7	4.0	HMF	2.00	1,000	2	5.8	230
Total	14.2				11		865

Note : VMF : Vertical Mixed Flow Pump
HMF : Horizontal Mixed Flow Pump
I : Submerged Pump

Table VII.5.1 MAIN FEATURE OF PROPOSED DRAINAGE FACILITIES (2/2)

(3) Connecting Culvert and Inverted Syphon

Location	Dimensions		
	Width (m)	Height (m)	Length (m)
Connecting Culvert			
R-1 - R-2	2.0	2.0	190
R-3 - R-4	2.0	2.0	85
Inverted Syphon			
R-2 - R-5	2.0	2.0	145
R-6 to the existing drainage channel	2.0	2.0	85
R-7 - R-8	2.0	2.0	132

Note : "R" means regulating pond shown in Fig.VII.5.4.

(4) New Channel

Drainage District	Catchment Area (km^2)	Design Discharge (m^3/sec)	Channel Number	Catchment Area (km^2)	Channel Length (m)	Design Capacity (m^3/sec)	Dimension of New Channel Width (m)	Height (m)	Number of Box
Garcia River Basin									
G-1	3.94	52.0	-	3.94	-	-	-	-	-
G-2	2.50	47.0	-	2.50	-	-	-	-	-
G-3	1.13	23.0	-	1.13	-	-	-	-	-
G-4	5.17	48.0	(1)	5.17	200	48.00	2.5	2.0	4
Velha River Basin									
V-1	0.43	13.0	(1)	0.43	-	-	-	-	-
V-2	0.62	19.0	(1)	0.30	300	9.20	2.0	2.0	1
			(2)	0.32	450	9.80	2.0	2.0	1
V-3	0.67	17.0	(1)	0.30	150	7.60	2.0	2.0	1
			(2)	0.37	-	-	-	-	-
V-4	0.68	16.0	(1)	0.68	500	16.00	3.0	2.0	1
V-5	0.59	15.0	(1)	0.27	100	6.90	2.0	1.5	1
			(2)	0.32	250	8.10	2.0	1.5	1
V-6	1.17	31.0	(1)	0.72	350	0.72	2.5	2.0	2
			(2)	0.45	200	0.45	2.5	2.0	1
V-7	2.34	39.0	(1)	2.34	300	39.00	2.5	2.0	3
Total	19.24			19.24	2,800				

Note : Channel number is shown in Fig.VII.5.4.