Part II
Feasibility Study

PREPARATORY SURVEY
FOR
THE PROJECT ON DISASTER PREVENTION
AND
MITIGATION MEASURES FOR THE ITAJAI RIVER BASIN

FINAL REPORT

VOLUME II : MAIN REPORT
PART II : FEASIBILITY STUDY

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CHAPTER 1 INTRODUCTION

1.1 Background of the Feasibility Study

The JICA Preparatory Study Team submitted the Interim Report to the State Government of Santa Catarina on the 10th December 2010 in accordance with the Scope of Works of the Preparatory Survey. The Interim Report described the Master Plan of Disaster Prevention in the Itajai River Basin that was formulated in the first phase of the Preparatory Survey, which was commenced on the 25th March 2010 as the first field work in Brazil.

As detailed in Chapter 16 of the Part I Master Plan Study, the State Government decided to realize a master plan of the 50-year flood as the final goal of flood security level. In view of the required huge investment and long period for realization, the State Government decided to implement the master plan as a stage-wise development, gradually increasing a flood security level. The State Government also decided to adopt a security level for around 10-year flood level for the first stage of implementation. Along this line, the following priority projects that are subject to feasibility study in the second phase of Preparatory Survey were finally selected by the Sate Government for the first stage of implementation:

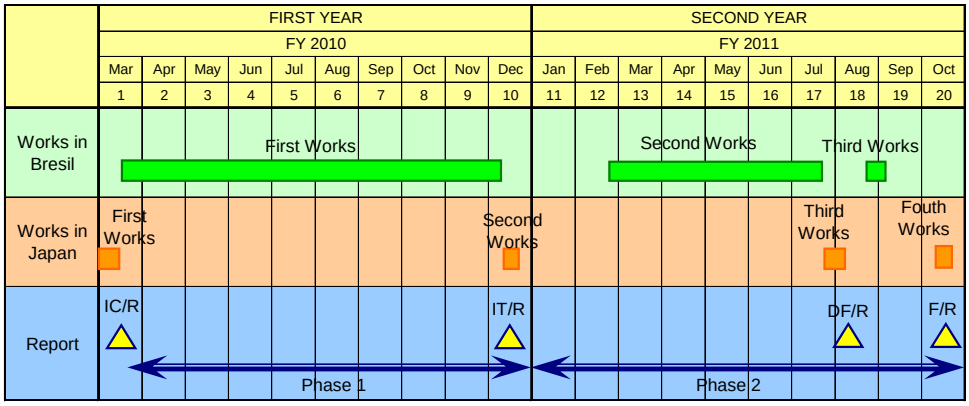
i) Water storage in the paddy fields
ii) Heightening of the existing flood control dam and change of gate operation method (2 dams)
iii) Utilization of the existing hydropower generation dam for flood control (2 dams)
iv) Strengthening of the existing flood forecasting and warning system (FFWS)
v) Installation of two floodgates on the Itajai Mirim River in Ttajai city

Together with the above, the following two projects were chosen for the first stage of implementation for realization of sediment disaster prevention master plan.

i) Slope protection of roads at 13 locations
ii) Installation of early warning system for sediment disaster and flush flood

1.2 Schedule of the Feasibility Study

The feasibility study was commenced in February 2011 under the work schedule as shown in Figure 1.2.1 below. The field works of the Survey ended in July 2011. The total duration of the second phase of the Preparatory Survey is scheduled to be around 8 months.



Remarks; IC/R: Inception Report, IT/R: Interim Report, DF/R: Draft Final Report, F/R: Final Report

Figure 1.2.1 Overall Work Schedule of the Preparatory Survey

1.3 Change of Executing Agency of the Preparatory Survey

In January 2011, a new administration system was launched under the new Governor in the Santa Catarina State. Along this line, the Defesa Civil was promoted to an independent secretary of the State Government. In April 2011, a new director general was officially inaugurated through approval of the State Congress. In this connection, the executing agency of the Preparatory Survey was changed from FAPESC to the State Secretary of Defesa Civil. However, FAPESC participates in the planning process of the feasibility study.

1.4 Feasibility Study Report

The Feasibility Study Report is prepared as the outcome of the second phase of the Preparatory Survey, describing the whole results of feasibility study on the selected priority projects.

In addition, same as the first phase of master planning, discussions with various State Government institutions and municipal governments as well as workshop and technical seminar were made during the second phase as listed in Table 1.4.1 below.

Table1.4.1 Record of Meetings with Related Organizations During Phase 2

No.	Data	Location	Organization/Interviewee	Agenda
1	2011/2/28	EPAGRI	Althoff Geraldo (General Manager of Civil Defense), Sato (Asst. manager of JICA Brazil), Taked (JICA Brazil)	Courtesy Call to New General Manager and Introduction of Study
2	2011/2/28	Mayor's office of SC State	Raimundo Colombo (Governor), Eduardo Pinho Moreira (Vice- Governor)	Introduction of summary of M/P and F/S
3	2011/2/28	Dep. of Finance	Ubirantan S. Rezende(General Manager of Dep. of Finance), Althoff(General Manager of Civil Defense)	Introduction of summary of M/P and F/S
4	2011/2/28	Dep. of International Cooperation	Marcelo J.Trevisani (Dep. of International Cooperation), Althoff (General Manager of Civil Defense)	Introduction of summary of M/P and F/S
5	2011/3/1	Dep. of Strategy and Implementation	Paulo Eli Consultor Geral (Deputy of General Manager), Althoff (General Manager of Civil Defense)	Introduction of summary of M/P and F/S and Budget for new Project
6	2011/3/1	Dep. of Administration	Milton Martini(General Manager of Dep. of Administration), Althoff(General Manager of Civil Defense)	Introduction of summary of M/P and F/S
7	2011/3/1	Dep. of Planning	Tulio Tavares Santos (Dep. of Planning Deputy of General Manager), Nortun (Manager), Selha (Manager of Urban Development (Ex Mayoer of Gravantal)) Althoff (General Manager of Civil Defense)	Introduction of summary of M/P and F/S
8	2011/3/2	FAPESC	Sergio Luiz Gargioni (President), Mario(GeneralManager), Veran (General Manager), Althoff(General Manager of Civil Defense)	Introduction of summary of M/P and F/S
9	2011/3/2	FATMA	Murilo Xavier (General Director), Heriberto Hulse Neto (Manager of Licence)	Introduction of summary of M/P and F/S、How to get the License
10	2011/3/10	Deinfra	Wojcikiewice (Manager), Roberto Alexandre Zattar (Manager), Antonio Romeo Branco Farias (Manager)	Survery and Geographic Surverey and introduction of the plan
11	2011/3/10	Deinfra (Division of Operational)	Celso Luiz Muller de Faria(Manager), Adolar Ferreira Filho	Survery and hearing of this years and the damage of heavy rain int this year
12	2011/3/10	SC State SC Parcerias (Public and Private implementation)	Enio Branco (General Director), Grauco Filho (Manager)	Introduction of summary of M/P and F/S、Private Project

No.	Data	Location	Organization/Interviewee	Agenda
13	2011/3/10	Dep. of Irrigation and Regional Development	Joao Rodrigues (General Manager), Luiz-Ademir Hessmann (Epagri General Director)	Introduction of summary of M/P and F/S
14	2011/3/16	SDR Ituporanga	Adelmo Cesar Santa (General Manager) Daniel Rogelio Schemitt (City chairman)	Introduction of summary of M/P and F/S
15	2011/3/16	SDR Rio Do Sul	Italo Coral (General Manager), Garibaldi Antonio Ayroso (Vice mayor), Othre Mayore and staffs total 20	Introduction of summary of M/P and F/S
16	2011/3/16	SDR Taio	Hugo Lembeck (General Manager),Ademar Dalfovo (Mayor) AMMAVI President, Othre Mayore and staffs total 20	Introduction of summary of M/P and F/S
17	2011/3/16	SDR Ibirama	Osvaldo Tadeu Beltramini (General Manager), Othre Mayore and staffs total 8	Introduction of summary of M/P and F/S
18	2011/3/17	SDR Timbo	Rogerio Raul Theiss(General Manager)	Introduction of summary of M/P and F/S
19	2011/3/17	SDR Blumenau	Cesar Bitelho (General Manager), Rufinus Seibt (Vice Mayor), Pemerodo Mayoer, Althoff (General Manager of Civil Defense)	Introduction of summary of M/P and F/S
20	2011/3/17	SDR Brusque	Fabricio Satiro de Oliveria (General Manager), Raquel Fabiane Mafra(SDS Community of Itajai)	Introduction of summary of M/P and F/S
21	2011/3/17	SDR Itajai	Fabricio Satiro de Oliveria (General Manager)	Introduction of summary of M/P and F/S
22	2011/3/22	EPAGRI	Pauro Arruda (Manager)	Introduction of summary of M/P and F/S
23	2011/3/22	DEINFRA	Paulo Meller (General Directore), William Ernst Wojcikiewics (Manager of Plan and Project)	Countermeasure for Road
24	2011/3/21	State of Councilor	Kennedy Nunes (State Councilor, Defesa Civil Chairperson)	Introduction of summary of M/P and F/S
25	2011/3/23	Itajai City	Jandir Bellini Mayor), Joao Omar Macagnan (General Manager of Dep. of Planning), Everlei Pereria (Director)	Introduction of summary of M/P and F/S, and schemes for flood control
26	2011/3/30	Blumenau City	Joao Paulo (Mayor)	Introduction of summary of M/P and F/S and counter measure for land slide at road
27	2011/3/30	Rio do Sul City	Milton Hobus (Mayor)	Introduction of summary of M/P and F/S and the Itajai Community
28	2011/3/31	SDS	PauloBornhausen (General Manager), Edison pereira de lima (Manager of Water Resources)	Introduction of summary of M/P and F/S, and Rader rain gauge
29	2011/4/6	CELESC	Antonio Gavazzoni (Predident), Michel Becker (Directer of Technical and Electric Power Supply), Andre Rezende (Manager of Public Relations)	Explanation of M/P and selected projects for F/S, Request for cooperation for project
30	2011/4/19	Civil Defense (Rio do Sul)	Eng. Andoro	Flood forecasting and result of evaluation
31	2011/4/19	CEOPS/FURB (Blumenau)	Prof. Helio Santos	Flood forecasting and result of evaluation
32	2011/4/29	UNIDAVI (Rio do Sul)	70 perticipatnts	Workshop for dam operation and early warning system for flood
33	2011/5/05	Defesa Civil (Itajai)	Everlei Pereira (Director, Coordinater)	Explanation of station for hydrology and meteorology
34	2011/5/06	Defensa Civil	Defesa Civil Key Staffs (30 persons)	Seminar for kick off of the department (new organization structure, mandate)

No.	Data	Location	Organization/Interviewee	Agenda
35	2011/5/10	Defesa Civil	Reginete,Frederico (Section Chief)	Explanation and discussion of early warning system
36	2011/5/13	CELESC	Power House Operation Staffs, Daniel Pedro Medeiros Jose Belmontt Verzola	Discussion about function of dam operation
37	2011/6/3	CRAVIL	Harry Dorow (President), Moacir (Engineer), Almir Krugeer (Engineer)	Discussion of method for water storage in paddy field
38	2011/6/3	Epagri (Itajai)	Jose Alberto Noldin (Chief of Experimental Center)	Experimental Center EPAGRI (water storage in paddy field)
39	2011/6/8	EPAGRI	200 perticipants	The 3rd technical seminar
40	2011/6/9	SC State Association of Engineers	30 perticipants	Explanation of the project
41	2011/6/9	AMAVI	Wilando Kurth (Emviromental Reachercher)	Discussion about opinions of the Itajai Committee and environmental assessment of the project.
42	2011/6/9	SDR Blumenau	Prof. Sheila	Discussion about reformation of river forest conducted by the Itajai Committee
43	2011/6/13	Deinfra (Sul dam)	Eng.Henz	Discussion about situation of houses in the reservoir area
44	2011/6/21	Defesa Civil (Itajai)	Everlei Pereira (Dairector, Coordinator)	Explanation of station for hydrology and meteorology

Source: JICA Survey Team

Workshop on Dam Operation and FFWS in Rio do Sul on the 29th April 2011

Technical Seminar in Florianopolis on the 8th June 2011

CHAPTER 2 FEASIBILITY STUDY ON WATER STORAGE IN PADDY FIELDS PROJECT

2.1 Project Context of the Water Storage in Paddy fields

2.1.1 Background

The paddy fields, accounting an area of 26.295 ha, distribute in all basins, and mainly locate in the higher basin between the Taió to Rio do Sul, Timbó area, and the lower basin among Gaspar to Itajaí. In spite of the paddy fields does not exceed 1, 8% of the total basin, the rice field has an important element for the inundation regulation, being distributed in the margins of the river from higher basin to river mouth. The existence of paddy fields shows significant roll in the control / reduction of the inundations in the lower basin. However, the potentiality to mitigate or attenuate an inundation does not still explore efficiently. On the other hand, in Brazil, the demands tendency, in all of the productive areas, has if more rigorous control, besides in the area of agricultural production. The main norms regulations implicated in the agricultural sector are:

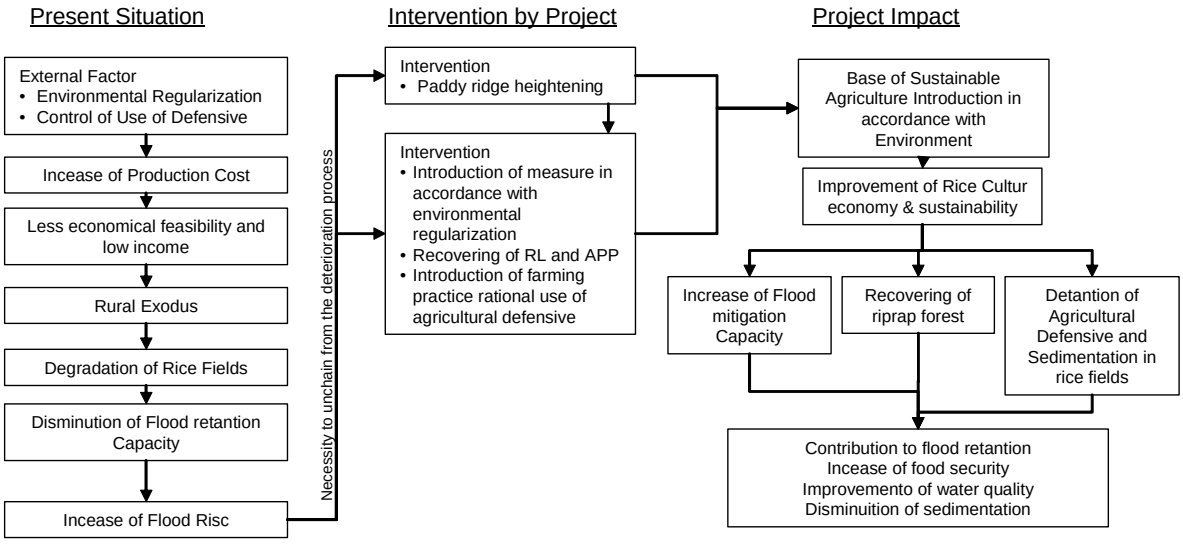
- Land Tile regulation in accordance with the Forest Code (require existence of the legal reservation (RL) and the permanent reservation areas (APP), besides of riparian forest)
- Regulation of the use of agricultural defensive

In the forest Code, it forces to obtain the "Certificate of Land Title Regulation" for every rural property that requires the normalizations of the APP and of the RL. Besides, in the agricultural production sector, the consumers' demands in relation to safety foods have been increasing, requesting the certifications and traceability of the productive chain from seedling to commercialization.

This rigidity tendency in the control and quality demand in the productive chains, bring to increase the complexity in the production and consequently, elevation of the productions cost, until provoking rural exodus, because of the deterioration of the agricultural economy. As well as most of the rice farmers of the basin are of small scale farmers who doesn't have capacity to accompany the demands and of quality. Its tendency takes risks of abandoning rice cultivation, consequent abandonment of the paddy and deteriorating in the decrease of the rain retention capacity in the paddy for the loss of ridge of the farming in the point of basin management.

Like this, with the abandonment of the farming caused by the rural exodus, it brings to degradations of the paddy, consequent the disappearance of the paddy ridge, and the loss of the capacity of reduction of the rains retention in the basin. To maintain and to improve the capacity of attenuation of the rains in the paddy, it is necessary to realize the measures and strategies for the producers to stay in the rural area and to motivate the productions through the measures that favor the productions of rice in the Basin.

In this project, through construction of paddy ridge that contribute in the reductions of the floods, the farmers can modernize the productive system, capable to adjust to the forest codes, taking place the necessary activities, such as topographical survey, recoveries of the riprap forests and introduction of the PIA (integral rice production). In following Fig, it is indicated the interrelations between the paddy and the project of heightening of paddy ridge:



Source: JICA Survey Team

Figure 2.1.1 Relation between the Project Water Storage in Paddy fields and Rice Culture

2.1.2 General Policy of Plan

(1) Objective of Plan

This plan, based on the above mentioned background, in purpose to enlarge the flood retention capacity, being used of the paddy fields expanded in the all sub-basins, will heighten paddy ridge and gradually to introduce the rice production with better quality and safety. As measures, it will develop the following activities:

Increase of capacity of reduction of the floods effect	- Elevation of the paddy ridge.
Use of the land in accordance with Environmental Legislation	- Recovery of the riprap forest. - Incentive to use of farm land in accordance with environmental legislation
Safety foods Supply	- Incentive to introduce the Integrated Rice Production

Source: JICA Survey Team

Through the materialization of the elements above, the following effects will be produced:

Construction of paddy ridge	- Increase of the attenuation capacity of the rains in the paddy (for an increase from 40.000.000 to 1.000.000.000 retention m³). - Retention of the defensive used inside of the paddy fields. - Decrease of the soil erosion loss
Recovery of riprap forest	- Transformation of the area to the rice production area balanced with the environmental codes. - Protection of riprap area - Make the bases of to acquisition of "Certificate of legalized lands"
Incentive to use land in accordance with environmental regulation	- No penalty - Improvement to accessibility to Official Agricultural Credit
Strengthening of PIA	- Offer of healthy and safe foods. - Maintainable and financial Stability of the producers through the production of valued rice

(2) Extents of Plan

The extent of the plan is expansion of the rice field in the Itajaí basin. In the following Table, it is indicated the basin area, the paddy area and the percentage regarding the total area.

Table 2.1.1 Sub-basin area, Rice field's area and percentage of rice field's area

	Basin (km^2)	Paddy fields (km^2)	Percentage
Total	15,221	262.95	1.76%
Itajaí do Oeste	3,014.9	99.45	3.30%
Itajaí do Sul	2,026.7	19.64	0.97%
Itajaí do Norte	3,353.8	10.64	0.32%
Benedito	1,500.3	30.20	2.01%
Luis Alves	580.0	19.64	3.39%
Itajaí Açú	3,358.6	60.80	1.81%
Itajaí Mirim	1,678.9	22.57	1.34%

Source: JICA Survey Team

(3) Implementation method for the Project of Water Storage in Paddy fields

Considering the nature of this type of measure that depend on the paddy fields and the inundation risk falling directly to the producers, the project seeks to benefit both side, so much of production and of inundation mitigation in the same time, without only sacrificing the producers, exploring the paddies potentialities in the mitigation of flood and improvements of the productive infrastructures through the construction of paddy ridge heightening. At the same time, as the compensatory measures of the paddy fields, it will be implemented the introduction of the Integrated rice production (PIA) that the producers can be adjust to the environmental demands, guaranteeing them financial means for so much, facilitating them the obtaining of the CRF.

Inside of this plan, the government will finance the construction of paddy ridge heightening works, and the producers will participate in their activities of implementing the paddy ridge in their property. The government's contribution and of the producers in the heightening of the paddy ridges will be the following:

Table 2.1.2 Activity of the Project Rain Containment in the Paddy Fields

	Governments Support	Producers Contribution
Plan	- Support for formation of the Term of Agreement of the producers. - Support to organizations of the associations. - Support to the obtaining of C.R.F. - Topographical survey - Formulation of the Plan / Project (amount of works, calendar of the works, determination of the participation)	- Agreements between the producers and Establishment of the associations of the producers. - Arrangements of the registrations of the participants' registers. - Agreement among the producers in the accomplishment of the Plan. - Contract of the Execution of the Project
Heightening of paddy ridge	- Dispatch of consultants - Definition of the methodologies of project implementation. - Disbursement of Construction Cost of Heightening of Paddy Ridge (80%) - Supervision of the works	- Execution of the Construction of Heightening of Paddy Ridge - Co-payment of Construction Cost (20%)
Recovering of riprap forest		- Placement of that material in the margins of Rio. - Planting of nursery plants
Adjustment for Environmental legislation	- Certification of the property registration. - Survey of properties. - Emission of APP, R.L. - Establishment of the reach of APP	- Title of the property. - Certificate of Land title
Promotion of the PIA	- Technical Orientation for the PIA	- Introduction of PIA

Source: JICA Survey Team

Due to the paddy fields extend for the whole basin, and there are approximately of 2.000 farmers, there is complexity of the implantation of this plan to make format the implementation plan if it implement in contract base. Besides, because of the characteristics of this plan, and having a lot of

stages of processes in materialization, it is suggested that the execution is executed in the following way:

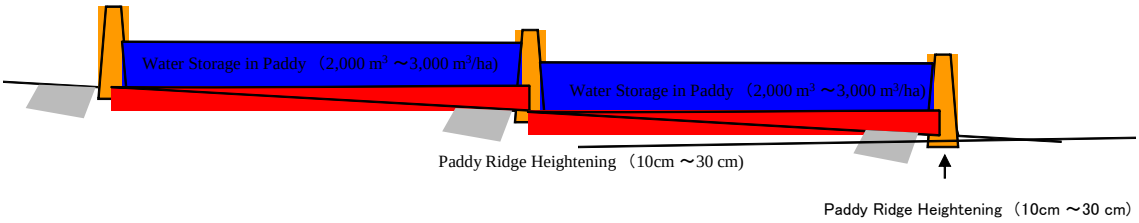
Government	Producers
- Lend of services and consultancies for the implementation of the Plan. - Disbursement of construction Cost (80%)	- Construction of paddy ridge heightening. - Provision of riprap forest area - Co-payment of Construction Cost

2.2 Project of the Rain Containment in the Paddy fields

2.2.1 Outline

(1) Scheme for the retention of flood water in the paddy fields

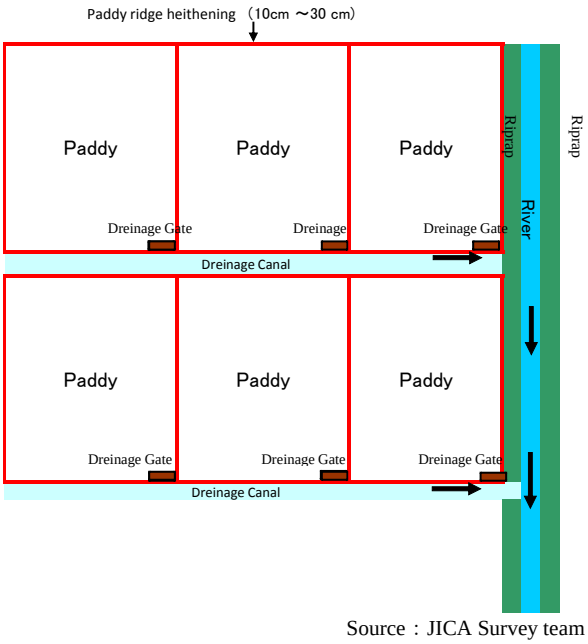
It is foreseen to execute the heightening of the paddy ridge (currently 10 cm) for more 10 to 30 cm, hoping to increase the rain water retention capacity for more 2.000 ~ 3.000 m3 per hectare, as well as it is indicated in following figure;



Source: JICA Survey Team

Figure 2.2.1 Retention Methodology of Flood water in paddy fields

The paddy ridge heightening works will be realized in the margins of the suitable paddy with red lines in following Fig. For not accompanying the damage in the rice production, the gates will be installed capable to control/mitigate the effects of floods, especially in the times of flowering season period of rice when larger risk of loss of the products exists.



Source：JICA Survey team

Figure 2.2.2 Retention of rain in paddy fields

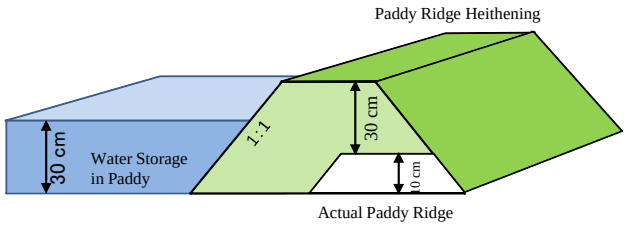
(2) Definition of the flood depth and height of paddy ridge

The rice culture, being the certain resistant culture for flood, it allows to accomplish the control of the floods, through the floods of the fields with the appropriate water managements. However, vulnerable times exist as in the period 20 days before flowering season in that the culture can be

damaged by the excess of water. The required height of paddy ridge will be defined, being considered the heights of rice, to minimize the damages that can be caused by the floods by this project. The depths of projected floods depth are the following ones;

- During the period of non cultivation, it settles down 30 cm of water depth. From the period of 20 days before the formation of the ears of rice, until the time of flower of these, the maximum depth will be of 30 cm, being the normal depth of 20 cm.
- After the seedling, given the fact of the young plants does not support for a long time be submerged, one should not leave submerged for more than 4 consecutive days

The height of the heightening is of 30 cm, to make possible the installation of floodgates and to guarantee the depth of until 30 cm of the water.



Source：JICA Survey team

Figure 2.2.3 Cross section of Paddy Ridge

The amount of work for the paddy ridge is the following ones:

Present (0.5+0.7)/2 x 0.1 m= 0.06 m^3

After heighten: (0.5+1.3)/2 x 0.4m= 0.36m^3

Difference of earth volume: 0.30 m^3

(3) Extents of Project Area

The extent of the Project will be the areas where appropriate rice field expansion exists inside of the entire paddy areas expanded in the Basin. As the first phase, it is considered 5,000 ha of the paddy expanded in the basin. The objective areas of project will be selected in the basic study phase and it will be settled down the following goals:

Paddy Areas:	26.295 has
Objective Project Area:	20.000 has
First phase Area of the Project:	5.000 has

(4) Heightening of Paddy Ridge and required work quantities

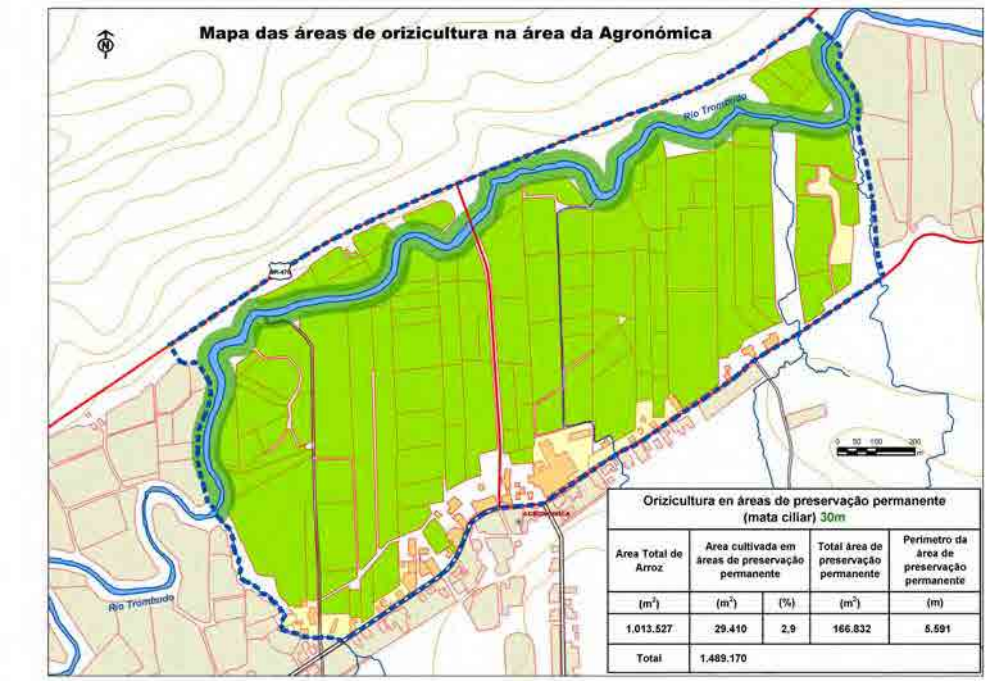
The dimensions of the works were estimated, being taken the area of Agronomic as sampling. The estimated amounts of works are;

Table 2.2.3 Agronômica – Quantities of necessary works

Item	Present	Projected	Cost/ha
Total Area			
Paddy Ares	101.4 ha		
Extension of ridge	29.4 km		
Number of farm	106		
Area of Riprap forest		0.03 ha/ha	R$ 5,000/ha
Length of paddy ridge	m/ha	300 m/ha	
Required volume for heightening of Paddy ridge		90 m3/ha	R$ 3.150/ha
Extension of medium paddy	ha	1 ha	
Required Gate		1 per ha	R$ 250/ha
Specific riprap Forest area for 1 hectare	16.6 ha	0.16 ha/ha	
Length of riprap forest	5,600 m	55 m/ha	

Note: The cost of paddy ridge heightening works was estimated (90 m3/ha x R$ 35/m3 = R$ 3.150 /ha) and of riprap forests were estimated (Nursery Plant 1.000 x R$ 3,0 / plants + Fence)
Source: JICA Survey Team

In following Fig, the Agronomic area as a sample is indicated, in order to estimate the amounts of works requested for this measure;



Source: JICA Survey Team

Figure 2.2.4 Paddy Fields in AGRONOMICA

The estimated costs of the project, included topographical survey, formulation of the plan, environmental licensing and the environmental regulation are:

Table 2.2.4 Estimated required budget in a Contract Base

Item	Quant.	Unit	Unit Price (R$)	Total Value (R$1,000)
Work for heightening of paddy ridge	5.000	Ha	3,400	17,000
Recovering of riprap forest	200	Ha	5,000	1,000
Subtotal				18.000
Design of paddy ridge	20.000	Ha	100	2,000
Detailed design and Bidding assistance	5,000	Ha	200	1,000
Construction Supervision	5,000	Ha	600	3,000
Topographic Survey	5,000	Ha	100	500
Emission of C.R.F	500	Family	100	500
Support to Environmental Regularization	500	Family	200	1,000
Training	500	Family	1,000	500
Total				26,500

Note: The cost of measures of contention of floods in the paddy was esteemed in the following form: Works of heightening (R$ 3.150 / ha) + Floodgate (R$250/unit. The Cost of riprap forest was estimated in the following form: Plants (1.000 x R$3.0 / unit) + fence
Source: JICA Survey Team

Implementation Method

The work of the heightening/preparation of the paddy ridge will be executed by the producers, and the implementations work methodology is as follows:

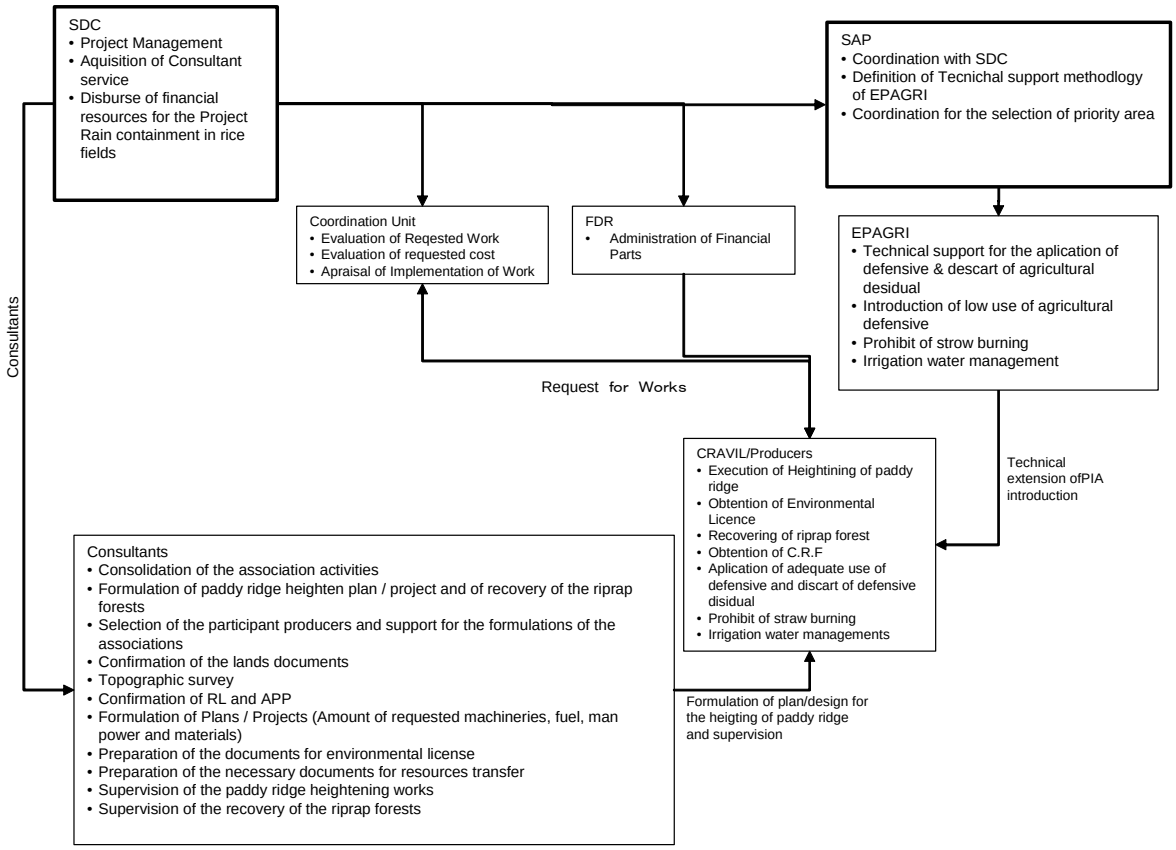
- Promotion to the producers to participate in the project of containment of rains in paddy fields, through the explanations of its benefits and activities to be accomplished by the project.
- Formation of the Agreement among the producers on implementation of the project.
- Realization of the Study, preparation of the Projects and necessary topographic survey.
- Project Design/Estimation of Cost
- Estimation of Cost
- Request for the implementation of Works for the Coordination Unit
- Request for FDR
- Evaluation of the Project, Appraisal and Contract for the Execution of the Project
- Construction by producers
- Disbursement of Construction Cost (80%)

It is foreseen to promote the understanding of the producers, in agreement, projects and survey. This type of service will be accomplished through support activity of contracted consultancy. The construction of paddy ridge heightening work will be carried out by producers.

2.2.2 Organization of Project Implementation

(1) Process

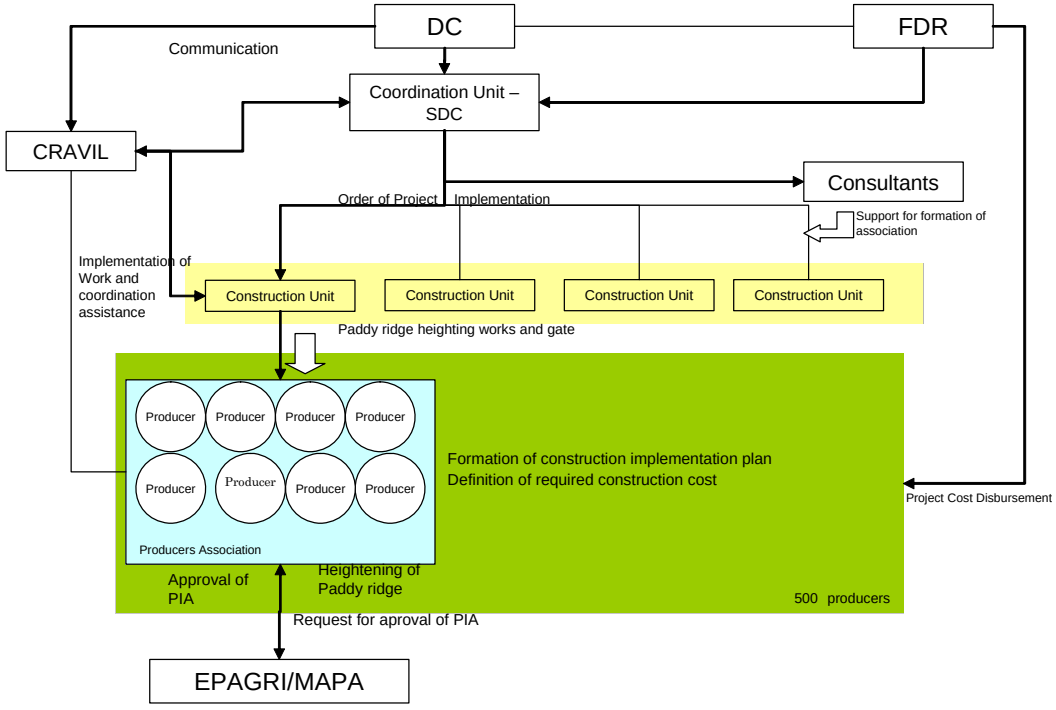
The implementation of the project will have as base, the rational and economical use of the budget, with the wide participation of the rice producers in the work. The State government will disburse the construction cost for the work, as well as consultancy services and training. Below, it is the organization chart of the implementation of the works:



Source: JICA Survey Team

Figure 2.2.5 Organization Chart

The executive organization of this project is the State through the Secretariat of Civil Defense (SDC). For the implementation of this project, the SDC will be acquired the Constructor through the bidding.



Source: JICA Survey Team

Figure 2.2.6 Project Implementation Flow

(2) Consultancy Service

The Consultancy of this operation will have the following attributions:

- To determine the outline of execution of the whole plan.
- To chooses of the candidate farmers and organization of the associations (final objective, 500 families of farmers).
- Verification of the participants' (final objective, 500 families of farmers) land titles situation.
- Verification of land title documents
- Topographic Survey and verification of Legal Reserve and Riprap Forest Area
- Detailed design and Cost Estimation
- Cost estimation
- Obtaining of the environmental license.
- Preparation of application document for appraisal
- Supervision and orientation of the work of heightening of walls (paddy ridge).
- Supervision of the countermeasures of APP

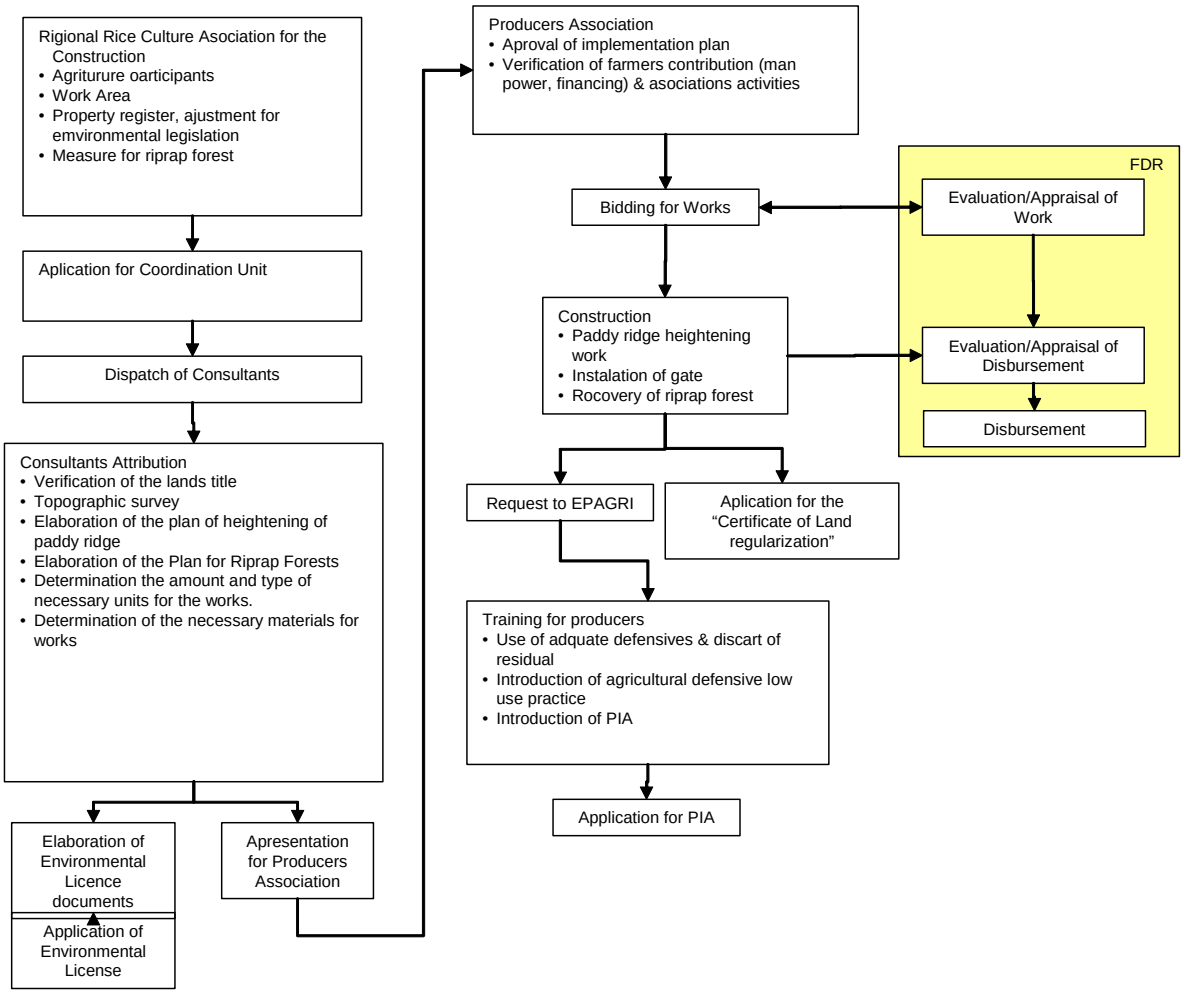
(3) Technical support for the introduction of PIA

With support of the EPAGRI/SAP, the following necessary activities will be implemented for the introduction of the PIA

- Managements of defensive use and appropriate discard of package of defensive.
- Introduction of low defensive use agricultural.
- Prohibition of the burnings of the straw.
- Administration of water resources

2.2.3 Project Implementation Guide

The process of the Project Contain of the rains in the paddy fields will be implemented in the following forms:



Source: JICA Survey Team

Figure 2.2.7 Project Implementation Process

(1) Assembly of the rice producers of the area for the execution of the works

The assembly of the rice producers of the area, with objective of obtaining support of the municipal districts, will be established at the level of the each municipal district, town or irrigation scheme established already, and it will be unit responsible of the implementation of the work. Like this, each unit of those assemblies will be, hereafter, them unit of implementation of the construction of paddy ridge works, administering the system and also making the devolution of the financing.

It is desirable that each unit has a minimum of 10 families, so that there is a harmonic work in the works. Each assembly will have to decide on the following items:

- Participants of the project.
- Area where the project will be accomplished.
- Outline of the registrations of the land (for adaptation to the environmental legislation).
- Measures are taken with regard to the riprap forest.
- Place from where will leave earth.

- Administration Methods and supervision and choice of the leadership of the association.
- Methods for the devolution of the financing of the FDR

(2) Requirement of work for the Coordination Unit of the Project

In the Project of containments of rains water in the paddy fields, each association will make request to the Coordinating Unit of the Project for its implementation. The coordinating Unit will establish the order of service of each work and execution, in view the applications done by each area and area. The coordinating Unit will do, also, allocation of the consultants, in order to make design of paddy ridge heightening, cost estimation and make request for the FDR for the implementation of the Project.

(3) Paddy Ridge construction works and recovery of riprap forest

To execute the paddy ridge works and recoveries of the riprap forests will be accomplished the following activities;

- Verification of the lands registrations.
- To execute the measurement (topographic survey).
- To elaborate the project of construction of paddy ridge.
- To elaborate the project of the riprap forest.
- Project of earth (for the paddy ridge) retreat.
- To determine the amount of machines and the necessary days of use.
- Methods of reproduction of seedlings.

The measurement area will be basically of those foreseen for the heightening of paddy ridge, lands that are out of the Project, the costs for measurement will be covered by the proprietors. As for the riprap forests, through the verification of the land registrations, will be divided in areas of individual responsibility and community. The plan of borrow pit as for the earth will be resolution item in the assemblies of each unit, as for the place from where will be removed, and means of providing resources for such. It is also due to calculate the amount of workers, the number of necessary machines, the cost, the necessary materials, to base the applications to the CIDASC and the FDR.

As for the recovering of the riprap forest, it is just due not to foresee the species and varieties of the nursery plants, production and planting, but also from where the resources will come for so much.

(4) Application for obtaining of the environmental authorization

The allocated consultants will elaborate the document and necessary applications to the obtaining of the environmental license; especially, close to the FATMA (General office of the Environment of the State).

(5) Last confirmations of the Assemblies of the rice producers associations

Through the assemblies, it will be verified the following points:

- Lines as for the methods and means of the elevation of the barriers (of the heightening

of paddy ridge).

