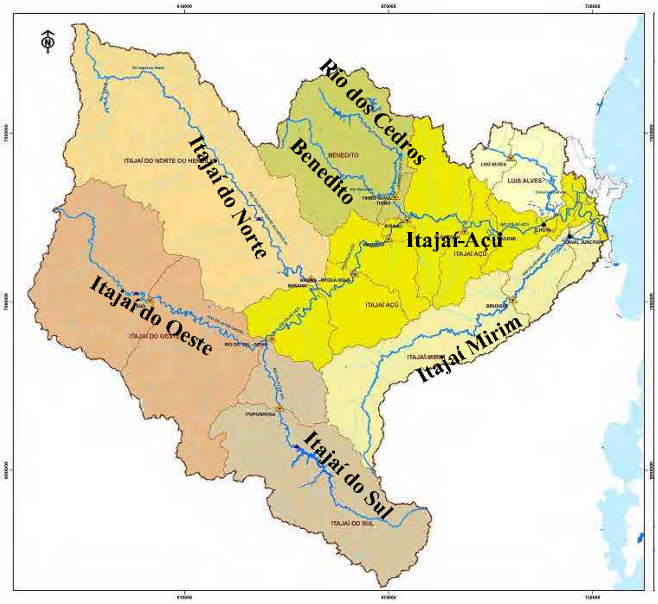
CHAPTER 3 CHARACTERISTIC OF FLOODS AND PROBABLE FLOOD DISCHARGES OF THE ITAJAI RIVER

3.1 Characteristic of the Itajaí River

(1) Itajaí River

The Itajaí River is largely divided into six sub-basins of main tributaries and the Itajaí-açu River (hereinafter referred to the Itajaí River) as the basin of its mainstream as shown below. Both the Itajaí do Oeste and Itajaí do Sul Rivers originate in the Serra Geral mountain range that runs from north to south at the western fringe of the basin (elevations between 1,000 to 1,800 m) join each other the Itajaí-açu River in Rio do Sul city, which is the biggest city in the upper Itajaí valley, and this meeting point of these rivers is where the Itajaí-açu River starts. In the middle valley, the Itajaí-açu River meets the Itajaí do Norte River in Ibirama city, then the Benedito River in Indaial city and it joins the Luis Alves River Ilhota city in the lower valley and finally the Itajaí Mirim River in Itajaí city before running into the Atlantic Ocean.



Source: JICA Survey Team

Figure 3.1.1 Basin Division of the Itajaí River

(2) Characteristics of River Channel

As explained in detail in sub-section 3.6, the Itajaí River is characterized by very gentle channel slopes of 1/15,000 to 1/20,000 over the low-lying flat areas in the lower reaches until Blumenau city. As a result, inundation during large floods can be extensive. In particular, the riverbed elevation in Blumenau city is lower than the mean sea level. In the middle reaches from Blumenau city to Lontras city (near the upstream location of 170 km from the river mouth), it becomes very steep with gradients between 1/100 and 1/1,500, and gentle again of over 1/3,000 in the upper reaches between Lontras and Rio do Sul cities.

The river width varies from 200 to 300 m in the lower reaches, from 150 to 200 m near Blumenau city, and between 100 and 150 me in Rio do Sul city, being increasingly narrower in its upstream reaches. The Itajaí River is nearly a natural river without significant dykes due to river improvement works, having partial works such as the concrete walls at the Itajaí Port and several shortcut channels in the Itajaí Mirim River.

3.2 Existing River Facilities

3.2.1 River Facilities

(1) Flood Control Facilities

The most typical flood control facilities are three dams constructed in the tributaries (detailed explanation in sub-section 3.2.2); the Oeste, Sul and Norte dams. As these dams are exclusive for flood control purpose, reservoirs always remain empty for retaining flood water. Besides these dams, there are limited facilities such as revetment of concrete blocks at the water colliding portion on the right bank of the Itajaí River in Blumenau city, and small scale revetment works by means of simple gabions and ripraps. Almost no flood control works have been so far implemented by means of diking and widening of ricer channel to increase flow capacity.

In the Itajaí Mirim River, a straight shortcut channel was constructed to flush floods more rapidly near Itajaí city. However, it might be said that the shortcut channel could not solve flooding issues because of some opinions that this shortcut channel had caused an increase of flood discharge in the downstream reaches in Itajaí city.

Revetment works in the Itajai River in Blumenau city

Gabion works after the 2008 flood damage in the Garcia River, Blumenau city

(2) Water Use Facilities

There exist several intake facilities for domestic and irrigation water supply constructed municipal governments. The water intake gate with pumping station is constructed on the shortcut channel Itajaí Mirim River to supply domestic water for Itajaí and Navegantes cities. The sluice gates at the intake functions as a protection of see water intrusion. At the confluences of the Benedito and Cedros Rivers, there is a intake with double-arch in Timbó city.

Water Gate at the Itajaí Mirim River, Itajaí city

Intake in the Benedito River, Timbó city

(3) Hydroelectric Power Plant

In the Itajaí River and its tributaries, there are various dams for hydroelectric power generation and power stations. These facilities were constructed mainly by Celesc, a state owned company of the Santa Catarina State. Main features of the facilities are as follows:

1) Rio Bonito and Pinhal Dams

The Rio Bonito and Pinhal Dams exclusive for hydropower generation owned by CELESC are located in the Cedros River, a tributary of the Benedito River as shown in Figure 3.2.1. Because of utilization for energy generation without flood control function, these dams are equipped with only power generation facilities and spillways. According to CELESC, these dams had been operated by lowering the maximum reservoir water level by 50 cm to create flood control capacity in reservoir based on the instruction of State Government. Although this flood operation had been carried out based on the information on rainfall forecast by EPAGRI/ CIRAM, no operation has been made in these years. This is mainly due to low accuracy of the forecast. There have been occurred some cases that no flood occurred after lowering the reservoir water level and flood arrived earlier before the lowering. Main features of the dams are shown in Table 3.2.2.

Table 3.2.1 Main Features of Rio Bonito and Pinhal Dams

Features		Rio Bonito Dam	Pinhal Dam
Construction year		1963	1949
Reservoir	Dimension of the Basin*	C.A.=119.8km^2	C.A.=179.9km^2
	Capacity	32 million m^3	18 million m^3
Dam	Model	Embankment dam	Embankment dam
	Crest elevation	EL.589.5m	EL.652.0m
	Dam height	19.0m	15.0m
	Crest length	118.0m	150.0m
	Dam volume	60,750m^3	26,460m^3
Spillway	Width	20m	25m
	Design discharge	150m^3/s	353m^3/s
Hydroelectric Power Plant	Name of the plant	Palmeiras	Cedros
	Number of turbines	3	2
	Generation capacity	24,602MW	8.4MW
	Maximum water consumption	11.1m^3/s	4.1m^3/s

Source: Questionnaire survey to CELESC by JICA Survey Team

2) Salto Hydroelectric Power Plant

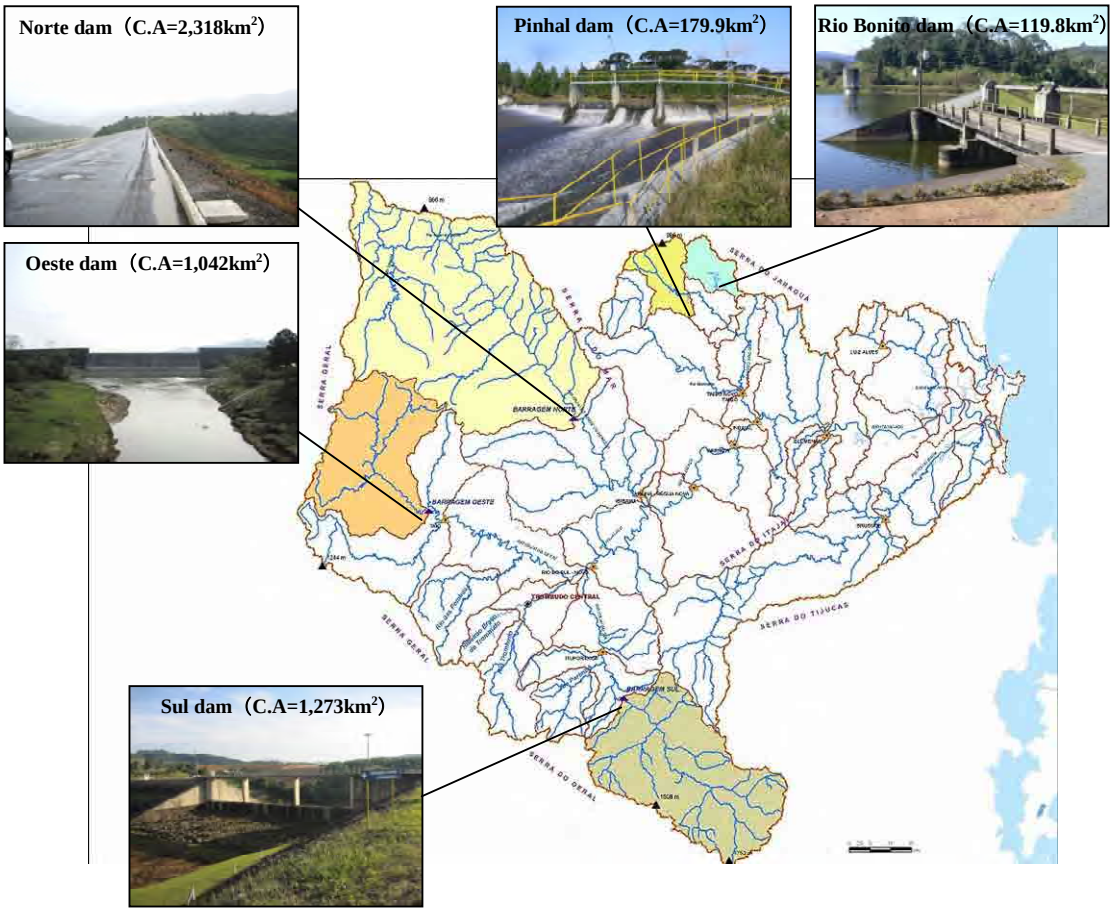
The Salto hydroelectric power plant was constructed in 1914 on the Itajaí River upstream Blumenau city. The intake dam and power plant are located at the right river course, where the Itajaí River is divided into two river courses due to the existence of large sand bank (island). Main features of the power plant are summarized below.

Table 3.2.2 Main Features of Salto Hydroelectric Power Plant

Name of the plant		**Salto Hydroelectric Power Plant**	
Owner		**CELESC**	
Reservoir Hydrological characteristic	Dimension of the Basin*	C.A.=11,700km^2	
	Flooded area	0.03ha	
	Average discharge	220m^3/s	1977 - 1990
	Maximum daily discharge	1,907m^3/s	
	Monthly average minimum discharge	23.0m^3/s	
	Flood discharge for 100-year return	4,820m^3/s	
Dam (Spillway)	Dam profile	Tall type made of concrete	
	Discharge format	Free discharge	
	Dam height		Not identified
	Crest length	800m	
Generation	Outlet power	6.7MW（effective = 6.3MW）	

Name of the plant		**Salto Hydroelectric Power Plant**	
Owner		**CELESC**	
	Number of turbines	4	
	Maximum fall	10.1m	
	Maximum water volume utilization	89m^3/s	

Source: Questionnaire survey to CELESC by JICA Survey Team



Source: JICA Survey Team

Figure 3.2.1 Location Map of Major Existing Dams

(4) Urban Drainage

Although the detailed information on the drainage system for main cities has not obtained, current issues on urban drainage were summarized in Table 3.2.3 below.

Table 3.2.3 Current Issues on Urban Drainage of Major Cities

Municipality	Population (Person)	Urban Drainage Issues	Information Source
Itajaí	172,081	Only poor drainage system with 600mm in diameter of pipeline network. Under construction of new drainage canal with 1.5×1.0m and 15 km long (however, no sluice to avoid the tidal inflow is equiped)	Construction department of Itajaí city
Navegantes	57,324	No serious drainage issues because of higher elevation than in Itajaí	of Navegantes
Gaspar	55,489	No information	
Blumenau	299,416	A macro-drainage problem in Velha River. Poor drainage system in harmony with rapid urbanization	Civil Defense of Blumenau city
Indaial	50,917	No drainage and flood problems	
Rio do Sul	59,962	Poor development of sewage system and almost no function of urban drainage system	CRAVIL
Brusque	102,280	No information	

Source: Questionnaire survey to municipalities by JICA Survey Team

In Blumenau city, water gate was installed in the Fortaleza River near the confluence to the Itajaí River to avoid the reverse flood flow from the Itajaí River. An installation of pumping station with a capacity of 8,000 l/s is planned to drain the flood flow from the Fortaleza River to the Itajaí River during closure of the sluice gate. However, there are several opinions in the community that the water gate would hamper drainage of the Fortaleza River.

(5) River mouth area and the Port

As mentioned earlier in sub-section 2.1.4, there are two ports in the mouth of the Itajaí River. They are the Itajaí Port at the right bank and the Portonave at the left bank. According to Itajaí Port, annual dredging of 3 million m^3 of the deposited sediments (fine sand, silt and clay) in the Port is necessary to maintain the water depth at 11 m for port function. On the other hand, the riverbed in the Port was seriously eroded due to the 2008 year flood, and thus the pier walls were destroyed (14 m deep to the pier foundation). The flow velocity in the Port was recorded 8.7 m/s during the 2008 year flood. At the river mouth, a jetty was installed to avoid blockage of river mouth due to sedimentation and groins (spur dike) are also installed to increase flow velocity by means of decreasing the flow area for controlling sedimentation in the mouth.

3.2.2 Flood Control Dams

The location map of 3 flood control dams is shown in Figure 3.2.1 and their main features are summarized in Table 3.2.4. The total drainage area of these 3 dams is 4,633km^2, which is equivalent to 31% of the total drainage area of the Itajaí River mainstream. The flood control capacity of three dams is evaluated in terms of the equivalent rainfall to be stored (= reservoir storage capacity/drainage area). The estimated equivalent rainfall of the Norte dam shows the highest value of 154 mm. This means that the Norte dam has the largest flood control capacity among the dams compared to its drainage area and thus the likelihood of becoming full of water in reservoir and resulting in overflowing through spillway due to heavy rainfall might be low.

On the other hand, the estimated equivalent rainfalls of the Oeste and Sul Dams are 80 mm and 73 mm. which are almost half value of the Norte dam. Therefore, the reservoirs of these two dams easily become full. Especially the Oeste Dam has been full of water due to the floods in 2001 and 2010, causing overflowing through spillway, although no overflowing occurred at the Sul Dam. This might be due to more heavy rainfall occurred during the floods in the upper catchment of the Oeste Dam and smaller releasing capacity compared to that at the Sul Dam.

Table 3.2.4 Main Features of Flood Control Dams

		Oeste Dam	**Sul Dam**	**Norte Dam**
Reservoir	Catchment area	1,042 km^2	1,273 km^2	2,318 km^2
	Reservoir area	950 ha	840 ha	1,400 ha
	Gross storage capacity	83,000,000 m^3	93,500,000 m^3	357,000,000 m^3
	Equivalent rainfall	80 mm	73 mm	154 mm
	Minimum water level	EL.340.0 m	EL.372.9 m	EL.257.0 m
	Maximum water level	EL.363.0 m	EL.408.0 m	EL.304.25 m
Dam	Completed year	1973	1976	1992
	Dam type	Gravity	Rock fill	Anchoring
	Dam height	25.0 m	43.5 m	58.5 m
	Crest length	422 m	390 m	400 m
	Crest elevation	364.5 m (crown top)	410.0 m	306.5 m
Spillway (flood control)	Number of conduits	7	5	2 (with sluice) 5 (without sluice)
	Type	Sluice regulation	Sluice regulation	Part with Sluice regulation
	Conduit diameter	1500 mm	1500 mm	B2.6 x D2.6m x 2
	Elevation (center of the conduit)	340.05 m	nearly 368 m	nearly 251 m
	Discharge capacity	163 m^3/s	194 m^3/s	258 m^3/s

		Oeste Dam	Sul Dam	Norte Dam
	(Normal HWL)	(WL 360 m)	(WL 399 m)	(WL 295 m)
Spillway (Emergency)	Width	+- 100m	65m	
	Crest elevation	360.0m	399.0m	295.0m
	Discharge capacity (Water level: full reservoir level)	Emergency 175 m^3/s Normal 1,125 m^3/s Total 1,300 m^3/s (WL 363m)	Emergency 217 m^3/s Normal 3,053 m^3/s Total 3,270 m^3/s (WL 407m)	

*Shadowed cell: DEINFRA website (http://www.deinfra.sc.gov.br/barragens/sobre-as-barragens/)
*Equivalent rainfall = reservoir storage capacity / drainage area
*The discharge capacity was estimated based on the estimated H-Q curve estimated.

3.3 Characteristics of Flood Inundation in the Itajaí River

3.3.1 Records of Major Floods

Table 3.3.1 shows the records of affected municipalities due to major floods occurred in recent years in the Itajaí River basin, and Table 3.3.2 shows the number of victims. Considering the frequency and scale of flood damages by municipality, basic needs for flood mitigation measures by municipality are set out below.

i) In recent years, the floods caused relatively significant damages are the July 1983, August 1984, May 1992, October 2001 and November 2008 floods.

ii) The most serious flood damages occurred in Blumenau city, followed by Itajaí, Gaspar and Rio do Sul cities. These 4 cities are subject to high priority for mitigation measures because of have a great number of inhabitants and industries.

iii) Besides these 4 cities above, Timbó and Taió cities are also subject to consideration for measures because of occurrence of flood inundation. In this connection, it is necessary to clarify the interferences to Timbó city due to the operation of hydropower dams (Rio Bonito and Pinhal Dams) upstream of the Cedros river, and to Taió city due to the operation of Oeste Dam.

iv) Although Navegantes and Ilhota cities are relatively suffering from flood, the level of safety against floods would increase, resulting from the provision of flood control measures to priority cities such as Itajaí, Blumenau and Gaspar cities.

v) On the other hand, in Brusque and Ituporanga cities, no serious flood damage has been occurred in recent years, although these cities are expected influenced by larger floods with recurrence interval of more than 50 years such as the 1984, 1984 and 2008 floods (see Table 3.3.3). Accordingly these cities might be of low priority on flood control measures due to relatively high flow capacity of the current river channel compared to those in priority cities.

vi) Flow capacity of the Itajaí River is relatively high in the stretch between Blumenau city and the confluence to the Itajaí do Norte River (see details of flow capacity in Section 3.6). The cities located along this river stretch such as Indaial city and others have low priority of measures because the damages caused by flood inundation are small.

Table 3.3.1 Records of Major Floods of Recent Years

Year	Month	Itajai Acu										Itajai Mirim		L.A.	Benedito			Itajai Do Norte		Itajai Do Oeste				Trombudo			Itajai Do Sul	
		Itajai	Navegan-tes	Ilhota	Gaspar	Blumenau	Pomerode	Indaial	Rodeio	Lontras	Rio Do Sul	Brusque	Guabiruma	Luiz Alves	Timbo	Benedito Novo	Rio Dos Cedros	Ibirama	Presidente Getulio	Taio	Lauren-tino	Rio Do Oeste	Rio Do Campo	Trombudo Central	Braco do Trombudo	Pouso Redondo	Itupoa-ranga	Alfredo Wagner
1980	10					□																						
1981	10												□															
1983	5					●																						
	7	●	○		○	●				○	●				○					◎		○		○			○	
	12					◎																						
1984	8	○			●	●						●								○				○			○	
1989	1				○																							
1990	1					△																						
	10					○																						
1991	11					◎							○															
1992	1					△																						
	5	●	○	◎	○	●		△			△				○													
1993	2	△																										○
1995	1					△						△																
1996	2																						△					
1997	1				◎	△																						
	2									△																		
	10										△																	
1999	7										△																	
2000	2														△													
2001	10	△			△	△		△	△	△	○				△				○		△			△				
2002	11																			△					△	△		
2005	9										□																	
2008	11	○	□	○	○	◎	△	□	△			○		△	△	△	△											
2009	10										□																	
2010	4	□									□				□					□								

出典: 1980年～2004年 ATLAS DE DESASTRES NATURAIS DO ESTADO DE SANTA CATARINA
2005年,2009年 GTC提供資料（イタジャイ川流域防災対策事業その1報告書より）
2008年 AVANDANs enviados pelos municipios a Defesa Civil de Santa Catarina, nos dias 24 e 25 de novembro de 2008（イタジャイ川流域防災対策事業その1報告書より）
MAPEAMENTO DAS INUNDACOES – NOVEMBRO 2008
DESASTRE DE 2008 NO VALE DO ITAJAI
2010年 Hearing(地元市町村及び住民)

凡例
- ● 家を失った人の数10,000人以上
- ◎ 同 5,000～10,000人
- ○ 同 1,000～5,000人
- △ 同 1,000人未満
- □ 資料なし
- （橙色）対策の優先度が非常に高い都市
- （黄色）対策が必要な都市
- （白色）対策の必要性が低い都市

Table 3.3.2 Main Occurrence of Damages Caused by Floods

Year	Month	Water level	Municipality	Victims	Deaths	Pop.	% of victims	Damages (R$)
1980	10		Blumenau	No record	1	157,258	-	
1981	10		Guabiruba		2	7,362		
1983	5	12.46	Blumenau	10,000	2	170,491	5.86	
	7	15.34	Blumenau	50,000	8		29.3	
	12		Blumenau	5,000	1		2.93	
	7		Gaspar	3,981	2	28,012	14.2	
	7		Itajaí	40,000	5	94,449	42.3	
	7		Ituporanga	1,820		18,149	10	
	7		Lontra	4,000		7,390	54.1	
	7		Navegantes	3,070		15,747	19.49	
	7		Rio do Oeste	2,820		7,280	38.7	
	7		Rio do Sul	25,000	5	38,616	64.74	
	7		Taio	5,079	1	18,809	27	
	7		Timbó	1,610		19,368	8.31	
	7		Trombudo Central	2,980		7,404		
1984	8	15.46	Blumenau	70,000		175,145	39.96	
	8		Brusque	20,000		46,558	42.95	
	8		Gaspar	10,000		28,863	34.64	
	8		Itajaí	1,000	2	97,273	1.02	
	8		Ituporanga	1,000		18,499	5.4	
	8		Taio	1,500		18,878	7.94	
			Trombudo Central	1,000		7,511		
1989	1		Gaspar	167		33,523	0.49	
1990	1		Blumenau	594			0.26	
	10		Blumenau	1,310	20	220,741	0.59	
1991	11	12.8	Blumenau	8,528	10	212,025	4.02	
	11		Guabiruba	1,038		9,905	10.47	
1992	1	10.62	Blumenau	21			0.01	
	5		Blumenau	35,000	2	216,422	16.17	
	5		Rio do Sul	800		46,827	1.7	
	5		Gaspar	2,830		36,516	7.75	
	5		Ilhota	5,580		9,548	58.44	
	5		Indaial	817		30,853	2.64	
	5		Itajaí	11,938		122,401	9.75	
	5		Navegantes	4,780		24,204	19.74	
	5		Timbó	1,544		24,434	6.31	
1993	2		Itajaí	750		125,266	0.59	
	7		Alfredo Wagner	3,244		9,856		
1995	1		Blumenau	600		225,556	0.26	
	1		Brusque	520		62,328	0.83	
1996	2		Rio do Campo	196		6,576		
1997	1	9.44	Blumenau	353		231,401	0.15	
	2		Lontra	300		7,936	3.78	
	10		Rio do Sul	336		47,822	0.7	
	1		Gaspar	6,000		40,584	14.78	
1999	7		Rio do Sul	201		47,822	0.42	
2000	2		Timbó	150		26,497	0.56	1,473,000
2001	10		Rio do Sul	2,885	1	47,822	6.03	2,071,076
	10		Presidente Getulio	2,100		11,523	18.22	4,648,600
	10		Gaspar	469		40,584	1.15	549,000
	10	11.02	Blumenau	400		231,401	0.12	2,999,300
	10		Itajaí	383		134,942	0.28	2,385,381
	10		Timbó	350		26,497	1.32	57,000
	10		Rodeio	175		9,623	1.81	1,252,200
	10		Indaial	144		35,400	0.4	524,083
	10		Lontras	144		7,936	1.81	786,300
	10		Laurentino	120		4,532		732,490
	10		Trombudo Central	120		5,895		244,500
2002	11		Taio	257		15,997	1.6	1,730,302
	11		Pouso Redondo	450		11,778	3.82	1,233,946
	12		Braço do Trombudo	120		3,531	3.39	1,325,000

Source: ATLAS OF NATURAL DISASTERS OF SANTA CATARINA STATE

3.3.2 Magnitude of Major Floods

(1) Return Period of Major Floods

Magnitude of the major floods was evaluated in terms of the probability of occurrence on the flood events, which is called the return period. In this connection, the probability of occurrence was estimated based on the relationship between the 4-day basin mean rainfall during flood and its probability of occurrence. The results of evaluation are summarized in Table 3.3.2 (see detailed explanation in Section 3.5). As seen, the 1983 and 1984 year floods that caused serious damages over the basin are evaluated 76 and 66 years of return period, respectively, followed by the 1992 year flood with a return period of 33 years. Other floods fall on the return period of approximately 5 to 10 years.

Torrential rainfall concentrated in the lower Itajai River basin during the flood in 2008. However, magnitude of the flood was evaluated only a 5-year flood, because the estimated 4-day basin mean rainfall over the whole basin becomes small due to locally concentrated rainfall distribution over the downstream basin.

Table 3.3.3 Return Period of Major Floods

Occurrence Date	4-day Rainfall (Average of the whole basin)	Return Period (Years)	Situation of Damages
31.10.1961	139 mm	6	―
26.09.1963	149 mm	8	―
25.08.1972	166 mm	13	―
19.12.1980	147 mm	7	―
06.07.1983	223 mm	76	Big damages between Itajaí and Blumenau cities Big damages between Lontras and Rio do Sul cities Medium to big damages in Timbó, Taió, Rio do Oeste and Ituporanga cities
05.08.1984	218 mm	66	Big damages in Itajaí, Gaspar and Blumenau cities Big damages in Brusque city Medium damages in Taió and Ituporanga cities
28.05.1992	196 mm	33	Big damages between Itajaí and Blumenau cities Relatively small damages in Rio do Sul city Medium scale damages in Timbó city
31.01.1997	134 mm	5	Relatively big damages Gaspar city Small damages in Blumenau city
02.07.1999	150 mm	8	Small damages Rio do Sul city
29.09.2001	147 m	7	Small damages in Itajaí, Gaspar, Blumenau, Indaial,and Lontras cities Medium scale damages in Rio do Sul city Small damages in Timbó and Taió cities
18.05.2005	144 mm	7	No significant damages.
21.11.2008	135 mm	5	Big damages in the downstream cities. However, due to localized torrential rainfall, the calculated basin mean rainfall shows smaller return period
23.04.2010	130 mm	4	No official information is available. In the field survey, there were small damages in Rio do Sul, Timbó and Taió cities

Source: JICA Survey Team

(2) Evaluation of Magnitude of the 2008 Flood

As the 2008 year flood was caused locally concentrated torrential rainfalls, its magnitude was evaluated comparing to the probable basin mean rainfalls of sub-basin. As indicated in Table 3.3.4, the probable 4-day basin mean rainfalls during the 2008 year flood are far smaller than those in the Itajaí Oeste, Sul and Norte sub-basins. However, basin mean rainfalls in the Benedito River and Itajaí Açu River sub-basins are evaluated the return periods of 30 years and 60 years, respectively. The return period of 4-day rainfall in the Itajaí Mirim sub-basin is evaluated to be only 10 years.

Table 3.3.4 Evaluation of 4-day Basin Mean Rainfalls (November 21 to 24) by Sub-basin during the 2008 Flood

Sub-basin		Itajaí do Oeste	Itajaí do Sul	Itajaí do Norte	Benedito	Itajaí-Açu	Itajaí Mirim
4-day Basin Mean Rainfall		49	36	31	214	236	160
Probable Rainfall (mm)	5 years	153	141	140	155	144	140
	10 years	175	161	160	179	169	161
	20 years	196	181	179	202	194	180
	25 years	202	186	184	208	205	185
	50 years	224	207	204	232	230	205
	80 years	238	220	217	248	249	218
	100 years	244	226	223	255	258	224
	150 years	256	237	233	268	276	235
	200 years	265	245	241	277	288	243
Return Period (years)		-	-	-	**30**	**60**	**10**

Source: JICA Survey Team

The magnitude of past floods and associated flood damages are used for economic evaluation of the master plan to be proposed (see Chapter 13). Considering that the evaluated magnitude of the 2008 flood of only 5-year return period seems to be underestimated compared to the big damages incurred, magnitude of the 2008 flood is assumed to be 50 years of return period referring the estimated probable 10-year to 60-year rainfalls in the table above.

There was a localized concentration of torrential rainfall on the Itajaí-Açu basin (mainstream of the Itajaí River) mainly in the downstream areas from Indaial city, and among cities the biggest rainfall occurred in Blumenau city reaching 575 mm of 4-day rainfall on 21 to 24 November in the 2008 flood. The maximum 2-day rainfall is observed 494mm on 23 to24 and the maximum daily rainfall of 251mm occurred on 25 November. In this connection, characteristics of the localized rainfall with short duration were analyzed in view of the analysis on flush floods.

Table 3.3.5 shows the analysis result of probable rainfalls in Blumenau city. As shown below, return periods of the recorded rainfalls in the 2008 flood were evaluated 470 years for 1-day rainfall, 3,900 years for 2-day rainfall and 8,400 years for 4-day rainfall, respectively.

Table 3.3.5 Evaluation of Rainfalls during the 2008 Flood, Blumenau City

Duration		1-day	2-day	4-day
Rainfall during the 2008 Flood (mm)		251	494	575
Probable Rainfall (mm)	5 years	113	150	173
	10 years	135	182	208
	20 years	158	216	243
	25 years	171	236	265
	50 years	189	263	293
	80 years	207	289	320
	100 years	215	301	333
	150 years	231	325	357
	200 years	242	342	375
Return Period (years)		**270**	-	-

Source: JICAS urvey Team

3.3.3 Characteristics of Major Floods

Among the main floods previously mentioned, the floods in 1983, 1984, 2008 and 2010 are herein selected considering the availability of rainfall and discharge data.

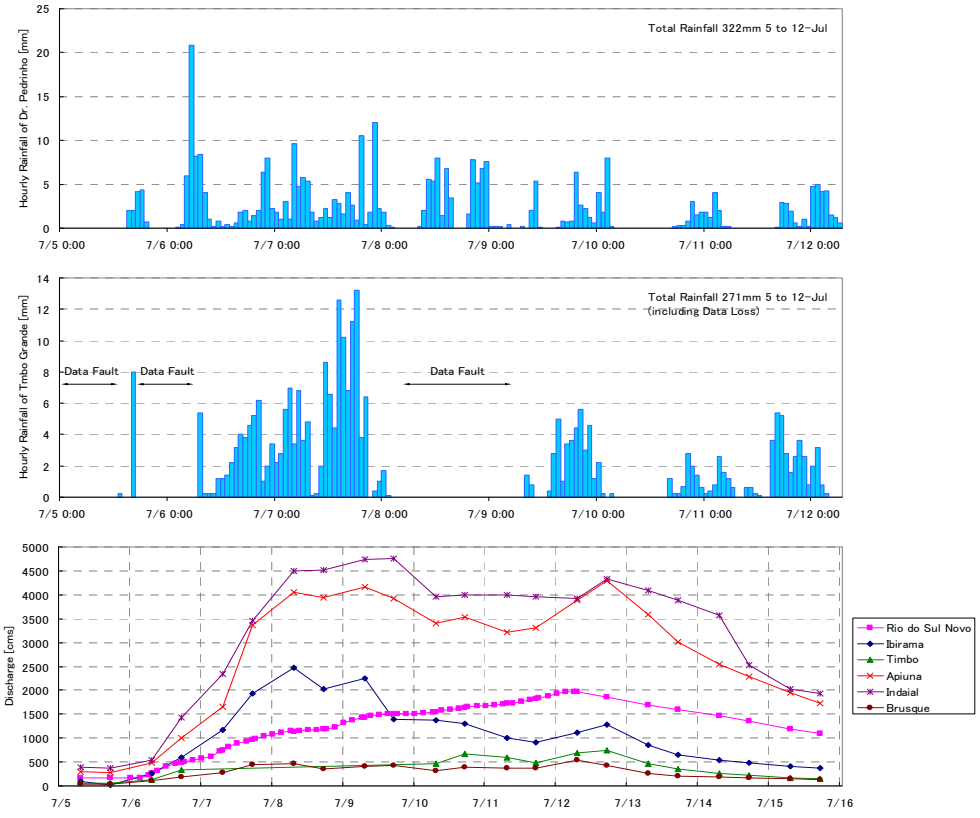
(1) The 1983 Flood

In the 1984 flood, heavy rainfalls occurred in 8 days from 5 to 12 July and the maximum 4-day rainfall occurred from 6 to 9. The basin mean 4-day rainfall is estimated around 210 mm by the arithmetic mean method. The rainfall distribution is almost uniform over the Itajai River basin with the order of around 200 mm for each sub-basin. Figure 3.3.1 shows the hourly rainfall and discharge distributions. From the hydro-meteorological viewpoints, the 1983 flood is characterized as follows:

i) The rainfall was more intense in an initial stage of the flood (on 6 and 7 July). The maximum hourly rainfall is 21mm/h at the Doutor Pedrinho station, and less than 15mm/h at other stations.

ii) The discharge peak occurred between 8 and 9 July, which is delayed in more than one day after the rainfall peak. The discharge peak seems far delayed at the Rio do Sul station, although it is not clear due to absence of hourly data. This might be due to the flood control operation of the existing dams.

iii) The maximum discharge was 4,760m^3/s at the Indaial station, around 2000 to 2500m^3/s at the Rio do Sul and Ibirama stations, and 500 to 1000m^3/s at the Brusque and Timbo stations.

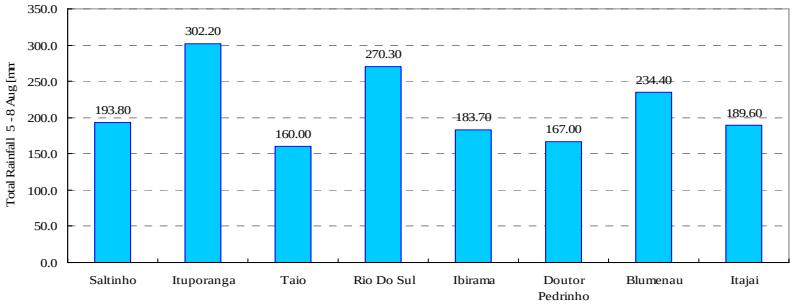


Source: Final Report on The Itajaí River Basin Flood Control Project Part II Data Book, JICA, 1988

Figure 3.3.1 Hourly Distribution of Rainfall and Discharge during the 1983 Flood

(2) The 1984 Flood

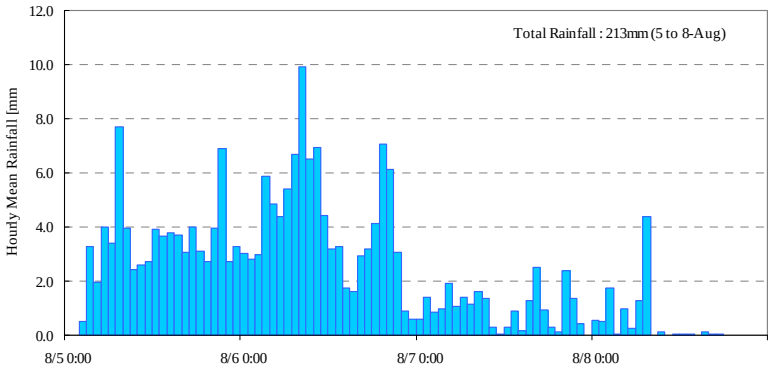
Hourly rainfall data is available only at 8 stations. Figure 3.3.2 shows the comparison of accumulated rainfalls at these stations from 5 to 8 August in 1984. As seen, 4-day rainfall varies 160mm to 300mm.



Source: Final Report on The Itajaí River Basin Flood Control Project Part II Data Book, JICA, 1988, reformulated by JICA Commission (missing data were supplemented).

Figure 3.3.2 Comparison of Total Rainfalls at Gauging Stations during the 1984 Flood

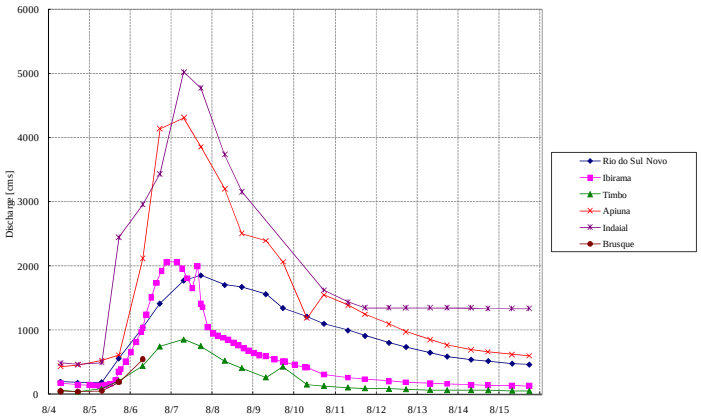
Figure 3.3.3 shows the hourly distribution of basin mean rainfall (estimated by the arithmetical mean of the stations and total rainfall of 4 days is 213mm). Heavy rainfall concentrated on 5 and 6 August at the initial stage of the flood and the maximum peak was 10mm/h at noon on 6 August (maximum per at the station was 18mm/h). From on 7 August, rainfall decreased 1 to 2mm per hour.



Source: Final Report on The Itajaí River Basin Flood Control Project Part II Data Book, JICA, 1988, reformulated by JICA Commission

Figure 3.3.3 Hourly Distribution of Basin Mean Rainfall during the 1984 Flood

Figure 3.3.4 shows the discharge hydrographs at gauging stations.



Source: Final Report on The Itajaí River Basin Flood Control Project Part II Data Book, JICA, 1988

Figure 3.3.4 Discharge Hydrographs during the 1984 Flood

i) The discharge peaks in the 1984 flood (peak value among the data measured twice/day) were 5,000m^3/s at the Indaial station and 4,300m^3/s at the Apiúna station. Lag time

between the peaks of rainfall and discharge is approximately 20 hours.

ii) As seen in the 1983 flood, the discharge peak was also delayed compared to those other stations. This might be due to the flood control operation of the existing dams.

iii) The peak discharges were around 4,000m^3/s at the Apiúna station, 2,000m^3/s at the Rio do Sul and Ibirama stations, and 1,000m^3/s at the Timbó station.

(3) The 2008 Flood

The 2008 flood occurred from 18 to 27 November in 2008. The biggest rainfalls occurred during 4 days from 21 to 24, and the 4-day basin mean rainfall was 121 mm. As mentioned earlier, the 2008 flood was characterized as localized concentration of heavy rainfalls in the downstream sub-basins, reaching 236 mm in the Itajaí Açu sub-basin, 214 mm in the Benedito sub-basin, and 160 mm in the Itajaí Mirim sub-basin. Hourly rainfall distribution is shown in Figure 3.3.5**.**

Although no water level and discharge data at the gauging stations during the 2008 flood are available, river level records at four stations are available in the report "2008 Disaster in Itajaí Valley" published by the Itajai River Basin Committee in 2010 as presented in Figure 3.3.6. As seen, the maximum river water level at the Blumenau station is 11.5 m in the midnight on 24 November (this data might be the reading of water level gauge). The discharge peaks are estimated by use of the H-Q curve that was prepared by the Survey Team as follows:

Blumenau station	H=11.5m	Q=4,200m^3/s
Timbó station	H=8.0m	Q=710m^3/s
Indaial station	H=6.0m	Q=3,100m^3/s

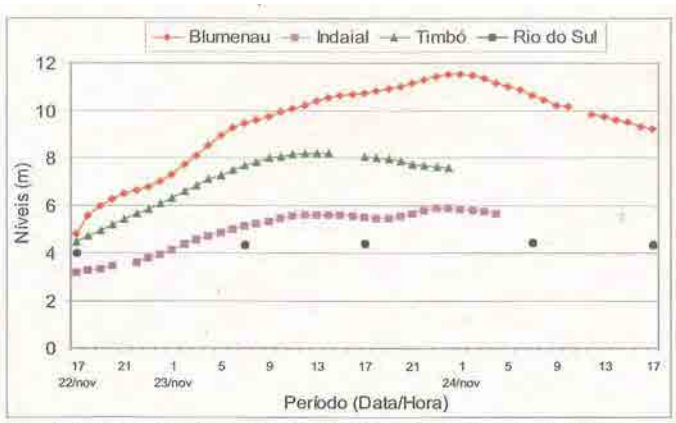
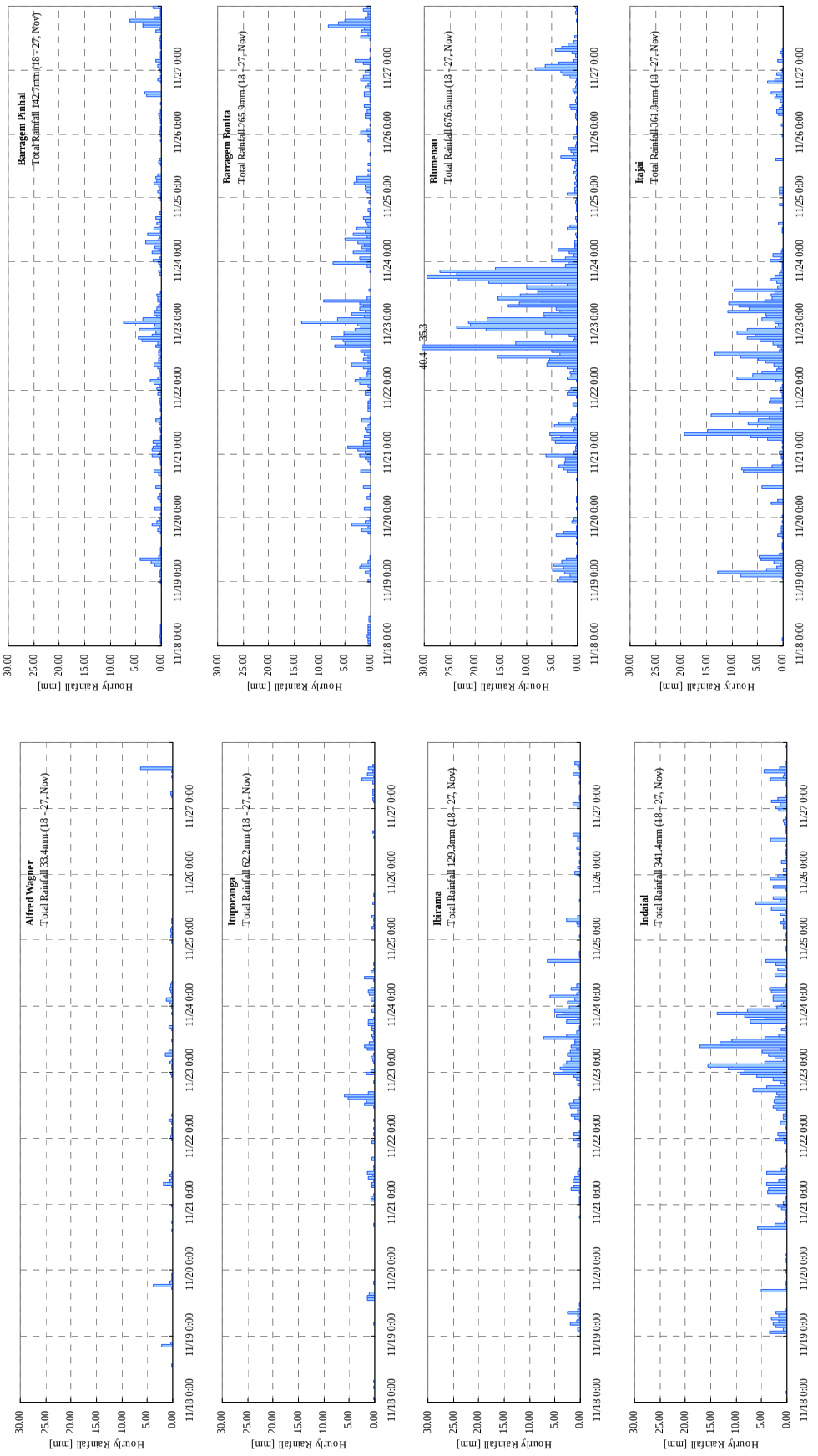


Figura 2 - Evolução temporal dos níveis em Rio do Sul, Timbó, Indaial e Blumenau entre 22 e 24/11/2008. Fonte: CEOPS/IPA/FURB.

Source: 2008 Disaster in Itajaí valley, 2010

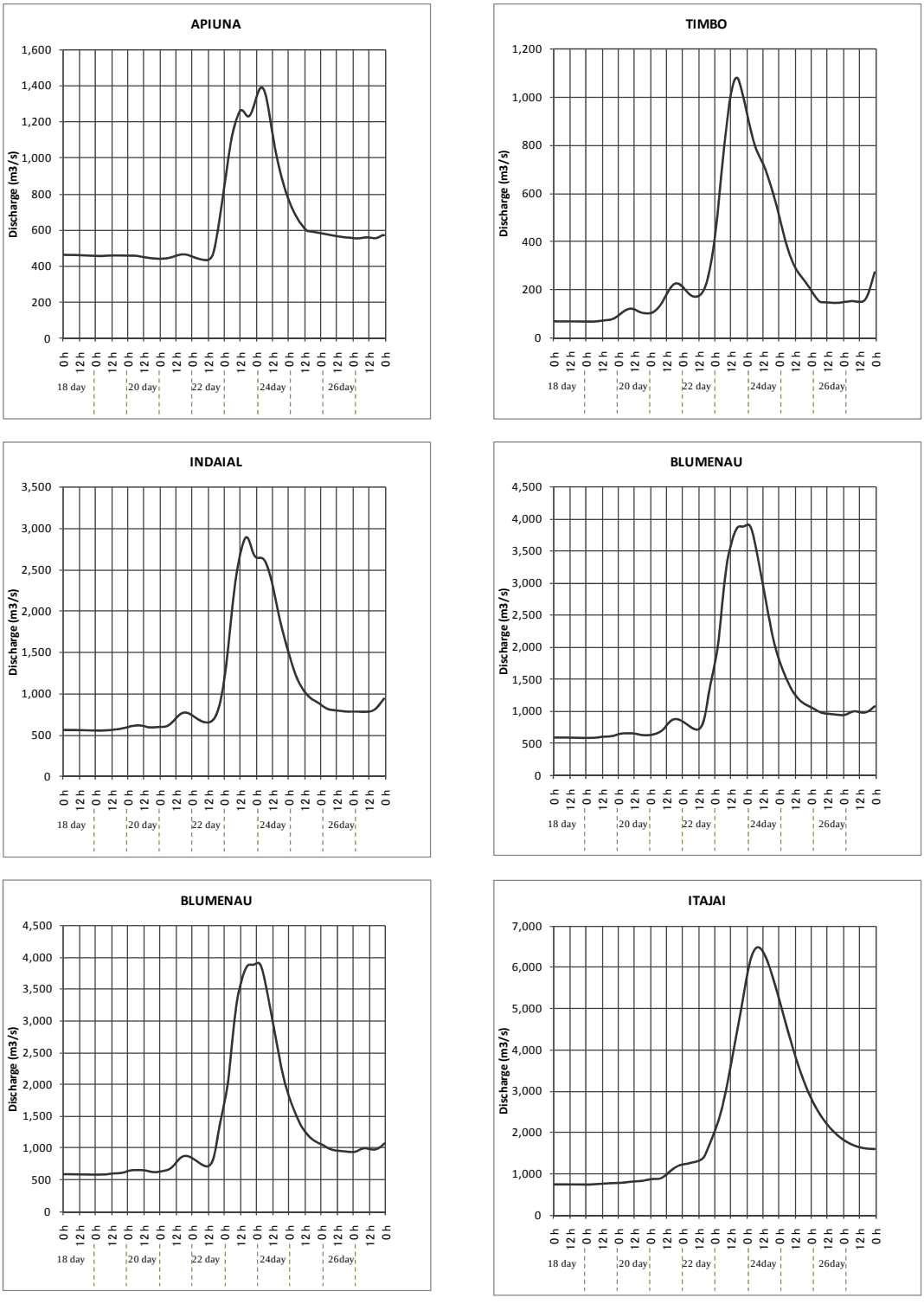
Figure 3.3.6 Recorded of River Water Levels during the 2008 Flood

Figure 3.3.7 shows the simulated discharges for the 2008 flood by the developed runoff simulation model (see details of the runoff simulation in Section 3.5). These simulated discharges are of preliminary estimation due to limitation of available hourly data. The estimated peak discharges are around 4,000 m^3/s at the Blumenau, 1,200 m^3/s at the Brusque, and 1,000m^3/s at the Timbó stations. Although the peak discharge in Itajaí city was estimated approximately 6,500 m^3/s, actual peak discharge might be far smaller due to retardation effect by inundation over the flood plain below Gaspar city.



Source : UFSC, INMET, CELESC, ANA, CAPSUL/IBAMA

Figure 3.3.5 Hourly Rainfall Distribution during the 2008 Flood



Source: JI)CA Survey Team

Figure 3.3.7 Simulated Discharges during the 2008 Flood

(4) The 2010 Flood

The 2010 flood occurred from 21 to 26 April in 2010. Rainfall data at 18 stations were collected. The hourly distribution of basin mean rainfall is shown in Figure 3.3.8. It is noted that the data was supplemented by the Survey Team because of several data of lacking and low reliability (although several stations are observed by several institutions, there was significant difference between the observed data by institutions). The rainfall characteristics of the 2010 flood are

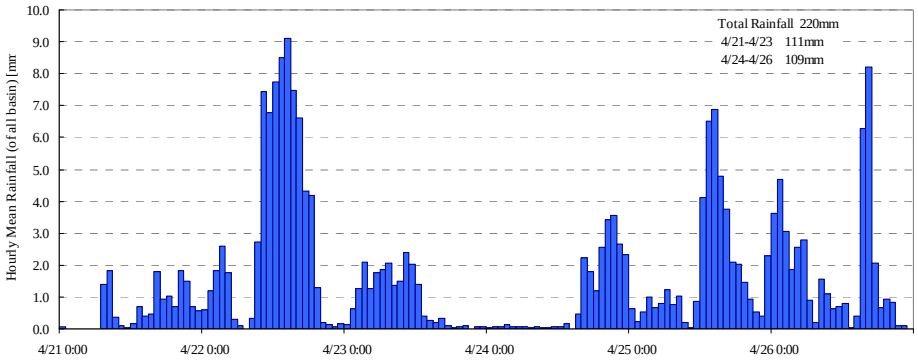
summarized as follows:

i) The 2010 flood had 2 peaks; the first one from 21 to 23, and the second one from 24 to 26 April. The rainfall volumes during both peaks were almost the same as shown in the hourly basin mean rainfall distribution below (estimated by arithmetical mean of all the stations).

ii) The maximum hourly rainfall in the basin average was approximately 9 mm/h. The maximum rainfalls were 30mm/h at the Brusque station and 28mm/h in the Boiteux Dam station, and other stations are in the range of 10 to 30mm/h.

iii) The total rainfall was high mainly at the Boiteux Dam station in the Itajaí do Norte River basin (400mm), at the Rio do Campo and Oeste Dam stations in the Itajaí do Oeste River basin, and at the Rio Bonito Dam in the Benedito River basin. More rainfalls were received from the north to northwest regions.

iv) On the other side, rainfall was relatively small in the Itajaí do Sul River basin such as at the Alfredo Wagner and Ituporanga stations.



Source: JICA Survey Team

Figure 3.3.8 Distribution of Hourly Basin Mean Rainfall during the 2010 Flood

The data of river water levels during the flood were obtained from 7 gauging stations. Figure 3.3.9 shows the river level hydrographs, and the discharge hydrographs are shown in Figure 3.3.10. The hydrological characteristics of the 2010 flood are enumerated below:

i) The peak discharge at Rio do Sul station occurred approximately 850 m^3/s. According to the city government, the city area was partially inundated.

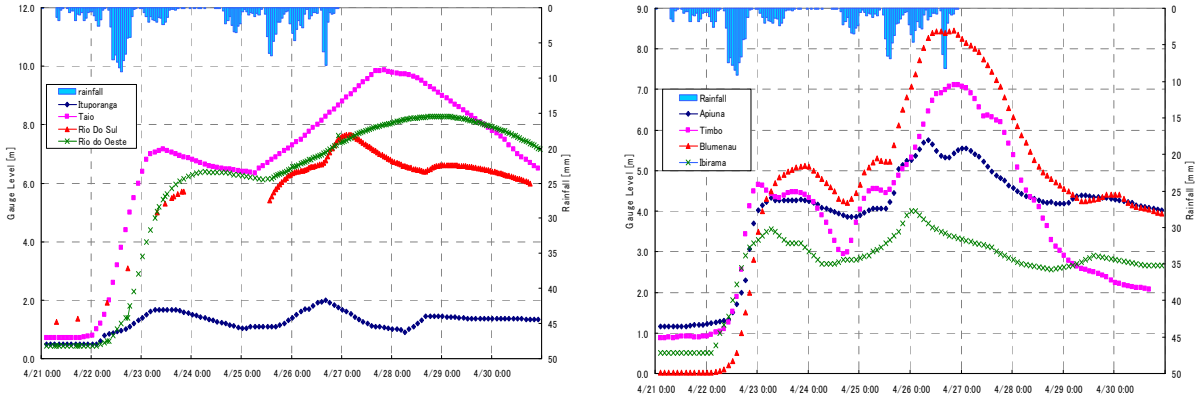
ii) In Taió city, occurrence of the discharge peak was delayed due to gate operation of the Oeste Dam. The Oeste Dam reservoir became full, resulting in overflow. In Taió city, the city area was also partially inundated.

iii) In Ituporanga city, river discharges were fluctuated due to gate operation of the Sul Dam. The Sul Dam fulfilled responsibility of flood control without full water in reservoir and thus the city area was not inundated.

iv) The discharge peak at the Ibirama station was approximately 800 m^3/s. The Norte Dam fulfilled responsibility of flood control without full water in reservoir and thus the city area was not inundated.

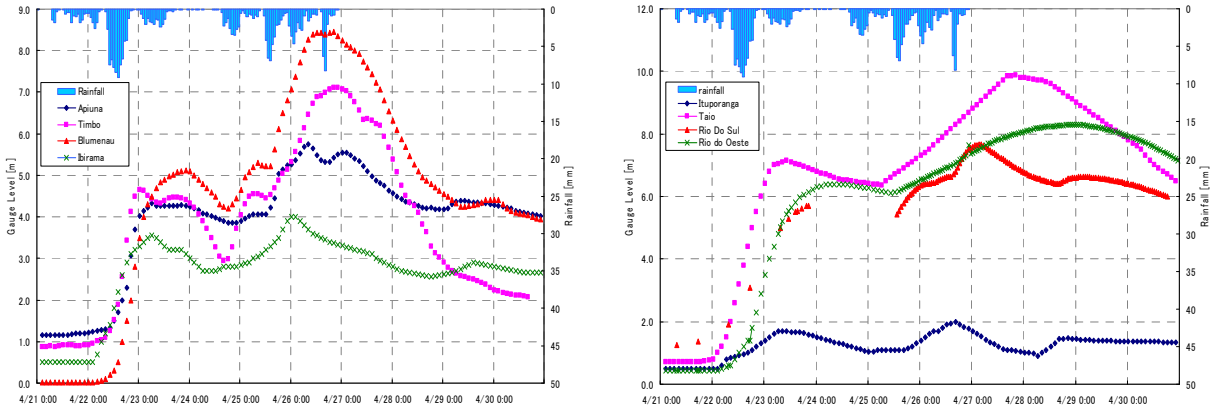
v) In Timbó city, there was a discharge peak of approximately 600 m^3/s. According to the city government, part of the city was inundated.

vi) The discharge peak in Blumenau city was approximately 2,600 m^3/s.



Source: River levels measured by FURB

Figure 3.3.9 Registration of River Levels in the 2010 Flood



Source: River levels measured by FURB and converted into discharge by JICA Commission.

Figure 3.3.10 Discharges in 2010 Flood

3.4 Estimation of Damages due to the Floods and Sediment Disasters in November 2008

3.4.1 Damages Value Estimation

Since the big floods in 1983 and 1984, other floods causing damages in the whole Itajai River basin has been continuously occurred in 1992, 2001 and 2008. Unlike the past floods, rainfall storm in November 2008 was concentrated in the downstream areas, causing serious damages in these areas. Conceivable economic losses incurred by this disaster might be as follows:

i) Damages of fixed assets
ii) Damages of products and goods
iii) Loss of job opportunities
iv) Loss of human lives
v) Damages of houses and private facilities
vi) Damages of public facilities
vii) Expenditure for emergency activities

In this Preparatory Survey, the economic losses due to the 2008 November disaster were estimated as follows, largely dividing into three categories:

i) Expenditure for emergency activities: R$ 2.72 billion (equivalent to approximately 136 billion yens)
ii) Loss in the sector of social activities: included in the estimated cost of emergency

activities above

iii) Loss in the sector of economic activities: R$ 1.7 billion (equivalent to approximately 85 billion yens)

Details of the estimation are discussed below.

3.4.2 Expenditure for Emergency Activities

The Expenditure for emergency activities was estimated by dividing the expenditures for emergency works and restoration works conducted by the State Government as follows:

Table 3.4.1 Expenditure for Emergency Works by the State Government

Institution	Budget (R$ million)	Contents
DEINFRA	254.8	Restoration of roads
Municipal Governments	25.8 19.0 29.0 64.0	Restoration of municipal roads Removal of debris from rivers Restoration of bridges Restoration of public facilities
COHAB/SC	8.6	Construction of houses for victims of house collapse
SST	6.5	Relief works
State Secretariat of Health	70.0	Measures for sanitary and epidemics
Civil Defense	34.8	Measures for emergency evacuation
Regional Development Department (SDR)	48.2	Disaster prevention works
Civil Defense Fund	1.5	Emergency works
State Secretariat of Public Security and Safety (SSP)	3.0	Emergency works
State Secretariat of Administration (SEA)	11.3	Restoration of schools
Water and Sanitation Company (CASAN)	2.0	Restoration for water and sewerage systems
CELESC	29.0	Restoration of electric supply system
State budget	49.0	Expenditure for emergency measures for victims
Total	**656.5**	

Source: Reconstruction of Areas affected by the November/2008 Catastrophe, Santa Catarina State

Table 3.4.2 Expenditure for Restoration Works by the State Government

Institution	Budget (R$ million)	Contents
Itajaí Port	350.0	Restoration of Itajaí Port
DEINFRA	1.0	Establishment of information monitoring system for the areas downstream and upstream of dam
EPAGRI/CIRAM	10.0	Preparation of land use maps and of risk maps, meteorological analysis, flood risk zones, improvement of meteorological alert system, GIS improvement, etc.
Divil Defense	1.0	Training
GTC	10.0	Formulation of the disasters risk mitigation plan in the Itajaí River basin
DEINFRA	112.0 1.0	Detours Restoration of asphalt roads, restoration of earth roads
CELESC	1.5 3.8	Protection works for substations Electric supply system
SDS	20.3	Establishment of map information system, meteorological and hydrologic monitoring system of FURB, and meteorological monitoring system of EPAGRI
SAR	526.0	Postponement of debt repayment, installation of special credit lines, etc.
SEF	1,029.2	Measures of R$ 845 million for administrative damages, R$ 71.2 million for product losses, and R$ 113 million for infrastructure damages

Institution	Budget (R$ million)	Contents
		- Exemption of ICMS tax (until February 2009) - Postponement of ICMS tax payment - Deduction of ICMS tax regarding loss of goods
Total	**2,065.8**	

Source: Reconstruction of Areas affected by the November/2008 Catastrophe, Santa Catarina State

3.4.3 Losses in Sector of Social Activities

The following table shows the damages due to flood and sediment disasters. Hude damages occurred in both Ilhota and Blumenau cities. Almost total populations in Blumenau, Brusque, Gaspar, Ilhota, Itajaí and Luis Alves cities were affected. The losses in the social activities sector such as damages to human lives and houses, and private and public facilities are considered to be included in the expenditure for emergency activities as presented in sub-section 3.4.2.

Table 3.4.3 Damages due to Flood and Sediment Disasters in November 2008

City	Population	Ratio of affected people	People evacuated	Affected people	Victims house collapse	Injured	Dead	Damaged houses	Damaged roads (km)
Benedito Novo	9,841	31 %	102	712	210		2	191	576
Blumenau	292,972	35 %		25,000	5,209	2,383	24	18,000	
Brusque	94,962	100 %		8,000	1,200	66	1	1,220	120
Gaspar	52,428	100 %		7,100	4,300	280	16	8,700	600
Ilhota	11,552	100 %	3,500	3,500	1,300	67	26	406	
Itajaí	163,218	100 %	100,000	18,208	1,929	1,800	5	28,400	
Luis Alves	8,986	100 %		3,232	239	41	10	220	40
Pomerode	25,261	1 %		182	48		1	50	100
Rio dos Cedros	9,685	88 %		595	96			283	300
Rodeios	10,773	5 %		27	42		4	35	144
Timbo	33,326	2 %						264	
Total	**713,004**		**103,602**	**66,556**	**14,573**	**4,637**	**89**	**57,769**	**1,880**

Source: AVADANs sent by the municipalities to the Civil Defense of Santa Catarina, on November 24 and 25, 2008.

3.4.4 Loss in the Sector of Economic Activities

In addition to the direct damages in the previous sub-section, delay of the economic recovery resulting from serious infrastructure damages can also be considered. Outstanding delays of economic recovery of the Itajaí Port and agricultural sector are recognized. The delay of restoration of the Itajaí Port due to hard rain of November 2008 resulted in indirect damages in the commercial and services sectors. In this Preparatory Survey, the losses of economic activities were estimated by dividing the damages of agricultural sector and the services and transportation sector.

(1) Damages of Agricultural Sector: RS 19.5 million (equivalent to approximately 980 million yens)

The agricultural sector suffered from serious damages, resulting in reduction of cultivation area in Ilhota and Itajaí cities. Especially, irrigated paddy area in Itajaí city was drastically decreased. The following table shows the reduction of cultivation areas of irrigated rice, maize and cassava due to the disasters, which are the main products of the 5 municipalities in the downstream reaches.

Table 3.4.4 Cultivation Areas of Main Agricultural Products of 5 Major Cities in the Downstream of Itajaí River

Unit: ha

City	Irrigated rice			Maize			Cassava			Other products		
	2008	2009	Balance	2008	2009	Balance	2008	2009	Balance	2008	2009	Balance
Blumenau	40	40	0	500	200	-300	340	510	170	392	462	70
Brusque	180	180	0	260	260	0	50	50	0	41	38	-3
Gaspar	3,400	3,400	0	185	185	0	160	220	60	423	578	155
Ilhota	3,200	1,280	-1,920	5	2	-3	20	12	-8	541	433	-108
Itajaí	2,300	1,800	-500	50	50	0	50	70	20	145	46	-99
Total	**9,120**	**6,700**	**-2,420**	**1.000**	**697**	**-303**	**620**	**862**	**242**	**1,542**	**1,557**	**15**

Source: Compiled by JICA Survey Team based on the data from EPAGRI/CEPA

The following table shows the transition of rice production in 5 cities:

Table 3.4.5 Transition of Rice Production in 5 Major Cities in the Downstream of Itajaí River

Unit: ton/year

City	1990	1995	2000	2005	2008	2009	Ratio of 2009/2008
Blumenau	740	860	240	240	280	280	100.0%
Brusque	1,025	745	453	1,260	1,260	1,260	100.0%
Gaspar	12,050	13,860	25,600	31,200	27,880	17,000	61.0%
Ilhota	7,200	7,650	14,000	19,500	20,800	9,152	44.0%
Itajaí	6,125	7,150	14,000	15,410	16,100	10,080	62.6%
Total	**27,140**	**30,265**	**54,293**	**67,610**	**66,320**	**37,772**	**57.0%**

Source: Compiled by JICA Survey Team based on the data from EPAGRI/CEPA

As seen above, rice production in Gaspar, Ilhota and Itajai cities has been drastically dropped. The following table shows the variation of production values of major agricultural crops. In this table, the same unit production values in 2008 were applied to 2009.

Table 3.4.6 Variation of Production Values of Main Agricultural Crops in 5 Major Cities in the Downstream of Itajaí River

Unit: R$ thousand

City	Rice			Maize			Cassava			Subtotal of 3 items
	2.008	2.009	Balance	2.008	2.009	Balance	2.008	2.009	Balance	
Blumenau	140	140	0	1,732	481	(1,251)	318	223	(95)	(1,346)
Brusque	630	630	0	6,527	5,397	(1,130)	162	81	(81)	(1,211)
Gaspar	13,940	8,500	(5,440)	21	21	0	176	264	88	(5,352)
Ilhota	13,312	5,857	(7,455)	477	95	(382)	60	22	(38)	(7,875)
Itajaí	9,660	6,048	(3,612)	-	0	0	428	300	(128)	(3,740)
Total	**37,682**	**21,175**	**(16,507)**	**8,757**	**5,995**	**(2,762)**	**1,144**	**889**	**(255)**	**(19,524)**

Source: Compiled by JICA Survey Team based on the data from EPAGRI/CEPA

As shown in the above table, the damage of three main agricultural products (rice, maize, cassava) is estimated to be approximately R$ 19.5 million. The reduced value of these crops corresponds to 26.5 % of the total agricultural GDP in 2007 as shown in the table below. Serious reduction occurred in Gaspar, Ilhota and Itajaí cities.

Table 3.4.7 Reduction of Agricultural Production Values in 2009

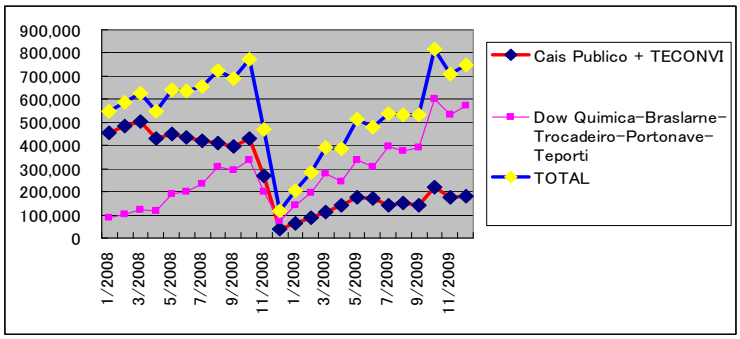
Unit: R$ thousand

City	Agricultural GDP in 2007	Reduction of 3 Major Crops in 2009	Ratio to the GDP in 2007
Blumenau	12,950	(1,346)	-10.4%
Brusque	20,948	(1,211)	-5.8%
Gaspar	11,566	(5,352)	-46.3%
Ilhota	16,333	(7,875)	-48.2%
Itajaí	11,788	(3,740)	-31.7%
Total	**73,583**	**(19,524)**	**-26.5%**

Source: Compiled by JICA Survey Team based on the data from EPAGRI/CEPA

(2) Damages of Services and Transports Sectors: R$ 1.68 billion (equivalent to approximately 84 billion yens)

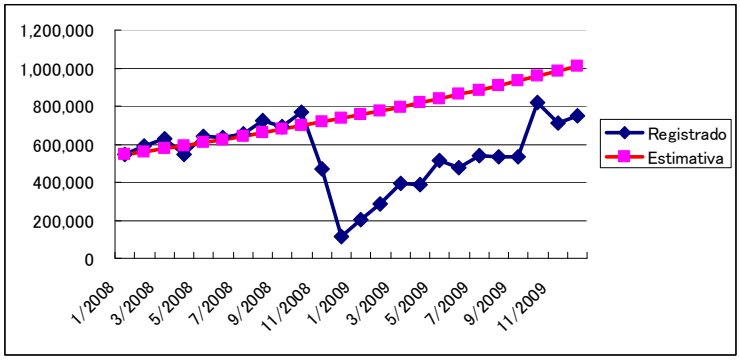
At the Itajaí Port, of which port infrastructure has suffered from serious damages, transaction volume has drastically dropped taking almost one year for restoration. This drastic decrease of transaction volume caused various negative impacts, resulting in a drastic reduction of tax collection in Itajaí city. The following figure shows the monthly transaction volume at the Itajaí Port.



Source: Compiled by JICA Survey Team based on the data from EPAGRI/CEPA

Figure 3.4.1 Change of Monthly Transaction Volume due to Disaster in 2008 at Itajaí Port

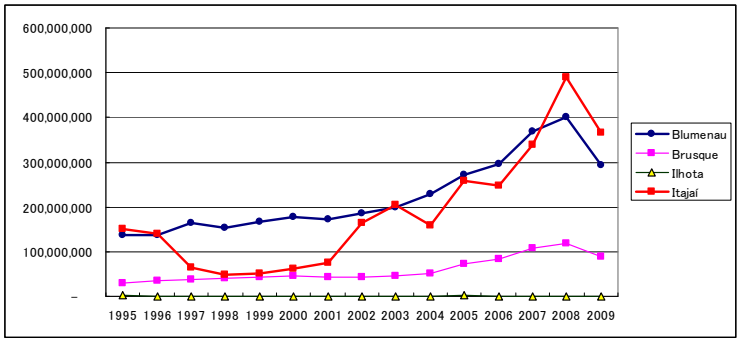
The delay of restoration at the Itajaí Port has caused the serious damage. As shown in the figure below, decrease in transaction volume at the Itajaí Port after the disaster was estimated comparing to the estimated transaction volume without the disaster. As the result, the decreased volume was estimated approximately 5 million tons.



Source: Compiled by JICA Survey Team based on the data from Itajaí Port

Figure 3.4.2 Estimation of Decreased Transaction Volume at Itajaí Port

The disaster in November 2008 strongly impacted the logistics as well, resulting in huge economic losses. The figure below shows the change of ICMS revenues (tax on transaction) since 1995 at 4 main cities in the downstream areas. As observed, Itajaí and Blumenau cities show strong economic development, and especially Itajaí city has been rapidly developed from 2001. However, the collected ICMS was drastically decreased due to the disaster in November 2008.



Source: Compiled by JICA Survey Team based on the data from SPG

Figure 3.4.3 Historical Change of ICMS Revenues at 4 Major Cities in the Downstream of Itajaí River

The table below shows the annual ICMS revenues together with the estimated ICMS revenue in 2009 without the disaster at 4 cities in the downstream of Itajaí River. As seen, the actual ICMS revenue in 2009 has decreased at the level of 2006 due to the disaster in 2008.

Table 3.4.8 Annual ICMS Revenues and the Estimated Revenue in 2009 at 4 Major Cities in the downstream of Itajaí River

Unit: R$

Year	2005	2006	2007	2008	2009
Blumenau (actual)	270,671,969	296,893,667	369,694,832	401,487,077	292,980,537
Blumenau (without disaster)					451,285,573
Brusque (actual)	71,689,589	83,850,329	106,517,392	119,558,942	90,124,608
Brusque (without disaster)					140,727,915
Ilhota (actual)	1,373,779	819,320	875,341	1,105,738	476,033
Ilhota (without disaster)					1,132,478
Itajaí (actual)	258,680,077	247,152,296	339,089,648	490,576,988	366,299,023
Itajaí (without disaster)					575,301,583
Total (actual)	602,415,413	628,715,612	816,177,216	1,012,728,747	749,880,202
(without disaster)	-	-	-	-	1,168,447,549
Difference					**(418,567,347)**

Source: Compiled by JICA Survey Team based on the data from SPG

As shown in the above table, the decrease of ICMS revenues at 4 cities was estimated to be approximately R$ 419 million.

3.4.5 Increase of Damage Potentials due to Flood and Sediment Disaster

In the preceding sub-sections, the damages caused by the disaster in November 2008 were estimated. In this connection, the damage potentials in the Itajai River basin would inevitably increase according to the progress of economic development. The table below presents the ratio of ICMS revenue to the GRDP in 5 main cities:

Table 3.4.9 GRDP and ICMS in 2007 at 5 Major Cities in the Downstream of Itajaí River

Unit: R$ thousand

City	GRDP	Agri-culture	Industry	Services	Tax	ICMS		
						ICMS Value	ICMS/tax	ICMS/GDP
Blumenau	6,682,445	12,950	2,287,656	3,578,843	802,996	369,742	46.0%	5.5%
Brusque	2,068,595	4,492	925,455	919,237	219,410	106,544	48.6%	5.2%
Gaspar	1,001,200	15,534	398,945	428,623	158,098	37,045	23.4%	3.7%
Ilhota	98,666	12,345	29,122	51,980	5,219	877	16.8%	0.9%
Itajaí	7,982,841	36,803	926,505	4,499,885	2,519,649	339,359	13.5%	4.3%

Source: Compiled by JICA Survey Team based on the data from SPG

The following table shows the projection of future damage potentials due to flood and sediment disasters based on the past floods damage records and the trend of economic growth in sub-basins in the Itajaí River.

Table 3.4.10 Projection of Damage Potentials due to Flood and Sediment Disasters in the Itajaí River Basin

Trend	Summary of Damage Potentials
Population Growth	・ Concentration of population might occur in the downstream areas, influenced by the intensification of economic activities, mainly in Itajaí, Gaspar and Navegantes cities. ・ Possibly the concentration of population would occur in the flood vulnerable areas. ・ Because of reasons above, there is a risk of increasing flood damage potential
Economic Growth	・ Economic growth is remarkable mainly in the downstream areas and thus the economic importance of these areas would increase every year. ・ In the downstream areas, current economic development is based on the port services. However, has been admitted. The rapid economic development is expected motivated by the recent trend of the fright transport complex formulation. Especially, import of textile, machinery, component etc. have been extremely increased as shown in Table 2.1.15. ・ Even in the share to GRDP, the share in the river mouth area (SDR Itajaí) has been increased from 21% in 1997 to 34% in 2007. This trend is expected to continue in the future. ・ The economy of Santa Catarina State depends on the export of frozen meat, and the Itajaí Port is its main exporting port. The performance of Itajaí Port has a key factor on the State economy. ・ In relation to tax revenue, it has been significantly increasing in all the regions with a remarkable increase in the region of SDR Itajaí. ・ Both of tax revenue and GRDP have been significantly increased. Thus according to an increase of the added economic value, the need of measures to mitigate disaster damages would increase.
Development Plans	・ In the Itajaí River basin, economic development is ongoing focusing in the river mouth area. ・ There are development plans by the State Government, that is, the re-development of Itajaí port (expansion and modernization) in the short term, and the development of transportation network (construction of railways and expansion of federal roads) etc. in the middle term.