- Methods for restoration of the riprap Forest, and their limits.
- Preparation of the document for the application for the implementation of the work

(6) Evaluation/Appraisal of requested document for the implementation of works and preparation of contract documents

The Coordination Unit will evaluate the appropriation of the construction cost requested by the producers and, after the appraisal of the document, it will be transferred the request for the FDR. Also, the Coordination Unit will make contract document subscribing the responsibility of farmers and implementation schedule, including the responsibility in the contention of rain water in their paddy fields.

(7) Start of Works by producers and request for the disbursement

The Rice producer will carry out the paddy ridge heightening works and riprap forest recovering. The cost for the work will be requested for the disbursement.

(8) Evaluation of construction cost and disbursement

The Implementation Agency will evaluate requested construction cost and after the appraisal of the requested document will be disbursed through the FDR. The disbursed amount is 80% of the construction cost.

(9) Training for Producers

To optimize the effects of the works in this basin, besides improving the quality of the water the producers they will receive the following trainings:

- Use of defensive / discard of residues and packing.
- Introduction to the low defensive use agriculture.
- Prohibition of burnings of the straw.
- Practice of the agriculture with low use of defensive.
- Handling of water

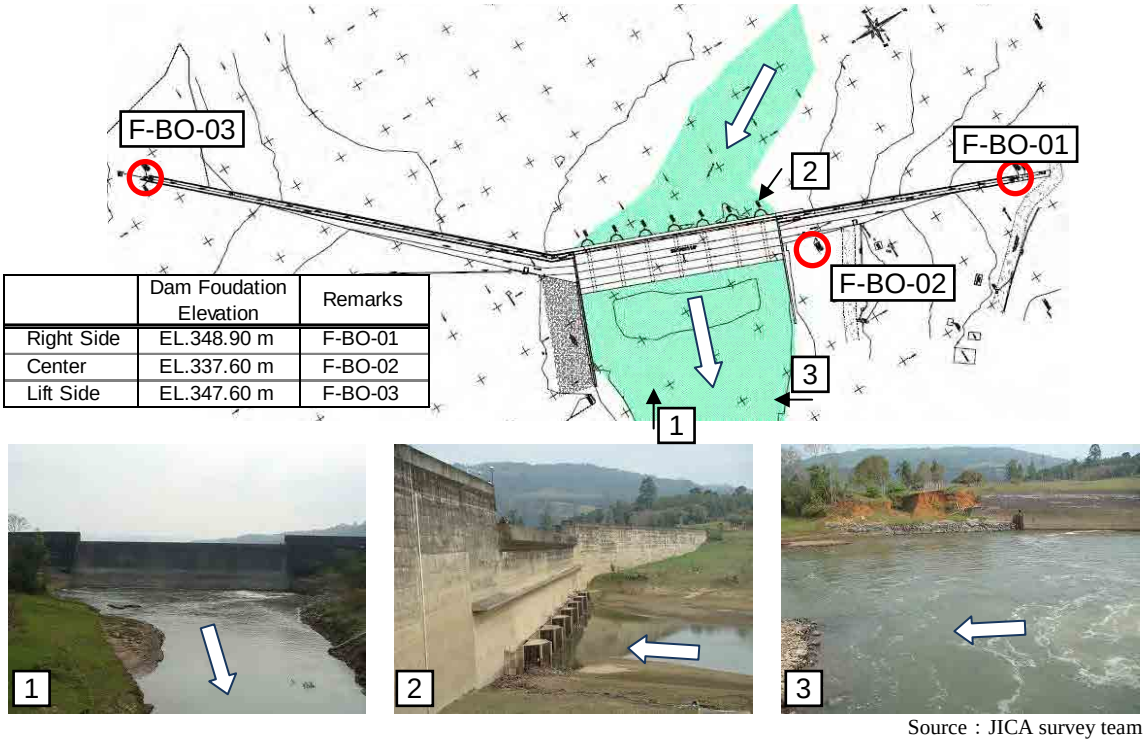
CHAPTER 3 FEASIBILITY STUDY FOR HEIGHTENING OF EXISTING FLOOD CONTROL DAMS AND MODIFICATION OF DAM OPERATION

3.1 Background of Dam Heightening

Heightening of the Oeste and Sul dams becomes necessary at the safety levels for the 25- and 50-year floods, respectively. For smaller probable floods, such as the 10-year flood, both dams are able to control the 10-year flood safely with full closure of the gates. However, this gate operation increases the risk of overflowing of the spillway. So, heightening of the dams becomes necessary to reduce the risk of overflowing. Due to this reason, heightening of these dams was proposed in the Master Plan.

3.2 Field Investigations

The topographic survey was carried out at two dams to confirm major structural dimension of both dams, which was basically required for feasibility level design for heightening. In addition, geological survey was carried out to estimate the foundation profile of the dams. Drillings were carried out at three (3) locations at the Oeste dam and one (1) location at the Sul dam as shown below.



	Dam Foudation Elevation	Remarks
Right Side	EL.348.90 m	F-BO-01
Center	EL.337.60 m	F-BO-02
Lift Side	EL.347.60 m	F-BO-03

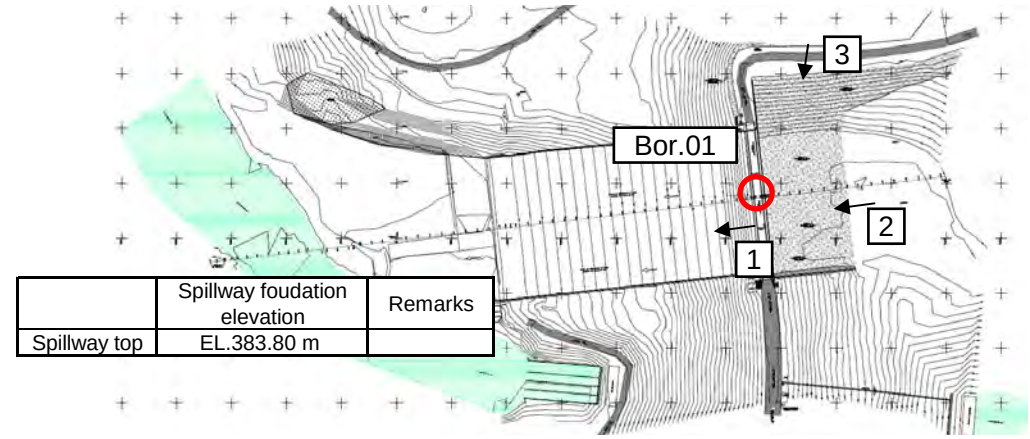
Source：JICA survey team

Figure 3.2.1 Location Map of Drilling Survey at the Oeste Dam

(1) Engineering Geology at the Oeste dam

The location of drilling points and outcrop, geological structure and distribution of geology are shown in the Fig.3.2.3. Drilling survey was performed at the left side of the existing concrete dam body (No: FB-O-01, total depth: 30.6 m), the central base dam (No: F-BO-02, 26.0 m) and the right side of the existing concrete dam body (No: F-BO-03, 25.5 m) with standard penetration tests, that were performed before reaching to the bedrock. Based on the results of drilling survey and detailed site investigation, the unconfined compression strength of fresh bedrock is estimated about 30M N/m2, classified as medium strong rock. In crack zone, crack

spacing is more than 5 cm. According to the existing result of shearing test for similar rock, shear strength is estimated as $\tau = 1.0 + \sigma\tan 38°$ (MN/m^2).



Source：JICA survey team

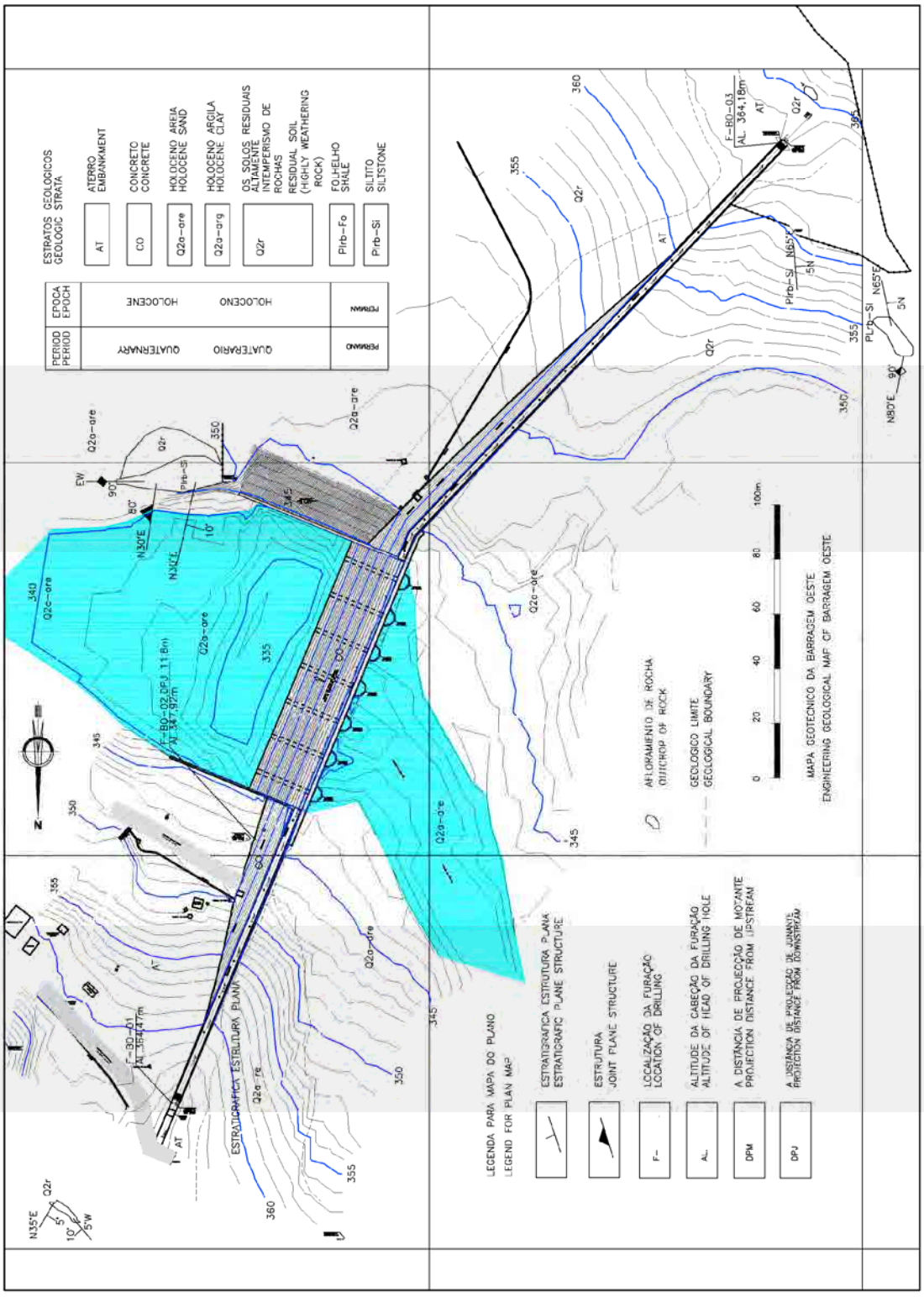
Figure 3.2.2 Location Map of Drilling Survey at the Sul Dam

(2) Engineering Geology at the Sul dam

The location of drilling point and outcrop, geological structure and distribution of geology are shown in the Fig.3.2.4. The drilling was performed at the top of spillway (No: F-BS-01, total depth: 20.0 m) in order to verify the quality of concrete and condition of bedrock at the spillway.

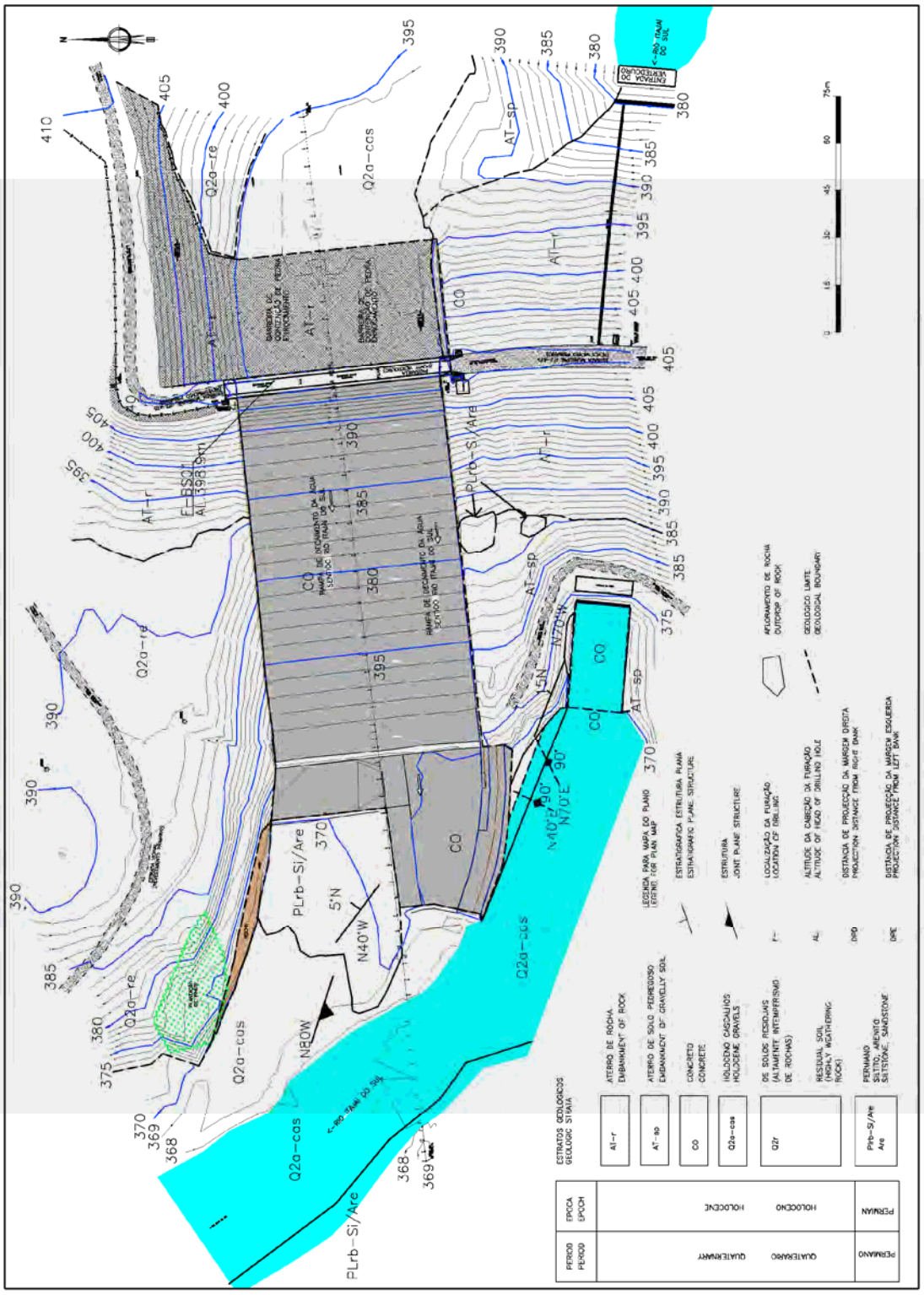
The unconfined compression strength of fresh bedrock is estimated about 30MN/m2, medium strong rock. In crack zone, crack spacing is more than 5cm. According to the existing result of shearing test for similar rock, the strength of shear is estimated as $\tau = 1.0 + \sigma\tan 38°$ (MN/m2).

The details of site geology and results of the survey are described in the Supporting Report Annex C Geology.



Source: JICA Survey Team

Figure 3.2.3 Geological Map for the Oeste Dam



Source: JICA Survey Team

Figure 3.2.4 Geological Map of the Sul Dam

3.3 Feasibility Design for Civil Structures

3.3.1 Criteria for Design

The following design criteria and standard were applied. The feasibility design was carried out mainly based on the first Brazilian standard, supported by other standards.

i) CRITÉRIOS DE PROJETO CIVIL DE USINAS HIDRELÉTRICAS Outubro/2003

ii) Technical Standard for River and Sabo Facilities, Ministry of Construction of Japan, 1997

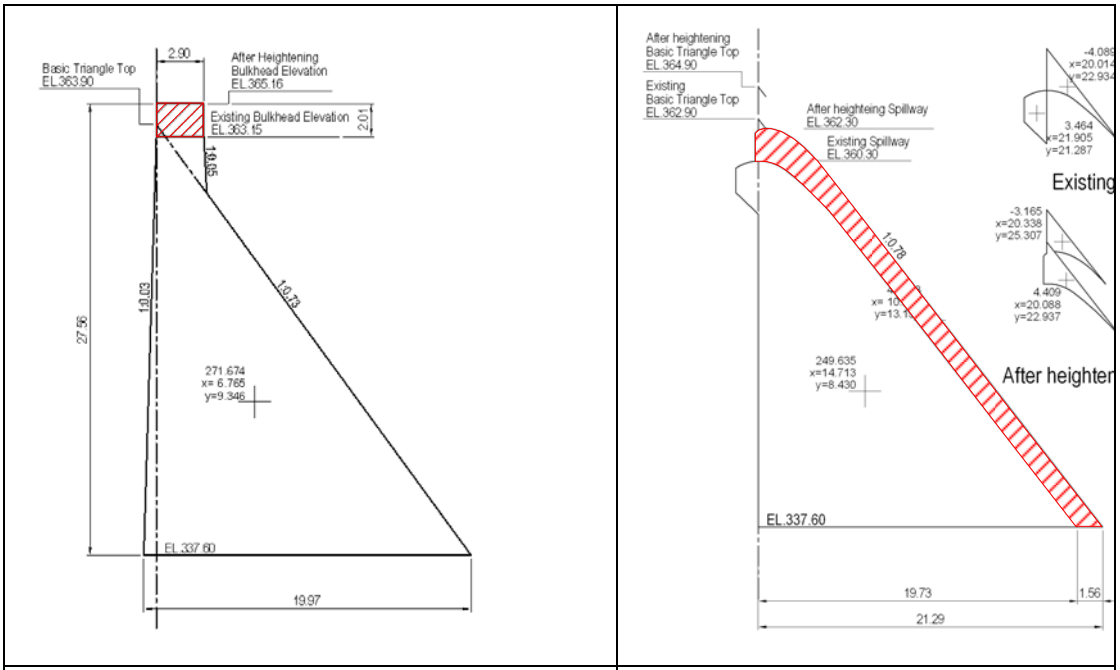
iii) Design of Small Dams, Bureau of Reclamation, Department of The Interior, USA, 1987

3.3.2 Feasibility Design

(1) Oeste dam

1) Non-overflow and Spillway Sections

It appeared by the topographic survey and hydraulic calculation of the design discharge that the non-overflow section of the dam body should be heightened by 2.01 m, although the spillway section is by 2.0 m. Figure 3.3.1 shows the designed sections. As seen, the shape of spillway crest is relatively sharp because of its sharpness of the crest.



Non-overflow Section	Spillway Section

Source : JICA Survey Team

Figure 3.3.1 Designed Sections of the Oeste Dam

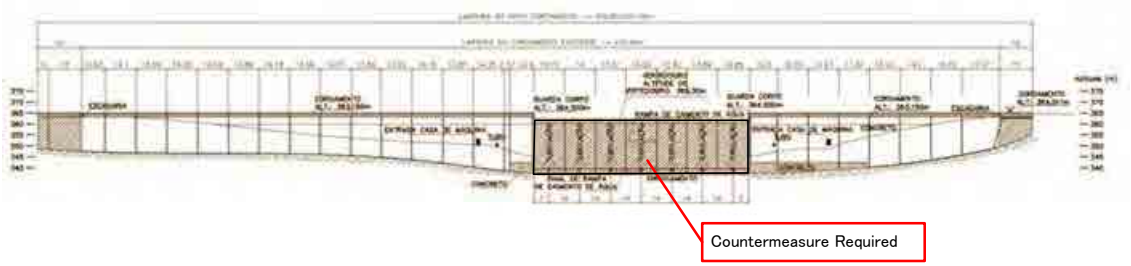
2) Stability Analysis against Overturning due to Heightening

Non-overflow section

Stability analysis was carried out to confirm the stability against overturning due to heightening, dividing the non-overflow section into several sub-sections. It appeared that all of the sub-sections are sufficient for the required safety factor of 1.10, which is required for the structure against overturning.

Spillway section

It appeared that spillway section is insufficient for the required safety factor. The facing concrete at the downstream slope was thus proposed in the whole section of spillway. The downstream slope is set at 1:0.78.

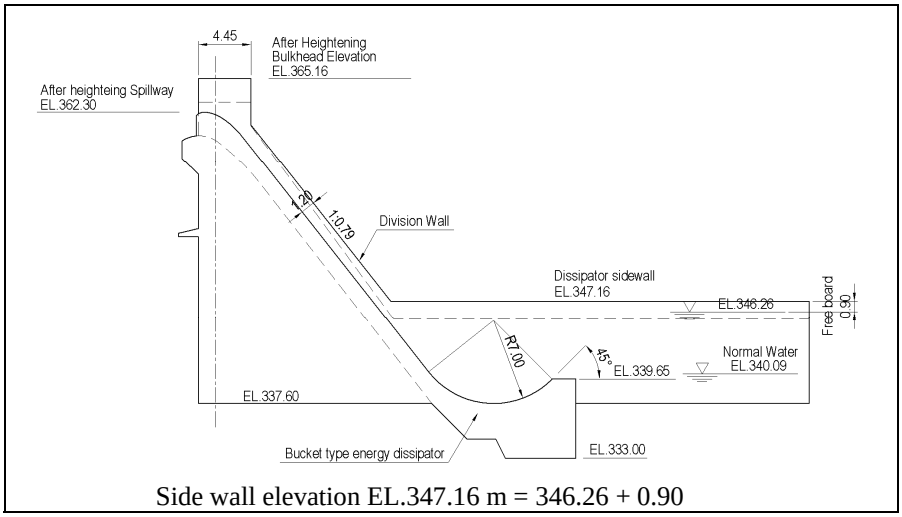


Source: JICA survey team

Figure 3.3.2 Proposed Countermeasure against Overturning at the Spillway Section of Oeste Dam

3) Energy Dissipater

No energy dissipater is provided at the Oeste dam. The energy dissipater is generally installed at the outlet of spillway to dissipate large energy of the overflowed water of spillway. Heightening of the spillway might cause larger energy since the overflow head becomes higher. From the hydraulic viewpoints, it was proposed to install the dissipater. The proposed dissipater is of the submerged bucket type considering that river water level immediately downstream of the dam is always high enough as illustrated below.

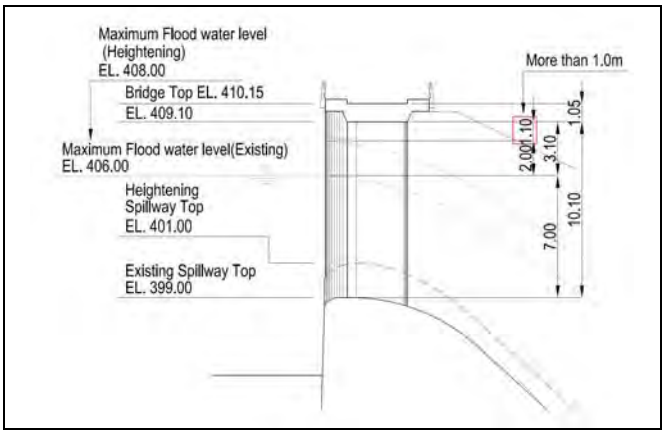


Source：JICA Survey Team

Figure 3.3.3 Proposed Energy Dissipater at the Oeste Dam

(2) Sul dam

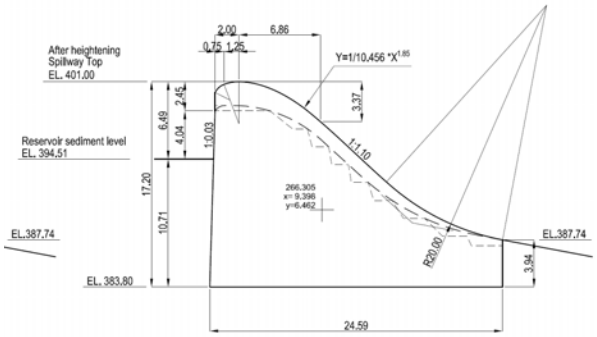
The Sul dam is proposed to heighten only the spillway section by 2.0 m because of sufficient freeboard to the dam crest after heightening as illustrated in Figure 3.3.6. As shown, the maximum overflow depth of design discharge of 2,570 m^3/s (= 10,000-year flood) is 7.0 m under the present spillway. However, even though the spillway is heightened by 2.0 m, there would be more than 1.0 m space as a freeboard.



Source：JICA Survey Team

Figure 3.3.4 Comparison of Overflow Depth of Design Discharge on the Spillway of Sul Dam

Figure 3.3.5 presents the designed spillway profile for heightening. The design calculationa are detailed in the Supporting Report F.



Source：JICA survey team

Figure 3.3.5 Proposed Spillway Section at the Oeste Dam

3.4 Feasibility Design of Conduit Gates

3.4.1 Site Investigation of the Existing Conduit Gates

(1) Objectives for Site Investigation

Since the conduit gates of both Oeste and Sul dams were constructed more than 40 years ago, it is concerned that the strength of conduit gates has been weaken due to long-team corrosion.

It is not clear about the design criteria, design condition, the material used and the dimensions because of no the design calculations available at this moment. Therefore the site investigation was carried out for the following purposes:

i) To clear the current condition of the gate and operation system

ii) To measure the plate thickness of bonnets of gates and conduit pipes, and

iii) To make an interview to the site manager concerning the operation system and maintenance record.

(2) Site Investigations

The current condition of the gates is clarified as shown in the following Table 8.2.1.Large water leakage was found at the both dam gates. It might be due to that the water leakage was caused by dismantling the bonnet flanges at the time of overhaul in 1983. A lot of sand has been accumulated in the pits. Although the accumulated sand and leakage water might not affect to the gate operation directly, drain pumps might be effected to cause trouble.

(3) Measurement of plate thickness of bonnets of gates and conduit pipes

The results of measurement are summarized in the following Table 3.4.2. Although the overhaul of conduit gates at both the dams have been undertaken in 1980s, it was found that no corrosion is observed and the conduit is sound condition. The result to measure the plate thickness and gates is that the values of corrosion are supposed to be 0.1 to 0.2 mm. Therefore the loss of the corrosion is estimate a little.

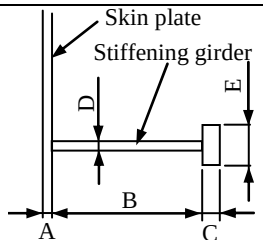

Photo: The Current Condition of Gates
(Left: Oeste Dam, Right:Sul Dam)

Table 3.4.1 Current Condition of Gates

Check item	Oeste Dam	Sul Dam
Water leakage	・Water leakage was observed at the flange of all gates. ・Water leakage was observed at the expansion joints of all gates.  No.1 slide gate	・Water leakage was observed at the flanges and expansion joints of all gates.  No.4 expansion joint
Oil leakage	・No oil leakage was observed from the hydraulic unit and cylinder.  Hydraulic unit	・No oil leakage was observed from the hydraulic unit and cylinder.  Cylinder of No.5 slide gate
Dirt	・Dirt caused by water leakage was observed at all gates.  Pit of No.5 slide gate	・No dirt was observed for all gates because the pits were covered with the leakage water.  Leakage water in pit (No.2 gate)
Damage	・No damage was observed at the gates.	・No damage was observed at the gates.

Source: JICA Survey Team

Table 3.4.2 Results of Measurement

Item	Oeste Dam	Sul Dam	Remarks
Plate thickness of conduit pipe	Upstream: 5.93mm Downstream: 6.51mm	Upstream: 9.17mm Downstream: 8.66mm	—
Plate thickness of stiffener girder	A: 12.50mm (12.7mm) B: 100.00mm (100.0mm) C: 20.00mm (20.0mm) D: 12.80mm (12.7mm) E: 65.0mm (65.0mm)	A: 12.58mm (12.7mm) B: 122.00mm (123.0mm) C: 26.00mm (25.4mm) D: 16.20mm (16.0mm) E: 100.00mm (100.0mm)	

Source: JICA Survey Team

3.4.2 Criteria for Design

The standard of ABNT NBR 8883:2008 in Brazil to the gate design was applied. Therefore, the strength of the existing gates and conduit pipe were analyzed using the said standard.

3.4.3 Study on Repairing the Conduit Gates

Even if the water level is raised up by 2.0 m, the existing gates have enough strength, judging from the calculations. The reason is due to that the corrosion-speed is slow and the thickness of margin (which was designed against the long-term corrosion, and it is supposed that about 1.0 mm) is still remain even 40 years passed. Thus it is proposed that the existing facilities should be satisfied even the dam heightening.

3.5 Modification of the Operation

3.5.1 Basic Approach

(1) Reference Point for Operation of Dams

The heightening of Oeste dam and modification of the operation can cope with the 10-year flood in Taio city, but can not achieve the 5-year safety in Rio do Sul city without basin storage (small dams). Therefore, Taio city should be selected as the reference point to modify the operation manual of Oeste dam.

On the other hand, the present safety level of Ituporanga city is more than 10-year flood. But the present safety level of Rio do Sul city along the Rio Itajai do Sul is less than the 10-year flood. Therefore, Rio do Sul city along the Itajai do Sul River should be selected as the reference point to modify the operation manual of Sul dam.

(2) Target Flood Protection Level

In the M/P, heightening of the dams is planned for the 50-year flood. But the safety of the downstream river shall be provisionally achieved for the 10-year flood by the projects of first stage. Therefore, the operation manual should be also prepared provisionally for the 10-year flood. When floods larger than 10-year flood occur, flood discharge might overflow from spillways. However, present situation in which flood dishcarge overflows once in approximately 5 years from spillways of both Oeste and Sul Dams will be improved.

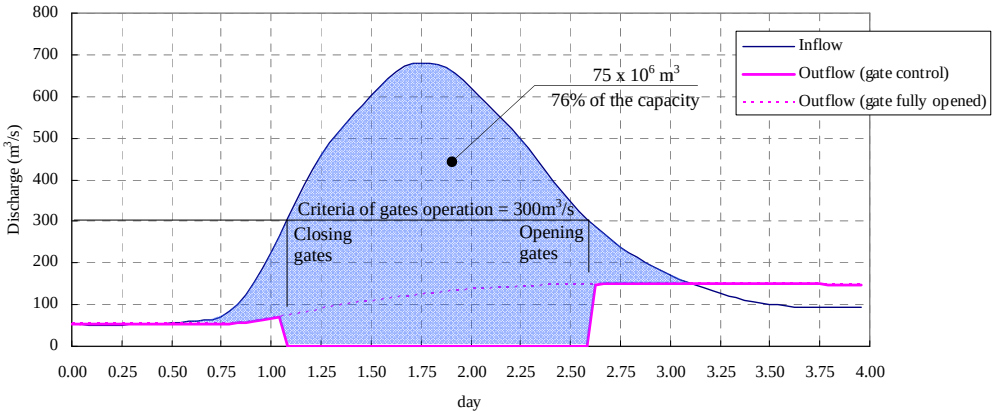
3.5.2 Method of Flood Control

(1) Flood Control Method at the Oeste Dam

If all the gates are fully opened during the 10-year flood, maximum flood discharge in Taio city is estimated 520 m^3/s. This discharge exceeds the current flow capacity of 440 m^3/s in Taio city. Therefore, the required peak cut for the 10-year flood at the Oeste Dam is estimated 80 m^3/s.

Additionally, it is desirable to close fully the gates during the flood as long as possible, expecting flood control effect in Rio do Sul city and simplification of the operation.

The criteria of opening and closing gates would be set at 300 m^3/s of the flood inflow into the reservoir, considering more than 20% of the storage capacity as a margin capacity in view of uncertainty of variety of the rainfall distribution and the occurrence of extraordinary floods.



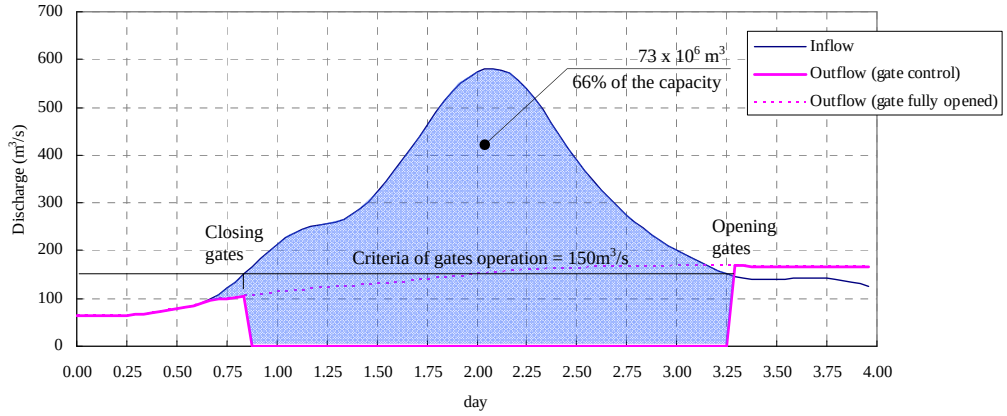
Source: JICA Survey Team

Figure 3.5.1 Method of Flood Control at the Oeste Dam

(2) Flood Control Method at the Sul Dam

If all the gates are fully opened during the 10-year flood, maximum flood discharge in Rio do Sul city in the Itajai do Sul River is estimated 570 m^3/s. This discharge exceeds the current flow capacity of 440 m^3/s in Rio do Sul city. Therefore, the required peak cut for the 10-year flood at the Sul Dam is estimated 130 m^3/s.

The criteria of opening and closing gates would be set at 150 m^3/s of the flood inflow into the reservoir. As storage volume for 10-year flood shall be 73 x 10^6 m^3, the margin capacity shall be 34% of storage capacity in view of uncertainty of variety of the rainfall distribution and the occurrence of extraordinary floods.



Source; JICA Survey Team

Figure 3.5.2 Method of Flood Control at the Sul Dam

(3) Method of Gate Operation

The method of gate operation mentioned above would be simple, but gate operator need to know the inflow discharge. The inflow discharge shall be estimated by the following equation.

$$Q_{in} = \frac{\Delta V}{\Delta t} + \overline{Q}_{out}$$

where, Q_{in} : inflow into the dam (m^3/s)

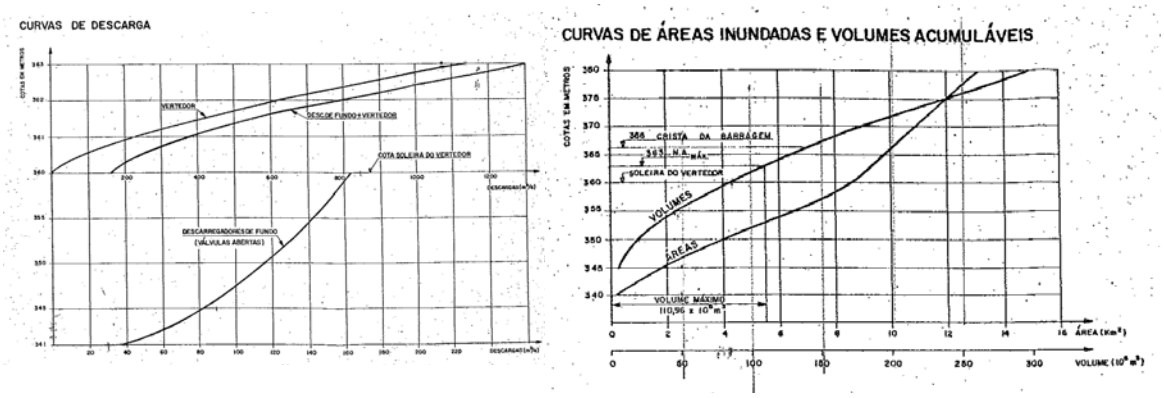
ΔV : increasing volume of reservoir storage during Δt (m^3)

$\overline{Q}_{out}$: average outflow during Δt (m^3/s)

Therefore, the gate operator should obtain the accurate data of reservoir water level and outflow through the conduits every 30 minutes or 1 hour to operate the gates properly. In this connection, the gate operators should also prepare the rating curve showing relationship between reservoir water level and storage volume, and the rating curve among reservoir water level, gate opening and outflow rate.

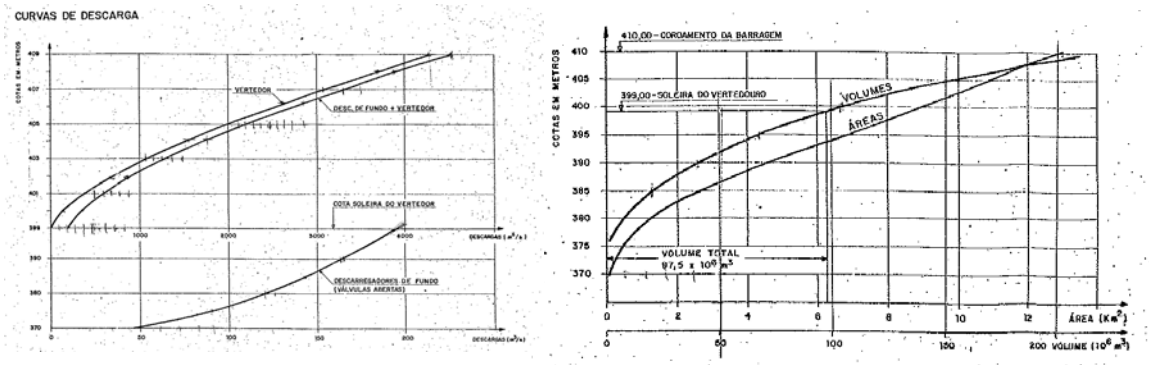
Figures 3.5.3 and 3.5.4 show those rating curves of the Oeste and Sul dams. But these drawings have not been considered gate opening, and might be fairly old and subject to confirmation from as-built drawings from the manufacture or the completion documents. Therefore, these rating curves should be reviewed at the project of the dams heightening.

Figures 3.5.3 and 3.5.4 also present the relationships between water levels and accumulated reservoir volumes. But these relationships have not been updated, though these relationships are also important to grasp inflow discharge into reservoirs. The dam management department (DEINFRA) should comfirm the relationship regularly by periodic topographic survey of reservoirs.



Source: Drawings (Obras Existentes de Conrole de Cheias, Barragem Oeste), CAEEB MME/DNAEE

Figure 3.5.3 Rating Curves between Water Level and Storage Volume, Outflow of Oeste Dam



Source: Drawings (Obras Existentes de Conrole de Cheias, Barragem Sul), CAEEB MME/DNAEE

Figure 3.5.4 Rating Curves between Water Level and Storage Volume, Outflow of Sul Dam

DEINFRA would be considered to be responsible for the existing flood control dams heightening projects and management after the projects implementation. In current operations of these dams, one person in charge of the dam operation is living next to dam body, and is engaged in ordinal dam

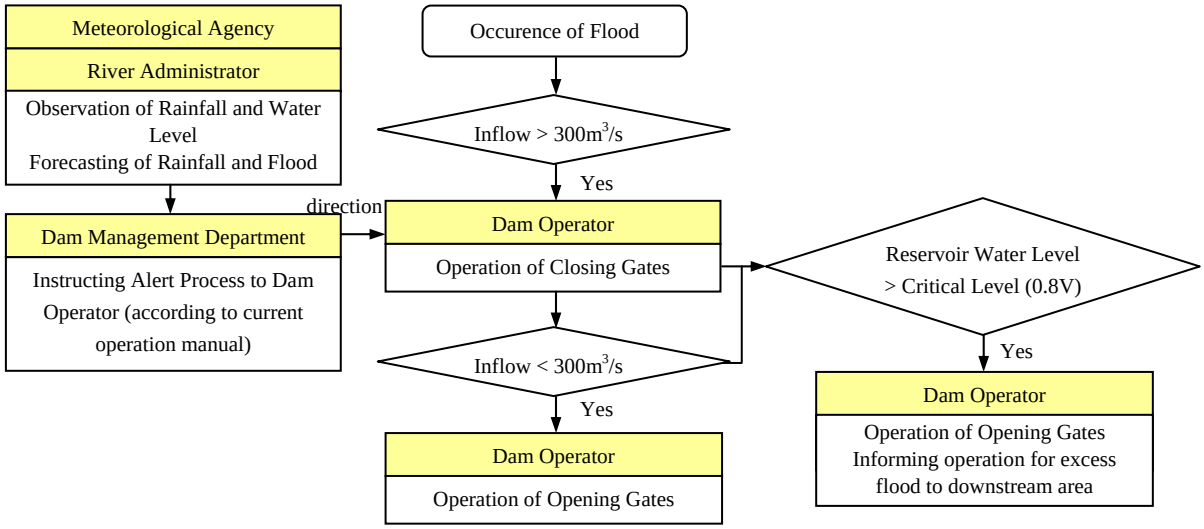
management and gates operation for flood control. In flood time, a manager of DEINFRA in charge of dam management comes from Florianopolis to support and instruct the operator for gates operation of flood control. When floods come, the operator has to watch scales in the reservoir to understand reservoir water level. Therefore, it is appropriate that the operator and the manager check the reservoir water level, outflow discharge, situation of downstream river in the interval of a hour to calculate accumulated reservoir volume, inflow dishcarge and to operate the gates.

3.5.3 Operation Against Extraordinary Floods

If extraordinary floods exceeding the design flood (hereinafter called “excess flood”) attack the dam during the operation of flood control, the operator should stop the normal operation of flood control. The excess flood may cause overflowing from spillway and rapid rising of the water level in the downstream river. The operator should make effort to mitigate the rising rate of the water level and reduce damages in the downstream area, as summarized below.

i) All of the gates should be slowly opened in order, when reservoir water level reaches the critical level. The water level considering 80% of the reservoir capacity is generally adopted as the critical level. This operation may mitigate the rising rate of water level in the downstream area, when the stored water is spilled out from the spillway.

ii) The operator should inform the operation of gates opening and possibility of overflowing in advance with the warning sirens to the people who lives along the downstream river from Taio to Rio do Sul.



Source: JICA Survey Team

Figure 3.5.5 Flowchart of Gates Operation (in case of Oeste Dam)

3.6 Increasing of Discharge Capacity in Sul and Oeste Dams

A huge flood attacked the Itajai River basin from 6th to 9th in September 2011, after the Feasibility Study carried out from February to July. As some problems such as insufficient discharge capacity of the outlets in Sul and Oeste Dams were revealed during the flood, the study team proposed increasing of the dicharge capacities in these dams as follows, at the time when study team submitted the draft final reports in September.

Defesa Civil of the SC State reported that there was a lot of raifall of around 200 mm over the Itajai River basin in average for 4 days during the flood. In this study, basin mean probable 4 days rainfall are estimated to be 188 mm for 25-year, 209 mm for 50-year. Therefore, if the report is accurate, the probability of the flood may be estimated to be 30 to 40-year. This estimation seems correct because maximum water level in Blumenau during the flood was reported to be 12.9 or 13.0 m, while the water levels of memorial floods in Blumenau were recorded to be 15.8 m in 1983 flood (around 70-year flood), 15.5 m in 1984 (around 70-year), 10.6 m in 1992 (around 30-year), and 11.0 m in 2001 (7-year).

On the other hand, the record by the operator in Sul Dam shows that the rainfall from 6th to 9th in September reached 220 mm, and DEINFRA of the SC State reported that around 300 mm rainfall was recorded at some gauging stations in the catchment area of the Sul Dam. It is inferred that a huge storm attacked this area. During this flood, flood discharge overflowed both Oeste and Sul Dams.

Overflow of Oeste Dam

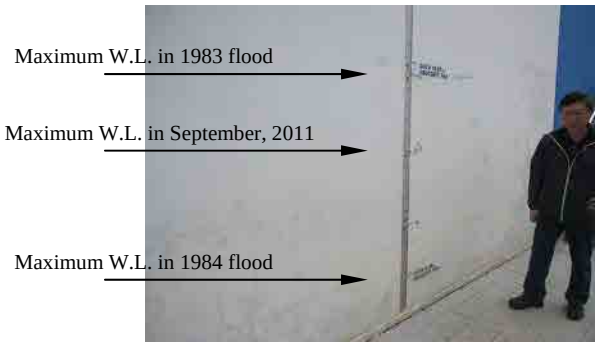
Source: DEINFRA

Inundation in Taio City

Damage in Rio do Sul City

Source: JICA Survey Team

Damage in Rio do Sul City



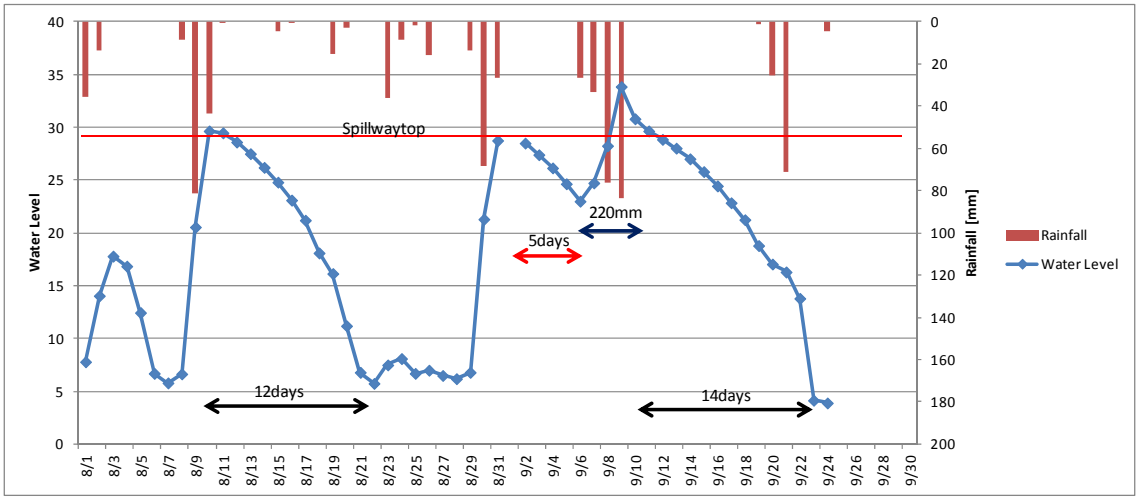
Source: JICA Survey Team

Flood Mark in front of the City Hall of Rio do Sul

Table 3.6.1 shows the variation of daily rainfall and water level at the Sul Dam from August to September in 2011.