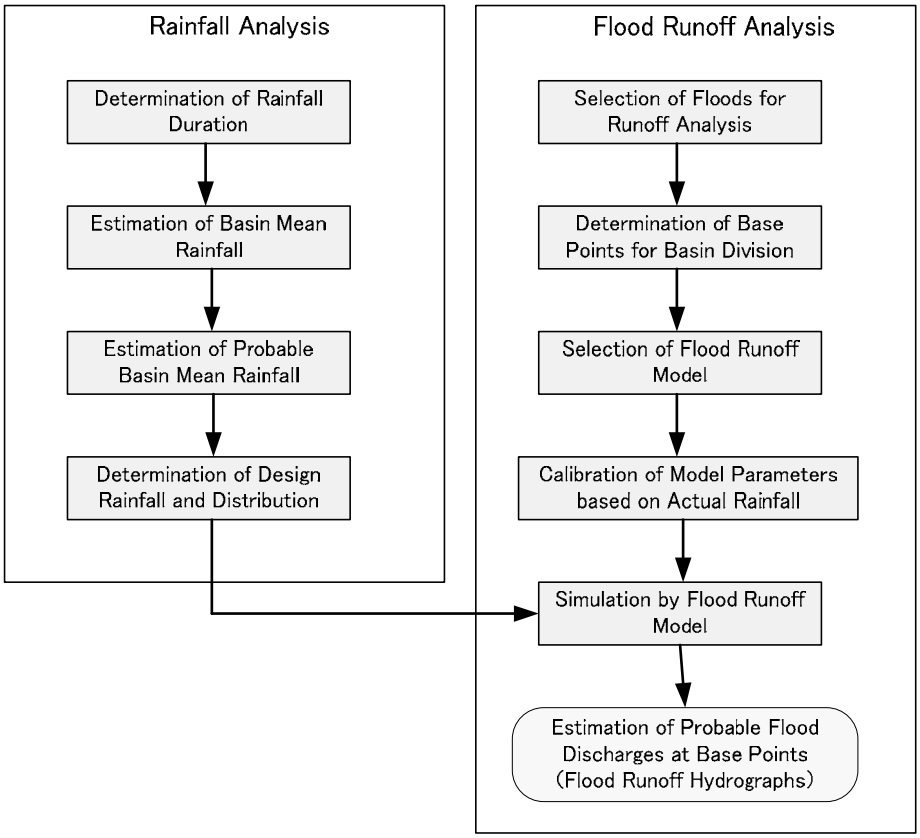
Source: JICA Survey Team

An economic importance of the Itajaí River basin has been increasing every year, resulting in increasing investment opportunities. In order to maintain the invested assets onwards, it becomes necessary to provide measures against natural disasters. The economic activities in Itajaí city have been increased five times only in the last 8 years from 1999 to 2007. To promote sustainable developments in the Itajaí River basin onwards, implementation of disasters prevention measures would be necessary, mainly focusing on the downstream area.

3.5 Flood Runoff Analysis

3.5.1 General

As explained in detail in Section 5.3, probable flood discharges with return period of 5, 10, 25, and 50 years were estimated through flood runoff analysis, because it was difficult to determine the safety level against probable flood. The design probable floods are estimated from the design probable rainfalls. Figure 3.5.1 illustrates the work flow of flood runoff analysis.



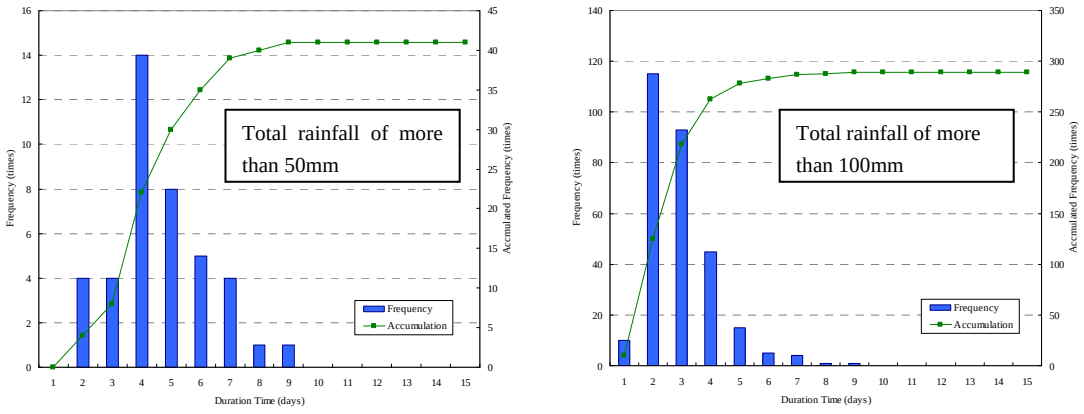
Source: JICA Survey Team

Figure 3.5.1 Flow Chart for Flood Runoff Analysis

3.5.2 Rainfall Analysis and Probable Rainfalls

(1) Rainfall Duration

For estimation of probable rainfalls, rainfall duration shall be determined first based on the rainfall records. The rainfall duration is determined in terms of the number of days with storm rainfall. Figure below show the comparison of frequency distribution of the rainfall durations of observed storm rainfalls; in terms of the total rainfall amounts of more than 50 mm and 100 mm, respectively.



Source: JICA Study Team

Figure 3.5.2 Frequency Distribution of Rainfall Duration

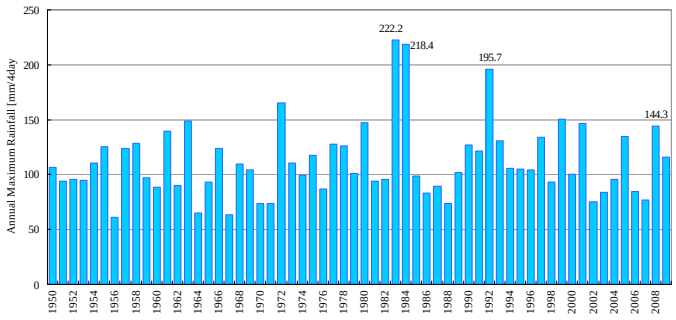
As seen above, the durations of total rainfall more than 50 mm are within 4 days. The durations of total rainfall over 100 mm are within 5 to 6 days, but the highest frequency occurs in 4 days. Considering these characteristics appeared, the design duration of rainfall is determined 4 days.

(2) Estimation of Probable Basin Mean Rainfalls

The probable basin mean rainfalls were estimated for the entire Itajaí River basin and divided sub-basins of major tributaries using the daily rainfall records by ANA.

a) Entire Itajaí River basin

The annual maximum 4-day basin mean rainfalls for the entire Itajaí River basin were analyzed in the period of 1950 – 2008 by applying the Thiessen method as illustrated below. The highest 4-day rainfall of 222 mm occurred in 1983, followed by 218 mm in 1984 and 196 mm in 1992. As for the extraordinary flood in November 2008, the basin mean 4-day rainfall was estimated 144 mm that is evaluated in the middle-sized rainfall event, since the rainfall distribution was concentrated in the downstream basin.



Source: JICA study team

Figure 3.5.3 Annual Maximum 4-day Basin Mean Rainfalls for the Entire Itajaí River Basin in 1950 - 2009

Frequency analysis was made for the estimated annual maximum 4-day basin mean rainfalls in the above. The results are shown in the table below.

Table 3.5.1 Estimation of Probable Basin Mean 4-day Rainfalls for the Entire Itajaí River Basin

Toda Bacia

Função distribuição de probabilidade		Distribuição exponencial	Distribuição de Gumbel	Distribuição raiz quadrada exponencial	Distribuição genérica de valores extremos	Distribuição de Pearson tipo III
Estimação de parâmetros		Método momento L	Método momento L	Máxima verossimilhança	Método momento L	Método momento L
Abreviação		Exp	Gumbel	SqrtEt	Gev	LogP3
Valor hidrológico provável (estimação de parâmetros em todas as amostras)	1/2	100.8	106.3	104.8	105.1	105.2
	1/3	115.2	120	118.5	118.4	118.8
	1/5	133.2	135.2	134.7	133.9	134.3
	1/10	157.7	154.3	156.3	154.2	154.6
	1/20	182.2	172.7	178.5	174.6	174.8
	1/30	196.5	183.2	191.9	186.8	186.7
	1/50	214.6	196.4	209.2	202.6	202.1
	1/80	231.2	208.5	225.7	217.4	216.7
	1/100	239.1	214.2	233.7	224.7	223.8
	1/150	253.4	224.6	248.5	238	236.8
	1/200	263.6	232	259.3	247.7	246.3
Coeficiente de correlação		0.942	0.996	0.996	0.997	0.996
SLSC		0.04	0.035	0.026	0.027	0.025
Método Jackknife 1/50	Valor estimado	214.6	196.4	210.5	202.5	201.6
	Erro estimado	16.8	14.4	14.1	21.9	20.3
Método aplicado				○		

Source: JICA Study Team

The square root exponential distribution of maximum values showed a best fit among the probability distribution functions in the above. The estimated probable 4-day basin mean rainfalls are 135 mm for 5-year return period, 156 mm for 10-year return period, 179 mm for 20-year return period, and 209 mm for 50-year return period. Both large floods in 1983 and 1984 are evaluated in the scale of 50 - 80 year return period in terms of the estimated probable 4-day rainfalls. The flood in 1992 is of around 30-year flood and the flood in 2008 is around a 10-year flood.

b) Tributary basins

The same frequency analysis was carried out for estimation of probable 4-day basin mean rainfalls for divided tributary basins (see Figure 3.1.1). The estimated probable basin mean rainfalls are summarized in the table below compared with the estimated probable 4-day basin mean rainfalls over the entire Itajaí River basin.

Table 3.5.2 Estimation of Probable Basin Mean 4-day Rainfalls for Tributary Basin in the Itajaí River

	1/5	1/10	1/20	1/25	1/50
Total Basin	135	156	179	188	209
Itajai do Oeste	153	175	196	202	224
Itajai do Sul	141	161	181	186	207
Itajai do Norte	140	160	179	184	204
Benedit	155	179	202	208	232
Itajai Acu	144	169	194	205	230
Itajai do Mirim	140	161	180	185	205

Source: JICA Study Team

The probable 4-day rainfalls are relatively high in the Itajaí do Oeste, Benedito, and Itajai-Acu River basins. On the other hand, the probable 4-day rainfalls are relatively small in the Itajaí South and Itajaí Mirim River basins.

3.5.3 Flood Runoff Model and Calibration

(1) Division of Sub-basins

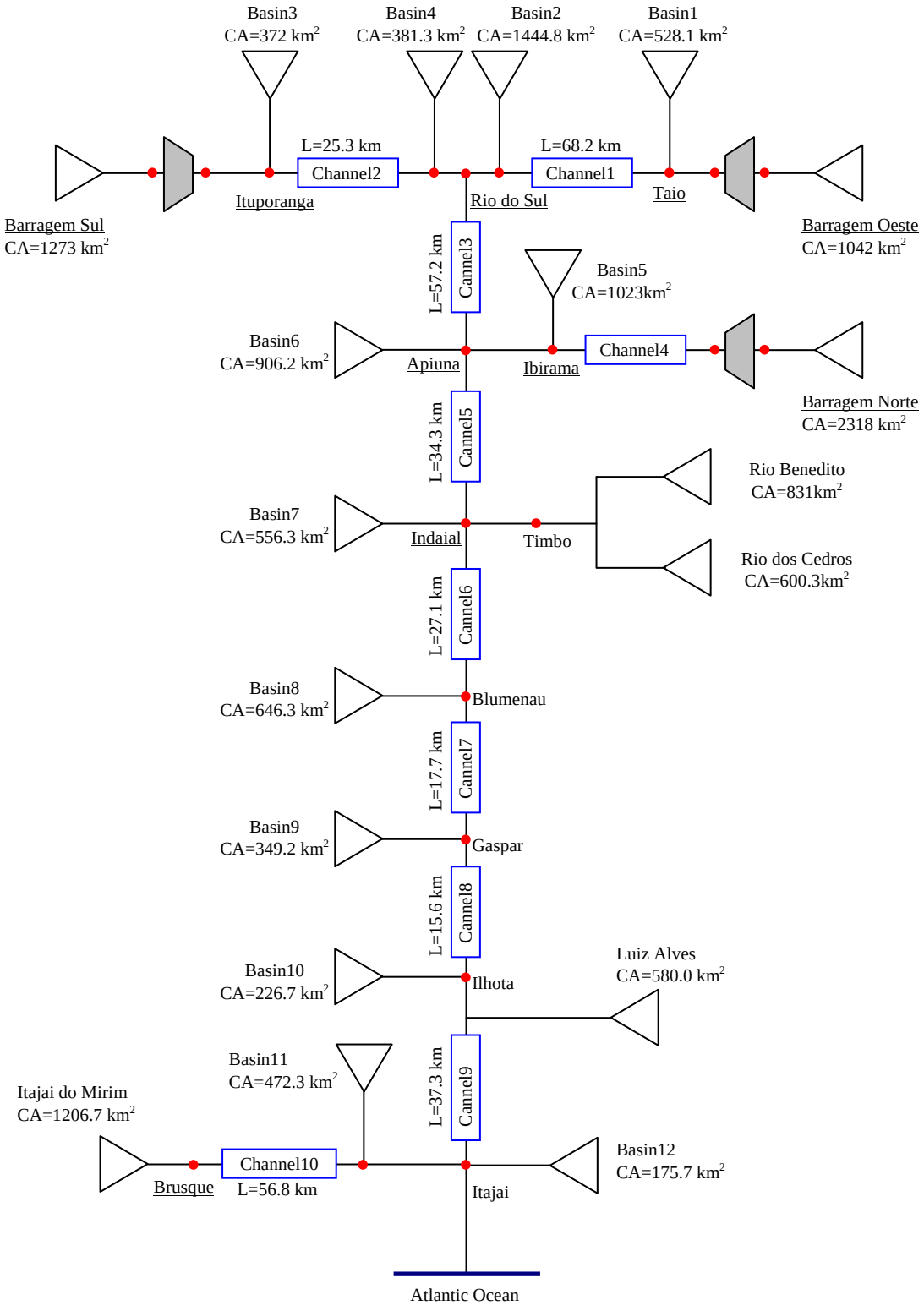
In order to develop a flood runoff model, the Itajai River basin is divided into 20 sub-basins and 10 channels as illustrated in Figure 3.5.4, considering main tributaries and base points along the mainstream where discharge estimation is necessary for flood control planning. As shown in this figure, sub-basins are connected to the channel.

(2) Flood Runoff Model

The HEC-HMS software program was selected for flood runoff model. This program is developed by the U.S. Army Corps of Engineers and is widely used for flood analyses in Brazil.

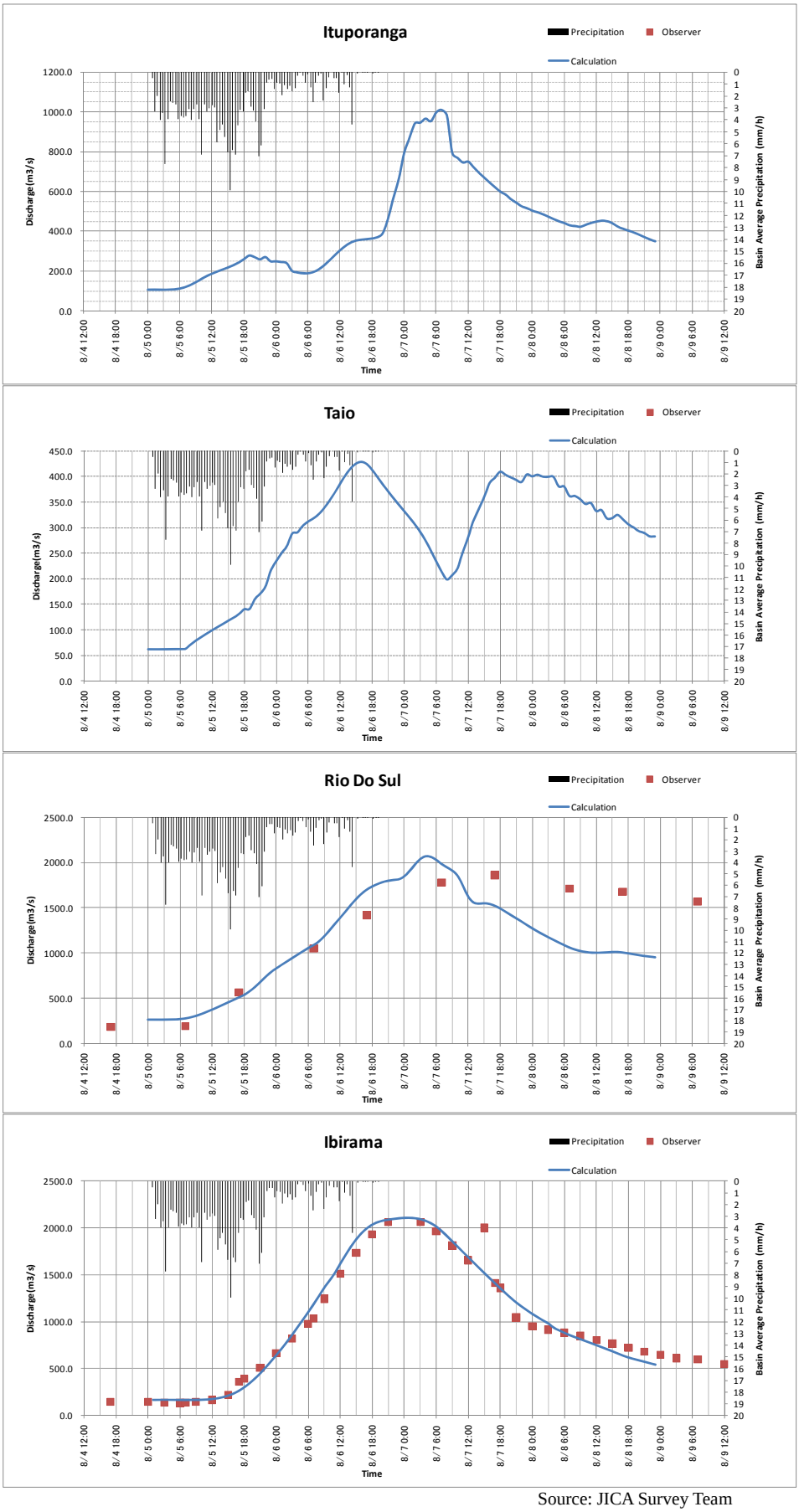
(3) Calibration of Model Parameters

Calibration of the model was carried out for two flood events in 1984 and 2010 to verify parameters used for obtaining the most accurate fit of the observed flood hydrographs at all stations. Figure 3.5.5 presents the results of calibration. The results considered to well simulate large flood events in terms of predicting peak discharges, hydrograph shape and time to peak. A detailed description of the calibration is presented in a separate Supporting Report No.1 Hydrology.



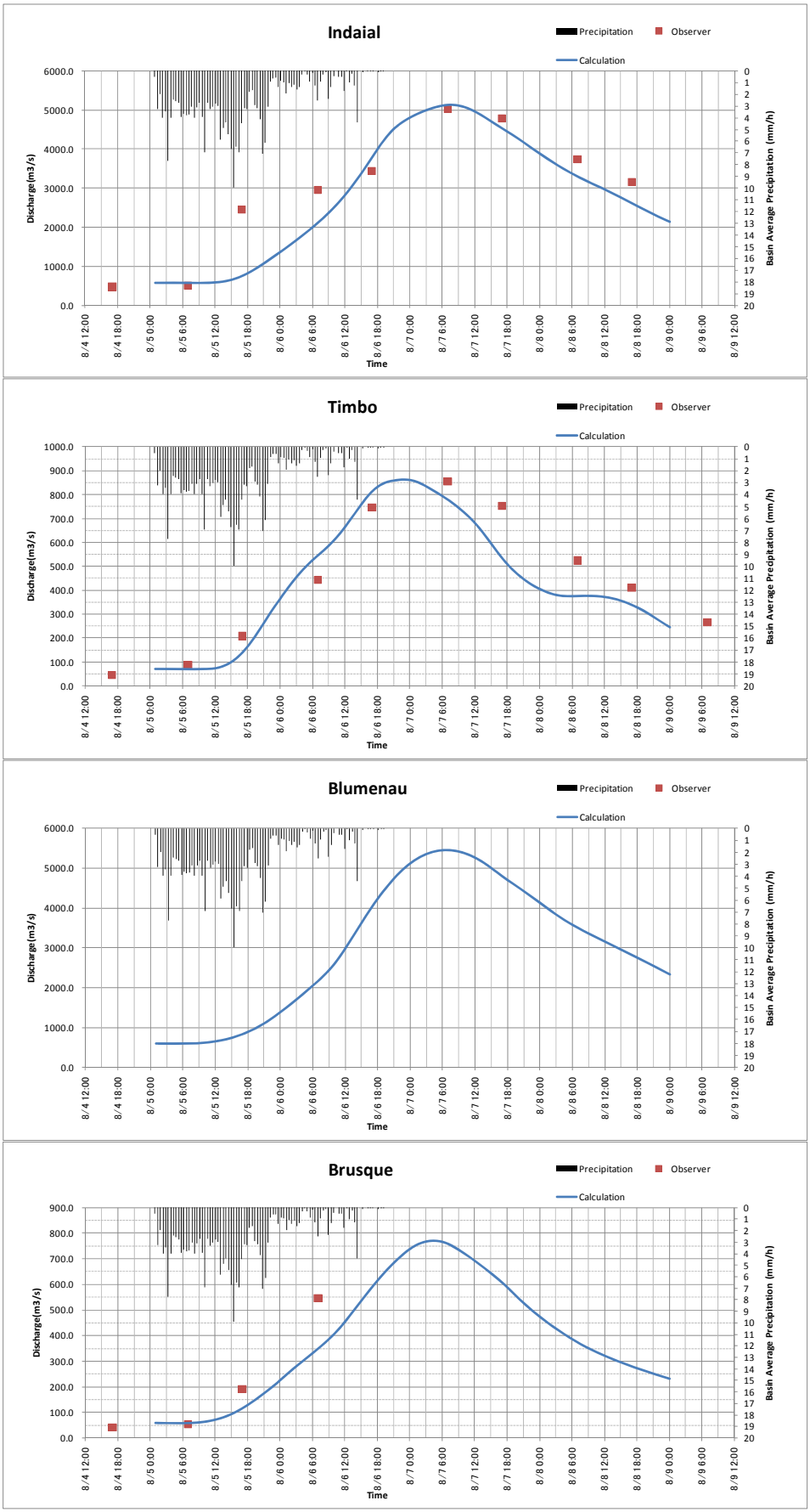
Source: JICA Survey Team

Figure 3.5.4 Flood Runoff Model for Itajai River



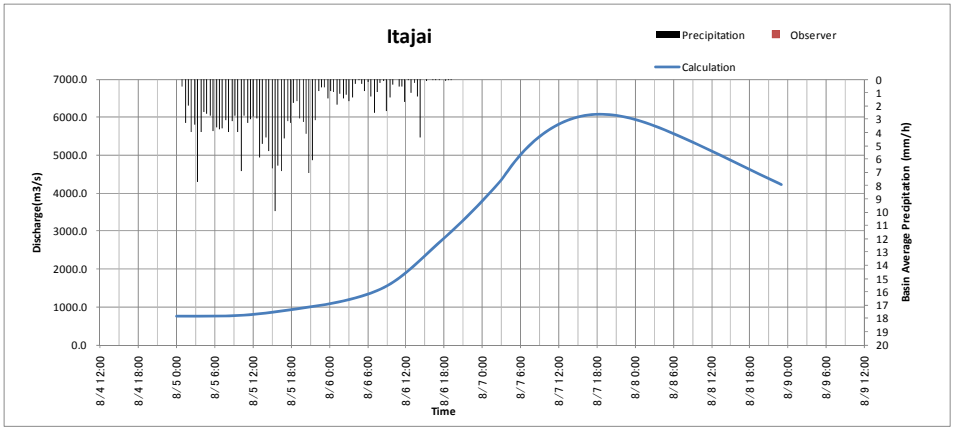
Source: JICA Survey Team

Figure 3.5.5 Results of Calibration for the 1984 Flood (1/3)



Source: JICA Survey Team

Figure 3.5.5 Results of Calibration for the 1984 Flood (2/3)

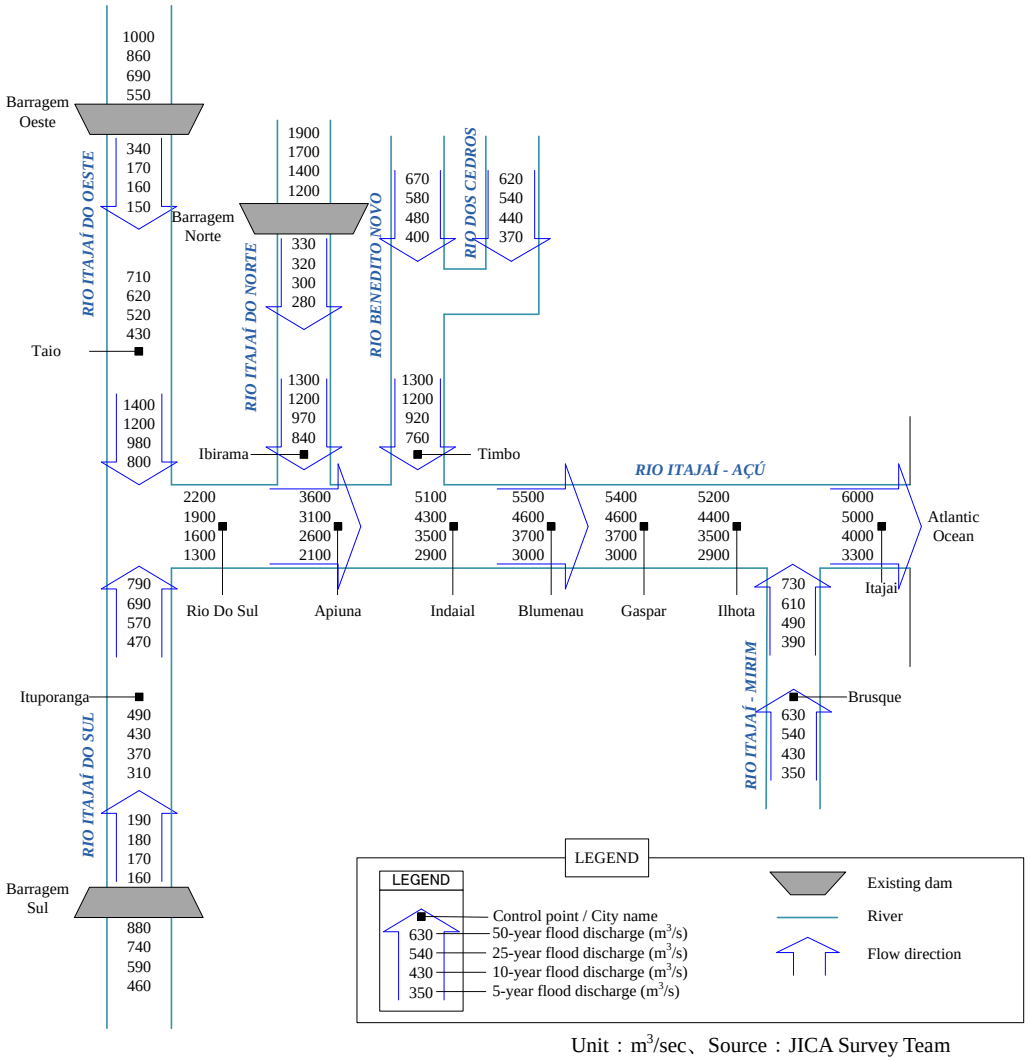


Source: JICA Survey Team

Figure 3.5.5 Results of Calibration for the 1984 Flood (3/3)

3.5.4 Estimation of Probable Flood Discharges

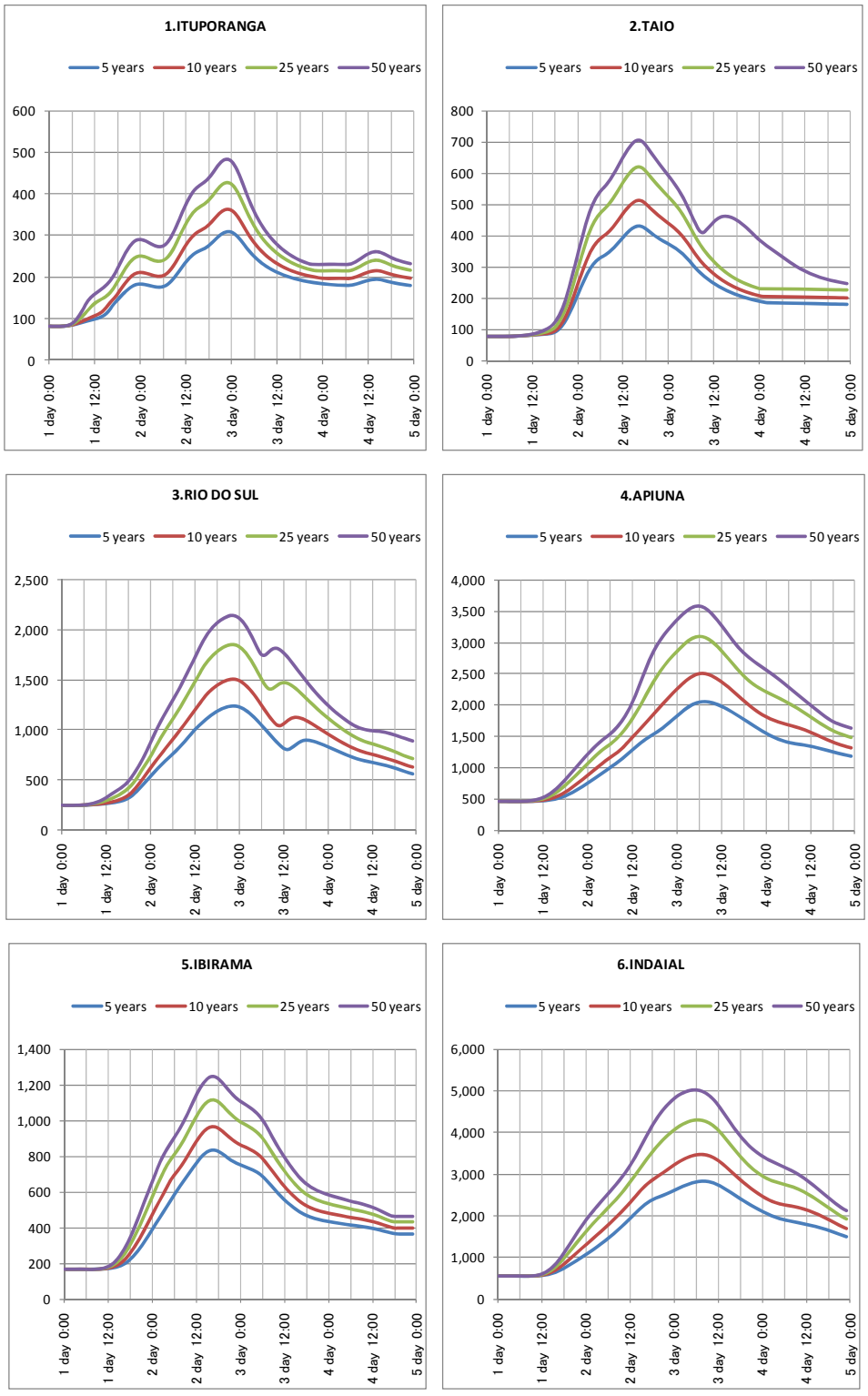
Probable flood discharges are estimated at the base points applying the calibrated flood runoff model. The distribution of probable flood discharges is shown below. In this estimation, releasing gates at the existing 3 flood control dams are assumed to be fully opened. A detailed description of the estimation of probable flood discharges is presented in a separate Supporting Report No.1 Hydrology.



Unit：m^3/sec、Source：JICA Survey Team

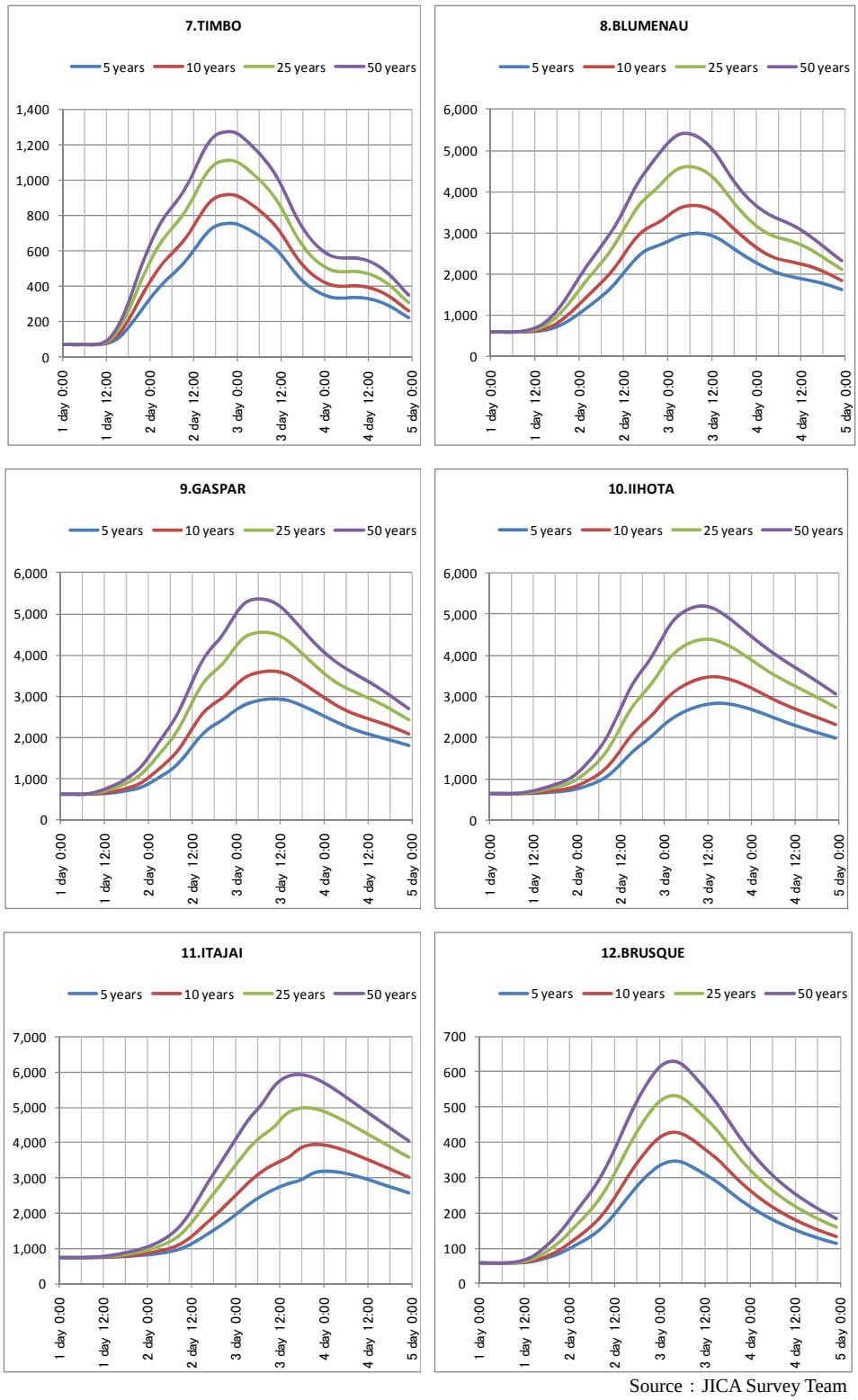
Figure 3.5.6 Probable Flood Discharges at Base Points

The difference in flood peak times between Rio do Sul and Blumenau cities is around 7 to 10 hours, and around 14 to 17 hours between Blumenau and Itajaí cities. The flood propagation time from Rio do Sul to Itajai cities is around one day. Figure 3.5.7 shows the probable flood discharge hydrographs at base points along the Itajai River.



Source : JICA Survey Team

Figure 3.5.7 Probable Flood Discharge Hydrographs (1/2)

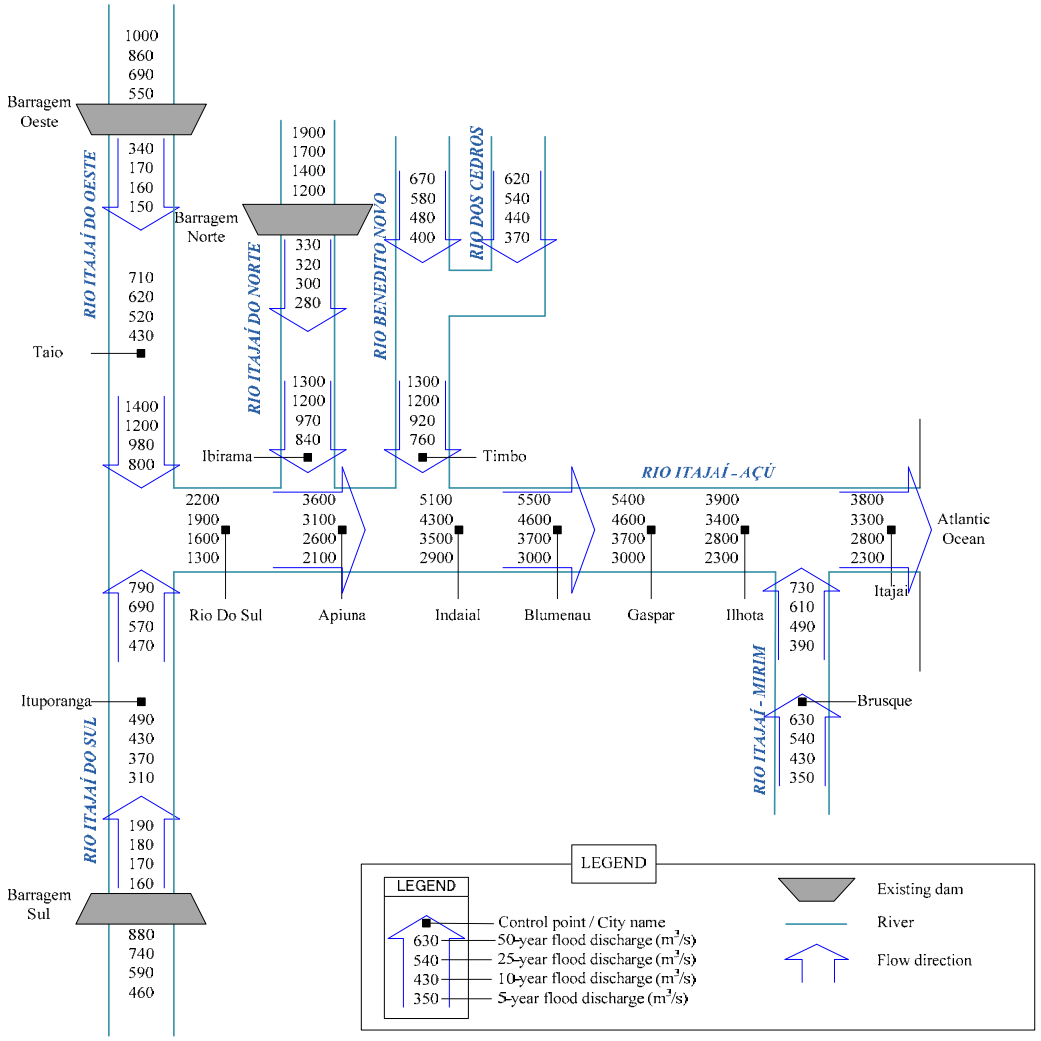


Source：JICA Survey Team

Figure 3.5.7 Probable Flood Discharge Hydrographs (2/2)

As shown above, the 50-year flood discharge at Itajai city is 6,000 m^3/s, which is very large compared to the current flow capacity as discussed in the succeeding Section 3.6. The flooding pattern due to large floods in the low-lying area from the federal highway BR 101 to Gaspar or Ilhota cities is characterized by widespread and prolonged inundation. This is due to the fact tat the downstream reaches of the Itajai River is unprotected by some dikes. Given the conservation of such flood retarding effect, the probable flood discharges at Itajai city for flood control

planning could be minimized and hence construction cost could be reduced. In light of such concerns, the probable flood discharges downstream from Ilhota city are re-estimated provided with such retarding effect to floods. Figure 3.5.8 shows the probable flood discharges estimated by the unsteady flow calculation using HEC-RAS (the floodplain elevation data was based on the existing topographical maps with a scale of 1/50,000. However recalculation using more precise and reliable flood plain elevation data is necessary after the completion of ongoing aerial photo mapping of 1/10,000).



Unit：m^3/sec、Source：JICA Survey Team

Figure 3.5.8 Probable Flood Discharges at Base Points after the Unsteady Calculation

Table 3.5.3 shows the flood control effects of the existing flood control dams against probable floods.

Table 3.5.3 Flood Control Effects of Existing Flood Control Dams

Unit：m^3/sec

Return Period	Norte Dam			Oeste Dam			Sul Dam		
	Inflow	Outflow	Peak Cut	Inflow	Outflow	Peak Cut	Inflow	Outflow	Peak Cut
5 year	1,200	280	920	550	150	400	460	160	300
10 year	1,400	300	1,100	690	160	530	590	170	420
25 year	1,700	320	1,380	860	170	690	740	180	560
50 year	1,900	330	1,570	1,000	*340	660	880	190	690

Remarks; *：Overflow, Source：JICA Survey Team

As seen above, no overflow over the spillway would occur against the 50-year flood at both the Norte and Sul dams. On the other hand, at the Oeste dam, the reservoir would almost filled with water against the 25-year flood and the maximum reservoir water level would exceed 0.9 m over the crest of spillway.

3.6 Evaluation of Flow Capacity

3.6.1 Profile and Cross Sectional Features of the Itajaí River

(1) River Cross Section Survey

The river cross section survey in the Itajai River was carried out under the Preparatory Survey in the period of June to August in 2010. Among the surveyed 143 sections in total, 79 sections were in the Itajai River mainstream and 64 sections were for tributaries as summarized below.

Table 3.6.1 Quantity of River Cross Sections Surveyed

River Name	No. of Sections	Remarks
Itajaí-Açu River	79	Mainstream
Itajaí Mirim River	17	Including 5 sections in the old Itajaí Mirim River
Garcia Stream	7	Blumenau city
Velha Stream	5	Blumenau city
Fortaleza Stream	2	Blumenau city
Benedito River	11	Including 4 sections in the Cedros River
Itajaí do Norte River	7	
Itajaí do Oeste River	9	
Itajaí do Sul River	6	

Source: JICA Survey Team

(2) Riverbed Gradient of the Itajaí River

Table 3.6.2 presents the average riverbed gradient by river stretch along the Itajaí River and major tributaries, which were estimated based on the results of river cross section survey.

Table 3.6.2 Average Riverbed Gradient by River Stretch

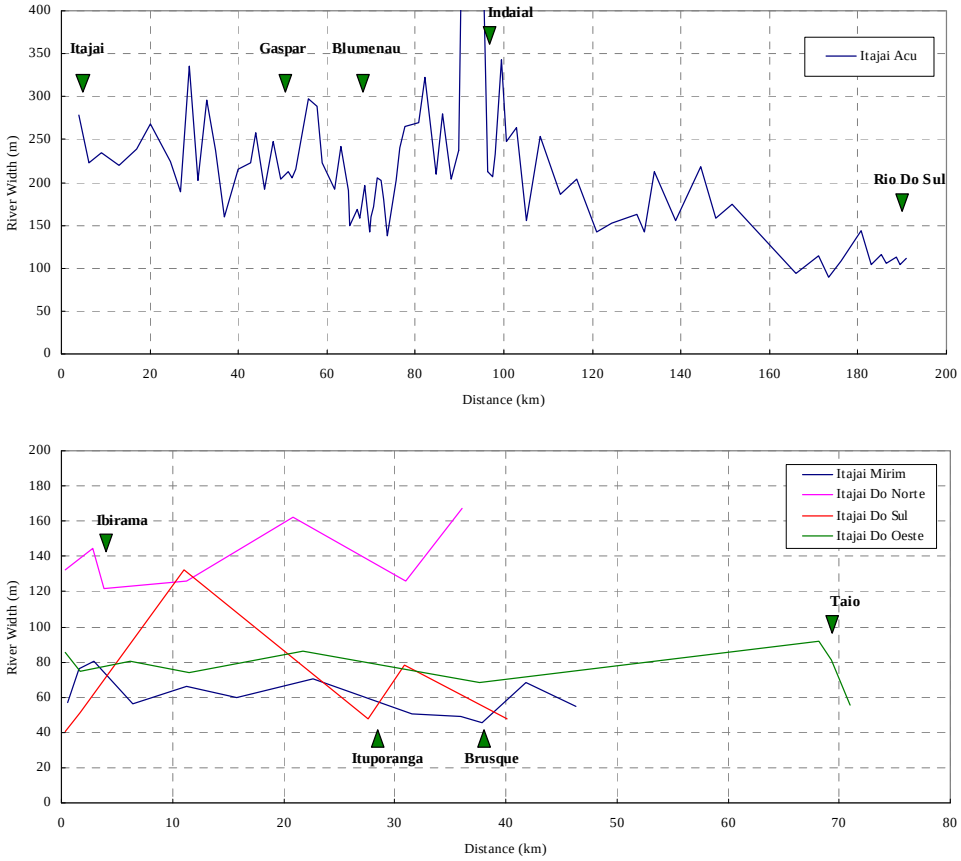
River	Stretch	Gradient
Itajaí-Açu River	Itajaí upstream Blumenau	1/20000
	Blumenau upstream to Indaial upstream	1/400
	Indaial upstream next to Itajaí do Norte confluence	1/1500
	Confluence with Itajaí do Norte until Lontras downstream	1/85
	Lontras downstream to Rio do Sul	1/3000
Itajaí Mirim River (Canal)	From the Itajaí-Açu confluence until the bifurcation at Itajaí Mirim Velho upstream	1/8000
	Bifurcation at Itajaí Mirim Velho upstream until Brusque upstream Brusque	1/1700
Itajaí Mirim Velho	From the bifurcation with the Canal until the Canal confluence	1/15000
Garcia Stream	From the Itajaí-Açu River confluence up to 3 km upstream	1/600
	Next 3 kms until 14 km upstream	1/200
Da Velha Stream	From the confluence until 2km upstream	1/200
	From 2 km upstream until 6 km	1/2000
Fortaleza Stream	From the confluence until 2 km upstream	1/500
Benedito River	Confluence until Timbó	1/2000
	Timbó to Benedito Novo	1/140
	Timbó to Dos Cedros River	1/2000
Itajaí do Norte River	Confluence to Presidente Getulio	1/170
Itajaí do Sul River	Confluence to Ituporanga	1/800
Itajaí do Oeste River	Confluence to Taió	1/5000

Source: JICA Study Team

(3) River Channels

Variation of river channel width along the Itajaí River and main tributaries is illustrated in the figure below. The mainstream of Itajaí River varies from 200 to 300 m from the river mouth to near Indaial city. From its upstream reaches, river channel becomes gradually narrow, and the river width in Rio do Sul city is around 150 m. However, river channels in Gaspar and Blumenau cities are 200 m and 150 m, showing slight bottle necks portions.

On the other hand, among the main tributaries, the Itajaí Mirim River varies between 50 to 80 m, the Itajaí do Oeste River is between 70 to 90 m, and the Itajaí do Sul River shows a large variation between 50 to 80 m. The Itajaí do Norte River varies from 120 to 160 m.

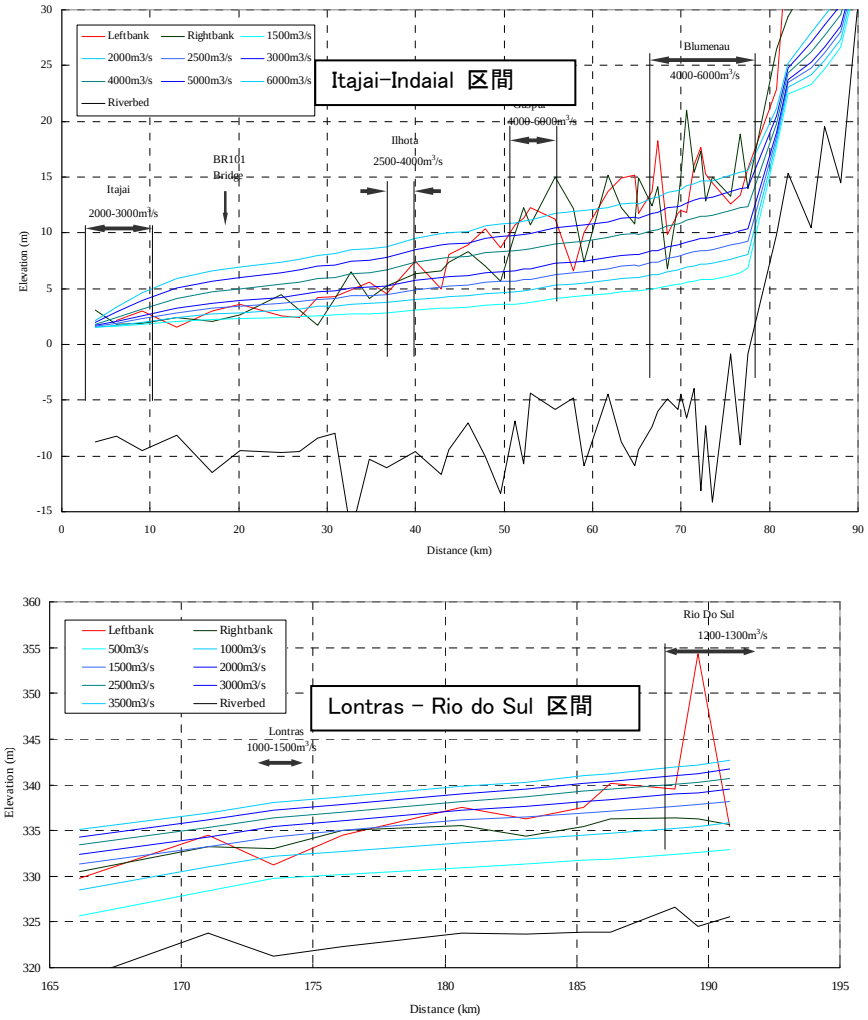


Source: JICA Survey Team

Figure 3.6.1 Variation of River Channel Width of the Itajaí River and Main Tributaries

3.6.2 Estimation and Evaluation of Flow Capacity of River Channel

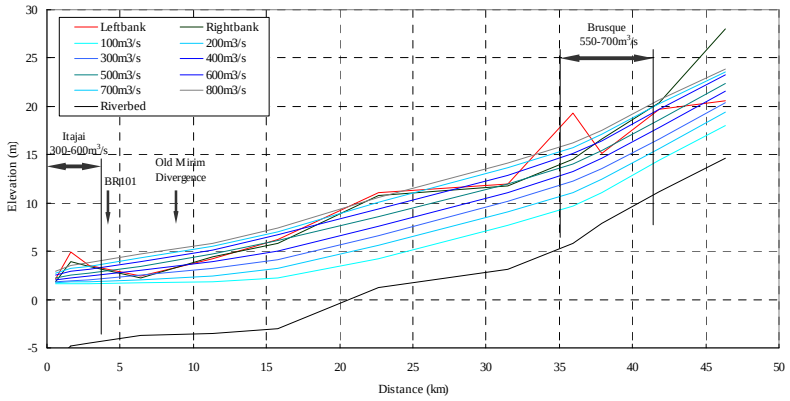
In order to evaluate the current flow capacity of river channels for the Itajaí River and main tributaries, non-uniform flow calculation was carried out by use of the river cross section data surveyed. In this calculation, several river water levels were calculated under several flood discharges referring to the estimated probable flood discharges as illustrated in Figure 3.5.8. Conditions and assumptions of the non-uniform flow calculation is discussed in detail separately in the Supporting Report, No.1 Hydrology. The results of the calculation in the mainstream of Itajaí River are illustrated below.

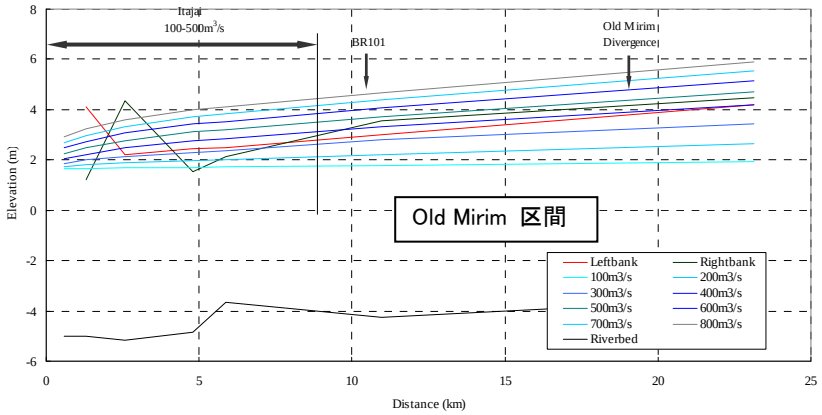


Source：JICA Survey Team

Figure 3.6.2 Results of Non-uniform Flow Calculation along the Itajaí River

The Itajaí Mirim River is divided into two river channels due to the past shortcut works in the upstream area from Itajaí city; the canal (shortcut channel) and old Mirim River (old river channel), and these two rivers join together again immediately upstream from the confluence to the Itajaí River. Distribution ratio of the flood discharge for the non-uniform flow calculation is assumed to be 2/3 to the canal and 1/3 to the old Mirim River based on the respective estimated flow capacity by the uniform flow calculation. The results of the non-uniform flow calculation of the canal and old Mirim River are illustrated below.





Note: Flood discharge in the figure is the total discharges of the canal and old Mirim River.

Source：JICA Survey Team

Figure 3.6.3 Results of Non-uniform Flow Calculation along the Itajaí Mirim River

Based on the results of non-uniform flow calculation, the flow capacity at various locations was estimated in terms of the bankfull discharge of river channel. The estimated flow capacity was evaluated compared to the probable flood discharges (see Figure 3.5.8) as summarized below.

Table 3.6.3 Flow Capacity and Considerations (Itajaí River)

River	City	Flow Capacity (m^3/s)	Necessity of flood mitiagtion measures
Itajaí	Itajaí, Navegantes	2,000 to 3,000	Flow capacity: around 5-year flood discharge (especially the right bank of Itajai city is low) Experiences of flood damages in the past and seriousness: low elevation area of Itajai city has flequently suffered from inundations, **high necessity** of flood mitigation. Damage potential by floods: **high damage potential** due to large population and importance in the economical aspect of the SC State. Necessity of flood mitigation measures: **high priority** for mitigation measures
	Ilhota	2,500 to 4,000	Flow capacity: around 10 to 25-year flood discharge Experiences of flood damages in the past and seriousness: damages have occurred in case of huge floods. Damage potential by floods: **low damage potential** due to small population. Necessity of flood mitigation measures: **low priority** for mitigation measures.
	Gaspar	5,100 to 6,000	Flow capacity: around 25 to 50-year flood discharge (large capacity at the central of the city) Experiences of flood damages in the past and seriousness: damages have occurred in case of huge floods. Damage potential by floods: **high damage potential** due to large population. Necessity of flood mitigation measures: mitigation measures are required but **midium priority.**
	Blumenau	4,200 to 6,000	Flow capacity: around 25 to 50-year flood discharge Experiences of flood damages in the past and seriousness: damages have occurred in case of huge floods. Damage potential by floods: **high damage potential** due to very large population and imortance in the economical and social aspects of the SC State. Necessity of flood mitigation measures: mitigation measures are required but **midium priority**, but as the flow capacities of small tributaries such as Garcia and Velha Rivers are 5 to 10-year, **flood mitigation measures along the tributaries are highly prior.**
	Indaial	5,700	Flow capacity: more than 50-year flood discharge

River	City	Flow Capacity (m^3/s)	Necessity of flood mitiagtion measures
			Experiences of flood damages in the past and seriousness: there has been few flood damages Damage potential by floods: large population, but hard to suffer from flood. Necessity of flood mitigation measures: **no necessity** of mitigation measures.
	Lontras	1,000 to 1,500	low capacity: around 5 to 10-year flood discharge Experiences of flood damages in the past and seriousness: there has been few flood damages in the urban area. Damage potential by floods: **low damage potential** due to small population. Necessity of flood mitigation measures: **no necessity** of mitigation measures.
	Rio do Sul	1,220	Flow capacity: around 5-year flood discharge Experiences of flood damages in the past and seriousness: low elevation area of Rio do Sul city has flequently suffered from even small flood, **high necessity** of flood mitigation. Damage potential by floods: **high damage potential** due to large population and importance as the economical center of upper Itajai River basin region. Necessity of flood mitigation measures: **high priority** for mitigation measures.

Source: JICA Study Team

Table 3.6.4 Flow Capacity and Considerations (Itajaí Mirim River and Main Tributaries)

River	City	Flow Capacity (m^3/s)	Considerations Compared to Probable Discharge
Itajaí Mirim	Itajaí	300 (downstream reach after the confluence) 500～600（Canal） 200～300（Old）	Flow capacity: less than 5-year flood discharge in downstream reach after confluence, around 25 to 50-year in Canal, less than 5-year in Old Mirim. Experiences of flood damages in the past and seriousness: low elevation area of Itajai city has flequently suffered from inundations, **high necessity** of flood mitigation. Damage potential by floods: **high damage potential** due to large population and importance in the economical aspect of the SC State. Necessity of flood mitigation measures: **high priority** for mitigation measures
	Brusque	550～700	Flow capacity: around 25 to 50-year flood discharge Experiences of flood damages in the past and seriousness: the present roads on the both banks function as a high water channel portion of the likely compound river channel, therefore, the roads have frequently suffered, but urban area has not suffered so frequently. Damage potential by floods: **high damage potential** due to large population in case of huge floods. Necessity of flood mitigation measures: mitigation measures are required but **low priority.**
Benedito	Timbó	860	Flow capacity: around 5 to 10-year flood discharge Experiences of flood damages in the past and seriousness: there are informations of frequent inundations. Damage potential by floods: **midium damage potential** due to midium size of population. Necessity of flood mitigation measures: mitigation measures are required but **midium priority.**
Itajaí do Norte	Ibirama	more than 2,000	Flow capacity: more than 50-year flood discharge Experiences of flood damages in the past and seriousness: there has been few flood damages Damage potential by floods: midium population, but hard to suffer from flood. Necessity of flood mitigation measures: **no necessity** of mitigation measures.

River	City	Flow Capacity (m^3/s)	Considerations Compared to Probable Discharge
Itajaí do Oeste	Rio do Sul	760	Flow capacity: less than 5-year flood discharge Experiences of flood damages in the past and seriousness: low elevation area of Rio do Sul city has flequently suffered from even small flood, **high necessity** of flood mitigation. Damage potential by floods: **high damage potential** due to large population and importance as the economical center of upper Itajai River basin region. Necessity of flood mitigation measures: **high priority** for mitigation measures.
	Taió	440	Flow capacity: around 5 to 10-year flood discharge Experiences of flood damages in the past and seriousness: urban area has suffered from frequent inundations. Damage potential by floods: **midium damage potential** due to midium size of population. Necessity of flood mitigation measures: mitigation measures are required but **midium priority.**
Itajaí do Sul	Rio do Sul	300～500	Flow capacity: less than 5-year flood discharge Experiences of flood damages in the past and seriousness: low elevation area of Rio do Sul city has flequently suffered from even small flood, **high necessity** of flood mitigation. Damage potential by floods: **high damage potential** due to large population and importance as the economical center of upper Itajai River basin region. Necessity of flood mitigation measures: **high priority** for mitigation measures.
	Ituporanga	450	Flow capacity: around 30-40 year flood discharge Experiences of flood damages in the past and seriousness: there are few record of flood damages Damage potential by floods: midium population, urban area extends on the hill, so hard to suffer from flood. Necessity of flood mitigation measures: **no necessity** of mitigation measures.

Source: JICA Study Team

CHAPTER 4 EXISTING FLOOD FORECASTING & WARNING

4.1 Existing Plan for Prevention and Mitigation of Natural Disaster Damages and Risks

The existing Integrated Plan for Prevention and Mitigation of Natural Disaster Damage Risks in Itajai River Basin (Plano Integrado de Prevencao e Mitigacao de Desastres Naturais na Basia Hidrografica do Rio Itajai) was formed by the S.C. state government in September 2009. The plan lists up 6 programs with 77 projects which were proposed by Technological and Scientific Group (GTC) (Table 4.1.1).

Table 4.1.1 Integrated Plan for Prevention and Mitigation of Natural Disaster Damage Risks in Itajai River Basin

Program	Detailed Measure	Priority
No.1	**Institutional development for the preparation for emergencies and disasters**	
	1a) Qualify human resources at basic, intermediary and advanced levels	
	1a1）Qualification of teachers, technicians and community leaders for the integrated support to the civil defense (natural disasters, introduction of risk management and environmental legislation).	**3**
	1a2）Qualification of municipal technicians in risk management.	**1**
	1a3) Creation of a post-graduate course on risk management.	**3**
	1a4) Qualification of municipal technicians in geological, geotechnical and engineering fundaments to interpret hazard maps (of the risk areas) and to subsidize master plans, qualification of planning technicians from municipalities associations, from Itajaí basin municipalities and from state agencies.	**3**
	1a5) Conduction of seminars for the integration of regional, national and international experiences about natural disasters.	**3**
	1a6) Exchange between national and international institutions in the field of risk management.	**3**
	1a7) Definition of cooperation with high education institutions to support the civil defense.	**2**
	1b) structure **of civil defense and other related agencies**	
	1b1) Restructuring and/or implementation of civil defense agencies at state and regional level, according to the Law in force.	**3**
	1b2) Restructuring and/or implementation of municipal civil defense coordination – COMdeCs.	**1**
	1b3) Reequipping of institutions responsible for emergencies, members of the state and municipal systems of civil defense, including purchase of equipment, vehicles, among others, to support disasters preparation actions.	**3**
	1b4) Development of municipal plan(s) of civil defense.	**3**
	1b5) Articulation between civil defense plans and the instruments of the sanitation, housing, environment, water resources and urban planning instruments for each municipality.	**3**
	1b6) Strengthening municipal environment agencies and municipal environment councils.	**1**
	1b7) Elaboration of the plan for the issuance of alert and alarm.	**3**
	1b8) Preparation of the manual of critical situations procedures.	**3**
	1b9) Periodic simulation and drill of the alert and alarm plan.	**3**
	1b10) Strengthening of a local inter-institutional scientific advisory group for the reduction of disaster risks.	**3**
No.2	**Monitoring, alert and alarm**	
	2a) Institutionally strengthen the monitoring, alert and alarm system	
	2a1) Implementation of an inter-institutional arrangement to strengthen the Alert system of Itajaí Basin (de INFRA, SDS, civil defense, Universities, Epagri/Ciram, Itajaí Committee/water agency Foundation), and improvement of the contacts network of the alert system at the Itajaí Basin.	**1**
	2b) Structure the alert system (equipments, methodologies and supports)	
	2b1) Development of the communication system for the alert and diffusion network of the alarm system.	**3**
	2b2) Maintenance and expansion of the hydro-meteorological-oceanographic telemetric network at Itajaí Basin.	**1**
	2b3) Development of models to monitor and forecast extreme events.	**2**

	2b4) Development of a hillsides monitoring system.	**2**
	2b5) Development of environmental monitoring methodologies including use of satellite (for rainfall/temperature).	**2**
	2b6) Development, implementation and validation of alert and alarm systems.	**2**
No.3	**Perception, communication, motivation and mobilization for resiliency and reduction of vulnerability**	
	3a) Diagnosis of natural disasters causes (landslides and inundations) from the point of view of the affected persons (perception).	
	3a1) Diagnosis of natural disasters causes (landslides and inundations) from the point of view of the affected persons (perception).	**2**
	3a2) Production of educational material about: natural disasters management, risk situations, appreciation of human life, first aid and cardiorespiratory reanimation, and technical and legal criteria for the occupation of risk areas.	**2**
	3a3) Socio-educational programs for natural disasters management and related themes.	**2**
	3b)Implement social participation mechanisms	
	3b1) Qualification and mobilization of volunteers for the integrated support to the civil defense.	**3**
	3b2) Development and maintenance of a volunteers network to support civil defense in risks.	**3**
	3b3) Development and maintenance of a bank of volunteer specialists to provide support at risks.	**2**
	3b4) Protection of populations against focal disaster risks.	**3**
	3c) Establish partnerships with utilities providers and private companies aiming at risk reduction	
	3c1) Creation of the certification seal for companies that develop good environmental conservation practices, including earthworks practices.	**2**
	3d) Establish culture and attitudes change in health and communication of epidemiological studies resulting from natural disasters	
	3d1) Studies on the implications of disasters on the human health.	**3**
	3d2) Importance of personal and housing hygiene in preventing epidemics.	**3**
	3d3) Formation of group for psychological assistance during disaster situations.	**3**
No.4	**Evaluation of disasters** risk**s reduction**	
	4a) Develop basic and thematic map**s**	
	4a1) Aero-survey of S.C. (SDS – 1:10,000 – 2009/2011), with priority for Itajaí basin.	**3**
	4a2) Elaboration of basic mapping (1:10,000 scale for the whole basin, and 1:2,000 scale for urban areas and potential higher risk areas).	**1**
	4a3) Detailed maps on soils, geology, geotechnology, land use and others, per hydrographic basin, and their land use aptitude focused on risk areas.	**2**
	4a4) Maps of available social equipments – such as temporary shelters – and of relevant public and private services in natural disasters situation including local roads, natural springs and alternatives of drinking water.	**2**
	4b) Develop integrated system of information on disasters	
	4b1) implementation of an integrated information system in Geographic Information system environment, containing the cartographic base and thematic maps (including geology, geo-technology, soils, rainfall, occurrence of disasters, levels of rivers in respective sections with elevation-discharge curves, among others) based on the existing information in different institutions, such as ANA, ANEEL, SDS, CEOPS, EPAGRI/CIRAM, CPRM, IBGE, Universities, Prefectures, water agency Foundation of Itajaí Valley among others, considering the need of data conversion.	**1**
	4c) Register and evaluate disasters risk	
	4c1) Analysis of meteorological systems, development and evaluation of intense rainfall models, and temporal and trend analysis of rainfall in Itajaí Basin.	**2**
	4c2) development of methodologies for the identification and evaluation of risk, for different types of disasters that occur in Itajaí Basin.	**3**
	4c3) Creating hazard maps of risk/multiple threats areas for developing a natural disasters registration system.	**1**
	4c4) Elaboration of the geo-statistics and probability analysis of the occurrence of different types of threats in the region, and identification of higher risk potential regions.	**2**
	4c5) Development of the Atlas of Natural Threats at Itajaí Basin.	**3**
	4d) Evaluate the drainage network	

	4d1) Inventory and registration of interventions in water courses, and evaluation of activities developed in the drainage network: study of influence (positive and negative impacts) of non-structural changes executed in the basin, and of structural measures executed in the drainage network.	**2**
No.5	**Reduction of disaster** risks	
	5.1）Subprogram of land use and occupation management – non-structural measures.	
	5.1a) Subsidize the development of municipal urban development legislation.	
	5.1a1）Development of municipal legislation aiming at the restriction of urban areas impermeabilization and/or at the incentive to the reservation of rainwater, opposing impacts resulting from impermeabilization.	**2**
	5.1a2) Development of state mechanism to update municipal legislation concerning urban land allotment, taking into consideration risk areas and their specificities.	**2**
	5.1a3) Revision, adjustment and update of municipal master plans including risk reduction of municipal civil defense plans.	**1**
	5.1a4) Development and approval of a Bill (of law) for the regulation and inspection of earthwork, sand extraction and rolling stone extraction activities.	**1**
	5.1b) Implement land use and occupation inspection	
	5.1b1) Development and implementation of municipal integrated systems of inspection, monitoring and evaluation of land use and occupation at the Itajaí Basin.	**2**
	5.1c) Establish a housing policy to avoid risk **areas occupation**	
	5.1c1) Development of alternative housing programs for low and no income population that live in risk area.	**2**
	5.1c2) Development of a housing registry at state level to control the beneficiaries of such programs.	**3**
	5.1d) Improve and expand the forest coverage	
	5.1d1) Establishment of ecological economic zones as areas intended for the implementation of commercial forests.	**3**
	5.1d2) Developments and implementation of municipal plans of forest coverage maintenance and enrichment, and of expansion of vegetal coverage in the urban area.	**2**
	5.1d3) Re-capitations and maintenance of Permanent Preservation Areas.	**2**
	5.1d4) Incentives to the implementation of legal reservations.	**3**
	5.1d5) Studies for the adoption of payment for environmental services.	**2**
	5.1d6) Studies on the restoration in areas affected by landslides.	**3**
	5.1d7) Analysis of successful step of reforestation for the containment of landslides.	**3**
	5.1e) Adjust the land use in rural areas	
	5.1e1) planning agricultural properties according to the aptitude of the soil and to legal restrictions.	**2**
	5.1e2) Implementation soil management practices that respect their natural aptitude, as well as measures of utilization, retention and infiltration of rainwater in agriculture management, in order to support the storage of water, as well as to stimulate the increase of forest coverage.	**2**
	5.1f) Provide a proper destination to solid waste and debris	
	5.2）Sub-program of adequate management of water courses	
	5.2a) Keep water courses in their original configuration and revitalize changed water courses	
	5.2a1) Elaboration of criteria and a guiding manual for the management of water courses.	**2**
	5.2a2) Projects of rivers revitalization.	**3**
	5.2b) Multiple use of existing hydraulic structures	
	5.2b1) Execution of inventory of existing hydraulic structures (dams, rice pads, lakes, tanks, etc.), including the verification of the compliance with technical and legal criteria in their construction.	**1**
	5.2b2) Evaluation of effects of the existing hydraulic structures in absorbing flood waves, and study on the optimization of such system.	**2**
	5.2b3) Modeling of the hydrological, hydraulic and sedimentological behavior of the drainage network, based on an updated diagnosis of the hydraulic-sedimentological situation, for evaluation of interventions with structural measures.	**2**
	5.2b4) Feasibility studies on water retentions and storages (at microbasin scale) through the implementation of pilot-projects.	**1**
	5.2c) Manage urban drainage waters	
	5.2c1) Development of drainage plans (municipal), considering the utilization, retention and infiltration of water.	**2**

	5.2c2) Adjustment and maintenance of existing drainage systems, according to such plans.	**2**
	5.2c3) Implementation of new rainwater drainage systems.	**2**
No.6	**Recuperation of areas affected by disasters**	
	6a) Identify affected areas	
	6a1) Mapping areas and quantity of families affected, and classification of areas per type of intervention: with removal and without removal of occupation.	**1**
	6b) Environmentally recuperate occupied areas, in conjunction with civil works (totally keeping the current occupation)	
	6b1) Elaboration of intervention project(s), with definition of interventions to be executed (structural and non-structural).	**2**
	6b2) Execution of the above elaborated projects, followed by future monitoring and inspection of the area.	**3**
	6c) Environmentally recuperate occupied areas, in conjunction with civil works (but totally or partially removing the current occupation)	
	6c1) Elaboration of intervention project(s), with definition of interventions to be executed (structural and non-structural), plus: • Quantification of families to be removed; • Determination of the approximate cost for the implementation of the removal measure, and • Definition of area for the production of regularized land lots, with housing units and available infrastructure.	**3**
	6c2) Execution of the intervention project(s) above elaborated, including: • Awareness building and negotiation with families; • Reallocation of families; • Psycho-social follow-up of reallocated families; and • Environmental recuperation, destination of use for the recuperated area, monitoring and inspection.	**3**
	6c3) Creation of conservation units in risk areas and high risk areas, where occupation is not allowed or recommendable.	**3**

Source: Plano Integrado de Prevencao e Mitigacao de Desastres Naturais na Basia Hidrografica do Rio Itajai

4.2 Existing Features & Issues of FFWS

4.2.1 Existing Institutional Framework

The present activities regarding FFWS in the Itajai River Basin are shared among the related institutions depending on the scale of the natural disaster. The related institutions and their responsibilities are shown in Table 4.2.1.

Table 4.2.1 Related Institutions and Activities for FFWS

Organization		Activity
ANA	National Water authority	ANA is responsible for policy execution and implementation of the national water resources in Brazil. ANA sets up hydraulic gauging stations all over Brazil and make the rainfall and river water level data available to the related institutions. In the Itajai River Basin, ANA owns 43 rainfall gauging stations and 23 river water level gauging stations. The past records from these gauging stations have been stored in a database and available to be downloaded on their website. However, most available data is daily record only. ANA is a national institution and so that currently their data is not sent at real-time to state institutions such as CIRAM.
EPAGRI/ CIRAM	S.C. state Agricultural Research/ Hydro-meteorology Information Centre	The information centre belonging to the Depart of Agriculture sends the meteorological data to the related organizations through the Internet. The S.C. state has precipitation stations at 41 locations and the river water level stations at 15 locations. The date is transmitted to the CIRAM Information centre by Tele-meteor or Satellite system. The CIRAM carries out simulation of weather forecast by using the data and other on-line information. The weather forecast is reported on the TV, Radio and WEB sites on the Internet. In a case of any emergencies, the CIRAM directly sends the forecast to the related organizations in the state.
FURB CEOPS	Information system control centre in Blumenau University	The control centre of flood Information system in Blumenau University, the flood forecast in Blumenau is executed by the precipitation and river water level of SDS separate from ANA/CIRAM. At flooding, the CONDEC with Mayor will be organized to issue a flood warning.
UNIVALI	ITAJAI	The university is a technical adviser for the Itajai municipality. Prof. Carvalho is a member of the Itajai River Basin Committee as well as the counterpart. The

	University	specialty of Professor is ocean and coastal engineering and in charge of the disaster prevention for flooding and reinforcement of monitoring for the Itajai River.
UNIFEBE	Brusque University	The university is a technical adviser for Brusque municipality and plans flood control dams in upstream of the Mirim River.
AMAVI	Association in upstream municipality of the Itajai River.	The municipal associations in upstream of the Itajai River report information of the river to the related organizations in order to manage the administration in upstream.
AMMVI	Association in midstream municipality of the Itajai River	The municipal associations in midstream of the Itajai River report information of the river to the related organizations in order to manage the administration in midstream.
AMFRI	Association in downstream municipality of the Itajai River	The municipal associations in downstream of the Itajai River report information of the river to the related organizations in order to manage the administration in downstream.
SEDEC	Civil defense for National level	The civil defense for the national disaster is activity for the emergency disaster, and carried out the Policy and management concerning the civil defense in the all Brazil.
SDC	Civil defense for state level	The civil defense for S.C. state is sent out at medium scale disaster which is not managed by municipalities. The S.C. state consist 293 political regions and 36 rural administrations. However, civil defenses are only set up in 7 municipalities in the S.C. state, and only 3 municipalities in the Itajai River Basin. The SIEDEC carries out capacity building and training for disaster prevention for the civil defenses. The SIEDEC is also in charge of planning state policy for disaster prevention.
COMDEC	Commission of civil defense for municipality	The civil defense for municipalities is sent out at small scale disaster to guide the refuges. The CONDEC usually patrols, and trains/educates the related organizations for disaster prevention. At a disaster, civil defense has to report the damage situation to the CONDEC which is formed by the Mayor.
CD Municipal Council	Council for flood prevention in municipality	The council is consisted the chairman of the Mayor and the vice chairman of the civil defense, and instruct to the civil defense in order to issue the warning and smoothly evacuate. In case of the large scale disaster, the CONDEC will request the support to state government.
GRAC	Prevention of flood in municipality	The GRAC is formed with fire fighters, polices, city officers and volunteers at a disaster. Their activity is guidance of refuge at disaster and restoration after disaster.
SDS	Economic development Sustains	The SDS is the economic development sustains in the S.C. state. The SDS executes the policy and operation regarding water resources and is responsible for water use planning related to economic development. Their main mission is to permit and approve the hydropower dam and irrigation facilities, and to manage water permission. Recently, the SDS is developing a meteorological model using the radar of Urubisi's Air Force other than CIRAM and now planning to develop a flood warning system using hydrology model (America, Texas model); this is to reduce flood damage in order to avoid negative impacts on economy.

Source: JICA Study Team

4.2.2 Institutional Organization in for FFWS Activities

Currently, FURB/CEOPS is charged FFWS activities for the Itajai River Basin committed by SDS. Although FURB/CEOPS is in charge of flood forecasting, it is not functioning well due to the following reasons.

i. FURB/CEOPS utilizes data only from 14 hydraulic gauging stations (rainfall and river water levels gauging station as one set) that are operated by themselves. Currently, though CIRAM which is the meteorological department of the SC State Gevornment collects meterological and hydrological data observed at 38 gauging statons of other variaous organizations, no data has been transmitted from CIRAM to FURB/CEOPS.

ii. The 14 gauging stations run by FURB/CEOPS have problems due to lack of financial

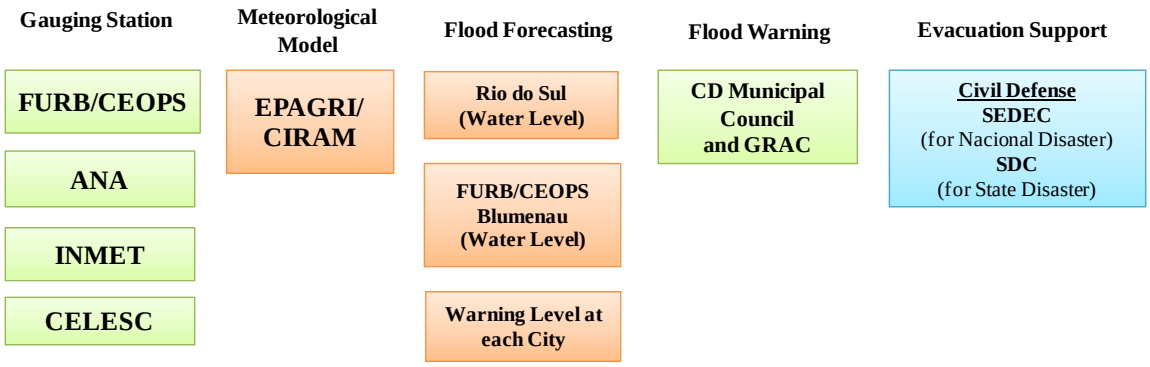
source; (1) the related equipments are not operating appropriately as they are not maintained well enough and; (2) data is not recorded appropriately as some delegated residents (who live nearby the stations and are charged to observe and record water levels by watching scales) have discontinued recording from delinquency in administration payment. The data, as a result, is not appropriate for practical use.

iii. However, currently FURB/CEOPS carries out flood forecasting only for Blumenau city not for other cities. The forecasted results are only informed to Defesa Civil in Blumenau. This is to say, the existing FFWS activities are not systematically planned and conducted among the related institutions throughout the entire Itajai River Basin.

iv. The present flood forecasting by FURB/CEOPS utilized the water level data only from three stations in Blumenau, Apiuna and Timbo; the data from the rest of 11 stations are currently not utilized for forecasting.

v. On the other hand, Defesa Civil in Rio do Sul city tries to conduct flood forecasting; however, the present forecasting is not appropriate for practical use. One of the reasons is that DEINFRA, the operator of the Oeste dam and Sul dams that locate at upstream areas of Rio do Sul has not recorded and informed the outflow discharges from the dams to the downstream rivers.

The schematic diagram for the existing institutional organization related to FFWS activities in SC State are shown in Figure 4.2.1.



Source: JICA Study Team

Figure 4.2.1 Present Institutional Organization in SC State for FFWS

4.2.3 Meteorological and River Water Level Observation

In Itajai River Basin, rainfall and river water level are observed by multiple institutions such as FURB/CEOPS, ANA, IMMET and CELESC as shown in Figure 4.2.1. However, data observation, equipments maintenance and data management has not been managed consistently. The numbers of related hydraulic gauging stations in the Itajai River Basin is listed in Table 4.2.2.

Table 4.2.2 The Existing Gauging Stations in Itajai River Basin

Gauging Types	FURB/CEOPS	ANA
Rainfall gauging stations	16	43
River water level gauging stations	14	23
TOTAL	**16**	**66**

Source: EPAGRI/CIRAM

Moreover, there are more gauging stations run by different institutions other than listed in Table 4.2.2.

- Itajai city: owns 9 rainfall gauging stations and 8 river water level gauging stations.
- CELESC: owns some hydraulic gauging stations around their dams and power plants.
- INMET and other universities that locate in the major cities: owns some hydraulic gauging stations.

FURB/ CEOPS has established 14 hydraulic gauging stations throughout the Itajai River Basin with an order from SDS in 1985. These stations were set up for the purpose of FFWS for the entire basin. However, this FFWS is not functioning well with the following problems.

- The 14 hydraulic gauging stations are not maintained enough so that the equipments for observation and transmission are currently not functioning well.
- The existing 14 gauging stations do not correspond the locations where the existing warning levels are set (refer Table 4.2.4).
- There is no gauging station along Luis Alves River which is one of the major tributary rivers.

Table 4.2.3 Situation of the Existing 14 Gauging Stations under FURB/CEOPS

Existing Stations			Situation of Stations
1	Taio	Rainfall/Water Level	Transmission system needs to be improved.
2	Rio Oeste	Rainfall/Water Level	Monitoring equipment does not function, GSM is defective, and there is not person in charge for maintenance.
3	Saltinho	Rainfall/Water Level	Monitoring equipment does not function, GSM is defective, and there is not person in charge for maintenance.
4	Ituporahga	Rainfall/Water Level	Transmission system needs to be improved.
5	Rio do Sul	Rainfall/Water Level	Operated
6	Barra do Prata	Rainfall/Water Level	Monitoring is not executed on time due to the failure of monitoring equipment and absence of persons in charge for maintenance.
7	Ibirama	Rainfall/Water Level	Transmission system needs to be improved.
8	Apiuna	Rainfall/Water Level	Thought residents around the station observed water level because of the failure of the sensor and telemetry, they now stop due to delinquency of administration payment from CEOPS.
9	Timbo	Rainfall/Water Level	Operated
10	Indaial	Rainfall/Water Level	Monitoring equipment does not function, GSM is defective, and there is not person in charge for maintenance.
11	Blumenau	Rainfall/Water Level	Operated
12	Salseiro	Rainfall/Water Level	GSM transmission system is defective.
13	Botuvera	Rainfall/Water Level	GSM transmission system is defective.
14	Brusque	Rainfall/Water Level	Water level gauging sensor does not function due to sedimentation

Source: JICA Survey Team

At present, some residents who live nearby the rivers are committed by FURB/CEOPS to observe and record water levels by watching scales and inform the record to FURB/CEOPS. However, this method involves three major issues: (1) there is high risk of danger in the observers; (2) many observers are elder residents and observation and reporting are not conducted at the appropriate time; (3) the number of observers that continues observation has been reducing due to delinquency in administration payment. As a result, the past data is sufficient and not appropriate for practical use.

4.2.4 Meteorological Forecasting by CIRAM

As the S.C. state's Meteorological/Hydrological Environment Center, CIRAM connects to the Doppler Radar (SIMEPAR) that is installed in Northern Parana area and Meso-data (1,200 m,

5,000 m and 12,000 m of Scale) that is set in the Florianopolis Airport through the Internet.

Besides these observatory data, the database (INMet, IDD and NCEp) called GEMPA and the meteorological simulation database called M9 (ETA40/20km model and GPS 100km model) are secured by cooperating with oversea metrological networks. Based on WRF (15km) program, weather forecasting every 1 hour, 3 hours, 6 hours and 12 hours are now implemented.

The weather forecasting information is announced to the S.C. state's citizen through TV, Radio and the Internet. In an emergency, information is reported to the civil defense of S.C. state government, CELESC (S.C. Electric Corporation), Fishing and Agricultural Union and FURB/CEOPS, which is located in Blumenau.

CIRAM is planning to upgrade the metrological forecasting by adopting satellite data from INPE. It is expected that this shall improve the precision of the forecasting.

4.2.5 Flood Forecasting and Warning Activities

Currently in Itajai River Basin, the hydraulic (rainfall and river water level) data is observed by multiple institutions for various purposes such as FURB/ CEOPS for flood control, ANA for river/water resource management, EPAGRI for agriculture and CELESC for hydraulic power generation(refer Figure 4.2.1). Then, CIRAM (the meteorological section for S.C. State) collects all the data and conduct weather forecasting using a model established by ETA (Brazil) and WRF (America). However the data is not well arranged as one database for practical use and therefore, presently this system is not used for practical FFWS.

The existing FFWS is not systematically planned and conducted throughout the entire Itajai River Basin. The flood forecasting is executed only in Blumenau and Rio do Sul cities. In Rio do Sul city, the City Defesa Civil has a flood forecasting method using rainfalls at the Oeste dam and Sul dam but this is not utilized for practical use. This is because the existing method does not reflect the DEINFRA's dam operation and outflow discharges from the two dams and the result is not reliable. Therefore, presently flood forecasting based on the observed data is only conducted in Blumenau city.

Other 16 cities including Itajai city have "warning levels" as guideline (based on river water level) for warning announcement (Table 4.2.4). These warning levels are established based on the past flood water level. When the river water level starts rising, the civil defenses of each city patrols and reports the river condition to CD Municipal Council immediately. However, some of the cities have no water level gauging stations or the lack of water level gauging stations in the upstream of the cities. For example, two cities (Agua Clera and Gurabiruba) that locate along the tributary river of Brusque, and three cities in mountain region (Salete, Mirim Doce and Pouso Redondo) where have been suffering from flood damage as an influence of recent land development.

Table 4.2.4 Warning Standards Based on River Water Level

Itajai River Basin (each city)	Elevation EL+m	Catchment Area (km^2)	Normal level (m)	Standby level (m)	Warning level (m)	Emergency level (m)
Taio	360	1,575	4.0 m	6.0 m	6.5 m	over 7.5 m
Rio do Oeste	-	-	4.0 m	6.0 m	9.0 m	over 9.0 m
Trombudo	350	248	3.0 m	4.0 m	7.5 m	over 7.5 m
Ituporanga	370	1,670	2.0 m	3.0 m	4.0 m	over 4.0 m
Vidal Ramos	-	-	3.0 m	4.0 m	6.0 m	over 5.0 m
Rio do Sul	350	5,100	4.0 m	5.0 m	6.5 m	over 6.5 m
Ibirama	151	3,314	2.0 m	3.0 m	4.5 m	over 4.5 m
Apiuna	93	9,241	3.0 m	6.0 m	8.5 m	over 8.5 m

Benedito Novo	90	692	1.5 m	2.5 m	3.5 m	over 3.5 m
Rio dos Cedros	80	510	1.5 m	2.5 m	3.5 m	over 3.5 m
Timbo	73	1,342	2.0 m	4.0 m	6.0 m	over 6.0 m
Indaial	60	11,151	3.0 m	4.0 m	5.5 m	over 5.5 m
Blumenau	12	11,803	4.0 m	6.0 m	8.5 m	over 8.5 m
Gaspar	11	12,141	4.0 m	6.0 m	8.5 m	over 8.5 m
Ilhota	-	12,357	6.0 m	8.0 m	10.5 m	over 10.5 m
Itajai	-	15,221				

Source: FURB/CEOPS

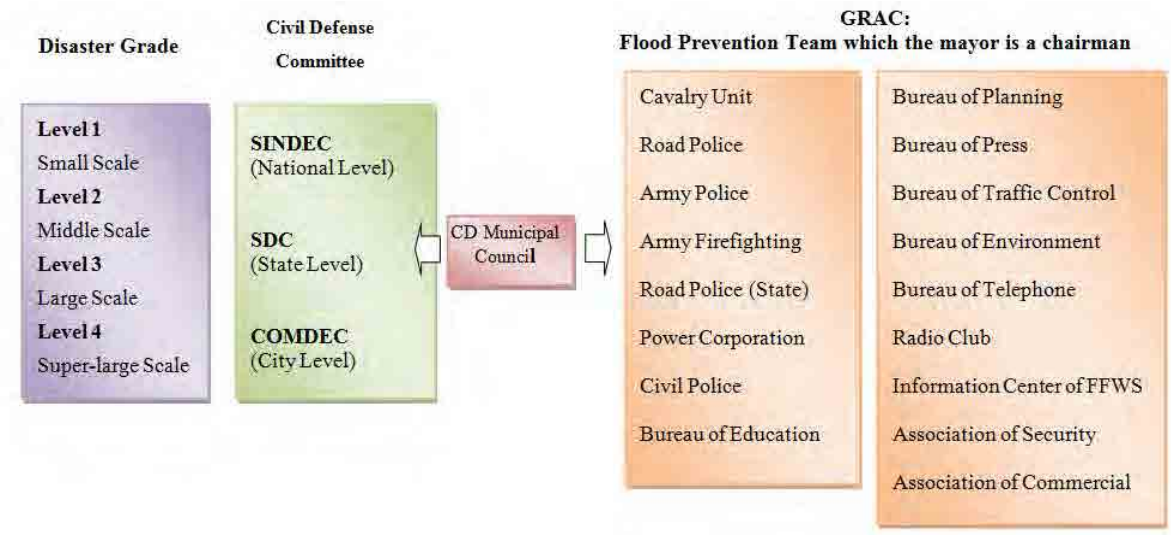
4.2.6 Evacuation and Flood Prevention Activities

In Itajai River Basin, each city owns evacuation manuals that were developed based on the present flood experiences. The manuals basically include institutional organization and instructions for evacuation activities at flooding but not compose the detailed flood prevention activities. (To note that the approved official evacuation manuals only exist in Rio do Sul and Blumenau cities. 13 other cities are currently developing their evacuation manuals to be approved following the two former cities.)

According to those evacuation manuals, CD municipal council is formed by the city civil defense with the city mayor as a chairman. The city civil defense patrols and reports the river condition (including river water levels) to the council. Then, the council is responsible for flood warning announcement according to the warning level as listed in Table 4.2.4.

In addition, GRAC, the flood prevention team is also formed by the institutions listed in Figure 4.2.2 (in a case of Blumenau city for example). GRAC is in charge of supporting and securing safe evacuation activities; however, the present situation is that they are like a communication coordinator among the related intuitions.

When a large or medium scale flood occurres, the CD municipal council reports the situation to the S.C. state's civil defense (SDC) and the nation civil defense (SINDEC) to requests their supports (refer Figure 4.2.2).



Source: JICA Study Team

Figure 4.2.2 Present Institutional Organization for Evacuation and Flood Prevention Activities in S.C. State

CHAPTER 5 BASIC STRATEGY FOR FORMULATION OF MASTER PLAN FOR FLOOD MITIGATION

5.1 Needs for Flood MITIGATION

5.1.1 Interviews with Various Government Institutions and Universities

Various government institutions and universities are participating in this Preparatory Survey and understanding and cooperation thereof is of great importance. A participatory planning process for disaster prevention master plan is also required. Along this line, courtesy calls and interviews with various government organizations and universities as well as the Itajai River Basin Committee have been carried out to understand various needs for disaster prevention measures in the Itajai River basin. Totally around 70 interviews were made. In this chapter, the needs related to flood prevention and the basic strategy for master plan formulation are described. The needs for sediment disaster prevention are explained in the succeeding Chapter 6.

5.1.2 Expected Disaster Prevention Measures of the Itajaí River Basin Committee

Through discussions with the Itajaí River Basin Committee, the Committee showed the following views on flood prevention measures:

i) The Itajaí River is a natural stream. Therefore, a flood mitigation master plan must duly consider the environmental aspects, including the preservation of riparian vegetation.

ii) The Committee expects the flood management for minimizing flood damages by means of hindering the concentration of flood runoff from river basins, instead of conventional flood control measures by dikes. The flood mitigation plan in the Rhine River, where the Committee previously visited as the mission, aimed at mitigation of flood damages and restoration of nature. The Committee considers that no large-scale structures are necessary, and flood information and flood damage mitigation are really required.

iii) Fifty (50) years ago, there was flooding problem only in Blumenau city. In recent years, however, flooding problem has been increasingly serious in Gaspar and Itajai cities in the lower reaches of Itajai River.

iv) Recently small scale flooding has occurred in small communities in upper Itajai River basin. Although the communities became conscious of floods, they are not considering serious issues. They desire small temporary storage of flood water for agricultural water supply in the dry season (especially, in the Itajai do Oeste and Sul River basins, where recently agricultural development has been significant causing water shortage in the dry season). Besides, as sediment production due to soil erosion by small floods is another problem, small dam reservoir for water supply in the dry season or an increase of water retention capacity in cultivated lands are considered necessary.

v) No serious flooding in the Itajai mainstream has occurred in Blumenau city since the 1984 flood. However, recently flood damages due to flush floods with rapid water level rising and inundation in relatively narrow areas have been increasing in tributary basins. Particularly, flush floods are significant in the urban areas rapidly developed on mountain slopes in tributary rivers in Blumenau city.

vi) The cause of flooding in Itajaí city is river improvement in the Itajaí Mirim River done in Brusque city and landfills for developments in the flood plain between two cities. It is favorable to preserve flood plain as a retarding basin in the downstream reaches from Brusque city as a flood control measure for Itajaí city.

vii) Programs such as riparian forest rehabilitation, intensification of disaster prevention, and promotion of water retention in upstream basins that were proposed in the Water Resources Management Master Plan for the Itajaí River Basin formulated by the Committee in March 2010 (see sub-section 2.7.3) would be related with a master plan for flood prevention to be proposed by the Preparatory Survey.

5.1.3 Needs for Flood Mitigation by City

In the previous sub-section 3.3.1, needs for flood mitigation at major cities along the Itajai River was mentioned based on the records of past floods. Table 5.1.1 summarizes flooding characteristics and issues peculiar to major cities based on the results of discussions with various government institutions and universities as well as site visits.

Table 5.1.1 Flooding Characteristics and Issues by City along the Itajai River

City	Population	Results of Interview and Site Visits	Source of information
Itajaí River			
Itajaí	172,081	・Flood damages have occurred 7 times since 1980. ・Many affected residents because of large population	Reports
		・In the urban area, flooding of Itajaí Mirim River is more severe than Itajaí River. ・Rising of water level of the Itajaí River and tidal level blocks the drainage of Itajaí Mirim River ・Drainage system is vulnerable, and there is no pumping stations ・Bridge over Itajaí Mirim River influences the flow capacity. ・There is alarm system, but it is not satisfactory like in Blumenau city ・There is APP plan (green belt along the old Itajaí Mirim River	Planning and Construction Department of Municipal Government and UNIVALI Site Visit
		・High sediment inflow into the port, requiring annual dredging of huge volume of sediment ・Necessity of measures to reduce sediment production in the basin	Itajaí Port Site Visit
Navegantes	57,324	・Less frequency of flooding (3 times since 1980) ・Small flood damages due to higher ground elevation ・Necessity of measures to sedimentation problem in the port	Reports Planning and Financial Departments Site visit
Ilhota	12,149	・Less frequency of flooding (twice since 1980 from report, but 5 times according to the municipal government) ・There is low lands along the state highway SC-470, where frequent flooding occurs due to poor drainage ・There is a plan to build a new bridge over the Itajaí River	Reports Planning Department of Municipal Government
Gaspar	55,489	・Flood damages have occurred 7 times since 1980 with many affected residents ・The river is narrow in the urban area, and the existing bridge in city obstacles significantly the flow area in river channel.	Reports Site visit
Blumenau	299,416	・Flood damages have occurred 14 times since 1980 with many affected residents ・The 1983 and 1984 floods caused inundation by gradual water level increasing of the Itajai mainstream ・In the 2008 flood, Itajaí River did not overflow, however there were damages caused by flush floods in tributaries (Garcia, Velha, Fortaleza Rivers)	Reports Site visit
		・Housing development on mountainous area has caused flush floods and landslides, and there are many illegal residences in the river area ・There are plans to construct bridge, revetment, drainage facilities and water gate with pumping station in tributaries (Fortaleza, Garcia, Velha, Itoupava Rivers) ・Urban development will expand to the North side in the future (Itoupava River) ・At present, no flooding problem in the Itoupava River ・Flood warning is announced based on the information from CIRAM and FURB/CEOPS through radio and internet, and CEOPS forecasts the river water level in 6 hours ahead	Planning and Construction Department of Municipal Government Site visit

City	Population	Results of Interview and Site Visits	Source of information
		・Flood damage potential has been increased due to illegal residents along rivers ・Bank and house collapses are likely occur on the sandy bank without vegetation ・According to the environmental law, the Committee plans to afforest 30m wide protection area on river banks and considers that riparian forest is very important in view of flood control. ・It is problem to install the water gate in the mouth of the Fortaleza River ・The project by the municipal government of Blumenau to install concrete revetment on the left bank of Itajai River would be no flood control effects, only losing valuable vegetation on the river bank.	Itajaí River Basin Committee and FURB Site visit
Indaial	50,917	・Less frequency of flooding (3 times since 1980 but in small scale) ・The flow capacity of the Itajaí River is large.	Reports Site visit
Ascurra	10,996	・No flood damages have occurred.	Reports Site visit
Apiúna	6,945	・No flood damages have occurred.	Reports Site visit
Lontras	9,660	・Less frequency of flooding (3 times since 1980 but in small scale)	Reports Site visit
Rio do Sul	59,962	・Although the affected population is small, flood damage has occurred frequently (8 times since 1980)	Reports Site visit
		・Small scale flooding has occurred frequently (2 to 3 times per year) ・There are many problems of illegal residents and land use. ・There are operation problems at the Oeste and Sul dams ・Information from the dams (reservoir level, outflow, etc.) is insufficient (the outflow of the dam is unknown at the dam office) ・It is very difficult to widen the river channel in the urban area. ・Evacuation manual is under preparation.	Planning Department of Municipal Government and Civil Defense Site visit
		・The project to retain rain water in paddy fields is under preparation ・There is also a plan to store river water in paddy fields by small dams in small tributaries.	CRAVIL Site visit
Itajaí Mirim River			
Brusque	102,280	・Less frequency of flooding (3 times since 1980) ・Recently less flooding problems due to the river improvement ・No flooding in the urban area except the 1984 flood has occurred only with inundation of roads. ・Bank erosion at the colliding portion of meandering channel might cause impact to residences on the river bank.	Planning Department of Municipal Government and Site visit
Benedito River			
Timbó	35,303	・Although the affected population is small, flood damage has occurred frequently (6 times since 1980) ・Due to abrupt releasing from the upstream two hydropower generation dams in the Rio dos Cedros River, flooding has occurred frequently. ・In June 2010, the City Councils of Timbo and Rio dos Cedros jointly submitted the petition containing the signatures of 1,200 residents to the Governor, requiring for lowering the normal operation reservoir water level ・In addition to the flood from the Benedito River, the flood from the Rio dos Cedros River joins together	Report DEINFRA FURB/CEOPS City Council Site visit
Benedito Novo	10,335	・No flood damages have occurred.	Report and Site visit
Rio dos Cedros	10,170	・Same as the Timbó city, frequent flooding has occurred due to abrupt releasing from the upstream two dams in the Rio dos Cedros River. ・In June 2010, the City Councils of Timbo and Rio dos Cedros jointly submitted the petition containing the signatures of 1,200 residents to the Governor, requiring for lowering the normal operation reservoir water level ・When the water depth in the Rio dos Cedros River exceeds 6 m, flooding starts in the urban area. Mapping of flood inundation map in the city has been completed.	Report FURB/CEOPS Mayor of the city and the City council Site visit

City	Population	Results of Interview and Site Visits	Source of information
Itajaí do Norte River			
Ibirama	17,469	・No flood damages have occurred.	Report Site visit
Itajaí do Oeste River			
Laurentino	5,757	・Almost no flood damages have occurred.	Report
Rio do Oeste	7,033	・Almost no flood damages have occurred.	Report
Taio	17,522	・Although the affected population is small, flood damage has occurred frequently (6 times since 1980) ・Taio city is prone to inundation due to overflow of the Oeste dam. ・Urban area near the city hall was inundated in around 1.5 m by the April 2010 flood. There is some opinion that the inundation was due to earlier closure of the gates at the dam. ・The current flow capacity is around 1,000 m3/s. However, the maximum releasing capacity under full opening of gates at the Oeste dam is around 160 m3/s.	Report DEINFRA Site visit
Trombudo	6,520	・Less frequency of flooding (3 times since 1980 but in small scale)	Report and Site visit
Itajaí do Sul River			
Ituporanga	21,496	・Less frequency of flooding (2 times since 1980 but in small scale)	Report and Site visit

Source: JICA Survey Team

5.2 Basic Principles for Planning

As stated in the Minutes of the meeting of understanding on November 5th, 2009, basic principles of the Preparatory Survey for planning the master plan of prevention and mitigation of natural disaster were established as follows:

i) To avoid negative natural and social environmental impacts, especially involuntary resettlement and biodiversity loss

ii) To avoid adverse effects to the downstream reaches of the river from the sites subject to countermeasures such as increase of flood velocity and discharge that might cause bank erosion and flooding

iii) To enrich rainwater storage function of each river sub-basin in order to delay quick flood runoff

iv) To promote multiple use of the existing hydraulic structures and spaces in the basin

5.3 Basic Strategy for Formulation of Master Plan

Based on an exchange of views and opinions with various government institutions, universities and the Itajaí River Basin Committee as well as the basic principles, basic strategy for formulating a master plan for flood prevention was set up below.

i) At this moment, since it is considered to be difficult to set up a target flood security level for a master plan, four levels of flood prevention master plans are to be proposed for the selected target regions to be protected. The master plans to be created are for the levels of a flood occurred once in 5, 10, 25 and 50 years[1]. Then, the flood security level shall be selected through discussions with the Itajaí Basin Committee as well as the State Government (Governor and State Secretaries).

ii) In addition, selection of the target regions for flood protection, combination of flood control alternatives and their flood control effects shall be discussed together with the the

[1] Study for the 50-year flood was solicited as a part of the Prepatory Survey at the first counterpart meeting held on May 19th, 2010

Itajaí River Basin Committee[2] (Technical sub-committee on flood prevention).

iii) A master plan for flood prevention shall be formulated taking into consideration the ongoing concept of comprehensive flood control measures in Japan, which aims to hinder the concentration of flood runoff from various river basins. A "flood control measures to scatter floods" shall be given high priority for formulating a master plan by minimizing flood damages allowing flood inundation.

iv) Temporary retention of rain water in paddy fields and small retention ponds (small irrigation dam) that are proposed in the Water Resources Management Master Plan for the the Itajaí River Basin might be able to hinder the concentration of flood runoff to the downstream reaches and therefore subject to examination. According to CRAVIL, the target paddy area for retention is around 27,000 ha in total along the Itajai River from the upstream reaches of Rio do Sul city to Itajai city.

v) Among existing 3 flood control dams, increasing of flood control capacity by heightening of Oeste and Sul dams also might contribute to delay the concentration of flood runoff to the downstream reaches (especially effective for flood mitigation in Taio and Rio do Sul cities located in the downstream reaches of the dams).

vi) The existing flood plain spreading from Gaspar city to Itajai city that acts a natural retarding basin are currently used for agricultural land and pasture. This flood plain shall be preserved without land developments because it contributes to reduce flood flow in the downstream areas.

vii) As for the target region for flood prevention, Rio do Sul, Blumenau and Itajai cities might be of higher priority. In addition to delaying the concentration of flood runoff as much as possible by provision of various measures in the upper basins, possible flood control alternatives shall be conceived for comparison duly considering current flood inundation characteristics and the existing urban plan (land use plan).

viii) In addition to the flood from Itajai mainstream, flood inundation in Itajai city is due to the back water to the Itajai Mirim River from the Itajai mainstream (added by tidal influence), poor drainage system in the urban area, and flood inflow from the Itajai Mirim River. Flood control measures shall be created based on the evaluation of these impacts.

ix) As for the measures for flush floods, adjustment with urban plan (land use regulation and zoning) might be necessary, because there are many illegal residents on the river banks.

x) When higher security level as a 50-year flood prevention plan is required, only basin measures to scatter floods would be limited from the aspects of flood control effects. In such case, widening of river channel by providing composite section will be necessary. Regarding the utilization of high water channel of composite section, the program of riparian forest rehabilitation under the Water Resources Management Master Plan by the Committee will be incorporated into the master planning. In addition, floodway is likely to be required as a alternative to reduce duration and depth of flood inundation in the flood plain downstream from Gaspar city and the urban are in Itajai city.

xi) The target year of flood prevention master plan depends on the selected flood security level. In order to ensure consistency with the target year of 2030 as proposed in the long-term plan of the Water Resources Management Master Plan in the Itajai River basin, a master plan for flood prevention shall be achieved by 2030 at the least.

[2] Itajaí Basin Committee requested at the meeting held on May 7th and July 28th, 2010.

5.4 Basic Strategy for Strengthening of Existing FFWS

Considering the current problems of the existing FFWS for the Itajai River basin, a plan to strengthen the existing FFWS shall be formulated based on the following basic strategies:

i) Strengthening of the existing hydro-meteorological observation network with provision of additional gauging stations

ii) Improvement of accuracy observed data and data transmission by updating observation equipments and data transmission method

The following are the aspects for consideration.

5.4.1 Aspects of River Characteristics

i) Flood runoff has been increasing due to land developments and deforestation in the upstream basin of Rio do Sul city, it will be necessary to observe rainfall focusing on mountainous tributaries. It is however difficult to predict floods from tributaries by use of only released discharges of two flood control dams, because flood traveling time to Rio do Sul city is short.

ii) As frequent flooding has occurred in both Timbo and Rio dos Cedros cities due to abrupt releasing from two hydropower generation dams in the Rio dos Cedros River, it will be necessary to monitor the releasing discharge from two dams for timely announcement of early warning.

iii) On the lower Itajai mainstream from Blumenau city, water level gauging station shall be newly installed in Gaspar, Ilhota and Itajai cities to monitor flood water levels and changes due to tidal conditions.

iv) As for the Itajai Mirim River, where recent urbanization in tributaries surrounding Brusque city has increased flood runoff, rainfall and water level gauging station shall be newly installed in tributaries for timely announcement of early warning in Brusque city.

5.4.2 Aspects of Observation Equipment and Data Transmission Method

The observation equipments of gauging stations are superannuated and have not been sufficiently maintained. The gauging devices of rainfall and water level and the current data transmission system should be updated in view of accurate data transmission with high reliability. As observation equipments have been improved in recent years from the aspects of maintenance, the following shall be noted:

i) The existing river water level gauge is of a pressure type that was installed on the riverbed. Due to riverbed erosion or sediment deposition by floods, observation troubles have occurred at several stations, causing the burden on maintenance. However, a radar type water level gauge can be installed gently on bridge less susceptible to temperature and wind, and is of low energy consumption and price.

ii) If the current radio-link data transmission system is replaced by the cellular phone system and packet switching method, observed data can be sent directly to CEOPS by email every 10 minutes. In addition, as its power source can be secured by solar panel, the necessary equipments such as rain gauge, water level gauge, solar panel, battery, data logger and telephone center can be installed on only one pole without any auxiliary equipment like repeaters at the transmission point.

iii) Furthermore, replacement of the current digital system of GSM (Group Special Mobile) of 2G (Mobile Telephone System of Second Generation) to GPRS (General Packet) of 2.5G enables to enhance stable communication and the increased data communication with

strengthened efficiency of broadband use.

iv) Due to the rapid spread of surveillance cameras, high-precision and lightweight CCTV (Closed Circuit TV) is available at low price. Therefore, CCTVs shall be intalled in Rio do Sul, Blumenau and Itajaí, cities to monitor flood situation in real time basis.

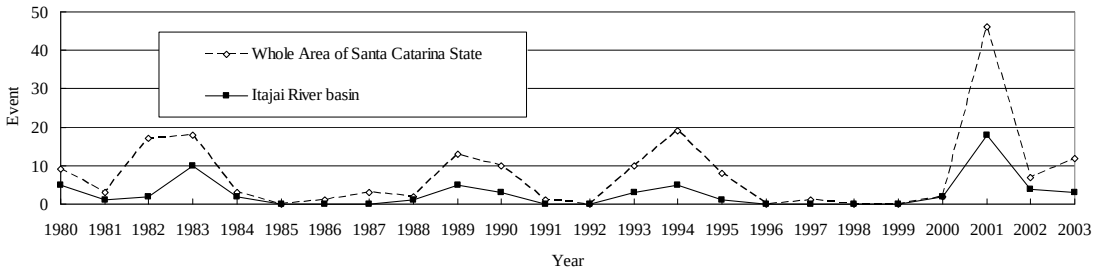
v) FURB/CEOPS is in charge of flood forecasting as a master station, where all of the observed data is gathered and stored in database. In addition, equipment to monitor the observed data via the internet will be installed at the office of Civil Defense in both Rio do Sul and Itajai cities to act as a monitor station. Moreover, a monitor center will be established in Florianopolis.

CHAPTER 6 BASIC STRATEGY FOR FORMULATION OF MASTER PLAN FOR LANDSLIDE MANAGEMENT

6.1 Actual State of Landslide Disasters and Restoration Works

(1) Landslide disasters situation over time

Figure 6.1.1 shows the number of landslide disaster events within the Itajai River Basin, which is based on Defesa Civil-SC data over 23 years from 1980 to 2003 in SC State. As shown in Figure 6.1.1, the number of landslides disaster events in the Itajai River basin is totally 65, corresponding to 35% of the total 185 landslide disaster events that occurred in the whole SC State.



Source：Prepared by JICA Survey Team on the basis of Defesa Civil-SC Data

Figure 6.1.1 Changes of the Number of Landslides in Santa Catarina State and in Itajai River Basin Over the Years (1980 - 2003)

The Itajai River Basin area accounts for 16% of SC State. The annual number of landslide events per thousand km^2 is 0.85 events/1,000 km^2/year in the whole SC State and 1.9 invents/1,000 km^2/year in the Itajai River Basin, respectively, indicating landslide disaster events in the Itajai River basin is relatively high, and 2.2 times of the whole SC State. In addition, the number of annual average landslide disaster events per one million populations is 1.6 events/million population/year in SC State and is 2.8 events/million population/year in the Itajai River basin, which is approximately 1.7 times of whole SC State. The population density in the Itajai River Basin is relatively high and 68.4 persons per square kilometer which is 1.3 times to SC State at 51.2 persons per square kilometer.

(2) Characteristics and damage of Landslide due to heavy rain in November 2008

Table 6.1.1 presents the damages of the serious landslides and floods due to the heavy rain in November 2008. The 89 deaths represent 0.09 % of the evacuated 103,602 persons, 0.13% of the affected 66,556 persons, and 0.61% of the 14,573 home lost persons. The official reports have no break down of victims numbers caused by floods or by landslides. According to the Defesa Civil-SC, 97% of deaths were caused by landslides. Because of the existing early warning and evacuation system against flood, most people were evacuated and avoided from death. On the other hand, many people were affected or killed by landslide disaster, probably due to no existing early warning and evacuation system against landslide.

(3) Restoration works of the 2008 landslide disasters

In the report (Reconstrução Áreas afetadas Catástrofe Novembro/2008) issued in November 2009, the restoration works of the landslide and flood disasters were described together because it is not possible to divide clearly. The expense of SC State for urgent activity for emergency evacuation, infrastructure rehabilitation, etc. was totally R$520 million.

In addition to the restoration works by SC State, the Federal BR470 Road was rehabilitated as federation restoration works. The BR470 Road was damaged by a complete blockage in

Blumenau Municipality and by partial blockages such as due to a huge rolling stone of approximate 5 m. In addition, a gas pipe explosion was occurred in the road body due to a landslide in Gaspar Municipality. The federal road was reopened to traffic on December 12 of the same year by emergency measures such as removal of debris, temporary detours and so on. After the emergent restoration, the total cost of the complete restoration works was R$ 17million.

Table 6.1.1 Records of Damage caused by Flood and Landslides in November 2008

City	Population	Proportion of affected persons	Evacuated persons	Affected persons	House Lost Persons	Injured	Dead	Damaged houses	Length of affected road (km)
Benedito Novo	9,841	31 %	102	712	210		2	191	576
Blumenau	292,972	35 %		25,000	5,209	2,383	24	18,000	
Brusque	94,962	100 %		8,000	1,200	66	1	1,220	120
Gaspar	52,428	100 %		7,100	4,300	280	16	8,700	600
Ilhota	11,552	100 %	3,500	3,500	1,300	67	26	406	
Itajai	163,218	100 %	100,000	18,208	1,929	1,800	5	28,400	
Luiz Alves	8,986	100 %		3,232	239	41	10	220	40
Pomerode	25,261	1 %		182	48		1	50	100
Rio dos Cedros	9,685	88 %		595	96			283	300
Rodeio	10,773	5 %		27	42		4	35	144
Timbo	33,326	2 %						264	
	713,004		103,602	66,556	14,573	4,637	89	57,769	1,880

Source: AVADAMs sent by the municipalities to the Civil Defense of Santa Catarina, on November 24 and 25, 2008.

6.2 Classification and Characteristics of Landslides

6.2.1 Outline

In Brazil, both of ‘Escorregamento’ and ‘Deslizamento’ have been used to similar meaning to express landslide in English. In this study, the term of ‘Escorregamento’ is used according to the Natural Disasters Atlas of Santa Catarina State of 2004.

The landslide classification of Varnes (1978) has been well known internationally. Five basic types of landslides are classified in it, in terms of movement type, including 1) Fall, 2) Topple, 3) Slide, 4) Spread and 5) Flow. In this study, for landslide disaster management, as shown in Figure 6.2.1, Fall and Topple have grouped as Collapse, and Slide and Spread as Slide, from the point of view of similar movement type and points for management. In addition, the term Escorregamento has been used as landslide in a broad sense and also as slide in a narrowing sense.

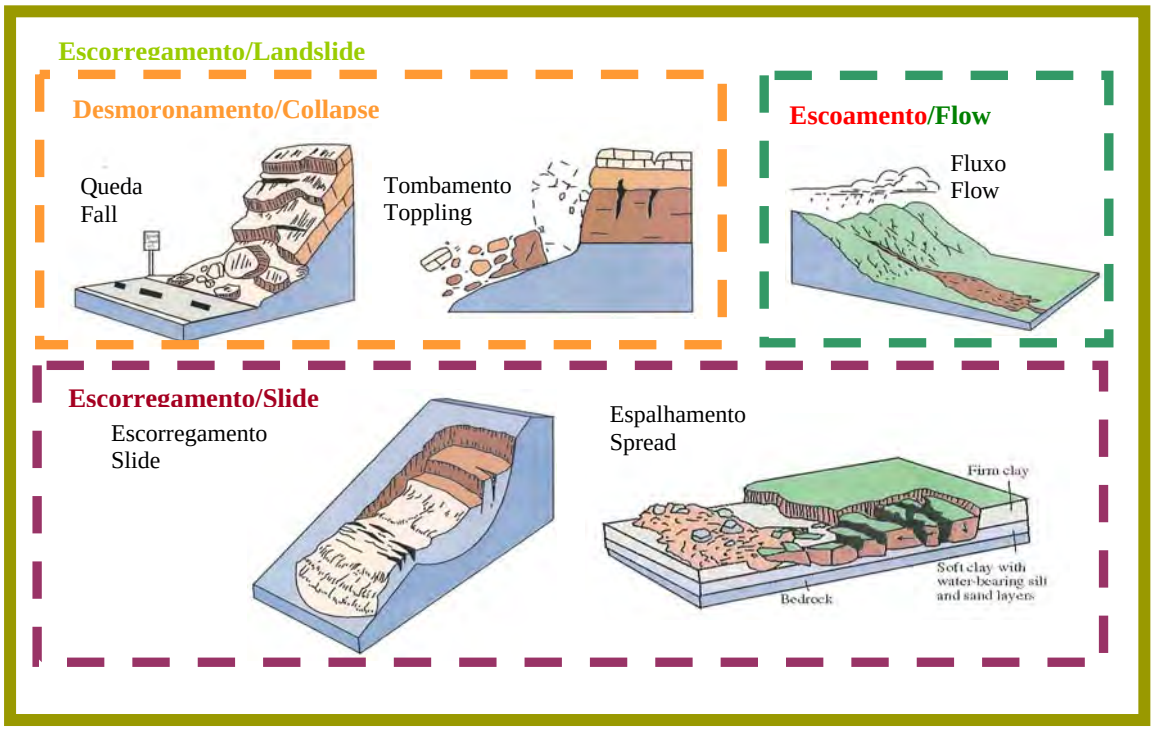
Table 6.2.1 summarizes classification of landslides according to the types of slope movement and slope materials. Characteristics and countermeasure methods of landslides are generally different depending on the type of a landslide. This study has made effort to classification of landslide types to contribute to landslide disaster management. It is generally known and same as in Itajai river basin that landslides movement/ material types can not be clearly defined; some landslides might be an intermediary type; and slide types of movement and materials are changed during movement in some case. For example, a collapse at the beginning of occurrence probably changes into flow when it flows into stream areas. Flow materials are dominated by gravel and cobble at tip area and become predominantly fine-grained soils far away from the tip.

6.2.2 Characteristics of collapse

In this study, the collapse is termed as the fast down slope movement of slope soils and rock debris in a relatively short time, due to rainstorms or earthquake. The collapse is distinguished from slide that is characterized by slow movement of slope soil and rock debris, and debris flow

of rushed movement of soil and debris accumulated or falling into torrent with big amount of water. They are different in damage characteristics and appropriate management procedure.

Collapse is the most common type of landslides in Itajai River basin. The collapses are characterized as rapid movement same as debris flow, and has relatively high possibility of human lives lost. These collapses have frequently occurred in residual soils due to weakening by heavy rainfall.



Source: Modification of 1982 Varnes Classification by JICA Survey Team

Figure 6.2.1 Landslide Classification According to Movement Type

Table 6.2.1 Landslide Classification Used in this Study According to Slope Movement and Material

Tipo de Movimento Type of Movement	Tipo de Material/Type of Material		
	Leito de Rocha Bedrock	Solos de Engenharia/ Engineering Soils	
		Predominantemente Áspero Predominantly Coarse-grained	Predominantemente Fino Predominantly Fine-grained
Desmoronamento (Queda, Tombamento) Collapse (fall, topple)	Desmoronamento de Rocha Rock Collapse	Desmoronamento de Detritos Debris Collapse	Desmoronamento de Terra Earth Collapse
Escorregamento(escorregamento, espalhamento) Slide (slide, spread)	Escorregamento de Rocha Rock Slide	Escorregamento de Detritos Debris Slide	Escorregamento de Terra Earth Slide
Fluxo Flow (flow)	-	Fluxo de Detritos Debris Flow	Fluxo de Terra Earth Flow

Source: Modification of 1978 Varnes Classification by JICA Survey Team

The type of soils in which collapses frequently occur is yellow-reddish soil. The yellow-reddish soil is formed as a result of deep weathering in a subtropical environment, and can reach the depth of over 10 m from the ground surface. The soil is further subdivided into the red soil (Upper layer) and yellow soil (Lower layer). The red soil layer becomes more fine-grained and considerably loses its strength once being wet. The collapsed fine-grained red soils have suspended the river into reddish brown color. These fine-grained soils can not easily become deposited and flows into the sea. On the other hand, the yellow soil layer has a relatively small weathering and therefore some strength.

The majority of collapses which occur only within the red soils with a collapse thickness of less than 1m, is shallow collapse. Along the section of the Itajaí-Açu River across the Serra do Mar, rock falls have been observed. The relation between rainfall and rock fall is not clear.

Damage caused by the rainstorm of November 2008
BR 470 Road was completely blocked by collapse of the yellow-reddish soils at sta. Km 44 around the municipality of Blumenau.

Photo: Provided by DENIT office in Rio do Sul

Damage caused by the rainstorm of November 2008
BR470 Road underlain by mainly the red soils was suddenly collapsed down at sta. Km 41 around the municipality of Gaspar, causing the fall of vehicles trafficking there.

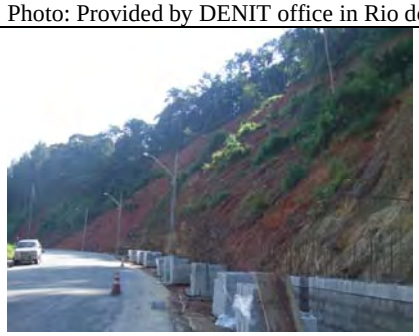
Photo: Provided by DENIT office in Rio do Sul

Damage caused by the rainstorm of November 2008
A 5m-long rock block contained in the yellow-reddish soil layer fell down into the road surface of BR470 Road around the municipality of Blumenau.

Photo: Provided by DENIT office in Rio do Sul

Damage caused by the rainstorm of November 2008
Collapse occurred with a thin surfacing soil layer overlying the bedrock in the urban area of the municipality of Gaspar along state road SC470 Road, and collapsed soils covered the whole road width and reached the ground floor of a gas station on the opposite side

Provided by Civil Defence - Gaspar



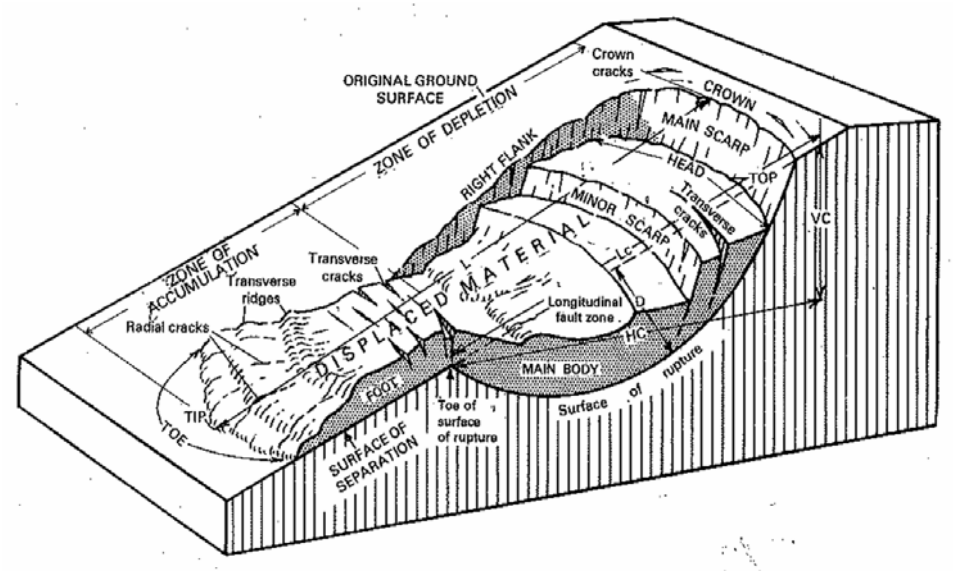
Site of disaster prevention work along the municipal road of Blumenau, executed by DEINFRA.
Collapse occurred within the thin yellow-reddish soil layer overlying bedrock.
Photo: by JICA Survey Team, May 26, 2010

Erosion and subsequent collapse in the yellow-reddish soil layer around the municipality of Pomerode..

Photo: by JICA Survey Team, May 08, 2010

6.2.3 Characteristics of Slide

Slide is a shearing tension phenomenon or shearing displacement along a definite plane or zone of separation. Slides generally occur progressively. Slides slowly move along sliding plane or sliding zone and are characterized by a large volume of displaced material and little disturbance of displaced material. The displaced material mostly remains within the occurrence area. Figure 6.2.2 shows the typical topographic characteristics of a rotational.



Source: Dr. Varnes 1978

Figure 6.2.2 Rotational Slide

According to landslide survey in Japan, collapses have a depth of less than 2 m, on the other hand, slides have an average length of approximately 300 m and an average depth of about 18 m. In addition, collapses commonly occur on steep slopes with gradient of over 30 degrees, whereas slides mainly on gentle slopes with gradient 15 to 30 degrees.

With comparison to collapses, slides are associated with displacement at larger depth, and are thus little influenced by rainfall. In the Itajaí River Basin, the slide in the municipality of Pomerode was activated at the end of August 2010 regardless of rainfall. In addition, the slide with 5-m high scarp in the municipality of Benedito Novo became active in December 2008, after a month of the rainstorm of November 2008.

The geological conditions prone to the occurrence of landslides in Itajaí River Basin are as follows:

i) Areas where surfacing soil layer is thick, especially within the yellow-reddish soil area. These soils are subject to the loss of soil strength once becoming wet, and thereby sliding plane is easily formed (hilly slopes with gradient of less than 30 degrees along the Itajaí-açu River and its tributaries).

ii) In regions of the Mesozoic argillaceous sedimentary rocks, especially basaltic volcanic rocks covered by the Serra Geral formation. In argillaceous sedimentary rocks, bedding planes are intruded by thin lava and are subsequently deteriorated through hydrothermal alteration, thereby collecting hot springs and consequently creating favorable conditions for formation of sliding plane.

The slide of the yellow-reddish soils in the southwest of Pomerode was activated at the end of August 2010 and has destroyed 2 houses. The surroundings of the two houses in the front side were a swamp up until 25 years ago. The slide became active in the dry period, presumably due to progressive deterioration of sliding plane within the yellow-reddish soil.

Photo: taken by JICA Survey Team on September 14, 2010

Photo: taken by JICA Survey Team on May 09, 2010

Slide of the Mesozoic argillaceous sedimentary rocks along the state road SC302, upstream of the Itajaí do Oeste dam in the municipality of Taio. The scarp of the slide is distributed on the slope of mountain side. The river is located at the left side of the photo. The mountain slope at the right side of photo is underlain by phyllite with water spring.

Photo: taken by JICA Survey Team on May 24, 2010

Road section between Luiz Alves - Massaranduba of the state road SC413 Road in the municipality of Luiz Alves. The sliding plane was formed within the yellow-reddish soils. The slide leaded to complete blockage of the state rock during the rainstorm of November 2008. The slide has a sliding plane just above the road surface and even at present causes a deformed road section of about 60m long. The total length of the affected road section is totally 240m.

Photo: Provided by the Civil Defence – Benedito Novo, taken in December 2008

Slide around the Benedito Novo city hall. The scarp of the slide is 5m high. The slide occurred in December 2001, approximately one month after the rainstorm of November 2008.

6.2.4 Characteristics of Debris Flow

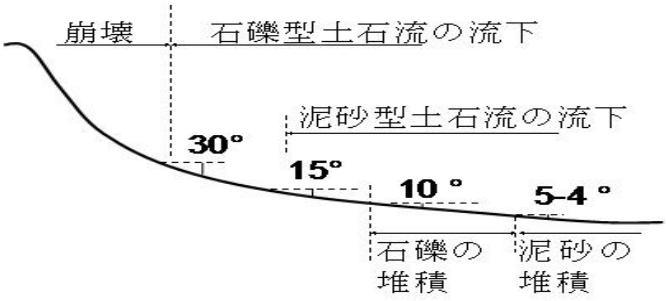
Similar to collapses, debris flows are characterized by the fact of causing huge damages to human lives, destroying houses and buildings, and demanding a long time and costs for the reconstruction.

The characteristics of debris flow disasters are summarized as follows:

i) The velocity of debris flow is great. In general, debris flow which contains a great amount of cobbles and rock debris flows down at velocity of 5 to 10 m/second, and earth flow which includes earth and mud comes down at velocity of 10 to 20 m/second.

ii) Debris flow contains cobbles, rock blocks and drafts. Especially debris flow at its front end contains boulder of some meters and draft and generates a great impact force, consequently causing damage to houses and other properties.

iii) Debris flow suddenly occurs. The occurrence of a debris flow is sudden without visible indications or warning signs



Source: Modification of 2003 Conference of Sabo and Landslide Technical Study (Eto, etc.) by JICA Survey Team

Figure 6.2.3 Gradient of Stream and Inundation Area and Type of Debris Flow

Figure 6.2.3 shows gradients of the source area, transport zone, and sedimentation area of a debris flow resulting from collapses in Japan.

Similarly, according to PWRI (Public Works Research Institute) Report No. 157 (1982), the stretched inclination of sedimentation area of a debris flow (before sedimentation) is above 2 degrees, and below 10 degrees in approximately 70% of the cases.

In the inundated area with a gradient of above 2 degrees, it is necessary to consider potential impact by debris flow.

According to case studies in Japan, these regions underlain by granitic rocks (southern parts of the municipalities of Gaspar, Blumenau and Indaial, as well as southern parts of Itajaí Mirim river in the municipalities of Brusque and Botuvera) and by metamorphic rocks (northern parts of Luiz Alves, Pomerode and Gaspar, northern part of Itajaí river within Blumenau city, northern part of Itajaí river within Timbo SDR, and center Ibirama, etc.) are susceptible to debris flow.

Source area of debris flow

Transport zone of debris flow, around the stream distributed are metamorphic gneiss rocks.

Sedimentation area of debris flow

Debris flow due to the rainstorm of November 2008 around Blumenau city within the Ribeirão Velha watershed, killed five people

Photo: taken by JICA Survey Team on May 27, 2010

Potential impacted Area of debris flow around Blumenau city within the Ribeirão Garcia basin. Many residences are concentrated in the stream.
Photo: taken by JICA Survey Team on May 27, 2010

Earth flow due to the rainstorm of November 2008 in the Ribeirão Pinheiro area of the municipality of Benedito Novo.
Photo: provided by the Civil Defence - Benedito Novo

Earth flow occurred in November 2008 in northern Benedito Novo. Earth flow included mainly yellow-reddish soil with some gneiss debris. Cunha river was temporarily dammed and a natural slide dam was formed. At the downstream of the natural dam is the municipality of Rio dos Cedros.

Photo: provided by the Civil Defence - Benedito Novo

Debris flow caused by the rainstorm of November 2008 around the hillside of Morro do Baú within in the municipality of Ilhota, contained a matrix of yellow-reddish soils and some boulders and rock blocks of 10-30 cm diameter. Around the hillside of Morro do Baú landslides extensively and widely occurred and killed 27 people, a largest record of death number in Ilhota city.

Photo: taken by JICA Survey Team in 2010

6.2.5 Characteristics of Landslide Risk of Each Municipality

Characteristics of landslide risks in high-risk municipalities are summarized in Table 6.2.2 on the basis of existing data survey and site reconnaissance. These high-risk municipalities include 1) those have landslide records of more than cases in the past 23 years between 1980 and 2003 according to date of Santa Catarina Civil Defence, 2) those were declared the state of emergency during the rainstorms of November 2008, and those have some designated landslide disaster hazard road sections according to DEINFRA.

Table 6.2.2 Characteristics of Landslide Rsks in High-risk Municipalities

SDR-Taio	Rio do Cameo Salete	Due to intrusion of basaltic magma, the bedding of Mesozoic argillaceous sedimentary rocks were deteriorated, contributing to a formation of potential sliding planes, consequently becoming prone to landslide occurrence.
	Taio	Same as above. With change of water table in Oeste dam reservoir, small-scale slides have intermittently occurred along the state road SC301.
SDR-Ibirama	Presidente Getulio Witmarsum	Since the yellow-reddish soils are formed as the result of weathering of argillaceous sedimentary rocks, the bedrocks have been deteriorated; this leads to susceptibility of landslide occurrence. These landslides have the soil is fragile and favors the occurrence of slides. These landslides have small influence on the State Road SC421.
SDR-Rio do Sul	Rio do Sul	Due to intrusion of basaltic magma, the bedding of Mesozoic argillaceous sedimentary rocks were deteriorated; this provides a probability of formation of potential sliding planes.

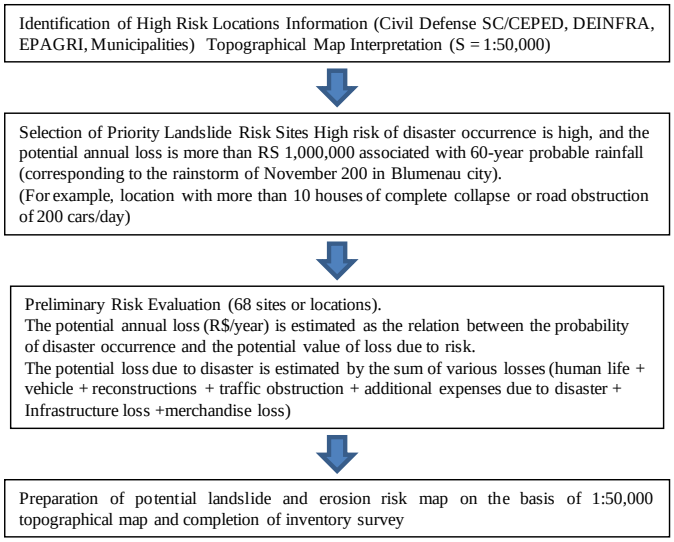
		In residential areas slides which provide materials of debris flow are present. These slides have probably impact on residential development area of approximately one hundred residences.
SDR-Timbo	Benedito Novo	A large-scale slide area is present beside the city hall. The region is underlain by granites and metamorphic rocks, and the probability of debris flow disaster is relatively high. In the border between Benedito Novo and Rio dos Cedros, debris flows due to the rainstorm of November 2008 occurred and leaded to blockage of Cunha river with slide materials. In addition, some slides destroyed some sections of the State Road SC416.
	Rio Dos Cedros	In regions of regional metamorphic gneiss and granitic rocks, debris flow hazard is present. Since no severe landslides had been reported before the rainstorm of November 2008, it has been thought that the probability of catastrophe landslides becomes higher with an intense rainfall of 20-years recurrence.
SDR-Blumenau	Blumenau	It is the area of the most frequent landslides in Santa Catarina. The major cause is the house construction in slope grounds and stream areas. Even in gentle slopes slide risks are present. Along the State Road SC474 which extends toward north with heavy traffic, road deformation due to collapses and slides are present.
	Gaspar	Many Collapses are distributed along the road slopes of the State Road SC486 and the municipal Road, as well as around the residential areas. Ground deformation due to slide are observed in new inclined residential areas. Road pavement was planned for the Gaspar-Luiz Alves road, the municipal road Gaspar-Blumenau and the bypath of BR470 in the right bank of the Itajaí river, if slope protection measures would not be executed, road closure and pavement damage due to collapse and slides would be caused, thus leading to a loss of money and efforts.
	Ilhota	Serious landslide disasters (slide, obstruction of rivers, debris flow) occurred Around the Morro do Baú during the rainstorm of November 2008. In the affected areas, the recovery of vegetation progressed slowly, leading to progressive production of sediments. It is thus necessary to promote the recovery of the vegetation.
	Luiz Alves	The potential of collapses and slides is higher between the Gaspar－Luiz Alves Road as well as along the northern sections of the State Road SC413 after the urban area. Some measures against landslide are probably required in the construction of the large-scale residential areas complex currently under execution by the state government; increases in rain water discharge probably have adverse influence on the occurrence of flood and landslide.
	Pomerode	Collapses and slides (road body slides) occurred along the State Road SC418 that extends toward north. These collapses and slides became active in August 2010, some had some influence on the residences and the printing facility.
SDR-Brusque	Brusque	The cut slopes of the State Road SC486 are steep with no vegetation cover, and therefore have high probability of collapses, probably leading to discharge of sediments toward the Itajaí Mirim River. Many landslide risk areas is associated with residential areas. Slides occurred in new residential areas.
	Botuvera	Road slopes of the State Road SC486 are steep without vegetation cover and have a high probability of road slope collapse, consequently generating sediments and discharging toward the Itajaí Mirim River.
SDR-Itajai	Itajai	Steep slope collapses are distributed along the edges of the flat lands. The slopes that are covered with the yellow-reddish soils earth are prone to collapse.

Note: SDR: Local civil engineering office — Source: From JICA Survey Team

6.3 Mapping and Evaluation of Landslide and Erosion Risk

6.3.1 Procedure of Risk Evaluation and Risk Mapping

The mapping and elevation of landslide risks is carried out according to the following procedure:



Source: JICA Survey Team

Figure 6.3.1 Procedure of Evaluation and Mapping Landslide and Erosion Risks

Preparation of risk map is briefly described below and given in more detail in appendix report.

6.3.2 Identification of Potential Landslide Location

Potential landslide locations were identified as shown in Table 6.3.1, based on disaster records, site reconnaissance conducted in this study and topographical interpretations (1:50,000 topographical maps covering the study area, 1:25,000 topographical map of Ilhota city and aerial photos in 1978 and 1979). Totally 949 potential landslide locations were finally identified.

Table 6.3.1 Information Source of Landslide Disasters Records

Data source	Reports	Potential locations (949 sites)
Defesa Civil-CEPED	Response to the disaster occurred in Santa Catarina in 2008: evaluations during the disaster / University Center of Studies and Researches about Disasters,	932sites
Defesa Civil-CEPED	Disaster updated information added to the above-mentioned in Nonmember 2010	943sites
EPAGRI/CIRAM	COMPLEXO DO MORRO DO BAÙ Aerial survey of potential landslide areas	62sites
DEINFRA/DIOT	Landslide sites due to the rainstorm of November 2008	34 sites
JICA Survey Team (between April and November, 2008)	Site reconnaissance conducted in this study	68 sites

Source: JICA Survey Team

6.3.3 Selection of Priority Landslide Risk Site

A landslide site that has high potential of a landslide occurrence and damage of more than R$ one million potential annual loss at 60-year probable rainfall shall be selected as priority landslide risk site. The potential annual loss of over R$ one million as a rough guide is defined to be damage with complete collapse of more than 10 houses or complete closure of over 200 daily traffic volumes. Consequently, 68 priority landslide risk sites were selected for further study. They are 32 sites along SC State roads, 35 sites along the municipal roads city road, and 1 site around the Itajai port.

6.3.4 Calculation of Potential Annual Loss

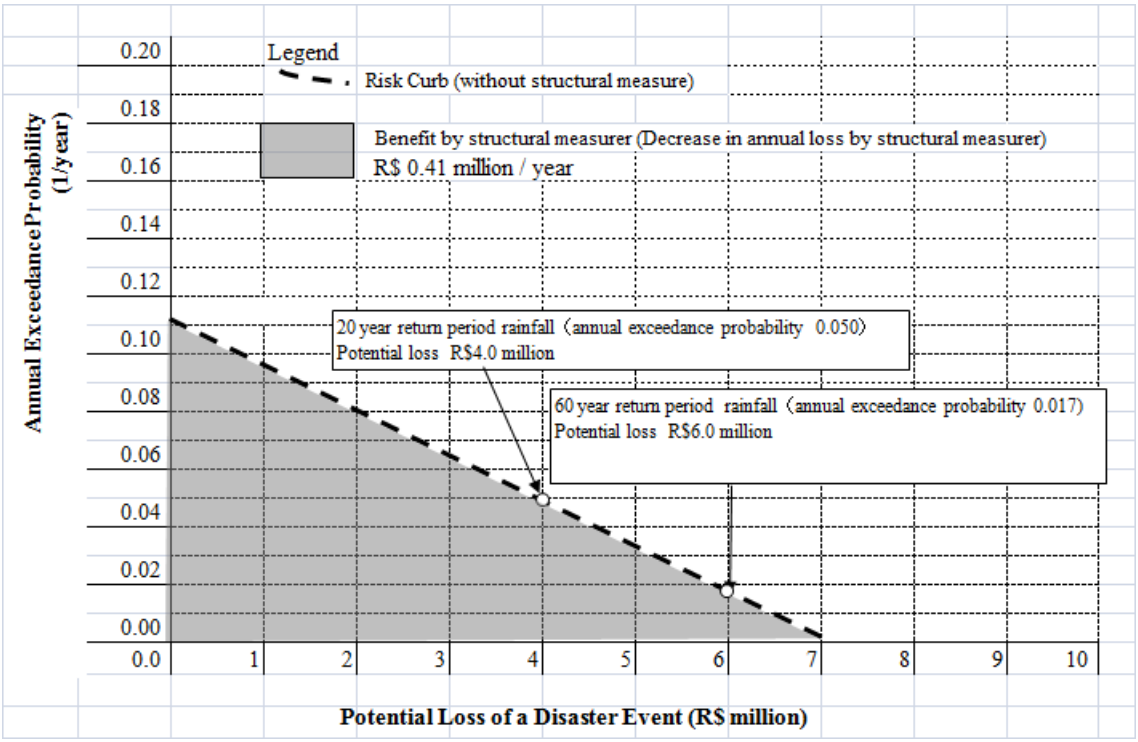
For the selected 68 priority landslide risk sites, the risk was quantitatively evaluated in terms of potential annual loss. For the same landslide site, the scale of landslide disaster (sediment volume reaching target facilities, section length of affected roads, deposited sediment volume in

port, etc.) depends upon the probability of landslide occurrence, scale of triggering factors such rainfall.

As shown in Figure 6.3.2, the potential annual loss (R$/year) calculated by using possibilities of non exceedance of landslide occurrences (vertical axis) and the potential loss (horizontal axis).

In the case of road damage, possibilities of non exceedance of landslide occurrences and the potential loss are first calculated and then the potential annual loss are done considering two kinds of damage scale, that is, complete closure and partial closure (one lane closure).

The possibility of non-exceedance of compete and partial closures was evaluated on the basis of the scale (volume) of landslide disaster similar to the rainstorm of November 2008, and the estimated probability of soil humidity index most close to landslide site. Calculation item and procedure are detailed in Appendix Report.



Source: JICA Survey Team

Figure 6.3.2 Risk Curve of Landslide Disaster and Example of Potential Annual Loss Calculation

The potential annual loss for the selected 68 priority landslide risk sites is shown in Table 6.3.2.

Table 6.3.2 Potential Annual Loss of the 68 Priority Landslide Risk Sites

Priority	Location	South latitude			West longitude			SDR	City	Potential annual loss
		G	M	S	G	M	S			R$ 10^3 / year
1	Itajai Port	26	53	56	48	40	7	Itajai	Itajai	9,000
2	SC 302 Taio-Passo Manso-5	27	1	45	50	8	18	Taio	Taio	1,255
3	SC470 Gaspar River Bank	26	55	2	48	58	37	Blumenau	Gaspar	1,095
4	Blumenau -Av Pres Casrelo Branco	26	55	7	49	3	58	Blumenau	Blumenau	1,021
5	SC418 Blumenau – Pomerode	26	51	32	49	9	18	Blumenau	Pomerode	989
6	SC474 Blumenau-Massaranduba 2	26	44	18	49	4	18	Blumenau	Blumenau	907
7	Gaspar - Luiz Alves, Gaspar 9	26	47	38	49	0	16	Blumenau	Gaspar	774
8	Gaspar - Luiz Alves, Luiz Alves 6	26	44	26	48	57	52	Blumenau	Luiz Alves	700
9	SC470 Gaspar Bypass	26	55	56	48	57	21	Blumenau	Gaspar	689
10	SC477 Benedito Novo – Dutor Pedrinho 1	26	46	50	49	25	6	Indaial	Benedito Novo	680
11	SC418 Pomerode - Jaraguá do Sul 1	26	40	29	49	8	35	Blumenau	Pomerode	651
12	Gaspar - Luiz Alves, Luiz Alves 4	26	46	38	48	59	31	Blumenau	Luiz Alves	629

Priority	Location	South latitude			West longitude			SDR	City	Potential annual loss
		G	M	S	G	M	S			R$ 10^3 / year
13	SC474 Blumenau-Massaranduba 1	26	44	51	49	4	10	Blumenau	Blumenau	601
14	SC 302 Taio-Passo Manso 4	27	6	26	50	4	7	Taio	Taio	526
15	Gaspar - Luiz Alves, Luiz Alves 11	26	43	53	48	56	6	Blumenau	Luiz Alves	497
16	SC486 Brusque - Botuverá 13	27	10	41	49	2	5	Brusque	Botuverá	473
17	SC416 Timbó – Pomerode	26	45	32	49	13	52	Timbó	Timbó	443
18	SC486 Brusque - Botuverá 1	27	7	44	48	56	23	Brusque	Brusque	430
19	R. Alamedia Rio Branco, Blumenau	26	54	54	49	5	6	Blumenau	Blumenau	398
20	Gaspar - Luiz Alves, Gaspar 2	26	48	59	49	1	11	Blumenau	Gaspar	384
21	Gaspar - Luiz Alves, Luiz Alves 7	26	44	13	48	57	22	Blumenau	Luiz Alves	380
22	Gaspar - Luiz Alves, Gaspar 1	26	49	5	49	1	9	Blumenau	Gaspar	379
23	Gaspar - Luiz Alves, Luiz Alves 3	26	46	54	48	59	41	Blumenau	Luiz Alves	372
24	Ponte Aldo P. de Andrade right bank	26	54	45	49	4	10	Blumenau	Blumenau	366
25	SC486 Brusque - Botuverá 3	27	9	5	48	58	50	Brusque	Brusque	344
26	SC486 Brusque - Botuverá 2	27	9	2	48	58	47	Brusque	Brusque	342
27	Gaspar - Luiz Alves, Gaspar 8	26	47	40	49	0	18	Blumenau	Gaspar	326
28	Gaspar - Luiz Alves, Gaspar 4	26	48	6	49	0	36	Blumenau	Gaspar	323
29	SC486 Brusque - Botuverá 9	27	9	31	48	59	24	Brusque	Botuverá	301
30	SC486 Brusque - Botuverá 7	27	9	20	48	59	10	Brusque	Brusque	298
31	Gaspar - Luiz Alves, Luiz Alves 2	26	46	57	48	59	42	Blumenau	Luiz Alves	278
32	Gaspar - Luiz Alves, Gaspar 7	26	47	48	49	0	20	Blumenau	Gaspar	276
33	Gaspar - Luiz Alves, Luiz Alves 1	26	47	10	48	59	47	Blumenau	Luiz Alves	271
34	Gaspar - Luiz Alves, Luiz Alves 5	26	45	3	48	58	34	Blumenau	Luiz Alves	271
35	Gaspar - Luiz Alves, Luiz Alves 8	26	44	4	48	56	56	Blumenau	Luiz Alves	270
36	SC486 Brusque - Botuverá 11	27	10	2	49	0	5	Brusque	Botuverá	260
37	SC486 Brusque - Botuverá 10	27	9	40	48	59	36	Brusque	Botuverá	260
38	Gaspar - Luiz Alves, Luiz Alves 10	26	44	1	48	56	30	Blumenau	Luiz Alves	227
39	SC486 Brusque - Botuverá 12	27	10	25	49	0	33	Brusque	Botuverá	221
40	SC486 Brusque - Botuverá 4	27	9	7	48	58	51	Brusque	Brusque	220
41	SC486 Brusque - Botuverá 6	27	9	18	48	59	7	Brusque	Brusque	220
42	SC486 Brusque - Botuverá 14	27	10	47	49	2	32	Brusque	Botuverá	220
43	SC486 Brusque - Botuverá 5	27	9	19	48	59	5	Brusque	Brusque	220
44	SC 302 Taio-Passo Manso 2	27	6	51	50	4	14	Taio	Taio	202
45	Gaspar - Luiz Alves, Gaspar 6	26	47	55	49	0	28	Blumenau	Gaspar	184
46	Gaspar - Luiz Alves, Gaspar 10	26	47	38	49	0	11	Blumenau	Gaspar	184
47	SC418 Pomerode - Jaraguá do Sul 2	26	39	38	49	8	39	Blumenau	Pomerode	184
48	Gaspar - Luiz Alves, Luiz Alves 12	26	43	45	48	55	58	Blumenau	Luiz Alves	184
49	Gaspar - Luiz Alves, Gaspar 3	26	48	42	49	1	5	Blumenau	Gaspar	184
50	SC413 Luiz Alves -Massaranduba 1	26	43	12	48	56	31	Blumenau	Luiz Alves	172
51	Gaspar - Blumenau 3	26	53	34	49	0	43	Blumenau	Gaspar	169
52	SC486 Brusque - Botuverá 8	27	9	25	48	59	16	Brusque	Botuverá	151
53	SC 302 Taio-Passo Manso 1	27	6	53	50	4	14	Taio	Taio	149
54	SC 302 Taio-Passo Manso 3	27	6	50	50	4	14	Taio	Taio	149
55	SC477 Benedito Novo – Dutor Pedrinho 2	26	46	3	49	26	13	Timbó	Benedito Novo	144
56	R. Bruno Hering, Blumenau	26	55	17	49	3	46	Blumenau	Blumenau	119
57	Gaspar - Luiz Alves, Luiz Alves 9	26	44	1	48	56	44	Blumenau	Luiz Alves	111
58	SC477 Benedito Novo – Dutor Pedrinho 3	26	47	3	49	21	54	Timbó	Benedito Novo	108
59	Gaspar - Luiz Alves, Gaspar 5	26	48	1	49	0	33	Blumenau	Gaspar	106
60	Bau	26	47	22	48	56	41	Blumenau	Ilhota	101
61	SC486 Brusque - Botuverá 15	27	9	46	48	59	45	Brusque	Brusque	78
62	Luiz Alves Municipality Road 1	26	43	33	48	57	31	Blumenau	Luiz Alves	67
63	SC413 Luiz Alves -Massaranduba 2	26	42	54	48	56	55	Blumenau	Luiz Alves	62
64	Luiz Alves Municipality Road 2	26	45	48	48	59	2	Blumenau	Luiz Alves	59
65	Brusque Municipality Road 1	27	7	43	48	53	53	Brusque	Brusque	56
66	Gaspar - Blumenau 2	26	53	48	49	2	19	Blumenau	Blumenau	55
67	Gaspar - Blumenau 1	26	53	42	49	2	20	Blumenau	Blumenau	55
68	Brusque Municipality Road 2	27	7	16	48	52	7	Brusque	Brusque	51

Source: JICA Survey Team

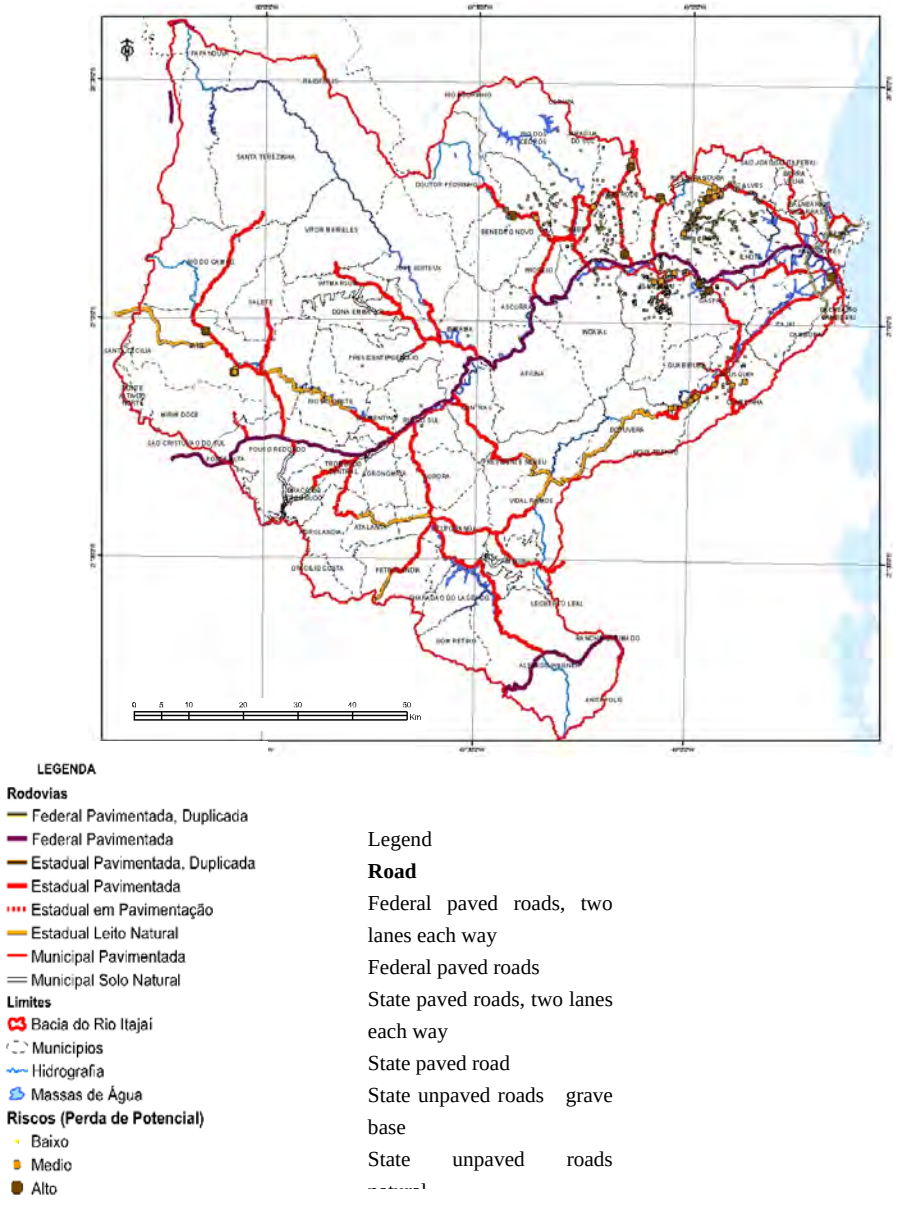
6.3.5 Mapping of Potential Landslide Site and Inventory Survey of Priority Landslide Risk Site

Figure 6.3.3 shows the distribution of the priority landslide risk sites with different levels of the potential annual loss. F-6.3.4 gives an example of priority landslide risk maps. The base map is composed of 239 sheets with 1:30,000 Itajai topographical maps in A3 size. Each site has GIS information as listed below.