- Large rainfall occurred on 10th and 30th in August, 6th to 9th in September.
- Reservoir water level in Sul Dam reached to the spillway top. Lowering of the maximum reservoir water level to normal level required 12 days and 14 days in the case of the floods on 10th in August and 6th in September.
- The floods of 6th in September attacked 5 days after the previous flood. The reservoir water level remained high at the time of the flood attack
- During the food from 6th in September, maximum water level at the Sul Dam was spillway top +5.0 m. The maximum outflow discharge from the spillway and conduit of the Sul Dam was estimated to be around 1,600m^3/s.

The overflows from both dams might be considered to be unavoidable. However, the discharge capacity of the conduits in both dams, 190 m^3/s for Sul Dam and 160 m^3/s for Oeste Dam, should be evaluated to be relatively insufficient against the catchment area of both dams (1,042km^2 for Oeste Dam, 1,273 km^2 for Sul Dam).



Source: JICA Survey Team

Figure 3.6.1 Variation of Daily Rainfall and Water Level at Sul Dam from August to September in 2011

Additionally, this flood destroyed the gate operation house at the downstream of the Sul Dam, washed away the panel for gate control, and made the gallery under the dam body impassable. Fortunately, the operator of the Sul Dam repaired the gallery, and made the gate operation possible.

However, such the trouble is considered to be a serious problem, because any damages of the structure under the dam body would directly cause collapse of the dam.

According to the hearing from the operator of the Sul Dam, the causes of the trouble are considered as follows,

- Flood water overtopping from the spillway flowed backward, and destroyed the downstream wall of the operation house. Spillway. Moreover, the flood water destroyed upstream slide door and reached the dam body.
- Outflow from the reservoir through the conduit gate under the dam body crashed the upper wall of the concrete channel, and the uplift or negativer pressure destroyed the upper wall concrete.

Source: JICA Survey Team

Damage of the Gate Operation House at Downstream of Sul Dam

Considering the problem mentioned above, increasing of the flow capacity of the conduits of the Sul and Oeste Dams by additional conduits was proposed and agreed at the Counter Part Meeting in September, 2011, in order to improve safety and flood control function of the dams.

As for the Sul Dam, an additional conduit will be installed under ground of the right bank of the Sul Dam as tunnel type, and as for the Oeste Dam will be installed in new block of the dam which will be consructed on the left abutment of the dam.

The capacity of the additional conduits should be same as existing conduits, that is why,

i) Velocity for lowering water level of the reservoirs will be doubled by both existing and additional conduits.

ii) Additional conduits will work as substitutes of the existing conduits.

The general features of the additional conduits are as follows,

i) **OesteDam:** the additional conduit and control gate will be installed in the new dam block on the left abutment, and the conduit will be connected to the enegy dissipator of the dam by new open channel;

- Design discharge: $180m^3/s$
- Control gate: width 5.0m x height 4.4m
- Bottomo elevation of the gate: EL.350.4m
- Connecting open channel: channel width 5.0m x length 180m

ii) **Sul Dam:** the additional conduit will be installed under ground of the right bank of the dam as tunnel type, flood control gate will be installed at the entrance of the tunnel, flood water will be dicharged to the downstream river through the tunnel by gravity.

- Design discharge: $200m^3/s$
- Control gate: $3.9m \times 3.9m$
- Bottomo elevation of the gate: EL.380m
- Tunnel type channel: length 430m, diameter 6.0m, gradient 1/60

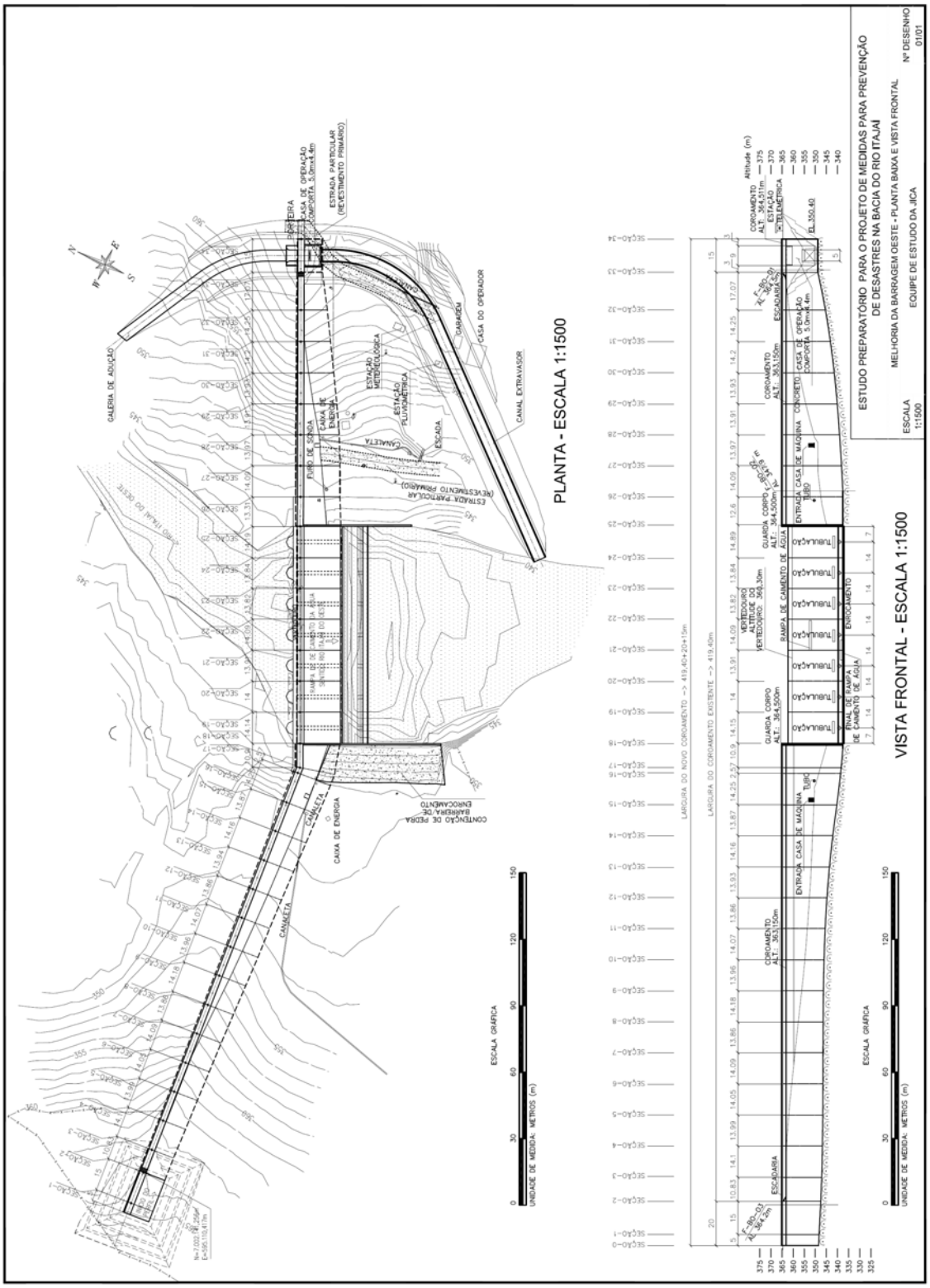


Figure 3.6.2 Heigtening of the Oeste Dam and Additional Conduit (1/2)

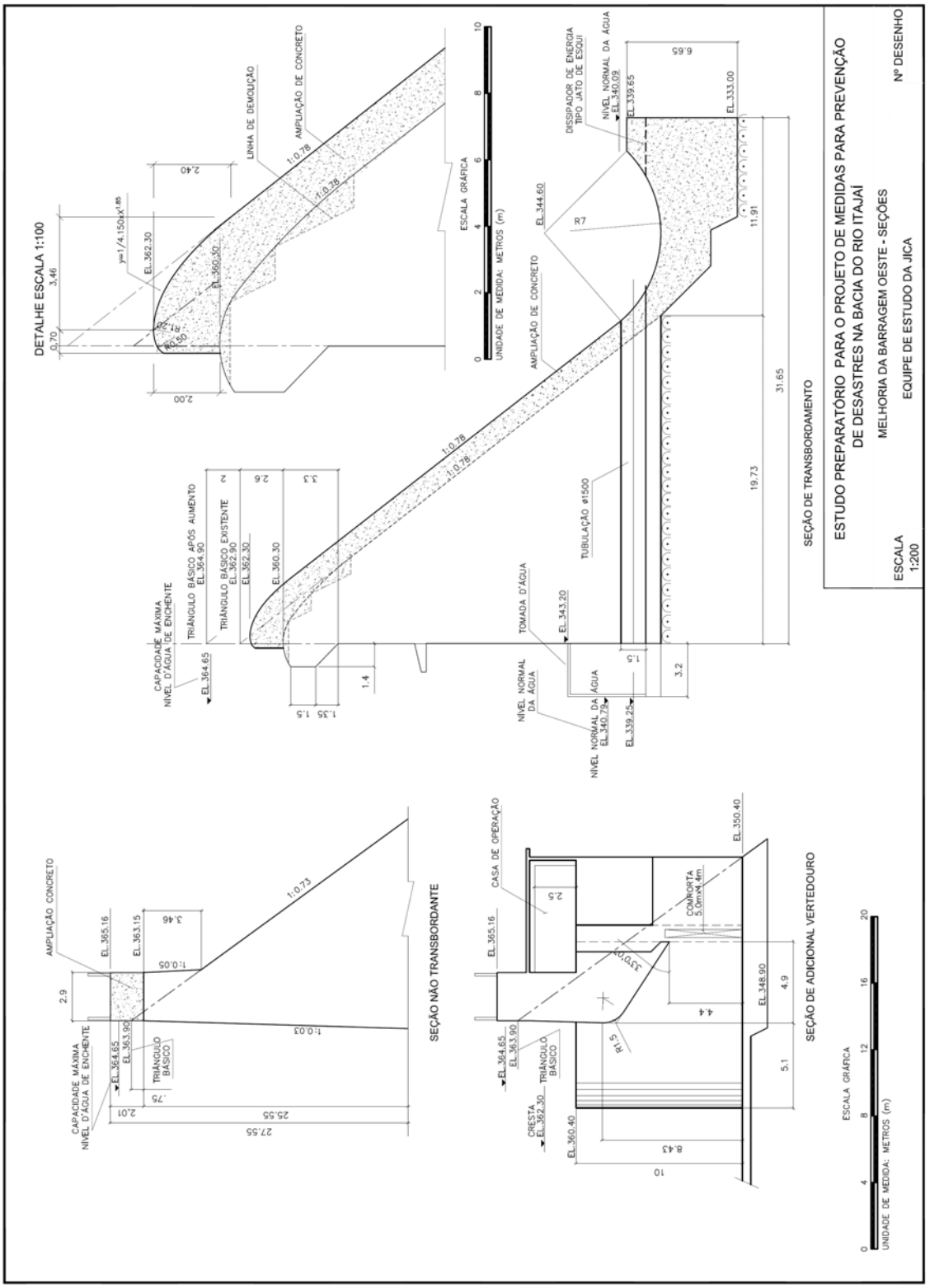


Figure 3.6.3 Heigtening of the Oeste Dam and Additional Conduit (2/2)

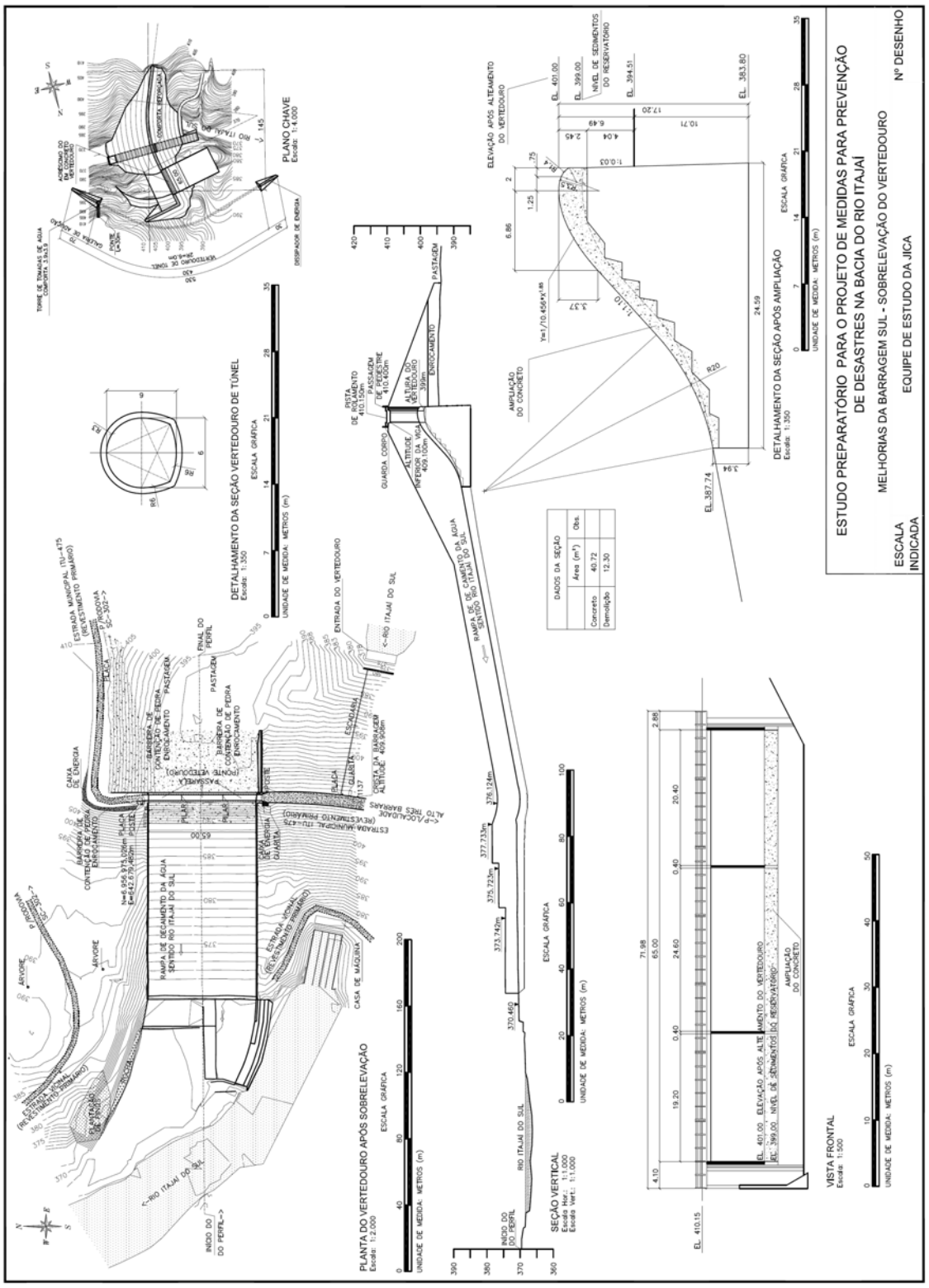


Figure 3.6.4 Heigtening of the Sul Dam and Additional Conduit

CHAPTER 4 FEASIBILITY STUDY FOR MODIFICATION OF OPERATION OF EXISTING HYDROPOWER DAMS

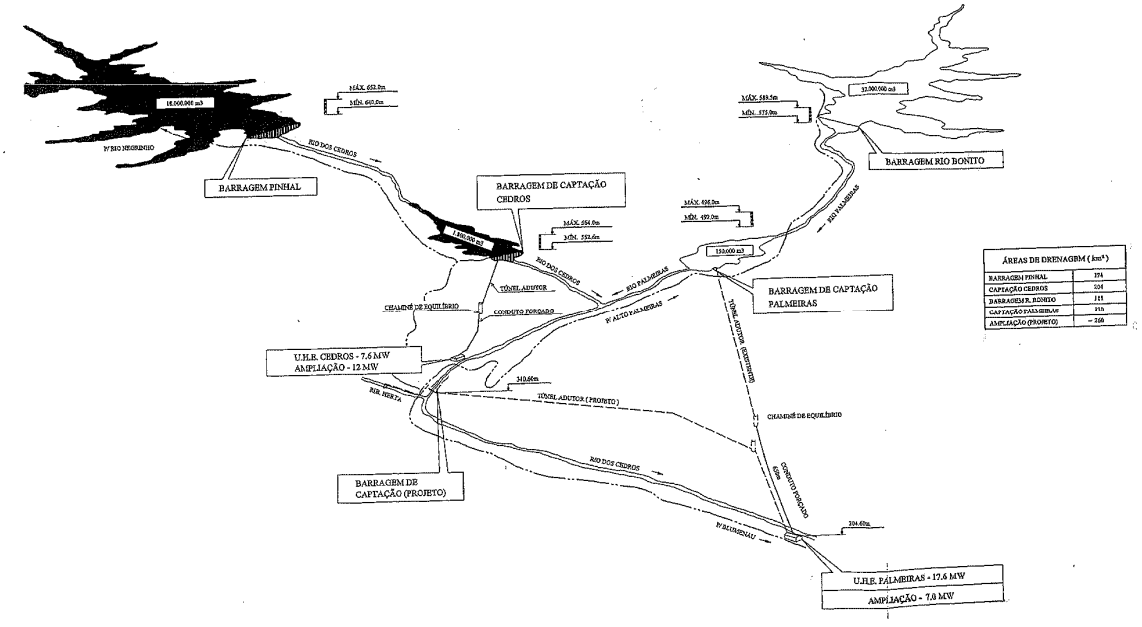
4.1 Background of Modification

In the master plan, the existing two hydropower generation dams of CELESC in the Rio dos Cedros River, named the Rio Bonito and Pinhal dams, were proposed to be used for flood control by means of pre-releasing when an impending flood is predicted. As described in sub-section 8.4.2 in Part I, the proposed pre-releasing aims at creation of flood control space in reservoir by means of lowering the reservoir water level by releasing the stored water before flood inflow into the reservoir.

The target city of pre-releasing is Timbo city, where the Rio dos Cedros city joins the Benedito River. The current flow capacity of the Benedito River in Timbo city is around 860 m^3/s, although the 10-year flood discharge is around 920 m^3/s. Therefore, the flow capacity is insufficient for the 10-year flood. On the he hand, the 10-year flood inflow into both dams is 210 m^3/s. The total outflow from both dams should be jointly controlled not to exceed 140 m^3/s to satisfy the current flow capacity in Timbo city by use of the created flood control space in reservoir by the pre-releasing.

4.2 General Features of Two Dams

Figure 4.2.1 shows the current hydropower generation system by CELESC in the Rio dos Cedros River. As shown in the figure, the system comprised two water storage reservoirs (Rio Bonito and Pinhal dams), two intake dams, and two hydropower stations.



Source: CELESC

Figure 4.2.1 General Features of Two Dams

Tables 4.2.1 and 4.2.2 present the general features of both dams.

Table 4.2.1 General Features of Rio Bonito Dam

		Features	Remarks
Dam	Dam type	Rock fill	
	Year of completion	1963	
	Height of dam	19.0 m	
	Crest elevation of dam	About EL.592 m (uncertain)	Visual estimation
Reservoir	Catchment area	119.8 km^2	
	Total volume	32,000,000 m^3	
	Maximum water level	EL.589.5 m	Not based on the IBGE system
	Minimum water level	EL.583.5 m	Not based on the IBGE system
Intake	Elevation of bottom	EL.573.7 m	Not based on the IBGE system
	Gate size	Height 3.0 m x Width 2.6 m	
	Gate type	Sluice gate (hoist type)	
	Gate control	Gate can be controlled to any opening positions by local control with electric power	
Spillway	Crest elevation	EL.587.3 m	Not based on the IBGE system
	Gate type	Flap gate (hoist type)	
	Gate size	Height 2.2 m x Width 9.0 m x 2 gates	Crest of gate : EL.589.5 m
	Gate control	Gates can be controlled to any opening positions by local control with electric power	

Source: CELESC (from existing materials and interview)

Spillway Gate (left) and Intake Tower (right) of Rio Bonito Dam

Table 4.2.2 General Features of Pinhal Dam

		Features	Remarks
Dam	Dam type	Earth and rock fill type	
	Year of completion	1949	
	Height of dam	19.0 m	
	Elevation of dam top	About EL.654 m (uncertain)	Visual estimation
Reservoir	Catchment area	179.9 km^2	
	Total volume	18,000,000 m^3	
	Maximum water level	EL.652.0 m	Not based on the IBGE system
	Minimum water level	EL.641.0 m	Not based on the IBGE system
Intake	Elevation of bottom	EL.638.2 m	Not based on the IBGE system
	Gate size	Height 2.6 m x Width 1.35 m x 2 gates	
	Gate type	Sluice gate (rack type)	
	Gate control	Gates can be controlled to any opening positions by local control with electric power	
Spillway (with gate)	Crest elevation	EL.651.0 m	Not based on the IBGE system
	Gate type	Sluice (rack type)	
	Gate size	Height 1.0 m x Width 4.0 m x 2gates	Crest of gate : EL.652.0m
	Gate control	Gates can be controlled to any opening positions by local control with electric power	
Spillway (without gate)	Crest elevation	EL.652.0 m	Not based on the IBGE system
	Crest length	53 m	

Source: CELESC (from existing materials and interview)


Spillway (left) and Intake Tower (right) of Pinhal Dam

4.3 Study on Pre-releasing

4.3.1 Current Operation for Floods

The operators of hydropower plant are usually on standby in the office at the Palmeiras power station, and two operators visit each dam once or twice a day for gate operation and inspection of the dam facilities. When flood is predicted to occur, one operator stands by at the dam throughout the flood for gate operation.

When a flood is forecasted to occur in the upper Rio dos Cedros River basin, CIRAM informs the forecasted information to CELESC, and CELESC decides to release the stored water to lower the reservoir water level by 50 cm from the maximum water level based on their own judgment. CELESC tries to maintain this reservoir water level during the flood to avoid overflowing from the spillway.

4.3.2 Modification of Dam Operation for Pre-releasing

(1) Possible Pre-releasing Discharge from Two Dams

According to the available H-Q curves at both dams, the total discharge capacity under the condition of full gate openings are around 190 m^3/s at the maximum reservoir water level of EL. 589.5 m for the Rio Bonito dam, and 80 m^3/s at the maximum reservoir water level of EL. 652 m for the Pinhal dam, respectively.

On the other hand, the estimated base flow into each dam reservoir is around 10 to 20 m^3/s in flood season. Therefore, the possible pre-releasing discharges are considered to be around 170 m^3/s for the Rio Bonito dam, and 60 m^3/s for the Pinhal dam at the maximum reservoir water level.

(2) Required Flood Control Volume for Pre-releasing

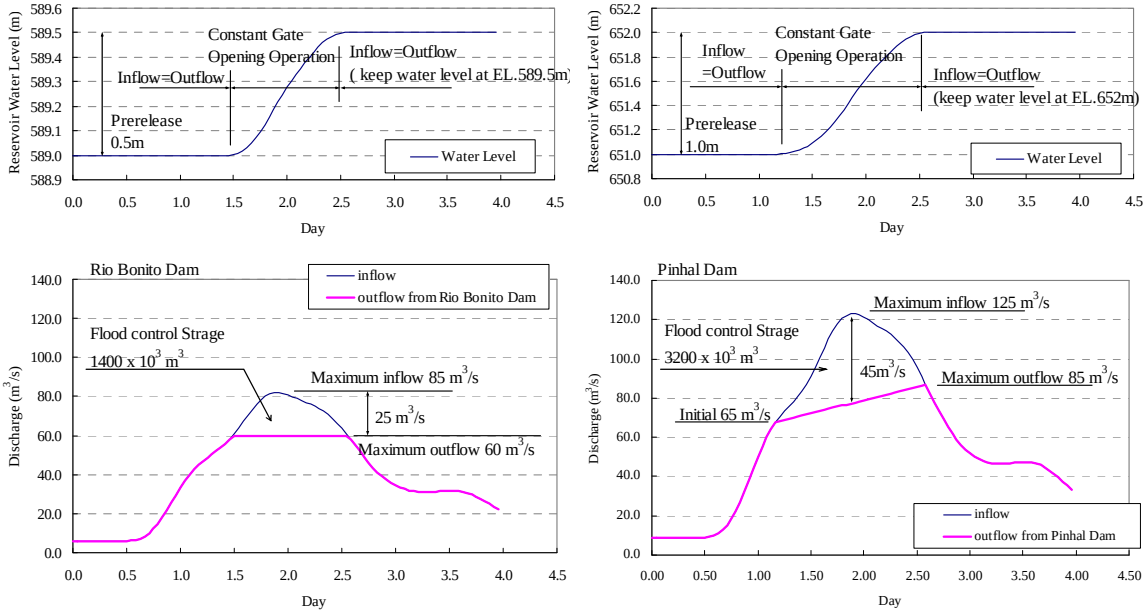
In order to regulate the outflow discharge from both dams not to exceed 140 m^3/s for the 10-year flood with a peak discharge of 210 m^3/s, the required flood control volume to be created by pre-releasing was examined by simulation of reservoir operation at both dams. The results of examination are summarized in Table 4.3.1. As indicated in this table, the required volume for pre-releasing was estimated to be 1.4 million m^3 for the Rio Bonito dam and 3.2 million m^3 for the Pibhal dam, respectively. Figure 4.3.1 shows the simulation results of the proposed flood control operations at both dams. The details of examination of described in the Supporting Report B Flood Prevention Plan.

Table 4.3.1 Required Flood Control Volume to be Created by Pre-releasing at Two Dams

	Rio Bonito Dam	**Pinhal Dam**
Maximum water level in operation	EL.589.5 m	EL.652.0 m
Drawing down by pre-releasing	0.5 m	1.0 m
Water level after pre-releasing	EL.589.0 m	EL.651.0 m
Volume for flood control by pre-releasing	1.4×10^6 m^3	3.2×10^6 m^3
Maximum inflow discharge	85 m^3/s	125 m^3/s

Maximum outflow discharge	60 m^3/s	85 m^3/s
Reduction of discharge at the peak time of inflow	25 m^3/s	45 m^3/s
Operation of gates during flood control Gate opening of the spillway Gate opening of the intake	Constant opening 0.5 m 2.6 m	Constant opening 1.0 m 2.6 m
Operation of gates before flood control	Keep the water level at EL. 589 m (inflow = outflow) by operating intake gate	Keep the water level at EL. 651 m (inflow = outflow) by operating intake gate
Operation of gates after flood control	Keep the water level at EL. 589.5 m (inflow = outflow) by operating spillway gate	Keep the water level at EL. 652 m (inflow = outflow) by operating spillway gate

Source: JICA Survey Team

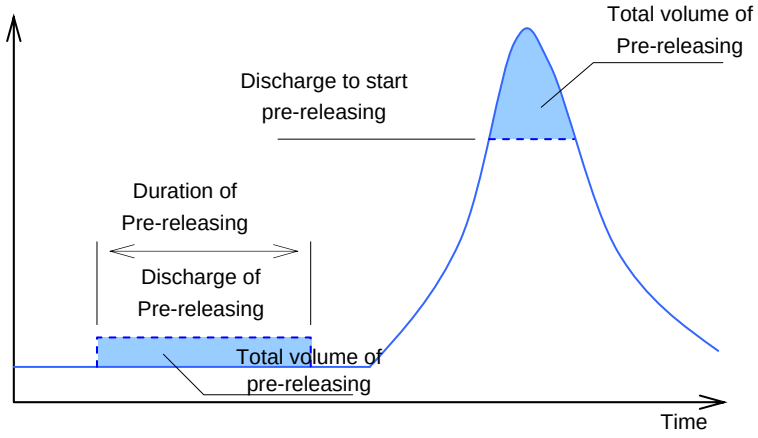


Source: JICA Survey Team

Figure 4.3.1 Operation of Rio Bonito Dam and Pinhal Dam for Flood Control

(3) Operation Method of Pre-releasing

Based on the required flood control volume by pre-releasing in the above, pre-releasing discharge and duration of pre-releasing shall be determined as illustrated in Figure 4.3.2.



Source: JICA Survey Team

Figure 4.3.2 Illustration of Pre-releasing Method

The possible pre-releasing discharge from the Pinhal dam is around 40 to 60 m^3/s at the water level of EL. 651 to 652 m. Assuming that the duration of pre-releasing is 18 hours, the required pre-releasing discharge at both dams were estimated as follows:

- Required duration for pre-releasing: 18 hours
- Average pre-releasing discharge: Rio Bonito dam 1400 x 10^3 m^3 / 18 hours = 22 m^3/s

  Pinhal dam 3200 x 10^3 m^3 / 18 hours = 50 m^3/s

  Total 72 m^3/s

As the pre-releasing increases the flow in the downstream reaches, the operators at the dams and river administrator should pay attention to the security of riparian residents along in the downstream reaches as follows:

i) For preventing overflowing from the river channel by pre-releasing, river water level along the downstream reaches should be monitored in Timbo and Rio dos Cedros cities.

ii) Warning of pre-releasing should be announced to the residents along the downstream reaches by sirens before the pre-releasing.

(4) Judgment for Pre-releasing

1) Current rainfall forecast

For rainfall forecast, CIRAM currently uses both the ETA model of INPE and WRF model of USA for the coming 5 days. The grid scale of the analysis is 40 km x 40 km, and 20 km x 20 km, respectively.

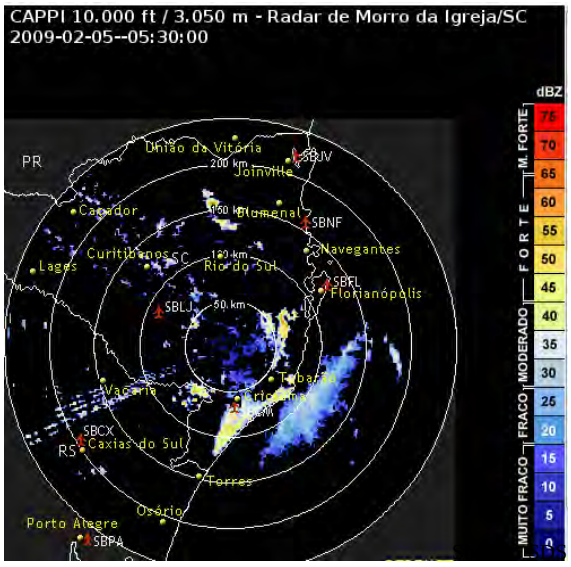


Figure 4.3.3 Location of Meteorological Rader and its Cover Area

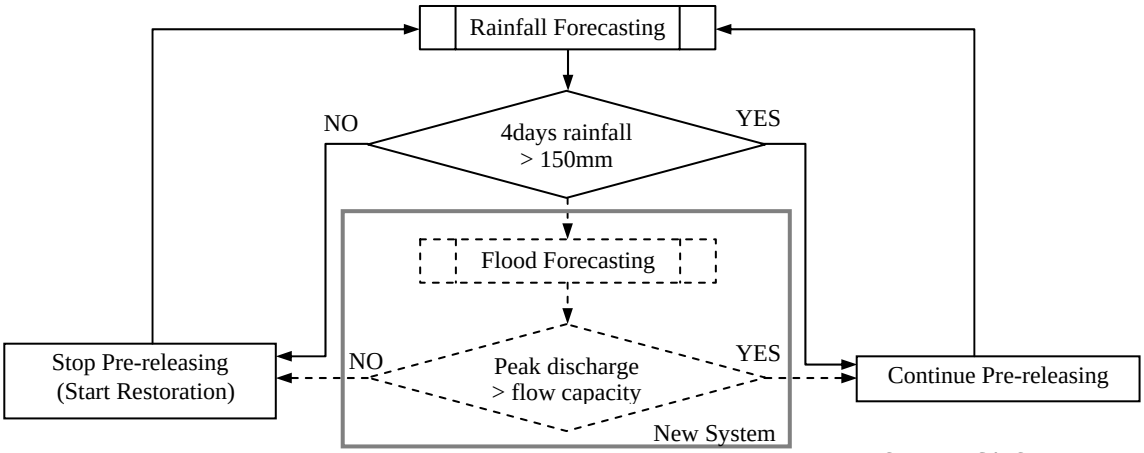
But the accuracy of the forecasting has not been satisfactory, as the meteorological radar is installed only in Urubici city, far from Timbo and Rio dos Cedros cities (see Figure 4.3.3).

At present, Defesa Civil, EPAGRI, and SDS intend to establish a new rainfall and flood forecasting system with satellite data from INPE. Accuracy of the flood forecast is expected to be improved by the new system.

2) Judgment for pre-releasing

When the flood discharge is forecasted to be more than the current flow capacity in Timbo city (5 to 10-year floods), pre-releasing shall be determine to be executed. One of the criteria of the judgment may be the rainfall of the 5-year probable rainfall (150 mm/4 days). Inaddition, after the first judgment, the forecasting and judgment should be repeated continuously by updating the hydro-meteorological information.

Determination of judgment for pre-releasing shall need more detail study during the implemetation stage.



Source: JICA Survey Team

Figure 4.3.4 Flowchart of Judgment for Pre-releasing

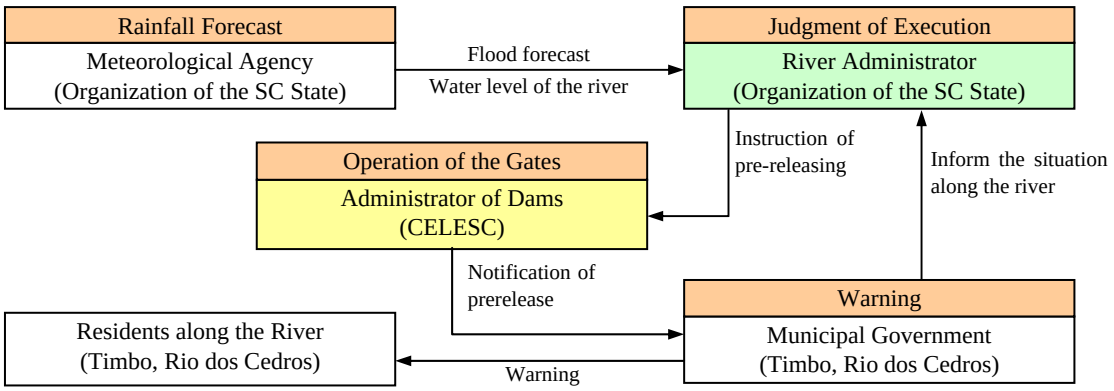
4.4 Recommendation of Organization for Operation

Figure 4.4.1 presents the recommendation of the organization for executing the pre-releasing in the existing hydropower dams.

i) As the river administrator shall be responsible for the judgment and operation of the pre-releasing, he instructs the execution of pre-releasing to CELESC based on the flood forecast by CIRAM and monitored water levels along the Rio dos Cedros River.

ii) CELESC should inform the pre-releasing to the municipal governments (Timbo and Rio dos Cedros cities) in advance and municipal governments should alarm the residents along the river.

iii) If any flood attacked to the catchment area of both dams though the pre-releasing was execued, lowered water levels of the dam reservoirs might not restore. The State organization responsible for flood management and CELESC should discuss and decide the regulation of such compensations.



Source: JICA Survey Team

Figure 4.4.1 Recommendation of Organization for Dam Operation

CHAPTER 5 FEASIBILITY STUDY ON FLOODGATES IN ITAJAI MIRIM RIVER

5.1 Characteristic of Floods and the Current Flow Capacity in Itajai Mirim River

5.1.1 Topographical Characteristics of Itajai Mirim River

(1) Itajai Mirim River

Itajai city is a famous port city located at the mouth of Itajai River. An urban area in Itajai city is located in the downstream area of the BR-101 (federal highway), and the upstream area of the BR-101 is mainly used for farmland and pasture.

The Itajai Mirim River is one of large tributaries of the Itajai River which joins the Itajai River at the urban center of Itajai city. The Itajai Mirim River originally flowed down with meandering through Itajai city, but the shortcut channel was constructed in 1970s. In this Chapter, the original channel is referred to “the Old Mirim” and shortcut channel is to “the Canal”.

The Canal diverges from the Old Mirim in the upstream of the BR-101, and meets again with the Old Mirim at about 1km upstream of the confluence with the Itajai River. And small tributary named the Canhanduba River drains into the Old Mirim.

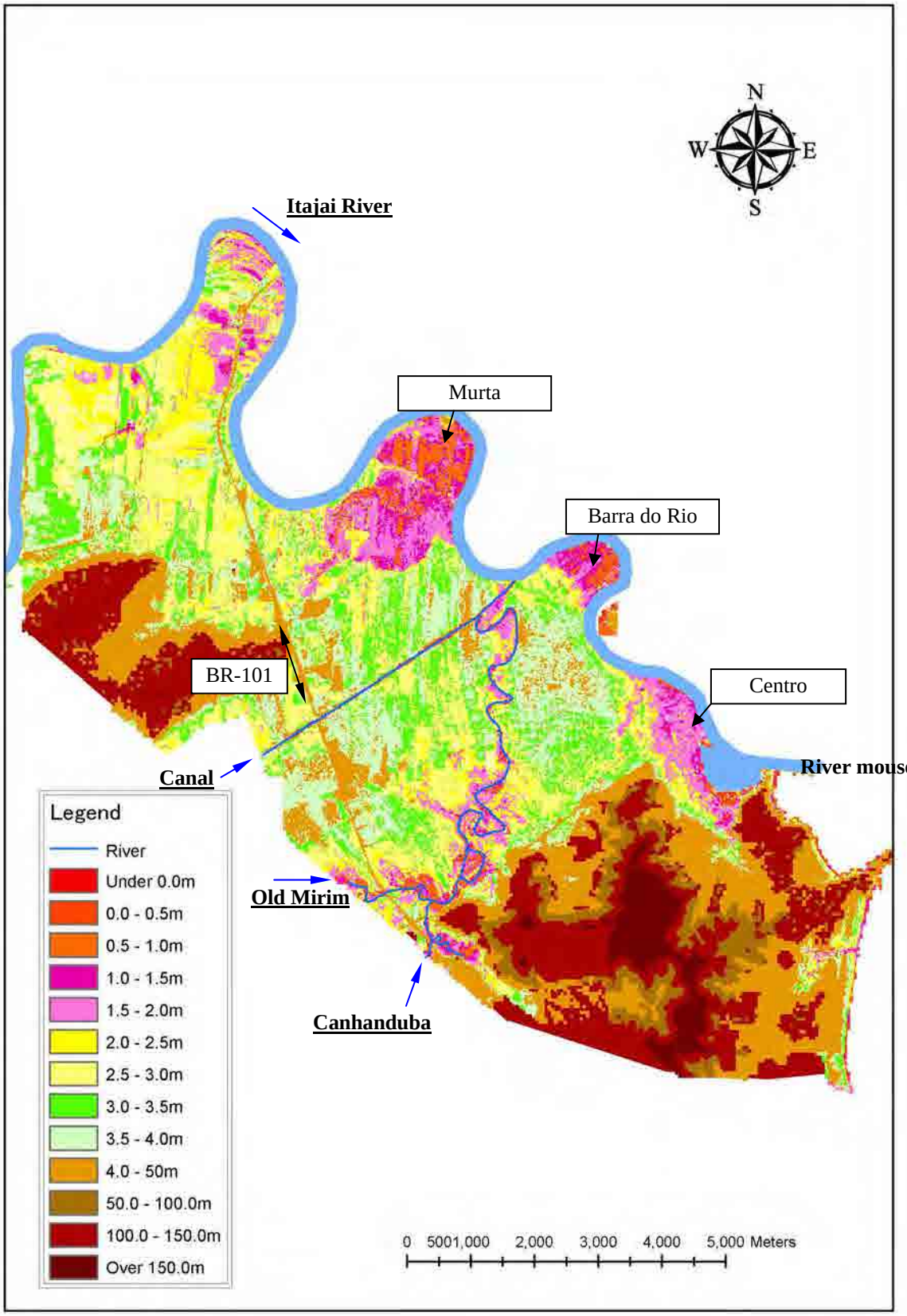
(2) Topography of Itajai Mirim River

Figure 5.1.1 presents the distribution of ground elevation in Itajai city based on the 1/2,000 topographical map prepared by the municipal government of Itajai city. As indicated in this figure, riparian area along the Old Mirim is generally low varying EL.1.0 to 3.0 m. On the other hand, the area along the Canal is relatively higher elevation in around EL.3.0 to 4.0 m. Though the Canal has larger flow capacity, the Old Mirim has caused frequent flooding and inundation to its riparian area. Two floodgates on the Old Mirim which were proposed in the M/P aim at mitigation of inundation along the Old Mirim.

5.1.2 Flood Characteristics of Itajai Mirim River

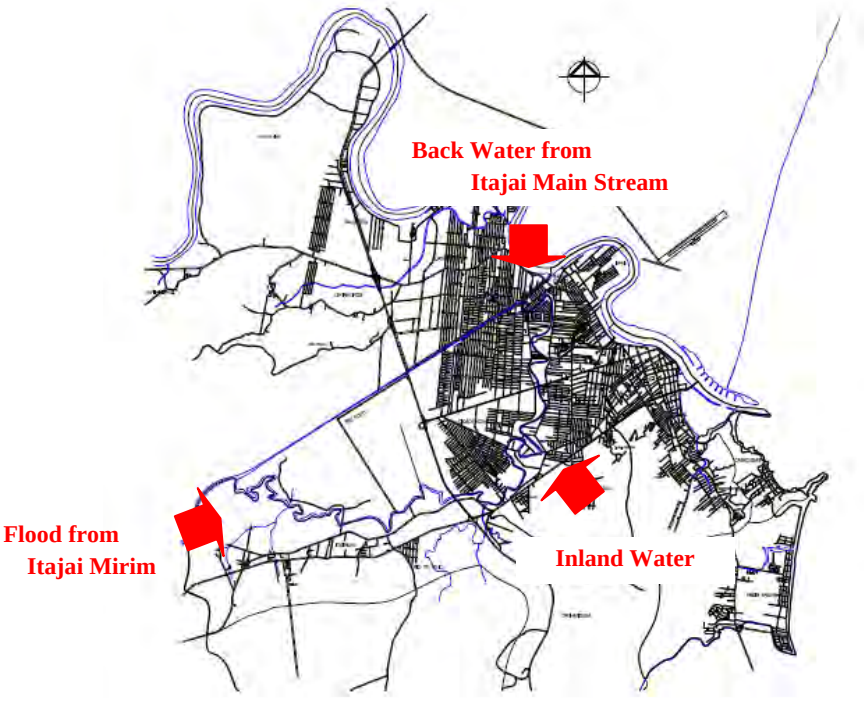
(1) Causes of Inundation in Riparian Area along the Old Mirim

There are mainly three causes of the inundation in Itajai city along the Old Mirim as illustrated in Figure 5.1.2. The first one is the flood from the upstream basin area of the Itajai Mirim River, the second one is the backwater from the Itajai River, and the third one is the inland water due to rainfall over this area.



Source: Municipal Government of Itajai city

Figure 5.1.1 Distribution of Ground Elevation in Itajai City



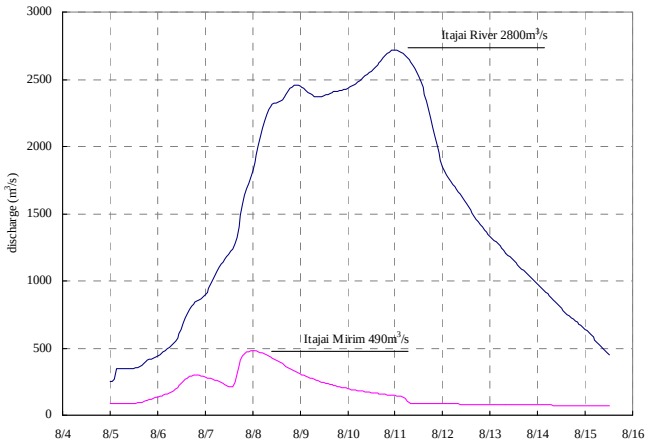
Source: JICA Survey Team

Figure 5.1.2 Causes of Inundation along the Old Mirim

(2) Probable Floods in Itajai City

Hydrographs of 10-year floods of both the Itajai and Itajai Mirim Rivers in Itajai city are shown in Figure 5.1.3. The characteristics of the hydrograph is described below.

- The peak discharge of the Itajai River come about three days later from the peak of the Itajai Mirim,
- The duration of the flood in the Itajai River is much longer than in the Itajai Mirim.



Source: JICA Survey Team

Figure 5.1.3 10-year Flood Hydrographs Itajai and Itajai Mirim Rivers

In the feasibility design, the 50-year flood was applied to for the floodgate design. This is based on the consideration that once the gate is constructed for the 10-year flood, it would be difficult to be modified for the 50-year flood in the future.

5.1.3 Estimation of Flow Capacity of the Itajai Mirim River

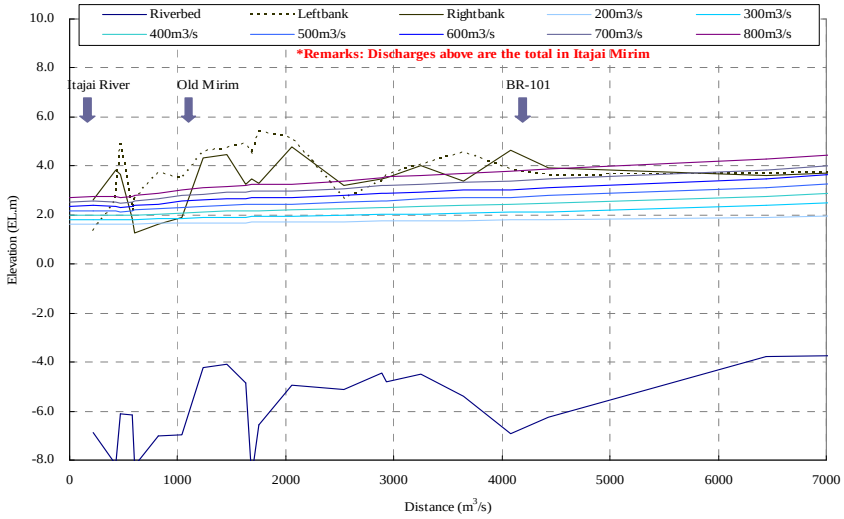
(1) Flow Capacity

The Flow Capacity of the Itajai Mirim River was estimated by the non-uniform flow calculation. As the boundary condition at the lowest end of river channel, calculation starting water level was set at the average high tidal level of EL. 1.49 m. Roughness coefficients of the Itajai River, the Canal and the Old Mirim were assumed respectively 0.030, 0.032 and 0.040. The discharge distribution rate between the Canal and the Old Mirim was determined through several trial

calculations to obtain the same water level at the upstream bifurcation point of the Itajai Mirim River.

a) Canal

- The flow capacity on the right bank of the downstream stretch (from 0.6 to 1.0 km) is extremely low. It is considered that inundation would occur even when the discharge is less than 200 m^3/s. The flow capacity in this stretch is evaluated lower than the 5-year flood discharge.
- River bank elevation of the stretch around 2.5 km also is low (about 3.0 m). The flow capacity of this stretch is estimated to be about 600 m^3/s in the Itajai Mrim (378 m^3/s in the Canal). This is equivalent to about 20 to 25-year flood discharge.
- The upstream stretch of the BR-101 along the Canal has also low riverbank, and the flow capacity of this stretch is equivalent to about 15 to 20-year flood discharge.
- Other stretch has the flow capacity of more than 800 m^3/s (504 m^3/s in the Canal). The flow capacity in this stretch is more than 50-year flood discharge.

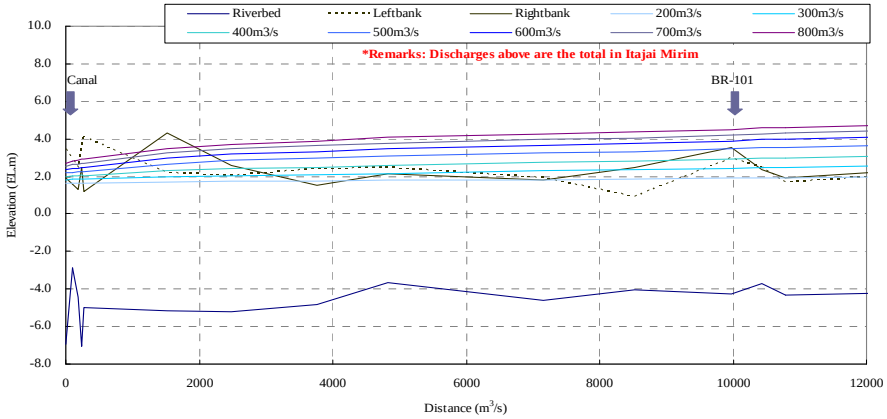


Source: JICA Survey Team

Figure 5.1.4 Water Levels by Discharge in the Canal

b) Old Mirim

- Riverbank elevation is very low except the right bank stretch around 2.5 km.
- The flow capacity varies 200 to 400 m^3/s in the Itajai Mirim River (52 to 124 m^3/s in the Old Mirim), which is evaluated to be less than 5-year flood discharge.
- The elevations in the stretch of 0 to 300 m on the right bank, and around 8.5 km on the left bank are extremely low. According to Defesa Civil of Itajai city, flooding occurs even in times of spring tide and small flood.



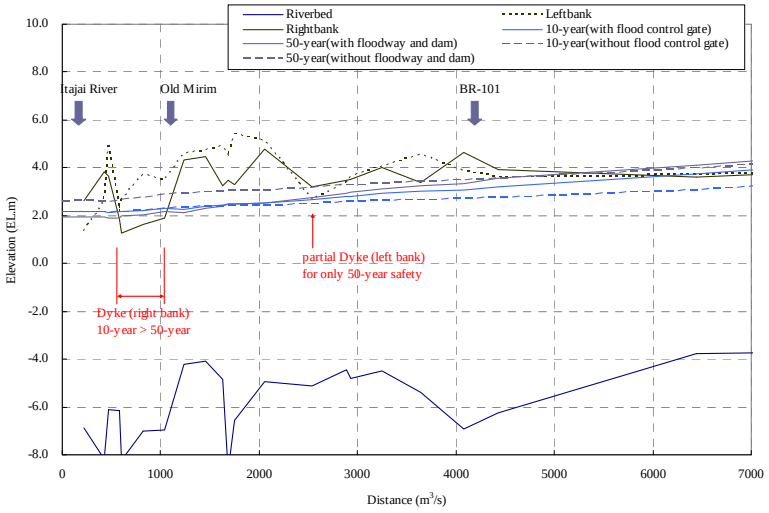
Source: JICA Survey Team

Figure 5.1.5 Water Levels by Discharge in the Old Mirim

(2) Water Level by Probable Flood

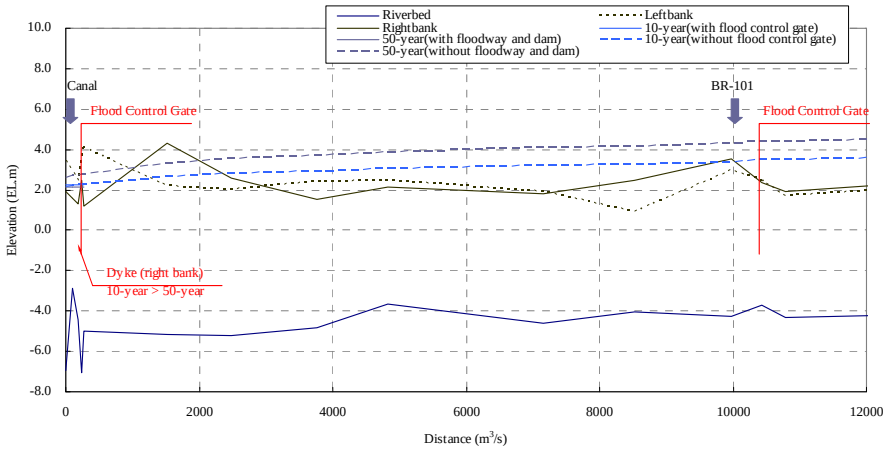
Figures 5.1.6 and 5.1.7 present the water levels due to the 10 and 50-year floods.

- In the stretch of around 0.5-1.0 km from the confluence of Itajai River, height of the right bank is lower than the water level of 10-year flood. The left bank of the stretch around 2.5 km in the Canal is lower than the water level of 50-year flood.
- Both banks along the Old Mirim are lower than the water level of 10-year and 50-year flood except the stretch from 0 to 2 km.



Source: JICA Survey Team

Figure 5.1.6 Water Levels by 10 and 50-year Floods in the Canal



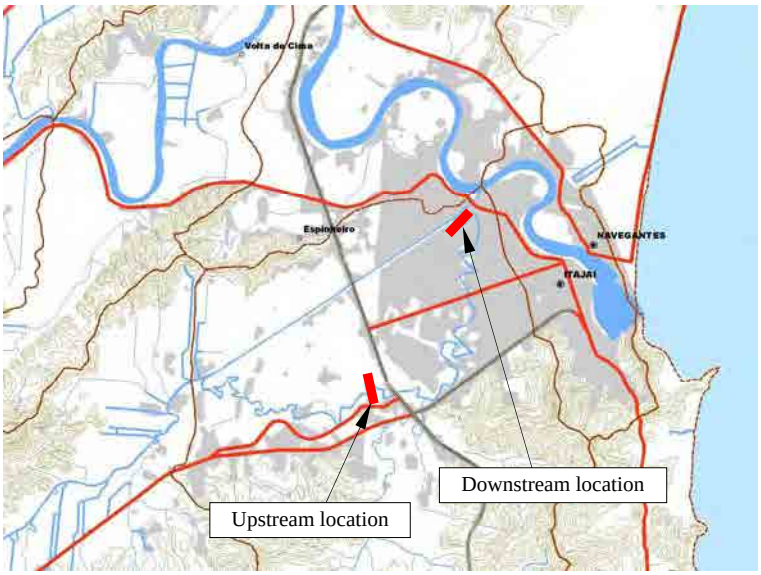
Source: JICA Survey Team

Figure 5.1.7 Water Levels by 10 and 50-year Floods in the Old Mirim

5.2 Function, Operation and Effectiveness of Floodgates

5.2.1 Function of Floodgates

Floodgate was proposed to be installed at two locations on the Old Mirim as shown in Figure 5.2.1 below. The gates of upstream and downstream locations are herein called the "downstream gate" and "upstream gate", respectively. The upstream gate would prevent the flood from the Itajai Mirim River from entering the urban area. And the downstream gate would avoid the intrusion of backwater from the Itajai River.



Source: JICA Survey Team

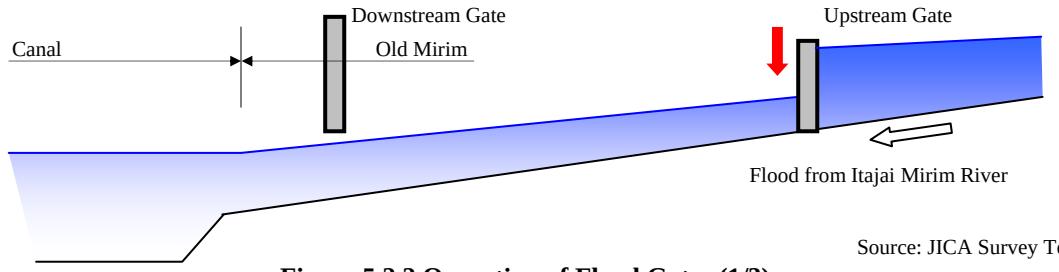
Figure 5.2.1 Location Map of Floodgates in Old Mirim

The upstream floodgate should be located in the nearby upstream reach of the crossing point of the Old Mirim and BR-101. However, if location of the upstream floodgate will be changed to be near the bifurcation of Old Mirim and Canal considering future landuse by the government of Itajai city, appropriate drainage facilities such as pump stations should be proposed newly in order to avoid inundation in Itajai urban area due to inflow from the Canhanduba River and other small tributaries.

5.2.2 Operation of Floodgates

(1) Basic Procedure of the Operation

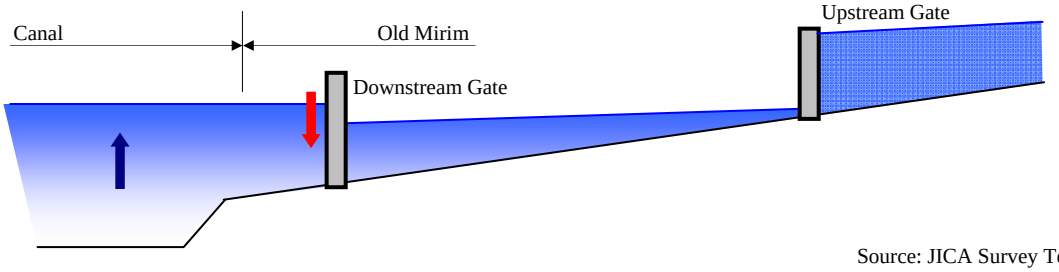
1) The upstream gate shall be closed when flood discharge exceeds the flow capacity of the Old Mirim as illustrated in Figure 5.2.2.



Source: JICA Survey Team

Figure 5.2.2 Operation of Flood Gates (1/3)

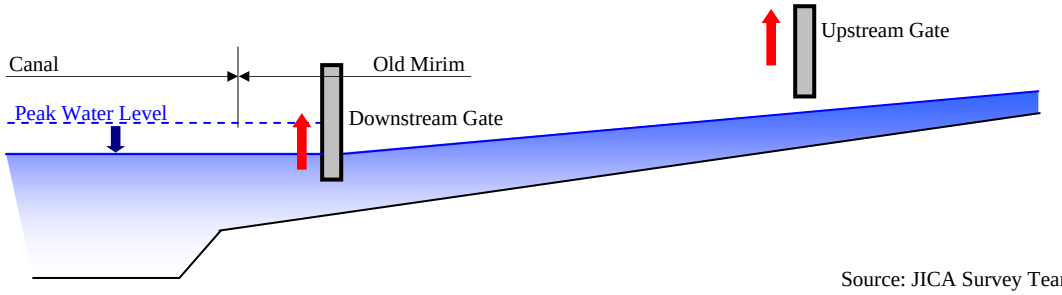
2) When the water level at the downstream end of the Itajai Mirim River reaches 1.7m in elevation, the downstream gate shall be closed.



Source: JICA Survey Team

Figure 5.2.2 Operation of Flood Gates (2/3)

3) When the water level at the downstream end of the Itajai Mirim River falls down and becomes equivalent to the water level in the Old Mirim, the downstream gate shall be opened.



Source: JICA Survey Team

Figure 5.2.2 Operation of Flood Gates (3/3)

The water level of Old Mirim must not be higher than Canal when the downstream gate is closed. As mistakes of the gates operation may cause man-made inundation, the operation rules of floodgates should be elaborated carefully.

(2) Operation of Floodgates for 10-year Flood

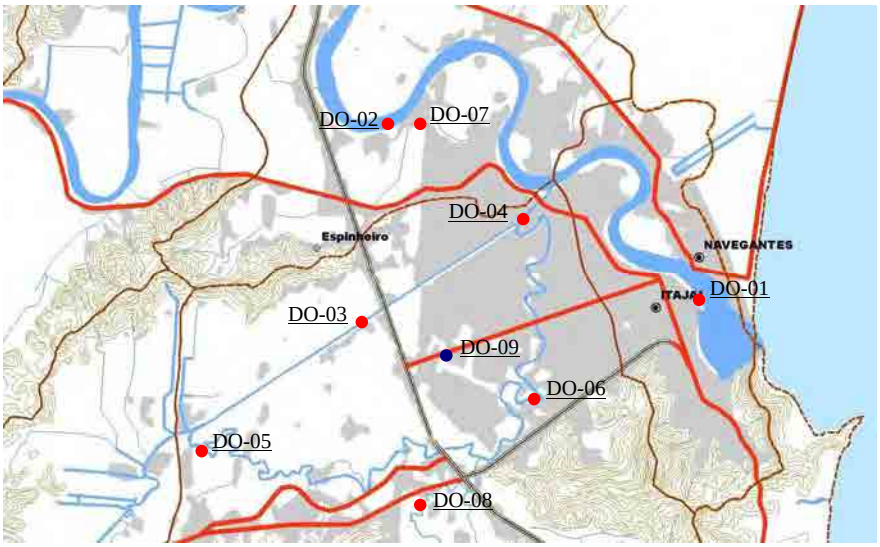
1) Necessity on Hydrological Information for Operation

The upstream gate would be closed when the discharge from the Itajai Mirim reaches to the flow capacity of the Old Mirim, in this respect, operation needs the information on the water level of the Old Mirim in the urban area (in the downstream area of the BR-101).

On the other hand, the downstream gate would be closed when the water level at the downstream end of the Old Mirim reaches to the critical water level. Therefore, the operation of

downstream gate also needs the information on the water level at the downstream end of the Old Mirim.

Civil Defense of the municipal government in Itajai city has already installed 9 gauging stations (with 9 water level gauges and 8 rainfall gauges) in February 2011. Location map is shown in Figure 5.2.3. Both the gauges "DO-06" and "DO-04" will be used for operation of both floodgates.

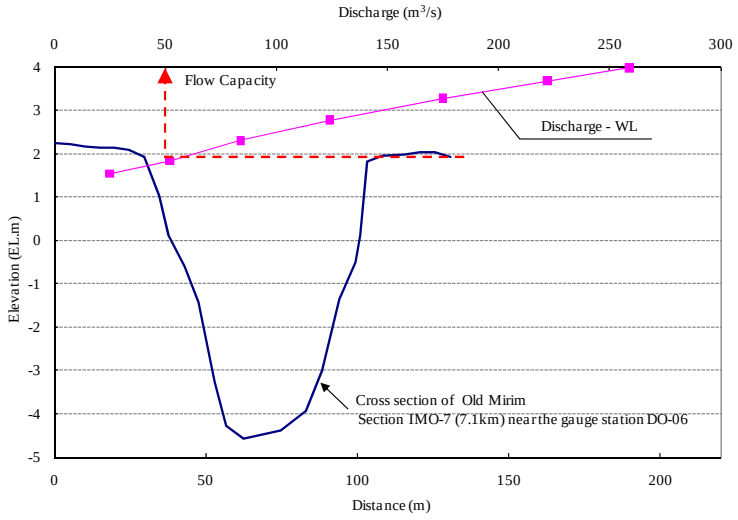


Source: JICA Survey Team

Figure 5.2.3 Location of Water Level and Rainfall Gauges Installed by Itajai City

2) Water Level of the Gates Operation

When the flood discharge into the Old Mirim reaches to the flow capacity of the Old Mirim, the pstream gate should be closed as shown in Figure 5.2.5. The flow capacity is equivalent to the water level of 2.0 m at the gauge DO-06 as shown in Figure 5.2.4.

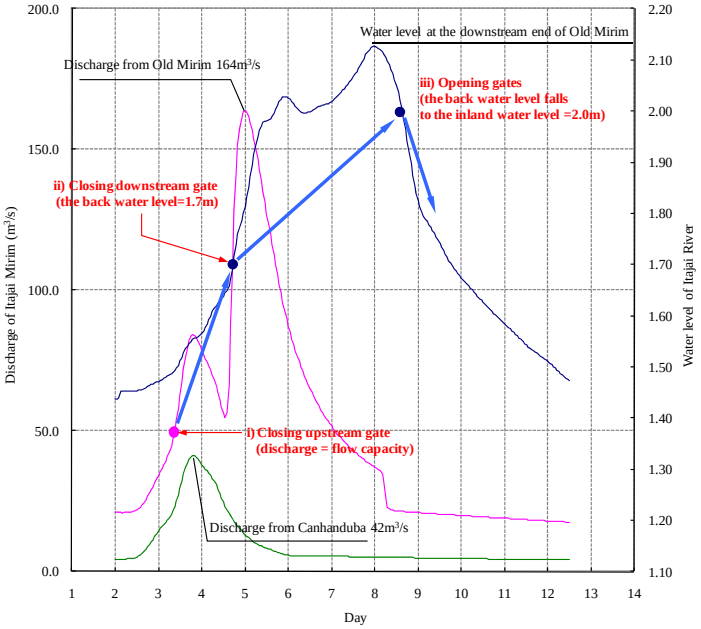


Source: JICA Survey Team

Figure 5.2.4 Relation of Water Level and Discharge at the Gauge DO-06

When the water level at the downstream end of the Itajai Mirim River reaches to EL.1.7 m, the downstream gate should be closed (see Figure 5.2.5).

When the water level at the end of the Itajai Mirim River falls down to be equal to the water level in the Old Mirim after the peak of the water level of the Itajai River, both the downstream and upstream gates will be opened in this order (see Figure 5.2.5).



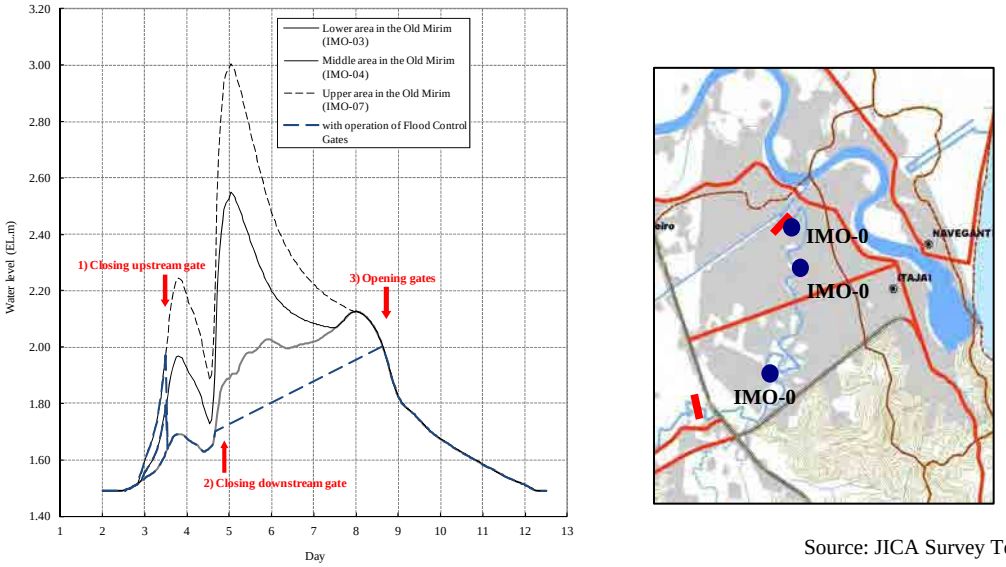
Source: JICA Survey Team

Figure 5.2.5 Operation of Floodgates for 10-year Flood

5.2.3 Effectiveness of Floodgates for 10-year flood

Effectiveness of floodgates for the 10-year flood is indicated in Figure 5.2.6. Maximum water levels at IMO-03, IMO-04, and IMO-07 without the floodgates are about EL.2.1 m, EL.2.5 m, and EL.3.0 m. And the maximum water level with operation of flood gates is EL.2.0m.

Furthermore, the floodgates will be also able to reduce the duration of high inland water level.



Source: JICA Survey Team

Figure 5.2.6 Effectiveness of Flood Gates Operation for the 10-year Flood

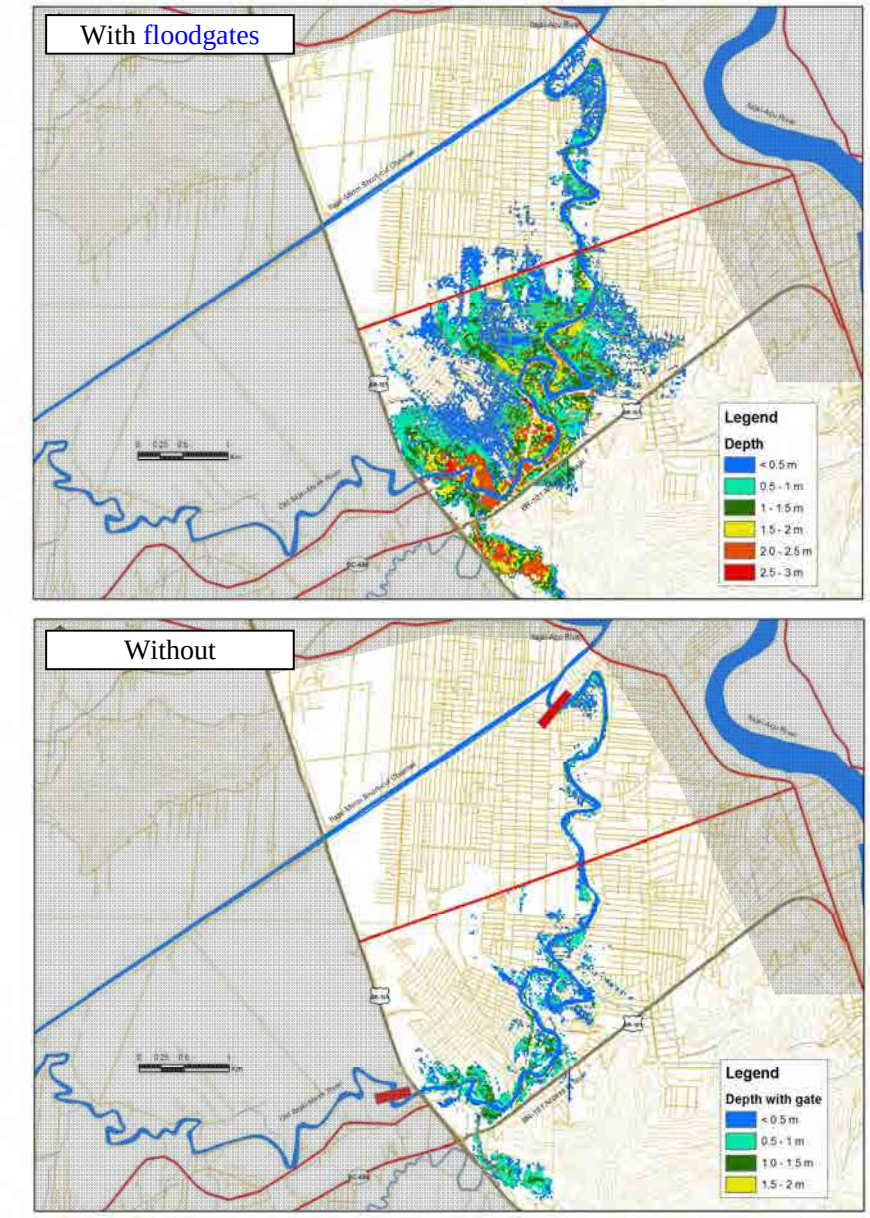
Inundation area and depth in the downstream area of BR-101 along the Old Mirim with and without the floodgates are illustrated in Figure 5.2.7. The effectiveness of the flood gates is evaluated in Table 5.2.1. Figure 5.2.8 shows the estimated inundation area along the lower reaches of Old Mirim River by probable floods.

Table 5.2.1 Estimated Inundation Area along the Lower Old Mirim

Inundation depth (m)	Area (m^2) without gate control	Area (m^2) with gate control	Effectiveness (m^2)
< 0.5	2,216,400	564,400	1,652,000
0.5 – 1.0	1,299,600	527,600	772,000

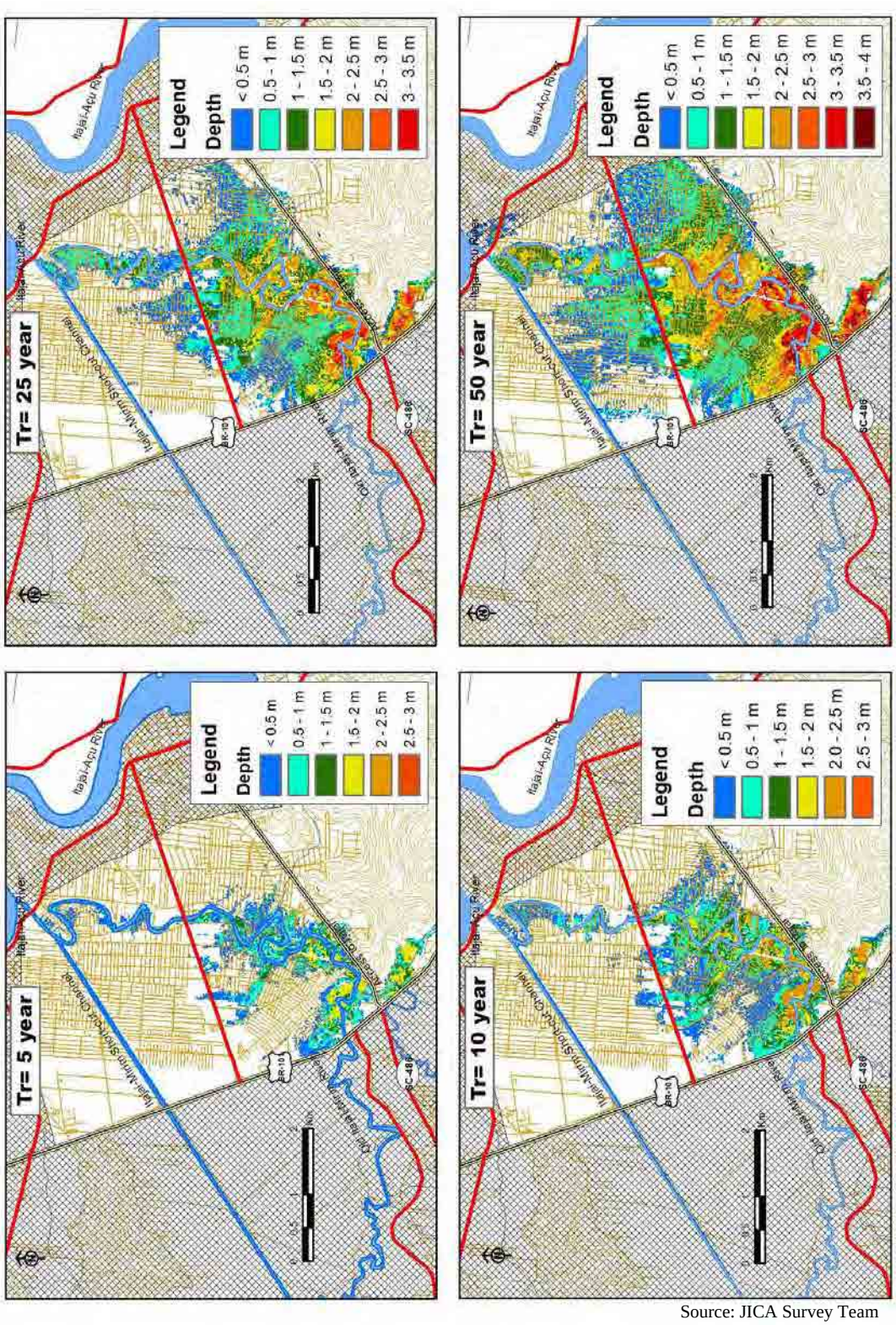
1.0 – 1.5	848,800	242,000	606,800
1.5 – 2.0	431,600	22,000	409,600
2.0 – 2.5	441,200	0	441,200
2.5 – 3.0	40,000	0	40,000
Total	5,277,600	1,356,000	3,921,600

Source: JICA Survey Team



Source: JICA Survey Team

Figure 5.2.7 Estimated Inundation Area along Old Mirim with and without Floodgates



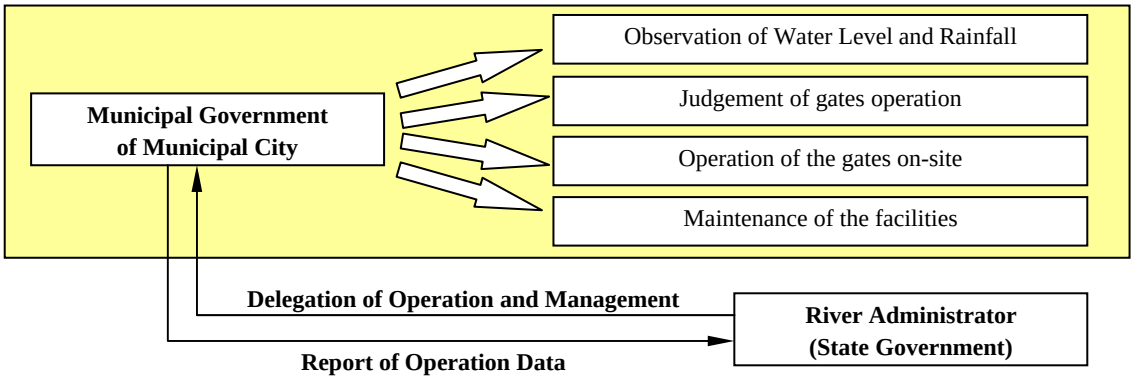
Source: JICA Survey Team

Figure 5.2.8 Estimated Inundation Area along the Lower Reaches of Old Mirim by Probable Flood

5.2.4 Recommendation of Organization for Operation

The operation of floodgates needs hydrological information only around Itajai city, and operation of the floodgates affects to only Itajai city area. The operation shall be executed by the municipal government of Itajai city. The flood management department of the State Government should be responsible for the implementation of the project (construction of the floodgates), study and

instruction of the gates operation method, supervision of the actual operation by Itajai city in flood time, preparing the maintenance plan and obtaining the budget for maintenance.



Source: JICA Survey Team

Figure 5.2.9 Recommendation of Organization for Operation

5.3 Feasibility Design of Floodgates

5.3.1 Geological Conditions

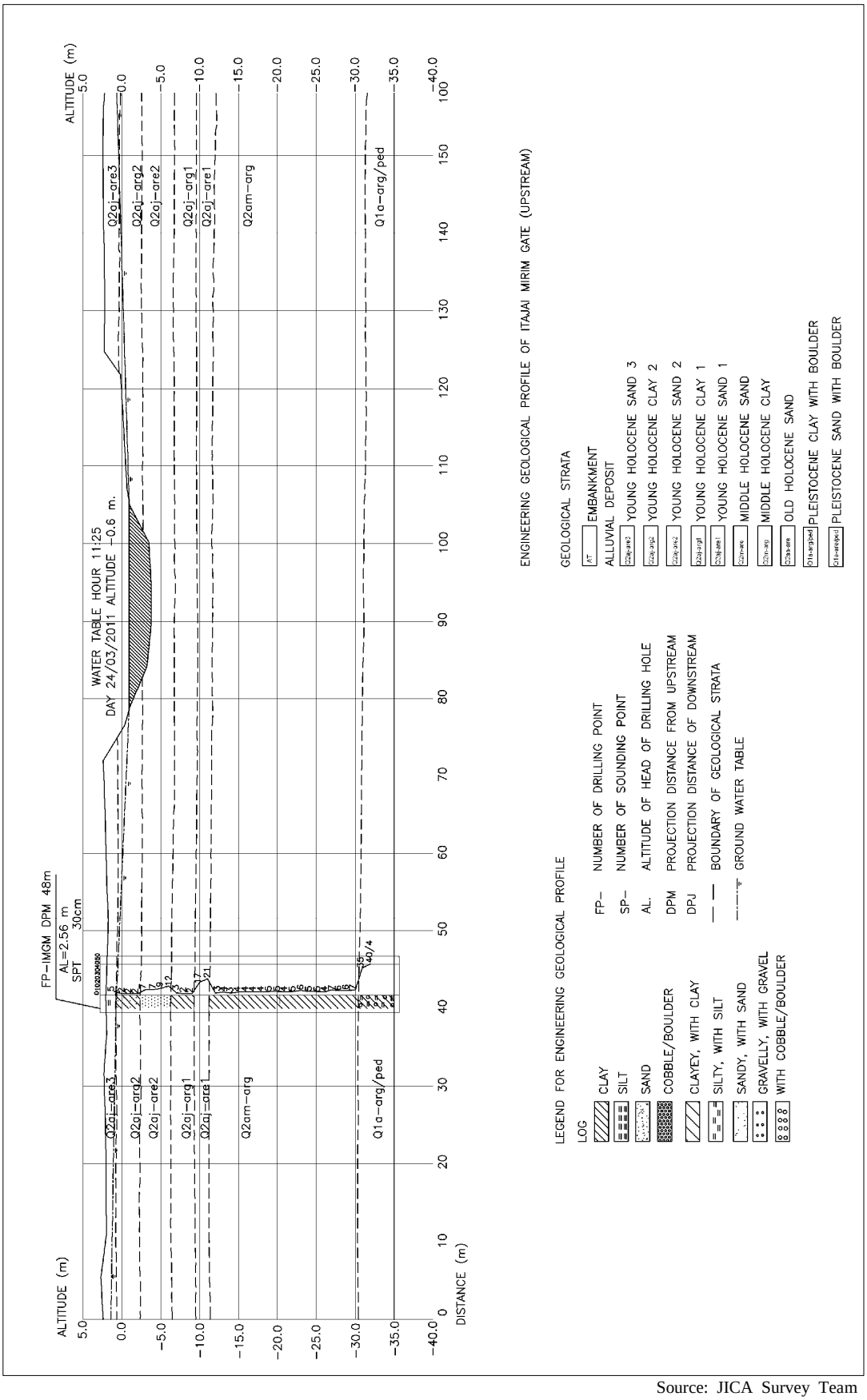
The proposed sites of both floodgates are in the alluvial plan on the Old Mirim River. Figure 5.3.1 shows the engineering geological profile at both locations. Theses profiles are prepared based on the results of drilling survey (the survey was carried out under the Preparatory Survey as field investigation in April-June 2011) and site reconnaissance. The geology of both sites is alluvial deposit in Quaternary System from surface to more than 38 meter deep, although the depth of bottom of the alluvial deposit is not confirmed.

Engineering properties such as N-values, angle of internal friction, unit weight were determined for each stratum based on the results of standard penetration test and empirical values. Tables 5.3.1 and 5.3.2 present the determined engineering properties by stratum for feasibility design.

Table 5.3.1 Determined Engineering Property of Each Stratum for the Upstream Floodgate

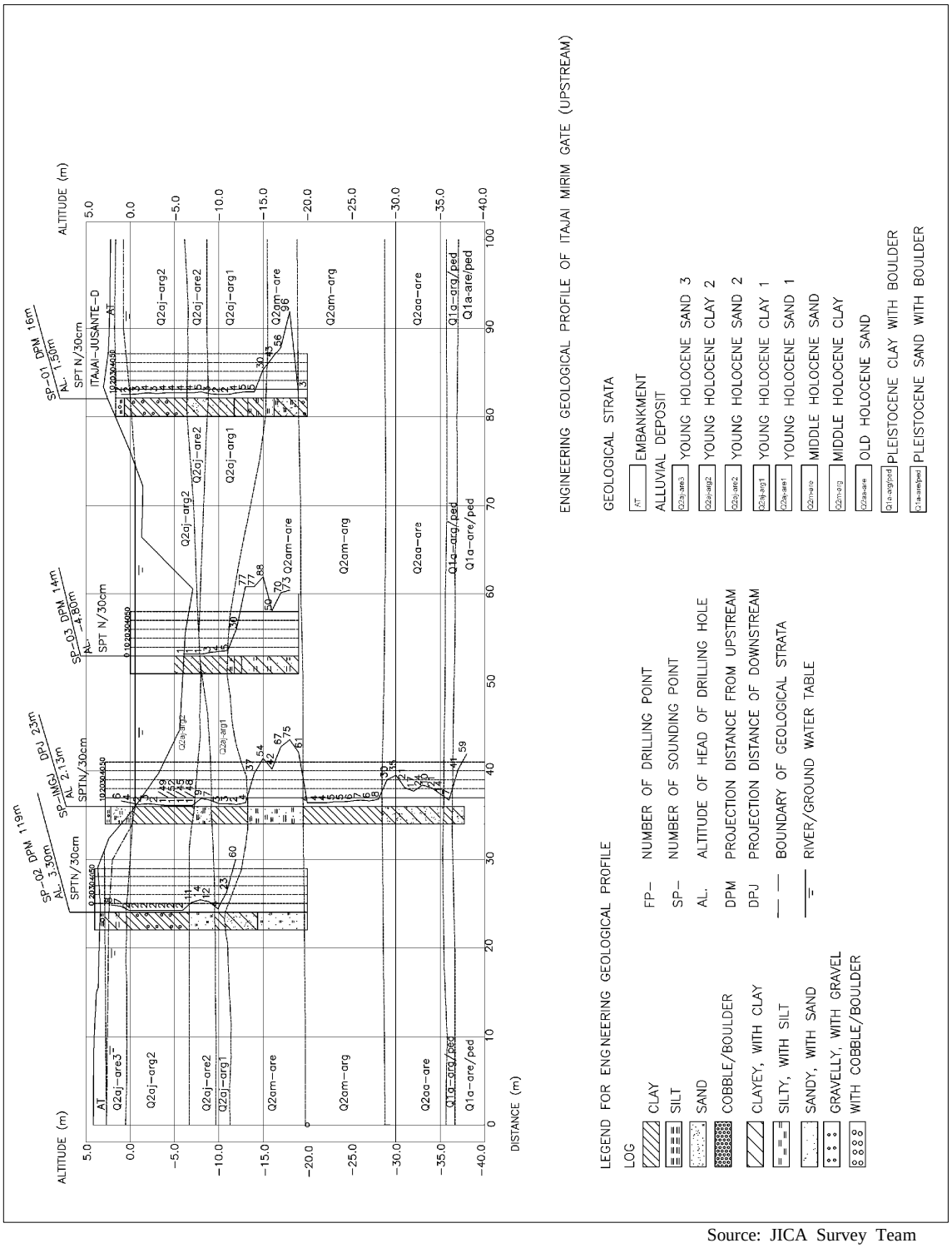
Symbol	Name of Strata	SPT N-Value Average (blows/ 30cm)	SPT N-Value Standard deviation (blows/ 30cm)	SPT N-value Adopted (blows/ 30cm)	Soil Strength c: cohesion (kN/m^2) φ: angle of internal friction (degrees)	Unit weight saturated γ_{sat} kN/m^3
Q2aj-are3	Young Holocene sand 3	4.5	0.7	4.2	C=0, φ=28	15
Q2aj- arg2	Young Holocene clay 2	2.2	0.4	2.0	C=13, φ=0	18
Q2aj- are2	Young Holocene sand 2	7.6	2.3	6.5	C=0, φ=29	16
Q2aj- arg1	Young Holocene clay 1	2.2	0.4	1.8	C=11, φ=0	17
Q2aj- are1	Young Holocene sand 1	16	4	14	C=0, φ=31	18
Q2am-arg	Medium Holocene clay	4.5	1.2	3.9	C=24, φ=0	19
Q1a- arg/ped	Pleistocene clay	109	130	23	C=100, φ=0	21

Source: JICA Survey Team



Source: JICA Survey Team

Figure 5.3.1 Engineering Geological Profile of Itajai Mirim Floodgate (Upstream)



Source: JICA Survey Team

Figure 5.3.2 Engineering Geological Profile of Itajai Mirim Floodgate (Downstream)

Table 5.3.2 Determined Engineering Property of Each Stratum for the Downstream Floodgate

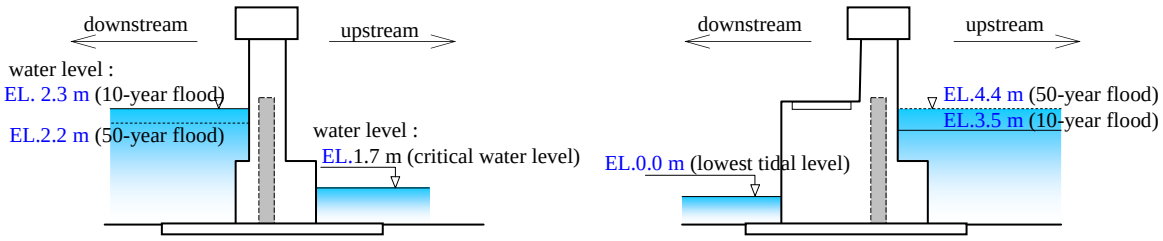
Symbol	Name of strata	SPT N-Value Average (blows/ 30 cm)	SPT N-Value Standard deviation (blows/ 30 cm)	SPT N-value Adopted (blows/ 30 cm)	Soil Strength c: cohesion (kN/m^2) φ: angle of internal friction (degrees)	Unit weight saturated γ_{sat} kN/m^3
AT/Q2aj-are3	Embankment/ Young Holocene sand 3	5.8	1.4	5.1	c=0, φ=29	15
Q2aj- arg2	Young Holocene clay 2	2.1	0.9	1.7	c=11, φ=0	17
Q2aj- are2	Young Holocene sand 2	8.4	4.5	6.2	c=0, φ=29	15
Q2aj- arg1	Young Holocene clay 1	3.3	1.2	2.7	c=17, φ=0	18
Q2am-are	Medium Holocene sand	57	29	43	c=0, φ=40	20
Q2am-arg	Medium Holocene clay	4.9	1.5	4.2	c=26, φ=0	18
Q2aa- are	Old Holocene sand	21	6.8	18	c=0, φ=32	18
Q2aa- are	Old Holocene clay	6.0	1.4	5.3	c=33, φ=0	18
Q1a- are/ped	Pleistocene sand with boulder	41	14	25	c=0, φ=35	19

Source: JICA Survey Team

5.3.2 Design Criteria and Design Conditions

Due to absence of Brazilian design standard for a floodgate, Japanese technical standard for river and sabo facilities was employed for current feasibility design.

Figure 5.3.2 shows design water levels of two floodgates. Aspects to be noted are that due to stage-wise implementation of the flood mitigation plan, gate structures are designed for the 10-year flood at the first stage, although civil structures of floodgate are designed for the 50-year flood.