Table 6.3.3 Inventory Item of Landslide Risk Site

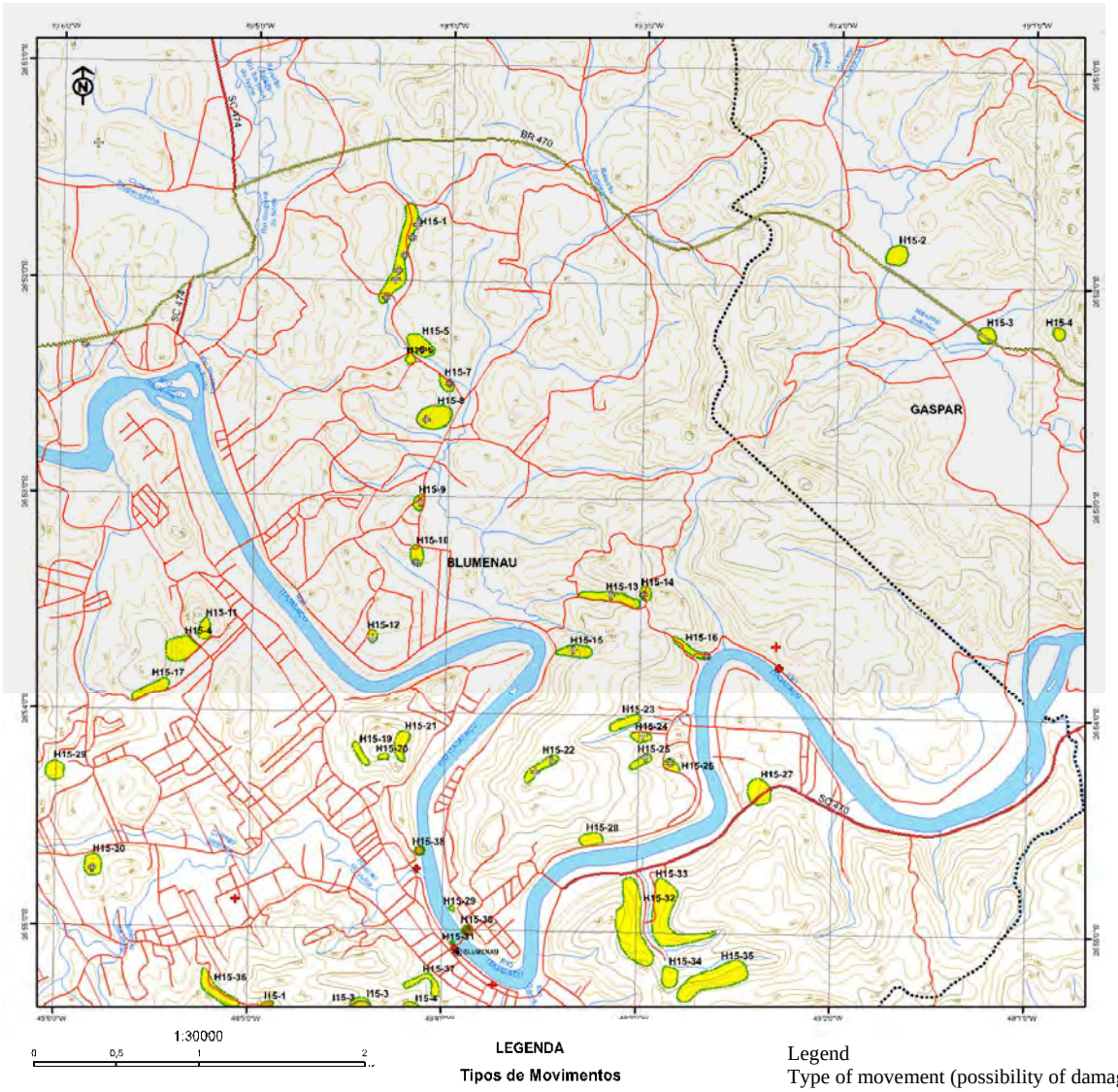
Regional number of landslide risk site (Map code + Serial number)
Location (longitude of latitude of central point of the target site)
SDR/Municipality
Type of Movement
Risk Area (Fall, Collapse, Movement, Runoff of mud, etc.)
Type of Geology, Soil, Vegetation
Classification of Elevations, Gradients

Source: JICA Survey Team



Source: JICA Survey Team

Figure 6.3.3 Maps of Priority Landslide Risk Site with Different Level of Potential Annual Loss



Source: JICA Survey Team

Figure 6.3.4 Example of Priority Landslide Risk Mapping

6.4 Needs of Landslide Disaster Mitigation

Table 6.4.1 shows the needs and comments on landslide measures by various originations.

In the study area, due to repeated floods and increased population, residential lands construction expands into inclined areas or slopes, this leads to an increase in landslide disasters. In damaged areas, because of multiple human factors such as uncontrolled residential area construction (steep cut slope, residence in flooding area, poor drainage, etc.). Accordingly, the Civil Defence of municipalities are requesting technical support and training related to management and control landslide disasters. In addition, the State Civil Defence and other entities also have similar requirements. On the other hand, DEINFRA has addressed the needs of implementing landslide preventive projects along state and municipal roads, as structural measures.

Table 6.4.1 Needs and Opinions on Landslide Disasters by Different Originations

Management origination	Outline of needs and opinions
（DINIT） National Department of Transports Infrastructure	- The necessity for Landslide preventive project along the federal highway BR-470 is low (Rio do Sul Administration Office). - The necessity for Landslide preventive project along the federal highway BR-282 is low. In addition, landslide preventive projects related to Coastal road BR-101, within the Itajaí River Basin and along the toll road sections of private administration should be implemented by concession companies (Santa Catarina Office)
DEINFRA	- Support the reconstruction of state and municipal roads affected by landslide disasters - Many road sections and sites necessary for implementing landslide preventive projects. - They have never executed No landslide preventive projects have implemented so far and no knowledge of planning landslide preventive project is available. - Counterparts will be brought into the plan of landslide preventive project in this study. - At the reconstruction of the 2008 disasters, the government of Santa Catarina resolved that landslide preventive projects should include municipal roads. In the JICA support project, landslide preventive projects related to municipal roads are considered as state government landslide preventive projects.
Defesa Civil- SC	- Issues are the lack of geology specialists. The task of training technicians should also include information and public health issues. - There is some inconsistency among the federal, state and municipal regulations related to land use for the irregular construction of residences in landslide risk areas, this leads to an increase in landslide disasters. The present landslide alert system is based on the daily of 200 mm/day, predicting the CIRAM. - Information from the National Institute of Spatial Researchers is not effectively utilized. - It is recommended that automatic rainfall gauges be installed in each municipality and managed by each municipality so as to issue alert and warning on landslide disaster. It is also necessary to provide training to the Civil Defence of municipalities. - It is planned to install automatic rainfall gauges in 293 municipalities of the the whole Santa Catarina State, in Program 5 (road improvement) with IDB funds.. - It is desirable to use low-cost structural measures.
UFSC (Federal University of Santa Catarina) CEPED	- Upon request of Santa Catarina Civil Defence Secretariat, the University is dispatching geological and civil engineering specialists will be dispatched to sites and carry out investigations. - Provide the most available information for JICA study. - Study on Urban Disaster Prevention Plan was proposed to Santa Catarina government, but it was not accepted.
CIRAM	- It would be desirable that low-cost structural works were applied in view of the current situation of Brazil (director). - The risks of flood and landslide is being studied by using 3 days rainfalls as a indicator.
FRUB CEOPS	- The forecast and warning against landslide disaster has not been conducted. - 16 automatic rainfall gauges installed within the basin, which are owned by the Sustainable Development Secretariat and managed by FURB, are recording and accumulating amount of rainfall per 15 minutes. - It is necessary to establish a forecast and warning system against landslide disasters.. - The Civil Defence Secretariats of municipalities, except for Blumenau, are little organized, and even if they install an automatic rainfall station in each municipality, it is unknown if they will be able to maintain and utilize them. - The relation between landslide disaster and amount of rainfall per day and per seven days have been studied, however their correlations were poor or not clear. - They have required to develop a model project for structural measures against landslide of

Management origination	Outline of needs and opinions
	the steep hill beside the New Market gallery in the urban zone of Blumenau. The model project would include investigation and analysis of landslide, and planning and design of structural measures for landslide disasters. For these issues, they request the cooperation from Japan.
CPRM	- It is necessary to update the disasters map done by the municipalities. - It will be necessary to further study geologic and soil issues.
FATMA	- In 2002, APP (Permanent Protection Area) regulated slopes with gradient of over 45 degrees, and the top portion of a mountain (upper third of mountain) as protection area. However, such APP areas are not regulated in federal and state laws. - Basically, structural measures are not allowed to be implemented in regulated APP areas, areas, but if it is a public disaster prevention project, structural measures are acceptable.
State Planning and Urban Development Departments.	- Residential areas development in any case of state, municipality or private development works is authorized solely by the municipality; on the other hand, the environmental preservation control is done by FATMA. - It is recognizable that it is necessary to pay attention to avoiding new slope instability associated with new residential area development and to install rain runoff control works within Itajaí River Basin to control discharge of rainfall water. - No residential area development is currently planned as state development project. - The Regional Development Secretariat (SDR) gives importance to development but comes short of disaster mitigation. For the regional development zoning, different opinions exist between the local development departments or municipalities of development intention, and the state of preservation intention, and therefore it is necessary to discuss these issues.
COHAB/SC	- In general, new housing projects are implemented as municipal government projects when the municipalities have engineers such as Brusque and Rio do Sul, whereas as state governmental projects when the municipalities have no engineers. - Design of state project is technically approved by COHAB (in case of the municipality project, by the chief of the sector in charge for the project in the municipality). - The final authorization for the projects is provided by municipal governor. - Environmental review is done by FATMA. - The necessity of new housing development in the municipality of Blumenau is considered the highest within the Itajaí River Basin. - For Japanese loan project, the municipality of Blumenau, which has a high technical level can be as the execution body for Japanese loan project.
CREA	- Because each municipality has no budget, the structural measures for landslide disasters associated with residential houses have not been implemented since the 2008 rainstorm. The municipality, CPRM and CREA in cooperation established a system to cope with structural measures against landslide disaster related to residential houses, by using the funds from private mining companies.

Source: JICA Survey Team

In addition, Table 6.4.2 summarizes the opinions and needs of each municipality regarding landslide disasters. The municipality of Blumenau is preparing the landslide hazard map. In other municipalities, some universities such as CEPED dispatched by Civil Defense/SC;the carried out geotechnical reconnaissance solely for individual affected site of activated landslide.

In the municipality of Pomerode, the landslides activated at the end of August 2010 were treated with drainage and earth works by landowners. In the municipality of Itajaí, some cases of landslide prevention measures (including drainage and cutting works) beside residential areas were conducted as municipal projects. In the municipality of Benedito Novo, the erosion prevention works by using Petibá grass were executed under the direction of DEINFRA. These measures are relatively simple and have limited effects.

Each municipality has addressed the needs to implement landslide prevention measures related to access roads to the water supply storage tank and near residential areas.

Table 6.4.2 Opinions and Needs of Each Municipality Regarding Landslide Disasters

Origination	Summary of opinions
Civil Defense of all municipalities	No forecast and warning system against landslide disasters was established and implemented. Structural measures should be implemented if approved as state governmental project.
Blumenau	Landslide disaster mitigation manual is available, including flood and landslide disasters. Landslide risk map can be prepared on the website. Further exploration (satellite images interpretation + site reconnaissance) is ongoing. Japanese technical cooperation and assistance are being expected. In landslide hazard areas, there are various irregular residences. Even if guided to move outside of landslide hazard areas, other residences come back into these landslide hazard areas.
Gaspar	Distribution map of landslide disasters due to the rainstorm of November 2008 is available, however, methodology for these landslide disasters has not been prepared.
Ilhota	The death during the November 2008 rainfall is due mainly to landslides occurring around the Baú mountain. After the 2008 disaster, they are providing psychological counseling to the affected people. According to recommendations by psychologists, a local leader was chosen for the community disaster prevention and the information network was established
Luiz Alves	The Gaspar/Blumenau road or the road connecting to Massaranduba is fragile, being necessary to adopt measures against landslide in these road sections. There is a concern about the collapse of the road connecting to source for public water supply of the municipality
Brusque	The new residential area development is being subject to landslide impact and at present stopped.
Rio do Sul	The municipality has little know-how on landslide issue and wants to send staff to Japan for OJT training.
Benedito Novo	Erosion protection works by Petibá grass is being implemented. (DEINFRA guidance). The municipality has no idea to mitigate the slide with a deep sliding plane beside the city hall buildings.
Timbo	The communication among the Civil Defense of all municipalities is poor.
Itajai	A great number of landslide hazard areas are distributed in the municipality. Ground deformations due to slide are active and these slides are at high risk. Existing slide preventive works (cutting works) are deformed and damaged presumably due to lack of drainage works.
Rio dos Cedros	Slides were activated due to the 2008 November rainstorm, the slide materials dammed up the river and temporarily formed natural slide dam. There is still some concern about the breaking of the natural slide dam and subsequent floods. .
Pomerode	Some slides were activated by the 2008 heavy rainfall at the end of August 2010. Mortar surface drainage, traditional bamboo underdrain and cut works with heavy machinery to change the sliding direction of slide were implemented by landowners. Some slide investigations were carried by CEPED.

Source: JICA Survey Team

6.5 Basic Policy of Landslide Mitigation Measures

The master plan for landslide mitigation was formulated according to the following polices:

(1) Introduction of structural and non-structural works

The master plan was prepared to combine structural and non-structural measures.

(2) Care for vulnerable people

Landslide disaster measures shall give consideration to different social groups to fairly receive the benefits from the construction of landslide measures.

(3) Environment-friendly comprehensive landslide disaster measures

In order to minimize the gap of benefit and loss distribution among the different regions within the water basin and to increase the benefit of the whole basin, the master plan for landslide disaster mitigation shall be formulated, from the standpoint of natural and social environments, especially with focus on as follows:

- To minimize the gap of benefit and loss distribution among the different regions.
- To maximize the benefit of the whole Itajaí River basin.
- To take good care of the natural and social environments

6.6 Basic Policy for Formulating Mater Plan of Landslide Disaster Mitigation

6.6.1 Outline

Landslide disasters due to the November 2008 rainstorms were concentrated within the lower basin of the Itajaí River. This was due mainly to the heavy rainfall as landslide trigger, which was concentrated disproportionately on the lower basin. The risks of landslide sites within the whole basin were identified. It is necessary to avoid the landslide measures to disproportionately address the lower basin damaged by the the November 2008 rainstorms.

In order to maximize the benefit of the whole basin, the priority of landslide sites necessary for landslide measures was evaluated in consideration of traffic affect by landslide disaster in wider regions.

Taking account of the above-mentioned issues and the needs of each municipality, the basic policies for the formulation of master plan were determined as follows

i) As non-structural measure, forecast and warning system against landslide and flood were installed for the whole State of Santa Catarina.

ii) Structural measures shall give priority to landslide sites with highest level of the potential annual loss. .

iii) In the implementation of non-structural and structural measures, it should be addressed to conduct technology enhancement for relevant organizations and disaster education for related organizations and residences.

6.6.2 Non-structural Measures

In order to reduce and avoid human loss, the forecast and warning system against landslide and flood disasters shall be installed.

(1) Areas in application of the forecast and warning system against landslide and flood

It has been planned to install the forecast and warning system in whole State of Santa Catarina by Defense Civil-SC and EPAGRI/CIRAM, mainly because 1) landslide sites are widely distributed in the whole State of Santa Catarina, 2) the administrative boundary of the municipalities are different from that of the Itajaí River basin, the traffic volume between these boundaries are heavy, accordingly not the Itajaí River basin, the whole State of Santa Catarina was selected as target area.

(2) Outline of the forecast and warning system against landslide and flood

Automatic rainfall gauges shall be installed in all 293 municipalities of the State of Santa Catarina. The employees of the Civil Defense shall monitor and manage these automatic rainfall gauges. These rainfall data shall automatically be sent to the state meteorological data centre. The state meteorological data centre shall analyse and accumulate these rainfall data, determine and revise the standard rainfall, and inform Civil Defense-SC, mayor and public media once the recording rainfall reaches the standard rainfall value for warning. The mayor shall issue warning to the municipal residents. The Civil Defense-SC shall transmit the landslide information through radio and TV, and warning boards that DEINFRA will install in state roads. The residents and tourists can avoid going to school or to work, or to travel, in view of the landslide warning, and take refuge going through predetermined escape ways to determined locations (schools, churches, etc.) to protect themselves.

(3) Points with attention to the forecast and warning system against landslide and flood

To integrate the delivery and transmission of information as well as warning and evacuation

methods for flood disaster,

To make daily use of the warning boards installed by DEINFRA, and

To give extra consideration to vulnerable people in the implementation of delivery and transmission of information as well as warning and evacuation so as to fairly receive the benefit for different groups.

6.6.3 Structural Measures

(1) Selection of priority landslide sites for structural measure implementation

Priority landslide sites shall be selected depending on risk – high level of the potential annual loss.

(2) Structural measure project related to the main infrastructures

Project of the Itajaí port sediment discharge control was evaluated to be the first priority in terms of the potential annual loss. The ongoing dredging project can be evaluated effective. Sabo dams at the upstream of the Itajai port are required to control sediment inflow into the port. The unit price of sediment removal is almost equal to that of dredging project. In addition, landslide disaster measures are generally associated with the effectiveness of the sediment production reduction, and vegetation works shall be as basic measures to increase the effectiveness of landslide disaster measures.

Landslide preventive works have already been executed along the federal roads BR470 and BR282, decreasing the risk of landslide disasters. DNIT has not planned further landslide preventive works.

A great number of landslide sites are distributed along the State roads; the ongoing landslide preventive works are still insufficient. DEINFRA has also addressed the necessity of structural measures for landslide risk sites. Concerning municipal roads, the municipalities of Gaspar, Luiz Alves and Brusque have also indicated the need of structural measures for landslide risk sites. Landslide sites related to the roads with traffic volume of 200 cars/day showed the potential annual loss of over 50,000 R$/year, being in the order of 2 through 68. In addition, landslide preventive works of the municipal roads as state governmental project have actually been implemented since the 2008 rainstorm, and such projects can be continued if approved by the State House of Representatives.

(3) Structural measures project related to personal property

In the municipalities of Rio do Sul, Benedito Novo and Blumenau, some active landslides related to the residential areas. For these landslides underwater drainage works seem effective. These landslides have the potential annual loss of less than 50,000 R$/year, and are evaluated to be low priority for the implementation of structural measure.

(4) Structural measure project related to new residential area development

Some landslides have impact on new land development for residence and factory. It is necessary to prepare technical standards for inclined land development, and simultaneously contributing to open or close drains for land development, discharge control facilities and flood control facilities. It has been proposed to select a high-risk landslide site related to the ongoing or new land development as model project - loan technical assistance project. The technical assistance will include surveys, suitability evaluation of land development, as well as planning, design and execution supervision of structural measures.

CHAPTER 7 ENVIRONMENTAL AND SOCIAL CONSIDERATION AND STRATEGIC ENVIRONMENT ASSESSMENT (SEA)

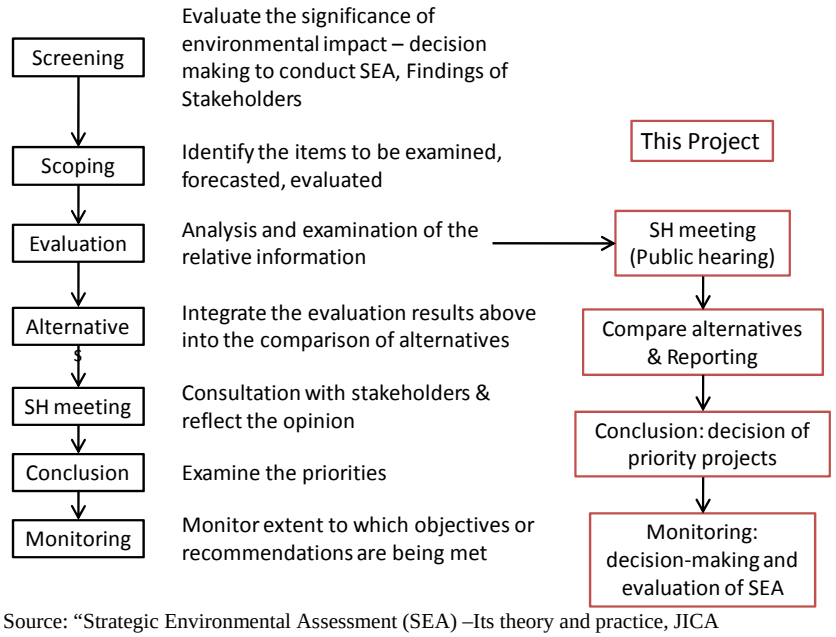
7.1 Strategic Environment Assessment (SEA)

7.1.1 Outline of SEA and its Methodology

The objectives of JICA Guidelines for Environmental and Social Consideration (the New Guidelines, April 2010) are; i) to encourage Project proponents etc. ii) to have appropriate consideration for environmental and social impacts, as well as iii) to ensure that JICA's support for and examination of environmental and social considerations are conducted accordingly. The guidelines outline JICA's responsibilities and procedures, along with its requirements for project proponents etc., in order to facilitate the achievement of these objectives. In doing so, JICA endeavors to ensure transparency, predictability, and accountability in its support for and examination of environmental and social considerations.

In the revision in 2010, the basic principle is "Avoid or minimize impact", and to consider broader impacts, JICA intended the project phase from earlier phase to monitoring phase to implement environment and social consideration. For this revision, implementing Strategic Environment Assessment (SEA) was included in the new guidelines.

The first phase of this Preparatory Survey is the Master Plan Study. An Initial Environmental Examination (IEE) was carried out depending on the principle of the SEA, such as "Integrate the Environmental and Social Consideration into decision making through the strategy of planning process", in the process of formulation of the flood mitigation plan and the sediment disaster management plan. The process and the flow of the SEA in this study is shown in Figure 7.1.1



Source: "Strategic Environmental Assessment (SEA) –Its theory and practice, JICA

Figure 7.1.1 SEA Process and the Flow of SEA in this Master Plan Study

The objective of this Master Plan is to reduce flood and sediment disaster damages in the whole Itajai River basin with 52 municipalities. In Brazil, the movement of resident participation is developing, it is the most important to make a decision of watershed management plan with participatory approach in the Itajai River basin; there are a lot of stakeholders such as municipal

government, State Government, Itajai River Basin Committee, municipal associations and universities.

In this situation, the Survey team has had so many meetings and presentations to gather a wide range of opinions from the member of Itajai River Basin Committee, relative governmental and non-governmental organizations, lecturer of universities and so on. In these meetings and presentations, we made record of meetings and reflect these opinions to the master plan and making alternatives (Screening phase of SEA).

The alternatives of construction measures for the flood mitigation plan, it includes combination of measures for the 5, 10, 25 and 50-year floods. As described in Section 5.3, normally the government should set the target frequency flood at the first time of study, but the Santa Catarina State or Brazilian Federal Government had not have such kind of target. The Santa Catarina State Government requested through counterpart meeting that they wanted to compare the combinations of four measures, 5, 10, 25 and 50-year floods, which were made by the Survey team. The plan of flood forecasting and warning system (FFWS) and the sediment disaster management plan are as one alternative in each plan.

The Initial Environmental Examination (IEE) for each alternatives and each structural measure was done as scoping process (see Chapter 10, Table 10.2.1).

The public audience had held three (3) times in Itajai, Blumenau and Rio do Sul, according to the ordinance of JICA commission/SC No. 002/2010 (Portaria Comissão JICA/SC No 002/2010, see Section 10.4). In these public audience, and we explained with easier words for understanding and we put many visual materials with explanation of each structural measure in a poster with illustration and 3D graphics.

Considering comprehensively the result of preliminary evaluation of IEE, validity of engineering aspect, economic aspect, social urgency, comments from public audience and so on, the selection of alternatives for the feasibility study had done with discussion with the State Government of Santa Catarina. The result of comprehensive evaluation is shown in Section 16.1.4.

7.1.2 Stakeholder Analysis

The stakeholder analysis, which aims to identify the stakeholders who might be affected by the master plan and assess the possible environmental and social impacts on the stakeholders, was carried out as a screening phase of SEA.

The Survey area are spread on 50 municipalities and 9 SDRs, the related governmental institutions are State Administration, 9 Regional Development Offices (SDR), 50 Municipal Governments and 3 Municipal Associations. In the study period for Master Plan, many hearing of opinions were held with these governmental institution, especially main municipalities of Itajai river basins (Taio, Ituporanga, Rio do Sul, Timbo, Blumenau, Gaspar, Ilhota, Itajai, Brusque cities) and related state administrations (State Sustainable Economical Development Office: SDS, Infra-structure Department: Deinfra).

The Itajai River Basin Committee is organized with 50 members of representatives of each institution, responsible to represent opinions about water resources from water users (20 members), residents (20 members) and public institutions (10 members). This committee includes many members from representatives of stakeholders in this Survey. The opinions were also collected from this committee.

7.1.3 Consultations/Discussions with the Stakeholders in the Master Plan Study

The meetings which had held in the first phase are shown in Chapter 1, Table 1.6.1.

7.2 Legislation and Institutions in Federal, State and Municipalities

7.2.1 Major Environmental Laws and Water Resources Laws

This section presents a compilation of major legal instruments such as laws (leis), decrees (decretos), resolutions (resolução), and rules that regulate the environmental licensing for the project, also including those related to use of water resources and property acquisition and relocation/resettlement of families and business.

(1) Federal Legislation

Federal Laws:

- Law No. 6,938, August 31, 1981 - It sets forth the National Environmental Policy, its purposes, and formulation and application mechanisms, constitutes the National Environmental System (SISNAMA).
- Law No. 4,771, September 15, 1965 – Outlines the New Brazilian Forest Code
- Law No. 9,433, January 8, 1997 – Institutes the National Policy for Hydro-Resources and creates the National System for the Management of Hydro-Resources.
- Law No. 9,984, July 17, 2000 – Outlines the creation of the National Water Agency (ANA), a federal entity that was implemented by the National Policy for Hydro-Resources and is under the coordination of the National System for the Management of Hydro-Resources.
- Law No. 9,795, April 27, 1999 – Outlines the National Policy for Environmental Education.
- Federal Law No.9985/2000 – It institutes the National System of Conservation Units (SNUC), defining criteria and rules for the creation, implementation and management of conservation units.
- Law No. 10,257, June 10, 2001 – City Statute – Regulates articles 182 and 183 of the Federal Constitution, covering a new series of principles and instruments in the search for a new way of building cities.
- Law No. 7,803, July 18, 1989 – Outlines the National Policy for river, spring, and water body use.
- Law No. 7,754, April 14, 1989 – Establishes protection measures for existing forest land around water/spring sources for rivers and other sources;
- Law No. 10,257, July 10, 2001 – City Statute.
- Law No. 7,661, May 16, 1988 – Outlines the National Plan for Coast Management

Federal Decree:

- Decree No. 99,274 as of 06/06/1990 – It defines the composition of SISNAMA and sets forth the environmental licenses to issue in each stage of the project
- Decree No. 6,848, May 14, 2009 – Alters and adds to Decree No. 4,340, August 22, 2002, to regulate environmental compensation.
- Decree No. 4,340, August 22, 2002 – Regulates articles of Law No. 9,985, July 18, 2000, which outlines the National System for Nature Conservation – SNUC, and other proceedings.
- Decree No. 4,613/2003 – Regulates the National Advisory Board for Hydro-Resources.
- Federal Decree No. 3,365/41 – It provides for property expropriation for public interest and known as the General Law of Property Expropriation.
- Federal Law No. 4,132/62 – It defines the cases of property expropriation for social interest. In other cases, Decree-law No. 3,365/41 is applicable.
- Federal Decree No.1075/70 – It regulates the provisional right in possession of urban residential properties inhabited by their owners or by promise purchasers that have their titles registered in the Property Registry.

Federal Resolutions:

- CONAMA Resolution No. 001 as of 23/01/1986 – It sets forth the definitions, responsibilities,

basic criteria and general guidelines for the use and implementation of the Environmental Impact Appraisal as one of the instruments of the National Environmental Policy.

- CONAMA Resolution No. 237 as of 19/12/1997 – It provides for the revision and complementation of procedures and criteria utilized for the environmental licensing set forth by CONAMA Resolution No.001/86.
- Resolution No. 357/2005 – CONAMA – Outlines the classification of bodies of water and the environmental guidelines for their qualification, as well as establishing conditions and standards for sewage release, and other proceedings.
- Resolution CONAMA No. 302, March 20, 2002 – Outlines the parameters for areas of permanent preservation around artificial reservoirs and the regime for use of these surrounding areas.
- CONAMA Resolution No. 371/2006 – It prescribes guidelines to the environmental agencies for the calculation, collection, application, approval and control of expenditures of resources resulting from environmental compensation, according to Law No.9.985, as of July 18, 2000, and defines other provisions.
- Resolution No. 2/199, National Civil Defense Policy.
- Resolution No. 5/2000 – CNRH – Establishes the guidelines for the creation and workings of the hydrographic basin committees.
- Resolution No. 12/2000 – CNRH – Establishes the procedures for classification of bodies of water according to their preponderant use.
- Resolution No. 16/2001 – CNRH – Establishes the general criteria for granting the rights to hydro-resource use.
- Resolution No. 14/2001 – CNRH – Establishes the guidelines for the preparation of a Hydro-Resource Plan in the Hydrographic Basin.
- Resolution No. 32/2003 – CNRH – Institutes the national hydrographic division.
- Resolution No. 48/2005 – CNRH – Establishes the general criteria for payment and taxing for water resource use.
- Resolution No. 65/2006 – CNRH – Establishes the guidelines for carrying out the procedures for granting the rights for water resource use with the environmental licensing procedures.

Other Relevant Federal Environmental Laws and Regulations

- IPHAN Administrative Rule No.07/1988 – It regulates the requests of permission and authorization and previous communication for the development of field surveys and archaeological excavations in the country with the purpose of protection of scientifically and culturally valuable objects present in the location of such surveys, as provided in Law No.3,924, as of July 26, 1961.
- IPHAN Administrative Rule No. 230/2002 – It makes the preventive archaeological studies compatible with the environmental licensing phases of projects which potentially affect the archaeological heritage, as well as defines the procedures to adopt in each phases of environmental licensing.
- SMA Resolution No.34/2003 – It provides necessary measures for the protection of the archaeological and pre-historic heritage during the environmental licensing of projects and activities potentially causing significant environmental impact, subject to the presentation of EIA/RIMA.

(2) State Legislation

State Laws:

- Law No.14, 675, April 13, 2009 – Institutes the State Environmental Code for the State of Santa Catarina.
- Resolution CONSEMA No. 001/2006 – Approves the List of Activities Considered Potential

Causers of Environmental Degradation passes through environmental licensing by the Environmental Foundation (FATMA) and indicates the competent environmental study for licensing.

- Law No. 6,739/1985 – Creates the States Advisory Board for Hydro-Resources (CERH).
- Law No. 9,022/1993 – Institutes the State System for Hydro-Resource Management
- Law No. 9,748/1994 – Institutes the State Policy for Hydro-Resources.
- Law No. 10,959/1998 – Outlines the characteristics of the State's hydrographic regions
- Law No. 11,508/2000 – New rendition of article 2, Law No. 6,739

State Decree:

- Decree No. 14,250/81 – Regulate the Law for the State Environmental Policy
- Decree No. 1,003/91 – Approves the Internal Regiment of the State Advisory Board for Hydro-Resources
- Decree No. 2,648/1998 – Regulates the State Hydro-Resource Fund (FEHICRO)
- Decree No. 4,778/2006 – Regulates Grant for Use Rights for Hydro-Resources
- Decree No. 4,871/2006 - Approve the Fee table for analysis and expedition by the Grant for Use Rights for Hydro-Resources

CERH Resolutions:

- Resolution No. 03/1997 - CERFI – Approves the General Norms for composition, organization, competency and functioning of the Hydrographic Basin Committees, in accordance with the guidelines in Articles 20 and 25 of Law No. 9,748.
- Resolution No. 01/2002 - CERH – Establishes the guidelines for the creation of the Santa Catarina State Basin Committees
- Resolution No. 08/2004 - CERH – Institutes the procedures for the creation of Technical Chambers together with the State Advisory Board for Hydro Resources
- Resolution No. 01/2005 - CERH – Creates the Technical Commission for the State Hydro Resource Plan
- Resolution No. 01/2007 - CERH – Creates the Technical Commission for Granting Use Rights of Hydro Resources
- Resolution No. 02/2007 - CERH – Creates the Technical Commission for Legal and Institutional Matters
- Resolution No. 017/2008 - CERH – Outlines the classification of bodies of water in the State of Santa Catarina

State Directive:

- Directive No. 2/2006 - SDS – Institutes the State Registry for Users of Water Resources
- Directive No. 35/2006 - SDS – Outlines the technical and administrative procedures to be observed with examining grant orders
- Directive No. 35/2007 - SDS – Establish the technical and administrative procedures for emitting the declaration of hydro reserve availability and the Grant for potential hydraulic energy use in State Rivers.
- Directive No. 36/2008 - SDS – Establish the technical criteria for granting water resource use rights for capturing surface water in Santa Catarina State river and other proceedings.

Municipal Legislation:

- Complimentary Law Blumenau-SC, No. 615, 15/12/2006 – Outlines the Blumenau City Master Plan
- Complimentary Law Blumenau-SC, No. 751, March 23, 2010 – outlines the zoning codes, land use and occupation in Blumenau city and other proceedings.
- Complimentary Law Blumenau-SC, No. 747, March, 23 2010 – Institutes the environmental code in Blumenau city and other proceedings.

- Complimentary Law Blumenau-SC, No. 144, September 22, 2008 – Institutes the Zoning Code norms, soil subdivision and use in Itajai City.
- Complimentary Law Blumenau-SC, No. 2763, October 26, 1992 – Institutes the Construction Code in Itajai City among other proceedings.
- Complimentary Law Blumenau-SC, No. 2543, December 19, 1989 – Institutes Zoning Norms and Soil Use norms in Itajai City.
- Complimentary Law Itajai-SC, No. 94, December 22, 2006 – Institutes the Master Plan for Management and Development of Itajai City Territory.
- Complimentary Law Gaspar-SC, No. 2803, October 10, 2006 – Institutes the Master Plan for Urban Development in Gasper City and other proceedings.
- Ordinary Municipal Law No. 1924/1999 of Gaspar – Creates the Municipal Advisory Board for Environmental Defense (COMDEMA) and revokes Law No. 829/84
- Complimentary Law No. 163/2006 of Rio do Sul – Outlines the Master Plan for the city of Rio do Sul
- Ordinary Municipal Law No. 3609/2001 of Rio do Sul – Creates the Municipal Advisory Board for Environmental Defense (CONDEMA) and other proceedings
- Complimentary Law No. 136/2008 of Brusque – Institutes the Zoning Codes and Soil Use Codes in Brusque City and other proceedings (Integrated with the Master Plan)
- Complimentary Law No. 140/2008 of Brusque – Institutes the Construction Code for the city of Brusque and other proceedings (Integrated with the master plan)
- Complimentary Law No. 15/1992 of Brusque – Institutes the Physical-Urban Territory Master Plan
- Law Complimentary No. 135/2008 of Brusque – Outlines the Evaluation, Revision and Update of the Master Plan for the Physical-Territorial Organization of Brusque, Santa Catarina and its accordance with the City Statute and other proceedings. (Integrate the following complimentary Laws Nos. 136, 137, 138, 139 and 140)

7.2.2 Federal and Local Institutions and Authorities

(1) Federal Organs and Institutions

- **Environmental Ministry – Ministério do Meio Ambiente – MMA:** Created in 1992, its mission is to promote the adoption of principles and strategies that spread knowledge, promote protection and recuperation of the environment, the sustainable use of natural resources, the value of environmental services and the insertion of sustainable development in the creation and implementation of public policy, in a transverse, sharing, participative, democratic manner, at all levels and instances in the government and society.

- **Brazilian Institute for the Environment and Natural Renwable Resources – Instituto Brasileiro do Meio Ambiente e dos Recursos Naturais Renováveis – IBAMA:** Organ responsible for executing the National Environmental Policy – Política Nacional do Meio Ambiente (PNMA), developing activities for preservation and conservation of the natural patrimony, exercising the control and inspection of natural resource use. Carry out environmental studies and grant environmental licenses for projects with significant environmental impact in a national and regional scope.

- **The Chico Mendes Institute for the Conservation of Biodiversity – Instituto Chico Mendes de Conservação da Biodiversidade – ICMBio:** Environmental organ responsible for managing the Conservation Units, proposing the creation of new protected reas and supporting the Natural Patrimony´s Private Reserves (RPPN). It is also responsible for defining and applying strategies to reucuperate endangered species through the Specialized Centers for Research and Conservation.

- **National Environmental System – Sistema Nacional Do Meio Ambiente – SISNAMA:** Instituted by Law n. 6,938 on August 31, 1981 and regulated by Decree n. 99,274, on June 06, 1990, and is made up of organs and entities of the Union, the States and the Federal Districts, the Cities and the Foundations instituted by the Public Power, responsible for protection and improvement of environmental quality.
- **National Water Agency – Agência Nacional de Águas – ANA:** Its mission is to implement and coordinate the management and integration of water resources in Brazil and regulate water Access, promoting its sustainable use to the benefit of current and future generations.
- **National Environmental Advisory Board – Conselho Nacional do Meio Ambiente – CONAMA:** Consulting and deliberative organ of SISNAMA, with the goal of assessing, studying and proposing environmental and water resource government policy guidelines and deliberating, within its competency, the norms and standards compatible with an ecologically balanced environment and with a healthy quality of life.
- **National Indigenous Foundation – Fundação Nacional do Índio – FUNAI:** Brazilian governmental organ that establishes and executes the Brazilian Indigenous Policy in accordance with the 1988 Constitution.

(2) State Organs and Institutions

- **Santa Catarina State Environmental Foundation - Fundação do Meio Ambiente do Estado de Santa Catarina – FATMA:** Santa Catarina state environmental organ, created in 1975, whose mission is to guarantee the preservation of state natural resource and is responsible for state environmental licensing processes.
- **State Forest Institute - Instituto Estadual de Florestas – IEF:** The State Forest Institute is an autarchy linked to the State Environmental and Sustainable Development Secretary whose objective is to execute state Forest policy and promote preservation and conservation of fauna and flora, and sustainably develop natural renewable and fish resources and as well as to research biomass and biodiversity.
- **State Environmental Advisory Board - Conselho Estadual do Meio Ambiente – CONSEMA-SC:** Superior organ to the State System for State Protection, it is a deliberative and normative organization, responsible for approving and accompanying the implementation of the State Environmental Policy and for improving state environmental management.

7.2.3 Brazilian Environmental Impact Legislation (EIA)

(1) Legislation on Environmental Impact Assessment

The National Environmental Policy (PNMA), implanted by the Federal Law No. 6,938/1981, focuses on environmental licensing and environmental impact evaluation.

Environmental licensing is a legal obligation before beginning any potential environmentally polluting project or activity. One of the most important aspects of the environmental licensing is the fact that the population and the society participate in the decision making process through Public Audiences held throughout the process. This obligation is shared with the State environmental organs and with IBAMA, as well as members of the SISNAMA.

The main guidelines for executing the environmental licensing are expressed in Laws .938/81 and in Resolutions CONAMA No.. 001/86 and No. 237/97. Besides these, there is also the Legal Opinion MMA No. 312/CONJUR/MMA/2004 which discusses the state and federal licensing competencies and is evidenced by the reach of the impact and Resolution CONAMA

No. 09/87, with discusses the Public Audiences. Depending on the reach of the impact, the licensing competency could fall under federal, state or municipal jurisdiction.

In case of licensing for projects and activities with significant environmental impact n a national or regional level, the organ responsible is IBAMA, the executing organ is SISNAMA, in accordance with item 4, article 10 of PNMA, collaborated by article 4 of Resolution CONAMA No. 237/97. If the case does not fall under IBAMA´s responsibility, the case should be delegated to state environmental organs or even to municipal organs to conduct the licensing process, because, according to article 7, Resolution CONAMA No. 237/97, the project and activities will be licensed on only one level of competency. The environmental licensing process should obey the following steps:

"I – The responsible organ should define, with the participation of the entrepreneur, the documents, projects, and environmental studies needed to begin the licensing process depending on the type of license being requested

II – The project may be published after receiving an environmental licensing request by the entrepreneur accompanied by the proper documents, projects and environmental studies.

III – An analysis of the presented documents, projects and environmental studies ensues by the responsible environmental organ, member of SISNAMA, as well as any technical visits that may be necessary;

IV – During the analysis of the documents, projects and environmental studies presented a single solicitation for clarification or information may be made. If an unsatisfactory clarification is made, a reiteration of the same solicitation may be made;

V – Public audiences, when necessary, should be in accordance with the pertinent regulation.

VI – If an unsatisfactory clarification is made, a reiteration of the same solicitation may be made;

VII – The emission of a conclusive technical opinion and, when necessary, a legal opinion;

VIII – Deferment or rejection of the license request and the due publication."

Resolution No. 237/97 establishes that, during the environmental licensing process, a mandatory certificate from the City Government must be provided declaring that the location and the type of project or activity are in accordance with the relevant legislation for soil use and soil occupation and the authorization for vegetation suppression and for water use grants (Article 10, 1)

In reference to the license, as outlined in the Federal Decree No. 99,274/1990, there are three types of licensing for the licensing process:

"I – "Preliminary License (LP) in the preliminary planning phase of the activity basic prerequisites must be followed in regard to location, installation and operation in accordance with the municipal, state and federal land use plan;

II – Installation License (LI), authorizes the beginning of implantation in accordance with the specifications explained the approved Executive Project; and

III – Operation License (LO), after the necessary verification, authorizes the start of the licensed activity and the workings of the pollution control equipment according to the Preliminary License and the Installation License."

The basic criteria and the general guidelines for the EIA and for the RIMA, are defined in Resolution CONAMA No. 01/1986, which evaluates the environmental impact.

Article 2 of Resolution No. 01/86 approval depends on the EIA/RIMA for licensing activities that have a modifying affect on the environment, according to item 7.2.4 – Types of projects that requires an EIA, in the present report.

The EIA is a detailed diagnosis of the environmental conditions in the area influenced by the project before implantation. The soil, subsoil, air, water, climate, life forms, natural ecosystems, and the socio-economic factors should be considered. An analysis of the consequences of the project´s implantation or non-implantation should be presented, evaluated the positive and negative impacts and presenting measures that will lessen the impact, and their respective ways of monitoring and accompanying progress.

The RIMA should reflect the EIA's conclusions, demonstrating the environmental, social and economic advantages and disadvantages of the project in a language accessible to the entire community. It should be composed of tables, graphs, maps and other visual resources that ease understanding and should be made available for consult in the public library of the licensing organ and at the affected municipal headquarters.

The EIA and the RIMA should be prepared according to the criteria, methodologies, and norms established by the Reference Terms approved by the organ responsible for the licensing process.

The organs involved in the process will have a period to manifest themselves about the presented RIMA. After receiving the RIMA the responsible organization should release an announcement in the journal announcing the opening of the period for solicitation and execution of the public audiences.

The Public Audiences previewed in the CONAMA Resolution No. 01/86 and the Resolution CONAMA No. 09, December 03, 1987, "should express the interests of the product under analysis and of the relevant RIMA, to clarify doubts and discuss critiques and suggestions."

Remember that, besides the licensing organ, the entrepreneur should also distribute the EIA/RIMA to the following organs involved directly in the licensing process of the project: Municipal Governments in the area influenced by the project, the State Environmental Secretary and the State Public Ministry; The Agrarian Colonization and Reform Institute (INCRA); The National Indigenous Foundation (FUNAI); The Historical Patrimony and National Art Institute (IPHAN); and the Federal Public Ministry (MPF), among others.

In general, the environmental licensing phase around the EIA/RIMA should obey the following steps, after the licensing process has been defined by the responsible organ and has been introduced to the federal, state and municipal competencies:

- Preparation of the EIA and the RIMA;
- Send the EIA and the RIMA and the LP requirement to the competent organ, then publish the required LP;
- Verify the scope of the EIA and the RIMA in relation to the TR;
- The Entrepreneur must distribute the EIA and the RIMA to the involved organs and to the licensing organ for merit analysis;
- The technical visit should be done by the licensing organ and any complementary solicitations;
- Accept the EIA/RIMA
- The entrepreneur should publish the EIA/RIMA, making available copies at the locations indicated by the licensing organ, who then publishes the RIMA, making it available on the site and communicating the location at which the EIA is available;
- Realize the Public Audience;
- The Licensing Organ should define the impact level of the Project with the necessary environmental compensations in mind.

- Deferment or rejection of the LP solicitation by the licensing organ;
- Payment of the licensing taxes by the entrepreneur
- Emission of the LP

(2) Institutional Initiatives for SEA Legalization in Brazil

In Brazil, there are many cases of SEA implemented by projects in lines with institutional funding agencies or on the independent initiatives of some state and/or municipal governments, although the application of SEA has not been legalized yet in the federal government. In response to the worldwide trend of SEA, the federal government has undertaken the following activities to l the guidelines on the application of SEA.

Year	Implementing Agency	Descriptions of the activities
2002	Ministry of Environment	Promotd a study on SEA recommending its adoption by legislation
2004	Brazilian Court of Audit	Court Decision No. 464 – Adoption of SEA in developing the Multi Year Plan and planning policies, plans and sectoral programs
2004	Ministry of Environment	Public consultation – aims to establish the principles, conditions and basic criteria for the use of SEA as a tool to advance environmental policy processes of formulating strategies for action that occur at different levels of decision of the Federal Government.

Source: Strengths and Weakness of SEA in Brasil, IAIA 11 Conference Proceedings, 2011

7.2.4 Type of Projects that Requires EIA

Article 2, in Resolution CONAMA No. 01/86 determines the importance of the EIA and RIMA to be submitted for approval to the state and federal organs responsible, for licensing for environmentally modifying activities, such as:

"I – Road with two or more lanes;
II – Train ways;
III – Ports and terminals for mining, petroleum and chemical products;
IV – Airports, as defined in Item 1, Article 48, in Decree-Law No.32, 18.11.66;
V – Oil lines, gas lines, mineral lines, storage tanks and sewage channels;
VI – Electric Energy Transmission Lines, above 230 KV;
VII – Hydraulic constructions for exploring hydro resource, such as: hydroelectric barrages, above 10 MW, sanitation and irrigation, opening of navigation channels, drainage and irrigation, modification of the water course, opening water tubes and mouths, basin transposition, and dikes;
VIII – Extraction of Fossil Fuels (petroleum, shale, and coal);
IX – Mineral extraction, including Class II defined in the Mining Code;
X – Landfills, processing and final destination of toxic and dangerous waste;
Xl – Plants for generating electricity, independent of the primary energy source, above 10 MW;
XII – Industry and Agro-Industrial complexes and units (petro chemical, iron works, chloro chemical, alcohol distilleries, coal, and cultivation and extraction of hydro resources);
XIII – Industrial districts and strictly industrial zones – ZEI;
XIV – Economic exploration of wood and firewood in areas larger than 100 hectares or smaller, when they significantly affect in percentage terms or in environmental terms;
XV – Urban projects larger than 100 hectares or in areas considered to be of relevant environmental interest under the SEMA criteria and by the municipal and state organs;

XVI – Any activity that involves organic (vegetable) coal in quantities larger than ten tons per day."

7.2.5 Types of Projects that Require for Preparation of an EIA in Santa Catarina

The Santa Catarina State Environmental Foundation – FATMA, is responsible for state licensing processes and follows the guidelines of the National Environmental Advisory Board – CONAMA. So, the Environmental Impact Study (EIA) will be demanded in Santa Catarina as long as the activity being licensed is a part of the Relation of Potentially Polluting Activities, emitted by CONAMA (Article 2, Resolution No. 01/86), in accordance with the previous sub-section 7.2.4.

Besides the activities outlined in the CONAMA Resolution, we add the activities considered by CONSEMA to be potential causers of environmental degradation, referred to in Annex I of the CONSEMA Resolution No. 001/2006 (Annex I – List of Activities Considered to be Potential Causers of Environmental Degradation and the minimum studies demanded by the environmental licensing).

7.2.6 Procedure of Projects that Require for Preparation of an EIA in Santa Catarina

Licensing Projects outlined in the Project Measures for Disaster Prevention in the Itajai River Basin and in Law No. 6,938/81 and in Resolution CONAMA Nos. 001/86 and 237/97, as well as the Legal Opinion No. 312/CONJUR/MMA/2004 states that the environmental licensing is under state jurisdiction as long as the span of the direct environmental impacts do not pass the limits of the State of Santa Catarina.

The Organ responsible for licensing processes in the State of Santa Catarina is FATMA. FATMA follows the PNMA guidelines as well as those outlined in law No. 14.675/09 and in the CONSEMA Resolution SC Nos. 01/2006 and 03/2008.

The FATMA licensing process begins by filling out the Integrated Project Characterization Form (FCEI. After analyzing the FCEI and the LAP solicitations and verifying that the project is a part of the Relation of Potentially Pollutant Activities, FATMA will demand that the entrepreneur prepare the EIA/RIMA. The study, which will be available for consult in the public library of the licensing organ and at the headquarters of the directly affected cities, should be presented in accordance with the Reference Term approved by this organ and according to the established norms in CONAMA Resolution No. 237/97. Remember, as an essential part of the licensing process before the EIA/RIMA, a mandatory public audience should be held according to CONAMA Resolution No. 09/87.

In cases where the EIA/RIMA is not necessary for the preliminary environmental license, FATMA will demand the preparation of the Preliminary Environmental Report (RAP) or the Simplified Environmental Study (EAS) in accordance with the list of activities that may potential cause environmental impact (Annex I of the CONSEMA Resolution No. 001/2006).

In accordance with the federal legislation guidelines (Law No. 6,938/81 and Decree No. 99,274/90), the following licensing are issued for Santa Catarina State:

The Preliminary Environmental License (LAP): Is given in the preliminary planning phases of the activity. During the phases of location, installation and operation the project was be in compliance with the municipal, state and federal land use laws. The LAP is issued after approving the preliminary environmental studies. The objective of the LAP is to define the conditions so that the entrepreneur can move forward with the project within the defined prerequisites. The LAP does not authorize the beginning of any construction or services on the project location.

The Environmental Installation License (LAI): Is given after analyzing and approving the executive project and other studies, specifying the environmental control measures for the project in accordance with the type, dimension, characteristics, potential environmental impacts and the recuperation plan for degraded areas. The IAF authorizes the beginning of the project implantation.

The Operational Environmental License (LAO): License that authorizes the beginning of the operational phase of the project. The LAO is given after construction and verification of the environmental control measures during functioning and other environmental requirements specified in the previous phases of the licensing process.

Following is a presentation of a flowchart referring to the environmental licensing procedures in the State of Santa Catarina for emission of the LAP and other procedural information related to the issuance of the LAI and LAO environmental licensing.

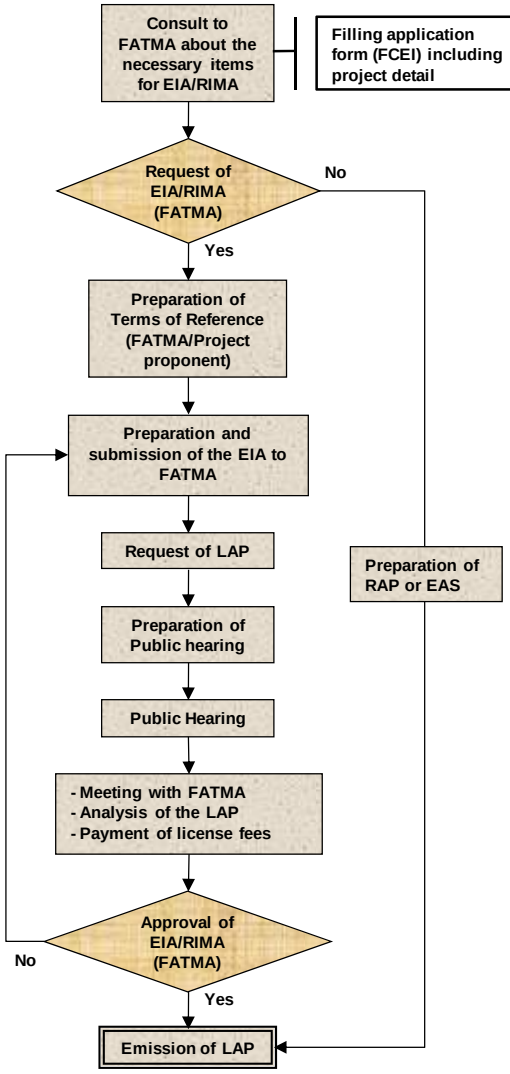


Figure 7.2.1 Flowchart of Issuance of LAP

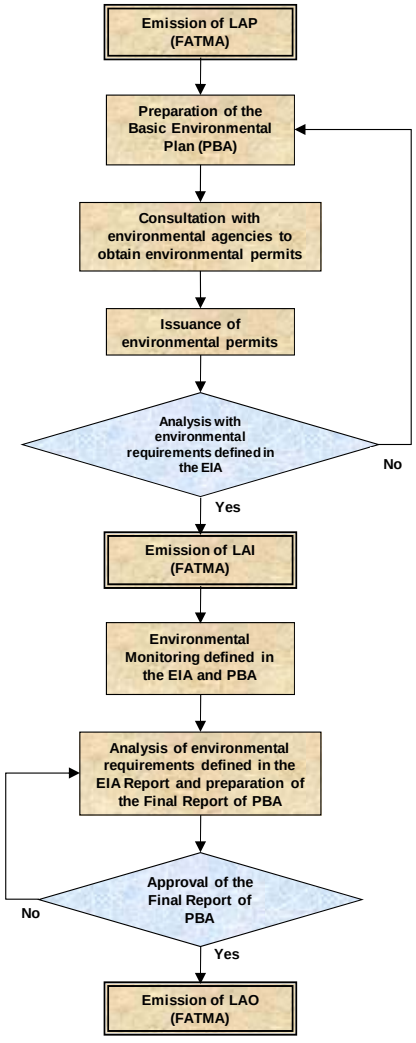


Figure 7.2.2 Flowchart to Issuance of LAO

7.3 Natural Reserves, Valuable Ecosystems and Wildlife

As main important laws about protected area, there are many Federal laws such as Federal Constitution, Law Federal No. 9,985/2000 and Decree Federal No. 4,340/2002. In Federal Constitution, it is prescribed about natural environmental conservation, “It is responsible of Federal, State and Municipal government to designate where should be conserved and restrict development activity to affect sensible environment” and “The sustainable use of natural

resources and conservation of natural environment should be done in major natural environmental area; Amazon rainforest (legal Amazon area), Atlantic Coast Forest (Mata Atlântica) and Wetland area in Mato Grosso (Pantanal)".

The objective of Law Federal No. 9,985/2000 is as follows;

- Preserving genetic resource and diversity
- Conservation of endangered species
- Recovery and conservation of ecosystem diversity
- Promotion of sustainable development of natural resources
- Promotion of utilize natural resources in the process of development
- Conservation of natural landscape
- Conversation of cultural, paleontological, historical and geological heritage
- Conservation of water and soil resources
- Recovery of degraded ecosystem
- Facilitation of environmental monitoring and basic research activity
- Economical and social evaluation of biodiversity
- Facilitation of environmental education, research and ecological recreations
- Conservation and recognition of economical and social value of natural resources and knowledge which are necessary for indigenous people

The protected area such as national park in Brazil is called "Conservation Units" (Unidades de Conservação: UC), it is legislated by SNUC Law (Federal Law No. 9,985/00) written in the succeeding sub-section 7.3.1. There are some more important laws of protected area such as Forest Code and Animal Conservation Law other than SNUC law

In Federal Law No. 9,605/98, Chapter 5, Article 40, there is regulation about the penalty for whom made any damage of fauna and flora in the conservation units.

7.3.1 Law of Conservation Units (SNUC Law)

"Conservation Units" (Unidades de Conservação: UC) is the protected area defined by Federal Law No. 9,985/00 (so-called SNUC Law), which also stipulates the institutionalization of the "Sistema Nacional de Unidades de Conservação (SNUC)", criteria/regulations of protected area designation, and the procedures for designation of the area.

There are two (2) types of Protection Units; Integrated Protection Units and Sustainable Use Units. The objectives of each unit, their definition and restriction are shown in Table 7.3.1.

Table 7.3.1 Classification and Contents of Conservation Unit

Name	Definition and restriction
1. Integrated Protection Units (Unidades de Proteção Integral)	The basic objective of Integrated Protection Units is conservation of nature, it is allowed only for indirect use of natural resources except the case which is designated in SNUC Law.
1.1 Ecological Station (Estação Ecológica)	In Ecological Station, natural conservation is the objective, it is allowed only for scientific research and environmental education. It is necessary for scientific research to have permission preliminary. And for environmental education, it has to be based on management plan of the station. This area is only for public use, so the land should be property of public institutions (federal, state or municipal). Basically it is prohibited to change its land use, there are some exception as follows. · Recovery program of ecosystem · Implementation to conserve biodiversity · Collecting samples only for scientific research · Implementation of scientific project, only less than 3% of the area or less than 1,500ha

Name	Definition and restriction
1.2 Biological Reserve (Reserva Biológica)	The objectives of Biological Reserve are the conservation of natural resources without direct effect by human and total environmental conservation as nature. It is allowed only for environmental education use, except implementation of project to maintain activities of ecosystem and biodiversity conservation. This area is only for public use, so the land should be property of public institutions (federal, state or municipal).
1.3 National Park (Parque Nacional)	The objectives of National Park are conservation of important natural ecosystem, with the activities of scientific research, environmental education, keeping dynamic landscape, ecological leisure and eco-tourism. It can be allowed the visitation only with management plan of National Park, it is necessary to take a permission to do scientific research. This area is only for public use, so the land should be property of public institutions (federal, state or municipal). There are similar classification other than Federal Park, such as State Park and Municipal Natural Park.
1.4 Natural Monument (Monumento Natural)	Natural Monument is the rare, unique or magnificent landscape, it is designated for conservation of these value. It can be allowed the visitation only with management plan of National Monument. It is allowed to own as private land , but it has to agree to have some restrictions same as national park. If the objective of use is different of national park, it should be acquired.
1.5 Forest Wildlife Refuge (Refúgio de Vida Silvestre)	The objective of Forest Wildlife Refuge is keeping and conserving environment for local vegetation, herd of moving animals, reproduce of species. It can be allowed the visitation only with management plan of National Park, it is necessary to take a permission to do scientific research. It is allowed to own as private land , but it has to agree to have some restrictions same as national park. If the objective of use is different of national park, it should be acquired.
2. Sustainable Use Units (Unidades de Uso Sustentável)	The basic objective of Sustainable Use Units is to balance natural conservation with sustainable use of natural resource.
2.1 Environmental Protection Area (Área de Proteção Ambiental)	Environmental Protection Area has normally vast area and some occupation of human living, with important, artistic and cultural habitat for satisfied life and quality of life. The objectives of Environmental Protection Area are basically protection of the biodiversity, orderly habitat and sustainable use of natural resources. Public and private land can be designated to this area, it is possible to do producing activity. The regulation in this area is designated by management authority. It would be organized supervising institution, citizen institution and advisory council by representatives of citizen in this area.
2.2 Ecological Relevant Interests Area (Área de Relevante Interesse Ecológico)	Ecological Relevant Interests Area is basically with small area and very scarce or zero population. It has special natural characteristics or rare local fauna and flora, keeps important natural ecosystem in local or regional level. The objective of this area is preserving land use with balance. Public and private property can be applicable. It can be restricted of land use in this area.
2.3 National Forest (Floresta Nacional)	National Forest is consisted mostly of forest of native species, its objective is scientific research mainly for multiple and sustainable use of forest resources. It would be organized supervising institution, citizen institution and advisory council by representatives of citizen in this area. There are similar classification other than Federal (National) forest, such as State Forest and Municipal Forest.
2.4 Extraction Reserve (Reserva Extrativista)	Extraction Reserve is used by traditional people who makes living mainly by extraction and complementary subsistence agriculture and keeping animals, the basic objectives are protecting their way of living and culture and guarantee their sustainable use of natural resources. This Reserve should be public property, delegated to this traditional people. It can be allowed the visitation only with regulation of this Reserve, it is necessary to take a permission to do scientific research. It is prohibited to exploit minerals and hunt by people who come from other places. It would be organized supervising institution, citizen institution and advisory council by representatives of citizen in this area. The management plan of this Reserve would be approved by advisory council. Tree cutting is allowed according to this management plan.

Name	Definition and restriction
2.5 Fauna Reserve (Reserva da Fauna)	Fauna Reserve is the natural conservation area which is applicable for research of use of animal resources, as economically sustainable. This Reserve should be public property. It is allowed the visitation within the management plan of the Reserve. It is prohibited hunting.
2.6 Sustainable Development Reserve (Reserva de Desenvolvimento Sustentável)	Sustainable Development Reserve is rural area which traditional people are living with sustainable use system of natural resources for many generations. This sustainable use system played a important role for conservation of nature and biodiversity, because it is developed through long time and many generations, adapted with local environmental limitation. In this Reserve, it can be achieved natural conservation and sustainable development of people's living simultaneously. The land property should be public. It would be organized the advisory council by representatives of citizen in this area. The economic activity is allowed with criteria as below:。 · The disclosure for the public along with management plan · Scientific research · Sustainable natural resource development
2.7 Private Reserve of Natural Heritage (Reserva Particular do Patrimônio Natural: RPPN)	It is private reserve which is registered forever for the conservation of biodiversity.

Source: Lei Federal n. 9.605/98, modified by JICA Survey Team

According to the Article 40 of the Federal Law No. 9,605/98, the penalty of infraction is doubled in Integrated Conservation Units than Sustainable Use Units.

7.3.2 The Forest Code (Federal Law No. 4,771/1965)

The Forest Code was established in 1965 to protect forest and native vegetation from unregulated development. This Code is superior law in the Brazilian Federal Law, it is complicated to revise so that there is no major revision although there are some addition of articles. Now the major revision of the Forest Code is proceeding of the Senate, it will come into force in this year.

In the Forest Code, it is legislated the "Permanent Preserve Area (Área Preservação Permanente: APP)" and "Legal Reserve (Reserva Legal: RL)".

The area which is described below is designated as APP (Article 2). However, in the urban area, it should be considered federal legislation when the master plan of urban planning or municipal city ordinance.

1. The width of the river when it is the highest water level, the width of APP in both sides:
   - Less than 10 m : 30 m
   - 10 m～50 m : 50 m
   - 50 m～200 m : 100 m
   - 200 m～600 m : 200 m
   - More than 600 m : 500 m
2. Lakes and man-made lakes
3. Sources of the river：radius 50 m
4. The top of the hills or mountains
5. Slope with more than incline of 45 degrees
6. Sand area (dry vegetation) which is controlling dunes or stabilizing mangroves
7. At least 100 m from the edge of table mountain
8. The vegetation in higher than 1,800 m of altitude

Using APP is limited, it is allowed only for public use and high social request, technically impossible to mitigate. The conditions to issue permission are follows (Article 4):

1. It is approved by federal, state or municipal environmental organization after enough

discussion.

2. When APP located in urban area, it is founded the city master plan (O Plano Diretor Municipal) and municipal environment council.
3. The effect for APP is temporal, and environmental organization decided that the impact of the activity is marginal.
4. If environmental organization had shown mitigation measure to the project proponent before the issuance of permission for APP use.
5. It is limited only for public use in source of river, littoral vegetation and mangroves.
6. The new APP would be established when artificial lake would made.
7. It is allowed only for getting water to enter APP human or animal.
8. Legal Reserve (RL) are designated in rural private land for preserving natural resources and sustainable use of ecosystem except the land already designated as APP. The percentage of the property is 20% out of legal Amazon area (Article 16).

The designation of RL is done by state or municipal environmental organization, or the environment council if it is established. For social use, it would be considered with classification as below.

- Water Resources Master Plan of river basin (Plano de Recursos Hídricos da Bacia)
- City Master Plan (O Plano Diretor Municipal)
- Environment-Economic Zoning (O zoneamento ecológico-econômico)
- Other environmental zoning (outras categorias de zoneamento ambiental)
- Other RL, APP, UC, or legal protected area

The related federal legislation related to Forest Code is shown in Table7.3.2.

Table 7.3.2 Major Federal Legislations Related to Forest Code

Name of Law	Contents
Federal Law No. 7,754/89	Designation of APP in forest around the source of river
Decree IBAMA No. 218/89	Application of permission to develop Atlantic Forest (Mata Atlântica)
Federal Decree No. 750/93	Restriction of cutting and development in native and reforested Atlantic Forest
IBAMA Normative No. 44-N/93	Application of permission to transport forest products
Inter organizational Normative No. 1/96	Restriction of native forest development in SC state
Federal Law No. 9,605/98	"Environmental Criminal Law": the penalties for infraction of environmental restriction
CONAMA Resolution No. 261/99	The criteria of succession stage of littoral vegetation in SC state
CONAMA Resolution No. 302/02	Designation of APP in artificial lakes and its land use
CONAMA Resolution No. 303/02	Detail definition of vague point in Forest Code (width of river, city, littoral vegetation etc.)
CONAMA Resolution No. 317/02	Restriction of development to conserve endangered species in Atlantic Forest
CONAMA Resolution No. 317/06	The exemptions of restrictions about vegetation destruction in APP (public use, social profit, definition of low environmental impacts)
Federal Law No. 11,428/2006	Regulation of use and conservation of natural vegetation in Atlantic Forest
Federal Decree No. 5,975/2006	Restriction for development activity in the process of succession
Federal Decree No. 6,660/2008	The detail regulation of Federal Law No. 11,428

Source：Eletrobras, 2009. LEGISLAÇÃO AMBIENTAL DE INTERESSE DO SETOR ELÉTRICONÍVEL FEDERAL

7.3.3 Other Ecosystem or Wildlife which is Protected by Law

There are some more important legislation other than Conservation Units and Forest Code, such as the "Federal Law No. 7,653/67 (Animal Protection Law)" and "Normative Guideline of endangered plant species". The important legislations about important ecosystem and fauna and flora which are related to the master plan are shown in Table7.3.3.

Table7.3.3 Major Federal Legislations to Protect Valuable Ecosystem and Wildlife

Name of Law	Contents
Federal Law No. 5,197/67	Animal Protection Law: restriction of hunting of wildlife
Federal Decree No. 92,446/86	Designation of restriction of import and export of animal and plant species according to Washington Convention
Federal Law No. 7,679/88	Prohibiting fishery in reproductive period of fish
IBAMA Decree No. 1,522/89	The list of endangered species
IBAMA Normative No. 146/07	Norms for planning wildlife management (study, monitoring and conservation)
IBAMA Normative No. 168/08	Criteria of classification of wildlife use and management

Source：Eletrobras, 2009. LEGISLAÇÃO AMBIENTAL DE INTERESSE DO SETOR ELÉTRICONÍVEL FEDERAL

7.3.4 Other Ecosystem or Wildlife which is Not Protected by Law

There are other protected areas which are designated by State or Municipality, same category of Conservation Unit and original category. These category and restriction of protected area are based on federal category and restriction, and license is authorized by State or municipal government.

Figure 7.3.1 shows the distribution of conservation units in the Itajai River basin.

7.4 Indigenous People

According to the Federal Constitution, the lands originally occupied by the indigenous are now owned by the Union. In Item XVI of article 49, the Constitution determines that it is within the National Congresses power to authorize exploring and hydro resource use on Indigenous lands. In the terms explained in article 176, it is distinct property of the land and can be carried out under authorization from the Union in the interest of the nation.

The Constitution recognizes the Indians, their social organization, customs, languages, beliefs and traditions, and the original rights over the land they traditionally occupied and it is in the Unions to protect and respect all the aforementioned in accordance with Article 231, caput Federal Constitution.

According to Article 231, Item 3 in the Federal Constitution, the use of hydro resources on indigenous lands can only be carried out if authorized by the National Congress after having heard from the affected communities.

Besides the Federal Constitution, many other legal proceedings regulate the questions related to the indigenous people´s rights and demarcation of their land, such as:

- Law No. 6,001/73 and Decree No. 88,985/83 – outlines the Indian Statute, regulating the judicial situation for the Indians and their communities. The environmental protection actions that have taken place on indigenous lands and their surrounding area are destined to maintain the balance necessary for the survival of the indigenous people, physically and culturally.
- Directive FUNAI No. 422/89 – Creates the Environmental Service for Indigenous Lands - SEMATI
- Decree No. 1,141/94 – outlines the environmental, health and support protection actions for the productive activities in the indigenous communities.
- Decree No. 1,775/96 – outlines the administrative for the demarcation of indigenous lands.

The TI Ibirama-LA Klanô, located in the northeast region of the Itajai River basin, is inhabited by the Kaingang, Guarani and Xokleng Indian. They refer to themselves as the "Laklãnõ",which means “the Sun people.” The last census carried out by FUNAI in 1997 indicated that besides the total of 1,009 people living in the TI Ibirama, there are also 20 Xokleng families living on the outskirts of Blumenau, Joinville and Itajai. Also, according to the data from the Indigenous Missionary Council in 2005, there are 2,068 people currently living in TI.

Located along the Hercílio (the old Itajai do Norte) and the Plate, that mold the valleys in the Itajai-Açu basin, the TI Ibirama is about 260 km northeast of Florianopolis and 100 km east of Blumenau.

According to the FUNAI information, the TI Ibirama-LA Klanô had their land approval situation register in the Real Estate Registry Office (CRI) and the Secretary of the Union Patrimony (SPU) (1996), being reserved initially by the Decree No. 15 of 03.04.1926, with an area of approximately 20,000 ha, altered in 1952 according to the State Directory of Land and Colonization and the SPI. In 1956, a new measure showed the area to be 14,156 ha and in 1987, the limits were verified at 14,084 ha, approved in Decree without No.1,502.96.

The updated data in the Indigenous Missionary Council in 2005 points out that there are studies that search to expand the area to 37,000 ha. According to this data the judicial situation of the TI Ibirama has been declared in a directive by the Justice Ministry, MJ No. 1,128, August 13, 2003, published in the DOU No. 14.08.03.

The Itajai Açu river has always served a great importance for the nomad life of the TI Ibirama inhabitants, as it offers food (fish) and the possibility to travel to different regions, as well as other basic necessities. However, after colonization this subsistence base became scarce and obligated them to adapt to a different way of survival.

Still about the TI Ibirama population´s relationship with the Itajai River, its worth mentioning the construction of the barrage north of the Hercilio River (Itajai do Norte) from 1976 to 1980, which generated many conflicts with the indigenous people due to its proximity to the TI. The construction brought many changes to the life of the community. With the damming of the river, there was a loss of over 95% of the fertile area of the TI, which resulted in a direct intervention from a social organization due to the need to relocate families to higher regions in the TI. The population flow in the region was changed with the arrival of workers from different regions of the Country, which resulted in interethnic weddings and the entrance of non-indians into the TI.

The constructed area was set up by the FUNAI and the National Sanitation and Construction Department (DNOS). Furthermore, the construction began before the damages were given to the families whose land rights were broken, the beneficiaries of the lands natural resources.

Keeping in mind the negative impacts and the non-participation of the Xokleng in the damage negotiation process, the Indians pressured the FUNAI and the DNOS. The Indian leaders had the support of universities, non-governmental organizations (NGOs) and judicial help. The movement resulted in the signing of a pact between FUNAI and DNOS, which secured damage payments. At the time, only one part of the agreement was activated, creating internal conflicts with the indigenous communities as far as the distribution of resources and houses for the families who were benefited.

With the damage payment delays and the relocation to higher lands, where a small village called Bugio formed, there was a political reorganization of the group. The experiences increased the pressure against external governmental and non-governmental institutions, increasing the group´s representatives in these instances. Although there was an internal factionalism, the group united against external agents, the state government and FUNAI, who represented the non-indigenous society.

There were two invasions by the Indians into the North Barrage construction site. The first occurred in the 1990s, where the Indians stayed for one and half years, pressuring for the signing of the “Intentions Protocol” between the Regional Development Secretary, the DNOS, the FUNAI and the Federal Legal Board. The agreement took place in 1992. The document recognized the legitimacy claims that were made by the Indians and assumed the responsibilities

for carrying out the agreement. With the further construction delays from the damage payments, the Indians invade the barrage again in 1997, where they stay for more than a year. Only in October of 2006, the rest of the houses previously promised in the agreement were built.

In this way, considering the history of conflicts generated by the building of the north barrage, the demarcation of the land and the federal legislation, we do not recommend flood control measures around the TI Ibirama nor the implantation of any projects that could cause any direct or indirect impact to the life of the community.