(a) downstream gate (b) upstream gate

Source: JICA Survey Team

Figure 5.3.3 Design Water Levels of Floodgates

As mentioned in sub-section 5.1.3, some stretch along the right bank in the Canal has insufficient flow capacity for the 10-year flood discharge. Dyke should be provided to prevent overflowing from this stretch. The height of the dyke is determined from the water level of the 10-year flood. The water level of the 50-year flood is lower than that of 10-year flood because of provision of the floodway.

5.3.3 Feasibility Design

(1) Civil Structure

Main features of the designed floodgates are summarized in Table 5.3.3 below. Figures 5.3.3 and 5.3.4 show the general layout plan of floodgates.

Table 5.3.3 Main Features of Floodgates

Gate	Downstream Gate	Upstream Gate
Nos. of Gate	3	3
Span of Gate	12.5 m	12.5 m
Foundation Elevation	EL.-5.0 m	EL.-4.3 m
Bottom Elevation of Gate	EL. -1.0 m	EL. -1.0 m
Main Structure	Separate slab and pier	Separate slab and pier
Gate Pier	EL. 7.70 m 6.00 m wide 14.20 m high	EL. 12.00 m 11.20 m wide 17.80 m high
Gate Operation System	On the top of pier	On the top of pier
Apron Length	6.0 m	8.0 m
Sheet Pile for Seepage	Downstream 2.0 m Upstream None	Downstream 2.5 m Upstream 5.5 m
Revetment	Downstream 10.0 m Upstream 10.0 m	Downstream 10.0 m Upstream none
Stair	Installed	Installed
Foundation	Pile foundation Pier :L=11.0 m ϕ 400 mm Slab :L=11.0 m ϕ 300 mm	Pile foundation Pier :L=27.0 m ϕ 400 mm Slab :L=27.0 m ϕ 300 mm

Source: JICA Survey Team

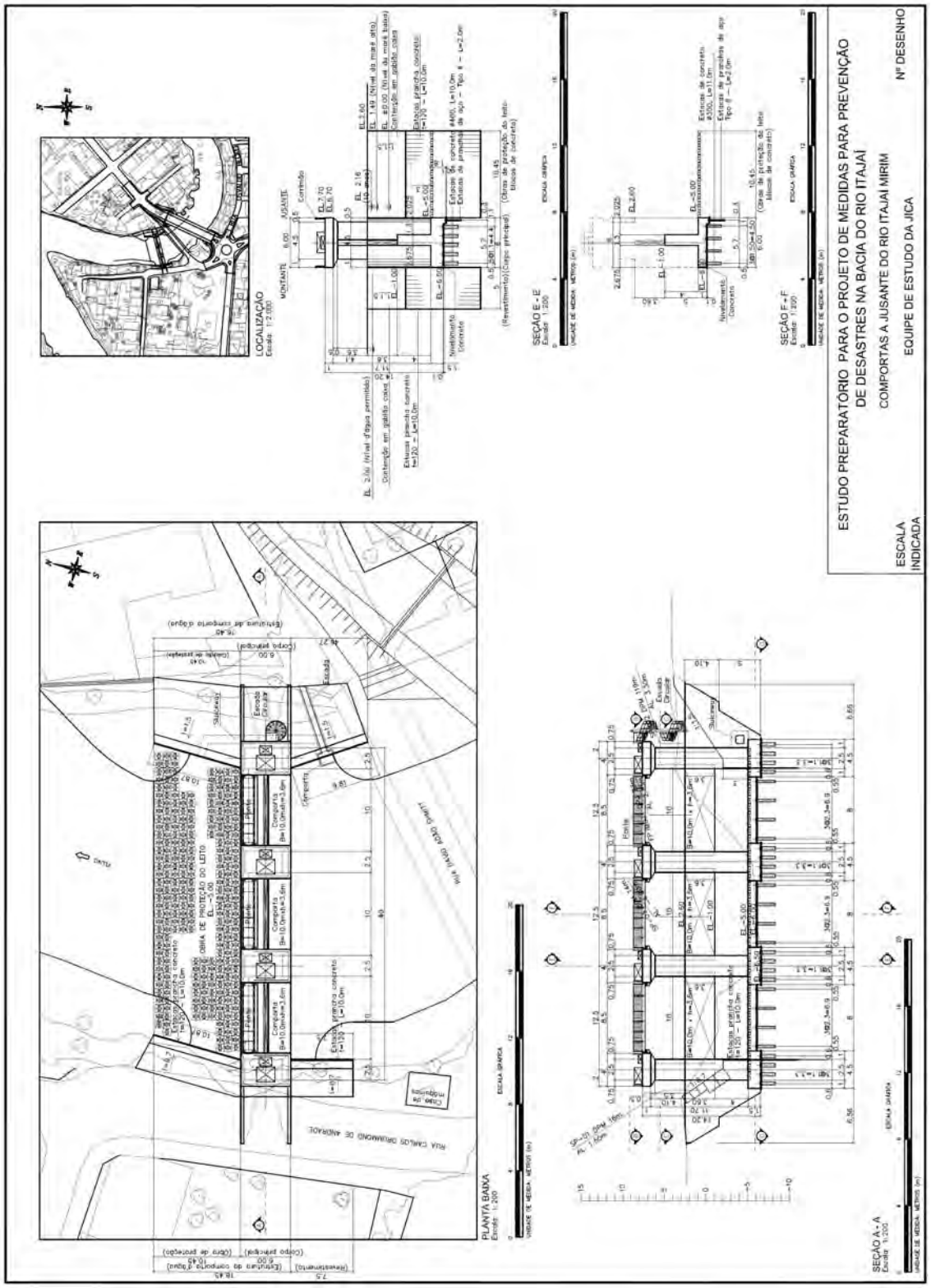
Technical factors considered in the feasibility design were as follows:

i) It appeared through the drilling survey that bearing layers were located under the riverbed 12 m deep at the downstream floodgate and 30 m deep at the upstream floodgate. Therefore, pile foundation was proposed for both floodgates.

ii) The lowest riverbed elevations are around EL.-6.8 m at the downstream floodgate and EL.-4.5 m at the upstream floodgate. As shown in Figure 5.3.2, the design top elevations of gate are EL.2.3 m at the downstream floodgate and EL.3.5 m at the upstream floodgate, respectively. In order to reduce the cost of gates, gate height was minimized by providing the convex part of the concrete foundation.

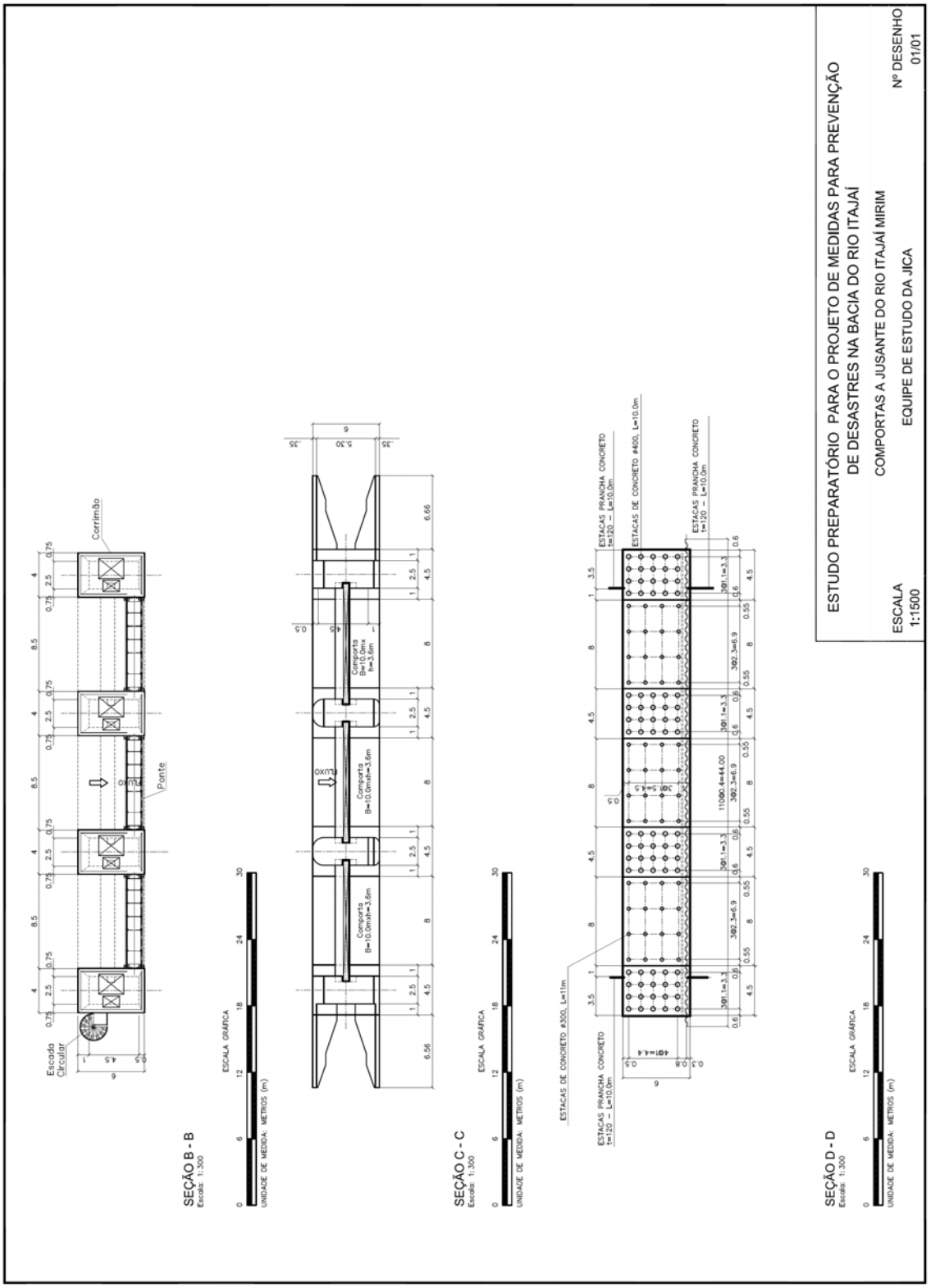
iii) Considering local navigation by small boat on the Old Mirim River and the mean low tide elevation of EL. 0.00 m, the crest elevation of convex part was set at EL.-1.0 m at both floodgates.

iv) Considering the existence of local scouring at the foot of bank, especially at the downstream floodgate section located immediately downstream of the existing bridge, the elevations of foundation were determined EL.-5.0 m at the downstream floodgate and EL.-4.3 m at the upstream floodgate, respectively.



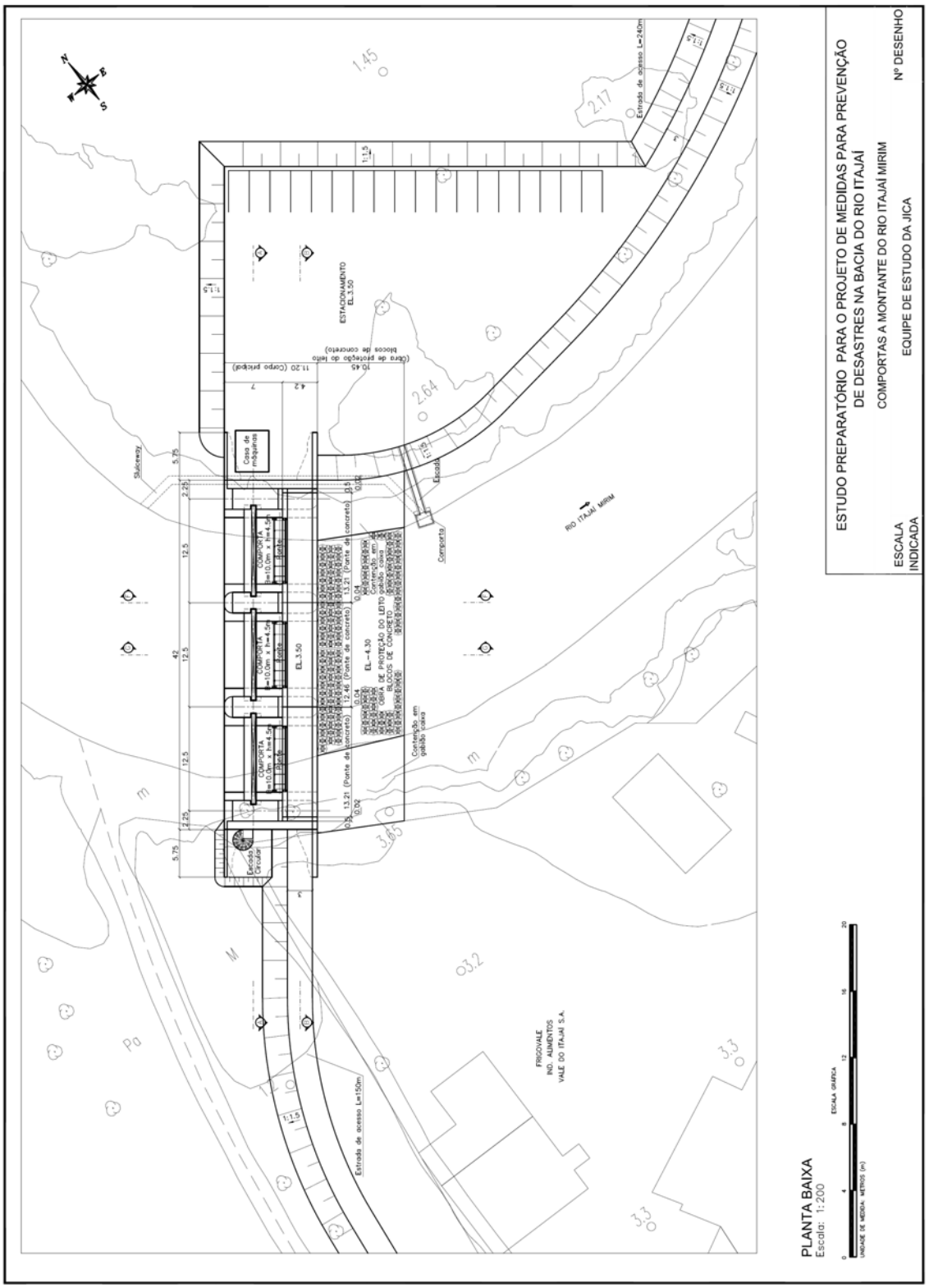
Source: JICA Survey Team

Figure 5.3.4 General Layout Plan of Downstream Floodgate (1/2)



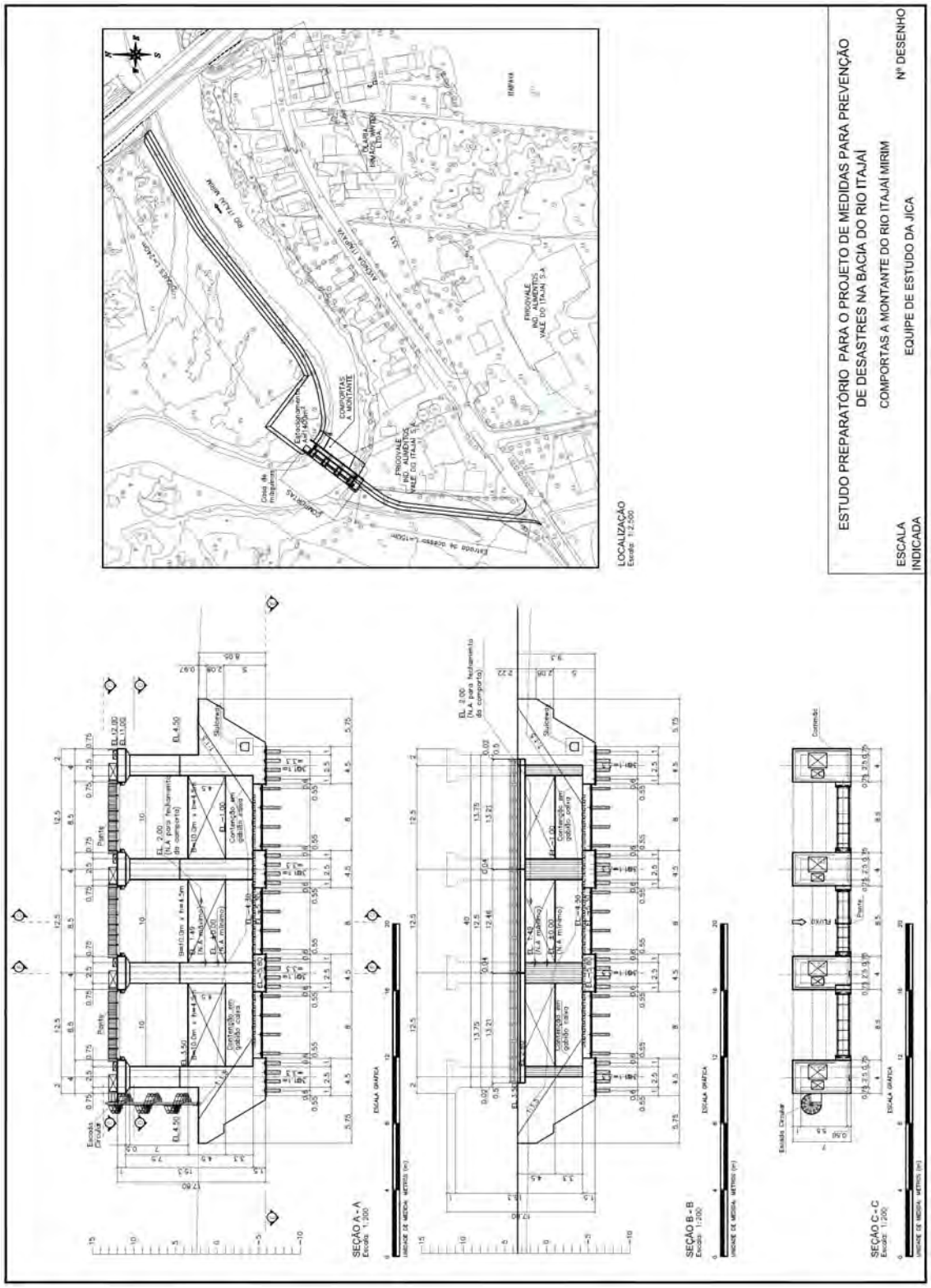
Source: JICA Survey Team

Figure 5.3.5 General Layout Plan of Downstream Floodgate (2/2)



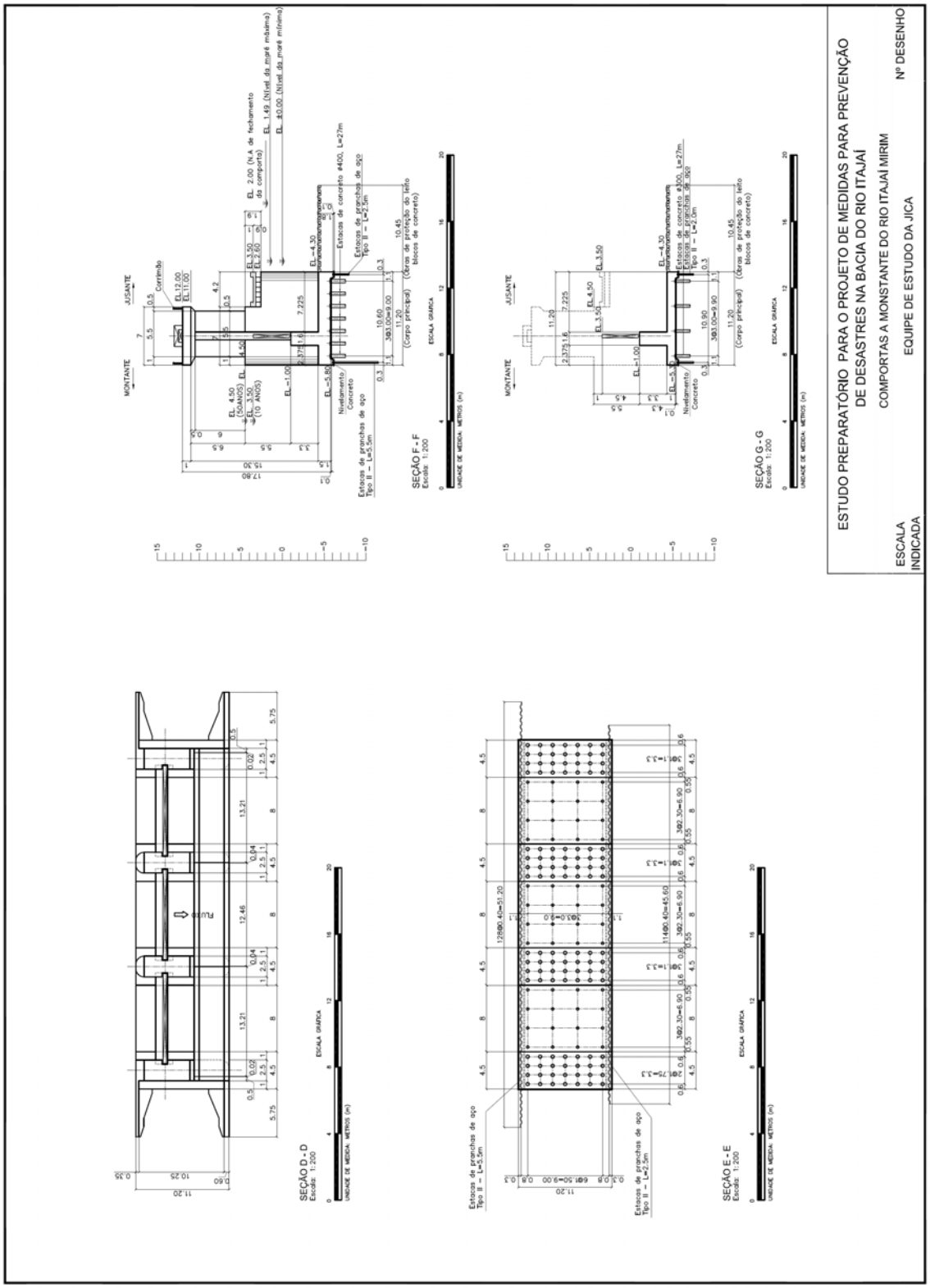
Source: JICA Survey Team

Figure 5.3.6 General Layout Plan of Upstream Floodgate (1/3)



Source: JICA Survey Team

Figure 5.3.7 General Layout Plan of Upstream Floodgate (2/3)



Source: JICA Survey Team

Figure 5.3.8 General Layout Plan of Upstream Floodgate (3/3)

(2) Backwater Dyke

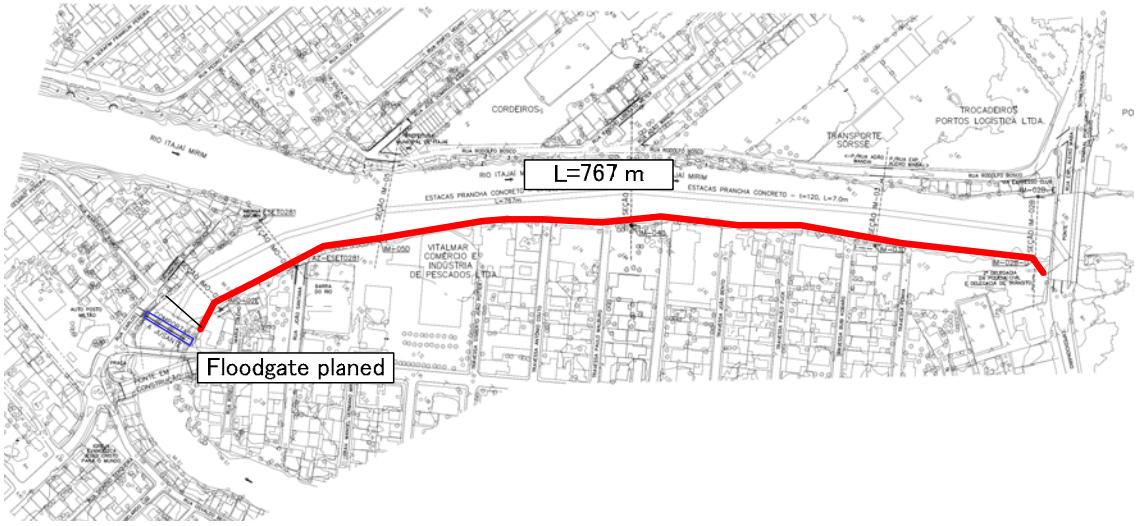
Around 1.0 km long river stretch along the Itajai Mirim River between the confluence with the Itajai River and the downstream floodgate is subject to backwater effect of the Itajai River. The river cross section survey along the Itajai Mirim River has revealed the following findings (see Figure 5.1.6):

i) The existing road (the Rodolfob Bosco Avenue) on the left bank has sufficient elevation to the design water level of 10-year flood and functions as a dyke.

ii) In the stretch of around 0.5-1.0 km from the confluence of Itajai River, height of the right bank is lower than the water level of 10-year flood.

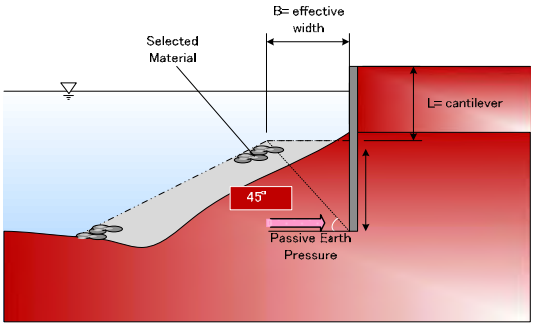
iii) There are several residences immediately riverside on the right bank, where residents have been adapting to the backwater effects due to floods from the Itajai mainstream and tidal level fluctuation by providing brick walls on the riverside and stilt residences with raised floor.

Although the backwater dyke was proposed to provide embankment on both the banks in the Master Plan due to limited availability of river section data, concrete sheet piling was conceived as the alternative for backwater dyke on the right bank (see Figures 5.3.5 and 5.3.6 below) with the main focus on minimizing social issues such as relocation of residences. With provision of backwater dyke by means of sheet pile, no relocation of residences is required.



Source: JICA Survey team

Figure 5.3.9 Objective Stretch of Backwater Dyke at the Downstream Floodgate



Source: JICA Survey team

Figure 5.3.10 Image of Sheet Piling as Backwater Dyke

(3) Gate

The fixed wheel gate is proposed because of its plate girder structure or box girder structure. Comparing with the box girder structure, the plate girder structure is selected as the type of gate because of the following reasons.

i) With the ratio of gate height and clear span is 3:1, the box girder structure type is not recommended for high costs.

ii) Interviewing with the maker in Brazil, the box girder structure is not common in Brazil.

The type of hoist is selected as "1M-1D" (M:Motor, D:Drum)since its type is consisted from a few component parts and the initial and maintenance cost is minimized.

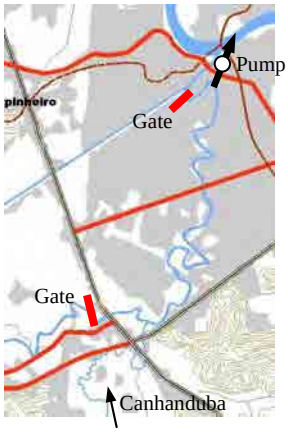
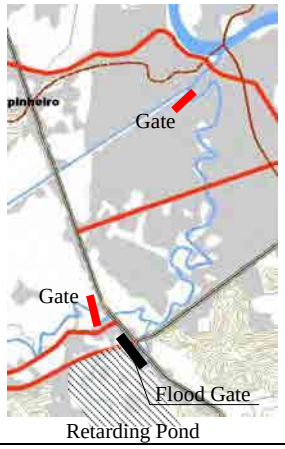
The floodgates are proposed to locate in the tidal area. Thus they are likely to be rusted by seawater. The countermeasure against the corrosion is considered as two methods; using of stainless steel material instead of the mild steel and painting itself. In Brazil, the cost of stainless is higher (6 times) than the mid steel. Thus there are few cases to use for the gates, and it is proposed for the gate itself that is floodgates. Accordingly, the floodgate is to be fabricated by the mild steel and the painting.

5.3.4 Local Drainage

(1) Drainage of Canhanduba River

The inflow from the Canhanduba River must be drained by appropriate measure with discharge of about 7.0 m^3/s to maintain the inland water level not exceed EL.2.0 m which is the allowable water not to bring local damage and not to disturb evacuation in the lower area along the Old Mirim. A drainage channel shall be recommendable based on the comparison results of drainage methods as shown in Table 5.3.4 below.

Table 5.3.4 Comparison of Drainage Methods for Inland Water from Canhanduba River

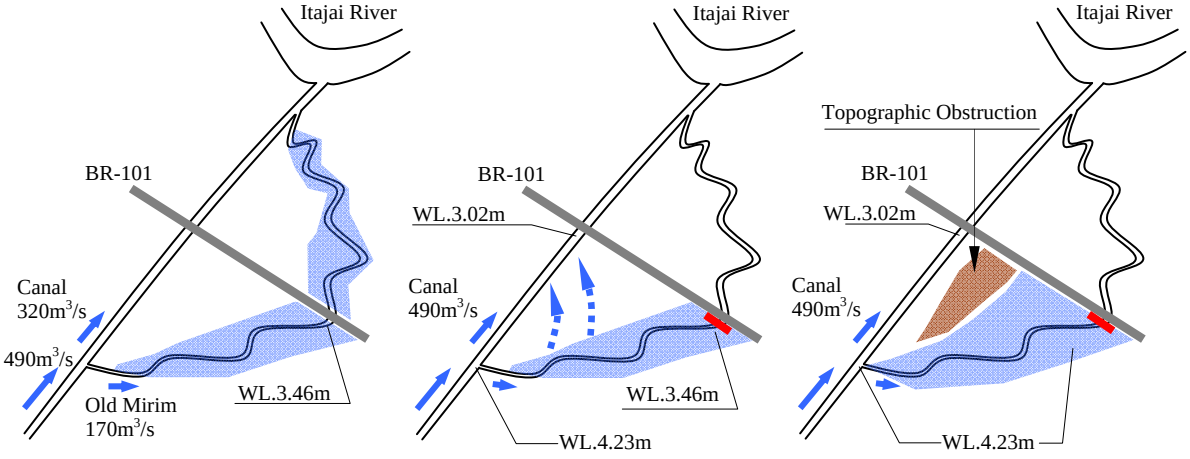
Method	Pumping Station from Old Mirim to Itajai River	Floodgate and Retarding Pond	Drainage Channel from Canhanduba to Old Mirim
Location			
Cost	High	Medium	Low
Impact	No impact	Retarding pond might affect the upstream agricultural area along the Canhanduba River.	No impact
Evaluation	Not recommendable	Not recommendable	Recommendable

Source: JICA Survey Team

(2) Drainage of Stored Water in the Old Mirim

As flood water levels in the upstream of the BR-101 along the Canal were estimated lower than the Old Mirim by non-uniform flow calculation, the flood water from the Old Mirim flows into the Canal naturally when the upstream gate is closed. Therefore, closing of the upstream gate may not affect the upstream area of the Old Mirim as illustrated in Figure 5.3.7 (ii).

However, if there is some topographic obstruction like mound or slightly elevated ground between the Old Mirim and the Canal as illustrated in Figure 5.3.7 (iii), inundation water level in the upstream area along the Old Mirim would increase because of the retention effects. It is strongly recommended that the impact to the inundation level in the upstream area of the BR-101 shall be studied by two-dimensional inundation analysis by use of 1:10,000 scale topographical maps which is under preparation by the State Government.



(i) without Floodgates (ii) with Floodgates (iii) with Floodgates

Source: JICA Survey Team

Figure 5.3.11 Necessity of Drainage in the Upstream Area of BR-101

CHAPTER 6 FEASIBILITY STUDY FOR STRENGTHEN OF EXISTING FFWS

6.1 Summary for Feasibility Study

The master plan for mitigation measures against the flood disaster was proposed to strengthen the existing FFWS including 16 new gauging stations (See Part I, M/P Table 8.5.1). The following items shall be studied in this F/S.

i) Verification for existing flood forecasting system

ii) Cost analysis for strengthening for proposed FFWS

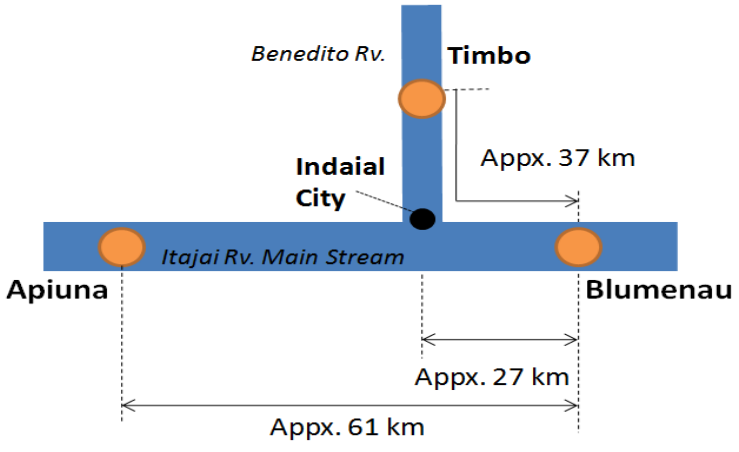
6.2 Verification of Existing Flood Forecasting Method

Existing FFWS is not systematically planned and conducted for total Itajai River Basin. Especially the flood forecasting is only conducted at Blumenau (by FURB) and Rio do Sul (by City Defesa Civil) but the Rio do Sul is still in "Trial and Error" stage.

In this section the present flood forecasting formula at Blumenau and Rio do Sul shall be verified. For Itajai city which is one of the most important cities along the Itajai River basin, the flood forecasting method shall be proposed in this section. For other cities and towns, it is important to maintain that the present warning system due to the river water level shall be adopted using existing gauging stations and additional gauging stations which are proposed under the study.

6.2.1 Verification of Existing Flood Forecasting Formula at Blumenau

The forecasting flood water level at Blumenau is computed based on the correlation of the water level (ARIMAX Model Method) at Blumenau, Apiuna and Timbo. The schematic diagram for gauging stations of Blumenau, Apiuna and Timbo is shown in Figure 6.2.1. Apiuna and Timbo are approximately located in 61 km along Itajai River and 37 km along Benedito River upstream respectively from Blumenau.



Sorce: JICA Study Team

Figure 6.2.1 Schematic Diagram for Gauging Stations

The water level correlation formula for the flood forecasting at Blumenau was developed by the FURB/ CEOPS in 1990's as follows.

$$Y(t)=1.98063 \times Y(t-1) - 0.98506 \times Y(t-2) + 0.009200 \times u1(t-4) - 0.08732 \times u1(t-5) + 0.01806 \times u2(t-4) - 0.01411 \times u2(t-5) + 0.03083 \quad \cdots\cdots (1)$$

where,
- Y(t): Forecasted water level at time of (t) hour at Blumenau station
- y(t-1): Water level at time of (t-1) hour at Blumenau station
- y(t-2): Water level at time of (t-2) hour at Blumenau station
- u1(t-4): Water level at time of (t-4) hour at Apiuna station
- u1(t-5): Water level at time of (t-5) hour at Apiuna station
- u2(t-4): Water level at time of (t-4) hour at Timbo station
- u2(t-5): Water level at time of (t-5) hour at Timbo station

The evacuation manual of Blumenau city says that the evacuation shall be announced 3 hours before the flood in consideration of priority people to be protected such as aged people, handicapped people, children and tourists and so on.

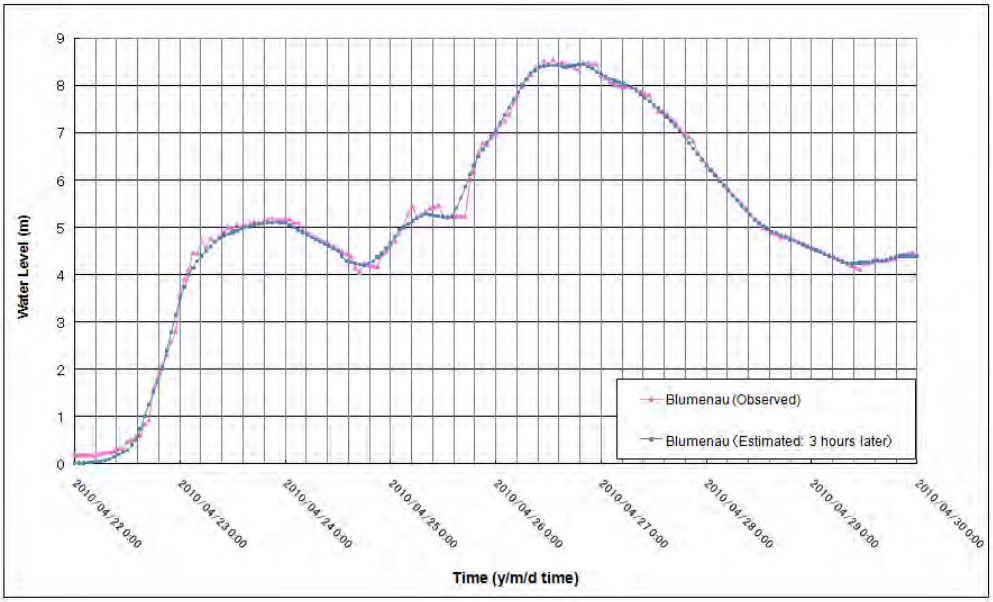
The required water level at Blumenau for calculating of forecasted flood water level using the proposed formula is the 1 hour before and 2 hours before the flood therefore, the following steps shall be conducted to compute the forecasted water level after 3 hours from present.

i) To forecast water level after 1 hour at Blumenau using present and 1 hour before water level at Blumenau

ii) To forecast water level after 2 hours at Blumenau using forecasted water level after 1 hour and present water level at Blumenau

iii) To forecast water level after 3 hours at Blumenau using forecasted water level after 1 hour and after 2 hours at Blumenau

The formula was developed approximately 20 years ago. This verification shall be conducted using the flood data in April 2010. The Figure 6.2.2 is shown the comparison between the actual flood water level at Blumenau and the forecasted flood water level (after 3 hours at Blumenau) computed by the proposed formula. The forecasted water level is quite similar to the actual one.



Source: JICA Study Team

Figure 6.2.2 Comparison between Actual and Water Level Forecasted by Present Formula at Blumenau

In addition to above verification, new multiple correlation formula is created using water level at Blumenau, Apiuna and Timbo as described Table 6.2.1 and the accuracy of forecasted water level used by the new multiple correlation formula shall be confirmed with the actual.

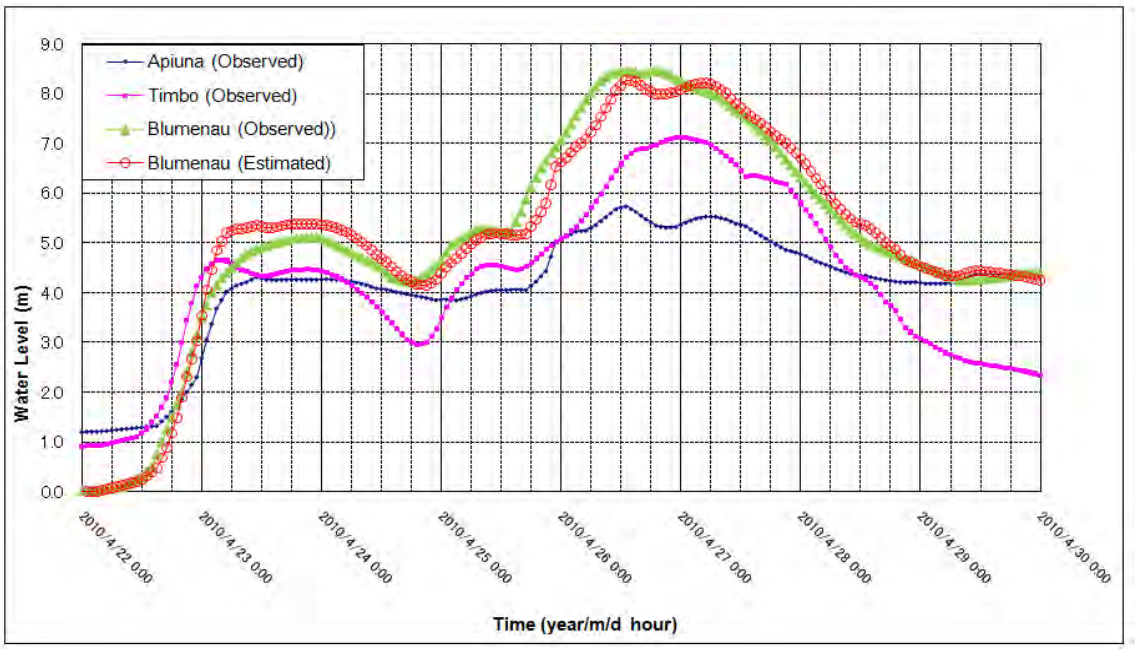
Table 6.2.1 Summary of Forecasting Formula by Multiple Correlation at Blumenau

Method	Gauging Sta.1	Gauging Sta.2	Coefficient of Correlation	Forecasting Formula
Multiple Correlation	Using 6 hours before actual water level at Apiuna considered arrival time	Using 3 hours before actual water level at Timbo considered arrival time	0.991	Y= 1.1012259 * X1 + 0.5622697 * X2 - 1.830675 …… (2)

Source: JICA Study Team

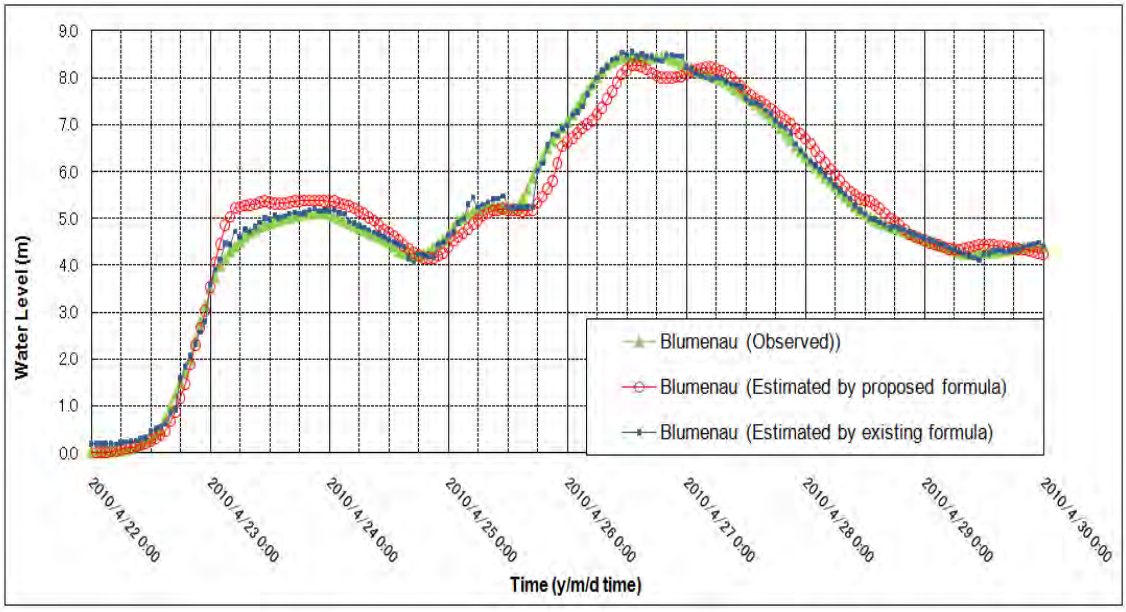
The forecasting formula by the multiple correlation among Blumenau, Apiuna and Timbo using the flood in April 2010 is quite accurate as shown in Figure 6.2.3 and the correlation coefficient is R=0.991 but not as highly accurate as the present forecasting formula (see Figure 6.2.4).

Therefore the present forecasting formula at Blumenau is still maintaining accuracy and even now it is applicable to use the present forecasting formula for forecasting flood water level at Blumenau. In future, whenever the flood comes the formula should be checked and updated if necessary.