It should be noted that, any project that is planned for this region should first be approved by the National Congress and should be subjected to a series of environmental studies of an anthropological nature

Preparatory Study for the Proposed Action
Prevention and Disaster Mitigation
Itajaí River Basin

ID	UNITS OF CONSERVATION STATE AND MUNICIPAL	Area (km²)
01	REBIO Estadual da Canela Preta	18.30
02	Parque Natural Municipal Nascentes do Garcia Inserido no PARNA Serra do Itajaí	46.72
03	RPPN Fazenda Pousada Serra Pitoco	7.07
05	REBIO Estadual do Sassafrás	37.85
06	Parque Natural Municipal Rio Fortuna	3.14
07	Parque Natural Municipal Araponguinhas	3.14
08	F.N. Ibirama	5.19
09	A.R.I.E. Serra das Abelhas - Rio da Prata	49.44
10	RPPN Reserva Bugerkopf inserido no PARNA Serra do Itajaí	0.86
11	Parque Natural Municipal São Francisco de Assis	2.95
12	RPPN Reserva Rio das Furnas	7.07
13	RPPN Chácara Edith	3.14
14	Parque Municipal Foz do Ribeirão Garcia	3.14
15	APA do Bateias	1.70
16	APA da Serra do Brilhante	17.52
17	APA Cedro Margem Esquerda	3.14
18	Parque Botânico do Morro do Baú	9.20
19	RPPN Bio Estação Águas Cristalinas	7.07
20	Parque Ecológico Spitzkopf	3.14
21	Parque Ecológico Municipal Rio Camboriú	3.14
22	Parque Ecológico das Quedas (a ser confirmada)	3.14
23	APA Cedro Margem Dereita	3.14
24	Parque Florestal Refúgio (a ser confirmada)	7.07
25	Parque Florestal Butner (a ser confirmada)	3.14
26	APA São Francisco de Assis	0.19
27	APA Ilhas Fluviais Rio Itajaí-Açu	3.14
30	Parque Cachoeira (a ser confirmada)	3.14
31	Parque Véu de Noiva	7.07
32	Parque da Canhanduba (a ser confirmada)	7.07
39	Parque Natural Municipal Grutas de Botuverá	7.07
40	Parque Natural Municipal Franz Damm	3.14
41	APA do Rio Itajaí Mirim Boutuverá Inserido no PARNA Serra do Itajaí	57.92
42	Reserva Ecológica do Bom Retiro	3.14
48	Terra Indígena de Ibirama	133.26
82	Reserva Ambiental Natureza Viva	3.14
83	Setor Campo dos Padres	52.05
84	Setor Chapadão do Lageado	136.15
85	Setor Serra da Moema	197.73
86	Setor Serra do Mar	24.89
S/N	Zona de Amortecimento, Livre Acesso ao Exercito Brasileiro	2.72
	TOTAL	891.03

ID	ATLANTIC FOREST	Area (km²)
01	Anitápolis	143.99
02	Serra Geral de Agrolândia	21.25
03	Serra do Pitoco	208.52
04	Timbó Grande	1326.08
	TOTAL	1699.84

ID	FEDERAL CONSERVATIONS UNITS	Area (km²)
01	P.N. da Serra do Itajaí	573.75
02	RPPN Lontra	1.11
03	F.N. Ibirama	5.32
04	A.R.I.E. Serra das Abelhas - Rio da Prata	50.14
05	RPPN CHÁCARA EDITH	1.07
06	RPPN RESERVA RIO DAS FURNAS	1.06
07	RPPN BIO ESTAÇÃO ÁGUAS CRISTALINAS	1.07
08	P.Ec ARTEX	1.12
09	RESERVA BURGERKOPF	1.11
10	FAZENDA POUSADA SERRA PITOCO	1.11
	TOTAL	636.86

LEGEND
- Major Cities
- Mountains
- Dam
- Major Rivers
- Tributary rivers
- Sub basins
- Atlantic Forest
- Units of conservations
- State and Muncipal
- Federal Conservations Units

Status of Highways
- Paved Road
- Highway Duplicate
- Road Bed Natural

Sistema de Projeção Coordenado:
Universal Transverse de Mercator
Falso Leste: 500.000
Falso Norte: 10.000.000
Meridiano Central: -51.00
Datum: SAD 1969
0 2.5 5 10 15 Km

Japan International Cooperation Agency

Map of Areas and Conservation Units
Itajaí River Basin

6

Sources: IBGE, STATES GOVERNMENT, IBAMA, FATMA Date: SEPT., 2010

Figure-7.3.1 Environment Conservation Unit in Itajai Basin

CHAPTER 8 FORMULATION OF THE MASTER PLAN FOR FLOOD MITIGATION

8.1 General

As described in Chapter 5, a master plan for flood disaster mitigation for the Itajaí River basin aims to hinder the concentration of flood runoff from various river basins taking into consideration the ongoing concept of comprehensive flood control measures in Japan. It is highly expected to hinder the concentration of flood runoff due to natural retarding effects by the lands subject to frequent flooding such as pasture, paddy and dry fields. “Flood control measures to scatter floods” should be given high priority for formulating the master plan by means of active use of flooding allowable lands above. The Itajaí River Basin Committee recommends the policy of “Living together with Flood” [1] and thus the “flood control measures to scatter floods” corresponds to this policy. However, when higher degrees of flood safety level are required such as for the 25-year and 50-year floods, only the method to scatter floods would be limited. In such case, structural flood control measures such as dyke, flood diversion channel and flood control dam would be added for comparative study as flood control alternatives.

Flood control measures are usually selected and justified in combination with various measures. Along this line, various flood control alternative measures are herein proposed for the comparative study under the Preparatory Study, fully considering regional flood control needs and flooding characteristics of the Itajaí River. In the Itajaí River basin, major cities are located along the mainstream and its major tributaries, where development of residences and commercial facilities has been in progress. Municipal governments in the basin are already aware of how difficult it is to implement structural measures such as widening of the rivers in the populated urban area, and therefore, an introduction of the non-structural measures such as strengthening of the existing FFWS is to be studied in addition to the introduction of natural retardation basins.

8.2 Selection of Cities for Flood Protection

Flooding and inundation resulting from floods are occurring in the regions of along the Itajaí River and its tributaries. It is considered unrealistic from economical and financial point of view to implement a flood control project for protecting the whole areas subject to habitual flooding and inundation in the Itajaí River basin. The Itajaí River Basin Committee showed the same opinion.

The river improvement project by dykes tends to become costly due to drastic increase of flood discharges in the downstream reaches resulting from the upstream river improvement works by dykes. To avoid such an increase of project cost, the areas with low flood damage potential along the river such as pasture, paddy and dry fields should be actively remained in the current condition, intentionally no dykes provided for protection. From this point of view, target areas subject to flood protection shall be major cities along the Itajaí River.

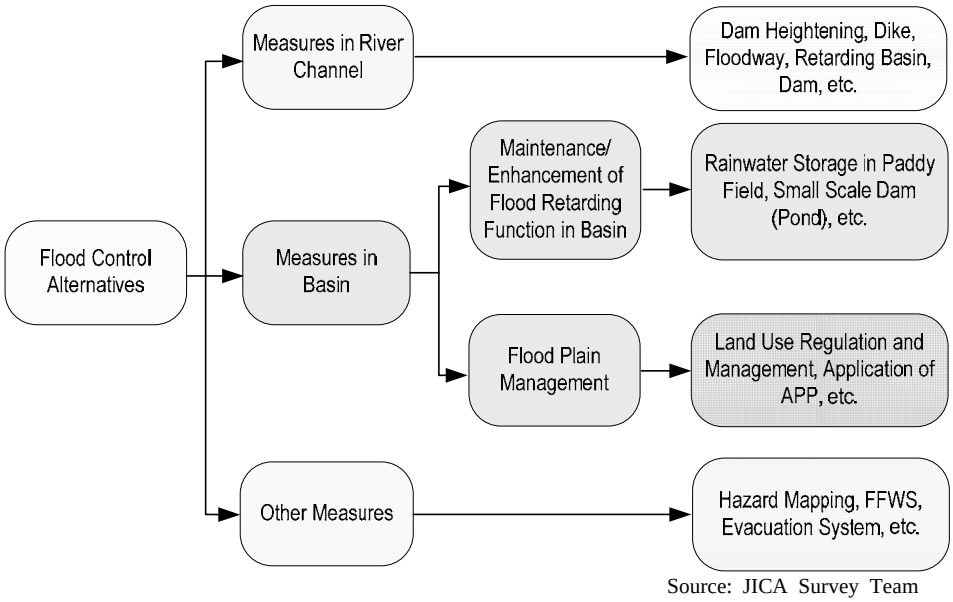
As explained in subsection 3.3.1, eight cities were selected as higher priority for flood disaster mitigation based on the consideration of the frequency and damages caused by floods (see Tables 3.3.1 and 3.3.2) and the results of various visits and interviews to municipal governments (see Table 5.1.1). The selected cities are Rio do Sul, Blumenau, Gaspar, Ilhota, Timbó, Taió, Itajaí and Brusque cities.

[1] Beate Frank, Adilson Pinheiro (organizers), Floods in Itajaí Basin: 20 years of experience), Blumenau 2003, Chapter 9 A Formalization of Flood Management within the Sphere of Itajaí River Basin

As for the measures for the flush flood, urban streams in Blumenau city (Garcia and Velha Rivers) were selected as the target river, where urban developments on the hill slope together with residential development along the stream have been in progress in recent years, resulting in an increase of damage potential due to flush floods. In addition, Itajaí city located at the river mouth of the Itajaí River was also selected, where there are flooding affected by the backwater of the Itajaí mainstream and flood inflow from the Itajaí Mirim River.

8.3 Selection of Flood Control Alternatives

Taking into consideration the current condition of river canal, flood inundation situation and topographic conditions, various alternatives of flood control measure that would be applicable to the Itajaí River basin are proposed as listed below.



Source: JICA Survey Team

Figure 8.3.1 Flood Control Alternatives Applicable to Itajai River Basin

The proposed alternatives are outlined below.

8.3.1 Measures in River Channel (Structural Measures)

(1) Heightening of Existing Flood Control Dams

As described in sub-section 3.2.2, there are currently three flood control dams on the Itajaí River (see Table 3.2.5 for dam features). Among the dams, the Norte dam constructed in 1992 has the largest flood control capacity of 357 million m^3. No overflowing through the spillway due to large floods has so far occurred. On the other side, overflows have occurred in several times at both the Sul and Oeste dams in times of the medium-sized flood inflow.

For both the Oeste and Sul dams, reinforcement to increase flood control capacity is contemplated by means of the following measures:

i) Oeste Dam: Heightening of the existing dam body and spillway
ii) Sul Dam: Heightening of the existing spillway

As for the Sul dam of a rock fill type, heightening of the existing spillway is examined because of its technical difficulty to heighten the dam body. By this reinforcement of two dams, flood control effect (reduction of the flood peak discharge) would be expected in Rio do Sul city as well as downstream major cities along the Itajaí River.

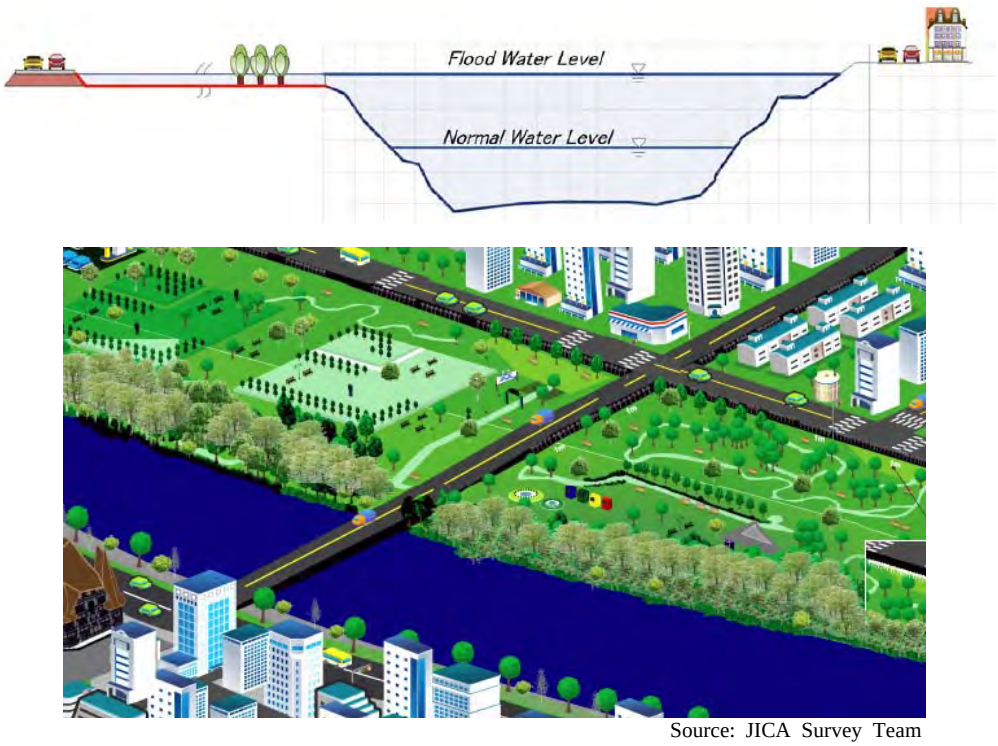
Spillway at the Oeste dam

Spillway at the Sul dam

(2) Dykes (River Improvement)

In order to increase the current flow capacity of river channel, river widening and riverbed excavation are most commonly applied for flood control projects. In the flood control master plan formulated by JICA in 1988, widening and riverbed excavation of river channel were proposed in the stretches between Blumenau and Gaspal cities in the Itajaí River. However, these measures are not to be applied as much as possible for the Itajaí mainstream under the current Study. Nevertheless, river widening with provision of composite section preserving the existing riparian forest is included in the flood control alternatives, because it is inevitably required to increase the current flow capacity when the higher flood safety level is required.

Figure 8.3.2 illustrates the image of composite section of the Itajaí River. As shown in the figure, when the composite section is applied to river widening, the current riparian forest shall be preserved to be used as a park and open space. Furthermore, the existing road shall be utilized as dyke (including raising of road) or proposed new road to be used as dyke. In this connection, the current river channel forms a low-water channel of the composite section.



Source: JICA Survey Team

Figure 8.3.2 Illustration of Composite Section in Blumenau City

(3) Floodway

The flood control master plan in 1988 proposed a floodway to divert part of the large flood discharge of the Itajai River to the Atrantic Ocean crossing Navegantes city from immediately

downstream reaches of the bridge of BR 101, considering that it was very difficult to widen the river channel and provide dykes on the both banks to increase the flow capacity to pass the flood. The floodway is added as the flood control alternative, because it is expected to reduce the depth and duration of flood inundation that is likely to occur widely over the alluvial plain spreading from Gaspar city.

(4) Ring Dyke

Various cities have been developed along the banks of Itajaí River. Obviously, potential of flood damages has become large at major urban areas where the main assets are concentrated. Ring dyke is also added into the flood control alternatives to the urban areas where river widening by composite section might be difficult due to urbanization. This is based on the priority to protect the urban areas from overflowing from river channel in times of flood.

(5) New Flood Control Dam

Only the natural retarding effects in paddy fields and cultivated lands might be limited for controlling the floods safely in the cities of Blumenau and Brusque, when it is required to increase the safety level against the floods. Therefore, a new flood control dam in the upstream river basin is added to the flood control alternatives.

8.3.2 Measures in River Basin

(1) Water Storage in Paddy Field

The area of paddy fields by municipality in the Itajaí River basin is summarized in the table below. Although the total paddy area is 26,295 ha, the paddy area in the Itajaí Mirim River basin is not included because the farmers in the Itajaí Mirim River basin are not the corporation member of CRAVIL. CRAVIL has a plan to build water storage in the existing paddy fields to store rainfall water in the existing paddy fields covering the area of 22,000 ha, which is equivalent to around 80% of the total paddy area. Out of the paddy fields, 20% of the area is irrigated by small tributary rivers, and 80% is the rainfed paddy (including pumping up of river water), which is the target area for water storage project.

Table 8.3.1 Paddy Fields in the Itajai River Basin

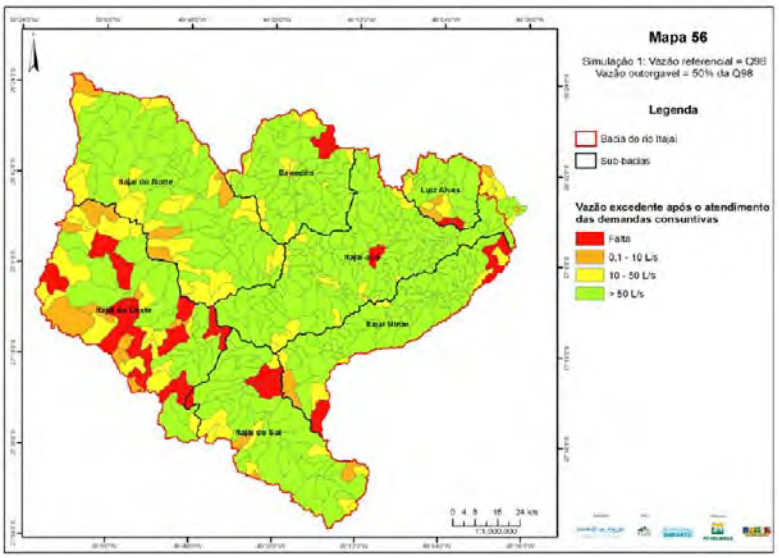
Upper Itajai Valley		Middle and Lower Itajai Valley	
City	**Area (ha)**	**City**	**Area (ha)**
Agronomica	360	Ascurra	567
Agrolandia	260	Brusque	170
Alfredo Wagner	155	Benedito Novo	300
Ibirama	70	Dr. Pedrinho	808
Lontras	100	Gaspar	3,400
Mirim Doce	1,850	Indaial	250
Pouso Redondo	2,045	Ilhota	3,000
Presidente Getuilo	65	Itajai	2,400
Rio do Campo	1,800	Luis Alves	558
Rio do Sul	300	Navegantes	1,200
Rio do Oeste	1,600	Rio dos Cedros	1,100
Salete	100	Rodeio	617
Taio	2,400	Timbo	700
Trombuto Central	80		
Vitor Meirelis	40		
Sub-total	**11,225**	**Sub-total**	**15,070**
Total			**26,295**

Source : CRAVIL

According to the plan, the furrow in paddy field with the average height of 10 cm is to be raised by 20 cm. At the maximum, 66 million m^3 of rainfall is expected to be stored in the water storage.

(2) Basin Storage (Small Dam)

Small dam is planned to be installed on small tributary rivers as basin storage. The stored water is to be utilized for irrigation on the micro basin basis. Selection of small dam sites shall be given high priority to micro basins in the Itajai do Oeste and Sul Rivers as shown below.



Source : Itajai River Basin Committee

Figure 8.3.3 Micro Basin of Water Shortage for Irrigation in the Itajai River Basin

8.4 Flood Control Planning by Flood Protection Level (Safety Level)

8.4.1 Protection for the 5-year Flood

(1) Flood Discharge and Flow Capacity

Figure 8.4.1 shows the distribution of 5-year flood discharge and flow capacity at major cities under the present condition (without flood control measures). As is apparent from the figure, the flow capacity is smaller than the 5-year flood discharge only at Rio do Sul (Itajai River mainstream and Itajai do Oeste River)and Itajai cities (Itajai Mirim River).

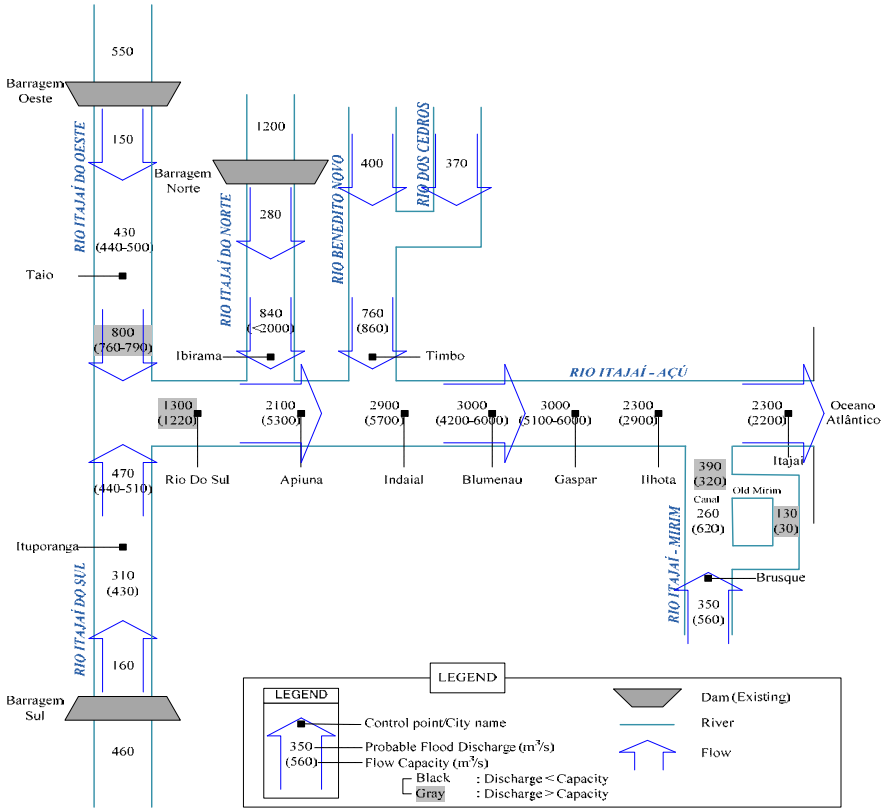
(2) Basic Approach for Planning

Priority is given to the alternative measures in river basin such as water storage in paddy fields and small dam in micro basin, followed by effective utilization of the existing flood control dams. These alternatives are considered small impact on natural and social environments.

(3) Flood Control Planning

a. Water storage in paddy field

The flood control effect of water storage in paddy field is expressed as an initial loss of rainfall. The rainfall volume to be stored is converted the initial rainfall loss by dividing the catchment area of its sub-basin where the paddy field is located (see Figure 3.5.4). Table 8.4.1 shows the calculated initial rainfall loss due to water storage in paddy field for each sub-basin in the flood runoff simulation model. The initial rainfall loss are as small as less than 1 mm in the Itajai do Sul and Itajai do Norte River basins with little paddy fields, as large as 10 to 20 mm for the Itajai do Oeste (Basin 1 in Table 8.4.1) and Itajai River mainstream (Basins 9, 10 and 12).



Source: JICA Survey Team

Figure 8.4.1 Distribution of 5-year Flood Discharge and Flow Capacity by City under Present Condition

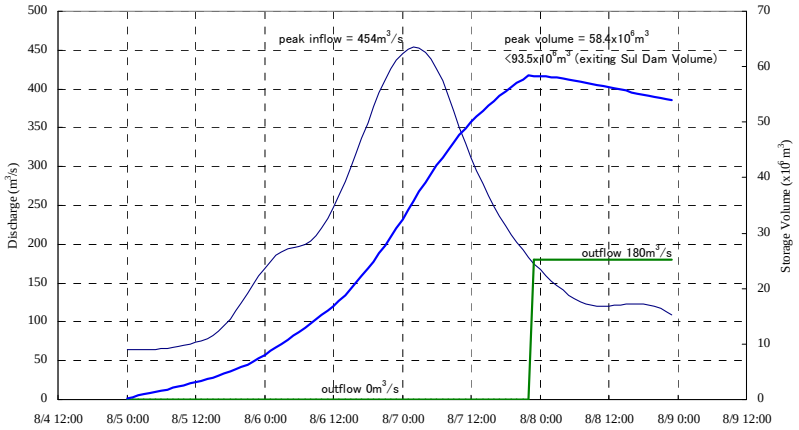
Table 8.4.1 Initial Rainfall Loss due to Water Storage in Paddy Field by Sub-basin

Sub Basin		Catchment Area	Municipality	Paddy Area	Depth	Rate of using	Storage		Initial Loss
		km²		ha	cm	Rainwater	m³		mm
Itadai do Oeste	Barragem Oeste	1042	**Rio do Campo**	1,800	20	0.8	2,880,000	2,880,000	2.8
	Basin 1	528	**Mirim Doce**	1,850	20	0.8	2,960,000	6,960,000	13.2
			Taio	2,400	20	0.8	3,840,000		
			Salete	100	20	0.8	160,000		
	Basin 2	1445	**Agrolandia**	260	20	0.8	416,000	7,192,000	5.0
			Pouso Redondo	2,045	20	0.8	3,272,000		
			Agronomica	360	20	0.8	576,000		
			Rio do Oeste	1,600	20	0.8	2,560,000		
			Trombuto Central	80	20	0.8	128,000		
			Rio Do Sul	150	20	0.8	240,000		
Itajai do Sul	Barragem Sul	1273	**Alfredo Wagner**	155	20	0.8	248,000	248,000	0.2
	Basin 4	381	**Rio do Sul**	150	20	0.8	240,000	240,000	0.6
Itajai do Norte	Basin 5	1023	**Ibirama**	70	20	0.8	112,000	280,000	0.3
			Presidente Getuilo	65	20	0.8	104,000		
			Vitor Meirelis	40	20	0.8	64,000		
Benedito	Rio Benedito	831	**Benedito Novo**	300	20	0.8	480,000	2,332,800	2.8
			Dr. Pedrinho	808	20	0.8	1,292,800		
			Timbo	350	20	0.8	560,000		
	Rio dos Cedros	600	**Rio dos Cedros**	1,100	20	0.8	1,760,000	2,320,000	3.9
			Timbo	350	20	0.8	560,000		
Itajai Acu	Basin 6	906	**Lontras**	100	20	0.8	160,000	160,000	0.2
	Basin 7	556	**Ascurra**	567	20	0.8	907,200	2,294,400	4.1
			Indaial	250	20	0.8	400,000		
			Rodeio	617	20	0.8	987,200		
	Basin 9	349	**Gaspar**	3,400	20	0.8	5,440,000	5,440,000	15.6
	Basin 10	227	**Ilhota**	3,000	20	0.8	4,800,000	4,800,000	21.1
	Luiz Alves	580	**Luis Alves**	558	20	0.8	892,800	892,800	1.5
	Basin12	176	**Navegantes**	1,200	20	0.8	1,920,000	3,840,000	21.8
			Itajai	1,200	20	0.8	1,920,000		
Itajai Mirim	Basin11	472	**Itajai**	1,200	20	0.8	1,920,000	1,920,000	4.1
	Itajai Mirim	1207	Brusque	170	0	0.8	0	0	0.0
Sum		11596		26,295				41,800,000	

Source: JICA Survey Team

b. Change of the current dam operation method at the Sul dam

As the Sul dam has a larger storage capacity against the flood inflow compared to the Oeste dam, the inflow of 5-year flood is able to be fully stored in the reservoir with closure of all the gates. As shown in Figure 8.4.2, the stored volume is 58.4 x10^6m^3, which is within its storage capacity 93.5 x10^6m^3. According to DEINFRA, almost no overflowing from the spillway has occurred to date except the large floods in 1983 and 1984. As for the 5-year flood, the current dam operation method shall be changed to close all of the gates. In this connection, however, heightening of dam would be required because this change of dam operation method might increase the risk of overflowing through the spillway in times of large floods.



Remark: After the peak of flood, gates are opened in order when the flood inflow decreases to be 180m^3/s, which is sufficiently smaller than the current flow capacity in the downstream river channel.

Source: JICA Survey Team

Figure 8.4.2 Proposed Dam Operation against 5-year Flood at Sul Dam

c. Basin storage (small dam)

The results of flood runoff simulation showed that even if the 5-year flood at the Oeste dam is fully stored in the reservoir with closure of all gates, its effect for decreasing the flood discharge in the downstream stretch of Itajai do Oeste River near Rio do Sul city is small due to its 80 km long river length from the dam to the city and gentle river slope of 1/5,000. Moreover, the effect of water storage in paddy field is also limited, and therefore small dam is examined.

Since the current flow capacity at the stretch of Itajaí do Oeste River is 760m^3/s against the 5-year flood discharge of 800m^3/s, the lack of flow capacity is 40m^3/s. The required storage volume of small dam is estimated to be around 8,140,000m^3 to increase the flow capacity by 40m^3/s in this river stretch (detailed in the Supporting Report No.2 Flood Control Plan). Selection of the candidate location of small dams is necessary for detailed topographic maps with a scale of 1:10,000, mapping of which is under preparation by SDS. The site selection was made based on the available maps of 1:50,000 as shown in Figure 8.4.3 and the storage capacity of small dam are as follows:

Table 8.4.2 Required Storage Capacity of Small Dams for 5-year Flood

Candidate location	Trombudo River	Braço do Trombudo River
Catchment area	294 km^2	117 km^2
Storage capacity	5,830,000 m^3	2,310,000 m^3

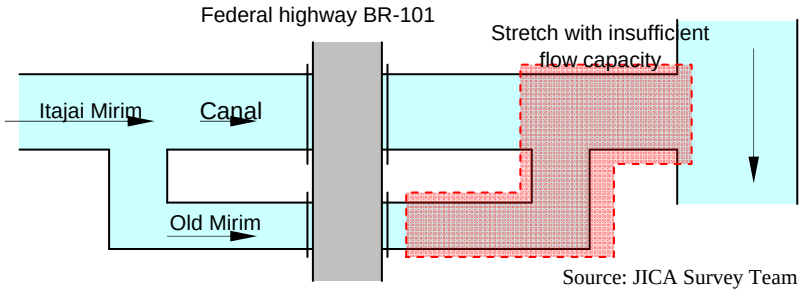
Source: JICA Survey Team

Source: JICA Survey Team

Figure 8.4.3 Location Map of Small Dams（5-year Flood Level）

d. Itajaí Mirim River

The Itajaí Mirim River branches into two rivers; the old Mirim River and the Canal in the upstream area of Itajaí city, and these two rivers joins each other approximately 1 km upstream of the confluence to the Itajaí River as illustrated in Figure 8.4.4. As shown in the figure, river stretches of small flow capacity less than the 5-year flood discharge are from the federal highway BR 101 to the junction with the Canal along the old Mirim River and from the junction to the confluence with the Itajai River along the Canal. Other stretches along the Canal have larger flow capacity.



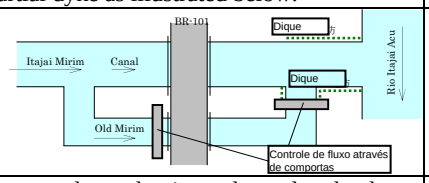
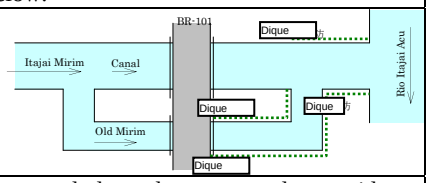
Source: JICA Survey Team

Figure 8.4.4 Stretches of Smaller Flow Capacity than 5-year Flood Discharge along the Itajai Mirim River

As shown in Table 8.4.3, comparative study was carried out for two alternatives for the less flow capacity stretches. They are the “two flood gates with partial dyke” and “full dyke along the stretches”. As a result, the “two flood gates with partial dyke” was selected from the aspects of cost and social impacts to be associated in the populated urban area along the stretches. Two flood gates are planned at locations of both upstream and downstream of the old Mirim River as shown in this table. The upstream flood gate would control the flood inflow into the old Mirim River within its flow capacity in times of flood and the downstream gate would control the influence due to back water of the Itajai River mainstream.

The general features of both flood gates are summarized in Table 8.4.4. (as described in the succeeding sub-sections, the “two flood gates with partial dyke” were proposed for all of the probable floods. Therefore, the height of gates and partial dyke is also indicated in this table).

Table 8.4.3 Comparison of Flood Control Alternatives in the Itajai Mirim River for the 5-year Flood

Aspect	Two Flood Gates with Partial Dyke	Full Dyke
Outline	To protect the populated urban area along the less flow capacity stretches with provision of two flood gates and 1 km long partial dyke as illustrated below.	To protect the populated urban area along the less flow capacity stretches with provision of full dyke system as illustrated below.
Layout		
Project Cost	Apparently predominant due to less land acquisition	Apparently less advantageous due to wide area for land acquisition and replacement of existing seven bridges to be required
Impact to Social Environment	Small social impact due to few residences to be reallocated	Large social impact due to many residences to be reallocated
Impact to Natural Environment	Although no significant impacts might occur, some influence due to temporal inundation during the closure of flood gates shall be noted.	No significant impacts.
Evaluation	Appropriate as a plan to be adopted	Inappropriate as a plan to be adopted due to significant social impacts and disadvantage in cost to be required

Source: JICA Survey Team

Table 8.4.4 General Features of Flood Gates and Dyke per Protection Level

Flood Protection Level		5-year flood	10-year flood	25-year flood	50-year flood
Upstream Flood Gate	No. of Gate	4 nos.			
	Gate Width	10 m			
	Gate Height	4.1 m	4.5 m	4.9 m	5.3 m
	Total width	61 m			
Downstream Flood Gate	No. of Gate	4 nos.			
	Gate Width	10 m			
	Gate Height	3.0 m	3.3 m	3.6 m	4.0 m
	Total width	61 m			
Dyke Height*	Left bank	0.6 m	0.8 m	1.3 m	1.7 m
	Right bank	1.0 m	1.3 m	1.7 m	2.1 m

Remarks: The dyke height is based on the ground elevation at the river section IMa surveyed under the JICA Survey.
Source: JICA Survey Team

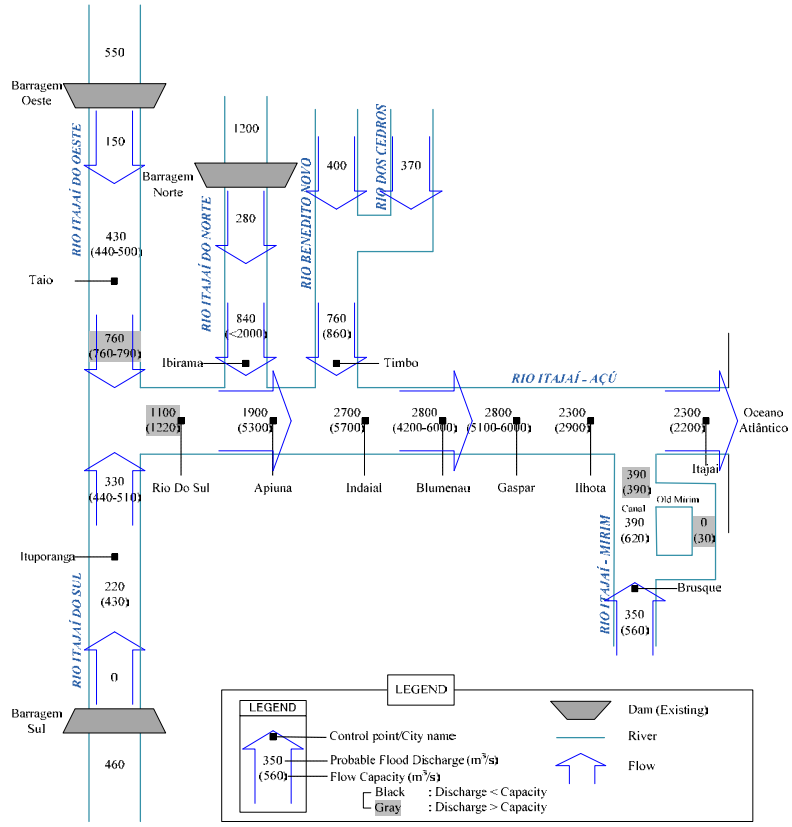
(4) Flood Discharge after the Proposed Plan

Figure 8.4.5 shows the distribution of 5-year flood discharges after implementation of the proposed flood control plan above. It is to be noted that the flood discharges in the figure is based on the conditions that the existing wide flood plain along the Itajai River from Gaspar to Itajai cities is preserved without any development.

8.4.2 Protection for the 10-year Flood

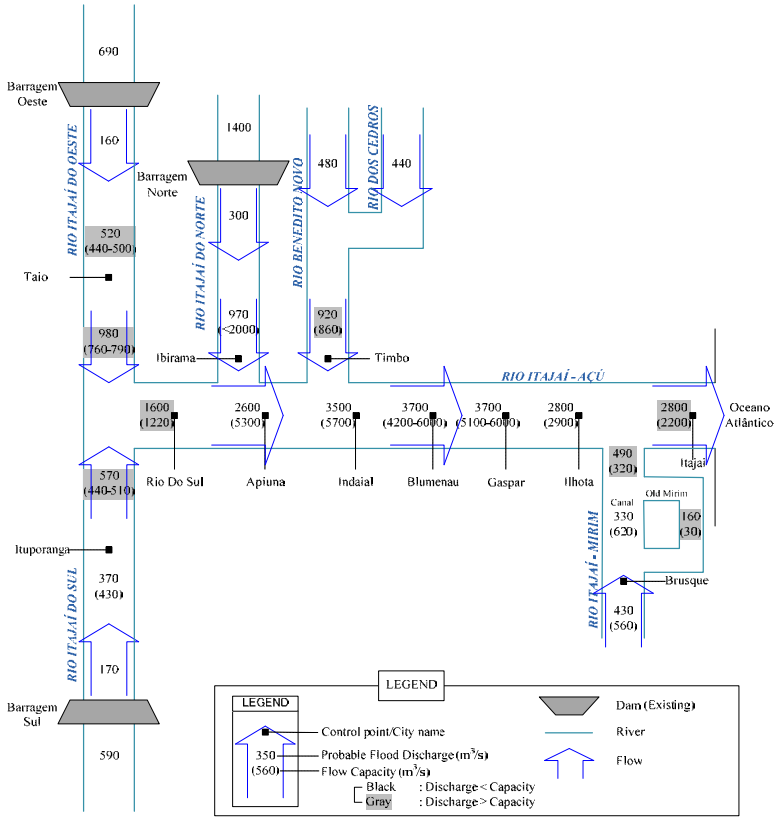
(1) Flood Discharge and Flow Capacity

Figure 8.4.6 shows the distribution of 10-year flood discharge and flow capacity at major cities under the present condition. As indicated in the figure, cities having smaller flow capacity than the 10-year flood discharge are Taio, Rio do Sul (Itajai River mainstream, Itajai do Oeste and Itajai do Sul Rivers) and Itajai cities (Itajai River mainstream and Itajai Mirim River).



Source: JICA Survey Team

Figure 8.4.5 Distribution of 5-year Flood Discharge and Flow Capacity by City for Flood Control Plan



Source: JICA Survey Team

Figure 8.4.6 Distribution of 10-year Flood Discharge and Flow Capacity by City under Present Condition

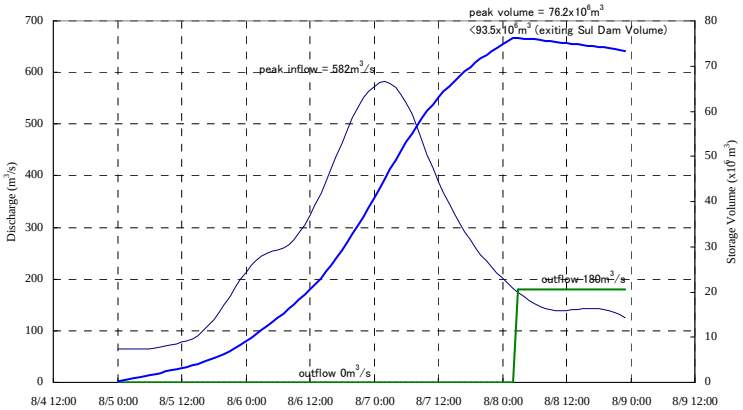
(2) Basic Approach for Planning

Same as the flood control planning for the 5-year flood, priority is given to the alternative measures in river basin such as water storage in paddy fields and basin storage (small dam), followed by effective utilization of the existing flood control dams. As for the Itajai Mirim River and water storage in paddy field, the same measures for the 5-year flood are applied to the 10-year flood.

(3) Flood Control Planning

a. Change of the current dam operation method at the Sul dam

The inflow of 10-year flood is able to be fully stored in the reservoir with closure of all the gates at the Sul dam. As shown in Figure 8.4.7, the stored volume is 76.2 x10^6 m^3, which is within its storage capacity 93.5 x10^6 m^3. As mentioned in preceding sub-section, heightening of dam would be also required because this change of dam operation method might increase the risk of overflowing through the spillway in times of large floods.



Remark: After the peak of flood, gates are opened in order when the flood inflow decreases to be 180m^3/s, which is sufficiently smaller than the current flow capacity in the downstream river channel.

Source: JICA Survey Team

Figure 8.4.7 Proposed Dam Operation against 10-year Flood at Sul Dam

b. Change of the current dam operation method at the Oeste dam

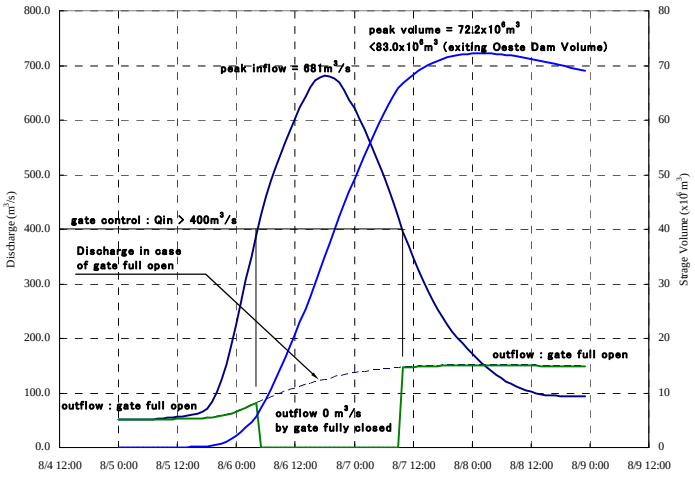
Overflowing from the spillway has occurred in several times to date at the Oeste dam, as the Oeste dam has a smaller storage capacity compared to the Sul dam. However, the 10-year flood is able to be controlled with full opening of gates when the flood inflow exceeds 400 m^3/sec to avoid inundation in Taio city located immediately downstream of the dam. As shown in Figure 8.4.9, the stored volume is 72.2 x 10^6 m^3, which is within its storage capacity 83.0 x 10^6 m^3. Same as the Sul dam, heightening of dam would be also required to reduce the increased risk of overflowing due to the change of dam operation method.

c. Utilization of the existing hydropower generation dams for flood control

To overcome the lack of flow capacity is 50m^3/s in Timbó city, utilization of the existing two hydropower generation dams for flood control was contemplated, which is belong to CELESC and located in the upstream Rio dos Cedros River. Along this line, pre-releasing of the stored water was studied considering the fact that both municipal governments of Rio dos Cedros and Timbó cities expect to lower the reservoir operation level of two dams[2]. As illustrated in Figure

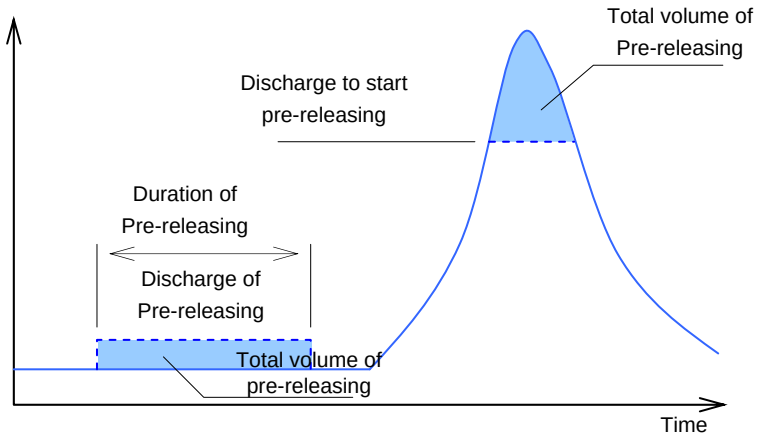
[2] The petition containing the signatures of 1,200 local residents was submitted to the State Government in June 2010, requiring for lowering the reservoir water level by pre-releasing.

8.4.9, the pre-releasing discharge, total water volume for pre-releasing, duration of pre-releasing, and discharge for starting the pre-releasing shall be studied and then determined. The study is detailed in the Supporting Report No.3 Flood Mitigation Plan. The study results proposed the operating reservoir water level would be lowered by 80 cm for the Pinhal dam and 70 cm for the Rio Bonito dam.



Source: JICA Survey Team

Figure 8.4.8 Proposed Dam Operation against 10-year Flood at Oeste Dam



Source: JICA Survey Team

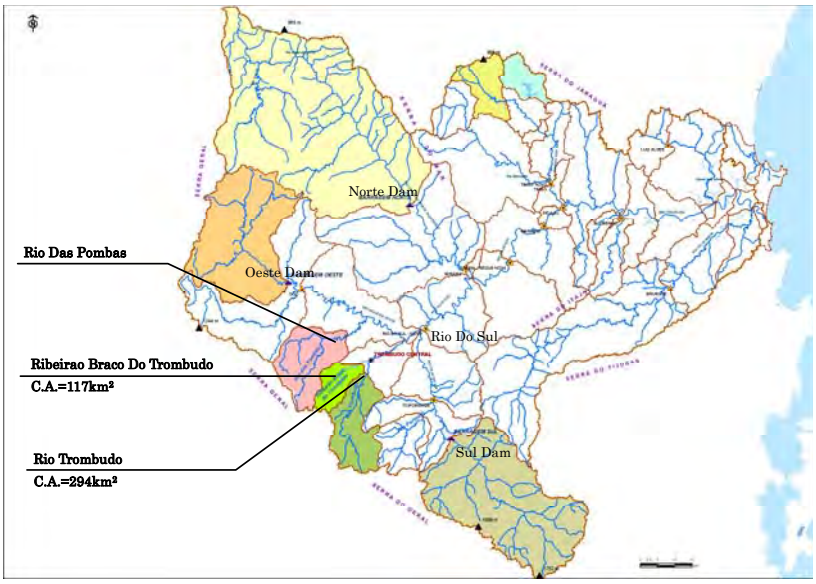
Figure 8.4.9 Schematic Diagram of Dam Operation through Anticipated Discharge

d. Comparison study on flood control alternatives for Rio do Sul City

Even if the change of dam operation method at both the Sul and Oeste dams as well as water storage in paddy field are provided, there remains lacks of flow capacity of 180m^3/s in the Itajai River mainstream in Rio do Sul city and 150 m^3/s in the Itajai do Oeste River, requiring further flood control measures. Three alternatives; i) small dam, ii) retarding basin, and iii) river widening of downstream reaches of Rio do Sul city were compared. River widening aims at increasing of the current flow capacity in Rio do Sul city by means of lowering the flood water level in the downstream reaches. The comparison is outlined below.

1) Basin Storage (Small dam)

The required storage volume of small dam is estimated to be around 27,550,000 m^3 to increase the flow capacity in Rio do Sul city. Figure 8.4.10 shows the location map of candidate dam sites and the required storage capacity of small dams are as follows:



Source: JICA Survey Team

Figure 8.4.10 Location Map of Small Dams（10-year Flood Level）

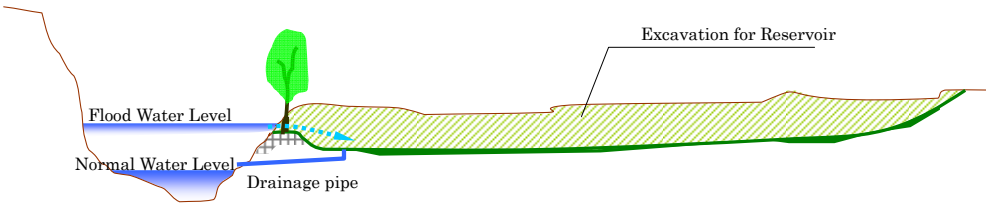
Table 8.4.5 Required Storage Capacity of Small Dams for 10-year Flood

Candidate Location	Trombudo River (2 dams)	Braco do Trombudo River (1 dam)	Rio das PombasRiver (2 dams)
Catchment area	294 km^2	117 km^2	315 km^2
Storage capacity	11,160,000 m^3	4,420,000 m^3	11,970,000 m^3

Source: JICA Survey Team

2) Retarding basin

Retarding basin was planned immediately upstream of Rio do Sul city. As illustrated in Figure 8.4.11, retarding basin is constructed by excavation widely on the river bank. A part of flood would be laterally overflowed into the retarding basin.



Source: JICA Survey Team

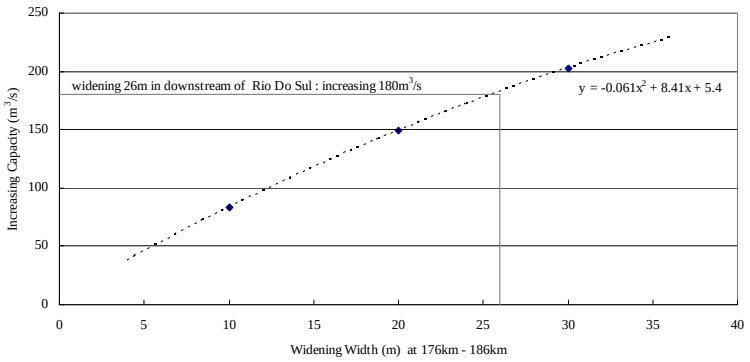
Figure 8.4.11 Illustration of Retarding Basin on River Bank

From the site inspection, possible wide areas for retarding basin are near Agronômica city along the Trombudo River and stretch between the cities of Laurentino and Rio do Sul along the bItajaí do Oeste River. As the result of runoff calculation, the required storage volume of retarding basin is 15,400,000 m^3. As the bottom elevation of retarding basin shall be set at the higher elevation than the average river water level, the maximum depth of retarding basin is around 3 m. Therefore, it is necessary to acquire widely the lands of at least of 513 ha to ensure the required volume.

3) River widening of downstream reaches of Rio do Sul city

Due to the gentle riverbed gradient of the Itajai River and the backwater from its downstream reaches, significant effect of lowering the flood water level would not be obtained by widening of the current river channel in Rio do Sul city. Therefore, river widening in the 10 km long downstream reaches from Rio do Sul city is planned to lower the flood water level in the city

due to its backwater effect, resulting in an increase of the current flow capacity in the city. Figure 8.4.12 presents the relationship between the width of river widening in the downstream reaches and the expected increase of flow capacity in Rio do Sul city. As indicated in this figure, it is necessary to widen the river channel by 26 m to increase the current flow capacity by 180 m^3/sec, which is equivalent to the lack of flow capacity against the 10-year flood.



Source: JICA Survey Team

Figure 8.4.12 Relationship between Width of River Widening in the Downstream Reaches and Expected Increase of Flow Capacity in Rio do Sul City

4) Comparison result of alternatives

As a result of comparison of three alternatives above, flood control plan by basin storage (small dam) is apparently advantageous from the following factors:

i) The retarding basin plan needs a large scale of excavation. The required cost of such excavation is extremely high associating the issues of spoil bank areas. Moreover, it might be difficult to acquire the extensive area for retarding basin as large as around 523 ha.

ii) The river widening plan requires huge excavation volume of 2,600,000m^3, resulting in a high construction cost. There is also the problem of spoil bank areas for excavated materials.

iii) The plan of 5 small dams would create the storage volume of approximately 28,000.000m^3 with provision of agricultural use of the stored water, allowing to store a great volume of water with a relatively low cost.

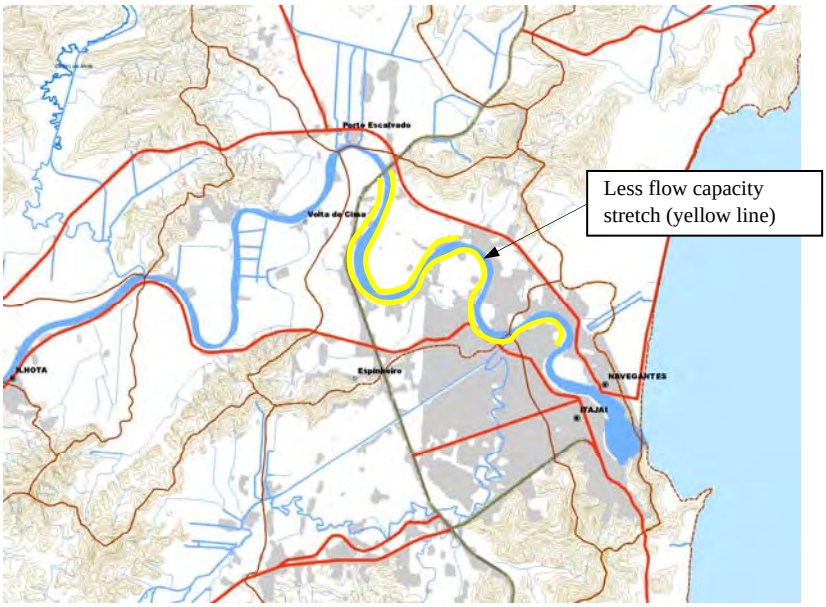
e. Itajai Mirim River and Itajai River mainstream near Itajai city

1) Itajai Mirim River

Same as the plan for the 5-year flood, the two flood gates with partial dyke was proposed. The general features are shown in Table 8.4.4.

2) Itajai River mainstream

Figure 8.4.13 shows the river stretches of less flow capacity against the 10-year flood in the lower reaches of Itajai River. Comparative study was carried out for two alternatives for the less flow capacity stretches; the “lateral dyke (only on the right bank to protect Itajai city)” and a “new floodway”. As indicated in the comparison result of Table 8.4.6, the lateral dyke plan is advantageous in view of the required cost. In case of the lateral dyke, natural retarding effect in the inundation area on the left bank from the federal highway BR-101 to Navegantes city and thus no negative impact to the upstream stretches might occur because no flood water level might increase due to the lateral dyke.



Source: JICA Survey Team

Figure 8.4.13 River Stretche of Less Flow Capacity along the Itajai River for the 10-year Flood

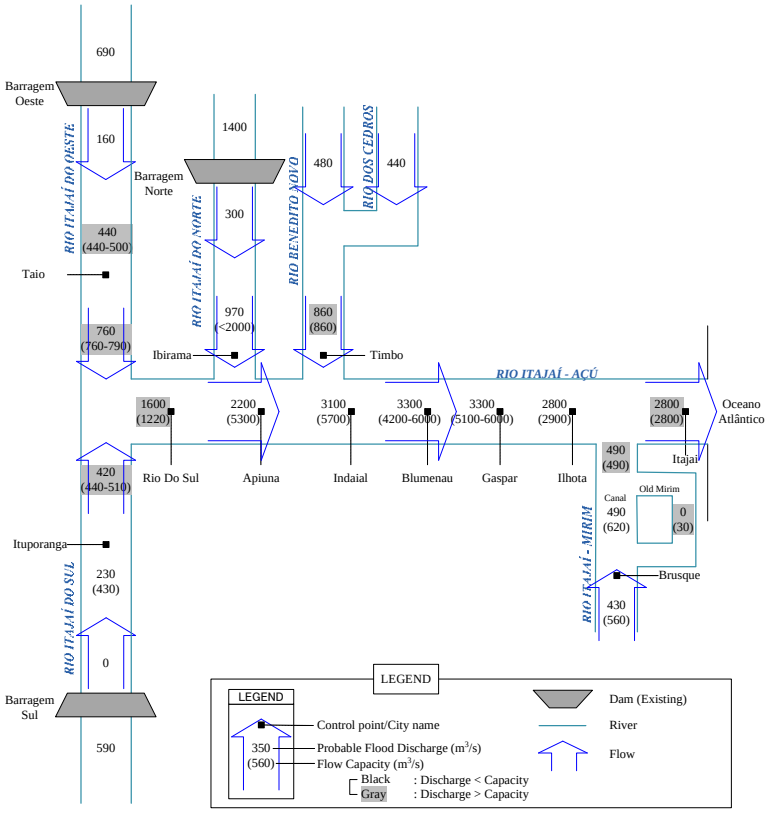
Table 8.4.6 Comparison of Flood Control Alternatives in the Itajai River Mainstream for the 10-year Flood near Itajai City

Aspect	Lateral Dyke	New Floodway
Outline	To install the lateral dyke on the right bank to protect Itajaí city and to preserve the left bank as retarding basin	To install a new floodway immediately downstream of BR-101 to divert the discharge exceeding the flow capacity directly the sea in Navegantes city
Project Cost	Construction cost and land acquisition cost: R$ 171,000,000. The land acquisition cost in the urban area is high, but the project cost is smaller than the floodway.	Construction cost and land acquisition cost: R$ 273,000,000. As a diversion weir is required on the Itajaí river to regulate the discharge in the Itajaí river, the project cost becomes huge.
Impact to Social Environment	Large impact because of relocation of residences in the urban area	Large impact because of separation of Navegantes city by the floodway
Impact to Natural Environment	No significant impact might occur.	Significant impact might occur. Many impacts such as sedimentation at the outlet and the salt water intrusion shall be studied.
Evaluation	Despite large social impact, it is more advantageous than the floodway plan from the cost and natural environment points of view.	It is inferior to the lateral dyke plan from the cost and natural environmental impact points of view.

Source: JICA Survey Team

(4) Flood Discharge after the Proposed Plan

Figure 8.4.14 shows the distribution of 10-year flood discharges after implementation of the proposed flood control plan above. It is to be noted that the flood discharges in the figure is based on the conditions that the existing wide flood plain along the Itajai River from Gaspar to Itajai cities is preserved without any development.



Source: JICA Survey Team

Figure 8.4.14 Distribution of 10-year Flood Discharge and Flow Capacity by City for Flood Control Plan

8.4.3 Protection for the 25-year Flood

(1) Flood Discharge and Flow Capacity

Figure 8.4.19 shows the distribution of 25-year flood discharge and flow capacity at major cities under the present condition. As indicated in the figure, cities having smaller flow capacity than the 25-year flood discharge are Taio, Rio do Sul (Itajai River mainstream, Itajai do Oeste and Itajai do Sul Rivers), Timbó, Blumenau, Ilhota, and Itajai cities (Itajai River mainstream and Itajai Mirim River).

(2) Basic Approach for Planning

Same as the flood control planning for the 10-year flood, priority is given to the alternative measures in river basin such as water storage in paddy fields and basin storage (small dam), followed by effective utilization of the existing flood control dams.

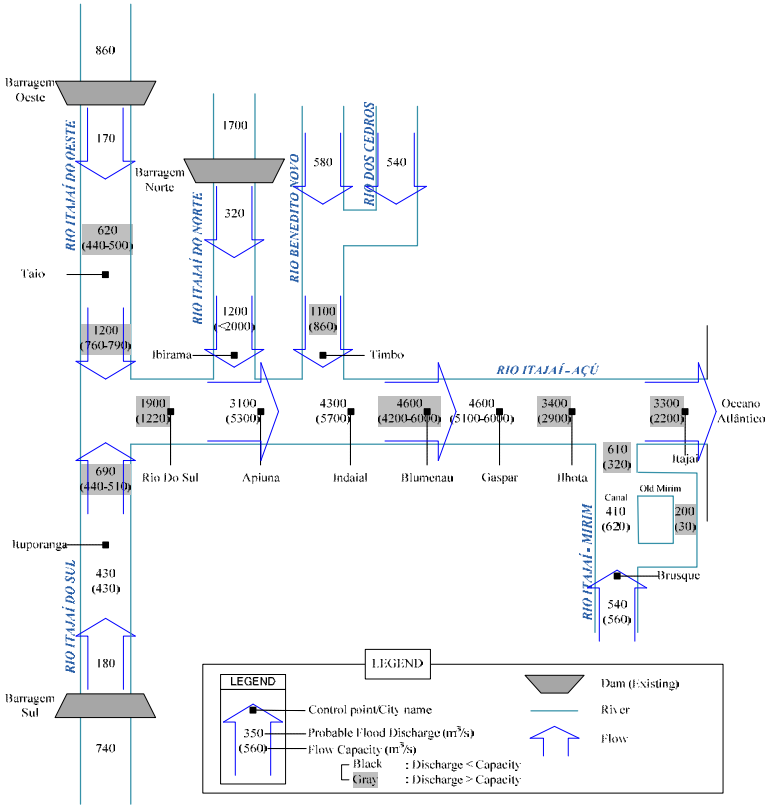
The flood inflow from remnant river basin other than the drainage area of Oeste dam exceeds the flow capacity in Taió city. Therefore, it becomes necessary to store in remnant basin or to widen the existing river channel in Taió city together with heightening of the Oeste dam. As for Rio do Sul city, addition of small dam and river improvement are considered for the comparative study.

Even though the pre-releasing of two hydropower generation dams is provided, Timbó city would still continue with insufficiency of 240m^3/s in its flow capacity. However, as insufficiency might be in the limited river stretch in the city, partial river improvement is to be conceived.

(3) Flood Control Planning

Same as the proposed plan for the 10-year flood, water storage in paddy field and pre-releasing of two hydropower generation dams are incorporated into the plan for the 25-year flood. Other flood control measures are outlined below. The content of the study is detailed in the Supporting

Report on Flood Mitigation Plan.

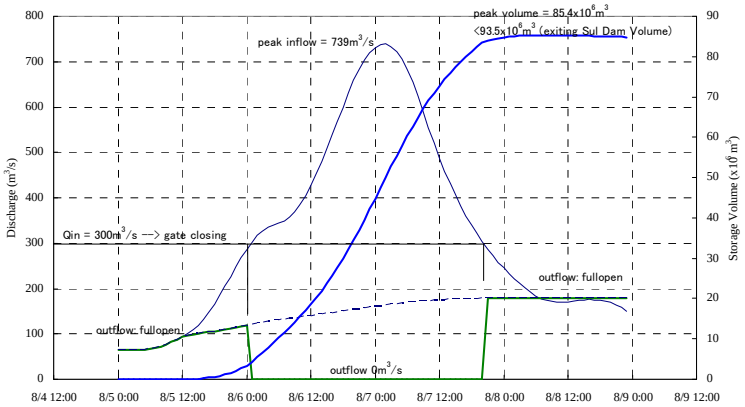


Source: JICA Survey Team

Figure 8.4.15 Distribution of 25-year Flood Discharge and Flow Capacity by City under Present Condition

a. Change of the current dam operation method at the Sul dam

As shown in Figure 8.4.16, the 25-year flood is able to be controlled with full opening of gates when the flood inflow exceeds 300 m^3/sec. No overflowing from the river has occurred in Rio do Sul city when the Sul dam released 300 m^3/sec.

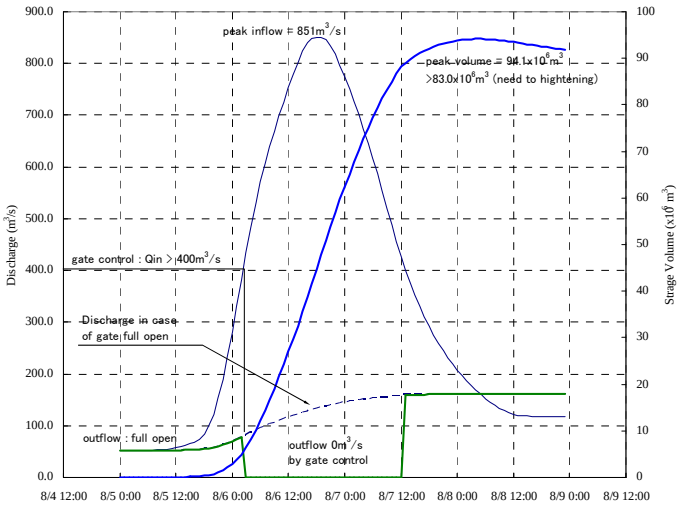


Source: JICA Survey Team

Figure 8.4.16 Proposed Dam Operation against the 25-year Flood at Sul Dam

b. Heightening and change of the current dam operation method at the Oeste dam

The Oeste dam is proposed to be heightened by 2 m to increase flood control capacity. The capacity will be increased by approximately 16,200,000m^3. Figure 8.4.17 shows the dam operation against the 25-year flood. When the flood inflow exceeds 400 m^3/sec, all the gates shall be closed in order.



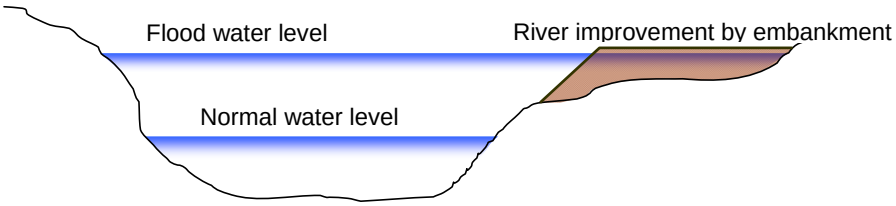
Source: JICA Survey Team

Figure 8.4.17 Proposed Dam Operation against the 25-year Flood at Oeste Dam

c. River improvement in Taió and Timbó cities

For both cities, river improvement is proposed considering that they are relatively small cities and river improvement might be possible without any relocation of residents. As for Taió city, river widening was proposed because of gentle riverbed slope. The current flow capacity would be increased 490 m^3/s from 440 m^3/s.

The Rio dos Cedros River joins the Benedit River in Timbó city. The current flow capacity downstream of the confluence is 860m^3/s, which is smaller than the 25-year flood discharge of 1200 m^3/s. Beside, the flow capacity of the Rio dos Cedros River in Timbó city is around 450 m^3/s less than the he 25-year flood discharge of 590m^3/s. However, since only partial portions of river stretches have insufficient flow capacity, where the river bank elevation is relatively low, partial river improvement by embankment was planned as illustrated below.

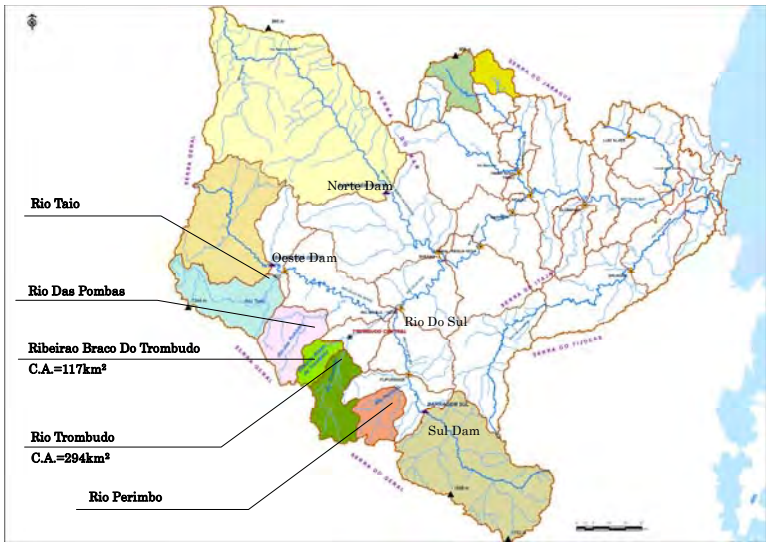


Source : JICA Survey Team

Figure 8.4.18 Image of River Improvement in Timbo City

d. Flood control measures in Rio do Sul City

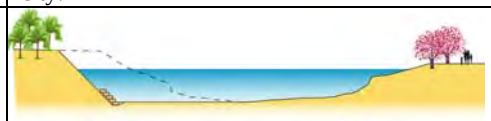
The proposed measures for Rio do Sul city is the combination of basin storage (small dams) and river widening. Due to delay of the ongoing topographical mapping, seven small dams are proposed in maximum having a total storage capacity of 41 million m^3. The location map of candidate basins for small dam is shown in Figure 8.4.19. As a result of flood runoff analysis, the 25-year flood discharge becomes 1,300 m^3/s in Rio do Sul city. Therefore, river improvement was studied to increase the current flow capacity of 1,220 m^3/s by 80 m^3/s. Along this line, two alternatives are compared as summarized in Table 8.4.7, which are the same alternatives as for the 10-year flood. As a result, flood control by river widening of the downstream reaches is concluded to be advantageous in view of the required cost and less social impacts.



Source: JICA Survey Team

Figure 8.4.19 Location Map of Small Dams（25-year Flood Level）

Table 8.4.7 Comparison of Flood Control Alternatives in Rio do Sul City for the 25-year Flood

Aspect	River Widening of Downstream Reaches	Dyke
Outline	To enlarge the current river channel by 10 m (see Figure 8.4.12) in the downstream reaches to lower the flood water level in Rio do Sul city.	To install 1.6 m high dykes on both banks to increase the current flow capacity in Rio do Sul city
Layout		
Project Cost	Construction cost and land acquisition cost: R$ 154,000,000. Although the construction cost is high, but the land acquisition cost for unpopulated area and project cost are smaller than the dykes in Rio do Sul city.	Construction cost and land acquisition cost: R$ 169,000,000. Although the construction cost is smaller than the river widening, but the land acquisition cost for the populated urban area and project cost are higher than the river widening.
Social Environmental Impact	Relatively smaller impacts, because the river widening is proposed in agricultural land	Large impacts, because of required relocation of many residences in the populated urban area
Natural Environmental Impact	No significant impacts, but the excavated earth materials shall be properly disposed	No significant impacts.
Influence on the Flood Condition	River widening might increase river velocity in Rio do Sul city and flood discharge in downstream reaches, but from the aspect of basin-wide flood control, flood discharge in the downstream cities is substantially decreased by the effect of small dams and change of flood control dam operations.	Flood water level will increase because of the confined dykes in both sides, and it is necessary to be careful not to contribute to flooding in the stretches with sufficient flow capacity.
Evaluation	It is more advantageous than the dyke plan from the cost and social environmental impact points of view.	It is inferior to the river widening plan from the cost and social environmental impact points of view

Source: JICA Survey Team

e. Flood control measures in Ilhota City

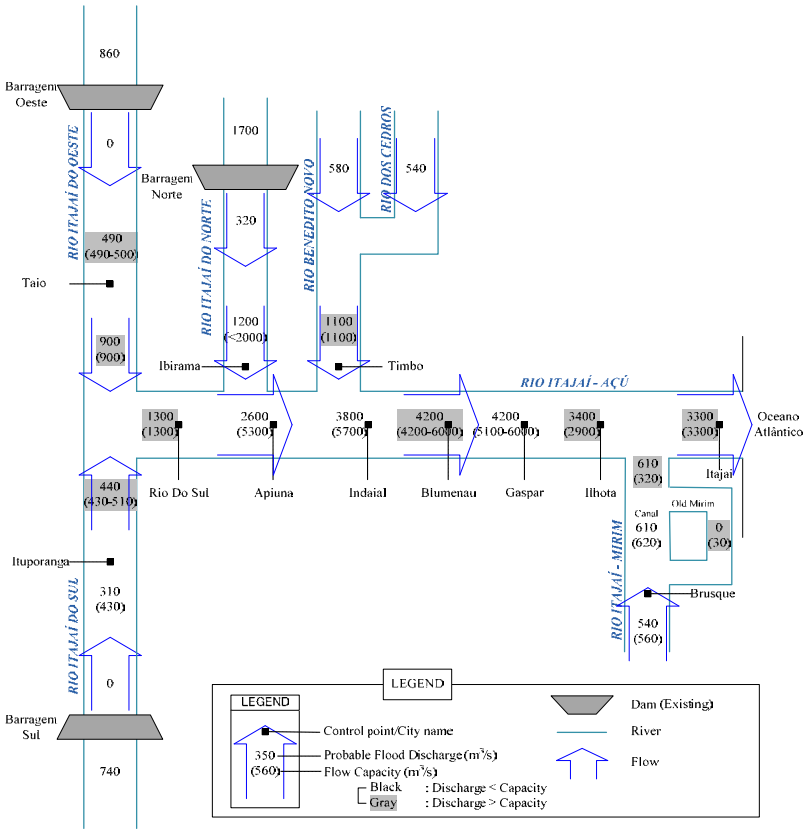
As the flood inundation area spreading from Itajai city (BR 101) to Gaspar city is unprotected as a natural retarding basin, ring dyke is proposed to protect Ilhota city from flood inundation.

f. Itajai Mirim River and Itajai River mainstream near Itajai city

Same as the plan for the 10-year flood, two flood gates with partial dyke was proposed in the Itajai Mirim River. The general features are shown in Table 8.4.4. As for the Itajai River mainstream, the lateral dyke plan is proposed compared to the floodway in view of the required cost and natural environmental impacts.

(4) Flood Discharge after the Proposed Plan

Figure 8.4.20 shows the distribution of 25-year flood discharges after implementation of the proposed flood control plan above.



Source: JICA Survey Team

Figure 8.4.20 Distribution of 25-year Flood Discharge and Flow Capacity by City for Flood Control Plan

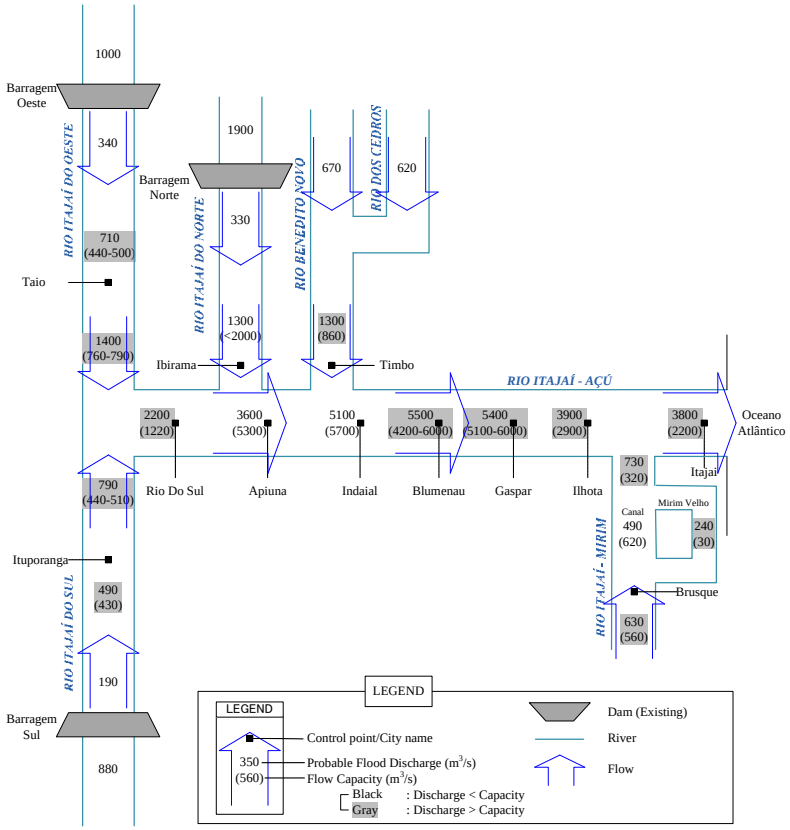
8.4.4 Protection for the 50-year Flood

(1) Flood Discharge and Flow Capacity

Figure 8.4.21 shows the distribution of 25-year flood discharge and flow capacity at major cities under the present condition. As indicated in the figure, t6he current flow capacities in almost all cities along the Itajai River having are smaller than the 50-year flood discharge.

(2) Basic Approach for Planning

Even though river basin measures such as water storage in paddy fields, basin storage (small dam), effective utilization of the existing flood control dams are provided, it is difficult in Rio do Sul, Taió, Timbó Blumenau, and Itajai cities to control the 50-year flood discharges smaller than the current flow capacity. Therefore, river improvement such as river widening, dyke and floodway are added to the alternatives for comparative study. In addition, a new flood control dam is considered to decrease the 50-year flood discharge in Brusque city.



Source: JICA Survey Team

Figure 8.4.21 Distribution of 50-year Flood Discharge and Flow Capacity by City under Present Condition

(3) Flood Control Planning

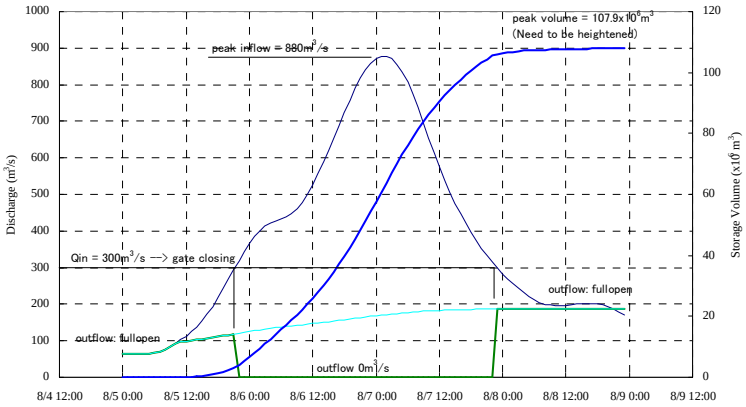
Same as the proposed plan for the 25-year flood, water storage in paddy field, pre-releasing of two hydropower dams and 7 small dams are incorporated into the plan for the 50-year flood. Other flood control measures are outlined below. The content of the study is detailed in the Supporting Report on Flood Mitigation Plan.

a. Heightening of the Sul dam

The crest of existing spillway is proposed to be heightened by 2 m. Due to the heightening, the storage capacity of the Sul dam would be increased to be 110 million m^3. As shown in Figure 8.4.22, the 50-year flood is able to be controlled with full opening of gates when the flood inflow exceeds 300 m^3/sec. The stored water volume will be 107.9 million m^3.

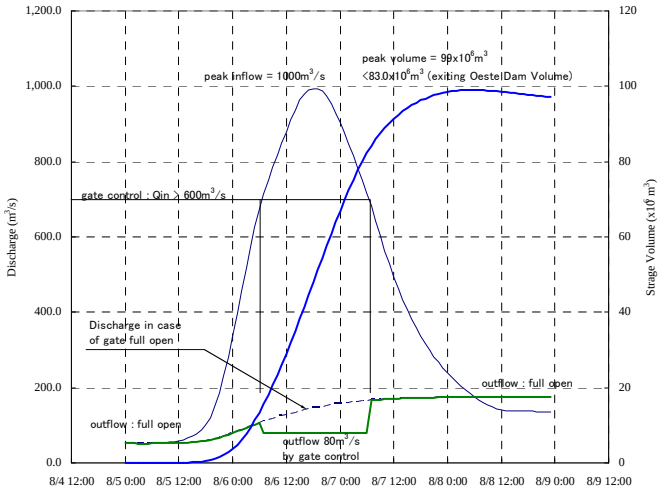
b. Heightening of the Oeste dam

The Oeste dam is proposed to be heightened by 2 m. Due to the heightening, the storage capacity would be increased to be 99.3 million m^3. As shown in Figure 8.4.23, the 50-year flood is able to be controlled with full opening of gates when the flood inflow exceeds 700 m^3/sec. The stored water volume will be 99.0 million m^3.



Source: JICA Survey Team

Figure 8.4.22 Proposed Dam Operation against the 50-year Flood at Sul Dam



Source: JICA Survey Team

Figure 8.4.23 Proposed Dam Operation against the 50-year Flood at Oeste Dam

c. Flood control measures in Rio do Sul, Taió, Timbó cities

Same as the 25-year flood control plan, two alternatives are compared for Rio do Sul, Taió, Timbó cities. Table 8.4.8 shows the comparative study result for Rio do Sul city. It is concluded that flood control by dyke is advantageous in view of the required cost. The same results were obtained for both Taió and Timbó cities.

Table 8.4.8 Comparison of Flood Control Alternatives in Rio do Sul City for the 50-year Flood

Aspect	River Widening of Downstream Reaches	Dyke
Outline	To enlarge the current river channel by 40 m (see Figure 8.4.12) in the downstream reaches to lower the flood water level in Rio do Sul city.	To install 2.2 m high dykes on both banks to increase the current flow capacity in Rio do Sul city
Project Cost	Construction cost and land acquisition cost: R$ 616,000,000. Due to huge excavation volume, the project cost will significantly increase compared to the dyke plan.	Construction cost and land acquisition cost: R$ 246,000,000. Although land condemnation in the urban area is necessary, the project cost will be far smaller than the river widening plan due to small work volume for embankment.
Evaluation	It is inferior to the dyke construction plan from the aspect of required cost.	It is more advantageous than the river widening plan from the aspect of required cost.

Source: JICA Survey Team

d. Flood control measures in Blumenau city

The 50-year discharge in Gaspar city will be reduced to be 4,900m^3/s with provision of the basin measures such as water storage in paddy fields, small dam, effective utilization of the existing flood control dams, and heightening of two flood control dams, which is smaller than the current flow capacity. Therefore, no measures might be necessary in Gaspar city.

On the other hand, although the 50-year discharge in Blumenau city will be reduced to be 4,790m^3/s with provision of the same basin measures above, the current flow capacity is still insufficient in around 600 m^3/s. Two alternatives; i) river improvement with provision of composite river section and ii) a new flood control dam in the Benedit River were compared. As summarized in Table 8.4.9, composite river section was proposed in Blumenau city.

Table 8.4.9 Comparison of Flood Control Alternatives in Blumenau City for the 50-year Flood

Aspect	Composite River Section	New Flood Control Dam
Outline	To widen the river channel with provision of composite section and adopt APP to high water channel (see Figure 8.3.2). The existing road on the left bank is heightened by approximately 1.0 m used as dyke.	To construct two new flood control dams; one is a 46 m high dam in the upstream Benedito River and the other is a 34 m high dam in the upstream Rio dos Cedros River
Project Cost	Construction cost and land acquisition cost: R$ 163,000,000. Although heightening cost of the existing road is very small, land condemnation cost in the urban area is high. However the project cost will be smaller than the dam construction plan.	Construction cost and land acquisition cost: R$ 205,000,000. The project cost is very high, including land acquisition cost.
Social Environmental Impact	Large impacts, because of the required relocation of many residences on the left bank in the urban area of Blumenau city.	Relatively small impacts with reallocation of several residences in the Rio dos Cedros River
Natural Environmental Impact	No significant impacts.	Because of the construction of new dam in two locations, there will be natural environmental impacts to the reservoir area to be inundated.
Flood Control Effect	The current flow capacity can be increased to the design discharge for the 50-year flood.	Despite construction of two dams, the design discharge will be decreased to be 4400m^3/s, exceeding the flow capacity. Therefore, it is not completely solving the problem (it becomes necessary to combine with river improvement, requiring additionally more cost).
Evaluation	It is more advantageous than the new flood control dam plan in terms of the cost and the expected flood control effect.	It is inferior in relation to the cost. It is not capable to fully control the 50-year flood only by flood control dams.

Source: JICA Survey Team

e. Flood control measures in Ilohota city

Same as the 25-year flood control plan, ring dyke is proposed.

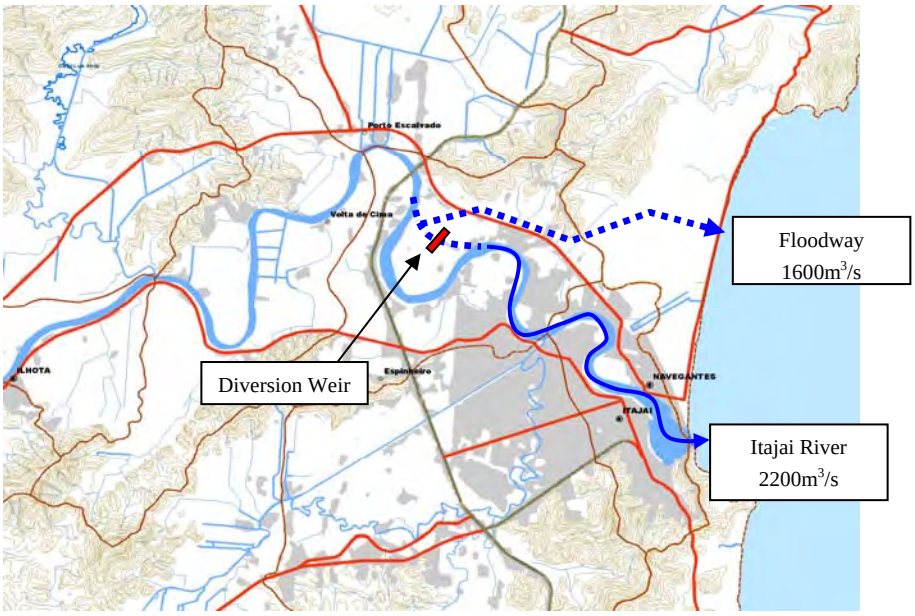
f. Itjai River mainstream (Itajai city)

Although the lateral dyke plan on the right bank is proposed for both the 10-year and 25-year flood protection levels, it becomes necessary to provide further the dyke in the urban area on the left bank in Nevegantes city, increasing the cost and associating significant impacts on the social environments. For the 50-year flood protection level, the plan of dyke on the both banks was compared to the plan of a new floodway as summarized in Table 8.4.10. As shown in this table, the floodway plan to the contrary was concluded advantageous because of less land acquisition cost in the urban area. Therefore, the floodway plan was proposed for the 50-year flood to protect Itajai city. The layout plan is shown in Figure 8.4.24.

Table 8.4.10 Comparison of Flood Control Alternatives in the Itajai River Mainstream for the 50-year Flood near Itajai City

Aspect	Dyke	Floodway
Outline	To install dykes both on the left bank (Itajaí city) and right bank (Navegantes city) along the main course of Itajaí River.	To install a new floodway immediately downstream of BR-101 to divert the discharge exceeding the flow capacity directly the sea in Navegantes city.
Project Cost	Construction cost: R$ 23,000,000 Land acquisition cost: R$ 449,000,000 Total cost: R$ 472,000,000 Due to huge land acquisition cost in the urban area, the project cost becomes more expensive than the floodway plan.	Construction cost: R$ 25,000,000 Land acquisition cost: R$ 425,000,000 Total cost: R$ 450,000,000 Although the construction cost is high, the land acquisition cost is smaller. Due to this, the floodway plan is more advantageous than the dyke plan.
Social Environmental Impact	Significant impacts, because of the required relocation of many residences on both banks in the urban areas of two cities.	Significant impacts, because of separation of Navegantes city by the floodway.
Natural Environmental Impact	No significant impacts.	Environmental impacts shall be subject to assessment on sediment deposition at the floodway outlet, changes of coastal line, and see water intrusion along the floodway.
Evaluation	It is inferior to the floodway plan from the cost and social environmental impacts point of view.	It is advantageous from the cost and social environmental impacts point of view. However, it is necessary to assess various natural environmental impacts in detail.

Source: JICA Survey Team



Source: JICA Survey Team

Figure 8.4.24 Layout Plan of Floodway and Design Flood Discharge

f. Itajai Mirim River and Itajai River mainstream near Itajai city

Same as the 25-year flood level, two flood gates with partial dyke was proposed in the Itajai Mirim River. The general features are shown in Table 8.4.4. However, the 50-year flood discharge might overflow the Canal due to the concentration of flood water by the closure of flood gates. Further, the current flow capacity in Brusque city is insufficient to pass the 50-year flood. To solve these problems simultaneously, a flood control dam is planned in the upstream

Itajaí Mirim River (mountainous area in Botuverá city) to decrease the 50-year discharges in Brusque city and in the Canal in Itajaí city.

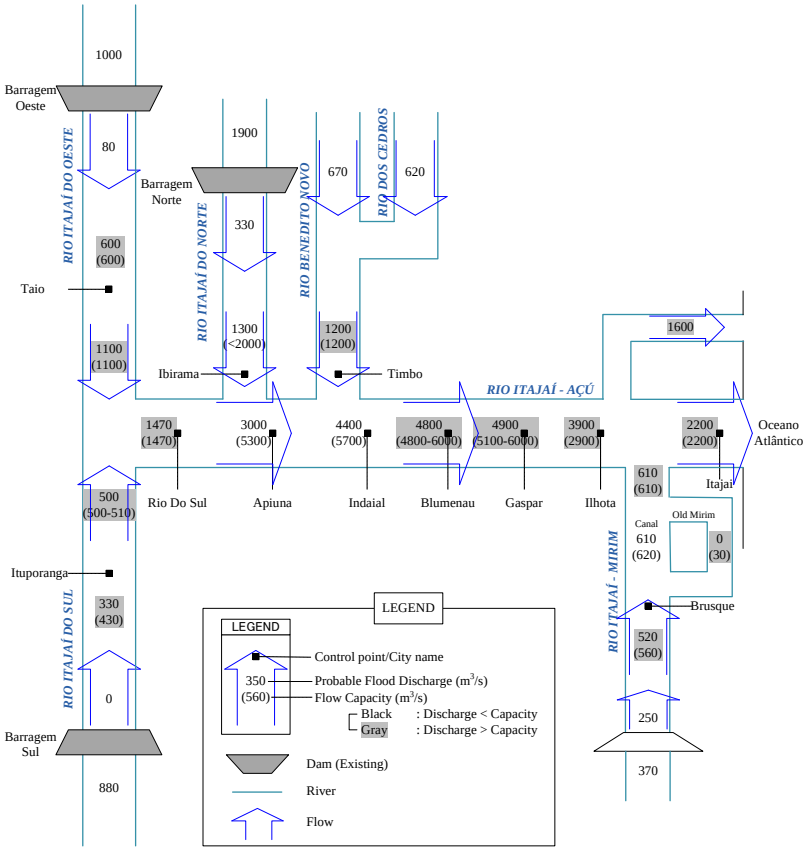
Table 8.4.11 General Features of New Flood Control Dam in the Itajaí Mirim River for 50-year Flood

Plan Item	Feature	Remarks
Catchment area	630 km^2	Upstream river of Botuvera city
Maximum inflow discharge	370 m^3/s	
Maximum outflow discharge	250 m^3/s	Regulating discharge: 120m^3/s
Flood control volume	15,700,000m^3	
Dam height	34.2 m	

Source: JICA Survey Team

(4) Flood Discharge after the Proposed Plan

Figure 8.4.25 shows the distribution of 50-year flood discharges after implementation of the proposed flood control plan above.



Source: JICA Survey Team

Figure 8.4.25 Distribution of 50-year Flood Discharge and Flow Capacity by City for Flood Control Plan

8.4.5 Flood Control Measures in Urban Rivers (Garcia and Velha Rivers)

(1) Flood Discharge and Flow Capacity

The Garcia and Velha Rivers flow down in the urban area of Blumenau city and join the Itajaí River. These rivers are small tributary rivers having drainage areas of 163.3 km^2 for the Garcia River and 52.9 km^2 for the Velha River. Riverbed slope of these rivers is steep compared to that of Itajai River (approximately 1/200 to 1/600 in the Garcia River). In recent years, the "flush flood" has been highlighted in such urban rivers. The flush flood is sudden and violent rising of river water level and runoff caused by localized torrential rainfall, of which mud flow containing some sediments and debris flow are included.

According to various interviews in cities as Blumenau, the flush flood caused in the November 2008 flood brought about huge damages including much sediments caused by slope collapses and landslides, which were triggered by localized heavy rainfall over the fully saturated ground with the antecedent rainfalls. It is generally said that such debris and sediment flows are very difficult to be controlled by means of conventional structural measures. In this respect, introduction of flush flood alert system is desirable giving top priority to human lives. This system is proposed in the succeeding Chapter 9.

As many residences have been built near the banks of Garcia and Velha Rivers, the cross section of river channel are small with insufficient flow capacity, causing frequent flooding by normal flood (however, a sharp flood because of narrow watershed and steep river gradient). In this section, conventional river channel improvement plan was studied based on the evaluation of various water levels by probable floods.

(2) Probable Flood Discharges

Although the duration of design rainfall was set at 4 days for flood runoff analysis to estimate probable flood discharges along the mainstream of Itajai River and its main tributaries considering the characteristics of rainfall of past flood events, probable flood discharges for both the Garcia and Velha Rivers were estimated through flood runoff analysis based on the results of frequency analysis on 1-day rainfall in Blumenau city, where localized heavy rainfall with short duration is predominant for urban rivers as mentioned above. Table 8.4.12 summarizes the estimated probable flood discharges together with probable 1-day rainfalls.

Table 8.4.12 Probable Rainfalls and Discharges in Garcia and Velha Rivers

Flood Level	5-year	10-year	25-year	50-year
Probable 1-day Rainfall	113 mm	135 mm	168 mm	190 mm
Garcia River	320 m^3/s	390 m^3/s	490 m^3/s	550 m^3/s
Velha River	140 m^3/s	170 m^3/s	210 m^3/s	240 m^3/s

Source: JICA Survey Team

(3) Proposed Flood Control Measures

As for the flood control measures for both rivers, water storage in reservoirs is almost impossible because of many residential houses along the rivers and existence of the National Park therein. Besides, absence of flat lands makes it difficult to provide retarding basins. Moreover, due to the backwater from the Itajai River, it might be difficult to increase the current flow capacity by widening of the Garcia River near the confluence with the Itajai River. Therefore, embankment in the river stretches with insufficient bank elevation is proposed to increase the flow capacity.

On the other hand, embankment is not appropriate in the middle reaches of both rivers, where both rivers flow down in hilly area with relatively steep gradient and meanderings, considering the existence of some flow velocity and water colliding portions of the river channel. Therefore, expansion of the river area is proposed by adopting APP in such river stretches, forming the high water channel by slightly lowering the bank elevation by means of excavation. Table 8.4.13 presents the proposed measures by flood protection level. The study details are described in the Supporting Report on Flood Mitigation Plan.

Table 8.4.13 List of Flood Controls for Garcia and Velha Rivers

River	River Section	Method	Bank Elevation (EL. m)	Dyke Height/APP Width (m)			
				5-year	10-year	25-year	50-year
Garcia River	GA01	Dyke	-	-	-	-	1.0 – 1.5
	GA02	Dyke	-	-	-	1.5 – 2.0	2.5 – 3.0
	GA03	Dyke	-	-	-	1.0 – 1.5	2.0 – 2.5
	GA06	APP	29.0		15	20	25

River	River Section	Method	Bank Elevation (EL. m)	Dyke Height/APP Width (m)			
				5-year	10-year	25-year	50-year
	GA07	APP	60.0	20	30	45	55
Velha River	VE04	APP	13.5	5	10	20	35
	VE05	APP	15.0	5	25	30	30

Source: JICA Survey Team

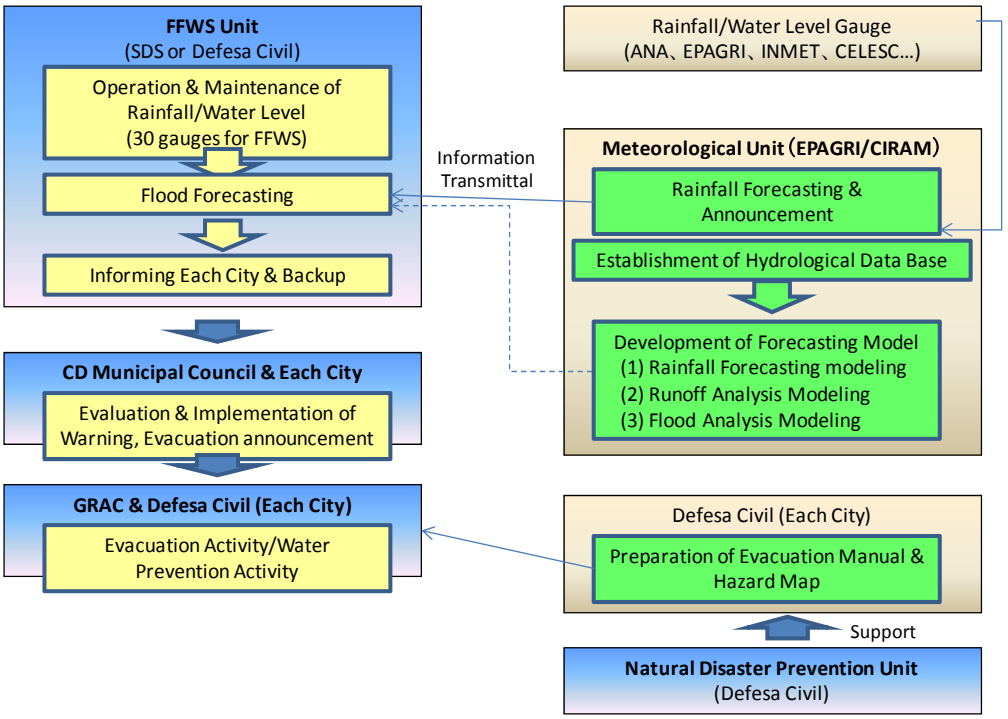
8.5 Master Plan for Strengthening FFWS in Itajai River Basin

8.5.1 Proposed Organization for Strengthening Existing FFWS

The appropriate institutional organization must be properly constructed so that the proposed FFWS exercise effectively. Presently the FFWS conducted by FURB/CEOPS which is delegated by SDS is not functional enough and it has no good communication between FURB/CEOPS and other organizations of the SC State.

For the proper implementation of the FFWS all over the Itajai River basin, the State government must have a responsibility for the matter but not just by FURB/CEOPS as a local university unit (Refer to Figure 8.5.1).

This study proposes the improvement of 14 existing gauging stations and additional 16 gauging stations so that all cities in the basin are able to have the flood forecasting and warning system or warning system (Section 8.5.3). All of 30 gauging stations must be managed and operated by the state government unit responsible for FFWS (SDS/Defesa Civil).



Source: JICA Study Team

Figure 8.5.1 Proposed Institutional Organization for FFWS

i. The state government unit in charge for FFWS shall improve the flood forecasting method and waning level not only Blumenau but also other cities in the basin. On the other hand, EPAGRI/CIRAM of meteorological unit of the state must establish new system which transmits all hydrological and meteorological data observed by different organizations. CIRAM must manage data and develop data base system for all data comes from different organizations including aforementioned 30 gauging stations. These data must be utilized for future development of FFWS such as runoff analysis, inundation analysis and rainfall forecasting.

ii. The result for flood forecasting should be transmitted to all of CD Municipal Counsel in the basin and the flood warning and evacuation announcement shall be implemented and evaluated by each city in consideration of warning level. Therefore the propriety of warning level shall be verified.

iii. GRAC shall conduct evacuation activities based on the evacuation announcement. Defesa Civil of the state government unit for prevention and mitigation of natural disaster should support to make the evacuation manual and hazard map for some cities which have not prepared yet.

8.5.2 Proposal for Target City for Flood Warning

(1) Proposal for Establishment of Warning Level

As described in Section 4.2.4/Chapter 4, presently 16 cities have been established the warning level but not for Brusque City which is third important city in the Itajai River Basin. In addition to those cities, Mirim Doce, Salete, Pouso Redondo located in mountainous area in upstream of Rio do Sul and Agua Clera, Gurabiruba in mountainous area along tributaries of Brusque City are endangered by sudden flood caused by local downpour due to estate development.

Therefore these 6 cities have to establish the warning level newly and the hydrological gauging station is needed together with siren which announces the evacuation.

Moreover, the existing warning level was established 25 years ago and the situation of the river channel and its riparian area has been changed. The existing warning level should be reviewed based on study of discharge capacity in urban area and H-Q curve at the gauging station. The target cities to be set warning levels including existing are shown in Table 8.5.1.

(2) Cities for Flood Forecasting

The flood forecasting for the Itajai River Basin should be conducted due to the system together with rainfall forecasting, runoff analysis and flood forecasting in future, therefore presently Defesa Civil, EPAGRI/CIRAM and SDS is planning for establishing the model.

On the other hand, Rio do Sul, Blumenau and Itajai City, which is major city of upper, middle and lower area of Itajai River respectively and have had serious damages by floods, need the warning system with flood forecasting using the water level correlation formula as a provisional solution until establishment of aforesaid model.

8.5.3 Proposal for Improvement/Additional Rainfall and Water Level Gauging Station

(1) Improvement for Existing Rainfall and Water Level Gauging Station

The existing 14 gauging stations described in Table 4.2.3 in Chapter 4 are the most important stations for the FFWS. Improvement of equipments and transmission systems for these stations should be prioritized for current observation of rainfall and water level. In discussion with SDS, the improvement and updating will be implemented by the finance of state government lead by SDS. Improvement of these existing stations must be implemented certainly.

(2) Proposal for New Gauging Stations for Rainfall/ Water Level

i) New Gauging Stations for Target Cities for Proposed FFWS

New gauging stations shall be installed for cities which have no rainfall/water level gauging station in spite of the target for setting warning level.

Those cities are 11 in total such as Ilhota、Gaspar、Benedito Novo、Rio dos Cedros、Agura Clera、Burabiruba、Vidal Ramos、Trombudo Central、Pouso Redondo、Salete and Mirim Doce.

ii) New Gauging Station for Flood Forecasting and Early Warning and Evacuation

The informations of outflow discharge from Oeste and Sul Dams for flood control located in the upstream river of Rio do Sul are necessary for the flood forecasting at Rio do Sul. Presently DEINFRA as dam administrator has no data of outflow discharge from dams. DEINFRA should establish the system which is able to monitor the outflow discharge from dams in future, but in the present moment, new gauging stations should be installed at downstream reaches of dams to monitor the outflow discharge. These new station was strongly requested by Rio do Sul city. In addition to this purpose, these new stations are useful for early warning to Taio city and Ituporanga city.

On the other hand, existing stations of Blumenau and Brusque to be improved and new gauging stations at Gasper and Ilhota will be utilized for the flood forecasting at Itajai city. Presently municipal Defesa Civil has 9 automated rainfall stations and 8 automated water level stations in Itajai city. These data should be proposed to be cooperated with state observation system.

CELESC as hydropower dam administrator should have a responsibility for information of Rio Bonito and Pinhal Dams but it is difficult to establish immediately the system. Therefore, new gauging stations should be installed in the downstream reach of the dams for monitoring outflow discharge from the dams. These new stations are also useful for early warning to Rio dos Cedros and Timbo city. Timbo city strongly requested to install CCTV cameras for ocular inspection of floods together with gauging outflow discharge from the dams.

In the results of above, new 4 gauging stations in the downstream reach of Oeste, Sul, Rio Bonito and Pinhal Dams are proposed to install with 2 CCTV cameras.

iii) New Gauging Station for Establishment of Flood Forecasting Model in Future

Presently there is a rainfall station of ANA along Luiz Alves River which is a main tributary of Itajai River but hourly data is not available as mentioned in Chapter 4. New gauging station is proposed to be installed at Luiz Alves city for establishment of flood forecasting model in future which Defesa Civil, CIRAM, and SDS is planning now.

iv) New CCTV Cameras to Monitor River Situation

Though Defesa Civil and SDS as administrators of river and disaster prevention have no regional offices in the Itajai River basin, they must be responsible for the river and disaster prevention far from Florianopolis. Therefore, the nstallation of CCTVs is proposed at Rio do Sul, Blumenau and Itajai City. The existing and proposed new gauging stations are shown in Table 8.5.1 and Figure 8.5.2.

(3) Transmission of Observed data

The data of rainfall and water level from 30 gauging stations in total is transmitted to the server of Florianopolis' centre station through by Email of GPRS and saved in the data base. The saved data will be transmitted to the monitoring stations of Defesa Civil at Rio do Sul, Blumenau and Itajai City through the internet.

The pictures of Itajai River taken in every minute by CCTV at Rio do Sul, Blumenau and Itajai City are transmitted to Florianopolis' centre station through the internet and monitored.

The observation net work for Proposed FFWS is shown in Figure 8.5.3.

Warning and alarm should be announced through radio, TV, internet and electric bulletin board based on flood forecasting (predicted water level) and warning and alart level at each reference point. If needed, patrol and advice of evacuation should be carried out.

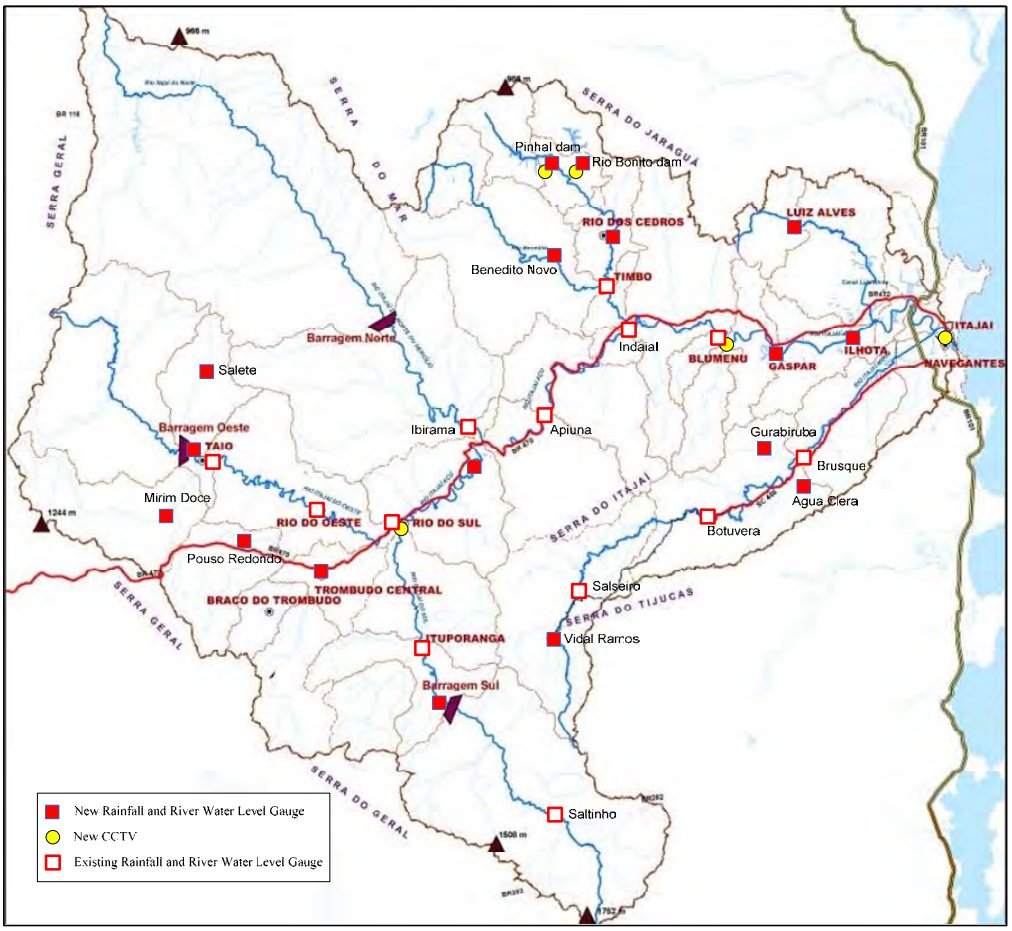
Presently, Digital Terrestrial Broadcasting has been spreading throughout Brazil, and Florianopolis and joiville cities are covered by Digital Terrestrial Broadcasting in SC State. In the future, when the Digital Terrestrial Broadcasting will cover the Itajai River basin, it will become possible that hydro-meteorological information can be transmitted through text broadcasting and cellular phone (like Japanese one-segment broadcasting). Transmission measures of information should multiplex according as the development of media

Table- 8.5.1 Target City for FFWS and Gauging Stations

No.	Name of River	Name of Sta.	Target City for FFWS			Gauging Station					
			Existing warning water level	Target Location for Warning	Forecasting & Warning	Existing Gauging Station (FURB/CEOPS) (Require for replacement/up-grade)			Proposed Gauging Station		
						Equipment		Present Condition	Equipment		Remarks
1	Rio Itajai	Rio do Sul	○	○	Reviewing existing warning level/Establishing flood forecasting formula	○	R/W	Operational	○	CCTV	Monitoring river from Florianopolis
2	Rio Itajai	Bumenau	○	○		○	R/W	Operational	○	CCTV	Monitoring river from Florianopolis
3	Rio Itajai	Itajai	○	○		City government already installed 8 water level gauges			○	CCTV	Monitoring river from Florianopolis
4	Rio Itajai do Sul	Ituporanga	○	○	Reviewing existing warning water level	○	R/W	Up-grade of transmission system			
5	Rio Itajai do Sul	Vidal Ramos	○	○					○	R/W	Warning for Vidal Ramos
6	Rio Itajai do Oeste	Taio	○	○		○	R/W	Up-grade of transmission system			
7	Rio Itajai do Oeste	Rio Oeste	○	○		○	R/W	Replacement of Equipments			
8	Rio Trombudo	Trombudo	○	○					○	R/W	Warning for Trombudo
9	Rio Itajai do Norte	Ibirama	○	○		○	R/W	Up-grade of transmission system			
10	Rio dos Cedros	Rio dos Cedros	○	○					○	R/W	Warning for Rio dos Cedros
11	Rio dos Cedros	Timbo	○	○		○	R/W	Operational			
12	Rio Benedito	Benedito Novo	○	○					○	R/W	Warning for Benedito Novo
13	Rio Itajai	Apiuna	○	○		○	R/W	Replacement of Equipments			
14	Rio Itajai	Indaial	○	○		○	R/W	Replacement of Equipments			
15	Rio Itajai	Gasper	○	○					○	R/W	Warning for Gasper
16	Rio Itajai	Ilhota	○	○					○	R/W	Warning for Ilhota
17	Rio Itajai Mirim	Brusque	-	○	Establishing warning water level	○	R/W	Replacement of Equipments			
18	Rio Itajai do Oeste	Mirim Doce	-	○					○	R/W	Warning for Mirim Doce
19	Rio Itajai do Oeste	Salete	-	○					○	R/W	Warning for Salete
20	Rio Itajai do Oeste	Pouso Redondo	-	○					○	R/W	Warning for Pouso Redondo/Rio do Sul due to flood by housing development
21	Rio Itajai Mirim	Agua Clera	-	○					○	R/W	Warning for Agua Clera
22	Rio Itajai Mirim	Gurabiruba	-	○					○	R/W	Warning for Gurabiruba
23	Rio Itajai do Sul	Saltinho	-	-	-	○	R/W	Replacement of Equipments			
24	Rio Itajai do Sul	Sul Dam	-	-					○	R/W	Flood forecasting at Rio do Sul/ Monitoring discharge from dam to protect Ituporanga
25	Rio Itajai do Oeste	Oeste Dam	-	-					○	R/W	Flood forecasting at Rio do Sul/ Monitoring discharge from dam to protect Taio
26	Rio Itajai do Norte	Barra da Prata	-	-		○	R/W	Replacement of Equipments			
27	Rio dos Cedros	Pinhal Dam	-	-					○	R/W, CCTV	Monitoring discharge from dam to protect Timbo
28	Rio dos Cedros	Rio Bonito Dam	-	-					○	R/W, CCTV	Monitoring discharge from dam to protect Timbo
29	Rio Luiz Alves	Luiz Alves	-	-					○	R/W	To obtain hydrological data of Luiz Alves river basin for flood forecasting model
30	Rio Itajai Mirim	Salseiro	-	-		○	R/W	Replacement of Equipments			
31	Rio Itajai Mirim	Botuvera	-	-		○	R/W	Replacement of Equipments			
TOTAL			16	22		14			19	16 R/W & 5 CCTV	

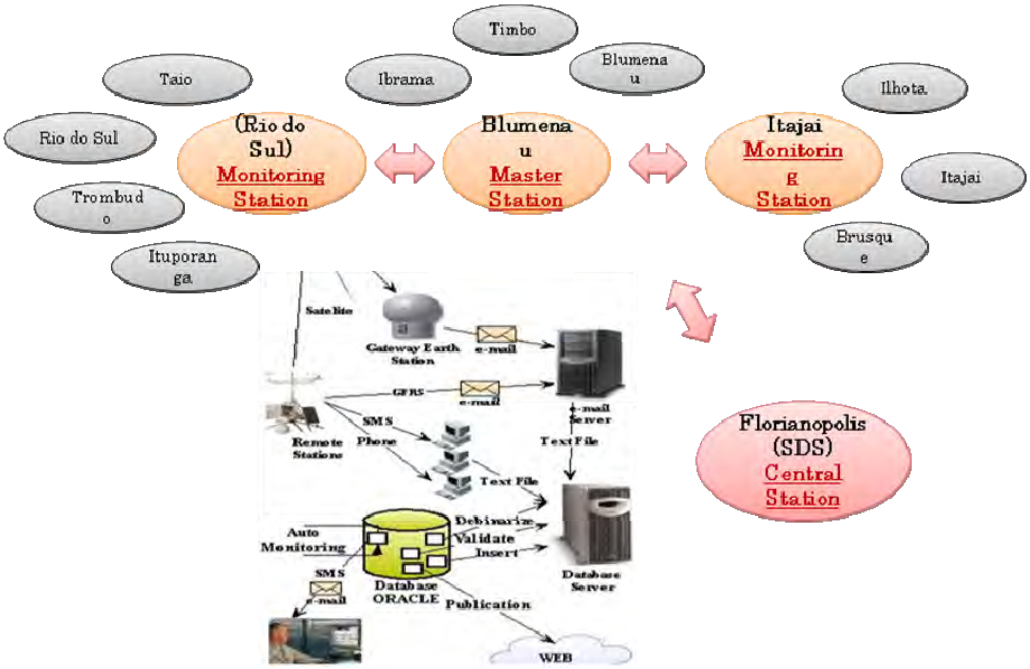
R/W: Rainfall and Water level gauge as one set

Source: JICA Study Team



Source: JICA Study Team

Figure 8.5.2 Location Map for Proposed Gauging Station and CCTV



Source: JICA Study Team

Figure 8.5.3 Observation Network for Flood Warning System

8.5.4 Proposal for Installment of New Transmission System

The following 8 steps shall be applied to maintenance and upgrade monitoring equipments and data transmission system.

1. Improvement of existing gauging stations (changing observation equipments)
2. Installing of additional gauging stations (rainfall and water level gauge)
3. Improvement of network system (internet) including additional monitoring stations
4. Extending server and establishing database of the central station (Florianopolis)
5. Analyzing and improvement of flood forecasting (review of water level correlation formula)
6. Installation of monitoring system at Monitoring Station (Rio do Sul, Itajai City)
7. Installation of monitoring system at Central Station (Florianopolis City)
8. Improvement of flood warning system and evacuation announcement

The flood warning must be announced immediately to the residents in the targeted cities by radio, TV, the Internet and an electronic board set up in cities as well. In hazardous areas, the patrol by the civil defense and real-time monitoring of the flood situation by CCTV enables to inform CD Municipal Counsel to ask earlier evacuation. In addition, when the flood warning is announced, sirens set up in cities are used to urge residents who live in hazardous areas to evacuate.

CHAPTER 9 PREPARATION OF THE MASTER PLAN OF LANDSLIDE MANAGEMENT

9.1 Contents of Master Plan

Table 9.1.1 shows the contents of master plan to mitigate landslide, sediment yield, and flash floods. The master plan is consisted of the following two components; non-structural measures for landslide and flash flood and structural measures for landslide.

Table 9.1.1 Contents of Master Plan to Mitigate Landslide, Sediment Yield, and Flash Flood

Purpose	Measures	Description in the Master Plan
Avoidance of human lives loss	(1) Non-structural measures (Implementation of early warning systems for landslide and flash flood) a) Formulation of system for monitoring/repository of rainfall data and communication of warning information. b) Disaster education and drills to the persons in charge and residents for reliable evacuation.	Plan including cost estimation is prepared as a main measure project.
Reducing economic losses	(2) Structural measures for landslide Structural measures will be implemented from the priority sites which have high potential annual loss.	
	(3) Mitigation of sediment yield. Forestation of bare collapsed land, prevention of river-bank erosion by river bank forest will be promoted. Prevention of sediment yield will be secured by vegetation at structural measures sites for landslide.	Detailed plan is not formulated in the master plan; the issues are treated in watershed/ forest conservation plans.
	(4) Mitigation of flash flood Installation of discharge regulation facilities for rainfall runoff will be promoted in order to mitigate floods and flash floods.	Detailed plan is not formulated in the master plan; the issues are treated in regional planning.
	(5) Capacity building for structural measure and support for private self - reliant effort a) Capacity building for structural measure project b) Support for private self –reliant effort Disaster education and subsidy of official/private fund will be promoted for private sectors in order to reduce damage of private preservation objects which have low priority and potential annual losses.	The master plan describes necessity as political policy.

Source: JICA Survey Team

9.2 Non-structural Measures (Mitigation Plan of Landslide/Flash Flood)

9.2.1 Formulation of System for Monitoring/Repository of Rainfall Data and communication of Warning Information

(1) Adaptation to the Whole SC State as Main Measure Project.

Non-structural measures will be installed to the whole SC State as a main measure project, because it is more practical than relocation from risk area. The reasons of installation to the whole SC state are follows;

i) Benefits by reduction of human lives losses are maximized in the whole SC State.

ii) Reducing human lives losses of travelers inside and outside of Itajai River basin in SC State.

iii) In case of Municipalities whose territories are extended both of inside/outside of Itajai River basin, the citizens are equally benefited both of residents living inside/outside of the Itajai River basin.

(2) General and Monitoring of Rainfall

Early warning systems for landslide disaster and flash flood, which is described in section 9.2.3, will be implemented as follows;

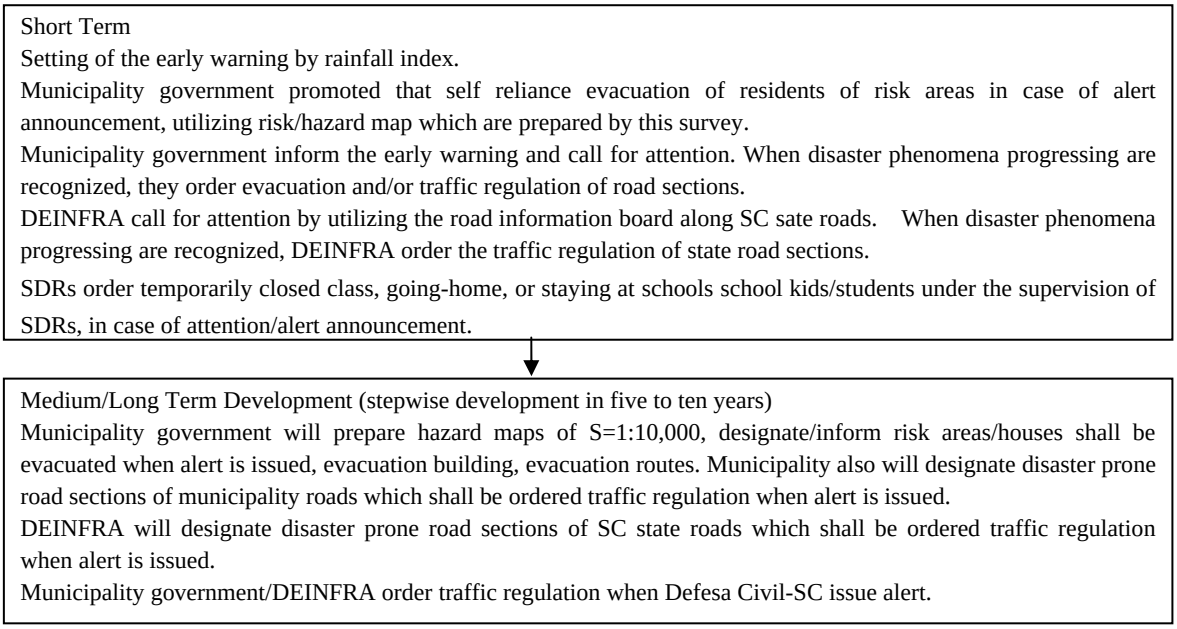
Defesa Civil -SC conduct general management and official issue of the early warning.

Municipality governments order evacuation for residents and traffic regulation of municipality roads.

DEINFRA orders traffic regulation of SC state road.

SDRs order temporarily closed class, going-home, or staying at schools to school kids/students under the supervision of SDRs in case of attention/alert issue.

Firstly the early warning (information calling for attention) by rainfall index will be set as the kick off to increase awareness of disaster, secondary designation of houses for evacuation and roads for traffic regulation corresponding to warning, as shown in Figure 9.2.1.



Source: JICA Survey Team

Figure 9.2.1 Instrument of Early Warning System of Landslide/Flash Flood and Stepwise Development

A automatic rain gauge will be installed to either municipality hall, Defesa Civil-municipality office, or office of CELESC. The gauges should be supplied by solar power in order not to lack of measuring data. The data will be transmitted to the data server of EPAGRI/CIRAM through GPRS (General Packet Ration Service) and VHS communication system of CELESC.

To avoid data lack due to transmission error of GPRS, the staffs of Defesa Civil- municipality should download the data from data logger and save to the computer once a week.

EPAGRI/CIRAM will calculate rainfall index criteria based on the exact data and forecasted data by WRF (Weather Research and Forecasting) model. When the rainfall is exceed to the rainfall index criteria, EPAGRI/CIRAM will announce through media and web sites and inform to Defesa Civil-SC, each SDR, Municipality. SDR announce attention/ alert to each school in the area, and Municipality government announce attention/ alert to the residents and travelers. Each municipality and DEINFRA announce early warning information by such as information boards along SC road and prepare for disaster.

(3) Setting of Attention/ Alert index criteria for Landslide and Flash Flood

Attention/ Alert index criteria will be decided based on a soil water index which is used in Japan and rainfall index which is studied by IPT (Instituto de Pesquisas Tecnológicas) in Sao Paulo State University. It is difficult to decide rainfall index criteria from the result of statistical analysis of rainfall index which is recorded at disaster occurrences, because there are no exact times of landslide and flash flood occurrence, and location of rainfall gauges are generally apart from disaster-occurrence points more than 10km.

Therefore an alert index is decided based on heavy rain of 10-year return period. Because, in Japan, 93 percent of landslide disaster mortality are happened under the conditions by maximum rainfall index in 10-years (based on 1991-2000 disaster occurrence excluding rock fall and disaster in construction sites).

While an attention index is decided based on heavy rain of 1.1-year return period for the purpose of preparation for state of alert, recognition for residents and training for the staffs.

The index criteria for attention/alert should be verified and revised by EPAGRI/CIRAM on every June (minimum rainfall month), based on accumulated rainfall and disaster occurrence data.

(4) Calculation of rainfall data and rainfall index, and issue/ announcement of attention/ alert

EPAGRI/CIRAM will estimate three-hour-later rainfall index by calculating current rainfall data and WRF data every 20 minutes. When the data is over rainfall index criteria, EPAGRI/CIRAM will announce by Internet and public media, such as television and radio. They should also report to the Mayor, Defesa-civil of related municipalities and Defesa civil-SC. The communication should be automatically conducted by text mail to mobile phone which previously registered by computer system.

Defesa Civil -SC will conduct official issue of attention/alert, announcement to corresponding municipalities, preparation for disaster.

Municipality government/Mayor will announce attention/alert to the residents by bulletin boards, telephone networks, church bells, and public relation vehicle, and call out staff for emergency. The method of information communication is as same as that of early warning system for floods).

Defesa Civil-SC, cooperation with DEINFRA and Municipalities, should announce attentions/ alerts to the target areas by advertising boards or bulletin boards at the major points of roadsides, and drive-inns in order to give information to the drivers. Commercial advertisement boards are effective for using as bulletin boards for attention/alert, by admitting from owners for emergency use. In case electric bulletin board, the boards are normally used for commercial advertisement or ordinary news, and are utilized for announcing attentions/alerts also.

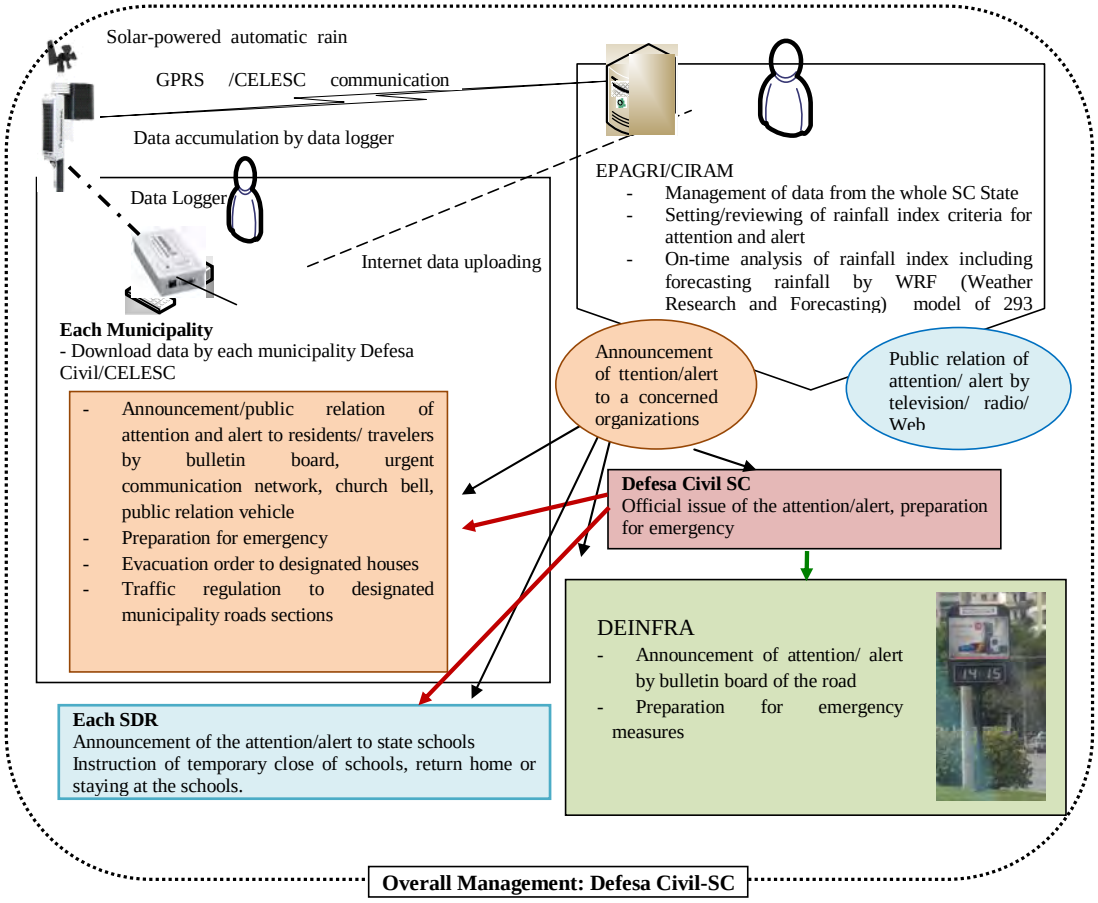
(5) Disaster Avoidance Activities

When attention is issued;

- SDR closes all state schools temporally and informs the students not to come to the schools. If the students are in the schools, instruct them to come back (or keep staying at the schools by situation). SDR also instructs all the offices to follow those actions.
- Road users hold back usage of roads in attention-issued areas by considering the attention.

When alert is issued;

- The residents, who live in risk areas which are designated in hazard maps, evacuate to designated evacuation sites (schools or churches) by designated evacuation routes.
- The Municipality and DEINFRA will order road traffic regulation of designated disaster-prone road sections in alert-issued areas when the alert is issued by Defesa Civil - SC.



Source: JICA Survey Team

Figure 9.2.2 Schematic Diagram for Early Warning System of Landslide and Flash Flood

9.2.2 Disaster Education and Evacuation Drills to the Persons Concerned and Residents

Defesa Civil of each municipality should give disaster education and evacuation drills to the persons concerned and residents to verify evacuation and communication of disaster information. Defesa Civil-SC should conduct disaster-related training to the staffs of Defesa Civil of each municipality.

The municipality should prepare a hazard map of S=1:10000 with the support of SC State and university. The hazard map contains risk sites, desirable evacuation routes and sites. After the hazard map is prepared and distributed, the municipality explains the contents of hazard map to the citizens and/or conducts fire drills to the residents who is living in a risk area.

The mayor orders to Defesa-Civil, firehouse and police to prepare evacuation sites for further alert state, announces to the residents and conduct patrols to the risk areas when the attention is issued. It is recommended for resident to evacuate to the evacuation sites as a evacuation drill even it is not a level for evacuation.

Teachers in state schools should order school kids/students to stay or return home and safety rout for return home depend on the safety of their homes. In case of staying, disaster education should be conducted to the school kids/students with hazard map and photographs of past disasters.

9.2.3 Rainfall Index which Considering Water Contents and Run off of Soil (Soil Water Index : SWI)

Soil Water Index (SWI) is a two-dimensional three-stage tank model which is designed as that: part of rainwater become groundwater through penetration and flowing out slowly to the surface.

Figure 9.2.3 shows the principle of the models and parameters which is formally used for Japanese landslide disaster alerts. SWI is calculated as a sum of the height of water levels of three tanks (S1+S2+S3).

Table 9.2.1 shows maximum SWIs of heavy rainfall in November 2008, which triggered enormous landslide disasters.

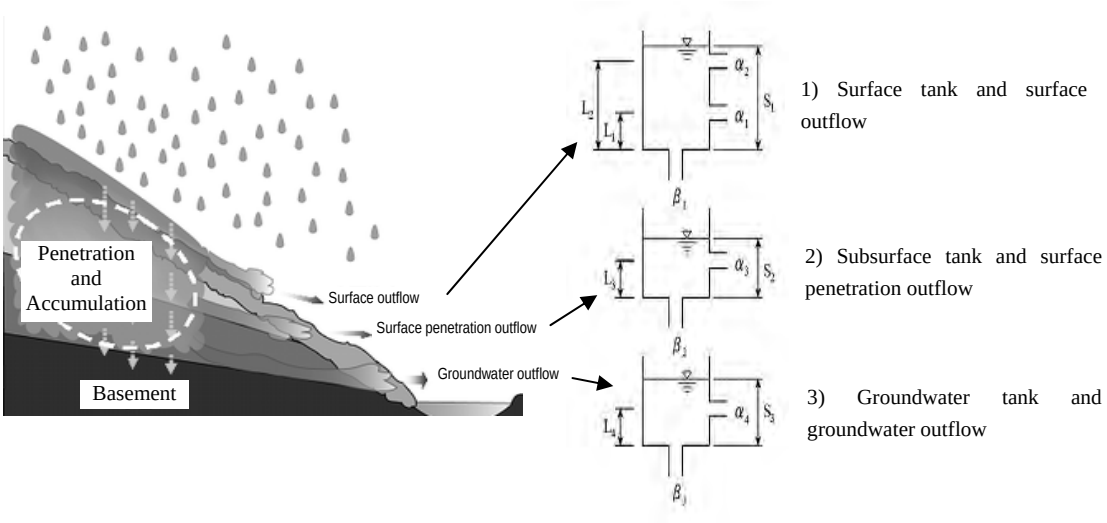
Those SWIs were carbureted by averaged hourly rainfall data of non- automatic monitoring by two or three time measurements per day. The data calculated are five (5) rainfall gauge stations which are located in Itajai River basin and has been monitoring for more than 10 years. The data are given from EPAGRI/CIRAM. There were damaged houses and fatality only in municipalities where state of calamity was issued, and these municipalities were in the area of maximum SWI were more than 145 mm of 20 years return period.

9.3 Structural Measures for Landslide

9.3.1 Priority and Plan of Structural Measures for Landslide

Structural measures will be conducted from priority sites which have higher potential annual loss, in order to prevent economic loss to be caused by landslide disasters.

Sixty-seven sites are selected as prioritized structural measure sites out of sixty-eight high risk sites excluding Itajai Port where continuous dredging might be appropriate. They are selected by landslide/sediment yield risk assessment and evaluated more than R$ 50,000 per year of potential annual loss. The risk sites selected are 33 state roads and 34 municipality roads.



Parameters formally used for Japanese landslide disaster alerts			
Parameters	**Surface tank**	**Subsurface tank**	**Groundwater tank**
Height	L1=15 (mm) L2=60 (mm)	L3=15 (mm)	L4=15 (mm)
Outflow coefficient	α1=0.1 (mm/hr.) A2=0.15 (mm/hr.)	α3=0.05 (mm/hr.)	α4=0.01 (mm/hr.)
Penetration coefficient	B1=0.1 (mm/hr.))	β2=0.05 (mm/hr.)	β3=0.01 (mm/hr.)

Source: The Meteorological Agency of Japan (edited by JICA Survey Team)

Figure 9.2.3 SWI Formally Used for Japanese Landslide Disaster Alerts

Table 9.2.1 SWIs of Heavy Rainfall in November 2008

Stations	No.	Maximum SWIs in November 2008	Recurrence	Reference data
Rio do Compo	639	37 mm	Less than a year	1995-2009 (15 years)
Ituporanga	191	43 mm	Less than a year	1988-2009 (22 years)
Indaial	167	145 mm	20 years	1991-2009 (19 years)
Blumenau	35	245 mm	60 years	1997-2009 (13 years)
Itajai	183	191 mm	30years	1987-2009 (23 years)

Source: JICA Survey Team

According to the site investigation and interview with DNIT, restoration and rehabilitation of federal road had completed after heavy rain in 2008, there are no high risk sites in federal roads.

The structural measures for landslide are planned to secure half width road traffic against heavy rain level of the November 2008 (60-year return period). Type for measures will be selected by learning form existing measures of similar condition slopes (mainly the Federal road BR470), which have not full width road closure disaster events under 60 years heavy rain. It is also referred that technical norm in Brazil, NORMA BRASILEIRA ABNT (Associação Brasileira de Normas Técnicas), NBR (Número de referéncia) 11682, Estabilidade Encostas (Slope Stabilization).

The slope vegetation for each risk site is principal measure in order to mitigate sediment yield. Furthermore, trees should be planted in no-risk sites of falling tree in order to contribute to environmental improvement by carbon fix.

Table 9.3.1 Selection of Structural Measure Type by Landslide Situation

Type of Landslide	Location of hazard origin to preservation object	Applicable Slope Condition		Type of Structural Measurers Vegetation and drainage are applied to the whole sites
Collapse Desmoronamento	Mountainside slope	Stability by slope cutting is impossible.		Rock bolting, Anchoring
		There are possibilities of rock falls/collapses.		Removal of unstable rocks, foot protection works, rock catch fence, rock catch/covering net.
		Stability by slope cutting is possible	Slope height of 15 m or more	Removal of unstable soils（Slope cutting）, Reinforced earth for cutting slope
			Slope height of lower than 15 m	Removal of unstable soils（slope cutting）, vegetation net, gabion placing on slope foot.
	Valley side slope	Erosion has occurred, and might influence to road body collapse in the long term.		Embankment, piling, sheet piling, large block placing, gabion drainage along gully.
	Riverbank	River erosion has approached a preservation object, and/or cracks and subsidence are recognized.		Gabion revetment with cover soil, connecting concrete blocks with cover soil
Landslide Escorregamento	From mountainside to valley side slope	Assumed deep slide surface, high groundwater level.		Horizontal drainage drilling, gabion walls, steel pile working
	Mountainside	Assumed shallow slide surface, high groundwater level.		Closed conduit width open ditch, reinforced earth for cutting slope, gabion wall
	Road body to valley side slope	Assumed deep slide surface, low groundwater level.		Alternative study of steel pipe piling and light weight embankment
	Shallow road body slide	Shallow road slide of road body due to shoddy workmanship and/or poor drainage.		Rehabilitation of road body
Debris Flow Escoamento	Torrent of mountainside	Event history of debris flow disaster		Sediment trap works

Source: JICA Survey Team

Location and type of structural measures for selected 67 risk sites are shown in Table 9.3.2.

Table 9.3.2 Order of Priority and the Plan of Structure Measures for Landslides Disasters

Priority Order	Place	Municipality	Road Management	Annual amount of potential damage (R$ x10^3/ year)	Type of disaster	Type of construction (slope protection with vegetation and drainage in all places)
1	SC 302 Taio - Passo Manso-5	Taió	State road	1,255	Landslide (on the lane)	Horizontal drainage drilling, gabion retaining wall, pile work.
2	SC470 Gaspar Riverside	Gaspar	State road	1,095	Collapse (riverside & valley side)	Gabion retaining wall
3	Blumenau - Av Pres Casrelo Branco	Blumenau	Municipality road	1,021	Collapse (riverside)	Connecting concrete block, sheet piling
4	SC418 Blumenau - Pomerode	Pomerode	State road	989	Landslide (mountainside)	Closed conduit with open ditch, gabion retaining wall
5	SC474 Blumenau - Massaranduba 2	Blumenau	State road	907	Collapse (mountainside)	Cutting, slope reinforcement

Priority Order	Place	Municipality	Road Management	Annual amount of potential damage (R$ x10^3/ year)	Type of disaster	Type of construction (slope protection with vegetation and drainage in all places)
6	Gaspar - Luiz Alves, Gaspar 9	Gaspar	Municipality road	774	Collapse (mountainside and riverside)	Cutting, slope reinforcement, Horizontal drainage drilling
7	Gaspar - Luiz Alves, Luiz Alves 6	Luis Alves	Municipality road	700	Collapse (mountainside)	Cutting, slope reinforcement
8	SC470 Gaspar Bypass	Gaspar	State road	689	Collapse (mountainside)	Cutting, slope reinforcement
9	SC477 Benedito Novo - Dutor Pedrinho 1	Benedito Novo	State road	680	Landslide (on the lane)	Alternative study of Light weight embankment and pile works.
10	SC418 Pomerode - Jaragua do Sul 1	Pomerode	State road	651	Lane collapse	Embankment with gabions at the bottom
11	Gaspar - Luiz Alves, Luiz Alves 4	Luis Alves	Municipality road	629	Landslide (mountainside)	Cutting, slope reinforcement
12	SC474 Blumenau - Massaranduba 1	Blumenau	State road	601	Collapse (mountainside)	Cutting, slope reinforcement
13	SC 302 Taio-Passo Manso 4	Taio	State road	526	Collapse (mountainside)	Cutting, slope reinforcement
14	Gaspar - Luiz Alves, Luis Alves 11	Luis Alves	Municipality road	497	Collapse (mountainside)	Cutting, slope reinforcement
15	SC486 Brusque - Botuverá 13	Botuverá	State road	473	Collapse (mountainside)	Cutting, slope reinforcement
16	SC416 Timbó - Pomerode	Timbó	State road	443	Landslide (mountainside)	Cutting, horizontal drainage drilling, gabion retaining wall
17	SC486 Brusque - Botuverá 1	Brusque	State road	430	Collapse (mountainside)	Cutting, slope reinforcement
18	R. Alamedia Rio Branco, Blumenau	Blumenau	Municipality road	398	Collapse (mountainside)	Cutting, slope reinforcement
19	Gaspar - Luiz Alves, Gaspar 2	Gaspar	Municipality road	384	Collapse (mountainside)	Cutting, slope reinforcement
20	Gaspar - Luiz Alves, Luis Alves 7	Luis Alves	Municipality road	380	Collapse (mountainside)	Cutting, slope reinforcement
21	Gaspar - Luiz Alves, Gaspar 1	Gaspar	Municipality road	379	Collapse (mountainside)	Cutting, Slope reinforcement
22	Gaspar - Luiz Alves, Luis Alves 3	Luis Alves	Municipality road	372	Collapse (mountainside)	Cutting, slope reinforcement
23	Ponte Aldo P. de Andrade - margem direita	Blumenau	Municipality road	366	Superficial landslide and lane sinking	Rehabilitation of road and pavement
24	SC486 Brusque - Botuverá 3	Brusque	State road	344	Collapse (mountainside)	Cutting, slope reinforcement
25	SC486 Brusque - Botuverá 2	Brusque	State road	342	Collapse (mountainside)	Cutting, slope reinforcement
26	Gaspar - Luiz Alves, Gaspar 8	Gaspar	Municipality road	326	Collapse (mountainside)	Cutting, gabion retaining wall
27	Gaspar - Luiz Alves, Gaspar 4	Gaspar	Municipality road	323	Collapse (mountainside)	Cutting, slope reinforcement
28	SC486 Brusque - Botuverá 9	Botuverá	State road	301	Collapse (mountainside)	Cutting, slope reinforcement
29	SC486 Brusque - Botuverá 7	Brusque	State road	298	Collapse (mountainside)	Cutting, slope reinforcement
30	Gaspar - Luiz Alves, Luis Alves 2	Luis Alves	Municipality road	278	Collapse (mountainside)	Cutting, slope reinforcement
31	Gaspar - Luiz Alves, Gaspar 7	Gaspar	Municipality road	276	Collapse (mountainside)	Cutting, gabion retaining wall
32	Gaspar - Luiz Alves, Luis Alves 1	Luis Alves	Municipality road	271	Collapse (mountainside)	Cutting, slope reinforcement

Priority Order	Place	Municipality	Road Management	Annual amount of potential damage (R$ x10^3/ year)	Type of disaster	Type of construction (slope protection with vegetation and drainage in all places)
33	Gaspar - Luis Alves, Luis Alves 5	Luis Alves	Municipality road	271	Collapse (mountainside)	Cutting, slope reinforcement
34	Gaspar - Luiz Alves, Luis Alves 8	Luis Alves	Municipality road	270	Collapse (mountainside)	Cutting, gabion retaining wall
35	SC486 Brusque - Botuverá 11	Botuverá	State road	260	Collapse (mountainside)	Cutting, slope reinforcement
36	SC486 Brusque - Botuverá 10	Botuverá	State road	260	Collapse (mountainside)	Cutting, slope reinforcement
37	Gaspar - Luiz Alves, Luis Alves 10	Luis Alves	Municipality road	227	Collapse (mountainside)	Cutting, slope reinforcement
38	SC486 Brusque - Botuverá 12	Botuverá	State road	221	Collapse (mountainside)	Cutting, slope reinforcement
39	SC486 Brusque - Botuverá 4	Brusque	State road	220	Collapse (mountainside)	Cutting, slope reinforcement
40	SC486 Brusque - Botuverá 6	Brusque	State road	220	Collapse (mountainside)	Cutting, slope reinforcement
41	SC486 Brusque - Botuverá 14	Botuverá	State road	220	Collapse (mountainside)	Cutting, slope reinforcement
42	SC486 Brusque - Botuverá 5	Brusque	State road	220	Collapse (mountainside)	Cutting, slope reinforcement
43	SC 302 Taio-Passo Manso 2	Taio	State road	202	Superficial landslide and lane sinking	Rehabilitation of road and Pavement
44	Gaspar - Luiz Alves, Gaspar 6	Gaspar	Municipality road	184	Collapse (mountainside)	Cutting, gabion retaining wall
45	Gaspar - Luiz Alves, Gaspar 10	Gaspar	Municipality road	184	Collapse (mountainside)	Cutting, gabion retaining wall
46	SC418 Pomerode - Jaraguá do Sul 2	Pomerode	State road	184	Collapse (mountainside)	Cutting, slope reinforcement
47	Gaspar - Luiz Alves, Luis Alves 12	Luiz Alves	Municipality road	184	Collapse (mountainside)	Cutting, slope reinforcement
48	Gaspar - Luiz Alves, Gaspar 3	Gaspar	Municipality road	184	Collapse (mountainside)	Cutting, slope reinforcement
49	SC413 Luiz Alves - Massaranduba 1	Luiz Alves	State road	172	Landslide (mountainside)	Horizontal drainage drilling, gabion retaining wall
50	Gaspar - Blumenau 3	Gaspar	Municipality road	169	Collapse (mountainside)	Cutting, slope reinforcement
51	SC486 Brusque - Botuverá 8	Botuverá	State road	151	Collapse (mountainside)	Cutting, slope reinforcement
52	SC 302 Taio - Passo Manso 1	Taio	State road	149	Landslide superficial and lane sinking	Rehabilitation of road and pavement
53	SC 302 Taio - Passo Manso 3	Taio	State road	149	Landslide superficial and lane sinking	Rehabilitation of road and Pavement
54	SC477 Benedito Novo - Dutor Pedrinho 2	Benedito Novo	State road	144	Superficial landslide (mountainside)	Drain ditch and pavement
55	R. Bruno Hering, Blumenau	Blumenau	Municipality road	119	Debris flow	Gabion
56	Gaspar - Luiz Alves, Luiz Alves 9	Luiz Alves	Municipality road	111	Collapse (mountainside)	Cutting, slope reinforcement
57	SC477 Benedito Novo - Doutor Pedrinho 3	Benedito Novo	State road	108	Superficial landslide and lane sinking	Concrete block retaining wall

Priority Order	Place	Municipality	Road Management	Annual amount of potential damage (R$ x10^3/ year)	Type of disaster	Type of construction (slope protection with vegetation and drainage in all places)
58	Gaspar - Luiz Alves, Gaspar 5	Gaspar	Municipality road	106	Collapse (mountainside)	Cutting, slope reinforcement
59	Baú	Ilhota	Municipality road	101	Debris flow	Gabion
60	SC486 Brusque - Botuverá 15	Brusque	State road	78	Collapse (mountainside)	Cutting, slope reinforcement
61	Luiz Alves Estrada municipal 1	Luiz Alves	Municipality road	67	Collapse (mountainside)	Cutting, Gabion
62	SC413 Luiz Alves -Massaranduba 2	Luiz Alves	State road	62	Collapse (mountainside)	Cutting, slope reinforcement
63	Luiz Alves Estrada municipal 2	Luiz Alves	Municipality road	59	Collapse (mountainside)	Removing unstable rock by explosion
64	Brusque Estrada municipal 1	Brusque	Municipality road	56	Collapse (mountainside)	Cutting, slope reinforcement
65	Gaspar - Blumenau 2	Blumenau	Municipality road	55	Collapse (mountainside)	Cutting, slope reinforcement
66	Gaspar - Blumenau 1	Blumenau	Municipality road	55	Collapse (vallyside)	Gabion
67	Brusque Estrada municipal 2	Brusque	Municipality road	51	Collapse (mountainside)	Cutting, slope reinforcement

Note: Itajai Port which problem is sediment discharge is not included in this table. The table shows landslide risk sites only.
Source: JICA Survey team

9.4 Mitigation Measures for Sediment Yield

Mitigation measures for sediment yield are promoted as reforestation projects which mainly aim to watershed /forest conservation and carbon fix by planting tree. The mitigation measures of sediment yield are also applied for the structural measure sites for landslides. Because main purpose is watershed and forest conservation, detailed plan will not be made for sediment yield mitigation in this master plan.

In Itajai River basin, Itajai port is only one site of remarkable economical loss caused by riverbed aggradation. The annual amount of the potential loss due to sedimentation is R$ 9 million per year and it is estimated at R$ 19 per m^3 of sediments (see supporting report C).

It should be promoted that the mitigation measures of sediment yield in the whole basin by the reforestation of bared collapsed land and prevention of riverbank erosion by riparian forest. The main objective of these programs is to preserve the water resources and forestry resources, and it might contribute environment improvement such as climatic changes measures by the carbon fix of trees. The prioritized areas for mitigation of sediment yields is the Luiz Alves River where there is no significant sand extraction business, especially the Morro do Bau surrounding area where there are still remaining of many collapsed bare lands and debris along streams after the storm in November 2008 .

Sediment yield will be mitigated at sites of structure measures for landslide. Vegetation measures should be applied basically for bared road slopes. Trees should be planted in gentle slopes and/or valley side slopes of the road, where falling three risks are not expected, in order to contribute climate change measures by the carbon fix.

The sediment control dame, and/or sand pocket are not economical to reduce sediment discharge of the Itajai Port, due to the reasons below;

- The cost per volume of debris exclude works from sediment control facilities is almost equivalent to the potential loss per volume of sediment discharge at the Itajai Port.
- All of the sediments which taken by virtual sediment control facilities are not discharge into the Itajai Port originally, some of them might be taken by sand extraction business, some of them are sediment on flood plain and not discharge into the Itajai Port for a long time.

The river bed altitude of the river in the Itajai Port area was minus 5 meters in the past, and since 1980 a dredging work has been done in order to deepen the port and, nowadays the altitude is minus 14 meters in order to enable the port call of vessels. Therefore sedimentation is activated; sedimentation from marine side might be large amount also. If sediment discharge from river side is decreased by sediment yield mitigation, the sedimentation speed might not decrease simply, sedimentation from marine side might be increased and total sedimentation volume might be balanced at some extent.

The volume of sedimentation and the dredging volume in the Itajai Port have not monitored so far. After the monitoring of the sedimentation volume and the clarification of deposition mechanism, it would be desirable to adopt measures for sedimentation including the sediment from the marine.

9.5 Mitigation of Flash Flood

Measures for reducing flash floods are aiming to promote runoff regulation facilities for the purpose to reduce surface runoff.

The flash floods increase seriousness due to the reducing rainwater permeability by decreasing of forest with land development in mountainous area. Furthermore, it is recognized that are many housing areas in stream where no water in normal time. The issue shall be treated in city plan.

9.6 Capacity Building for Structural Measures and Support for Private Self-reliant Effort

9.6.1 Capacity Building for Structural Measures

Land development by the State government is a disaster measure project to provide safe houses to the residents who are living in disaster risk area. Those land development should properly done not to cause further landslide disasters, flash flood and floods by increasing of surface runoff due to the land development. To tackle those problems, technical capacity development for land development shall be conducted.

Table 9.6.1 shows required techniques and measures for reducing disasters and sediment yield.

Table 9.6.1 Necessary Techniques and Plans to Mitigate Disasters of Landslide/Flash Flood and Sediment Yield

Technical Issues	Purpose and Objective	Recent condition	Measure
Installation of runoff regulation facilities for land development	To mitigate flash floods and floods by surface runoff increase due to land development	No technical standards	- Formulation of technical standards - Preparation of law to enable regal binding for new land development
Slope protection and slope stabilization	To stabilize slopes and protect slopes from erosion	Technical standards and methods for design review are available. The cases of instability of slopes and sedimentation are recognized. Drain ditch are not installed in some cases.	- Enhancement of design review to be conducted by State and Municipality. - Training of design engineers and construction engineers by the State government.
Disposal of waste soil	To protect sediment yield	FATEMA conducts legal instruction and management.	- Continuation of instructions and keeping laws and regulations

Source: JICA Survey Team

9.6.2 Support for Private Self-reliant Effort

Disaster education for such as simple measures will be conducted for private sectors in order to reduce damage of private construction objects which have low priority and potential annual losses with subsidy from official/private fund.

There are projects for structural measures funded by private mining company which was co-established by SC State, Municipality, Agency for institute of mining resources (CPRAM) and Association of engineers in SC State (CREA-SC), however those project cannot be applied to whole risk areas. It is recommended to promote disaster education for simple countermeasures such as drain ditches and support form official/ private funds.

CHAPTER 10 INITIAL ENVIRONMENTAL EXAMINATION (IEE) OF THE MASTER PLAN

10.1 Objectives of IEE

10.1.1 Objectives

In this Master Plan, the target probability years of flood coming was chosen by the environment and social conditions of each alternative. Therefore, we made the scoping matrix of social and environmental impacts for all possible measures of this Master Plan. The result of this scoping and IEE was taken into account the decision of the set of alternatives for implementation.

It can be made clearer the social and environmental impacts in scoping process, the necessary consideration and mitigation points were analyzed for more detail Environment Impacts Assessment Study and Project implementation.

The result of this scoping and IEE of set of selected measures (alternatives) would be important for next phase of this preparatory study, the feasibility study, and necessary study of the issuance of Brazilian environmental license (see Chapter 7.2.3) and the social and environmental consideration which is requested by JICA. It would be careful in detail study in phase 2 that the project components should be well considered and mitigated for smoother implementation.

10.1.2 The Baseline of Environment and Social Conditions

The existing environment and social conditions are adopted as the baseline for the assessment of alternatives. The existing condition of nature, pollution and socio-economy of the study area is described in Chapter 2.

10.2 Methodology and Result of the Scoping and IEE

10.2.1 Methodology of Scoping

33 major environmental and social elements were identified from JICA's Environmental and social consideration guideline and Brazilian normal EIA study. These elements are shown as follows:

Social elements: (1) Expectations in local and regional people/NGO/socio-political groups, (2) Land acquisition, (3) Productive economic activities, (4) Land use, (5) Regional Conflict, (6) Inequality between beneficiaries, (7) Effect / damage for low-income households, according to the socio-economic conditions, (8) Water usage, (9) Indigenous / traditional people, (10) Cultural heritage, (11) Basic sanitations, (12) Public health, (13) Traffic during constructions, (14) Change of income / living / livelihood, (15) Impacts for agriculture, (16) Impacts for downstream, (17) Involuntary resettlement, (18) Loss / improvement of land and house, (19) Regional infrastructure (transmission line, roads, bridges, access)

Pollution elements: (1) Water pollution, (2) Air pollution, (3) Soil contamination, (4) Noise and vibration, (5) Land subsidence, (6) Offensive odor

Natural environment elements: (1) Topography and geology, (2) Hydrological condition, (3) Solid waste, (4) Groundwater, (5) Fauna and Flora, (6) Coastal area, (7) Global issues: Greenhouse Gas, (8) Landscape.