Source: JICA Study Team

Figure 6.2.3 Comparison between Actual and Water Level Forecasted by Multiple Correlation Formula at Blumenau



Source: JICA Study Team

Figure 6.2.4 Comparison among Actual, Present Formula and Multiple Correlation Formula

6.2.2 Verification of Existing Flood Forecasting Formula at Rio do Sul

The present formula for forecasting flood water level at Rio do Sul was developed by Defesa Civil in Rio do Sul city. The formula was developed by the rainfall correlation method using the rainfall at Rio do Sul (C.A.:5,042 km^2), Oeste Dam (C.A.: 1,042 km^2, 81km upstream of Rio do Sul) and Sul Dam (C.A.: 1,273km^2, 43km upstream of Rio do Sul). The formula was developed in a trial stage therefore presently the flood/ evacuation warning shall be implemented without using the forecasted water level computed by this formula.

i. The daily average discharge shall be computed by the daily average water level using H – Q Curve at Rio do sul. The water level at Rio do Sul is ocularly observed at 7a.m. and 5 p.m. daily and the observation of flood water level is conducted hourly. The daily average water level means the average of 2 times of water level for ordinary days and maximum 24 times of water level for during the flood.

$$Q = 44.7757 (H - 0.235) 1.48789 \quad \cdots\cdots(3)$$

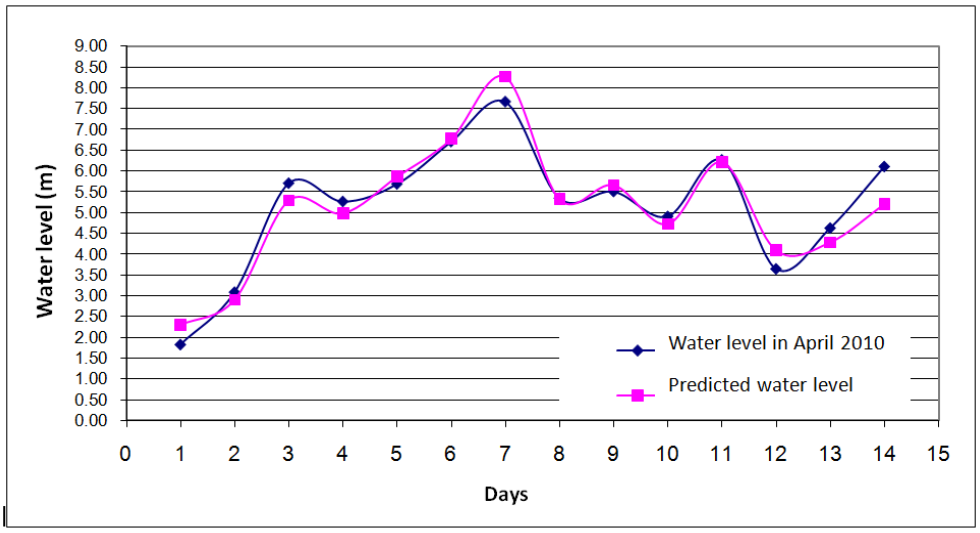
ii. The fluctuation discharge (ΔQ) shall be computed by daily rainfall data at aforementioned 3 locations using the following formula. The fluctuation discharge (ΔQ) means the different discharge volume between that day and next day.

$$Q = 6.07 + 1.66 * (\text{Rainfall at Rio do Sul}) + 2.51 * (\text{Rainfall at Sul Dam}) + 0.45 * (\text{Rainfall at Oeste Dam}) \quad \cdots\cdots(4)$$

iii. The daily average discharge for next day (Q2) shal discharge (ΔQ) to the daily average discharge for that day.l be computed to add the fluctuation

iv. The daily average water level for the next day shall be computed using aforementioned H-Q Curve formula (3).

The forecasted daily average flood water level at Rio do sul was computed by using above method regarding the flood on April 2010 and the comparison between the actual daily average flood water level and forecasted daily average flood water level is shown in Figure 6.3.5. The forecasted daily average water level is 30 cm in difference from the actual and it is quite accurate.



Source: Rio do Sul, Defesa Civil

Figure 6.2.5 Comparison between Actual Daily Average Water Level and Forecasted Daily Average Water Level at Rio do Sul

However:

- the forecasting method is only applicable for daily average but not allowed to compute hourly base. Therefore the forecasting method is not appropriate to utilize for the warning system. It can be used only for the warning announcement for the next day.
- The definition of the daily average water level is not clear for the ordinary day and the flood time. In case of the flood time, the daily average water level could not be computed until the end of day (12pm) therefore the water level for the next day could not be forecasted until midnight. In this case the warning for the next day maybe difficult due to preparation of the warning after midnight.
- DEINFRA as dam operator has no data of discharge from 2 dams and the information of discharge is not transmitted to downstream cities such as Rio do Sul, Ituporanga and Taio City.

Due to those above mentioned matters, the following comments are well considered for the future.

- In future, the correlation method should be applied for the flood forecasting at Rio do Sul as a ordinary method and it must be hourly forecasting.
- However Rio do Sul has 2 flood control dams in upstream. The coefficient of correlation among 2 locations is low therefore the flood forecasting modeling is needed to be developed by the runoff analysis including the mechanism of control gates at dams.
- In case of the modeling of the flow-runoff analysis, in addition to the existing rainfall gauging stations, the system for transmitting data of dam discharge including the gate control status to the city/ provincial Defensa Civil by the DEINFRA as the dam operator must be set up and implemented essentially.

6.2.3 Flood Forecasting System at Itajai City

The Itajai City has very important role for the economy in the Itajai River Basin and the flood forecasting system should be organized as same as Rio do Sul and Blumenau. However the Itajai City is located at the estuary and the city is seriously affected by the tide and influenced by the tributary of Mirim River. Therefore the forecasting of flood water level at Itajai city is

very complicated and difficult.

The Defesa Civil at Itajai City has already installed new 8 water level gauges around the city in February 2011 and they are planning to set up new system for the flood warning and evacuation announcement but they has presently hard time to set up the flood forecasting system since the information in upstream such as Blumenau and Brusque is not transmitted to Itajai City.

Other hand, the Defesa Civil, SDS and EPAGRI in SC Province are planning to develop the flood forecasting modeling for the flow-runoff analysis and inundation analysis but it needs more time to get accurate forecasting system using sufficient data collected by the proposed gauging stations under this FFWS. However the development of the flood forecasting modeling should be continued. Meantime the flood warning and evacuation announcement should be implemented by the SC Province due to the flood water level of upstream such as Blumenau and Brusque.

- There are no previous data for the flood water level at Itajai City at all. The inundation at Itajai City must be forecasted from the upstream flood water level at Blumenau and Brusque after researching previous flood water level at Blumenau and Brusque in relation to previous inundation record of Itajai City.
- In next study, the flood forecasting method at Itajai City should be prepared after analysis of relation of flood water level at Itajai City and upstream, relation of Itajai City inundation and upstream flood water level, analysis of flood arrival time using data from the water level gauges newly installed by the Itajai City, water level gauges at Gaspar and Ilhota proposed under this FFWS in addition to the existing gauges.

6.3 Cost Estimate for Strengthening FFWS

The cost estimation for strengthening FFWS is shown as follows.

i) Equipments cost including installation

ii) System development cost including consultant services

The summary of new gauging station is shown in Table 6.4.1. as follows.

Table 6.3.1 Quantity and Location of New Gauging Stations

Station		Rainfall	Water Level	CCTV	Warning Tower	Warning Siren
1	Rio do Sul			1	3	3
2	Blumenaur			1	3	3
3	Itajai			1	3	3
4	Vidal Ramos	1	1			3
5	Trombudo	1	1			3
6	Rio dos Cedros	1	1			3
7	Benedito Novo	1	1			3
8	Gasper	1	1			3
9	Ilhota	1	1			3
10	Mirim Doce	1	1			3
11	Salete	1	1			3
12	Pouso Redondo	1	1			3
13	Agua Clera	1	1			3
14	Gurabiruba	1	1			3
15	Sul Dam	1	1			3
16	Oeste Dam	1	1			3
17	Pinhal Dam	1	1	1		3
18	Rio Bonito Dam	1	1	1		3
19	Luiz Alves	1	1			3
Total		**16**	**16**	**5**	**9**	**57**

Source: JICA Study Team

In addition to above, the Master Station at the Defesa Civil at Florianopolis City shall be established as described Section 8.5.1, Chapter-8 and the three (3) monitoring Centers shall be established at the Defesa Civil at Itajai City, Blumenau City and Rio do Sul City.

Table 6.3.2 Specification of Equipments

Item	Specification	Nos.
Telemetry rainfall gauge	Radar type OTT/RLS model	16
Telemetry water level gauge	Radar type OTT/RLS model	16
Software	Automatic E-mail system	16
Solar panel/battery	Polycrystalline silicon type 12V	16
Data transmission (GPRS)	For data transmission 2.0Mbyte	16
CCTV	In-line transmission CCD	5
Data transmission (GPRS)	For CCTV 2.0Gbyte	5
Database	Memory capacity for 20 years record	5
Monitoring panel	52 inches display LDC	5
Electric bulletin board (warning tower)	5.0 m width and 3.0 m height Rio do Sul (3), Blumenau (3), Itajai (3)	9
Alarm (siren)	Large disaster warning siren, for external moisture	57

Source: JICA Study Team

The cost estimate for new gauging stations including the Master Station and Monitoring Centers is shown in Table 6.4.3.

Table 6.3.3 Cost Estimate for Proposed Gauging Stations

Item	Nos.	Unit Price (R$)	Amount (R$)
Telemetry rainfall gauge	16	5,300	84,800
Telemetry water level gauge	16	6,800	108,800
Software	16	-	-
Solar panel/battery	16	17,000	272,000
Data transmission (GPRS)	16	20,000	320,000
CCTV	5	26,500	128,000
Data transmission (GPRS)	5	20,000	100,000
Database	5	120,000	600,000
Monitoring panel	5	8,000	40,000
Electric bulletin board (warning tower)	9	30,000	270,000
Alarm (siren)	57	2,000	114,000
Monitor station	3	80,000	240,000
Central station	1	257,000	257,000
Total			**2,534,600**

Note: The cost for development of programs regarding the telemeter system is not included in the above cost.

Source: JICA Study Team

The unit price of equipments and establishment of center including system development is shown in the Supporting Report D. The river register book is needed to prepare for total river management together with the proposed gauging stations above. The river register book must include total 350 cross section survey (1.0 km interval) along Itajai Main River and major tributaries, cross section survey for existing water level gauges and km piles (KP) along the river. The work for river register book shall also include the development of modeling for the flood runoff analysis.

The purposes for the consultant services regarding the system development are as follows.

i) Tendering for procurement of equipments

ii) Training for concerned organizations

iii) Development for flood forecasting modeling and simulation modeling

iv) Establishment for H-Q curves for all water level gauging stations including existing and proposed stations

v) Study for preparation of operation system for Bonito and Pinhal Dams

vi) Study for preparation of operation system for Oeste and Sul Dams

The cost for the consultant services for system development is shown in Table 6.4.4.

Table 6.3.4 Cost for Consultant Services for System Development

Item	M/M	Unit Price (R$)	Amount (R$)
Project Manager	10	60,000	600,000
Hydrologist	8	50,000	400,000
River Engineer	8	50,000	400,000
Program Engineer	4	50,000	200,000
Telecommunication Engineer	5	50,000	300,000
System Engineer	5	50,000	300,000
Network Engineer	5	50,000	300,000
Database Engineer	5	50,000	300,000
Supporting Staff	10	20,000	200,000
Total	-	-	**3,000,000**

Source: JICA Study Team

The direct cost for the propose FFWS is shown in Table 6.3.5.

Table 6.3.5 Direct Cost for Strengthening Existing FFWS

Item	Amount (R$)
1. Equipment cost	2,534,600
2. River survey for a river inventory book	1,500,000
3. System development	3,000,000
Total	**7,034,600**

Source: JICA Study Team

CHAPTER 7 FEASIBILITY STUDY OF STRUCTUAL MEASURE FOR LANDSLIDE

7.1 General

The 13 priority sites (potential annual loss is more than R$500 thousand) are selected for structural measures. The safety target of the structural measure is to ensure full functionality of the infrastructure and/or buildings/lands against heavy rain of 60 years return period, or heavy rain level of in November 2008 at Blumenau Municipality (hereinafter referred to as '60 years heavy rain') . All of the priority sites are road slops, and the structural measures will be planed to ensure full width road traffic against 60 years heavy rain.

In the master plan, safety target is set to ensure half width road traffic against 60 years heavy rain. In this feasibility study, safety target is changed to ensure full width road traffic against 60 years heavy rain, because that high possibility of human lives lost is recognized on 13 priority sites by new finding of the field survey and comprehensible consideration as summarized in follows.

The partial width road closure is expected even structural measures have been conducted to ensure half width road traffic against 60 years heavy rain. In that case, the landform characteristics indicate that rapid slope collapse which directly attack road users, or tumble down of road users due to sudden road foundation failure.

Annual average daily traffic (AADT) of the priority 13 sites is relatively higher and from 1,800 to 43, 000 vehicles per day. The high traffic may increase possibility of direct hit by disasters; even they are partial width road closure.

Especially, 7 sites are Aregisso Vermelho-Anarelo (red-yellow soils) which has the character of remarkable strengths deterioration by water contains. The shallow slide deformations were recognized on sod facing cut slopes on Aregisso Vermelho-Anarelo by the inspection in April 2011. The deformations had been progressive by the comparison with the inspection in May 2010; even the slopes had not suffered by 60 years heavy rains. The new finding shows that cutting slopes of 7 meter height or more on Aregisso Vermelho-Anarelo have a high possibility of collapse by a 60 year heavy rain, because they are slightly deformed even with sod facing without 60 year heavy rains. In the master plan stage, reinforced earth of cut slop is planed on slopes on 15 meter height or more, because these slopes can not secure the half width road traffic when they are collapsed. In the feasibility study, reinforced earth on cut slope is adopted on more widely on cut slopes of 7 meter or more to avoid human lives loss and to secure whole width road traffic for 60 year heavy rains.

Type for measures will be selected by learning form existing measures of similar condition slopes, which have not been occurred disaster even 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 road drainage will be planed by using rainfall intensity- duration curve of 10 years return period, according to the practices of DEINFRA.

Following three methods have not utilized in Itajai River basin. It means that they has not be untried of 60 years heavy rain. In referring experience of similar slopes in Japan, they are also selected as alternative methods for this feasibility study..

Lightweight embankment of expanded polystyrene (EPS)

Reinforced earth of polypropylene (PP) fiber/cement/sand mixture

Connecting concrete blocks revetment which enable covering soil and vegetation

Landslides cause sediment discharge also, and it cause negative influence of flood, flash flood, further landslide process, and infrastructure function. Therefore vegetation and drainage ditch

will be utilized to protect erosion. In no risk place of falling trees, the trees will be planted. The tree plantation will contribute to the carbon fixation and the improvement of global environment, also.

7.2 Landslide Type and Selection of Type of Structural Measures

7.2.1 Classification of Landslide Type

Appropriate structural measures are different by type of landslide movement and landslide location from preservation object generally. In this feasibility study, types of landslide are a as Table 7.2 .1 for the selection of the appropriate structural measures.

Table 7.2.1 Type of Landslide

Landslide location from preservation object	Type of landslide movement
Mountainside slope	Collapse
Vallyside slope	
River bank slope	
-	Slide
-	Flow

Source: JICA Survey Team

The selected 13 priority sites and types of landslide are summarized in Table 7.2.2.

Table 7.2.2 Selected 13 Priority Sites and Type of Landslide

No. of priority order	Site	Municipality	Management	Potential annual loss mil R$/year	Type of landslide
1	SC 302 Taio-Passo Manso-5	Taio	State	1,255	Slide
2	SC470 Gaspar River Bank	Gaspar	State	1,095	River bank collapse
3	Blumenau -Av Beira Rio	Blumenau	Municipality	1,021	River bank collapse
4	SC418 Blumenau - Pomerode	Pomerode	State	989	Slide
5	SC474 Blumenau-Massaranduba 2	Blumenau	State	907	Mountainside collapse
6	Gaspar - Luiz Alves, Gaspar 9	Gaspar	Municipality	774	Slide, Mountainside, and valley side collapse
7	Gaspar - Luiz Alves, Luiz Alves 6	Luiz Alves	Municipality	700	Mountainside collapse
8	SC470 Gaspar Bypass	Gaspar	State	689	Mountainside collapse
9	SC477 Benedito Novo - Doutor Pedrinho 1	Benedito Novo	State	680	Slide
10	SC418 Pomerode-Jaragua do Sul 1	Pomerode	State	651	Vallyside collapse
11	Gaspar - Luiz Alves, Luiz Alves 4	Luiz Alves	Municipality	629	Mountainside collapse
12	SC474 Blumenau - Massaranduba 1	Blumenau	State	601	Mountainside collapse
13	SC 302 Taio - Passo Manso 4	Taio	State	526	Mountainside collapse

Source: JICA Survey Team

7.2.2 Selection of Measure against Mountainside Collapse

The selection criteria of measure structural type's alternatives against mountainside collapse are formulated by the policy described in section 7.1.1 and shown in Table 7.2.3. The vegetation works, and open ditch are included in basic measures to prevent sediment discharge.

There are many existing gabion retaining walls on slope foots with slope vegetation in the Itajai river basin. It is enough against 60 years heavy rain for the slope less than 7 m height. But in case of slope height is more than 7m, some slopes occurs deformation as shown in following photo.

Slope deformation in cut slopes which higher than 7 m on SC 474 Blumenau - Massaranduba road in Blumenau Municipality.

Source: JICA Survey Team

Table 7.2.3 Structural Measures against Mountainside Collapse

Slope condition		Typical measure alternatives	Common items
Stable cutting gradient is Not secured		Rock bolts, anchor works.	Open ditch, vegetation
There is rock falls probability		Removal of unstable rock, foot protection, rock protection fence, rock catch/cover net.	
Stable cutting gradient for deep collapse is secured	Slope height is more than 7 m.	Cutting of unstable portion, slope reinforcement works.	
	Slope height is less than 7 m	Cutting of unstable portion, vegetation net, and gabion on slope foot.	

Source: JICA Survey Team

Structural measures types are selected against mountainside collapse as Table 7.2.4. To prevent erosion or sediment discharge due to rainfall or springs, open ditch and vegetation are planed for all selected sites.

Table 7.2.4 Selected Measures for Mountainside Collapse

No. of priority order	Site	Height Gradient	Soil or rock type	Spring recognized	Selected structural measure
5	SC474 Blumenau-Massaranduba 2	15 m height 40 degree	Weathered rock	In rainfall time	1. Cutting of unstable portion 2. Open ditch 3. Slope reinforcement works 4. Vegetation
6	Gaspar - Luiz Alves, Gaspar 9	15 m height 45 degree	Clay, sand, or weathered rock		
7	Gaspar - Luiz Alves, Luiz Alves 6	10-20 m 60 degree	Clay, sand, or weathered rock		
8	SC470 Gaspar Bypass	20 m 50 degree	Weathered rock		
11	Gaspar - Luiz Alves, Luiz Alves 4	15 m 25 degree	Clay, sand, or weathered rock		
12	SC474 Blumenau-Massaranduba 1	30 m 50 degree	Weathered rock		
13	SC 302 Taio-Passo Manso 4	20 m 50 degree			

Source: JICA Survey Team

Comparison of alternatives of slope reinforcement measure for 1,000 m^2 is carried out and shown in Table 7.1.4. Reinforced earth method of PP fiber/ cement/sand is recommendable, because it is advantage of all evaluation items of the cost, construction period, and landscape.

- Crib works (shotcrete crib)
- Crib works (cast-in-place concrete crib)
- Reinforced earth of PP fiver/cement/sand mixture

Table 7.2.5 Comparison of Alternatives of Slope Reinforcement Measure

	Shotcrete crib works	Cast-in-place concrete crib works	Reinforced earth of PP fiver/cement/sand mixture
Example photo			
Constriction date estimation date estimation for 1000 m^2	Sub-work items / day/1000 m^2 Cleaning slope 5 Wire mesh 8 Crib works 25 Vegetation 5 Total 43	Sub-work items Cleaning slope Crib works including curing term Vegetation Total	Sub-work items / Day/1000 m^2 Cleaning slope 5 Anchor bar 40 Drainage Reinforced earth of PP 5 Vegetation 50 Total
Unit cost,	Sub-work items / R$/$m^2$ Cleaning slope 15 Wire mesh 45 Crib works 300 Vegetation 65 Total 425	Sub-work items / R$/$m^2$ Cleaning slope 15 Crib works 340 Vegetation 65 Total 420	Sub-work items / R$/$m^2$ Cleaning slope 15 Anchor bar 50 Drainage 35 Reinforced earth of PP 235 Vegetation 75 Total 410
Evaluation	Not recommendable - 2nd long construction period - Highest construction cost - Not good landscape	Not recommendable - Longest construction period - 2nd low cost Construction - Not good landscape	Recommendable alternative - Shortest construction period - Lowest construction cost - Good landscape

Source: JICA Survey Team

7.2.3 Selection of Measure against Valley Side Slope Collapse

The selection criteria of measures alternatives against valley side slope collapse are formulated by the policy described in section 7.1.1 and shown in Table 7.2.5. The vegetation works, and open ditch is included in basic measures to prevent sediment discharge.

Table 7.2.6 Structural Measures against Valley Side Collapse

Slope condition			Typical measure alternatives	Common item
Height (H) of collapse H>10	Height (H) and width (W) of collapse H/W > 0.5		Pilling, or large block placing	Tree planting Open ditch
	Height (H) and width (W) of collapse H/W ≦0.5		Gully filling by gabion and longitudinal drainage	
Height (H) of collapse H≦10	Height (H) and width (W) of collapse H/W > 0.5	Embankment on slope foot is Possible	Embankment	
		Embankment on slope foot is Impossible	Pilling, or large size block placing	
	Height (H) and width (W) of collapse H/W ≦0.5		Gully filling by gabion and longitudinal drainage	

Source: JICA Survey Team

Table 7.2.7 Selected Measures for Valley Side Collapse

No. of priority order	Site	Height of collapse	Width of collapse	Embankment possibility	Selected Measure
6	Gaspar - Luiz Alves, Gaspar 9	30m	3m	Impossible	Gully filling by gabion and longitudinal drainage, tree planting
10	SC418 Pomerode – Jaragua do Sul 1	8m	30m	Possible	Embankment, open ditch, tree planting

Source: JICA Survey Team

7.2.4 Selection of Measure against River Bank Collapse

Selections of measures for two river bank slope collapse (priority No.2 SC 470 Gaspar River Bank, priority No.3 Blumenau - AV. Pres Casrelo Branco) are conducted by considering river flow rate and advantage for environment preservation.

The flow rates are calculated by river cross section at the sites using height - quantities relation of river discharge at studied sites.

Table 7.2.8 Height - Quantities Relation of River Discharge at Studied Sites

Discharge (m^3/s)	Priority No.2 SC 470 Gaspar River Bank	Priority No.3 Blumenau AV. Beira Rio	Remark
500	1.98	2.41	
1,000	3.01	3.94	
1,500	4.13	5.37	
2,000	5.28	6.71	
2,500	6.29	7.88	
3,000	7.25	8.92	
3,500	8.27	9.96	
3,700	8.58	10.30	Discharge return period 10 year
4,000	9.04	10.81	
5,000	10.44	12.36	
5,500	11.09	13.06	Discharge return period 50 year
6,000	11.74	13.77	

Source: JICA Survey Team

Flow rate is calculated as shown in Table 7.2.9. Compensating rate of both sites is adopted 1.0, because Priority No.2 SC 470 Gaspar site is straight river course, and Priority No.3 Blumenau AV. Pres Casrelo Branco is fixed bed of solid rock and the radius of the river is about 2km.

Table 7.2.9 Design Flow Rate

Site	Return Period or Max value	Design discharge (m3/S)	Sectional area (m2)	Flow rate (m/s)	Straight or Incurve	Bed condition	Compensating rate	Design flow rate (m/s)
Gaspar	50	5,500	3,543	1.55	Straight	Fixed	1.0	1.55
	Max	5,609	3,995	1.40	Straight	Fixed	1.0	1.40
Blumenau	50	5,500	2,069	2.65	Curve	Fixed	1.0	2.65
	Max	6,008	2,182	2.75	Curve	Fixed	1.0	2.75

Source: JICA Survey Team

Experimentally applicable condition of revetment types for slope conditions shown in Table 7.2.10.

For priority No.2 SC 470 Gaspar River Bank, gabion revetment is applicable as shown in Table 7.2.11.

For priority No.3 Blumenau AV. Pres Casrelo Branco, revetment of connecting concrete blocks with cover soil and vegetation is applicable as shown in Table 7.2.12.

Table 7.2.10 Applicable Condition of River Revetment Types

River Revetment Type		Experimentally applicable condition	
		Design Flow Rate (m/sec) 2 3 4 5 6 7	The other condition
Vegetation	Sodding	Gaspar site	Area for higher than ordinary water level
Sheet	Geotextile	Blumenau site	Without area for gravels/cobbles sediments. Without water impact part.
	Block matt		
Wood material	Log crib works		Without area for gravels/cobbles sediment. Area where lower than ordinary ground level of area protected by levee
	Brushwood crib works		
	Woodpile fence		
Stone material	Dry stone pitching (without mortar)		In case of stone material is available near the site. Area where lower than ordinary ground level of area protected by levee
	Wet stone pitching (with mortar)		
Gabion	Wirer-cylinder		Without area for gravels/cobbles sediment. Area where lower than ordinary ground level of area protected by levee
	Flat gabion placing		
Concert material	Connecting concrete blocks		It is applicable at area of gravels/cobbles sediment
	Concert block pitching		

Legend

	Applicable range
	Applicable, but more low cost alternative is applicable.

Source: JICA Survey Team referring web-page of Ministry of Land Transportation and Infrastructure ,Japan

Table 7.2.11 Selection Result for Priority No.2 SC 470 Gaspar River Bank

Type of Revetment		Adaptabilitas
Vegetation	Sodding	NOT applicable. The site is broken portion by 60 year heavy rain. Local rapid flow rate might be occurred.
Sheet	Geotextile	
	Block matt	
Wood material	Log crib works	NOT applicable. Wood materials will be deteriorated in 10 years.
	Brushwood crib works	
	Woodpile fence	
Stone material t	Dry stone pitching (without mortar)	NOT applicable. It is difficult to stable cover soil as vegetation base.
	Wet stone pitching (with mortar)	
Gabion	Wirer-cylinder	Applicable. It is good landscape harmony with both side of stream by using cover soil.
	Flat gabion placing	
Concrete	Connecting concrete blocks	Applicable and Not Advantage in cost.
	Concert block pitching	NOT applicable. It is require the special type block material for stable soil covering as vegetation base

Source: JICA Survey Team

Table 7.2.12 Selection Result for Priority No.3 Blumenau AV. Pres Casrelo Branco

Type of Revetment		Adaptabilitas
Vegetation	Sodding	NOT applicable. It is NOT stable against design flow rate.
Sheet	Geotextile	NOT applicable. The site is beside the bridge pier and possibility of rapid flow rate.
	Block matt	
Wood material	Log crib works	NOT applicable. Wood materials will be deteriorated in 10 years.
	Brushwood crib works	
	Woodpile fence	
Stone material	Dry stone pitching (without mortar)	NOT applicable. It is difficult that stable cover soil placing as vegetation base.
	Wet stone pitching (with mortar)	
Gabion	Wirer-cylinder	NOT applicable

	Flat gabion placing	It is not harmony with continuous landscape with upstream and down stream. The landscape of the site is important for Blumenau Municipality.
Concrete	Connecting concrete blocks	Applicable. It shall be adopted the type of connecting concrete block revetment which available soil as vegetation base.
	Concert block pitching	NOT applicable. It is not available stable soil covering as vegetation base

Source: JICA Survey Team

Table 7.2.13 Selected Measures for Valley Side Collapse

No. of priority order	Site	Height of slope	Average slope gradient Horizontal: Vertical	Design flow rate (m/sec)	Selected Measure
2	No.2 SC 470 Gaspar River Bank	30m	1: 0.7 35 degree	1.6	Gabion revetment, cover soil, vegetation
3	No.3 Blumenau AV. Pres Castelo Branco	8m	1:0.6 31 degree	2.8	Connecting concrete blocks revetment, cover soil, vegetation

Source: JICA Survey Team

7.2.5 Selection of Measures against Slide

(1) Factor of Safety of Sliding

Stability analysis is conducted for determination of the scale and quantity of structural measure to maintain the stability of the sliding slope by ensuring the design factor of safety.

The Swedish slice method is used for stability analysis of a landslide slope, as follows:

$$Fs = \frac{(\Sigma N - \Sigma U) \times \tan\phi + C \times \Sigma L}{\Sigma T}$$

Where,

N(kN/m) = Normal force along sliding surface by gravity of slice, N=Wcosα

T(kN/m) = Tangential force along sliding surface by gravity of the slice, T=Wsinα

α（°） = Angle of the base of the slice to the horizontal

U(kN/m) = Uplift due to pore pressure acting on sliding surface of the slice

L（m） = Length of sliding surface acting on the slice

C(kN/m^2) = Cohesion of sliding surface

φ（°） = Internal friction angle of sliding surface

Table 7.2.14 Determination of Initial Factor of Safety (IFS)

Initial factor of safety	Movement conditions
IFS = 0.95	• A large number of obvious potential slide topography such as scarps, bulges, stepped land, ponds and swamps; and • Many visible ongoing and active movements of cracks, subsidence, upheaval, toe erosion, or small toe collapse as well as springs.
IFS = 0.98	• Obvious potential slide topography such as bulges, stepped land, ponds and swamps, but • Few or small ongoing movements of cracks, subsidence, upheaval, or small toe collapse.
IFS = 1.00	• Potential slide area is at rest, and • Cracks, subsidence, upheaval, or small toe collapse are visible, but not progressing.

Source: Modification from MANUAL FOR RIVER WORKS IN JAPAN, Published by River Bureau, Ministry of Construction Japan, November 1997

The design factor of safety (DFS) is the target value for enhancing the slope stability by structural measures as shown in Table 7.2.15.

Table 7.2.15 Determination of Design Factor of Safety (DFS)

Design factor of safety	Condition
DFS = 1.10 to 1.20	• Sudden and severe movement is expected; and • Slide prone cause significant damage to, houses, buildings infrastructures, and/or human lives.
DFS = 1.05 to 1.10	• A slide have little effect on houses, buildings or infrastructures; or • The proposed prevention works are temporary countermeasures.

Source: Modification from MANUAL FOR RIVER WORKS IN JAPAN, Published by River Bureau, Ministry of Construction Japan, November 1997.

The design factor of safety indicates multiplication ratio to the initial factor of safety IFS after completion of structural measures.

The slide slopes of this feasibility study, and initial/target factor of safety are determined in accordance with Table 7.2.14 and Table 7.2.15, and shown in Table 7.2.16.

Table 7.2.16 Object Slopes against Slide and Initial/Target Factor of Safety

Priority No.	Site	Initial factor of safety (IFS)	Design factor of safety (DFS)
1	SC 302 Taio-Passo Manso-5	1.00	1.15
4	SC418 Blumenau – Pomerode	1.00	1.15
6	Gaspar - Luiz Alves, Gaspar 9	1.00	1.15
9	SC477 Benedito Novo - Doutor Pedrinho 1	1.00	1.15

Source: JICA Survey Team

(2) Selection of Structural Measure Types

Table 7.2.17 shows the general structural measures for slides. The structural measure types are selected by flow as shown in Figure 7.2.1.

The selected structural measures for 4 slides sites are shown in Table 7.2.18.

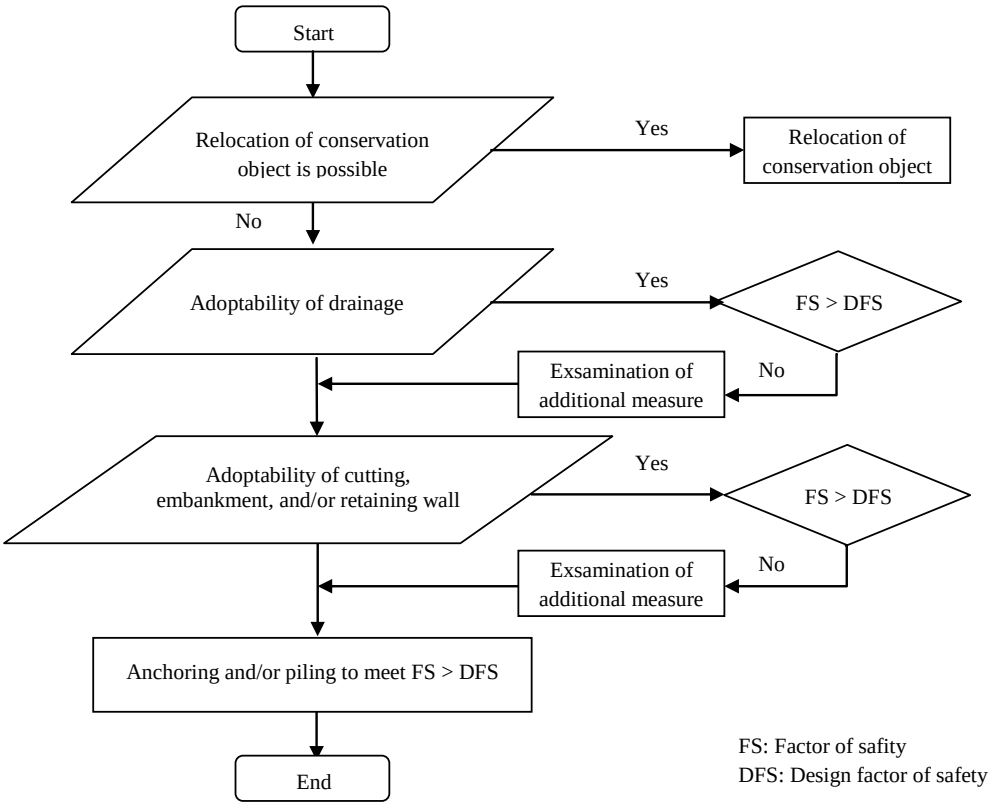
The effects of groundwater level lowering by installation of drainage are set experimentally as shown in Table 7.2.19.

For the site of the priority No. 9 SC477 Benedito Novo - Doutor Pedrinho 1, groundwater drainage is not appropriate; because groundwater table is initially low. Light weight embankment by EPS (Expanded polystyrene) is appropriate for the site condition of deep foundation rock and low groundwater.

Table 7.2.17 General Structural Measures for Slides

Classification		Type of Structural Measure
1. Drainage	Surface Drainage	Open ditch
	Underground Drainage	Closed conduit with open ditch
		Horizontal drainage drilling
		Drainage wells
		Drainage tunnels
2. Cutting and Embankment		Cutting of slide head
		Embankment of slide foot
		Light weight embankment of slide head
3. Retaining wall		Gabion walls
		Retaining walls
4. Anchoring		Rock bolts
		Ground anchors
5. Piling		Steel pipe piles
		Shaft work

Source: JICA Survey Team



Source: JICA Survey Team

Figure 7.2.1 Flowchart of Selection of Structural Measures for Slide

Table 7.2.18 List of Structural Measures and Result of Stability Analysis

No. of priority order	Site	IFS: Initial factor of Safety	DFS: Design factor of safety	Safety factor after groundwater drainage or light weight embankment	Measure
1	SC 302 Taio-Passo Manso-5	1.00	1.15	1.14 by 1.0 m lowering of groundwater table. 1.20 by 1.5 m lowering of groundwater table.	Horizontal drainage drilling Gabion retaining wall
4	SC418 Blumenau - Pomerode	1.00	1.15	1.15 by 0.5 m lowering of groundwater table.	Closed conduit with open ditch, Gabion retaining wall
6	Gaspar - Luiz Alves, Gaspar 9	1.00	1.15	1.150 by 1.0 m lowering of groundwater table.	Horizontal drainage drilling Gabion retaining wall
9	SC477 Benedito Novo - Doutor Pedrinho 1	1.00	1.15	1.15 by lightweight embankment.	Lightweight embankment

Source: JICA Survey Team

Table 7.1.19 Effects of Groundwater Level Lowering by Installation of Drainage

Type of Work	Lowering of groundwater table
Closed conduit with open ditch	-0.5m
Horizontal drainage drilling	From -1.0 to - 1.5m

Source: JICA Survey Team

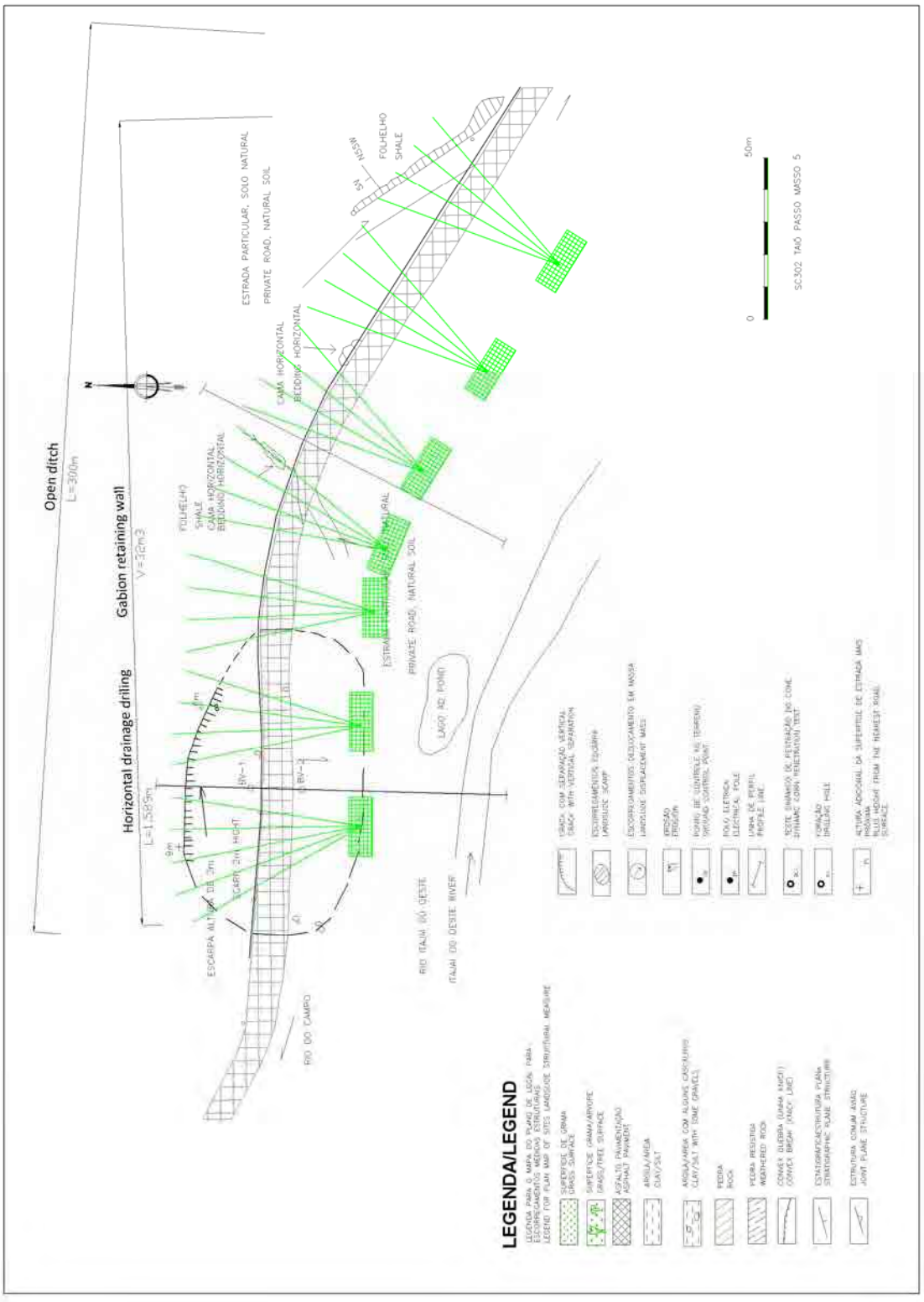
7 .3 Feasibility Design on Structural Measures for the Selected Site

The work quantities of structural measures are summarized in Table 7.3.1. Layout of the structural measures of priority No.1 Taio-Passo Manso is shown in Figure 7.3.1 and 7.3.2.

Table 7.3.1 Work Quantities of Structural Measures

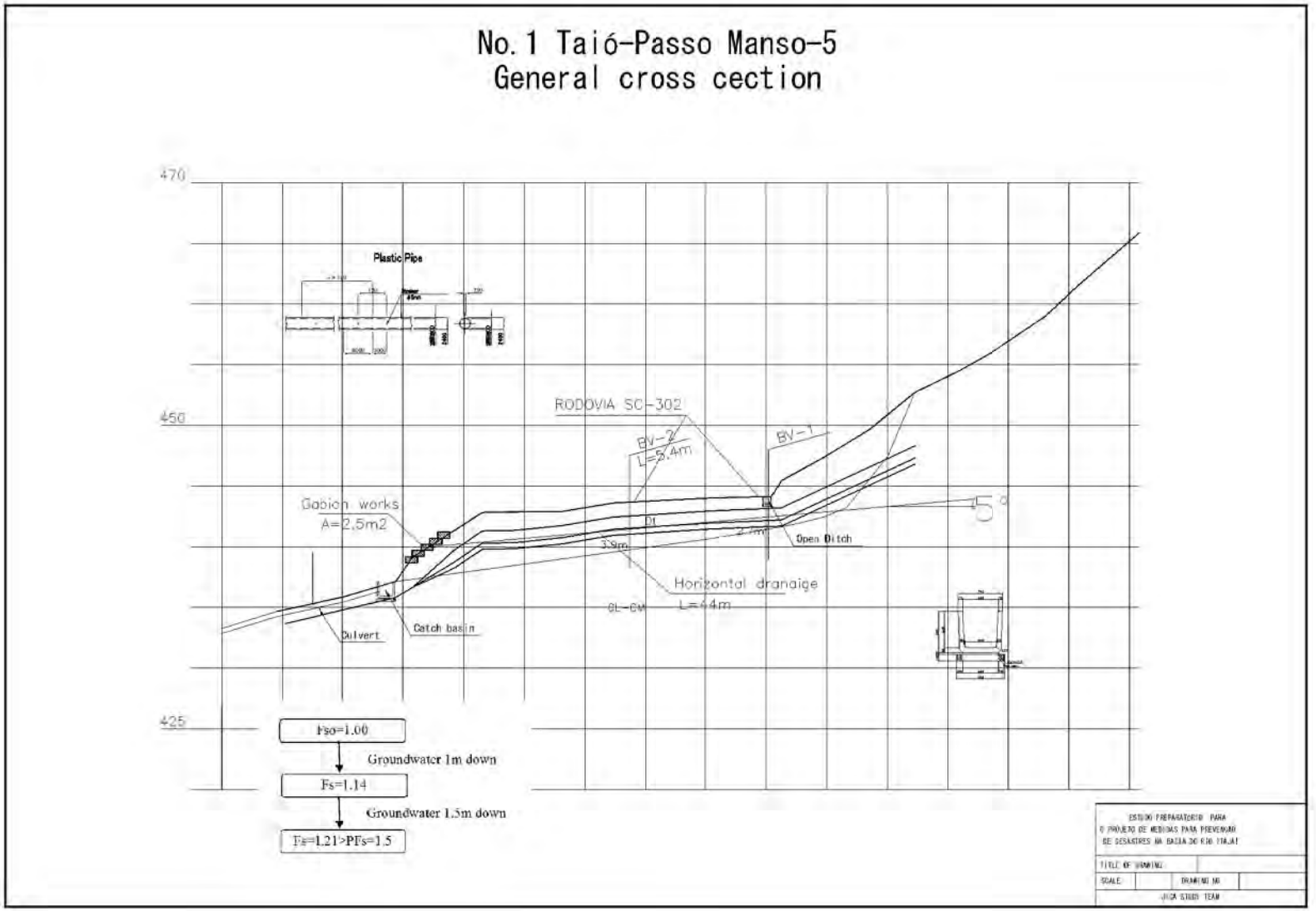
No. of priority order	Site name	Type of countermeasure	Unit	Quantities
1	SC 302 Taio-Passo Manso-5	Horizontal Drainage drilling	m	1,589
		Gabion retaining wall	m^3	32
		Open ditch	m	300
		Land acquisition (rural area)	m^2	7,000
2	SC470 Gaspar River Bank	Cutting, excavation	m^3	16,660
		Embankment	m^3	16,660
		Pavement	m^2	700
		Gabion retaining wall	m^3	2,000
		Nursery planting	m^2	3,400
		Concrete culvert pipe placing	M	27
3	Blumenau – Av Pres Castelo Branco	Sheet pile	m^2	598
		Connecting concrete block	m^2	4,852
		Geotextile	m^2	4,852
		Cutting	m^3	150
		Sodding	m^2	4,852
4	SC418 Blumenau – Pomerode	Closed conduit with open ditch	m	373
		Gabion retaining wall	m^3	238
		Open ditch	m	95
		Reinforced earth of polypropylene fiber/cement/sand mixture with vegetation	m^2	3,112
5	SC474 Blumenau-Massaranduba 2	Reinforced earth of polypropylene fiber/cement/sand mixture with vegetation	m^2	6,986
6	Gaspar - Luiz Alves, Gaspar 9	Reinforced earth of polypropylene fiber/cement/sand mixture with vegetation	m^2	5,560
		Gabion open ditch	m^3	572
		Waterproof sheet	m^2	312
		Open ditch	m	282
		Horizontal Drainage drilling	m	160
		Gabion retaining wall	m^3	100
		Nursery planting	m^2	14,952
		Land acquisition (rural area)	m^2	14,629
7	Gaspar - Luiz Alves, Luiz Alves 6	Reinforced earth of polypropylene fiber/cement/sand mixture with vegetation	m^2	2,662
		Open ditch	m	240
8	SC470 Gaspar Bypass	Reinforced earth of polypropylene fiber/cement/sand mixture with vegetation	m^2	5,151
		Open ditch	m	182
9	SC477 Benedito Novo - Doutor Pedrinho 1	Lightweight embankment by EPS(Expanded polystyrene)	m^3	1,930
		Cutting, excavation	m^3	1,930
		Open ditch	m	234
		Pavement	m^2	863
		Temporary Scaffold	m^3	450
		Land acquisition (rural)	m^2	500
10	SC418 Pomerode – Jaragua do Sul 1	Gabion retaining wall	m^3	764
		Embankment	m^3	10,216
		Nursery planting	m^2	5,930
		Pavement	m^2	404
		Open ditch	m	340
		Land acquisition (rural)	m^2	6,713
11	Gaspar - Luiz Alves, Luiz Alves 4	Reinforced earth of polypropylene fiber/cement/sand mixture with vegetation	m^2	6,930
		Open ditch	m	260
12	SC474 Blumenau-Massaranduba 1	Reinforced earth of polypropylene fiber/cement/sand mixture with vegetation	m^2	967
13	SC 302 Taio-Passo Manso 4	Reinforced earth of polypropylene fiber/cement/sand mixture with vegetation	m^2	2,182
		Open ditch	m	82

Source: JICA Survey Team



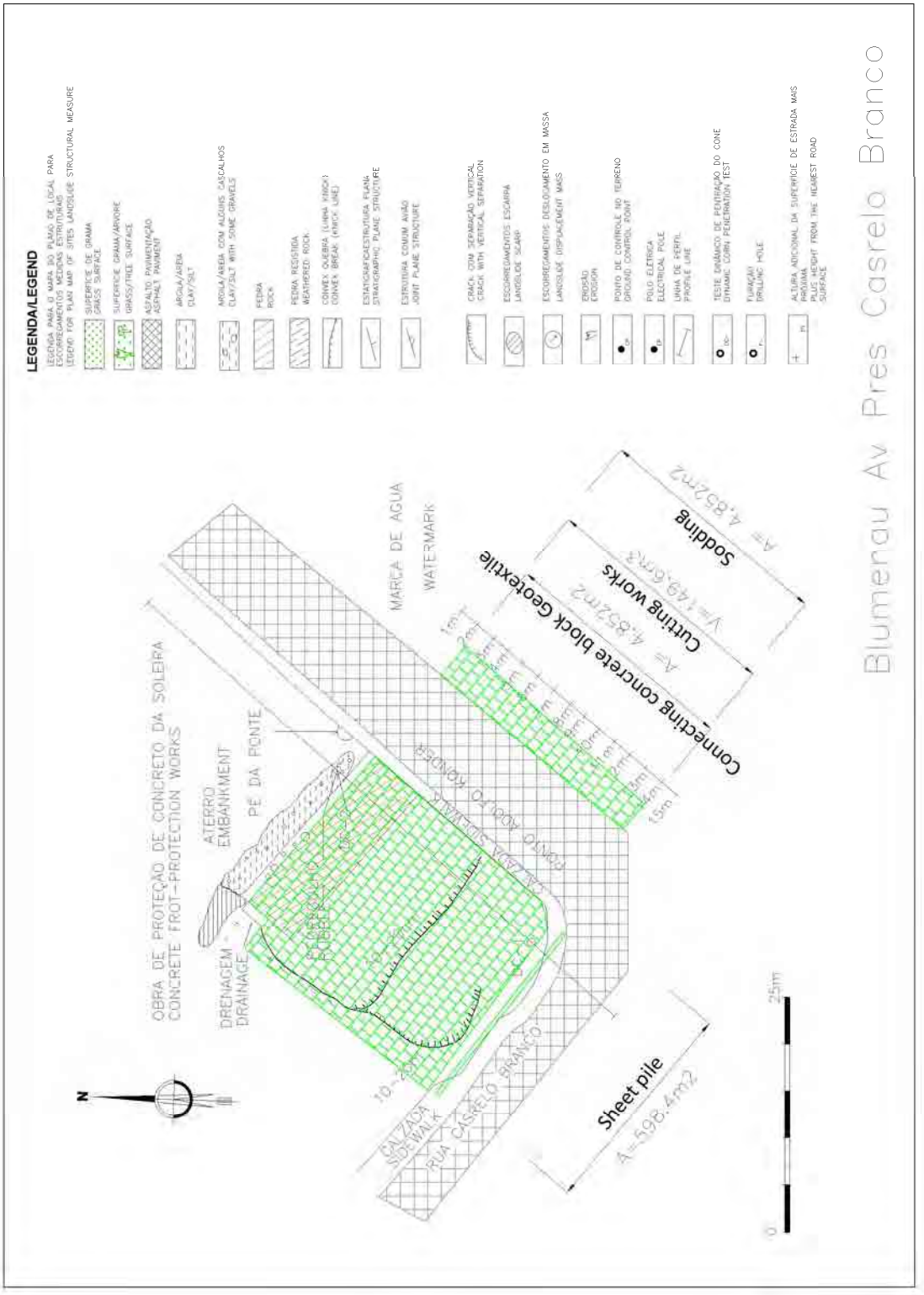
Source: JICA Survey

Figure 7.3.1 Plan Layout of Structural Measure for Priority No.1 Landslide SC 302 Taio-Passo Manso-5



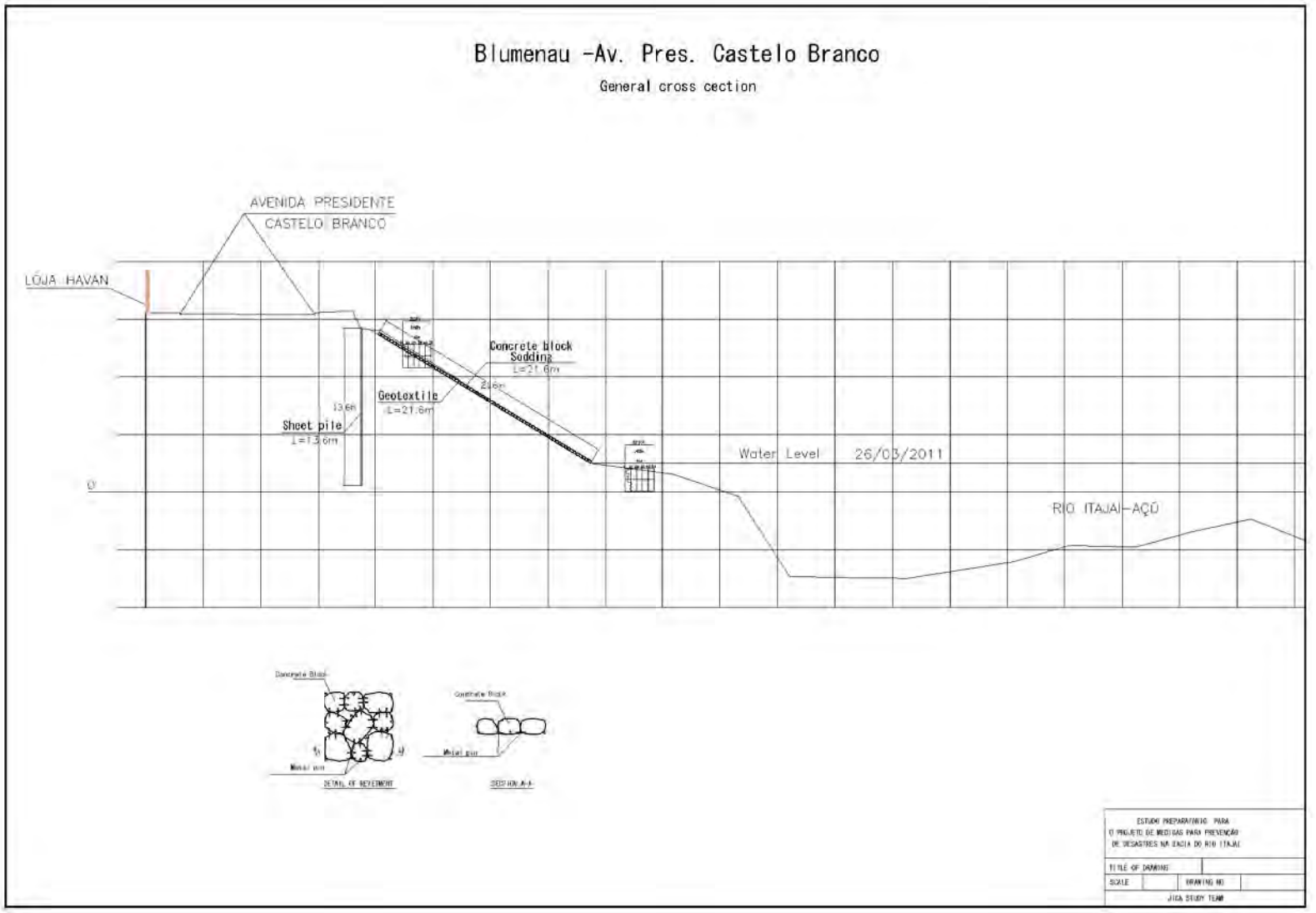
Source: JICA

Figure 7.3.2 Profile Layout of Structural Measure for Priority No.1 Landslide SC 302 Taio-Passo Manso-5



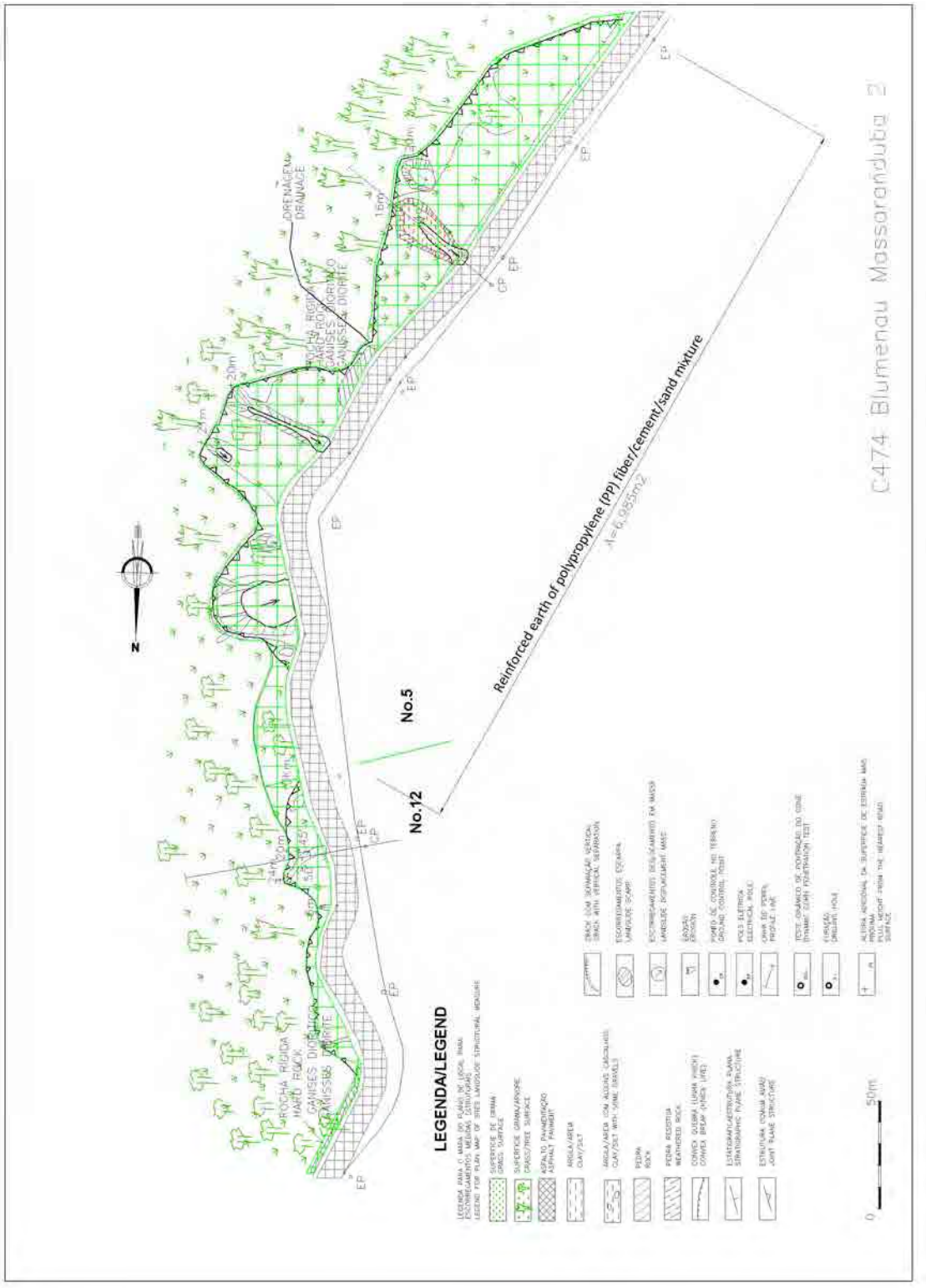
Source: JICA Survey

Figure 7.3.3 Plan Layout of Structural Measure for Priority No.3 Blumenau –Av Pres Casrelo Branco



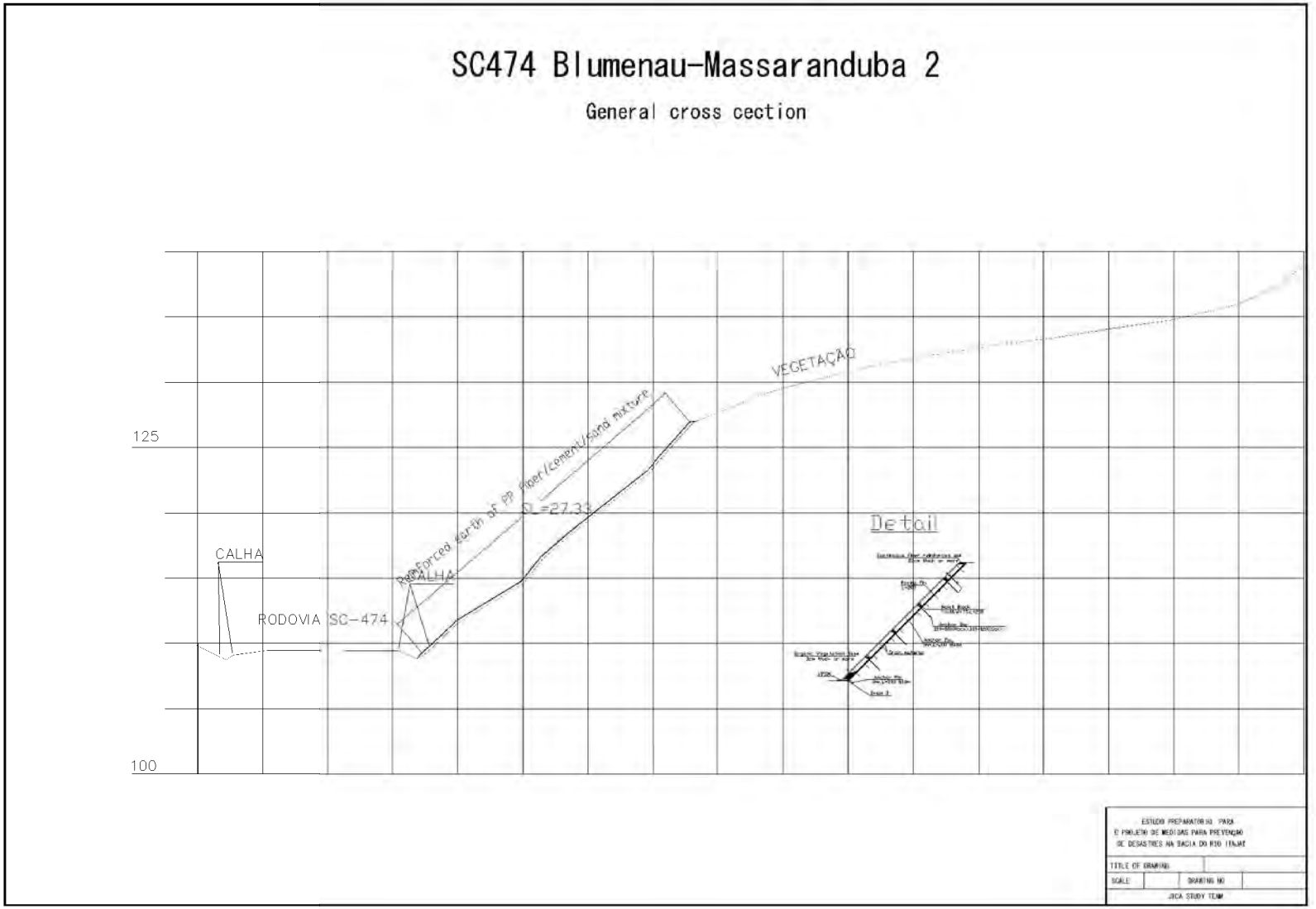
Source: JICA

Figure 7.3.4 Profile Layout of Structural Measure for Priority No.3 Blumenau –Av Pres Casrelo Branco



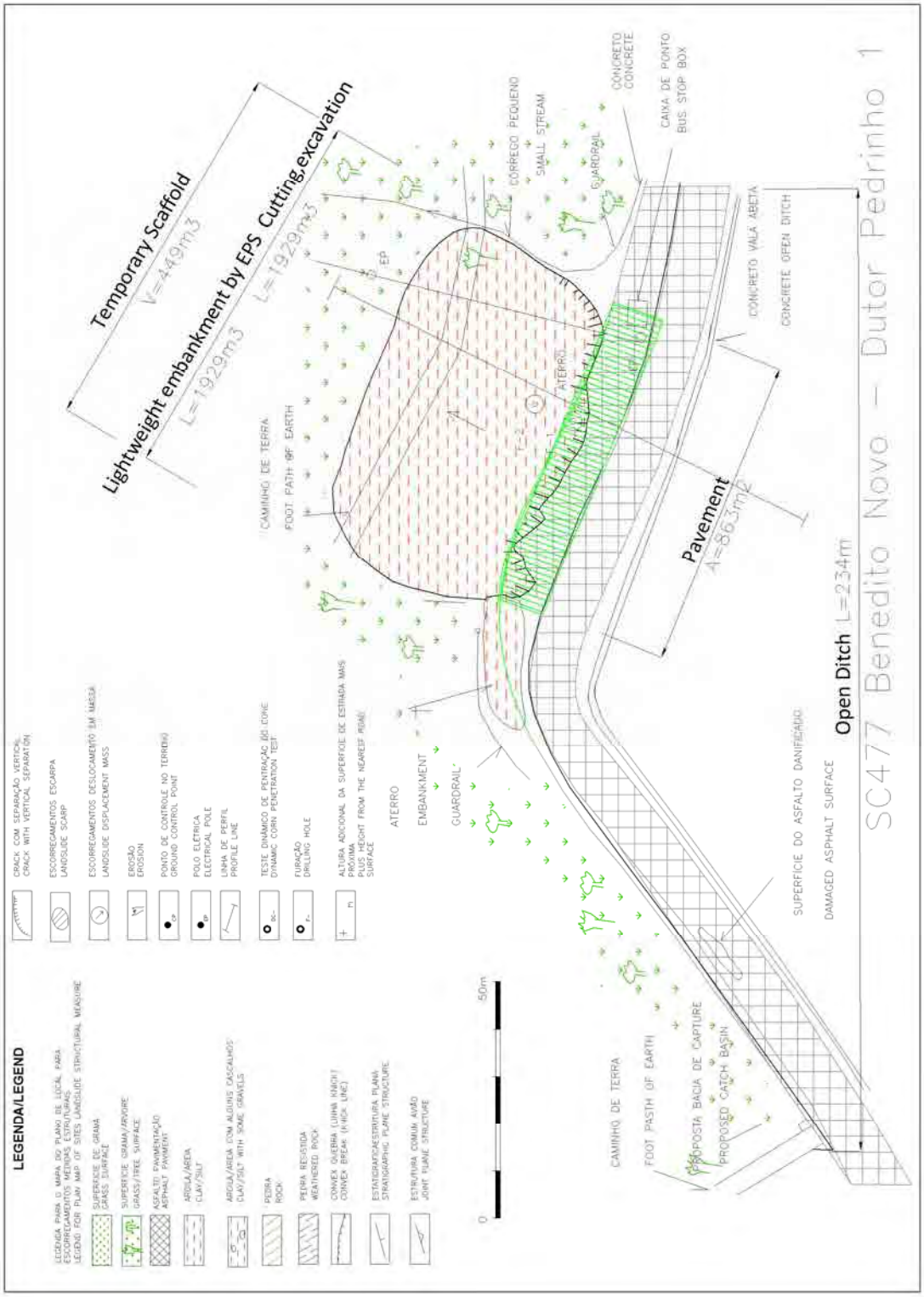
Source: JICA Survey

Figure 7.3.5 Plan Layout of Structural Measure for Priority No.5 SC474 Blumenau-Massaranduba 2



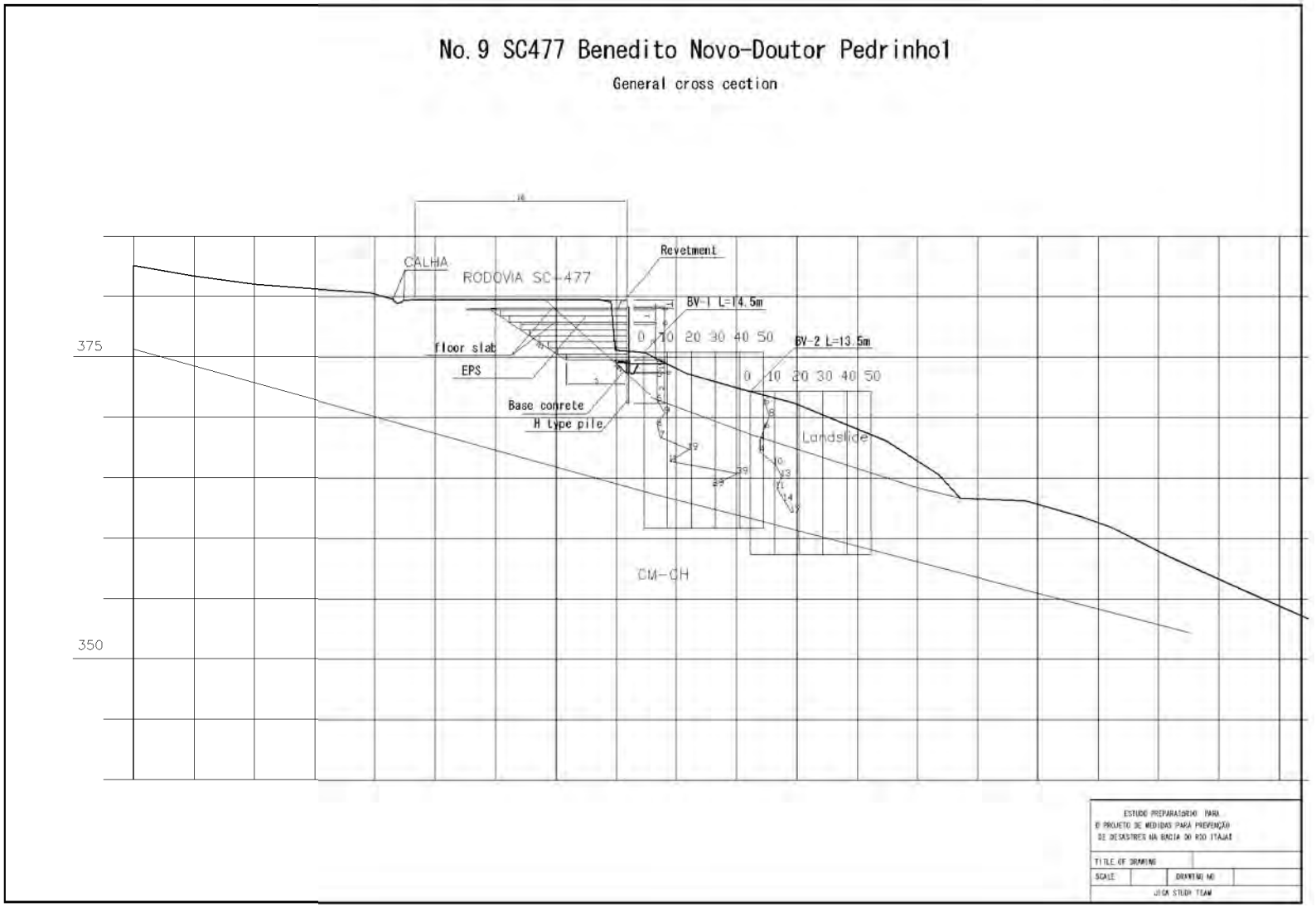
Source: JICA Survey

Figure 7.3.6 Profile Layout of Structural Measure for Priority No.5 SC474 Blumenau-Massaranduba 2



Source: JICA Survey

Figure 7.3.7 Plan Layout of Structural Measure for Priority No.9 SC477 Benedito Novo - Dutor Pedrinho 1



Source: JICA

Figure 7.3.8 Profile Layout of Structural Measure for Priority No.9 SC477 Benedito Novo - Dutor Pedrinho 1

CHAPTER 8 FEASIBILITY STUDY OF EARLY WARNING SYSTEM FOR LANDSLIDE AND FLASH FLOOD

8.1 General

The effectiveness and sustainability of the early warning system for landslide/flash flood are studied regarding following items.

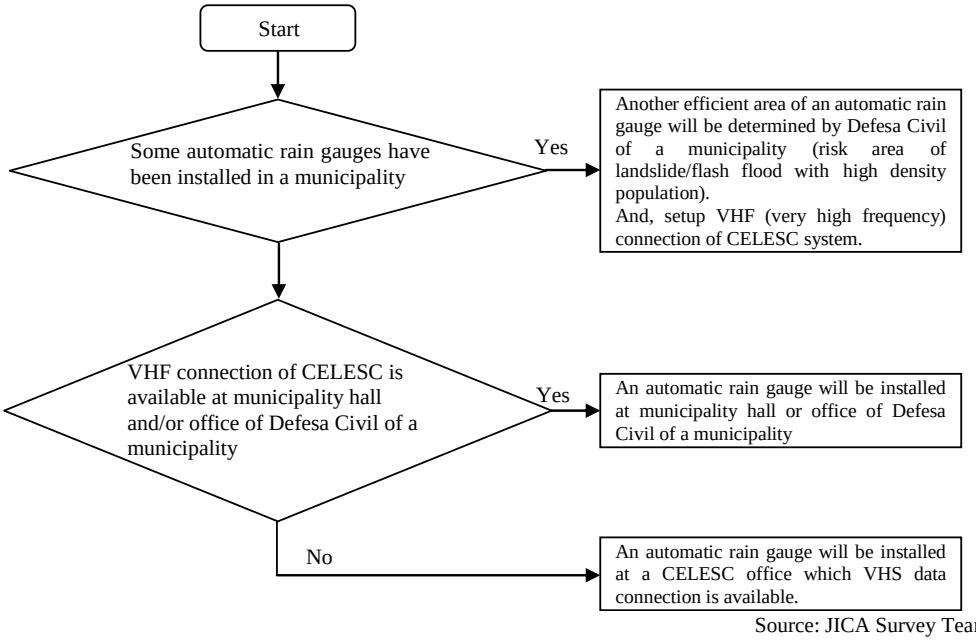
- Rainfall monitoring and data communication/repository
- Criteria of rainfall index for attention/alert
- Management of information, calculation of rainfall index, issue/announce of attention/alert
- Evacuation order and disaster education
- Road traffic regulation for risk avoidance

8.2 Rainfall Monitoring, Data Communication, and Repository

An automatic rain gauge will be installed in each municipality (293 municipalities in Santa Catarina State) for the early warning purpose.

Defesa Civil-SC is a responsible organization for establishment and maintenance of automatic rain gauges and equipments for data communication/repository. EPAGRI/CIRAM and each municipality are implementation organization for the rainfall monitoring, data communication and repository.

Location of automatic rain gauge will be determined by following procedure. Redundant data communication will be established by both of VHS (very high frequency connection) of CELESC system and GPRS (general packet radio services) to secure information communication even under stormy condition.



Source: JICA Survey Team

Figure 8.2.1 Flowchart to Determination Location of Automatic Rain Gauges

8.3 Criteria of Rainfall Index for Attention/Alarm

Criteria of rainfall index for attention/alarm will be set by Defesa Civil-SC by support of EPAGRI/CIRAM.

It is not available landslide/flash flood database with exact time and location of occurrence. The rainfall monitoring stations are sparse, so locations of landslide/flash flood are mostly more than 10 km distance.

Therefore the appropriate criteria setting by the following indexes are not possible so far, it shall be conduct when exact disaster database is furnished.

Accuracy on prediction of disaster occurrence:

$$\text{Correct\_Prediction\_Index} = \frac{\text{Number\_of\_disasters\_over\_the\_warning\_criterion\_value}}{\text{Total \_number\_of\_disasters}} \ (\%)$$

Efficiency on prediction of disaster occurrence:

$$\text{Efficiency Index} = \frac{\text{Total hours for early warning}}{\text{Number of disasters over the warning criterion value}} \ \text{(Hours / Numbers of disasters)}$$

The soil water index (SWI) is used for landslide early warning criteria in Japan as described in the section 9.2.3 of Main Report Part 1 Master Plan.

The Japan methodological agency analyzed that 93 % of fatality due to landslide was caused by most big SWI in past 10 years. The analysis was conducted by 53 thousand landslides data from 2001 to 2009. In case of the storm in November 2011 in the Itajai River basin, the fatalities were occurred only in area of SWI was more than 20 years return period. Therefore, the SWI of 10 years return period is appropriate for alert criteria as the initial setting.

The rainfall index criteria for attention are appropriate to be set once a year level. The purpose of the attention is preparation for alert level storm, reorganization of the warning system by inhabitants, checking of functions of the warning system, and training opportunity for risk avoidance activities.

8.4 Management of Information, Calculation of Rainfall Index, Issue/Announce of Attention/Alarm

Defesa Civil-SC is responsible organization for management of information, calculation of rainfall index, issue of attention/alarm.

The attention and alert are issued by Defesa Civil-SC formally. Because, the early information for the public is important, Defesa Civil-SC delegates EPAGRI/CIRAM the announcement of the rainfall level of attention/warning by web-page and/or mass media, as a part of routine or emergency weather report. The computer system of the early warning shall be included the function of automatic sending electronic mail to Defesa Civil-SC, mayor/defesa civil staff of each municipality, and EPAGRI/CIRAM staffs in charge.

8.5 Evacuation Order and Disaster Education

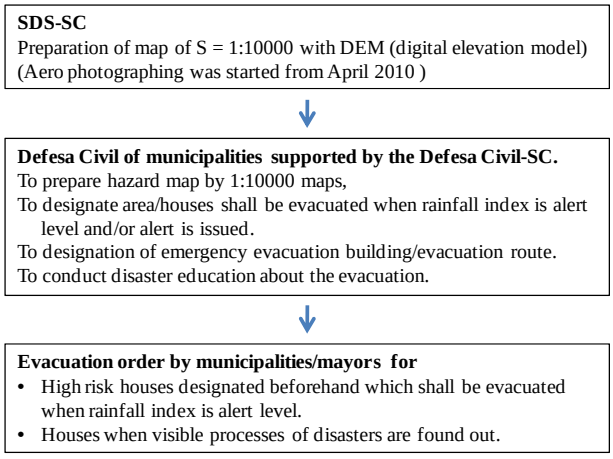
Municipalities/mayors are responsible official for evacuation order. Evacuation will be ordered for risk houses designated which shall be evacuated when rainfall index is alert level. The evacuation will be also ordered if visible processes of disasters are found out.

The Defesa Civil of municipalities will prepare the detailed hazard map (S=1:10000), and will designate the risk areas/houses, emergency evacuation building such as schools and/or churches, evacuation route. The disaster education about the evacuation will be also conducted. Santa Catarina State shall clarify the responsibility of the municipalities/mayors about evacuation order in a law.

The capacity of a municipality is not enough for the evacuation order generally. The Defesa Civil-SC shall coordinate the support of the municipalities, using human resources of universities, engineer of public/private, and/or international technical assistance. The early

warning system shall be started as soon as possible. And then, the risk areas/houses which shall be evacuated would be designated one by one by the maximum effort of municipalities to make mature the early warning system.

The summary of evacuation order and disaster education is shown in Figure 8.5.1.



Source: JICA Survey Team

Figure 8.5.1 Evacuation Order and Disaster Education

8.6 Road Traffic Regulation for Risk Avoidance

The structural measures for landslide will be conducted from high risk (big potential annual loss) slopes. But, there are many landslide/flash flood prone road sections mostly on low traffic volume mountainous road. The potential annual losses of road slopes on low traffic volume are generally not high and not prioritized even they are disaster-prone. Therefore it is required that the road traffic regulation for risk avoidance on disaster prone road segments.

Traffic regulation will be ordered to disaster prone road section designated when rainfall index is alert level. The traffic regulation will be ordered when disaster process associate with landslide/flash flood is found out. The disaster prone road sections would be designated one by one by the maximum effort to make mature the early warning system. After the completion of the structural measures, the designations of disaster prone road sections for early warning will be removed.

Municipality is responsible for municipality roads; DEINFRA is responsible for state roads for the road traffic regulation for risk avoidance. The capacity of a municipality is not enough for the traffic regulation order generally. The Defesa Civil-SC shall coordinate the support of the municipalities, using human resources of universities, engineer of public/private, and/or international technical assistance.

CHAPTER 9 ENVIRONMENTAL AND SOCIAL CONSIDERATION

9.1 Environmental and Social Consideration of Selected Projects

9.1.1 Introduction

The JICA Survey Team has held a series of meetings and public consultations with the relevant stakeholders in accordance with the JICA's Guidelines on Social and Environmental Consideration (2010) in the course of the master plan study. Comments and suggestions given by the stakeholders in the meetings were fully reviewed and examined in the preparation of the master plan. As a result, the JICA Survey Team adopted the disaster-prevention measures against the 50-year flood as the main framework of the master plan.

As described in Chapter 16 of this master plan, the Survey Team propsoed the implementation of the master plan in a stage-wise implementation since the implementation of the entire disaster-prevention measures against the 50-year flood would require an enormous amount of money and take a long period of time until its completion.

To this end, the Survey Team evaluated and examined all the measures proposed in the master plan for prioritization. Among others, the Team put emphasis on whether or not a consensus on the implementation of the proposed measure among the stakeholders is easy to get in the evaluation, as the meetings with the stakholders in the master plan study revealed that it would be difficult for them to accept the construction of a diversion chnnel for floodway and dykes along the river due to the likely impacts on the surrounding ecosystems and other natural environment. In fact, the Survey Team expected that the consensus building on the construction of those measures would not be easy and require a long-term process. As a result of the evaluation, the disaster-prevention measures against the 10-year flood were determined as the priority projects in the first phase.

The environemntal and social considerations in this study were carried out with the following limitations:

i) No interview survey on socio-economic conditions, such as land ownership, family structure, and household income, was made in the areas where the land acquisition might be required, as the information of the projects were not able to open during the study due to the uncertanty about the commencement of the projects. In fact, the study team did not disclose as much information as explained in the pulic hearings at the end of the master plan study.

ii) The topographic maps on a scale of 1:10,000 were not available when the feasibility study was made although they were supposed to be ready to use during the study. Alternatively, the topographic map of 1:50:000 and the results of a topographic survey of river conducted in the feasibility study were used for the detailed study and designing. In addition to them, the topographic maps of Itajai City on a scale of 1:2,000 was available and also used for the study on the urbanized areas of Itajai City.

The feasibility study revealed that the existing roads of Itajai Mirim River was sufficiently high and not necessarily heightened as a disaster-prevention measure. Hence, the Survey Team judged that no resettlement or extensive land acquisition except the areas to be affected by the heightening of Oeste Dam would take place.

This chapter describes: i) the results of a review of the initial environmental examination (IEE) made in the master plan; ii) the draft terms of reference for an environmental impact study (EIA) that would be needed for implementation of the priority projects; iii) the results of environmental and social considerations of the priority projects; and iv) the environment-related legislation and necessary steps and surveys for acquisition of an environmental lisense in Brazil.

9.1.2 Review of Initial Environment Examination (IEE) in M/P Study

(1) Requirement for Envrionmental Lisense

Since the catchment of Itajai river is locate within the territory of SC state, FATMA in SC state is the responsible institution for examining environmental study reports and issuing an envrionemntal license for the project. Therefore, the information on the environmental impact studies, especially crucial points in environmental and social assessments, were collected at FATMA in the study.

In SC state, an environmental assessment report to be submitted to FATMA varies with the extent of expected environmental impact. A proponent of a project shall submit one of the following reports based on the size, type and location of a project as described in Chapter 7 of the master plan study.

- Environmental Impact Assessment (EIA; Estudo de Impacto Ambiental)
- Simplified Environmental Study (EAS; Estudo Ambiental Simplificado)
- Previous Environmental Report (RAP; Relatório Ambiental Prévio)

As this project targets all the water sources in the whole catchment of Itajai river, FATMA is, therefore, obligated to submit an EIA report for a "macrodrenagem[1]" project, which covers all the components proposed as the priority projects in the first phase.

(2) Review of IEE

The Survey Team reviewed the initial environmental examination (IEE) made in the master plan study using the maps and data additionally collected in the feasibility study. The focus of the review was put on the coponents proposed as the priority projects in the first phase. The following sections describe the results of the review and Table 9.1.1 shows the revised environmental screening and scoping of the priority projects in the first phase.

a. Water Storage in Paddy Fields

The environmental and social impacts caused by this component are expected to be negligible, as the component does not require any large-scale engineering work. The component will be implemented by CRAVIL when the topographic maps of 1/10,000 are completed and the implementable areas are determined. Having determined the target areas using the topographic maps, CRAVIL shall prepare an implementation plan and take the necessary procedures for the registration of the target areas as Legal Reserve (RL) areas according to the Forestry Law.

b. Heightening of Sul and Oeste Dams

The lands used for heightening Sul and Oeste dams and those that might be inundated in the operation phase were considered as the areas affected by this component. In the feasibility study, the progress of the land acquisition made by the Government of SC state and the proposed designs of the dams, which were not available in the master plan study, were able to be collected and, therefore, fully reviewed and analyzed to identify and determine the

[1] It is used as the term standing for the project including "integrated flood control" and "basin management", although its literal meaning is "large-scale drainage."

potentially-affected areas. As detailed in the following sections, the assessment revealed that all the areas to be affected by the heightening of Sul dam and those up to the height of the existing spill way of Oeste dam had already been acquired, although the results of the IEE in the master plan study indicated that land acquisition and involuntary resettlement might be the possible impacts caused by the heightening of both dams.

Figure 9.1.1 shows the potential water level of the dams with and without heightening of dam crests and the progress of the land acquisition that the Government of SC state has made so far.

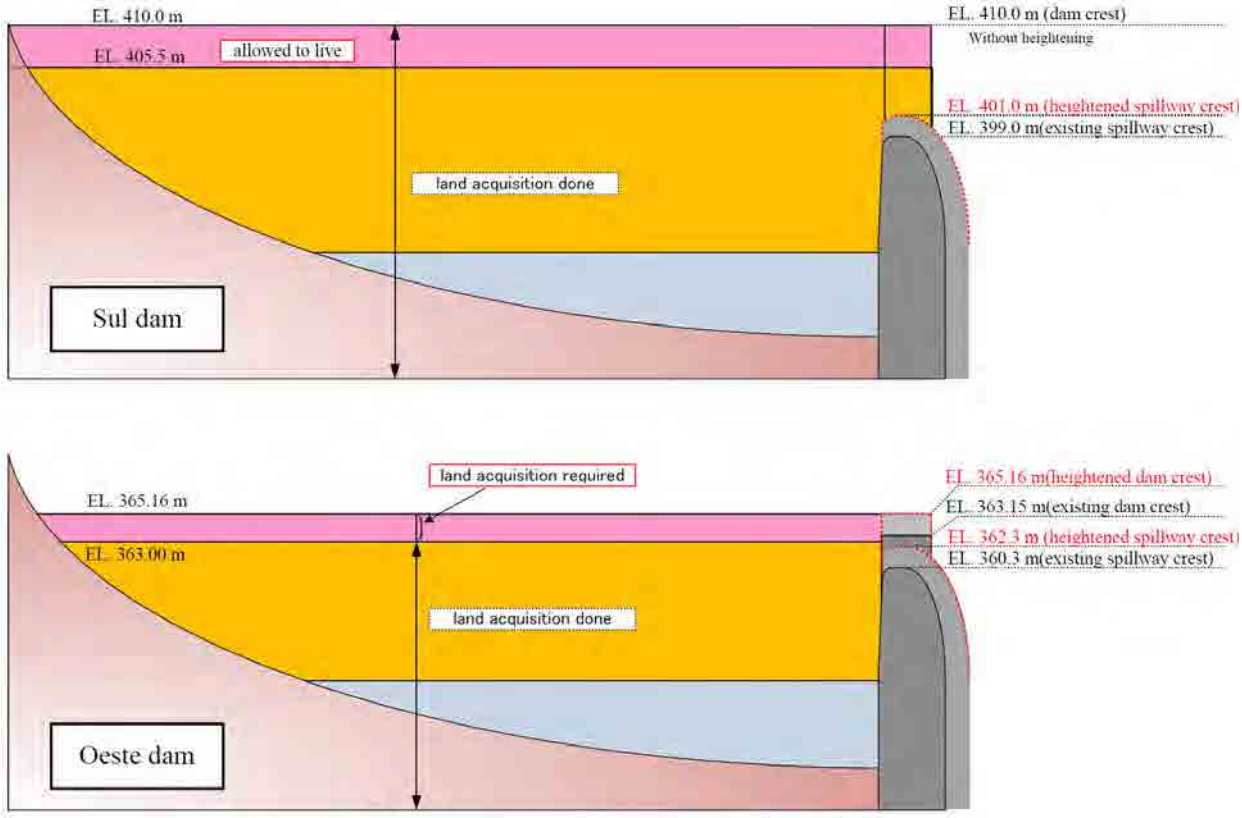


Figure 9.1.1 The Change of Altitude with Heightening and Existing Land Tenure

The heights of spillway of Sul dam will be heightened from 399.0 m to 401 m, but the dam crest will not be heighted. As the Government of SC has already acquired the potential inundation areas up to EL. 410.0 m, no further land acquisition will be required for this component. However, DNOS (former federal government who constructed Sul and Oeste Dam) has made an agreement with COOPERBASUL on the use of the lands extended from EL. 405.0 m to EL. 410.0 m elevation, which have been rarely inundated. As the agreement does not include a compensation clause on any damages caused by inundation, DNOS shall review and revise the current agreement with COOPERBASUL so as to ensure that COOPERBASUL could get compensation when such areas are inundated.

The dam and spillway crests of Oeste Dam will be heightened by 2 m, and therefore the heights of both crests will be EL. 365.16 m and EL. 362.3 m, respectively. Although Deinfra of SC state has already acquired the potential inundation areas up to 363.0 m, there is still a need to acquire the rest of the potential areas up to the height of the planned dam crest (EL. 365.16 m). In other word, the heightening of Oeste Dam is expected to affect households/communities residing in the potential inundation areas from 363.0 m to 365.16 m elevation.

An inventory of existing buildings (houses and barns) in the potential inundation areas of Oeste Dam was also carried out to assess the compensation cost for households who might be affected

by heightening its dam crest. The results of the simplified inventory are described in Section 9.2.1.

Besides, the heightening of Oeste dam might cause the adverse impact on the river environment (e.g., water quality, river bed, and riverine flora and fauna) since the engineering works will be done on the main body of the dam and need to divert the main stream of the Oeste river during the period of its construction works. On the other hand, no adverse impact on the river environment is predicted by the heightening of Sul dam, as the engineering works for Sul dam is to heighten the spillway by two meter and do not require any works on the mainstream of the river.

c. Utilization of CELESC's Hydro-Electric Dams for Flood Control (Introduction of Pre-release method)

This is the measure taken by CELESC, which is the operation of Rio Bonito and Pinhal Dams in Rio dos cedros river, to mitigate the flood risk by the pre-lease of storage water in the dams when having a flood warning. An alert system needs to be installed to alarm households living in the downstream areas of both dams to cope with a potential flood risk after discharging the storage water from the dams. More details about the pre-release along with an early warning system are described in Chapters 4 and 6 in Part II of this report.

d. Installation of Floodgates in Intajai Mirim River

This measure aims to install two floodgates and one back water dyke in the old river canal of Itajai Mirim river as described in Chapter 5 in Part II of this report.

The places of the floodgates are located in the residential area, the construction work for the floodgates might cause a vibration and/or noise or increase trafic. The construction work might also cause turbid water in the river. However, these impacts would be negligible if the necessary mitigation measures for these impacts are to be taken by the contracotr in the construction phase. On the other hand, there is no impact predicted in the operation phase as long as the floodgates are operated properly.

As described in Chapter 5 in part II of this report, driving sheet pile walls on the right bank was proposed to secure the safety of households living by the river in addition to the floodgates, as such areas on the right bank are subject to flood damage especaiily by high tide and back water. The construction work associated with driving sheet pile walls is exected to generate noise and vibration in the surrounding areas, the contractor should arrange and allocate temporary accommodations for households living in such affected areas in advance.

e. Structural Measure for Landslide

This measure is to apply slope protection measures to the slopes along the national roads to prevent landslides/slope failures. As the construction work will cause the traffic hindrance by parking a large truck in the road or blocking off one of the lanes, the contractor needs to take safety measures, such as traffic control, during the construction.

f. Development of Flood Forecasting and Warning System (FFWS)

Since this measure does not include any structural works, no environmental impact is predicted in the construction phase. Furthermore, the system will not change the lifestyle or any socio-economic conditions of households living in the area but help them protect their lives from flood damage. Consequently, no social impact is predicted by the introduction of the flood forecasting and warning system (FFWS). It is however important to ensure that such a system can disseminate the information up to the vulnerable groups and to conduct an

emergency drill with the participation of those groups using the system, so as to minimize the risk of a flood.

g. Development of Landslide and Flush Flood Warning System

Likewise, this measure is not predicted to cause any environemntal or social impact in both construction and operation phases since the measure does not include any structural work or cause any socio-economic change. As in the case of FFWS described above, what would be requisite for ensuring the effectiveness of the system are to disseminate the information to the vulerable groups using the system and conduct suffucuent emergency drills along with the system, so that the group could react properly when having an warning by the system.