In each alternative, qualitative evaluation was made by means of literature survey, and made each one matrix of Planning/Construction phase and Operation phase (see Tables 10.2.1 and 10.2.2).

The evaluation rating standards are:

A- is with serious impact is expected ;

B- is with some adverse impact is expected ;

C is impact is not certain with literature survey (it means some study is necessary in next phase);

A+ is with remarkable positive impact is expected by the implementation of the project;

B+ is with some positive impact is expected by the implementation of the project; and

"-" means that no impact is expected and it is not necessary any more study.

10.2.2 Result of Scoping and IEE for Alternatives

Overall impacts of all alternatives

The first aspect that is noteworthy as for the socio-economic impacts is related to the creation of expectations and to the mobilization and social articulation capacity of the project, which together represent a highly significant positive impact (A+), and which can be associated to all the proposed measures. There are great expectations of the local and regional people, during the disclosure of the undertaking and of the engineering and environment studies, especially when we consider the coverage of the measures proposed in the project, associated to the history of natural disaster in Itajaí Basin. Furthermore, we shall highlight the sociopolitical mobilization and articulation power of the project, gathering together non-governmental entities, sectors of the civil society and governmental institutions around a common objective, for the prevention of natural disasters in Itajaí River Basin.

Another common impact to all the measures and characteristic of the planning and construction phases is related to the uprising of conflicts, characterized as a high magnitude negative impact (A-), considering that there are various different social and economic interests involved in the project – public and private; municipal, state and regional; interests of the affected people and who had benefit by the project; interests of owners and rural workers; interests of the rural people and of the urban people, among others. Considering such aspects, it is necessary to establish mechanisms to minimize these conflicts, which shall be presented in the item Mitigation Measures ad Recommendations of the present report (see chapter 10.3).

The absence of impacts on the Ibirama Indigenous Land, located in the northwest region of the Basin, is also noteworthy. Environmental studies conducted in the current project phase indicated that, considering the history of conflicts at the time of the Norte dam construction, issues regarding land demarcation, as well as the federal legislation of indigenous peoples protection, it is not recommendable to propose flood control measures near TI Ibirama, nor the implementation of any project which might cause direct or indirect impacts on the way of life of such community. Following this recommendation, in the Disasters Prevention Project of Itajaí River Basin, no intervention was proposed in the Norte dam, or any other flood control measures near the TI Ibirama. We highlight that any intervention which might be proposed for this area shall be previously approved by the National Congress and by FUNAI, and shall require the conduction of a series of specific environmental studies of anthropological nature.

At last, we should point out that the conducted surveys also indicated that there are no traditional communities of slaves descendants certified by the Fundação Palmares in the municipalities affected by the measures proposed in the project.

For the pollution and natural environmental impacts, the most sensitive measure is floodway in Itajai and new dam in Itajai Mirim river. These two (2) measures are new artificial construction with changing dynamics of river (see 10.2 and 10.3) and making waste soil. The second sensitive measure is dredging. The river channel enlargement with dredging has negative impact for turbid water and waste soil.

The measures of this disaster prevention project are not only with negative impacts. Most of river enlargement measures would be positive impact for fauna and flora and landscape after the completion of construction. The width of river is limited by development (enlargement) of farm land or pasture field. With enough width of river, river can have its dynamics and more variety of animals, plans and landscape.

The qualitative analysis of the main impacts related to the planning/construction and operation phases of proposed measures are presented as follows.

(1) Control operation of Dams (Oeste Dam, Sul Dam)

This measure changes how to control operation of dam gate, more optimized to avoid overflow. It is applicable until 10-year flood and dam heightening is also proposed to prevent for bigger flood.

It would have only minor impacts neither in planning/construction and operation phase. Such measure does not cause socio-economic impacts during the planning/construction phase, nor during the operation phase.

In operation phase, the gate of dams would be opened in normal condition and closed in flood. There is only minor negative impact for downstream because the maximum water flow is limited as the size of pipe.

(2) Heightening of Oeste Dam

Planning / Construction Phase

Land acquisition (B-); Traffic during works (C); Involuntary resettlement (B-); Loss of land and improvements (B-); Water pollution (C); Noise and vibration (C); Hydrologic condition (C); Solid waste (C); Fauna and flora (C).

The design flood water level is calculated as EL. 365.0 m, the dam crest will be EL. 365.16 m after the dam heightening. So it is necessary to acquire land and resettlement between EL. 363.15 m to EL. 365.16 m (B-). Small numbers of people are living in this affected area, it could affect to affect their livelihood (normally stock farming) (B-). However, it is limited to reach until the highest level of dam crest is really rare like with 1,000-year flood, so that the negative impact is existed but small extent.

We point out that the works necessary to increase the height of Oeste dam are more complex than of the Sul dam, since they demand a longer construction period and the diversion of some of the proposed structures, which might increase the intensity of impacts connected to this measure. The construction of heightening of Oeste Dam includes base reinforcement, it has to make diversion for water. The impacts of this construction depend on the way to make diversion.

Operation Phase

Productive Economic Activities (C); Change of income / Alterations in Life / Way of Life / Support Conditions (C); Land use (C); Benefits in urban area x prejudices in rural area (C); Effects/prejudices for low income people (Impacts/prejudices according to socio-economic conditions) – (C); Impacts in agriculture (C).

(3) Widening river channel in Taió city (excavation of current river channel, 3.7km long)

Planning/Construction Phase

Land acquisition (B-); Involuntary resettlement (B-); Loss of land and improvements (B-); Traffic during works (C); Regional infrastructure (transmission grid, roads, bridges, accesses) (B-); Water pollution (B-); Air pollution (C); Noise and vibration (B-); Land subsidence (C); Topography and geology (C); Hydrologic condition (B-); Solid waste (B-); Fauna and Flora (B-); Landscape (C).

The land acquisition process (B-) and the consequent resettlement (B-) associated to the loss of land and improvements (B-) are the main negative impacts of this measure, considering that the studies conducted in the current project phase have identified a significant quantity of residences at the margins of Itajaí river and in areas originally constituted by the APP, possibly characterizing irregular occupation by low income people. However, only the conduction of a socio-economic survey at the project feasibility study phase might provide precise socio-economic information about the people now living in the area.

The construction work of this measure is necessary to dredge river canal, the dredging length is 3.7km. It would make roily water when dredging and much wet waste soil, so the impact would be A- for solid waste. According to this, water quality, noise and vibration, hydrologic condition and fauna and flora would be B-.

Operation Phase

Productive Economic Activities (C); Land use (C); Change of income / Alterations of Life / Way of Life / Support Conditions (C).

(4) Heightening of Sul Dam

Planning/Construction Phase

Land acquisition (B-); Traffic during works (C); Involuntary resettlement (B-); Loss of land and improvements (B-); Noise and vibration (C); Solid waste (C).

The construction work of Sul Dam is just modification of spillway and reinforced gate, not including dam base modification. It is not necessary to interrupt river in construction, there is only minor impacts. The socio-economic impact for expansion of inundated area is almost same

Operation Phase

Productive Economic Activities (C); Change of income / Alterations in life Conditions / Way of Life / Support (C); Land use (C); Benefits in urban area x prejudices in rural area (C); Effects/prejudices for low income people (Impacts/prejudices according to socio-economic conditions) – (C); Impacts in agriculture (C).

(5) Rain water storage in rice field

Planning/Construction Phase

The construction work of this measure is small manual work of heightening rim of rice field (20cm). It would have only minor impacts in construction phase.

Operation Phase

Productive economic activities (B-); Impacts for agriculture (B-); Fauna and Flora (B+)

This measure is rice field would be as flood plain, it is the most natural way for flood protection. It would have positive effect for biological cycle and fauna and flora (B+). In the operation phase, the main socio-economic impacts caused by this measure are related to productive economic conditions (B-), more specifically to the agricultural production (B-), because when there are floods, the cultivated area will be inundated, with consequent loss of production.

(6) Small-scale dam in micro-basin

Planning/Construction Phase

Land acquisition (B-); Involuntary resettlement (B-); Loss of land and improvements (B-); Regional infrastructure (C); Traffic during works (B-); Topography and geology (C); Hydrologic condition (C); Groundwater (C); Fauna and Flora (B-); Landscape (C)

The shut of these small dams and the filling of the reservoir during the floods will inundate land which might be currently productive and, thus, the main impact of such measure is related to the acquisition of land and to the indirect and direct inherent impacts to this process. However, because these are dams with small reservoirs, and considering that at the current phase of studies it is not possible to precisely locate such dams, in the present evaluation, the same impacts of all proposed small dams were considered, which cannot be measured yet.

Operation Phase

Productive Economic Activities (C); Change of income / Alterations in Life / Way of Life / Support Conditions (C); Agricultural activities (C); Land use (C); Topography and geology (B-); Hydrologic condition (B-); Groundwater (C); Fauna and Flora (B-); Landscape (B-)

In the construction phase of making irrigation pond, firstly the diversion of waterway would be made. The diversion would not be take long time, but the continuity of the river would cut. The continuity of the river includes fish migration, biological and physical cycle in nature, so the impact of irrigation pond would continue to operation phase (B-). If the irrigation pond would be with 10 to 15m height, it is big artificial construction which is made in rural area. The impact of landscape would be affected after construction (B- in operation phase).

(7) Widening river channel in downstream of Rio do Sul (dredging of river canal, 10.3 km long)

Planning/Construction Phase

Land acquisition (B-); Traffic during works (C); Involuntary resettlement (B-); Loss of land and improvements (B-); Regional infrastructure (transmission grid, roads, bridges, accesses) (B-); Water pollution (B-); Noise and vibration (C); Land subsidence (C), Topography and geology (C); Hydrologic condition (B-); Solid waste (A-); Fauna and flora (B-).

The main negative impact of such measure is related to land acquisition (B-) and to the direct and indirect inherent impacts to this process, with highlight on the involuntary resettlement of the rural people. The negative impact related to interferences in the roads infrastructure (B-) is also noteworthy, since there is a bridge along the area of the implementation of the measure, which shall be relocated.

The construction of this measure includes dredging for 10.3km, downstream of Rio do Sul city, it would be affected to water turbidity, hydrological condition and fauna and flora (B-). And the construction generates much wet waste soil (A-).

Operation Phase

Productive Economic Activities (C); Land use (C); Effects/prejudices for low income people (Impacts/prejudices according to socio-economic conditions) – (C); Benefits in urban area x prejudices in rural area (C); Change of income / Alterations in Life / Way of Life / Support Conditions (C); Impacts in agriculture (C); Impacts in downstream areas (C); Land subsidence (C); Topography and geology (C); Hydrologic condition (C); Fauna and Flora (B+); Landscape (B+)

The width of river would be wider after the construction, the flow would be more natural than now. There would increase more habitats for more plant and animals, and better landscape (B+).

(8) Dykes in Rio do Sul city (length total: 3.5km, height max.: 5.0m)

Planning/Construction Phase

Land acquisition (A-); Productive Economic Activities (C); Land use (C); Benefits in urban area x prejudices in rural area (C); Effects/prejudices for low income people (Impacts/prejudices according to socio-economic conditions) (C); Change of income / Alterations in Life / Way of Life / Support Conditions (C); Involuntary resettlement (A-); Loss of land and improvements (A-); Traffic during works (C); Regional infrastructure (transmission grid, roads, bridges, accesses) (A-); Water pollution (C); Air pollution (B-); Noise and vibration (B-); Topography and geology (C); Fauna and Flora (C); Landscape (C)

The main negative impact of this measure is related to land acquisition (A-) and to the inherent impacts to this process, with highlight on the resettlement of a great amount of people, because the area is highly occupied. The negative impacts related to interferences in the roads infrastructure (A-) are also noteworthy, considering that there are at least six bridges along the area in dikes construction area, which shall be relocated. As for impacts on current economic activities, it is noteworthy that, unlike in the city of Itajaí, there are no ports in the area of dikes construction. However, there is no precise information about the existence of industries in the area, which shall be checked through the socio-economic survey in the next project phase.

The civil construction work in the residential area would affect to the residents noise and vibration (B-) and sometimes air pollution (C).

Operation Phase

Productive Economic Activities (C); Benefits in urban area x prejudices in rural area (C); Change of income / Alterations in Life / Way of Life / Support Conditions (C); Land use (C); Effects/prejudices for low income people (Impacts/prejudices according to socio-economic conditions) – (C); Regional infrastructure (transmission grid, roads, bridges, accesses) (B-); Fauna and Flora (C); Landscape (B-)

The maximum height of dyke would be 4.6m after construction, it would affect to landscape (B-).

(9) Use of CELESC hydro-electric generation dams for flood prevention (introducing pre-release)

This measure is introducing pre-release of CELESC hydro-electric generation dams to make content for rainfalls. The pre-release makes water level higher suddenly in downstream cities, it is necessary to alert and announce for people in downstream when pre-release would be done.

(10) Dykes with APP in Blumenau city

Planning/Construction Phase

Massive land acquisition (A-); Involuntary resettlement (A-); Loss of land and improvements (A-); Traffic during works (B-); Regional infrastructure (transmission grid, roads, bridges, accesses) (A-); Water pollution (C); Air pollution (C); Noise and vibration (B-); Topography and geology (C); Hydrologic condition (C); Fauna and Flora (B-); Landscape (C)

The land acquisition process (A-) and the consequent resettlement (A-), associated to the loss of land and improvements (A-), are the main negative impacts of this measure, considering that, besides having residences, the area planned for the construction of such dikes is an APP area and, in some points, it is occupied with hotels, which shall cause huge negative impacts on the current economic activities. The negative impacts related to interferences in the roads infrastructure (A-) are also noteworthy, considering that urban ways and bridges shall be affected and will have to be relocated.

The construction site is the center of Blumenau city, so that the noise and vibration would be negative impact for residents and tourists (B-). There is some riparian forest and it would be affected by construction work (B-).

Operation Phase

Productive Economic Activities (A-); Change of income / Alterations in Life / Way of Life / Support Conditions (C); Land use (B+); Effects/prejudices for low income people (Impacts/prejudices according to socio-economic conditions) – (C); Regional infrastructure (B-); Fauna and Flora (B+); Landscape (B+)

One positive aspect of this measure might be highlighted, which is the possibility of using the APP area, through the implementation of a public park, allowing the people to enjoy a leisure area at the riverbanks of Itajaí river, in contact with nature, which is appraised as a middle magnitude positive impact (B+).

The riverside will be a park within APP, the landscape in the center of the city would be better (B+). The width of river would be wider and more space for living nature (B+).

(11) Dykes in Garcia river (urban river in Blumenau, length: 1.3km, height max.: 2.6m)

Planning/Construction Phase

Land acquisition (A-); Traffic during works (B-); Involuntary resettlement (A -); Loss of land and improvements (A-); Regional infrastructure (transmission grid, roads, bridges, accesses) (A-); Air pollution (C); Noise and vibration (B-); Solid waste (C); Landscape (C)

The main negative impact of this measure is related to land acquisition (A-) and to the direct and indirect inherent impacts to this process. The negative impacts related to interferences in the roads infrastructure (A-) are also noteworthy, considering that there are bridges along the area of land improvement, which shall be relocated.

The construction side is along the Ribeirão Garcia, it is residential area. Noise and vibration would affect next to residential area (B-).

Operation Phase

Productive Economic Activities (C); Change of income / Alterations in Life / Way of Life / Support Conditions (C); Land use (B+); Effects/prejudices for low income people (Impacts/prejudices according to socio-economic conditions) – (C); Regional infrastructure (B-); Landscape (C)

(12) Widening river channel in APP in Garcia and Velha river –without dredging (urban rivers in Blumenau, length of Garcia: 2.6km, length of Velha: 3.4km)

Planning/Construction Phase

Massive land acquisition (A-); Involuntary resettlement (A-); Loss of land and improvements (A-); Traffic during works (B-); Regional infrastructure (A-); Air pollution (C); Noise and vibration (B-); Topography and geology (C); Solid waste (C); Fauna and Flora (B-); Landscape (C)

There are residential areas along Ribeirão Garcia and Ribeirão Velha. The construction work is only above ground, and it is not included dredging but it would have soil waste (B-).

Operation Phase

Productive Economic Activities (C); Change of income / Alterations in Life / Way of Life / Support Conditions (C); Land use (B+); effects/prejudices for low income people (Impacts/prejudices according to socio-economic conditions) – (C); Regional infrastructure (B-); Topography and geology (C); Fauna and Flora (B+); Landscape (B+)

(13) Ring dyke in Ilhota (length: 8.0km, height: 2.0m)

Planning/Construction Phase

Land acquisition (B-); Involuntary resettlement (B-); Loss of land and improvements (B-); Regional infrastructure (transmission grid, roads, bridges, accesses) (A-); Traffic during works (C); Water pollution (C); Air pollution (C); Noise and vibration (C); Topography and geology (C); Hydrologic condition (C); Fauna and Flora (C); Landscape (C)

Operation Phase

Productive Economic Activities (C); Benefits in urban area x prejudices in rural area (C); Change of income / Alterations in Life / Way of Life / Support Conditions (C); Land use (C); Effects/prejudices for low income people (Impacts/prejudices according to socio-economic conditions) – (C); Regional infrastructure (A-); Topography and geology (C); Landscape (C)

The construction work is around Ilhota city for 8km long, but not inside the city. The main impact of such measure is related to the problems caused to the roads system and to the transports infrastructure of the region. After the construction of the dikes in a ring shape, it will be necessary to build bridges, viaducts and roads to normalize the access and traffic within the city of Ilhota, which can be considered a high magnitude negative impact (A-).

The pollution and natural environmental impact of construction and operation phase should be investigated. But it would be possible that water should be pumped out because Ilhota city would be closed with dyke. And the dyke is 2m high, there would be some impact for landscape.

(14) Flood gate installation in Itajaí Mirim river (two gates each in upper and lower in old Itajai Mirim river

Planning/Construction Phase

Land acquisition (C); Traffic during constructions (B-); Regional infrastructure (C); Noise and vibration (B-); Water pollution (B-); Topography and geology (B-); Hydrologic condition (B-); Landscape (B-)

The construction work of upstream gate would make with diversion, and work of gate of junction to Itajaí river would make half by half. It would not affect any impacts.

Operation Phase

Land use (C); Hydrologic condition (C); Fauna and Flora (C)

The gates will be closed when flood comes, the timing of opening gate is important. It is necessary to study and make gate operation manual to minimize flood damage and to decrease negative impacts for aquatic animals.

(15) Dykes in Itajaí city (one side dyke for 12.8 km long, max. 3.0 m height)

Planning/Construction Phase

Massive land acquisition (A-); Involuntary resettlement (A-); Loss of land and improvements (A-); Traffic during works (C); Effects/prejudices for low income people (Impacts/prejudices according to socio-economic conditions) (C); Air Pollution (C); Noise and Vibration (B-); Topography and geology (C); Hydrologic condition (C); Fauna and flora (B-); Landscape (C).

The land acquisition for the construction of dikes, in addition to the involuntary resettlement, will cause significant alterations in the local economic activities (A-), considering that various ports and industries are located in the region of the dikes construction. These economic activities currently developed in the area are highly relevant for the municipality of Itajaí and create jobs and income for the people of the city. Therefore, in addition to alterations in the economic dynamics of the municipality, and perhaps of the region, lots of jobs will be lost, which represents a significant impact, especially if we consider the socio-economic situation of most of the workers in ports and industries, in general low income people. However, there are no precise information about the socio-economic conditions of such workers, and thus to measure the intensity of such impact, it is necessary to conduct a socio-economic survey.

Operation Phase

Productive Economic Activities (A-); Change of income / Alterations in Life / Way of Life / Support Conditions (C); Land use (C); Effects/prejudices for low income people (Impacts/prejudices according to socio-economic conditions) – (C); Regional infrastructure (B-); Landscape (B-).

The height of dyke is 1.5m to 3.5m, it would affect for landscape in Itajaí port (B-).

(16) Floodway in Navegantes city

Planning/Construction Phase

Land acquisition (A-); Productive Economic Activities (C); Effects/prejudices for low income people (Impacts/prejudices according to socio-economic conditions) – (C); Involuntary resettlement (B-); Loss of land and improvements (B-); Traffic during works (C); Regional infrastructure (B-); Water pollution (B-); Air pollution (C); Noise and vibration (C); Hydrologic condition (A-); Solid waste (A-); Fauna and Flora (A-); Coastal zone (B-); Landscape (C)

The most significant impacts of such measure are related to land acquisition (A-) for the construction of the canal and to the affected roads infrastructure (B-), as well as to the infrastructure which will be necessary after the construction of the canal – construction of various bridges along the canal length to allow the people crossing. The impacts related to the involuntary resettlement might be considered middle intensity negative impacts (B-), because this area is not densely occupied.

In the construction phase, the closed dike and the new shortcut canal would be made at first, then the floodway and the flood gate would be constructed. The natural impact is quite big because the floodway would be made from farm field, as hydrologic condition, solid (soil) waste and fauna and flora (A-).

Operation Phase

Productive Economic Activities (C); Benefits in urban area x prejudices in rural area (C); Change of income / Alterations in Life / Way of Life / Support Conditions (C); Land use (C); Effects/prejudices for low income people (Impacts/prejudices according to socio-economic conditions) – (C); Regional infrastructure (B-); Impacts in agriculture (C); Water pollution (B-); Topography and geology (C); Hydrologic condition (A-); Groundwater (B-); Fauna and Flora (A-); Coastal zone (C); Landscape (C)

The floodway would be used when the flood comes only. The other time without flood would be empty canal. In case of flood, the flood gate would be closed and water would flow in the floodway. When flood water flow in the floodway, sedimentation of river water would flow out the Atlantic ocean and affect coastal area (B-). Itajaí port normally have problem of sedimentation, it can be happen same sedimentation problem in the exit of the floodway. The new canal in operation phase would be normal waterway of Itajaí river. This canal is artificial, therefore, a few decades are necessary to be like a natural river, it is the negative impact for hydrological condition and fauna and flora (A-). It is possible to come up seawater and salinization of groundwater (B-).

(17) New dam in Itajaí Mirim river

Planning/Construction Phase

Massive land acquisition (A-); Traffic during works / Interference with the roads system as a result of the works (C); Involuntary resettlement (B-); Loss of land/improvements (B-); Productive Economic Activities (C); Water pollution (A-); Air pollution (C); Noise and vibration (C); Hydrologic condition (B-); Solid waste (A-); Groundwater (C); Fauna and Flora (C); Landscape (B-)

The construction of the new dam has as main impacts those associated to the delimitation of the area intended to the formation of the reservoir. The implementation of the reservoir will cause a direct negative impact on the local people, which will be affected, among others, by the inundation of land proper for agriculture during the occurrence of floods. In view of this impact, the affected people shall be relocated to other areas. To minimize such impact, the implementation body shall acquire land near the affected area, and in addition shall keep the communities united so that the resettled community does not lose their neighborhood bonds.

The construction of the new dam will affect cultivated areas, improvements and residences located in the rural area that is intended for the formation of the reservoir, also interfering with the income of rural producers. However, such negative impact will be more significant for small and middle size producers, whose dependence on the land and on the river is much bigger. It is not possible to measure the intensity of such impact, because there is no socio-economic information about the people who currently lives in the area, thus the conduction of a socio-economic survey in the project feasibility phase is recommended.

The land acquisition process will result in a process of involuntary resettlement, associated to the loss of land and improvements, both considered middle intensity negative impacts (B-). Such process might cause the loss of the agricultural production, the change of productive activities and of the land use, but it is not possible to measure the intensity of such impacts in the current project phase, because there is no precise information about the people and the productive activities of affected areas. In general, the whole process is more strongly felt by the low income people (B-), who has more difficulties in adopting new forms of living in the resettlement area. Each group is affected in different intensities and timing, and develops different means to defend themselves in view of the ongoing changes that will result from the undertaking implementation.

In construction of new dam, it is make half by half using wall. This dam is designed as concrete gravity dam, it would discharge turbid and alkaline water and much soil waste (A-). And the construction work also affects for hydrologic condition (A-) and landscape (B-). The landscape would be affected the surface of concrete gravity dam is just concrete among the mountainous area.

Operation Phase

Productive Economic Activities (C); Effects/prejudices for low income people (Impacts/prejudices according to socio-economic conditions) (B-); Change of income / Alterations in Life / Way of Life / Support Conditions (B-); Impacts in agriculture (B-); Land use (B-); Benefits in urban area x prejudices in rural area (C); Water pollution (C); Topography and geology (B-); Hydrologic condition (C); Groundwater (C); Fauna and Flora (B-); Landscape (B-)

This dam would not make lake and have gate for water flow in normal condition because this new dam is single purpose for flood control. If the surface of water would be full of this new dam in operation phase, the lake would reach national park of Serra do Itajaí (B- for fauna and flora). It is difficult to evaluate the impact to the national park when the flood comes because the data is not enough. The impact for landscape is existent but small because the dam site is rural area.

(18) Measures for landslide disaster prevention

Planning/Construction Phase

Air pollution (C); Noise and vibration (C); Solid waste (C); Landscape (C)

The structural measure for landslide disaster prevention is slope protection structure. The only socio-economic impact which can be associated to the implementation of such measure relates to the traffic and interferences in the roads system as the result of works, which might be considered a middle magnitude negative impact (B-). In turn, in the operation phase, such measure does not cause significant socio-economic impacts.

Operation Phase

Landscape (C)

Depend on what kind of slope protection structure would be installed. If it is concrete, it is worse than protection by vegetation.

(19) Strengthening Flood forecasting and warning system (FFWS)

The installation of flood forecasting and warning system, it would be started from installing precipitation observing devices in each municipality in Itajaí basin, and devices would connect to telephone line or internet. It would have only minor impacts in operation phase.

10.3 Mitigation and Recommendation for the Alternatives

The mitigation and recommendation for the alternatives which have major negative impacts are presented as follows.

(1, 2) Heightening of Oeste Dam/ Sul Dam

The main mitigating measures for the impacts are the same as the construction of the new dam, however, taking into consideration that the impacts of this measures (Oeste and Sul dams) are smaller magnitude than new dam.

(3) Widening river channel in Taió city (excavation of current river channel, 3.7km long)

The mitigating measures for the impacts are the same as the construction of the new dams. It has to find soil disposal site in the Itajaí basin, and dispose adequately.

(5) Rain water storage in rice field

The main mitigating measure for this impact is the compensation of the production affected by flood. We recommend the conduction of a socio-economic survey for the purposes of a diagnosis of the productive activities that might be affected and the calculation of compensation for the producers.

(6) Small-scale dam in micro-basin

The main mitigating measures for the impacts of the construction of small dams are the same as the construction of the new dam, however, taking into consideration that the impacts of the construction of small dams are smaller magnitude than new dam.

For fish and biological passage, it should be careful for making diversion as easier to swim up. And for this scale of irrigation pond can be made by soil covered with grass.

(7) Widening river channel in downstream of Rio do Sul (dredging of river canal, 10.3 km long)

The main mitigating measures for the impacts are those adopted for the construction of new dams, added to the relocation of the affected roads infrastructure and to the creation of the necessary infrastructure to relocate the new crossing point in order to avoid changes in the routine of people's life. It includes dredging, so same mitigation of (3) Widening river channel in Taió city.

(8) Dykes in Rio do Sul city (length total: 3.5 km, height max.: 5.0 m)

The main mitigating measures for the impacts are same as the dikes in the city of Blumenau.

(10) Dykes with APP in Blumenau city

The main mitigating measures for the impacts are same as enlargement of the river in the APPs without dredging, added to the relocation of the affected roads infrastructure and to the creation of the necessary infrastructure to relocate the new crossing points in order to avoid changes in the routine of people's life. We also recommend the articulation with local authorities as a way to respect and harmonize the proposed measure with the City Master Plan of Blumenau city, aiming to reestablish the structure of economic activities affected by the construction of dikes.

For natural environmental aspects, this measure locates in the central of Blumenau city, which is famous for tourism. It is recommended to restore native riparian forest and ecosystem for comfortable place for people.

(11) Dykes in Ribeirão Garcia (urban river in Blumenau, length: 1.3km, height max.: 2.6 m)

The main mitigating measures for the impacts are same as the construction of dikes with APP without dredging.

(12) Widening river channel in APP in Ribeirão Garcia, Ribeirão Velha –without dredging (urban rivers in Blumenau, length of Garcia: 2.6km, length of Velha: 3.4km)

The main mitigating measures for the impacts of this measure are:

- Dialogue with residents and owners of areas to be acquired;
- Definition of negotiation, compensation criteria for the interferences caused;

- Compensation of properties and improvements affected;
- Search for locations for resettlement, considering the needs of the affected people;
- Monitoring and support during the whole resettlement process and compensation for all costs of the process;
- Relocation of the affected roads infrastructure.
- Creation of the necessary infrastructure to relocate the new crossing points in order to avoid changes in the routine of the people.

We also recommend the adoption of social communication actions with the affected people aiming to reduce the inherent impacts to the process of negotiation and resettlement, as well as the articulation with local authorities, in order to respect and harmonize the proposed measure with the City Master Plan of Blumenau city.

(13) Ring dyke in Ilhota (length: 8.0km, height: 2.0 m)

The main mitigating measures for the impacts are as follows:

- Construction of new segments of the roads that will be affected;
- Creation of the necessary infrastructure to relocate the new crossing points in order to avoid changes in the routine of the people's life.
- Compensation of properties and improvements affected;
- Search for locations for resettlement, considering the needs of the affected people;

(14) Flood gate installation in Itajaí Mirim river (two gates each in upper and lower in old Itajai Mirim river

When the flood comes and closes the gates, it should be careful about the closed period. If the closed period would be longer, it would be affect organisms. The gates should be open as soon as the water level is getting lower until safe level.

(15) Dykes in Itajaí city (one side dyke for 12.8 km long, max. 3.0 m height)

The main mitigating measures for the impacts presented for the measure of enlargement of river in APPs without dredging. We also recommend the systematic monitoring of the socio-economic situation of the people directly affected, through specific programs. In addition, it will be necessary to establish a strong sociopolitical articulation with the local authorities, in order to reestablish the structure of socio-economic activities affected by the construction of dikes.

It can be parapet instead of dyke if it is feasible. Parapet is like a concrete wall, can decrease area of land acquisition, but it seems really artificial structure. Dyke needs more area of land acquisition but it can be covered by vegetation.

(16) Floodway in Navegantes city

The main mitigating measures for this impacts of the canal construction are those adopted for the impacts of dikes in ring shape.

For decreasing the impact of hydrologic condition and fauna and flora by replacement of river canal, the recommendation is to keep width of the new canal and make riparian forest. For the sedimentation in the coastal area, a jetty is capable same as Itajaí port. There are some measure to avoid the rising seawater and groundwater salination, such as installing impermeable material sheet under de cover soil, poling board until impermeable layer, or coating by concrete.

(17) New dam in Itajaí Mirim river

The main mitigating measures for the impacts of the construction of the new dam are as follows:

- Dialogue with residents and owners of areas to be acquired;
- Definition of negotiation, compensation criteria for the interferences caused;
- Compensation of properties and improvements affected, as well as preparation of the condition for the continuation of the lives of people that make a living from the activities that will disappear or that will lose the current context;
- Search for resettlement locations, considering the needs of the affected people; resettlement of the families in equally productive land, providing technical assistance for the improvement of production and commercialization systems;
- Monitoring and support during the whole resettlement process and compensation for all costs of the process;
- Technical support for the adoption of a new way of life, support.

We also recommend the adoption of social communication actions aiming to reduce the inherent impacts to the process of negotiation and resettlement, as well as actions for the technical qualification of affected producers, such as:

- Qualification of the owners for the inclusion of new economic activities;
- Establishment of actions, in the resettlement process, that allow the continuity of activities providing income for the families that choose such condition;
- Reallocation of the people to an environment where it is possible to keep relationships and proximity with the communities which now have a bond;
- Guarantee of the recuperation of support bases (or through enough compensation or resettlement in an area with full working conditions) with full technical and social support, in a location always closer to their origins;
- Creation of guidance, qualification and support programs for the resume of the activities of the rural producers;
- Elaboration of qualification and guidance programs for the families who do not choose the resettlement, allowing them to develop income producing activities.

It has to be find adequate soil disposal site and dispose adequately with compliance of Brazilian law. The treatment of water discharge should be done with antalkaline treatment and sand basin. And it has to make with fish passage for swimming up.

(18) Strengthening Flood forecasting and warning system (FFWS)

The installation of FFWS is proposed in this Master Plan not only construction measure but also such non-construction measure. It is necessary to have socio-economic study to clarify the difficulties of this system for vulnerable groups such as poverty group or people with special needs. Normally, it is difficult for vulnerable groups to access the precise information. Therefore, it is recommended that vulnerable groups would access to the information same as normal people and start the evacuation process. It should be efficient system or mechanism to provide warning to every citizen, moreover, it should be earlier to provide warning to vulnerable people because it takes time to evacuate for them.

10.4 Result of the Public Audience

In the process of making Master Plan of Itajai basin, it was obligatory that the public hearing of the SC State projects. Therefore, three (3) public hearings were held at Itajaí, Blumenau and Rio do Sul in 16, 17 and 18 of November respectively. The disclosure process of public hearing was:

- The notification of the public hearing was published by two (2) major newspaper in Itajai basin, once before two (2) weeks
- The invite letter was forwarded to related SDRs (Itajaí, Brusque, Blumenau, Timbó, Rio do Sul, Ituporanga, Taió and Ibirama) all related municipalities and other related professional organizations
- The disclosure through electronic data for public relation department of SDRs, FAPESC, GTC, FURB and UNIVALI.

In the series of three (3) Public Audiences, the proposed Master Plan of flood control and landslide disaster prevention had been presented for 90 minutes by Power Point and eighteen (18) posters. The posters were prepared for further understanding, also 30 minutes of coffee break was set for reviewing these. We had 90 minutes for discussion, the questions and answers are concerned for selection of alternatives and mitigation plan. The summaries of Public Audiences are shown below.

Table 10.4.1 Public Audience in Itajai city (16/Nov/2010)

Item	Details
Date / Place	14:00-18:00, 16 November 2010 / Auditorium of AMFRI, Itajai
Chairperson	Ms. Reginete Panceri (Project coordinator of JICA, deputy of Dr. Diomário)
Participants	State staff : 3 City hall : 10 SDR : 7 Defesa civil : 2 Itajai committee : 4 Academic/NGO : 3 Residents : 1 Study team/staff : 8 Total : 43
Comments	Q1: Is this public audience is to ratify the proposals? A1: No. The measures have to do including the increasing volume by development activities. If it is difficult to do Itajai city area, it is necessary to cooperate with whole basin to be balanced. Q2 I'm radically opposed to dykes even if we live with flood here. We have time to get people away from flood. With dykes, it is impossible to do this. Many people will be died. We need a different solution for lower valley? A2 There are some risks of breaking dyke, but we can try to decreasing risks to almost zero. Normally the dyke is designed as soil dyke on the cost front, but concrete covered dyke also can be proposed for durability. Q3 The intensive rain is increasing in the world, also in Brazil. Do you have consideration to solve this problem? A3: It is not considered about global warming or climate change. Because we could not find any trend of increasing precipitation from the data what we have. Therefore there are just a few constructions for flood prevention, we proposed it is necessary for Itajai basin that make some flood prevention construction at first before thinking about climate change.

Source: JICA Survey team

Table 10.4.2 Public Audience in Blumenau City (17/Nov/2010)

Item	Details
Date / Place	14:00-18:00, 17 November 2010 / SDR Blumenau, Blumenau
Chairperson	Dr. Antônio Diomário de Queiros (President of FAPESC)
Participants	State staff : 4 City hall : 6 SDR : 2 Defesa civil : 4 Itajai committee : 3 Academic/NGO : 12 Residents : 7 Study team/staff : 6 Total : 54
Comments	Q1: The principles of PPRD is increasing water storage in the basin. This should in the area of paddy field. But in the first seminar of last year, Prof. Beate presented about the ideas of water retention as utilized in Germany and Swiss. It is a principle that must be considered, because it is a fundamental issue, if not, the Itajaí Committee never agree. A1: We did study and we want to propose strongly about water storage in rice field and pasture because the idea of Prof. Beate and CRAVIL was good. Although this is good idea, we front to the problem the amount of storage. For 5-years case, it is necessary 9,000,000m^3 to protect Rio do Sul city, it is equal to 900 storage area with 100m^2 and 1m depth only for upstream of Rio do Sul. For 50-years case, it is necessary 4,000 storage area, it seems too difficult to specify in these area. And also we have only map of 1/50,000, we cannot specify because of large-scale. Q2 I don't understand why the river dredging for 10km in downstream of Rio do Sul city. A2 The problem of Rio do Sul city is insufficient capability of passing water around Rio do Sul city. For 25-years case, still insufficient including heightening dams and irrigation ponds. We proposed that the river dredging is better than making dyke in the city of Rio do Sul because of land acquisition and resettlement. Comment: I'm living in Blumenau for 51 years, I'm advisor of commerce association. I remember the flood of 1983 and 1984 very much, I think the most important measure is floodway in Itajai. The flood of 2008 was really special because 498mm of rainfall was concentrated in 48hours, and any preparedness did not function. It is important non-construct measure, I'd like to do these measures. Itajai city has developed and increased factories much compared to 1983, the damage will increase when the flood would come.

Source: JICA Survey team

Table 10.4.3 Public Audience in Rio do Sul city (18/Nov/2010)

Item	Details
Date / Place	14:00-18:30, 18 November 2010 / Secretary of Education, Rio do Sul
Chairperson	Dr. Zenorio Piana (FAPESC)
Participants	State staff : 6 City hall : 12 SDR : 7 Defesa civil : 5 Itajai committee : 3 Academic/NGO : 0 Residents : 4 Study team/staff : 6 City council: 11 Total : 63
Comments	Q1: It is not mentioned about Norte Dam, I understand there is no influence. So that, is it possible to utilize Norte Dam to electric generation? I'd like to study and assess the possibility of utilize this dam. A1: The capacity of Norte Dam is 300,000,000m3, it is much more than three (3) times of Oeste Dam and Sul Dam. The capacity of Oeste Dam and Sul Dam is less than 100,000,000m3. The Norte Dam has never overflowed, it has more capacity than 50-years case. Flood control dam cannot combine with hydro-electric generation dam because flood control dam has to be empty but hydro-electric generation dam is necessary to keep water storage. Q2 Do you have some education components in this process? A2 No. It is already implemented by Itajai committee, each city halls and State Defesa Civil. Q3 In 1990s, the Regional Master Plan of High Valley of Itajai was developed. This

		Master Plan was for urban development office of SC state, it was saying that 140 thousand ha of reforestation in High Valley for water storage. I found that it is not considered about this in this project.
	A3:	I didn't know about this regional development plan. Please send me if you can. But the water storage capacity by reforestation is too difficult to evaluate. In Japan, the water storage capacity of forest is studied for many years, but no one could make this model.

Source: JICA Survey team

Table-10.2.1 Result of IEE (Planning/Construction Phase)

Flood Probablity	Object Region of study	Construction Phase: SOCIOECONOMIC IMPACTS, POLLUTION AND NATURAL ENVIRONMENT / PROPOSED MEASURES	Socio-economic impacts: Expectation in local and regional people / Mobilization of NGO	Land acquisition	Economic and Productive activities	Land use and occupation	Regional comflicts	Benefit to urban area vs. prejudice of rural area	Effects / prejudice of low income people	Water use	Indigeneous / traditional people	Cultural heritages	Sanitation	Public health	Traffic / interference of traffic during construction	Change of income, life condition	Impact of agriculture	Impact in downstream area	Involuntary resettlement	Impacts of land / buildings	Impacts of regional infrastructure (Transmission line, roads, bridges, etc.)	Pollution: Water pollution	Air pollution	Soil contamination	Noise and vibration	Land subsidence	Natural Environment: Offensive odor	Topography and geology	Bottom sedimentation	Solid waste	Groundwater	Fauna and flora	Coastal area	Global issues: Greenhouse gas	Landscape
5-year flood	Taió	—																																	
	Ituporanga	—																																	
	Rio do Sul	Rain water storage in rice field	A +	-	-	-	A -	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		Control operation of Sul Dam	A +	C	-	-	A -	-	-	-	-	-	-	-	B -	-	-	-	C	C	C	-	-	-	-	-	-	C	C	-	C	B-	-	-	C
		Small-scale dam in small basin (1)	A +	C	-	-	A -	-	-	-	-	-	-	-	B -	-	-	-	C	C	C	-	-	-	-	-	-	C	C	-	C	B-	-	-	C
		Small-scale dam in small basin (2)	A +	-	-	-	A -	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Timbó	—																																	
	Blumenau	—																																	
	Rios Urbanos em Blumenau	Dykes with parks in APP (without dredging)-Riberião Garcia	A +	A -	-	-	A -	-	-	-	-	-	-	-	B -	-	-	-	A -	A -	A -	-	C	-	C	-	-	C	-	B-	-	C	-	-	B+
	Ilhota	—																																	
	Itajaí	Rain water storage in rice field	A +	-	-	-	A -	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		Flood gate control installation in Itajai Mirim	A +	C	-	-	A -	-	-	-	-	-	-	-	B -	-	-	-	-	-	C	-	-	-	-	-	-	C	C	-	-	-	-	-	C
	Brusque	—																																	
10-year flood	Taió	Control operation of Oeste Dam	A +	-	-	-	A -	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Ituporanga	—																																	
	Rio do Sul	Rain water storage in rice field	A +	-	-	-	A -	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		Small-scale dam in small basin (1)	A +	C	-	-	A -	-	-	-	-	-	-	-	B -	-	-	-	C	C	C	-	-	-	-	-	-	C	C	-	C	B-	-	-	C
		Small-scale dam in small basin (2)	A +	C	-	-	A -	-	-	-	-	-	-	-	B -	-	-	-	C	C	C	-	-	-	-	-	-	C	C	-	C	B-	-	-	C
		Small-scale dam in small basin (3)	A +	C	-	-	A -	-	-	-	-	-	-	-	B -	-	-	-	C	C	C	-	-	-	-	-	-	C	C	-	C	B-	-	-	C
		Control operation of Sul Dam	A +	-	-	-	A -	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		Control operation of Oeste Dam	A +	-	-	-	A -	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Timbó	Preliminary discharge of CELESC hydro-electric dams	A +	-	-	-	A -	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Blumenau	—																																	
	Rios Urbanos em Blumenau	Dykes with parks in APP (without dredging)-Riberião Garcia	A +	A -	-	-	A -	-	-	-	-	-	-	-	B -	-	-	-	A -	A -	A -	-	C	-	C	-	-	C	-	B-	-	C	-	-	B+
		Widening parks in APP (without dredging)-Riberião Velha	A +	A -	-	-	A -	-	-	-	-	-	-	-	B -	-	-	-	A -	A -	A -	-	C	-	C	-	-	C	-	B-	-	C	-	-	B+
	Ilhota	—																																	
	Itajaí	Rain water storage in rice field	A +	A -	-	-	A -	-	C	-	-	-	-	-	C	-	-	-	B -	B -	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		Flood gate control installation in Itajai Mirim	A +	-	-	-	A -	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	C	C	-	-	-	-	-	C
		Dykes in itajai city	A +	C	-	-	A -	-	-	-	-	-	-	-	B -	-	-	-	-	-	C	-	C	-	B-	-	-	C	C	-	-	B-	-	-	C
	Brusque	—																																	
25-year flood	Taió	Heighteing of Oeste Dam	A +	B -	-	-	A -	-	-	-	-	-	-	-	C	-	-	-	B -	B -	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		Widening river canal in Taio city	A +	B -	-	-	A -	-	-	-	-	-	-	-	C	-	-	-	B -	B -	-	B-	C	-	B-	C	-	C	B-	A-	-	B-	-	-	C
	Ituporanga	—																																	
	Rio do Sul	Rain water storage in rice field	A +	-	-	-	A -	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		Small-scale dam in small basin (1)	A +	C	-	-	A -	-	-	-	-	-	-	-	B -	-	-	-	C	C	C	-	-	-	-	-	-	C	C	-	C	B-	-	-	C
		Small-scale dam in small basin (2)	A +	C	-	-	A -	-	-	-	-	-	-	-	B -	-	-	-	C	C	C	-	-	-	-	-	-	C	C	-	C	B-	-	-	C
		Small-scale dam in small basin (3)	A +	C	-	-	A -	-	-	-	-	-	-	-	B -	-	-	-	C	C	C	-	-	-	-	-	-	C	C	-	C	B-	-	-	C
		Small-scale dam in small basin (4)	A +	C	-	-	A -	-	-	-	-	-	-	-	B -	-	-	-	C	C	C	-	-	-	-	-	-	C	C	-	C	B-	-	-	C
		Small-scale dam in small basin (5)	A +	C	-	-	A -	-	-	-	-	-	-	-	B -	-	-	-	C	C	C	-	-	-	-	-	-	C	C	-	C	B-	-	-	C
		Changing operation of Sul Dam	A +	-	-	-	A -	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		Widening river canal in downstream of Rio do Sul (jusante de Rio do Sul)	A +	B -	-	-	A -	-	-	-	-	-	-	-	C	-	-	-	B -	B -	B -	B-	-	-	C	C	-	C	B-	A-	-	B-	-	-	-
	Timbó	Preliminary discharge of CELESC hydro-electric dams	A +	-	-	-	A -	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Blumenau																																		
	Rios Urbanos em Blumenau	Dykes with parks in APP (without dredging)-Garcia river	A +	A -	-	-	A -	-	-	-	-	-	-	-	B -	-	-	-	A -	A -	A -	-	C	-	C	-	-	C	-	B-	-	C	-	-	B+
		Widening parks in APP – Garcia river	A +	A -	-	-	A -	-	-	-	-	-	-	-	B -	-	-	-	A -	A -	A -	-	C	-	C	-	-	C	-	B-	-	C	-	-	B+
		Widening parks in APP (without dredging)-Velha river	A +	A -	-	-	A -	-	-	-	-	-	-	-	B -	-	-	-	A -	A -	A -	-	C	-	B-	-	-	-	-	C	-	-	-	-	C
	Ilhota	—																																	
	Itajaí	Rain water storage in rice field	A +	-	-	-	A -	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		Flood gate control installation in Itajai Mirim	A +	C	-	-	A -	-	-	-	-	-	-	-	B -	-	-	-	-	-	C	-	-	-	-	-	-	C	C	-	-	-	-	-	C
		Dykes in itajai city	A +	A -	-	-	A -	-	C	-	-	-	-	-	C	-	-	-	B -	B -	C	-	C	-	B-	-	-	C	C	-	-	B-	-	-	C
	Brusque	—																																	
50-year flood	Taió	Heighteing of Oeste Dam	A +	B -	-	-	A -	-	-	-	-	-	-	-	C	-	-	-	B -	B -	-	-	C	-	-	-	-	C	C	-	-	C	-	-	-
		Widening river canal in Taio city	A +	B -	-	-	A -	-	-	-	-	-	-	-	C	-	-	-	B -	B -	-	B-	C	-	B-	C	-	C	B-	A-	-	B-	-	-	C
	Ituporanga	Heighteing of Sul Dam	A +	B -	-	-	A -	-	-	-	-	-	-	-	C	-	-	-	B -	B -	-	-	-	-	C	-	-	-	-	C	-	-	-	-	-
	Rio Do Sul	Rain water storage in rice field	A +	-	-	-	A -	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		Small-scale dam in small basin (1)	A +	C	-	-	A -	-	-	-	-	-	-	-	B -	-	-	-	C	C	C	-	-	-	-	-	-	C	C	-	C	B-	-	-	C
		Small-scale dam in small basin (2)	A +	C	-	-	A -	-	-	-	-	-	-	-	B -	-	-	-	C	C	C	-	-	-	-	-	-	C	C	-	C	B-	-	-	C
		Small-scale dam in small basin (3)	A +	C	-	-	A -	-	-	-	-	-	-	-	B -	-	-	-	C	C	C	-	-	-	-	-	-	C	C	-	C	B-	-	-	C
		Small-scale dam in small basin (4)	A +	C	-	-	A -	-	-	-	-	-	-	-	B -	-	-	-	C	C	C	-	-	-	-	-	-	C	C	-	C	B-	-	-	C
		Small-scale dam in small basin (5)	A +	C	-	-	A -	-	-	-	-	-	-	-	B -	-	-	-	C	C	C	-	-	-	-	-	-	C	C	-	C	B-	-	-	C
		Dykes in Rio do Sul city	A +	A -	C	C	A -	C	C	-	-	-	-	-	C	C	-	-	A -	A -	A -	C	C	-	B-	-	-	C	-	-	-	C	-	-	C
	Timbó	Preliminary discharge of CELESC hydro-electric dams	A +	-	-	-	A -	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Blumenau	Dykes with APP area	A +	A -	A -	-	A -	-	-	-	-	-	-	-	B -	-	-	-	A -	A -	A -	C	C	-	B-	-	-	C	C	-	-	B-	-	-	B+
	Rios Urbanos em Blumenau	Dykes with parks in APP (without dredging)-Garcia river	A +	A -	-	-	A -	-	-	-	-	-	-	-	B -	-	-	-	A -	A -	A -	-	C	-	C	-	-	C	-	B-	-	C	-	-	B+
		Widening parks in APP – Garcia river	A +	A -	-	-	A -	-	-	-	-	-	-	-	B -	-	-	-	A -	A -	A -	-	C	-	C	-	-	C	-	B-	-	C	-	-	B+
		Widening parks in APP (without dredging)-Velha river	A +	A -	-	-	A -	-	-	-	-	-	-	-	B -	-	-	-	A -	A -	A -	-	C	-	B-	-	-	-	-	C	-	-	-	-	C
	Ilhota	Ring dyke system	A +	B -	-	-	A -	-	-	-	-	-	-	-	C	-	-	-	B -	B -	A -	C	C	-	C	-	-	C	C	-	-	C	-	-	C
	Itajaí	Rain water storage in rice field	A +	-	-	-	A -	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		Flood gate control installation in Itajai Mirim	A +	C	-	-	A -	-	-	-	-	-	-	-	B -	-	-	-	-	-	C	-	-	-	-	-	-	C	C	-	-	-	-	-	C
		Floodway in Navegantes	A +	A -	C	-	A -	-	C	-	-	-	-	-	C	-	-	-	B -	B -	B -	B-	C	-	C	-	-	-	A-	A-	-	A-	B-	-	C
	Brusque	New flood control dam in Itajai Mirim river	A +	A -	-	-	A -	-	-	-	-	-	-	-	C	-	-	-	B -	B -	-	A-	C	-	C	-	-	-	A-	A-	C	C	-	-	A-
		Measures for landslide disaster	A +	-	-	-	-	-	-	-	-	-	-	-	B -	-	-	-	-	-	C	-	C	-	C	-	-	C	C	C	C	-	-	-	B-
		Flood Forecasting and Warning System (FFWD)	A +	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Note: A+: Big positive impact, A-: Big negative impact, B+: Medium positive impact, B-: Medium negative impact, C: Impact of measure is unknown, -: No impact. . Note (2): Small-scale dam (1): Braço do Trombudo river, (2): Trombudo river, (3): Pombas river, (4): Taió river, (5): Perimbo river.

Table-10.2.2 Result of IEE (Operation phase)

Construction Phase			Socio-economic impacts																		Pollution					Natural Environment								
Flood Probablity	Object Region of study	SOCIOECONOMIC IMPACTS, POLLUTION AND NATURAL ENVIRONMENT / PROPOSED MEASURES	Expectation in local and regional people / Mobilization of NGO	Land acquisition	Economic and Productive activities	Land use and occupation	Regional comflicts	Benefit to urban area vs. prejudice of rural area	Effects / prejudice of low income people	Water use	Indigeneous / traditional people	Cultural heritages	Sanitation	Public health	Traffic / interference of traffic during construction	Change of income, life condition	Impact of agriculture	Impact in downstream area	Involuntary resettlement	Impacts of land / buildings	Impacts of regional infrastructure (Transmission line, roads, bridges, etc.)	Water pollution	Air pollution	Soil contamination	Noise and vibration	Land subsidence	Offensive odor	Topography and geology	Bottom sedimentation	Solid waste	Groundwater	Fauna and flora	Coastal area	Global issues: Greenhouse gas	Landscape
5-year flood	Taió	—																																
	Ituporanga	—																																
	Rio do Sul	Rain water storage in rice field	-	-	B -	-	-	-	-	-	-	-	-	-	-	-	B -	-	-	-	-	-	-	-	-	-	-	-	-	B+	-	-	-
		Control operation of Sul Dam	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	C	C	-	C	B-	-	-	B-
		Small-scale dam in small basin (1)	-	-	C	C	-	C	-	-	-	-	-	-	-	C	C	-	-	-	-	-	-	-	-	-	-	C	C	-	C	B-	-	-	B-
		Small-scale dam in small basin (2)	-	-	C	C	-	C	-	-	-	-	-	-	-	C	C	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Timbó	—																																
	Blumenau	—																																
	Rios Urbanos em Blumenau	Dykes with parks in APP (without dredging)-Riberião Garcia	-	-	C	B +	-	-	C	-	-	-	-	-	-	C	-	-	-	-	B -	-	-	-	-	-	-	C	-	-	-	B+	-	-	B+
	Ilhota	—																																
	Itajaí	Rain water storage in rice field	-	-	B -	-	-	-	-	-	-	-	-	-	-	-	B -	-	-	-	-	-	-	-	-	-	-	-	-	B+	-	-	-
		Flood gate control installation in Itajai Mirim	-	-	-	C	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	C	-	-	C	-	-	-
	Brusque	—																																
10-year flood	Taió	Control operation of Oeste Dam	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Ituporanga	—																																
	Rio do Sul	Rain water storage in rice field	-	-	B -	-	-	-	-	-	-	-	-	-	-	-	B -	-	-	-	-	-	-	-	-	-	-	-	-	B+	-	-	-
		Small-scale dam in small basin (1)	-	-	C	C	-	C	-	-	-	-	-	-	-	C	C	-	C	C	C	-	-	-	-	-	-	C	C	-	C	B-	-	-	B-
		Small-scale dam in small basin (2)	-	-	C	C	-	C	-	-	-	-	-	-	-	C	C	-	C	C	C	-	-	-	-	-	-	C	C	-	C	B-	-	-	B-
		Small-scale dam in small basin (3)	-	-	C	C	-	C	-	-	-	-	-	-	-	C	C	-	C	C	C	-	-	-	-	-	-	C	C	-	C	B-	-	-	B-
		Control operation of Sul Dam	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		Control operation of Oeste Dam	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Timbó	Preliminary discharge of CELESC hydro-electric dams	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Blumenau	—																																
	Rios Urbanos em Blumenau	Dykes with parks in APP (without dredging)-Riberião Garcia	-	-	C	B +	-	-	C	-	-	-	-	-	-	C	-	-	-	-	B -	-	-	-	-	-	-	C	-	-	-	B+	-	-	B+
		Widening parks in APP (without dredging)-Riberião Velha	-	-	C	B +	-	-	C	-	-	-	-	-	-	C	-	-	-	-	B -	-	-	-	-	-	-	C	-	-	-	B+	-	-	B+
	Ilhota	—																																
	Itajaí	Rain water storage in rice field	-	-	B -	-	-	-	-	-	-	-	-	-	-	-	B -	-	-	-	-	-	-	-	-	-	-	-	-	B+	-	-	-
		Flood gate control installation in Itajai Mirim	-	-	-	C	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	C	-	-	C	-	-	-
		Dykes in itajai city	-	-	A -	C	-	-	C	-	-	-	-	-	-	C	-	-	-	-	B -	-	-	-	-	-	-	-	-	-	-	-	-	-	B-
	Brusque	—																																
25-year flood	Taió	Heighteing of Oeste Dam	-	-	C	C	-	C	C	-	-	-	-	-	-	C	C	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		Widening river canal in Taio city	-	-	C	C	-	-	-	-	-	-	-	-	-	C	-	-	-	-	-	-	-	-	-	C	-	C	C	-	-	B-	-	-	B+
	Ituporanga	—																																
	Rio do Sul	Rain water storage in rice field	-	-	B -	-	-	-	-	-	-	-	-	-	-	-	B -	-	-	-	-	-	-	-	-	-	-	-	-	B+	-	-	-
		Small-scale dam in small basin (1)	-	-	C	C	-	C	-	-	-	-	-	-	-	C	C	-	-	-	-	-	-	-	-	-	-	C	C	-	C	B-	-	-	B-
		Small-scale dam in small basin (2)	-	-	C	C	-	C	-	-	-	-	-	-	-	C	C	-	-	-	-	-	-	-	-	-	-	C	C	-	C	B-	-	-	B-
		Small-scale dam in small basin (3)	-	-	C	C	-	C	-	-	-	-	-	-	-	C	C	-	-	-	-	-	-	-	-	-	-	C	C	-	C	B-	-	-	B-
		Small-scale dam in small basin (4)	-	-	C	C	-	C	-	-	-	-	-	-	-	C	C	-	-	-	-	-	-	-	-	-	-	C	C	-	C	B-	-	-	B-
		Small-scale dam in small basin (5)	-	-	C	C	-	C	-	-	-	-	-	-	-	C	C	-	-	-	-	-	-	-	-	-	-	C	C	-	C	B-	-	-	B-
		Changing operation of Sul Dam	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		Widening river canal in downstream of Rio do Sul (jusante de Rio do Sul)	-	-	C	C	-	C	C	-	-	-	-	-	-	C	C	C	-	-	-	-	-	-	-	-	C	-	C	C	-	-	B+	-	-	B+
	Timbó	Preliminary discharge of CELESC hydro-electric dams	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Blumenau																																		
	Rios Urbanos em Blumenau	Dykes with parks in APP (without dredging)-Garcia river	-	-	C	B +	-	-	C	-	-	-	-	-	-	C	-	-	-	-	B -	-	-	-	-	-	-	C	-	-	-	B+	-	-	B+
		Widening parks in APP – Garcia river	-	-	C	B +	-	-	C	-	-	-	-	-	-	C	-	-	-	-	B -	-	-	-	-	-	-	C	-	-	-	B+	-	-	B+
		Widening parks in APP (without dredging)-Velha river	-	-	C	B +	-	-	C	-	-	-	-	-	-	C	-	-	-	-	B -	-	-	-	-	-	-	-	-	-	-	-	-	-	C
	Ilhota	—																																
	Itajaí	Rain water storage in rice field	-	-	B -	-	-	-	-	-	-	-	-	-	-	-	B -	-	-	-	-	-	-	-	-	-	-	-	-	B+	-	-	-
		Flood gate control installation in Itajai Mirim	-	-	-	C	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	C	-	-	C	-	-	-
		Dykes in itajai city	-	-	A -	C	-	-	C	-	-	-	-	-	C	C	-	-	-	-	B -	-	-	-	-	-	-	-	-	-	-	-	-	-	B-
	Brusque	—																																
50-year flood	Taió	Heightening of Oeste Dam	-	-	C	C	-	C	C	-	-	-	-	-	-	C	C	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		Widening river canal in Taio city	-	-	C	C	-	-	-	-	-	-	-	-	-	C	-	-	-	-	-	-	-	-	-	C	-	C	C	-	-	B-	-	-	B+
	Ituporanga	Heightening of Sul Dam	-	-	C	C	-	C	C	-	-	-	-	-	-	C	C	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Rio Do Sul	Rain water storage in rice field	-	-	B -	-	-	-	-	-	-	-	-	-	-	-	B -	-	-	-	-	-	-	-	-	-	-	-	-	B+	-	-	-
		Small-scale dam in small basin (1)	-	-	C	C	-	C	-	-	-	-	-	-	-	C	C	-	-	-	-	-	-	-	-	-	-	C	C	-	C	B-	-	-	B-
		Small-scale dam in small basin (2)	-	-	C	C	-	C	-	-	-	-	-	-	-	C	C	-	-	-	-	-	-	-	-	-	-	C	C	-	C	B-	-	-	B-
		Small-scale dam in small basin (3)	-	-	C	C	-	C	-	-	-	-	-	-	-	C	C	-	-	-	-	-	-	-	-	-	-	C	C	-	C	B-	-	-	B-
		Small-scale dam in small basin (4)	-	-	C	C	-	C	-	-	-	-	-	-	-	C	C	-	-	-	-	-	-	-	-	-	-	C	C	-	C	B-	-	-	B-
		Small-scale dam in small basin (5)	-	-	C	C	-	C	-	-	-	-	-	-	-	C	C	-	-	-	-	-	-	-	-	-	-	C	C	-	C	B-	-	-	B-
		Dykes in Rio do Sul city	-	-	C	C	-	C	C	-	-	-	-	-	-	C	-	-	-	-	B -	-	-	-	-	-	-	-	-	-	-	C	-	-	B-
	Timbó	Preliminary discharge of CELESC hydro-electric dams	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Blumenau	Dykes with APP area	-	-	A -	B +	-	-	C	-	-	-	-	-	-	C	-	-	-	-	B -	-	-	-	-	-	-	-	-	-	-	B+	-	-	B+
	Rios Urbanos em Blumenau	Dykes with parks in APP (without dredging)-Garcia river	-	-	C	B +	-	-	C	-	-	-	-	-	-	C	-	-	-	-	B -	-	-	-	-	-	-	C	-	-	-	B+	-	-	B+
		Widening parks in APP – Garcia river	-	-	C	B +	-	-	C	-	-	-	-	-	-	C	-	-	-	-	B -	-	-	-	-	-	-	C	-	-	-	B+	-	-	B+
		Widening parks in APP (without dredging)-Velha river	-	-	C	B +	-	-	C	-	-	-	-	-	-	C	-	-	-	-	B -	-	-	-	-	-	-	-	-	-	-	-	-	-	C
	Ilhota	Ring dyke system	-	-	C	C	-	C	C	-	-	-	-	-	-	C	-	-	-	-	A -	-	-	-	-	-	-	C	-	-	-	-	-	-	B-
	Itajaí	Rain water storage in rice field	-	-	B -	-	-	-	-	-	-	-	-	-	-	-	B -	-	-	-	-	-	-	-	-	-	-	-	-	B+	-	-	-
		Flood gate control installation in Itajai Mirim	-	-	-	C	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	C	-	-	C	-	-	-
		Floodway in Navegantes	-	-	C	C	-	C	C	-	-	-	-	C	-	C	C	-	-	-	B -	B-	-	-	-	-	-	B-	A-	-	B-	A-	C	-	C
	Brusque	New flood control dam in Itajai Mirim river	-	-	C	C	-	C	B -	-	-	-	-	-	-	B -	B -	C	-	-	-	C	-	-	-	-	-	B-	C	-	C	B-	-	-	B-
		Measures for landslide disaster	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	C	-	-	C	-	-	-	B-
		Flood Forecasting and Warning System (FFWD)	-	-	-	-	-	-	C	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Note: A+: Big positive impact, A-: Big negative impact, B+: Medium positive impact, B-: Medium negative impact, C: Impact of measure is unknown, -: No impact. .

Note (2): Small-scale dam (1): Braço do Trombudo river, (2): Trombudo river, (3): Pombas river, (4): Taió river, (5): Perimbo river.

CHAPTER 11 PRELIMINARY DESIGN OF STRUCTURAL MEASURES OF THE MASTER PLAN

11.1 Flood Disaster Mitigation Measures

A preliminary structural design was carried out for the facilities proposed in the master plan. Due to the delay of ongoing topographical mapping with a scale of 1:10,000 by SDS and lack of geological information at the sites of facility, field investigation site conditions such as topography and geology for the design were assumed based on the field investigation as much as possible. As for the existing flood control dams, their structural dimensions were referred to the available old structural drawings. In addition, as no data is available on the geology of dam foundation, shear strength and bearing capacity of the foundation necessary for the design were determined based on the assumption that the current dams satisfy all of the stability conditions from the viewpoints of dam safety. The design criteria in Brazil titled "HYDROELECTRIC POWER PLANTS CIVIL DESIGN CRITERIA, October/2003, ELETROBRÁS" was applied to this preliminary structural design.

11.1.1 Heightening of Existing Flood Control Dams

(1) Selection of Heightening Method

The following table presents the criteria for setting dam height in Brazil.

Table 11.1.1 Criteria for Setting Dam Height in Brazil

Item	Condition	Dam Type/Flood	Criteria
Freeboard	Normal	Rock fill dam	The freeboard shall be defined to absorb wave height caused by wind. The wave height shall be estimated by the Saville method. At least 3.0m shall be secured as the minimum freeboard.
		Concrete dam	At least 1.5m shall be secured as the minimum freeboard.
	Flood	Rock fill dam	The minimum freeboard shall be secured 1.0m above the maximum flood water level in reservoir.
		Concrete dam	The minimum freeboard shall be secured 0.5m above the maximum flood water level in reservoir.
Extraordinary flood	Normal	Probable maximum flood	For dam higher than 30m, or there are permanent residents downstream and danger of dam failure
	Small scale dam	1000-year flood	For dam lower than 30m, or reservoir capacity of smaller than 50 million m^3 and there are no permanent residents downstream.

Source: Criteria for civil projects of Hydroelectric Power Plants, Eletrobrás – October/2003.

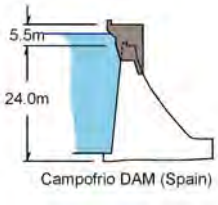
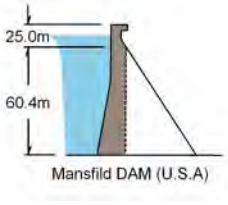
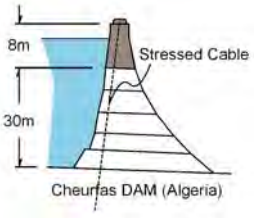
The Oeste dam shall be provided with the spillway to pass safely the 1,000-year flood (=1,010 m^3/s), as its height is less than 30 m and there is no residents in the immediately downstream of the dam. On the other hand, the Sul dam shall be equipped with the spillway for passing the 10,000-year flood (=2,570 m^3/s) due to its height over 30 m.

The Oeste dam is a concrete gravity dam, corresponding to the dam type to easy to be raised. As the dam is planned to be raised by 2 m at both the overflow and non-overflow portions, the form of existing spillway is just to be slid upward. The Sul dam is a rock fill dam of the zoned type. In case of heightening of the fill type dam, problems on the behavior of new and old joints of embankment have frequently occurred after the heightening, because it is difficult to ensure the quality of embankment materials. The fill type dam has generally smaller rock strength at the dam foundation compared to that of gravity dam, the maximum possible height for raising is therefore small for the fill type dam. Since it was difficult to confirm the conditions of foundation and embankment materials, it was decided not to raise the Sul dam. However, as the existing spillway allows to ensure sufficient freeboard for raising by 2 m, it was decided to raise the spillway (concrete structure).

(2) Heightening of Oeste Dam

The table below presents the comparison of methods for heightening concrete gravity dams. As the planned heightening is as small as 2 m at the Oeste dam, raising the dam crest was selected.

Table 11.1.2 Heightening Method of Concrete Gravity Dam

Covering of New Dam	Raising of Dam Crest	Thickening of Upstream Dam Body	Anchoring
			
Placing new concrete on the downstream face of existing dam and forming unified dam body of the new and old concretes	Placing new concrete on the dam crest and forming unified dam body of the new and old concretes	Placing new concrete on the upstream face of the existing dam and forming unified body of the new and old concretes	Placing new concrete on the dam crest and connecting to the upstream dam foundation by stress cable

Source：JICA Survey Team

i) Design Conditions

According to the Brazilian criteria, stability of dam shall be confirmed by the following four loading conditions:

Table 11.1.3 Loading Conditions for Dam Stability Analysis

Condition	Remarks
Normal (CCN)	Normal
Exceptional (CCE)	Normal＋Earthquake
Limite (CCL)	Flood＋Earthquake
Construção (CCC)	During Construction

Source：CRITÉRIOS DE PROJETO CIVIL DE USINAS HIDRELÉTRICAS Outubro/2003

Safety factors for stability analysis vary according to the loading conditions as presented below.

Table 11.1.4 Safety Factors for Stability Analysis by Loading Condition

Condition		CCN	CCE	CCL	CCC
FSF (Uplift)		1.3	1.1	1.1	1.2
FST (Turnover)		3.0	2.0	1.5	1.3
FSD (Sliding)	c	3.0	1.5	1.3	2.0
	φ	1.5	1.1	1.1	1.3
σt (Bearing Capacity)		3.0	2.0	1.5	1.3

Source：CRITÉRIOS DE PROJETO CIVIL DE USINAS HIDRELÉTRICAS Outubro/2003

As mentioned earlier, as no data is available on the geology of dam foundation, shear strength and bearing capacity of the foundation necessary for the design were determined based on the assumption that the current dams satisfy all of the stability conditions from the viewpoints of dam safety. In addition, an internal friction angle was fixed in φ=45° as the design value of foundation rock. The table below shows the combination of loads for respective stability analysis.

Table 11.1.5 Combination of Loads for Stability Analysis

Load	CCN	CCE	CCL	CCC
Own weight	Yes	Yes	Yes	Yes
Water weight	Yes	Yes	Yes	—
Dynamic pressure by earthquake	—	Yes	Yes	—
Earthquake force	—	Yes	Yes	—
Water pressure	Yes	Yes	Yes	—
Uplift pressure	Yes	Yes	Yes	—
Sediment weight	Yes	Yes	Yes	—
Sediment pressure	Yes	Yes	Yes	—

Source：JICA Survey Team

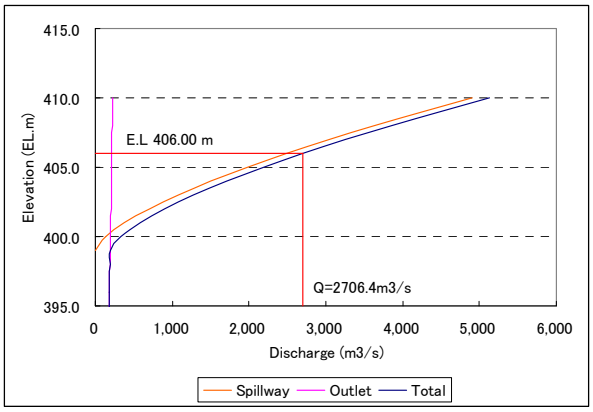
ii) Results of Stability Analysis

The necessary critical bearing capacity of the dam foundation was estimated through stability analyses for two cases of the existing and heightened conditions as summarized below. The details of stability analysis are explained in Supporting Report. Structural drawing for dam heightening is shown in Figure 11.1.3.

Foundation condition assumed: Internal friction angle φ=45°, Shear stress c=50 kiN/m^2
Definitive loading condition: CCL (flood + earthquake)
Critical bearing capacity: q_u=1,900 kN/m^2 (existing condition), q_u=2,000 kN/m^2 (heightened condition)

(3) Heightening of Sul Dam

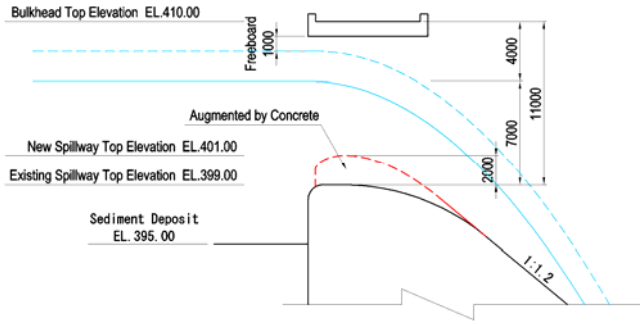
As indicated below, the Sul dam is able to release the 1,000-year flood with the overflow depth of 7 m through the spillway.



Source：JICA Survey Team

Figure 11.1.1 Spillway Capacity of Sul Dam

Even if the girder of spillway bridge is assumed to be 1m, the current clearance over the spillway is 10 m (= (410.0-399.0) -1.0). Therefore, 1.0 m of freeboard can be secured against the 1,000-year flood when the dam is heightened by 2 m as illustrated below.



Source：JICA Survey Team

Figure 11.1.2 Overflow Condition at Sul Dam Spillway against 1,000-year Flood

i) Design Conditions

The same conditions applied to the Oeste dam is applied for the stability analysis.

ii) Results of Stability Analysis

The analysis results are summarized below. The details of stability analysis are explained in Supporting Report. Structural drawing for dam heightening is shown in Figure 11.1.4.

Foundation condition assumed: Internal friction angle φ=45°, Shear stress c=50 kN/m^2
Definitive loading condition: CCE (1,000-year flood)
Critical bearing capacity: q_u=1,000 kN/m^2 (existing condition), q_u=1,200 kN/m^2 (heightened condition)

(4) Reinforcement of Existing Discharge Gates at Both Dams

As the hydraulic pressure will increase due to heightening by 2m at both dams , it is necessary to reinforce the existing discharge gates.

11.1.2 River Improvement

The planned river improvement stretches by the probable floods are as follows:

Table 11.1.6 Planned River Improvement Stretch by Probable Flood

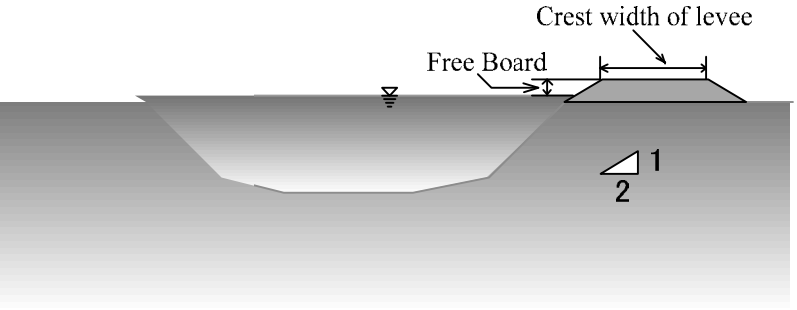
River / City \ Safety Level		5 year	10 year	25 year	50 year
Itajai River	Itajai		Dyke (3)* (L=12,830m)	Dyke (3)* (L=12,830m)	
	Ilhota			Ring Dyke (3)* (L=8,000 m)	Ring Dyke (3)* (L=8,000 m)
	Blumenau				Dyke (3)* (L=15,800m)
	Rio do Sul			Channel Excavation (L=10,270m)	Dyke (2)* (L=4,500m)
Benedito River	Timbo			Channel Excavation (L=1,000m)	Dyke (2)* Excavation (L=1,000m)
Oeste River	Rio do Sul				Dyke (2)* (L=3,000m)
	Taio			河道掘削 (L=3,700m)	Dyke (2)* (L=3,700m)
Sul River	Rio do Sul				築堤(2)* (L=700m)
Itajai Mirim River	Itajai	Dyke (1)* (L=950 m)	Dyke (1)* (L=950 m)	Dyke (2)* (L=950 m)	Dyke (2)* (L=950 m)

Remarks: (*) shows the category number in Figure 11.1.5. Source：JICA Survey Team

(1) Dyke and Ring Dyke

According to the information from DEINFRA, technical guidelines regarding the improvement of rivers have not yet established and almost no river improvement works have been undertaken. Under the current design, Japanese design criteria was applied. The design criteria for dyke are shown in Figure 11.1.5. As shown, freeboard and crest width of dyke vary according to the magnitude of design discharges. Regardless of the magnitude of discharges, stable dyke slope of 1:2 is applied for dyke design. Design condition of ring dyke is the same as the dyke design.

Dyke shall be provided to the river stretch in the urban area, where the flow capacity is smaller than the design discharge.



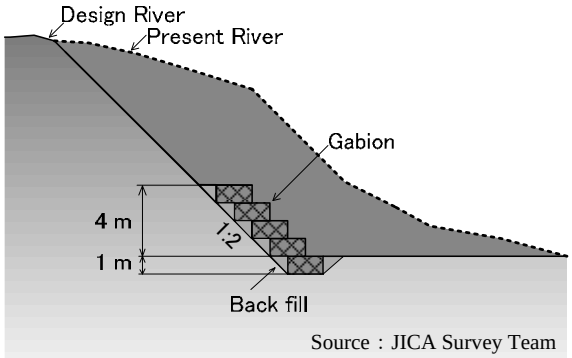
Category No.	Design Discharge (m3 s)	Free Board (m)	Crest width of levee (m)
1	200 ≤ Q < 500	0.8	3.0
2	500 ≤ Q < 2000	1.0	4.0
3	2000 ≤ Q < 5000	1.2	5.0

Source: JICA Survey Team

Figure 11.1.3 Design Conditions for Dyke

(2) River Widening and Channel Excavation

As for river widening and excavation of river channel, excavated slope is planned to be 1:2 as illustrated below. Gabions are to be placed to protect foot of the slope from scouring. The design river bed is set at the deepest riverbed of channel.



Source：JICA Survey Team

Figure 11.1.4 Design Conditions for Channel Excavation

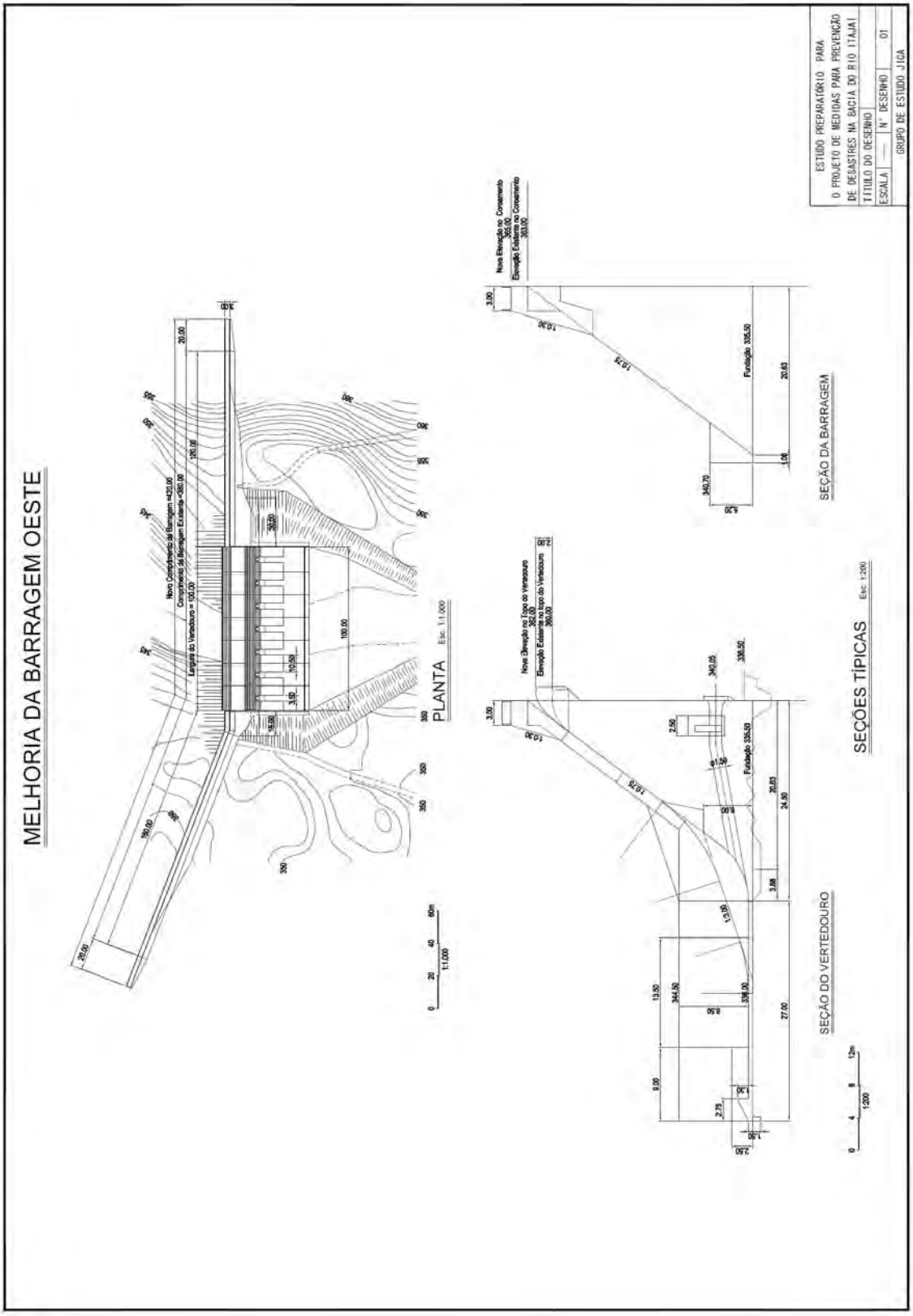


Figure 11.1.5 Drawing on Heightening of Oeste Dam

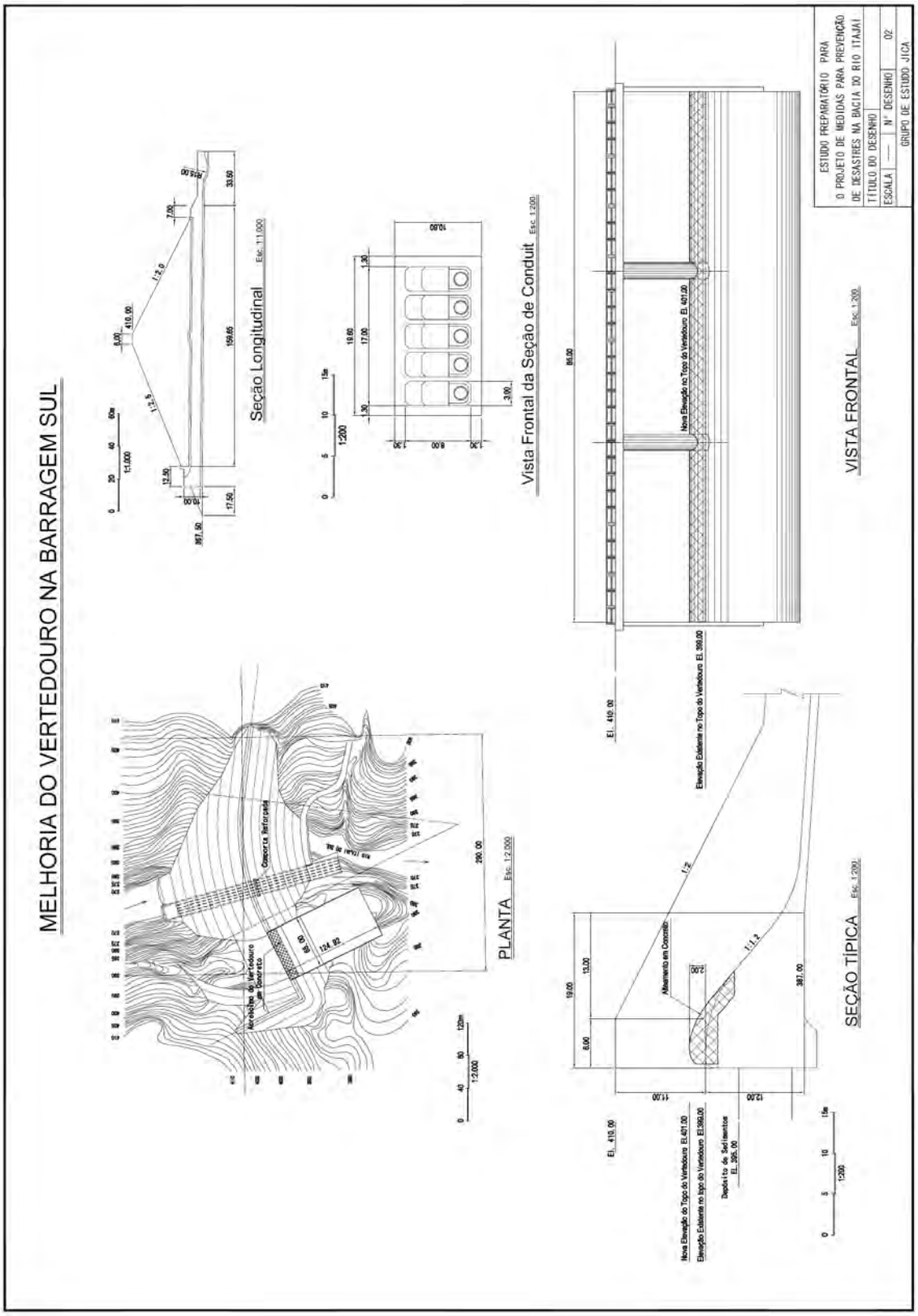
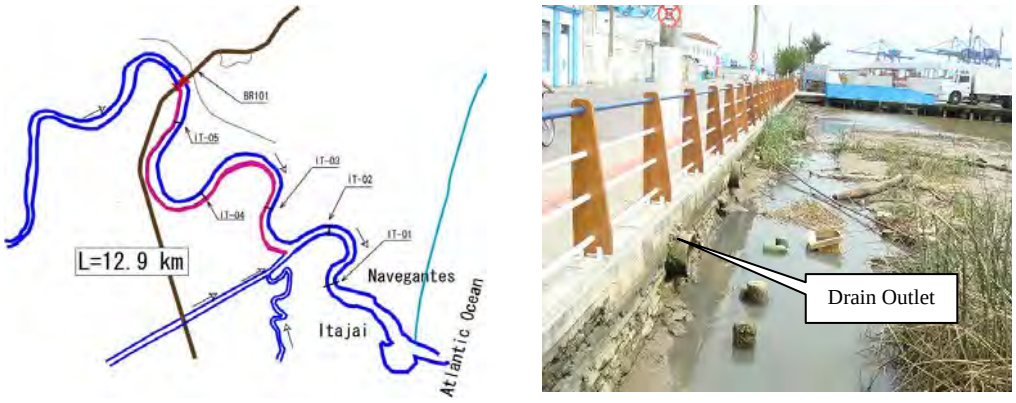


Figure 11.1.6 Drawing on Heightening of Sul Dam

(3) River Improvement Plan at Cities

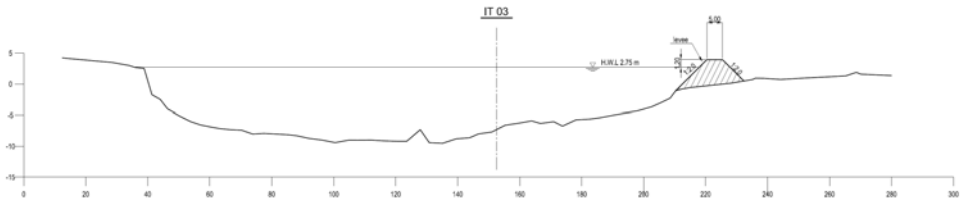
a) Itajai City, Itajai River

The river stretch subject to river improvement is on the right bank from the location 800 m downstream of the River Section IT-02 to the federal road BR 101 with a total length of 12.9 km. Although the low-lying area on the left bank (IT-03, IT-04) is below the design flood water level, this area will be unprotected by dyke considering that this area is subject to inundation and acts as a retarding basin. The river stretch to be improved is shown below.



Source : JICA Survey Team

Figure 11.1.7 River Improvement Stretch in Itajai City

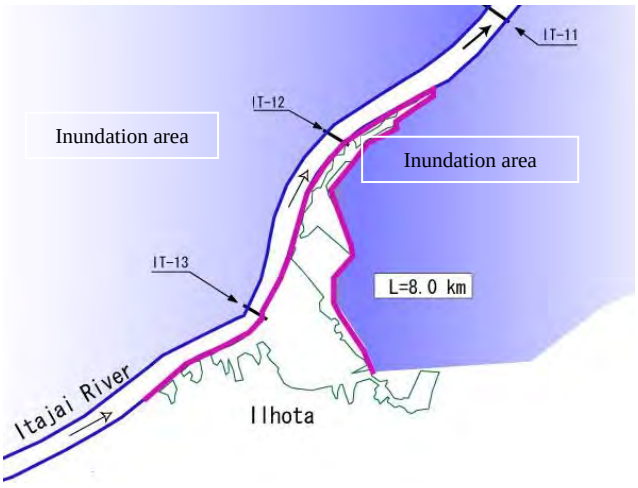


Source : JICA Survey Team

Figure 11.1.8 River Improvement Section in Lower Itajai River (Section IT-03, 25-year flood)

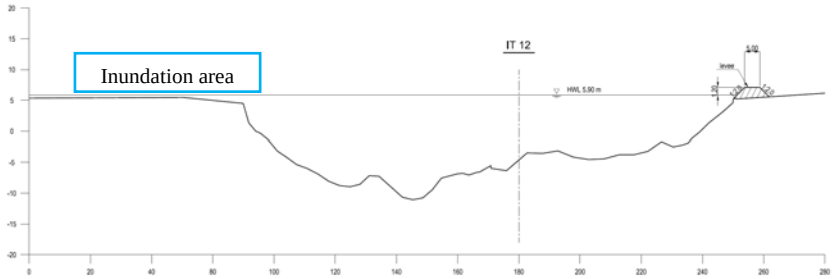
b) Ilhota City, Itajai River

As the flood inundation area spreading from Itajai city (BR 101) to Gaspar city is unprotected by dyke acting as a natural retarding basin, ring dyke is planned to protect Ilhota city from flood inundation. The existing road on the right bank along the Itajai River is heightened and the urban area of Ilhota city is surrounded by the dyke connecting to the location with higher elevation as illustrated below. The total length of ring dyke is 8.0km, comprising 4.4 km long heightening of the road and 3.6 km long dyke.



Source：JICA Survey Team

Figure 11.1.9 Ring Dyke Plan in Ilhota City

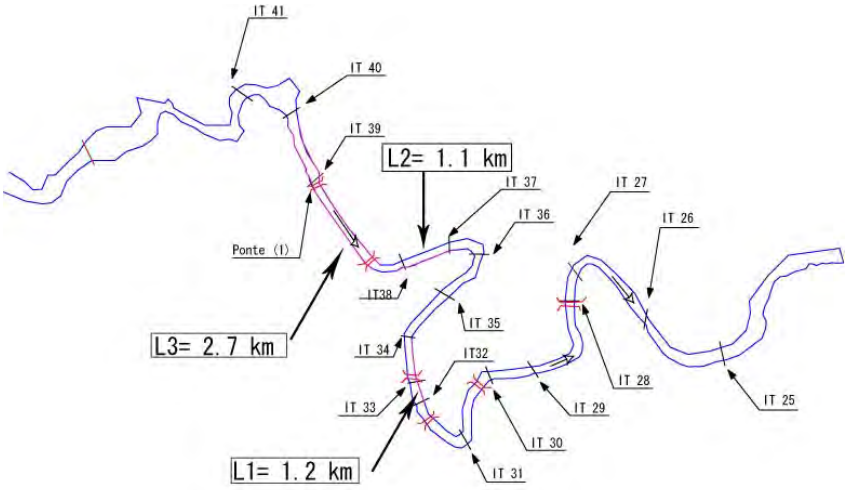


Source：JICA Survey Team

Figure 11.1.10 River Improvement Section in Ilhota City (Section IT-12, 25 year flood)

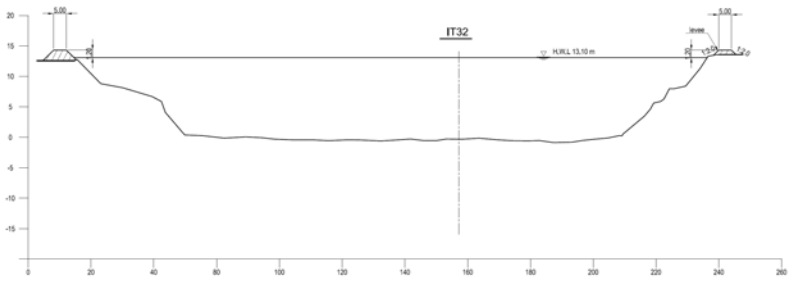
c) Blumenau City, Itajai River

River improvement in Blumenau city is proposed for the 50-year flood. The objective river stretches are 1.2 km long downstream stretch on the left bank (near sections IT-32 to IT-34), 1.1 km long stretch on the right bank from IT-37 to IT-38, and 2.7km long upstream stretch on the both banks from IT-40 as illustrated below. Relocation of residents along the river and reconstruction of one existing bridge are required as the associated works of river improvement.



Source：JICA Survey Team

Figure 11.1.11 River Improvement Stretch in Blumenau City



Source : JICA Survey Team

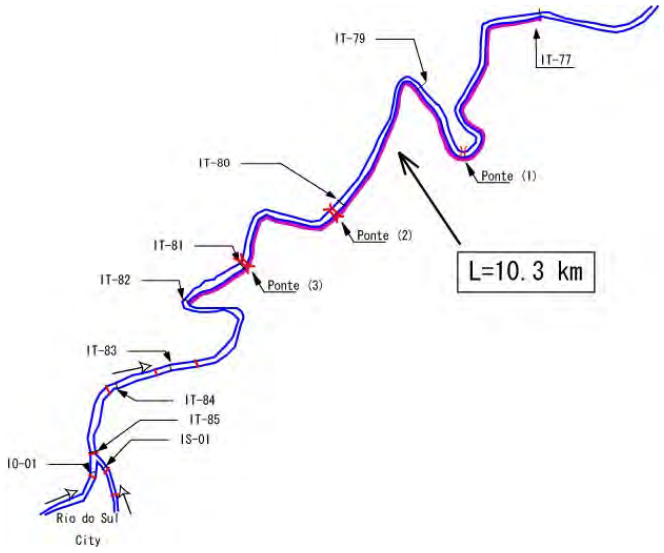
Figure 11.1.12 River Improvement Section in Blumenau City (Section IT-32, 50-year flood)

d) Rio do Sul City, Itajai River, Itajai do Oeste River, Itajai do Sul River

River improvement in Rio do Sul city is planned for both the 25-year and 50-year floods.

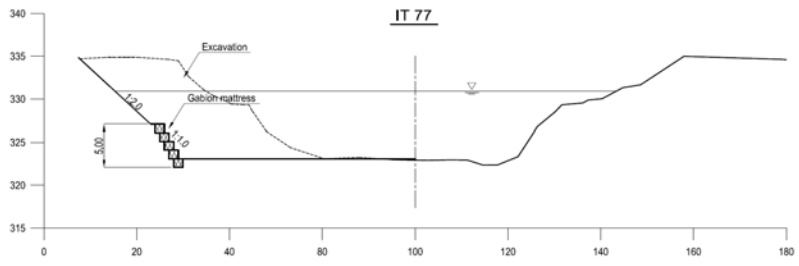
River improvement for the 25-year flood:

Both the Itajai do Oeste and Sul Rivers join each other in the urban area of Rio do Sul city. In order to lower river water level of the 25-year flood in Rio do Sul city, river widening in the downstream stretch is planned. The 10.3km long channel along the Itajai River is to be widened by around 10 m from the location approximately 4.5 km downstream of the confluence as illustrated below.



Source : JICA Survey Team

Figure 11.1.13 River Improvement Stretch in Rio do Sul City (25-year flood)

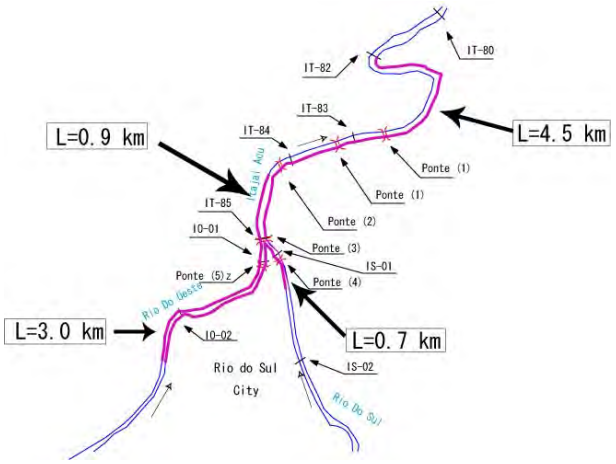


Source : JICA Survey Team

Figure 11.1.14 River Improvement Section in Rio do Sul City (Section IT-77, 25-year flood)

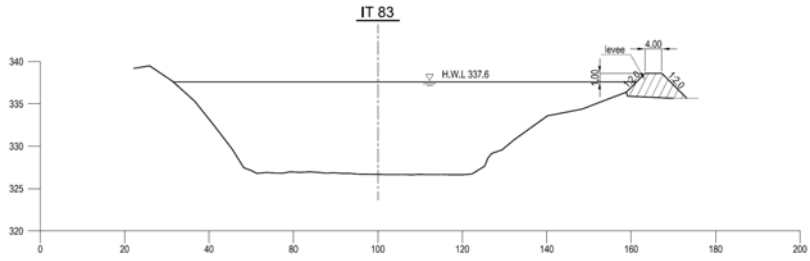
River improvement for the 50-year flood:

As illustrated below, three river stretches are improved by embankment; the Itajai River around 4.5 km long downstream of the confluence, the Itajai do Oeste River 3.0 km long upstream of the confluence, and the Itajai do Sul River 0.7 km long upstream of the confluence. Relocation of residents in the urban area and reconstruction of 5 existing bridges are required as the associated works of river improvement.



Source : JICA Survey Team

Figure 11.1.15 River Improvement Stretch in Rio do Sul City (50-year flood)

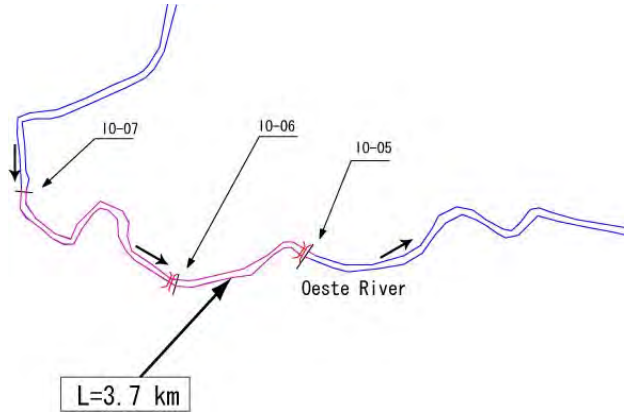


Source : JICA Survey Team

Figure 11.1.16 River Improvement Section in Rio do Sul City (Section IT-83, 50-year flood)

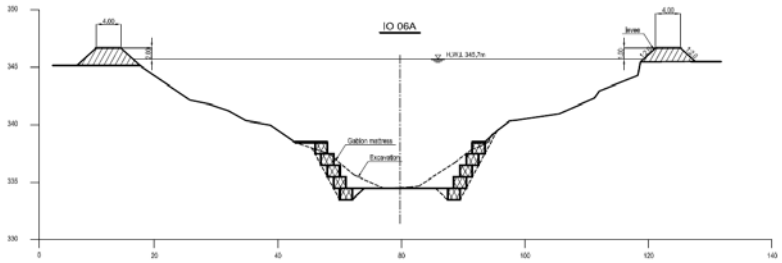
e) Taio City, Itajai do Oeste River

River improvement in Taio city is planned for both the 25-year and 50-year floods. River widening is proposed for the 25-year flood and combination of river widening and embankment is proposed for the 50-year flood. The objective river stretch is 3.7 km long in the urban area along the Itajai do Oeste River as shown below. The existing 2 bridges are necessary to be reconstructed due to river improvement.



Source : JICA Survey Team

Figure 11.1.17 River Improvement Stretch in Taio City

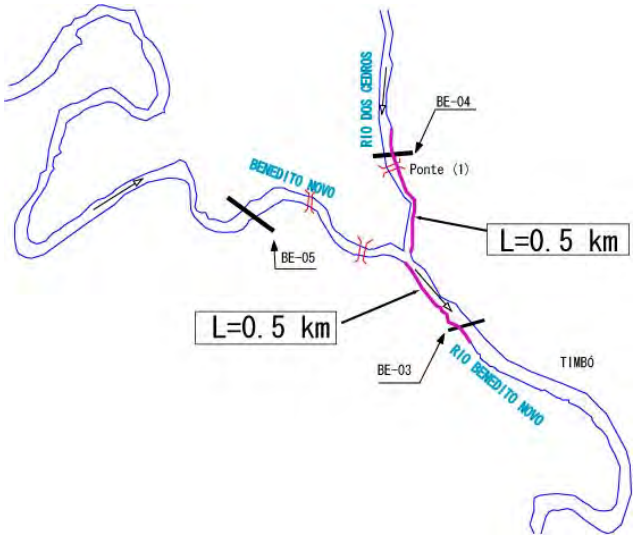


Source : JICA Survey Team

Figure 11.1.18 River Improvement Section in Taio City (Section IO-06a, 50-year flood)

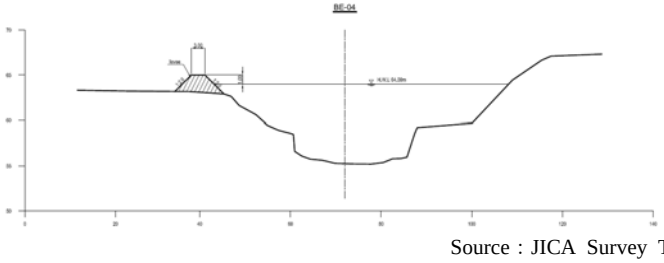
f) Timbo City, Cedros River

Timbo city is located at the junction of Benedito and Rio dos Cedros Rivers. As shown in Figure 11.1.20 below, part of urban area where the ground elevation is under the 50-year flood water level is to be protected by embankment. The objective stretches for improvement are 0.5 km on the left bank of Rio dos Cedros River upstream from the confluence and 0.5 km on the right bank of Benedito River downstream of the confluence as illustrated below. The existing bridge in the urban area is to be reconstructed due to implementation of river improvement.



Source : JICA Survey Team

Figure 11.1.19 River Improvement Stretch in Timbo City

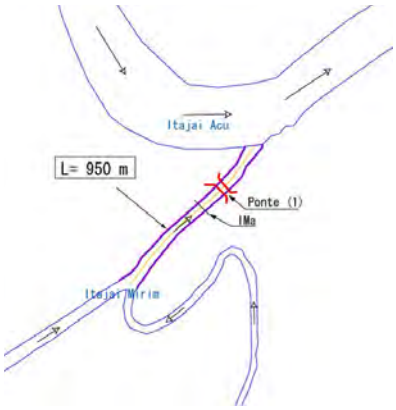


Source : JICA Survey Team

Figure 11.1.20 River Improvement Section in Timbo City (Section BE-04, 50-year flood)

g) Itajai City, Itajai Mirim River

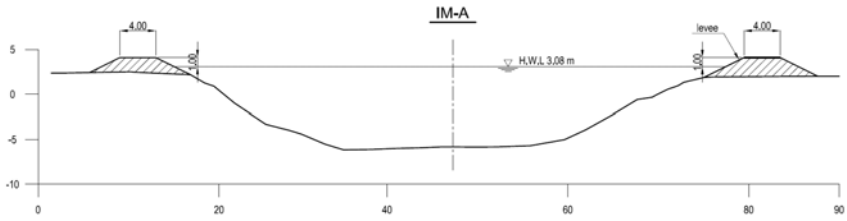
The objective stretch of the Itajai Mirim River subject to improvement is 950 m long stretch on its both banks between the confluence to the Itajai River and the junction of Canal and Old Mirim River as shown below. Residents along the stretch are to be relocated due to implementation of river improvement. Furthermore, the existing bridge is also to be reconstructed.



Upstream view of Itajai Mirim River from the bridge

Source : JICA Survey Team

Figure 11.1.21 River Improvement Stretch in Lower Itajai Mirim River



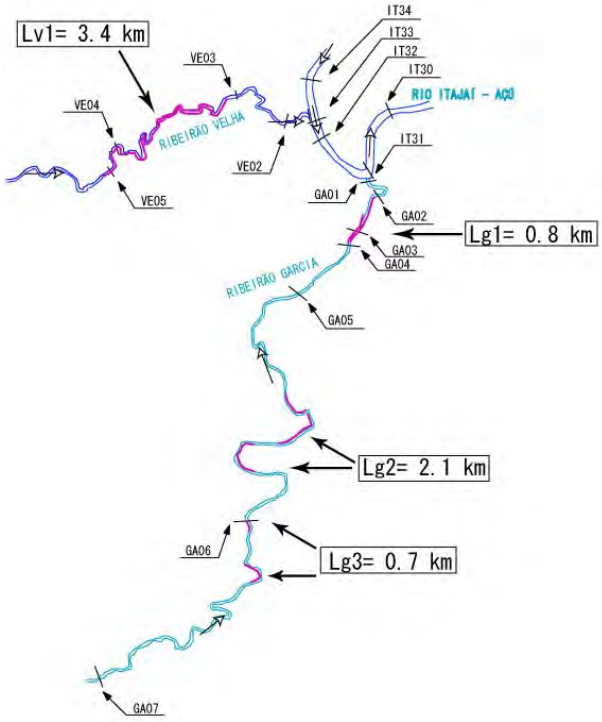
Source : JICA Survey Team

Figure 11.1.22 River Improvement Section in Itajai Mirim River (Section IM-A, 50-year flood)

h) Urban Rivers in Blumenau City

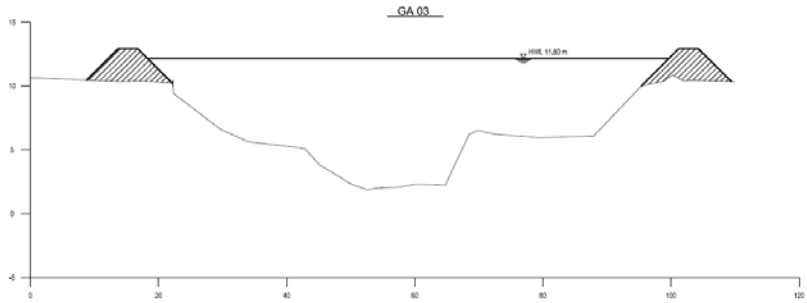
The Garcia River is seriously influenced by back water of the Itajai River in times of flood. Since the urban area along the Garcia River has been suffering from habitual flooding due to the back water effect, this area is planned to be protected by embankment against the 25-year flood. The stretches to be improved are 500 m on the right bank and 750 m on the left bank between river sections GA-02 and GA-04 as illustrated below. Furthermore, there are several channels in upper reaches, where the current flow capacities are insufficient to pass the 25-year flood. In these stretches, flow capacity is planned to be increased by means of excavation of the existing river channel with a total length of 2.8 km between sections GA-05 and GA-07 as shown below.

As for the Velha River, since no urban area is influenced by the backwater, river widening by excavation is planned to increase flow capacity in the 3.4 km long stretches between sections GA-03 and GA-05 as shown below.



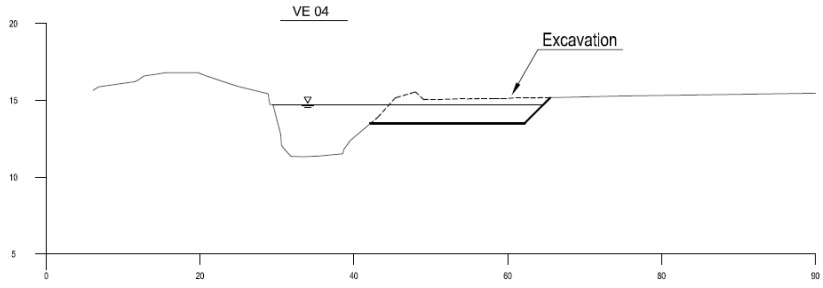
Source : JICA Survey Team

Figure 11.1.23 River Improvement Stretches of Urban Rivers in Blumenau City (Garcia and Velha Rivers)



Source : JICA Survey Team

Figure 11.1.24 River Improvement Section in Garcia River (Section GA-02, 25-year flood)



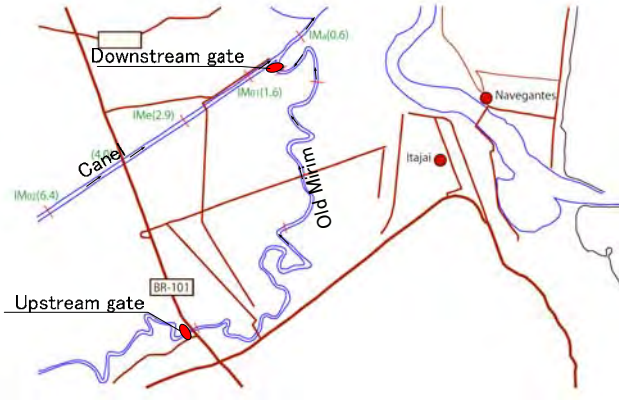
Source : JICA Survey Team

Figure 11.1.25 River Improvement Section in Velha River (Section VE-04, 25-year flood)

11.1.3 Water Gates

The Old Mirim River has been suffering from frequent flooding on both banks due to small flow capacity. As shown in the figure below, two water gates are planned to be installed on the Old Mirim River to control flood inflow from the Mirim River into the Old Mirim River and the backwater intrusion from the Itajai River. The water gate is designed for respective probable floods. The crest elevation of flood gate is determined based on the probable flood water level

estimated by the non-uniform flow calculation as well as freeboard. Figure 11.1.27 shows structural dimensions of the designed water gate for respective probable floods.

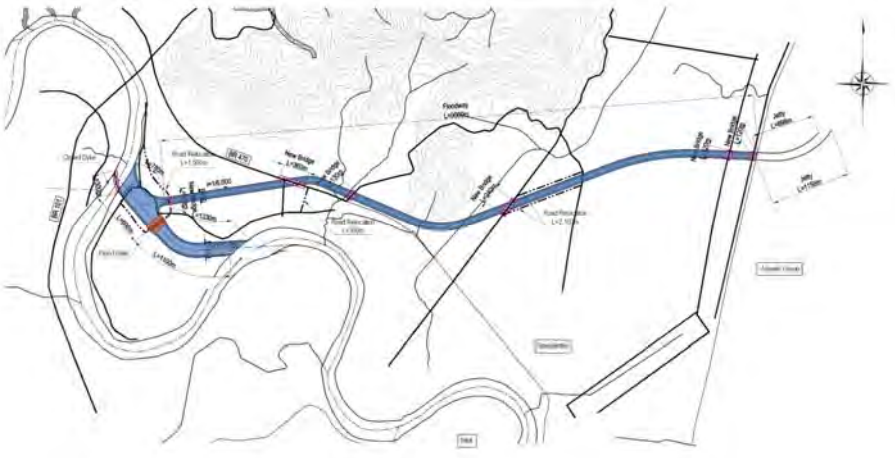


Source : JICA Survey Team

Figure 11.1.26 Location Map of Water Gates on the Old Mirim River

11.1.4 Floodway

Floodway is proposed to divert part of the 50-year flood discharge of the Itajai River to the Atrantic Ocean crossing Navegantes city from downstream reaches of the bridge of BR 101. The route of floodway route and the location of diversion weir are selected through field investigation confirming the current land use to minimize relocation of residents. As shown in the figure below, a gated diversion weir is to be installed on a new shortcut channel to divert the flood inflow smoothly into the floodway. The flood inflow into the lower reaches of Itajai River is controlled by the diversion weir so as not to cause overflowing into Itajai city. The design of floodway is described in detail in Supporting Report.



Source : JICA Survey Team

Figure 11.1.27 Location Map of Floodway and Diversion Weir

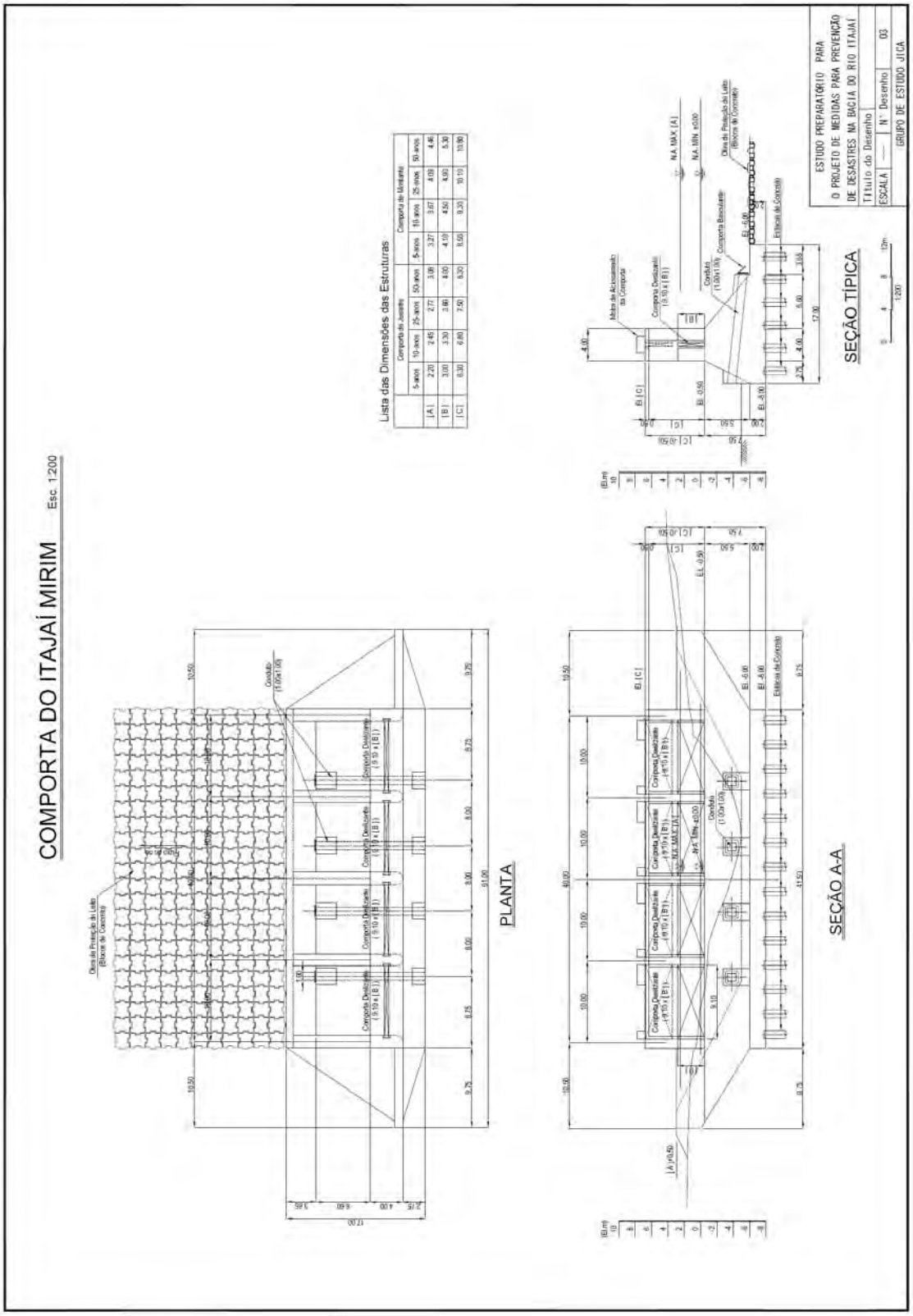


Figure 11.1.28 Structural Drawing of Water Gate on the Old Mirim River

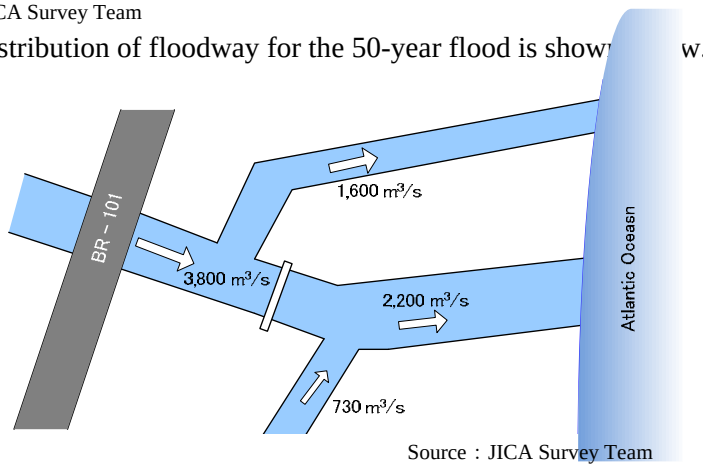
Table below presents the general features of the planned floodway and diversion weir.

Table 11.1.7 General Features of Floodway Plan

Floodway		B=50 m, h=12 m, L=9,000 m, 1:n=1:2.0、I=1/6000
Shortcut Channel	Upstream	B=190 m, h=12 m, L=600 m, 1:n=1:2.0
	Downstream	B=150 m, h=12 m, L=1,100 m, 1:n=1:2.0
Diversion Weir		Gate=20m × 9m × 8 nos., Width=190 m
New Bridge		6 nos.
Closure Dyke		L=300 m
Jetty		L=2,100 m（both banks）

Source：JICA Survey Team

Design discharge distribution of floodway for the 50-year flood is shown below.



Source：JICA Survey Team

Figure 11.1.29 Design Discharge Distribution of Floodway (50-year flood)

A jetty is to be provided at the outlet of the floodway to prevent sediment deposition caused by the littoral drift at the outlet portion and also to prevent sandbar formation. The extent and magnitude of changes of coastal line, tidal current and diffusion of discharged turbid water at the Navegantes coast due to construction of the floodway and jetty should be examined and assessed from the socio-environmental viewpoints before implementation. Furthermore, detailed study on the angle of jetty to the coastal line and the length of jetty should be also carried out. The structural plan is shown in Figures 11.1.30 and 11.1.31.

11.1.5 New Flood Control Dam on Itajai Mirim River

Regarding site selection for a new flood control dam, topographic maps with a scale of 1:10,000 are inevitably necessary. However, topographic mapping is still under preparation by SDS, site selection on the Itajai Mirim River was carried out based on the available topographical maps of 1:50,000. The dam site was selected in the upstream reaches of Brusque city.

The new dam was planned to be of a concrete gravity concrete type. The dam height is 34.2m considering the excavation of dam foundation by approximately 2 m. The dam is equipped with ungated spillway. . The energy dissipater was determined to be 20 m taking into consideration the current width of downstream river channel. The structural drawing is shown in Figure 11.1.32.

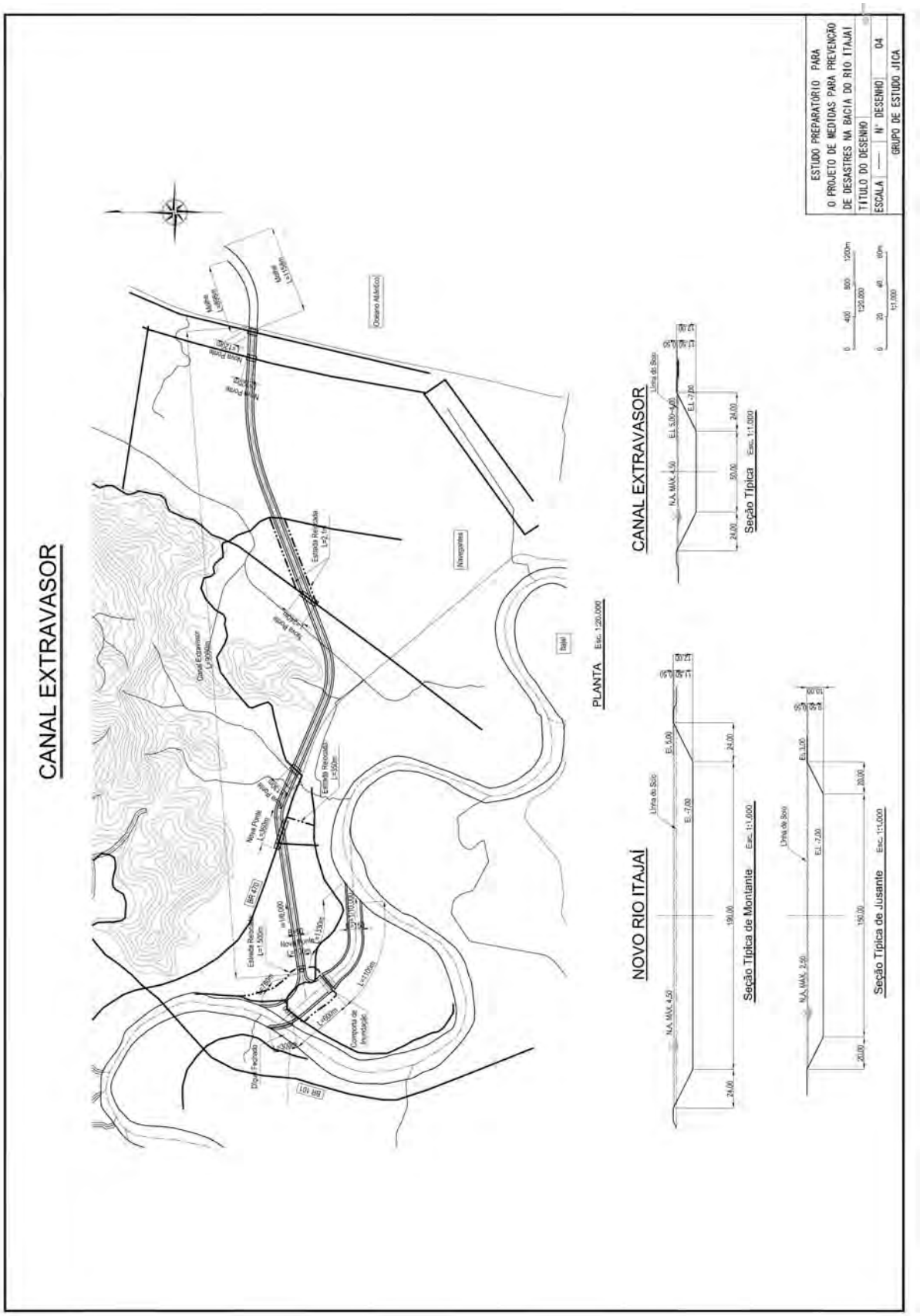


Figure 11.1.30 Structural Drawing of Floodway

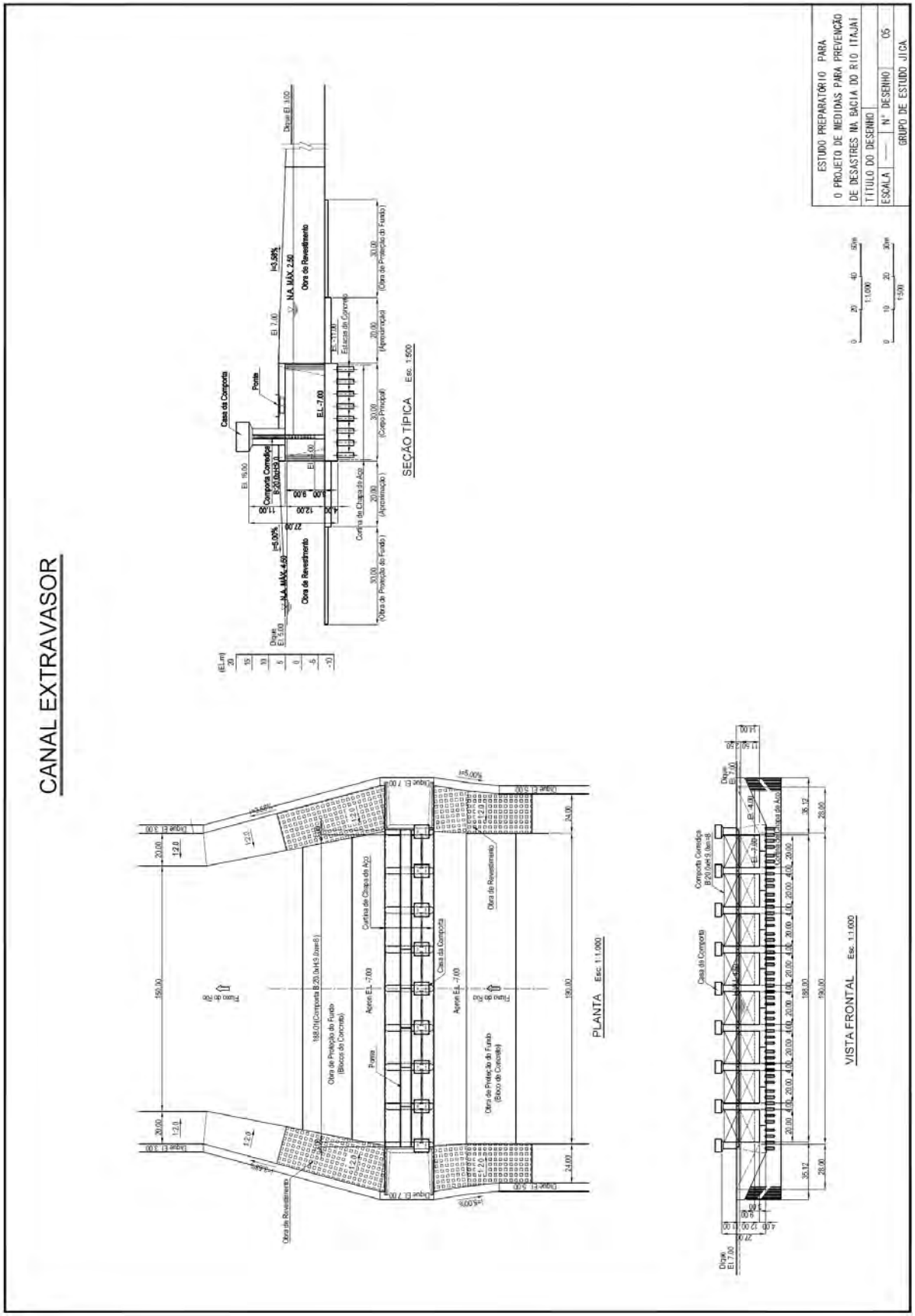


Figure 11.1.31 Structural Drawing of Diversion Weir

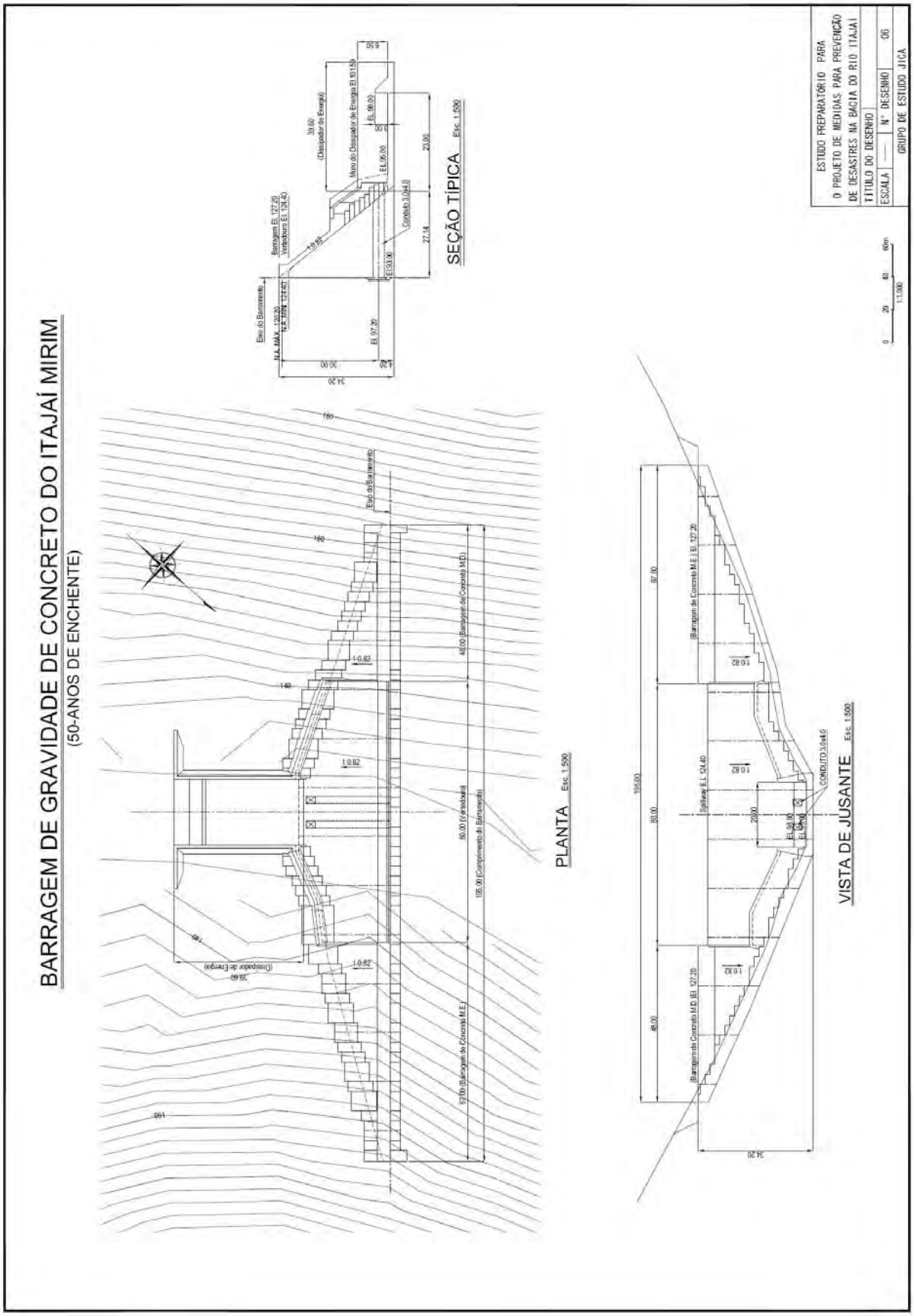


Figure 11.1.32 Structural Drawing of Flood Control Dam on Itajai Mirim River

11.1.6 Basin Storage (Small Dams)

Like the site selection of a small dam, candidate sites for small dam shall be selected based on the topographic map with a scale of 1:10,000. As mentioned in Chapter 8, promising rivers for installation of small dam are the Trombudo and Trombudo Rivers. The storage reservoir is expected to around 5 to 10m in depth. The dam is designed as a homogeneous fill type dam because of relatively low dam height. In Brazil, retention wall of more than 15m high is categorized as a dam. The structural drawing of small dam is shown in Figures 11.1.32 and 11.1.33. The typical shape of small dam is determined based on the actual topographical conditions through field investigation.

11.2 Landslide Mitigation Measures

Preliminary structural design was carried out with an aim to be protected from heavy rainfall equivalent to the rainfall caused the landslide disaster in November 2008 (60-year rainfall in Blumenau city) without the occurrence a disaster large enough to block an area the same size of a half lane of road. The measures were selected in accordance with the Brazilian ABNT Norms (Brazilian Association for Technical Norms), Reference Number 11682, Slope Stability @ ABNT 2009. Criteria to be applied during the selection of measures against sliding are as follows:

Table 11.2.1 Measure Type Recommended by Type of Damage

Type of Slide Damage	Area Scope	Slope Conditions	Measures to be applied Vegetation cover and superficial water collection are common construction measures	Figure for Reference
Landslide Type - Desmoronamento	On hillside of road	Slope height is more than 15m	Cuts for vulnerable land, concrete cellular elements	Figure 11.2.3
		Slope height is less than 15m, where there is a possibility to cut the slope at less than 45 degrees or where there is a space to install gabions	Cuts for vulnerable land, gabion	Figure 11.2.2
	On valley side of road	There are erosion symptoms and initial caving of the road.	Collection box and drain, gabion for protection of the river channel	Figure 11.2.1
	Valley	There is deep caving in the road and cracking along the road	Collection box and drain, arranged rocks, gabion, slope protection	Figure 11.2.2
Landslide Type - Escorregamento	Slope beside hill on road	There are symptoms of a slide more than 3m deep.	Tubes of drilled acero, bored draining and gabion	Figure 11.2.3
	Moderate Collapse	Where structural prevention measures are needed.	Compact landfill	Figure 11.2.1
		Others	Slope improvement	Figure 11.2.1
Mudslide - Escoamento de lama	Road on river	Slide erosion	Gabion	Figure 11.2.2

Source: JICA Survey Team

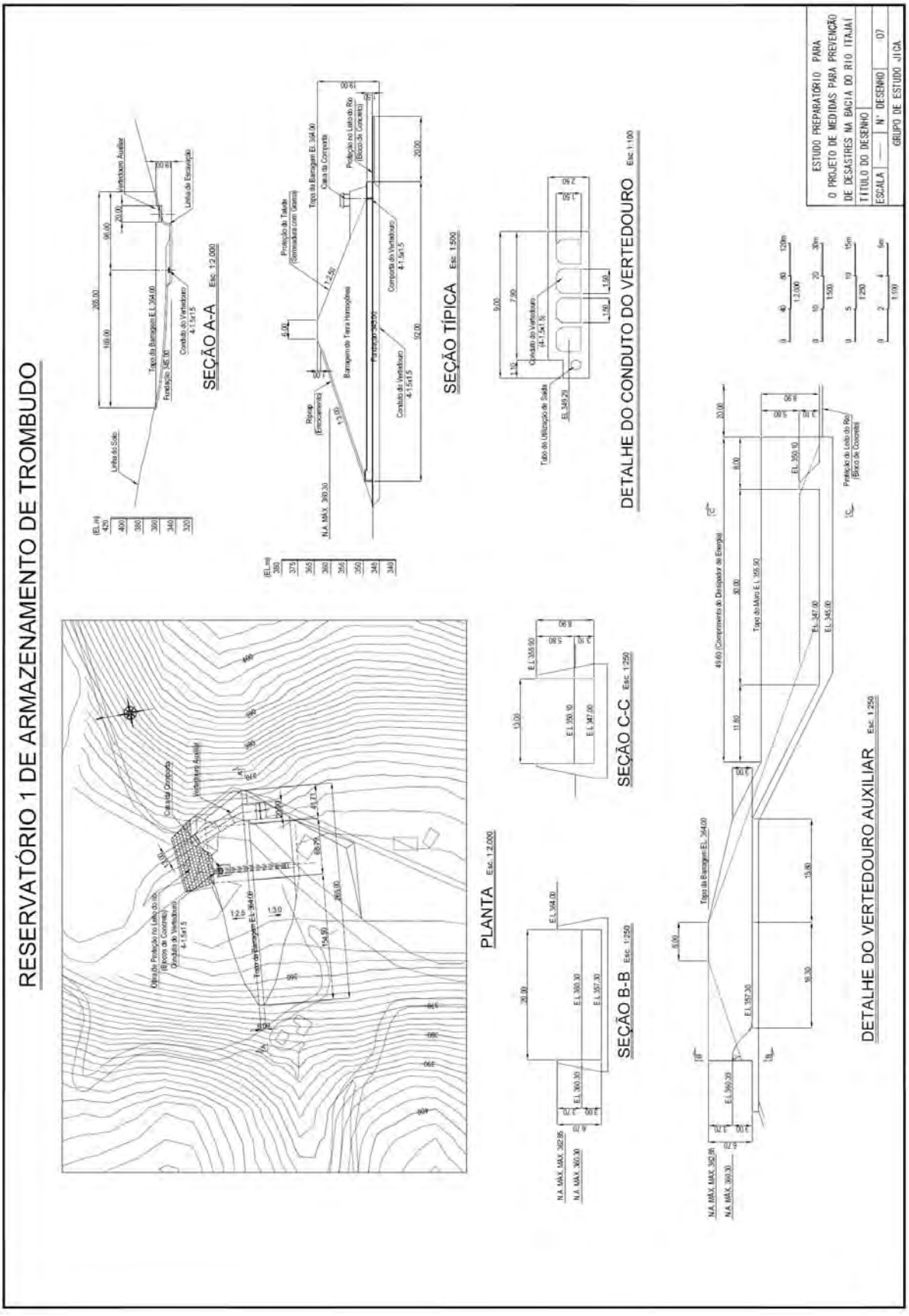


Figure 11.1.33 Structural Drawing of Basin Storage (Small Dam) (Site-1 on Trombudo River)

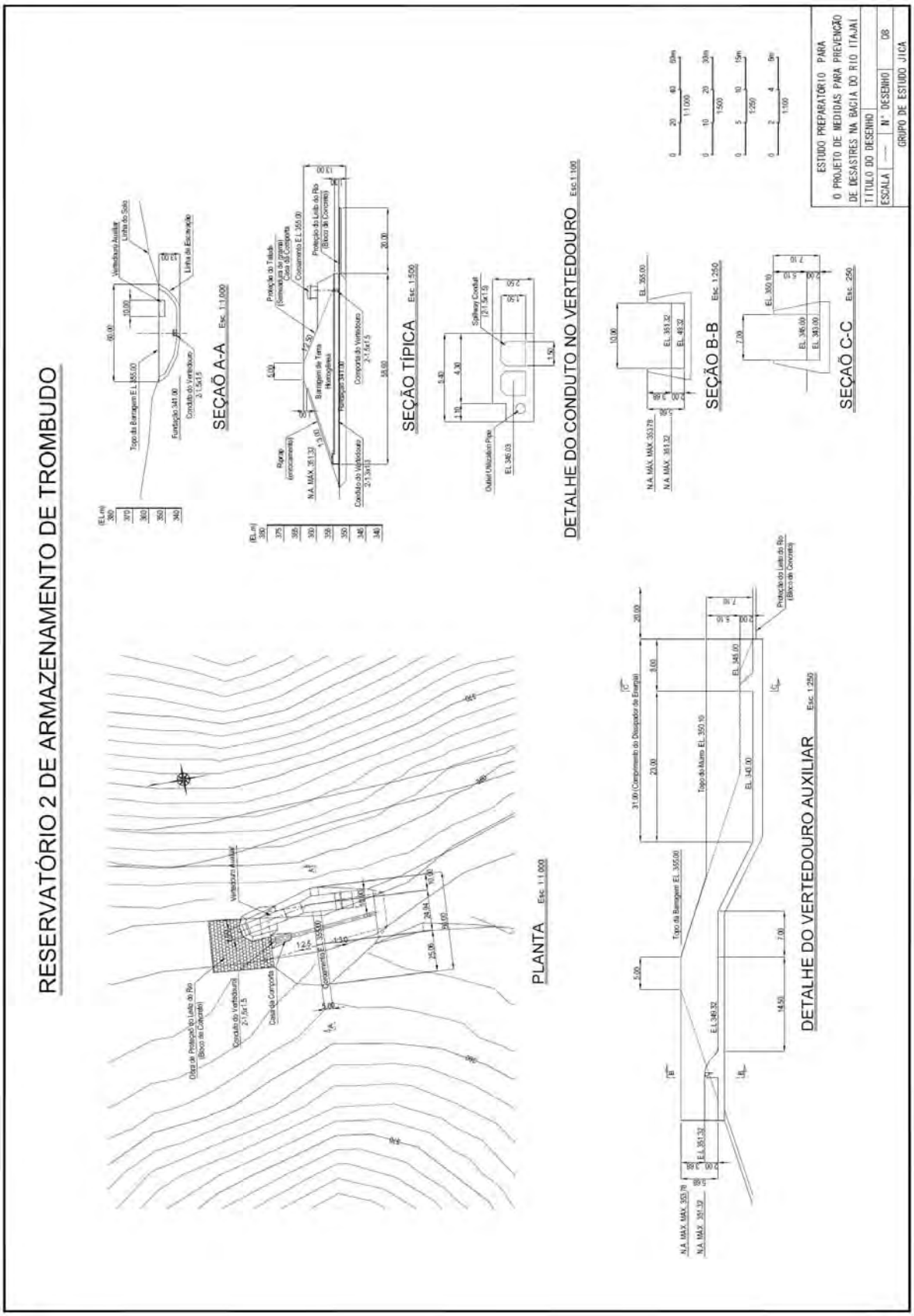


Figure 11.1.34 Structural Drawing of Basin Storage (Small Dam) (Site-2 on Trombudo River)

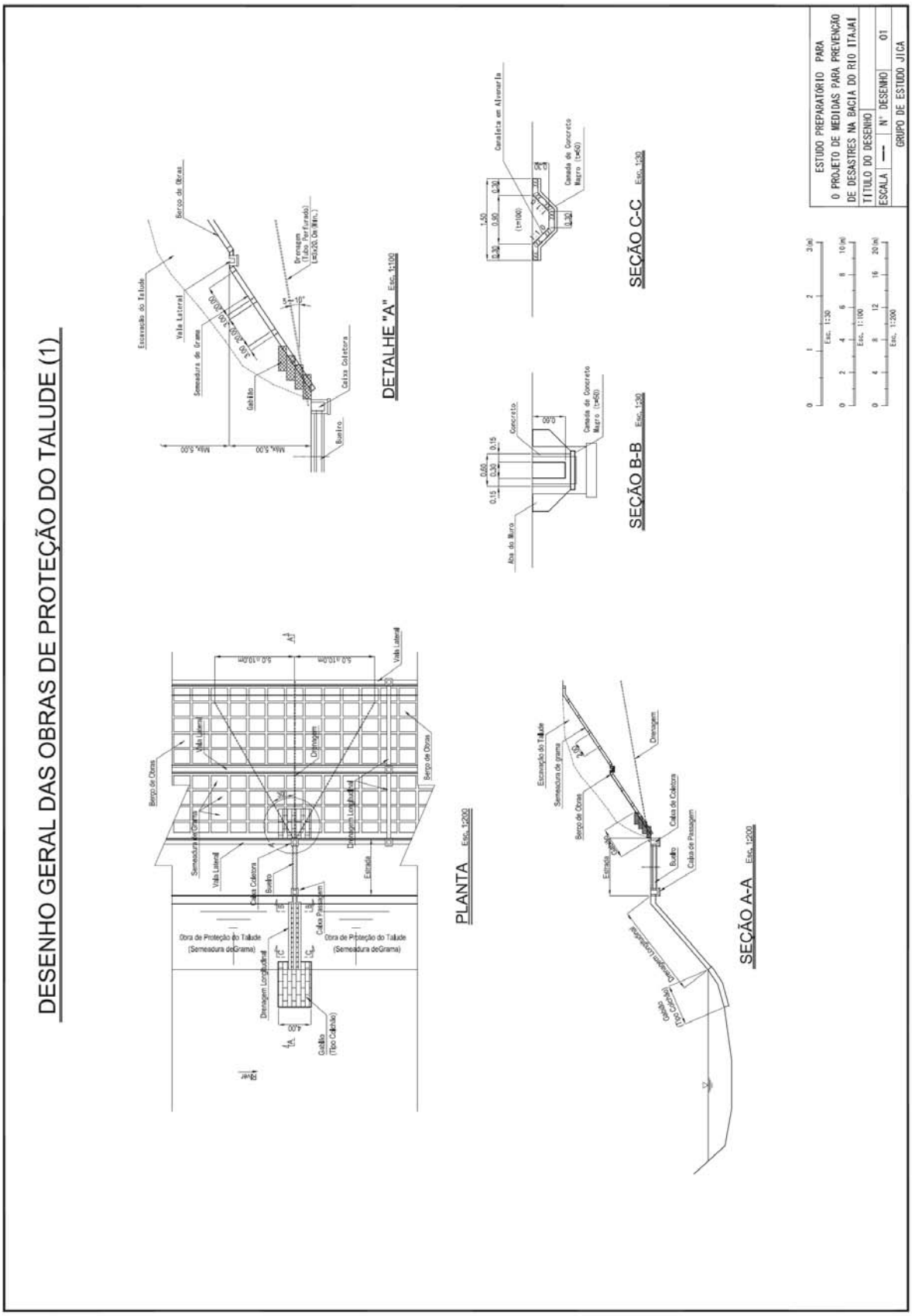


Figure 11.2.1 Structural Drawing of Landslide Mitigation Measures (1)

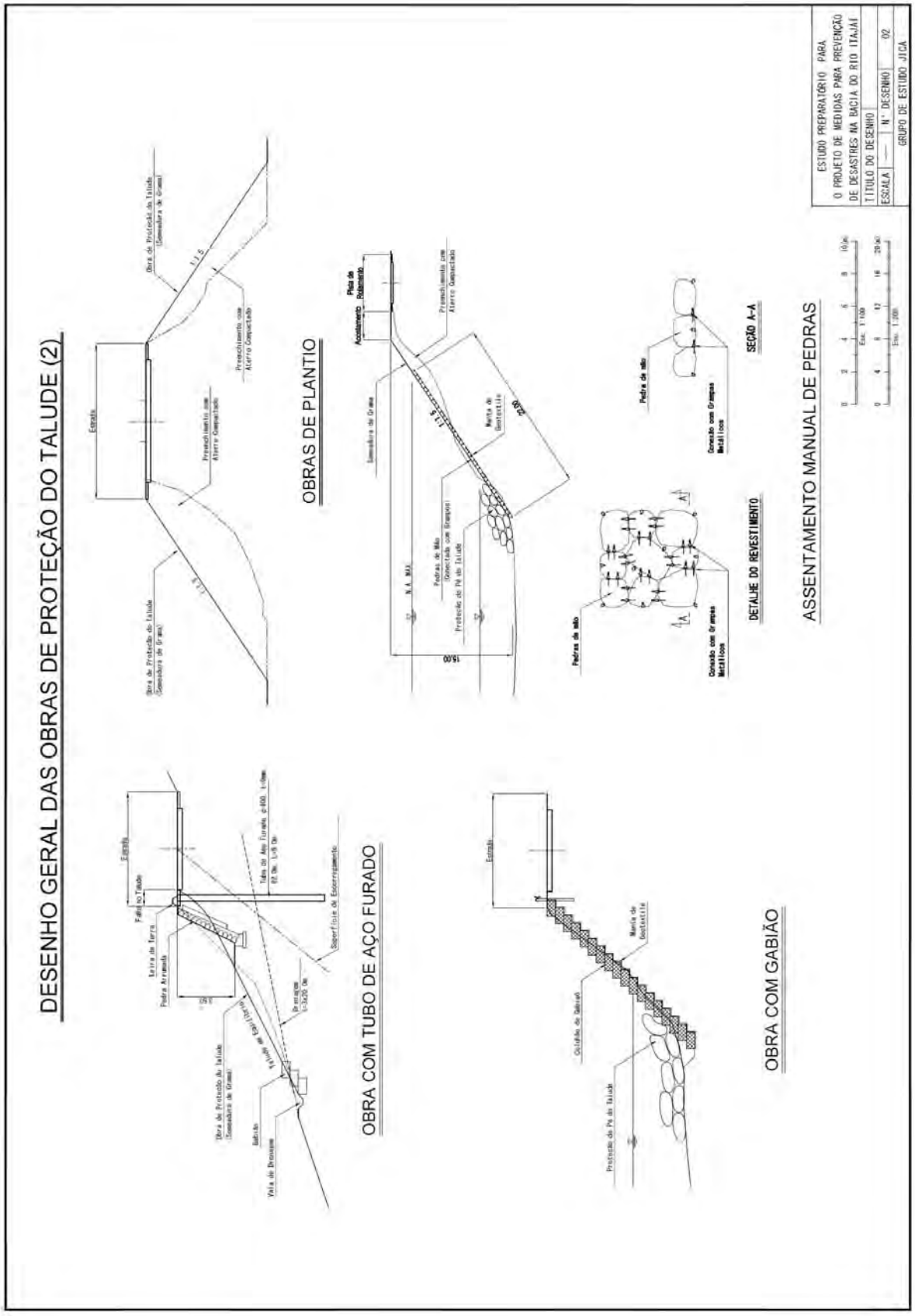


Figure 11.2.2 Structural Drawing of Landslide Mitigation Measures (2)

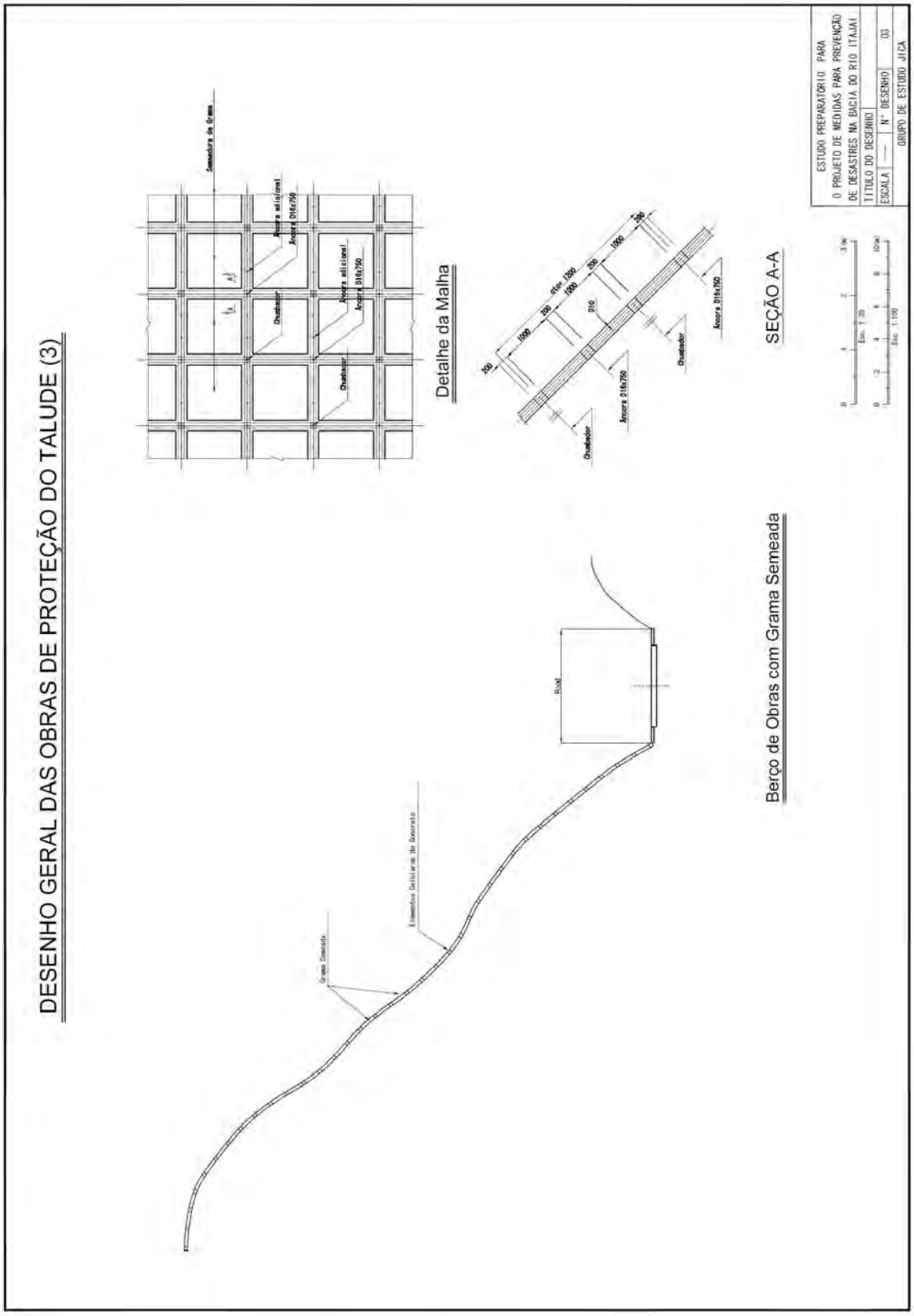


Figure 11.2.3 Structural Drawing of Landslide Mitigation Measures (3)