Table 9.1.1 IEE Results of Selected Components

	Construction Phase	Socio-economic impacts																			Pollution					Natural Environment								
Flood Probablity	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
Basin Storage Measures	Rain water storage in rice field	A+	-	-	-	A-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Heightening of Oeste Dam	A+	B -	-	-	A-	-	-	-	-	-	-	-	C	-	-	-	B -	B -	-	C	-	-	C	-	-	-	C	C	-	C	-	-	-
	Heightening of Sul Dam	A+	B -	-	-	A-	-	-	-	-	-	-	-	C	-	-	-	B -	B -	-	-	-	-	C	-	-	-	-	C	-	-	-	-	-
	Preliminary discharge of CELESC hydro-electric dams	A+	-	-	-	A-	-	-	-	-	-	-	-	-	-	-	B-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
River Improvement Measure	Flood gate control installation in Itajai Mirim	A+	C	-	-	A-	-	-	-	-	-	-	-	B -	-	-	-	-	-	C	B-	-	-	B-	-	-	B-	B-	-	-	-	-	-	B-
Others	Measures for landslide disaster	A+	-	-	-	-	-	-	-	-	-	-	-	B -	-	-	-	-	-	-	-	C	-	C	-	-	-	-	C	-	-	-	-	C
	Flood Forecasting and Warning System (FFWD)	A+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

	Construction Phase	Socio-economic impacts																			Pollution					Natural Environment								
Flood Probablity	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
Basin Storage Measures	Rain water storage in rice field	-	-	B -	-	-	-	-	-	-	-	-	-	-	-	B -	-	-	-	-	-	-	-	-	-	-	-	-	-	-	B+	-	-	-
	Heightening of Oeste Dam	-	-	C	C	-	C	C	-	-	-	-	-	-	C	C	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Heightening of Sul Dam	-	-	C	C	-	C	C	-	-	-	-	-	-	C	C	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Preliminary discharge of CELESC hydro-electric dams	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	B-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
River Improvement Measure	Flood gate control installation in Itajai Mirim	-	-	-	C	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	C	-	-	C	-	-	-
Others	Measures for landslide disaster	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	C
	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. .

9.1.3 Draft Outlines of TOR for EIA/RIMA Study

(1) Draft Contents of EIA required for the Environmental License

A daft TOR for EIA study on the flood management project in the Itajai river basin was prepared and shown as attached to this report. In the preparation of the draft TOR, the JICA Survey Team collected the existing TORs for the past EIA studies kept in FATMA in SC state. Although there was no EIA study made for a flood management or landslide disaster management project in SC state, those used for a basin management project in Minas Gerais state and an integrated port development project in SC state were referred for preparation of the draft TOR. The outlines of the draft TOR are shown below.

(2) Schedule of an EIA Study and Estimated Cost for the Study

An environmental impact assessment study is to be carried out by a consulting firm or consultants registered in the state. In general, an EIA study to be contracted out to a consulting firm/consultants encompasses: i) the preparation and finalization of TOR for the study; ii) the conduct of the study; iii) the preparation of enironmental reports (RIMA report and report for public disclosure); and iv) the arrangement and organization of public audience. Hence, the TOR for an EIA study is to be first drafted by a consulting firm/consultants after it is officially selected. The draft TOR is to be reviewed, examined and approved by FATMA in the state within 45 - 60 days after its submission. An EIA Study shall be carried out in accordance with the approved TOR.

A tentative works schedule of an EIA study and estimated cost for the study are shown in Tables 9.1.2 and 9.1.3, respectively.

Table 9.1.2 Tentative Schedule of EIA/RIMA Study

Items	Months											
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**(11*)**	**12**
Preparation of TOR	○	○										
EIA Study		○	○	○	○	○	○	○	○			
Preparation of RIMA										○		
Public consultations												○

Note* : The duration from the preparation of RIMA to the public consultations varies with the environmental examination institutions in the respective states

Source : JICA Study Team

Table 9.1.3 Estimated Cost for EIA Study

Unit: R$

Item	Unit Cost	Unit	Quantity	Contingency (20%)	Total
Preparation of TOR	6,880	MM	2	3,430	17,150
EIA Study	57,168	MM	3	114,336	571,680
Preparation of RIMA	36,587	L.S.	1	9,147	45,734
Public consultations	26,676.0	MM	1	6,644	33,220
				Total	667,785

Source：ECSA, Engenharia Socioambiental S/S

9.2 Necessary Land Acquisition and Resettlement in Priority Projects

9.2.1 Results of Field Survey of Target Area for Dam Heightening

(1) Introduction

Oeste and Sul dams, which respectively are located in Taió city and Ituporanga city, are targeted for dam heightening. In the planning stage of the dam heightening, the state government as an implementing body shall acquire the areas, which will be potentially inundated or impounded by heightining dam crests of both dams, from land owners. Both dams are located in upper tributaries of Itajai River, Oeste dam in Itajaí do Oeste River and Sul dam in Itajaí do Sul River.

This section describes the results on the study on the potential social impacts caused by the dam heightening works and mitigation measures against potential impacts. Oeste and Sul dams both are flood control dams which usually have no strage water during the non-flooded period.

In Brazil, there are some existing Environmental Impact Assessment (EIA) studies for hydro-electric generation dam projects, while EIA for flood control dam[2] had not been made so far[3].

The boundaries of the areas affected by the construction of Oeste and Sul dams were not ble to be determined due to lack of information, such as their design and completion drawings, as the construction works and resettlement was implemented more than 30 years ago. Accordingly, there had been no major complains made by the surrounding communities about land acquisition and dam operations of each dam site.

As described in Section 9.1.2, the heightening of dam is expected to affect the areas from the elevation of the existing dam crests to that of the heightened dam crests, especially for Oeste dam. In order to grasp the actual conditions of the affected area, the JICA Survey Team conducted a field survey composed of literature study and site reconnaissance as described below.

(2) Survey method

a) Literature study

During the literature study, the following information and data were obtained from Deinfra - SC, which is the responsible agency for operation and maintenance of Oeste and Sul dams.

- Base map of Sul Dam which shows the distribution and locations of areas to be acquired
- Engineering drawings of Sul Dam Body

[2] Since flood control dam does not form the inundation area, the dam storage area can be accessible by the communities during non-flooded period.

[3] Environmental licensing system had not been established yet when Oeste and Sul dams were constructed.

- Base map of Oeste Dam which shows the distribution and locations of areas to be acquired
- Results of trial evaluation of land prices of the areas to be affected by heightening both dams
- Results of interviews to the responsible agency of dam operations and the agricultural unions

Deinfra − SC has limited data and information relevant to Oeste and Sul dams possibly due to the transfer of the responsibility for operation and maintenance of dams from DNOS to Deinfra - SC.

b) Site reconnaissance

Site reconnaissance survey in Oeste and Sul dams was conducted during April 15-17, and April 14-16, 2011, respectively with an aim to collect information required for development of a resettlement program with cost estimation. During the survey, the geographical data, such as latitude, longitude, and elevation of the houses and barns located in the affected area, were collected by using the receiver devices, TOPCOM GR-3 under Global Navigation Satellite System (GNSS).

(3) Results of the field survey

a) Current condition of the affected and surrounding areas of Sul Dam

As for the heightening of spillway of Sul Dam, which is one of the priority projects, the design flood water level was set as EL 410.0m in consideration of the maximum water level of 10,000-year flood and freeboard in accordance with the official design standards of Brazil[4].

According to the design drawings of Sul dam and information obtained from key informants in Deinfra - SC, land acquisition had been already completed up to EL. 410.0 m when existing dam was constructed. Heightening the spillway would not require further land aqcuisition in principle. However, the satelite images covering the affected area indicated that some buildings, such as houses and barns, were located below EL. 410.0 m. Hence, the site reconnaissance survey was conducted. During the site reconnaissance, due consideration was given to keeping the residents in the affected area from having the project information.

The survey revealed that six (6) buildings, four (4) houses with kiosk and two (2) log cabins, were located at between EL. 401.276 m and EL. 409.314 m.

Furthermore, the survey identified the present land use classes in the potentially affected areas under Sul dam as follows:

- Paddy field (class I): 10.0 %
- Onion farm (class III and IV): 25.0 %
- Slope area (class V): 5.0%
- Grassland (class VI and VII): 35.0%
- Permanent Preservation Area (APP) (class VIII): 25.0 %

Details of the land use classification are shown in Section 9.3.4.

b) Current condition of the affected and surrounding area of Oeste Dam

Likewise, the design flood water level of Oeste dam was set as 365.0 m in consideration of the the maximum water level of 1,000-year flood and freeboard in accordance with the official

[4] Critérios de Projeto Civil de Ucinas Hidroelétricas", October, 2003

design standards of Brazil. Consequently, heightening the existing dam by 2 m was proposed by raising the dam crest from EL. 363.15 m to EL. 365.16 m. Although the land acquisition was completed up to EL. 363.0 m when the existing dam was constructed, the rough estimation based on the topographic maps of 1:50,000 revealed that the additional 67 ha of lands still need to be acquired.

The present land use in the affected areas are classified as follows:

- Agricultural farm (class III): 10.0 %
- Agricultural farm for short-term crops (class IV): 25.0%
- Perenial crops planted area (class V): 30.0%
- Grassland (class VI): 20.0%
- Steep grassland (class VII): 5.0%
- Permanent Preservation Area APP (class VIII): 10.0 %

The site reconnaissance survey further found that there were two (2) wooden houses, three (3) wooden sheds and one (1) brick house with barn in the potential affected areas between EL. 361.988 m and 354.979 m (See Supporting Report F).

9.2.2 Necessary Measures to be taken for Minimizing the Possible Impacts by the Dam-heightening of Sul Dam

As mentioned in 9.2.1 (3), land acquisition was completed up to EL. 410.0 m by DNOS for construction of the existing dam. In 1981, an agreement on land use concession for the area between EL. 405.5 m and 410.0 m was concluded by DNOS and COOPERBASUL, which was a cooperative organized by the surrounding communities, to allow the members of COOPERBASUL to use the said area for animal husbandry. The contents of the said contract are shown in Supporting Report F.

Currently, Deinfra - SC, which the responsibility for operation and maintenance of the dam was given from DNOS, follows the said contract signed by DNOS without any revision and allows the members of COOPERBASUL to use the area based on the contract.

To date, there have been no serious trouble with COOPERBASUL and Deinfra − SC, despite the fact that the water storage level had sometimes reached to the maximum water level.[5] The heightening of dam, which would increase the possibility of innundation in the concession area, might cause a negative impact on the use of the area, although its possibiloty is least-likely.

It is therefore recommended that Deinfra - SC discuss the possible negative impact with COOPERBASUL to ammend the current agreement on the use of land concession area on this occaision.

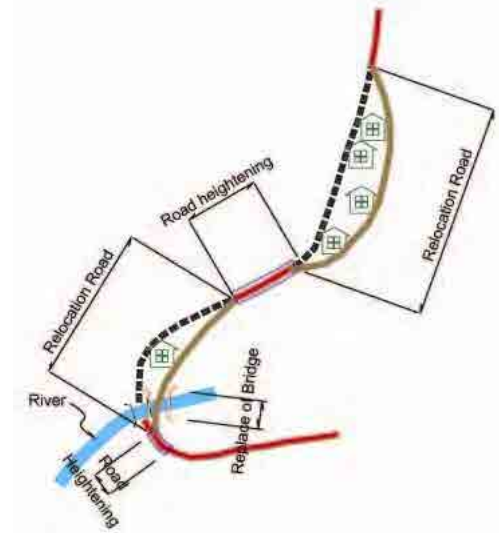
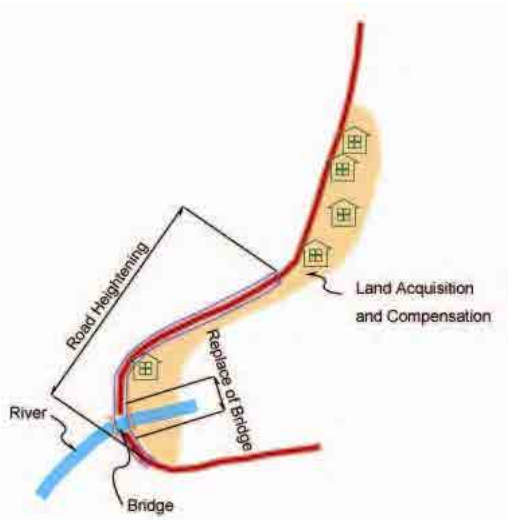
9.2.3 Mitigation Measures against the Possible Impacts Caused by the Heightening of Oeste Dam

As described in 9.2.1 (3), the heightening of Oeste Dam would require new land acquisition of 67 ha between EL. 363.0 m and EL. 365.16 m. The houses, sheds, some part of roads and bridges were located within the potential innundation areas as shown in Supporting Report F. With an aim to mitigate the possible negative impacts on the communities living in the possible innundation areas, JICA Survey Team proposes rerouting the existing roads and using them as dikes to protect the houses from being innundated.

[5] Several overflows from the spillway of Sul dam were recorded by Deinfra-SC.

Table 9.2.1 shows the general features of two (2) alternative measures, one with road relocation and the other with resettlement of the communities, while Table 9.2.2 compares the estimated costs for both alternatives.

Table 9.2.1 General Features of Alternative Measures

	Alternative measure-1: with road relocation	**Alternative measure-2: with resettlement**
Chart		
General description	・Some sections of roads and bridges shall be rerouted/relocated to protect existing buildings from being inundated by heightening the dam. Hence, the height of the rerouted roads and relocated bridges shall be higher than that of the heightened dam crest.	・The buildings located in the potential inundation areas shall be relocated. ・Some sections of the roads and bridges, whose heights are lower than that of the heightened dam crest, shall be relocated
Merit	・No resettlement of the communities	・Less cost due to decrease of volume of construction works
Demerit	・Increase of construction cost due to road relocation ・Reduction of inundation area due to installation of the road	・Resettlement of houses/communities necessary
Project cost	R$ 4,797,000 (100%)	R$ 2,819,000 (58.8%)

Source: JICA survey team

Table 9.2.2 Cost Estimation

(R$)

			Alternative of Road relocation		Alternative of Compensation		Remarks
	unit	unit cost	quantity	amount	quantity	amount	
Replacement of Bridge	m2	3,000	160	480,000	80	240,000	
Relocation of Road	m	1,570	1,500	2,355,000	500	785,000	
Other works	%	30	---	851,000	---	308,000	Main works *30%
[1] Sub total (Construction cost)				**3,686,000**		**1,333,000**	
Land Acquisition	LS	966,000	1	966,000	1	966,000	
House Compensation	LS	326,000	---	---	1	326,000	3houses+3sheds
Price contingency for area delineation	%	15	---	145,000	---	194,000	
[2] Sub total (Land, Compensation)				**1,111,000**		**1,486,000**	
Total [1]+[2]				**4,797,000**		**2,819,000**	

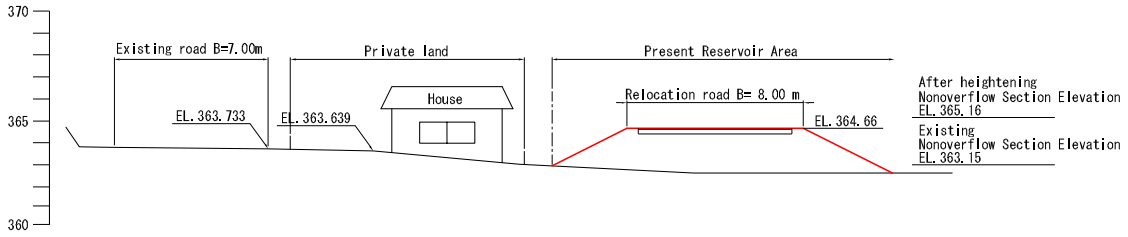
Source: JICA survey team

The cost breakdown for land acquisition and house compensation are also shown 9.2.3.

Table 9.2.3 Cost Breakdown for Land Acquisition and House Compensation

Land Acquisition	
7.0ha of Class III and 17.0ha of Class IV exploited with crops (R$ 20,000.00/ha)	480,000.00
20.0ha of Class V of pasture (R$ 15,000.00/ha)	300,000.00
13.0ha of Class VI and 3.0ha of Class VII with restrictions (R$ 7,500.00/ha)	120,000,00
7.0ha of Class VIII of APP (R$ 4,300.00/ha)	30,000.00
24.0ha permanent crops (R$ 1,500.00/ha)	36,000.00
Total	**966,000.00**
House Compensation	
Masonry house (100.0m^2), masonry wall (240.0m), wooden shed (90.0m^2).	165,000.00
Wooden shed (72.0 m^2)	28,000.00
Wooden shed (60.0 m^2)	23,000.00
Wooden house (60.0 m^2)	30,000.00
Wooden shed (96.0 m^2)	36,000.00
Wooden house (90.0 m^2)	44,000.00
Total	**326,000.00**
Reserve +15%	194,000.00
GENERAL TOTAL	**1,486,000.00**

Source: JICA survey team



Source: JICA survey team

Figure 9.2.1 Typical Section of Relocation Road

Conclusion

In Brazil, compensation for properties affected by public works has been generally conducted in accordance with the relevant laws and regulations, while administrative proceedings have been often taken against the process of resettlement due to lack of the relevant legislation. In fact, there have been many troubles and complaints caused by insufficient and improper support/arrangement in resettlement, such as i) relocation to remote areas and ii) limited opportunities for employment in relocated areas, especially for professions that the resettled people used to engage in.

Although the cost for the alternative measure-1 with road rerouting is 1.7 times higher than that for the alternative measure-2 with resettlement as shown in Table 9.2.2, JICA Survey Team recommends alternative measure-1 as a more reasonable and justifiable plan in order to avoid and minimize future negative impacts in line with the basic principles of JICA Guidelines for Environmental and Social Considerations.

9.2.4 Process of Resettlement Under Oeste Dam and the Proposed Resettlement Program

(1) Introduction

While the JICA Study Team recommends the relocation of road, the state government might possibly select the alternative measure-2 since the number of target families to be relocated is limited. If so, the preparation and submission of necessary plans, such as resettlement plan and monitoring plan, will be required.

The following sections further describe the processes of resettlement and compensation.

(2) Resettlement process

a) Type of applicable compensation measures

The resettlement program aims to secure the livelihoods of the resettled families/people providing necessary support to restore their livelihoods but not to alter their cultural features.

According to the general process of resettlement in the country described in Section 9.3.3, JICA Survey Team proposes the following options as compensation measures for properties to be affected by the heightening of Oeste dam. Nevertheless, the amount of compensation for losses shall be valuated in accordance with World Bank Operation Manual (OP) 4.12, Annex A-Involuntary Resettlement Instruments (WB OP 4.12, Annex A)[6] as stipulated in JICA Guidelines for Environmental and Social Consideration (2010).

1) Compensation for assets

Value of existing buildings and lands shall be appraised to determine the amount to be paid in cash to the affected families in accordance with the process described in Section 9.3.3. In valuation, it is important to estimate the compensation in accordance with WB OP 4.12, Annex A as described above.

2) Individual resettlement (Commitment Letter, CC)

The target public is responsible for searching and selecting the land and other properties equivalent to those they originally owned. If the implementing body judges that the properties selected by the target public meets the criteria set in the agreement between the implementing body and the affected families, the implementing body shall purchase the selected properties.

3) Individual resettlement of special cases (CE)

In case the target public has some limitations/handicaps who need a special care or considerations in its families, special arrangements shall be made such as allocation of urban lots instead of rural ones (but the size of the lots should be lower than the affected one.).

b) Target public for resettlement

As for the heightening of Oeste dam, the following persons are expected to be the target public:

- the person who conducts economic activities in the affected area
- the person who lives in the affected area but has no legal property in the same
- the person who has his/her property/ies in the area remaining unused by heightening the dam
- the person who depends on the affected property/ies for his/her livelihood

[6] Compensation for losses shall be valuated by the replacement cost, which is defied below.
"For agricultural land, it is the pre-project or pre-displacement, whichever is higher, market value of land of equal productive potential or use located in the vicinity of the affected land, plus the cost of preparing the land to levels similar to those of the affected land, plus the cost of any registration and transfer taxes. For land in urban areas, it is the pre-displacement market value of land of equal size and use, with similar or improved public infrastructure facilities and services and located in the vicinity of the affected land, plus the cost of any registration and transfer taxes. For houses and other structures, it is the market cost of the materials to build a replacement structure with an area and quality similar to or better than those of the affected structure, or to repair a partially affected structure, plus the cost of transporting building materials to the construction site, plus the cost of any labor and contractors' fees, plus the cost of any registration and transfer taxes. In determining the replacement cost, depreciation of the asset and the value of salvage materials are not taken into account, nor is the value of benefits to be derived from the project deducted from the valuation of an affected asset. Where domestic law does not meet the standard of compensation at full replacement cost, compensation under domestic law is supplemented by additional measures so as to meet the replacement cost standard." (Source: World Bank OP 4.12, Annex-A)

c) Resettlement Process

1) Individual Resettlement

In the case of individual resettlement, the implementing body shall issue the Commitment Letter (CC) which shows the estimated cost of the affected properties so that the target public can have an idea on the amount of compensation.

Upon the issuance of CC, the target public shall search and select the properties, and inform the implementing body of the selected properties. The implementing body shall examine the appropriateness of the selected properties prior to the approval of its acquisition. Having validated the legitimacy and appropriateness of the properties, the implementing body will permit the acquisition/purchase of the property and sign on to the official document for purchase.

In the procedures of individual resettlement, the following points shall be considered.

- Size of lot acquired

The size of lot acquired will range from 3.0 ha to 17.0 ha depending on the family structure and its type based on CSE (See Section 9.3.3). In determination of the size of lot, due consideration shall be paid to the concept of "replacement cost" defined in WB OP 4.12 Annex-A.

- Buildings for acquisition

Likewise, the buildings in each lot shall be determined in consideration of the family structure and type of houses based on CSE (See Section 9.3.3). Likewise, WB OP 4.12 Annex-A shall be referred for estimation of compensation for losses.

- Option for the commitment letter

The target public can prepare its request in writing on the acquisition of properties. Once such a request is developed in writing, no revision is allowed.

- Technical assistance for recovery of livelihoods

The implementing body is responsible for provision of ad hoc technical and social assistance for the target public upon the acquisition of the new property/ies to restore its livelihoods.

- Mode of reimbursement

In case that the target public is non-owner of the affected area, reimbursement of the resettlement cost might be required. The implementing body and the target public will go into negotiations and determine whether or not the repayment is arranged. In case the repayment is required, the mode of reimbursement such as total or partial reimbursement, should also be discussed between the implementing body and the target public.

2) Special cases of individual resettlement (CE)

The special case of individual resettlement (CE) shall go through similar procedures and give similar considerations in the process of resettlement in principle. It is noted that the size of lot can be determined according to the features of the affected families.

The necessary considerations to be made in determining the size of lot are described below.

- Lots size for acquisition

<u>Rural lots</u>

Area remaining unused shall be preferably utilized for resettlement of the target public in the rural area.

The lower limit of the area of rural lots shall be eighteen (18) ha according to the Minimum Fraction of Parceling (FMP) as defined by the National Institute of Colonization and Agrarian Reform – INCRA.

Urban lots

The target public who selects urban area to reside shall have the right to acquire the minimum size of lot in accordance with the central and/or local government legislation.

- Mode of reimbursement

The target public, who is the owner, heir, or other claimants of the affected lands and properties, shall be exempted from any payments, except the transfer of the affected lands and properties to the implementing body as a payment.

If the value of the existing properties acquired exceeds the benefit which the target public can obtain from the resettlement, the balance shall be paid in cash to the target public.

9.3 Environmental Legislation, General Resettlement Program, and Monitoring Program in the Post-Resettlement in Brazil

9.3.1 Legislation relating to Compensation

The major legislation relating to environmental and social considerations in Brazil is presented in Section 7.2 in Part I of the master plan study.

The Constitution of the Federative Republic of Brazil in 1988 stipulates that any projects shall pay sufficient monetary compensation to people who own the areas affected by projects prior to its implementation. The same also stipulates that the compensation shall include the costs for the maintenance of the environmental quality, necessary environmental management works, and land acquisition for reforestation in permanent preservation areas (APP).

A proponent of a project shall have the legal responsibility for land acquisition for implementation of a project. In a dam construction project, the implementing body of the government shall be responsible for acquiring the construction sites following the proper process of land acquisition. In case the implementing body and the affected families/people can not reach an amicable agreement on land acquisition, the implementing body shall take the necessary legal measures for compulsory land acquisition.

In Brazil, various laws and regulations relating to land acquisition and compensations have been enacted and implemented since the first regulation was enacted in 1821. The applicable laws and regulations, which are currently effective, are shown below.

- Constitution of the Federative Republic of Brazil, as of 05/10/88;
- Decree-Law No. 3,365, as of June 21, 1941, and as amended, and complementarily the Code of Civil Procedures (CPC);
- Federal Law No. 4,132, as of September 10, 1962;
- Brazilian Association of Technical Standards (ABNT), as of 2004, for appraisal of rural properties (NBR 14,653-3), and of urban properties (NBR 14,653-2).

It is noteworthy that there is no legislation or regulation specifying the procedures for resettlement, although the regulations and guidelines on estimation of compensation and compulsory land acquisition are already in place. Therefore, in most of the projects in the past, the framework for resettlement needed to be determined through negotiations with the affected families/people.

The following sections highlight the relevant points of the existing legislation on land acquisition in Brazil.

(1) Constitution of the Federative Republic of Brazil, 05/10/1988

The Constitution of the Federative Republic of Brazil of 1988, which was enacted on May 10, 1988, brought important innovations to the conditions of land acquisition. Clause 14 of Article 5 in the Constitution is summarized below.

> Article 5: Everyone is equal before the law, with no distinction of any nature. The law shall ensure to the Brazilian people and foreign residents in the Country the inviolability of the rights to life, to freedom, to equality, to safety and to property, under the following terms.
>
> Clause XIV: The law shall define the procedure for land acquisition for need or public interest, through a fair and previous compensation in cash, except for the cases provided for in this Constitution.

(2) Federal Decree-Law No. 3,365 dated June 21, 1941.

The Federal Decree-law No. 3,365, as of June 21, 1941, provides for land acquisition for public-interest purposes. This Decree-Law specifies the rules and process of the land acquisition in Brazil and also referred to by the Code of Civil Procedures in Article 271. On January 29, 1999, this Decree-Law was partially amended by Law No. 9,785.

(3) Federal Law No. 4,132 dated September 10, 1962

This Federal Law defines the procedures for land acquisition for public-interest purposes. It was amended by Law 6,513 in December 20, 1977 (art. 31).

(4) Others

Federal Decree No. 24,643 of July 10, 1934, amended by Federal Decree No. 35,851 on July 16, 1954, defines so-called the Code of Waters in item “b” of Article 151 as shown below.

> Article 151 item b: to acquire private buildings, and in pre-existing authorizations, the goods, including private waters upon which the concession is granted, and the rights which might be necessary, according to the law regulating land acquisition for public interest, being responsible for the resettlement and payment of compensations.

The Brazilian Association of Technical Standards (ABNT) in 2004 defines the standards for asset appraisal, such as general procedures in NBR 14,653-1, standards for asset appraisal in urban areas in NBR 14,653-2, and the same in rural areas in NBR 14,653-3.

9.3.2 Comparison between JICA’s Guidelines on Environmental and Social Considerations and Relevant Legislation in Brazil

Table 9.3.1 shows a comparison between JICA’s guidelines on environmental and social considerations and relevant legislation in Brazil.

Table 9.3.1 Comparison between JICA's Guidelines on Environmental and Social Considerations and Relevant Legislation in Brazil

No.	Descriptions	Relevant Legislation in Brazil and their Summaries
1) JICA Guidelines for Environmental and Social Consideration		
1.	Involuntary resettlement and loss of means of livelihood are to be avoided when feasible by exploring all viable alternatives. When, after such an examination, avoidance is proved unfeasible, effective measures to minimize impact and to compensate for losses must be agreed upon with the people who will be affected.	Not available (or follow social convention / protcol)
2.	Peopl who must be resettled involuntarily and people whose means of livelihood will be hindered or lost must be sufficiently compensated and supported by project proponents etc. in a timely manner.	Not available (or follow social convention / protcol)
3	Host countries must make efforts to enable peole affected by projects and to improve their standard of living, income opportunities, and production levels, or at least to restore these to pre-project levels.	Article 5 of Clause 24 in the Constitution of Brasil The article stipulates the procedures for land acquisition with fair and advance monetary compensation in consideration of the public benefit and necessity. Decree-Law No. 3365 (June 21,1941) This dicree stipulates the rules on and processes of condemnation/expropriation for public projects as well as any other purposes for public interest. The decree deifines that an owner of properties expropriated/acquired for pubic interest shall be compensated in cash.
T	Prior comensation, at full replacement cost, must be provided as much as possible.	Article 5 of Clause 24 in the Constitution of Brasil Same as above.
5.	For projects that will result in large-scale involuntary resettlement, resettlement action plans must be prepared and made available to the public. In preparing a resettlement action plan, consultations must be held with the affected people and their communities based on sufficient information made available to them in advance.	CONAMA Resolution No. 01 (as of Jan. 23, 1986) The resolusion stipulates that an EIA report shall be discosed to the public and SEENV or the municipality government should hold the public hearings or consultation meetings on a project and its potential impact. CONAMA Resolution No. 09 (as of Dec. 3, 1987) The resolution defines the purpose of the public hearings/consultations, outlines of public hearings/consultations (e.g., timing, timeframe, frequency, and venues), responsible agency, and the necessity of documentation of the hearings/consultations.
6.	When consultations are held, explanations must be given in a form, manner, and language that are understandable to the affected people.	CONAMA Resolution No. 01 (as of Jan. 23, 1986) Same as above. CONAMA Resolution No. 09 (as of Dec. 3, 1987) Same as above.
7.	Appropriate participation by affected people and their communities must be promoted in the planning, implementation, and monitopring of resettlement action plans and measures to prevent the loss of their means of livelihood.	Not available (or follow social convention / protcol)
8.	Appropriate and accessible grievance mechanisms must be established for the affected people and their communities.	CONAMA Resolution No. 01 (as of Jan. 23, 1986) Same as above. CONAMA Resolution No. 09 (as of Dec. 3, 1987) Same as above.
World Bank Safeguard Policy, OP 4.12 and OP 4.12, Annex A		
9.	Upon identification of the need for involuntary resettlement in a project, the borrower carries out a census to identify the persons who will be affected by the project, to determine who will be eligible for assistance, and to discourage inflow of people ineligible for assistance. (WB OP4.12 Para 6) The results of a census survey covers: (i) current occupants of the affected area; (ii) standard characteristics of dispalced households; (iii) the magnitude of the expected loss; (iv) information on vulnerable groups or persons; and (v) provisions to update information on the displaced people's livelihoods and standard of living. (WB OP4.12 Annex A Para 6)	Federal Decree No. 7342 (as of October 26, 2010) This decree institutionalizes the registration of the losses of properties of the persons who will be affected by a dam construction project for hydroelectirc generation. Types of losses to be registered and the organization (the inter-ministrial committee) to administer the registration are defied in the decree.

No.	Descriptions	Relevant Legislation in Brazil and their Summaries
10.	Displaced persons may be classified in one of the following three groups: (a) those who have formal legal rights to land; (b) those who do not have formal legal rights to land at the time the census begins but have a claim to such land or assets-provided that such claims are recognized under the laws of the country or become recognized through a process identified in the resettlement plan; and (c) those who have no recognizable legal right or claim to the land they are occupying. (WB OP4.12 Para 15)	Not available (or follow social convention / protcol)
11.	Preference should be given to land-based resettlement strategies for displaced persons whose livelihoods are land-based. These strategies may include resettlement on public land, or on private land acquired or purchased for resettlement. (WB OP4.12 Para 11)	No regulation
12.	The resettlement plan or resettlement policy framework also include measures to ensure that displaced persons are: (i) offered support after displacement, for a transition period, based on a reasonable estimate of the time likely to be needed to restore their livelihood and standards of living; and (ii) provided with development assistance in addition to compensation measures, such as land preparation, credit facilities, training, or job opportunities.(WB OP4.12 Para 6)	Not available (or follow social convention / protcol)
13.	To achieve the objectives of this policy, particular attention is paid to the needs of vulnerable groups among those displaced, especially those below the poverty line, the landless, the elderly, women and children, indigenous peoples, ethnic minorities, or other displaced persons who may not be protected through national land compensation legislation.(WB OP4.12 Para 8)	Not available (or follow social convention / protcol)
14.	In case that impacts on the entire displaced population are minor or fewer than 200 people are displaced, an abbreviated resettlement plan may be required.(WB OP4.12 Para 25)	Not available (or follow social convention / protcol)

Source: JICA Study Team

Although legislation and regulations on land acquisition and compensation are in place in Brazil, the resettlement and livelihood support after relocation have been generally based on the social convention or protocol according to Brazilian Constitution so far. However, the environmental examination for environmental licensing has been getting strict and examining a resettlement plan with its monitoring plan in the examination as there have been many troubles and complaints caused by insufficient and improper support and arrangements in resettlement, such as i) relocation to a remote area and ii) limited opportunities for employment in a relocated area, especially those for the professions that the affected people engaged in before resettlement.

It is therefore necessary for the state government to carry out an EIA study and resettlement measures pursuant to the JICA guidelines (JICA Guidelines for Environmental and Social Consideration) and those used by the international funding institutions, such as World Bank, so that the state government could avail of the loan scheme of the international funding institutions for implementation of the Project.

Consequently, it is recommended that an EIA Study should be carried out in accordance with the draft TOR attached to this report. Considering the sound financial status of the state government, the JICA Study Team judges that it would not be much difficult for the state government to finance the conduct of the EIA study for the project.

9.3.3 General Resettlement Procedures in Brazil

(1) Basic concepts

Some basic concepts to be considered in the formulation of a resettlent program for the people who would be affected by the construction of a dam are defined:

Socioeconomic records (questionnaire) – CSE: means a structured interview survey with a set of preset questionnaires. As CSE aims to statistically analyze the socio-economic profiles of the affected families in a quantitative and qualitative manner and prepare a resettlement program for all the potential families regardless of the possession of land and other assets in the affected areas, the interview survey shall target all the families living in the potential inundation areas and construction site.

Directly affected area: or simply **"affected area"**: means the area/areas that will be used for construction or heightening of dam crests and those that might be inundated or impounded after the heightening of a dam. A strip of permanent preservation area (APP) around the permanent reservoir area is also included in this category. APP is not necessarily formed in a flood control dam in general, but it might be required when necessary.

Affected property and affected people: means assets and families associated with or located in the affected areas. The terms are used as herein defined except when otherwise explained.

Workforce (FT): means the number of available workers/laborers who are engaged in agricultural development and exploitation works. The current data on workforce are estimated on the basis of the age structure in each family.

"Target Public" of a resettlement program: means the people directly and indirectly affected by the implementation of a project, which include; land owners, illegal occupants, tenants, investor and its partners, community organizations, salaried workers, and children of land owners and the other relevant people. The target public shall be defined in each step of a resettlement program.

(2) Resettlement measures and alternatives

In general, the target public of a resettlement program under a dam construction project for hydropower generation will be compensated or provided an alternative land for resettlement. The outlines of the resettlement measures are summarized below.

Compensation consists of the total or partial acquisition, with cash payment, of affected properties and/or areas including the unfeasible remaining areas[7] and any profits to be generated from the economic activities based on/in the affected properties as well as areas. The amount of the compensation will be determined by a mutual agreement between a proponent and the respective affected families/persons.

Provision of alternative lands means to provide the target public with alternative lands and assists them in relocating themselves to such lands. It consists of the following types of measures.

a) Collective Rural Resettlement (RRC): where rural lots with basic social infrastructure will be allotted to the whole communities in the affected areas.

b) Small Rural Resettlement (PR): where individual electrified houses and barns with a water supply system will be allotted to the affected families.

c) Individual Resettlement (Commitment Letter, CC): where the individual affected families will have negotiations with a proponent and determine the value of the affected areas and properties. In principle, each family is responsible for searching his/her relocating land and its associated facilities, which should be equivalent to the values of his/her affected

[7] The unfeasible remaining area means the area located outside the affected area but owned by the same owner and where the owner will not be able to gain profit from any economic activities based in.

properties/areas. The acquisition and registration of such properties shall be done by a proponent.

d) Resettlement in Remaining Area (AR): where land use rights for farming will be granted to the affected families. The areas that will neither be affected by a project nor be designated as APP among those acquired by a proponent for a project will be used for this purpose.

e) Resettlement in Special Cases (CE): where a special arrangement, such as arrangement for urban lots or downsizing of lots from the original plan, will be made for the affected families that have persons in need of special attention (e.g., the aged and disabled).

Due consideration shall be given to the socio economic aspects of the affected families in the preparation of a resettlement program. In particular, the conservation of customary norms/customs related to land and traditional culture in the affected areas shall be considered in a resettlement program.

Furthermore, in case CSE reveals that any indigenous communities or special social categories (such as Quilombos) might be affected by a project, specific standards should be employed to pay due attention to their traditional and cultural characteristics and peculiarities.

In principle, each target public shall select the resettlement measure by themselves considering the respective socio-economic as well as traditional characteristics and according to the guidelines and criteria based on the case studies in the past.

Furthermore, after the estimated values of the affected areas are presented to the target public, additional options should be determined and selected on the basis of the results of CSE in a participatory manner. Such a participatory process and continuous discussions would enable them to appraise their own conditions and determine appropriate resettlement measures.

9.3.4 Procedures for Compensation and Land Acquisition

The following sections describe the procedures taken for compensation and land acquisition in a dam construction project for hydropower generation as an example for the administrative procedures for compensation and land acquisition. Although these procedures are considered applicable to a project for the construction of a flood control dam in principle, there is a need to further examine whether or not all the procedures described below can be applied to the proposed project in a further study, since the existing flood control dam projects are rather scarce as compared to those for hydro-generation dams.

Based on the mutual agreements on land acquisition between a proponent and the affected families/people, compensation for the affected properties and lands and assets including the lands remaining unused due to a project should be made in money in principle. The close communication and good relationship between a proponent and the affected families/people is crucial to smooth progress of the land acquisition process as the land acquisition is based on negotiations with owners of the affected properties in principle. The amount of compensation for the affected lands and properties will be estimated on the basis of data and information collected through a market research on the prevailing market prices, in addition to the comments from the representatives of the owners of the affected lands and properties.

A field survey is to be carried out to assess the affected lands and properties with the presence of the land owners or their delegates/agents. The survey shall cover the lands that would not be directly affected by a project but should remain unused due to project activities and the properties owned by tenants or illegal occupants who do not have the ownership of the lands as well.

In case a proponent and land owners can not reach a mutual agreement on compensation, the compulsory land acquisition process will be taken based on the Public Declaratory Resolution on Public Facilities in the Affected Areas issued by the National Agency of Electric Energy (ANEEL). The Resolution is applicable to only the case when an amicable agreement with land owners is judged impossible to reach.

The procedures for compensation along with the implementation of a project are summarized below.

a) Preparation of the Registration Sheet

Prior to the field assessment surveys on the lands and properties that would be affected by a project, project outlines and other relevant information shall be disclosed to the owners or persons responsible for management of the properties as the first step of the process. In simultaneous with the disclosure of the project information, a proponent shall explain the procedures for land acquisition and compensation as well as the applicable guidelines on the same to them. At the same time, a field survey team will take the formal permission from the owners for entering the affected areas for assessment. The survey team shall prepare the Registration Sheet for each owner's properties filling in data and information of the target properties and obtain informed consent for the sheet from the owner with his/her signature.

b) Demarcation of Maximum Flood Elevation Line and of the Permanent Preservation Area (APP)

A field survey shall be carried out to delineate the maximum flood elevation level and boundaries of APP along the permanent reservoir[8] so as to clearly demarcate the areas to be inundated/impounded.

c) Determination of the Acquired Land and Properties

The distribution and areas of the potential land use types in the acquired lands shall be clarified by delineating the boundaries of the acquired lands and classifying the potential land use types in the same.

d) Market research on prices and determination of unit values

Unit values for buildings (non-reproductive immovables) and for the perennial crops (reproductive immovables) will be set to estimate the costs of replacement and reproduction. The information related to agricultural production (e.g., agricultural input, labor, and other operational costs including sales) and any other economic activities in the area shall be used for setting the unit values.

The value of the bare land will be estimated on the basis of information and data collected from the market research and interviews to available sources, such as realtors, notaries, brokers, unions, municipalities, banks, and other agricultural experts. It is necessary to collect sufficient information to set the reliable prices/values in line with the standard prices in the region.

An inspection survey shall be carried out to clarify the features of the lands, such as potential land capability, current management practices, and accessibility, for land acquisition. The unit value for compensation shall be determined by estimating the price of the bare land based on a statistical analysis of the above-mentioned data and assessing the quantity as well as quality of buildings and perennial crops existing in the lands.

[8] There is no official comment from environmental agency (FATMA), it is not clear whether it is necessary to set APP around the temporal reservoir.

The procedures described above are essential to ensuring the reliability of appraisal of the amount of compensation and avoiding future disputes that might be caused by any speculations.

The market research shall be carried out by an expert. A proponent and the affected families/people shall select the representatives who will verify the process of the survey to ensure the validity of the results of the research. In general, the market research shall target the affected families/people and those who own similar properties in the surrounding areas/municipalities.

Once the surveys for setting the unit values are completed, a matrix table showing the amounts of compensation shall be prepared. The table shall be reviewed and examined by a proponent and the representatives of the affected families/people for approval. The amounts of compensation shall be reviewed every six months and updated whenever the market prices rise drastically.

Table 9.2.3 shows the sample amounts of compensation described in Commitment Letter for individual houses around Oeste Dam.

Table 9.3.2 Cost Estimation for Commitment Letters

SITUATIONS	HOUSE VALUE	ROOF VALUE	LAND VALUE	TOTAL (R$)
House Type I = 54.00 m^2	31,398.00	33,480.00	202,550.00	267,428.00
House Type II = 63.00 m^2	35,961.00	33,480.00	202,550.00	271,991.00
House Type III = 72.00 m^2	40,963.00	33,480.00	202,550.00	276,993.00
House Type I. Minimum S = 40.50 m^2	23,388.00	0.00	45,000.00	68,388.00
House Type II. Minimum S = 45.00 m^2	24,536.00	0.00	45,000.00	69,536.00
House Type III. Minimum S = 50.00 m^2	23,388.00	0.00	45,000.00	68,388.00
House Type I. Maximum S = 40.50 m^2	23,388.00	23,315.00	137,500.00	184,203.00
House Type II. Maximum S = 45.00 m^2	24,536.00	23,315.00	137,500.00	185,351.00
House Type II. Maximum S = 50.00 m^2	26,659.00	23,315.00	137,500.00	187,474.00

Source: JICA survey team

e) Literature Survey

A literature survey shall be carried out to review and analyze the processes necessary for i) transfer of ownership of the lands and properties and ii) acquisition of easements recorded in the recording office and notary public office. Furthermore, this survey aims to i) confirm the ownership of the affected lands and properties; ii) identify the potential beneficiaries of compensation; and iii) collect other documents relating to lands and properties (e.g., legal documents, payment of taxes, registration of pledge, and registration and transfer of mortgage), to verify the validity of compensation.

f) Assessment of Affected Properties

To assess the lands and properties affected by a project in a qualitative and quantitative manner, a field survey shall be carried out to clarify the land-related information (i.e., i) classification of potential land capability, ii) present land use, iii) forest classification, iv) vegetation and forest covers, and v) density of forests in the affected areas) and to make an inventory of the existing properties and facilities, such as perennial crops, buildings, roads, electric power lines, telephone lines, wells, ponds, springs being used for water supply, community facilities, and tourism facilities.

The field survey shall be conducted by experts or a professional company with a wide range of expertise, and its results will be evaluated and validated by a proponent.

g) Appraisal of affected properties

The appraisal of properties shall be conducted in accordance with the official standards of the country for land evaluation[9], namely NBR 14653-3 and NBR 14653-2, which shall be applied to rural and urban properties, respectively.

Criteria for appraisal of reproductive immovables, such as perennial crops, and non-reproductive immovables, such as buildings, shall be determined by a evaluation method for immovables and economic values for crops.

The appraisal of buildings shall be estimated on the basis of the costs estimated for wrecking of buildings, transportation of materials, and rebuilding. In the case of residential buildings, the amount of appraisal estimated in the same manner shall be the basis for determining the range of the rental cost.

On the other hand, the appraisal of lands shall be based on the land capability, which has the following eight (8) classes.

Class I: Arable land without any limitations on production of annual and perennial crops, usage of pasture, and planting of trees. The soils are fertile and have a deep effective soil layer with a high capacity of water retention. The area has a low risk of flood and no shallow groundwater.

Class II: Arable land with few limitations on crop production and soil conservation. For example, the soils indicate either less or excess CEC (Cation Exchange Capacity) and needs some amendment for crop production. However, the area can be used for crop production with proper management in general.

Class III: Arable land with some limitations on crop production and soil conservation. The area would be rapidly degraded without application of soil conservation measures or other necessary management practices. The area might need to introduce complex conservation measures for production of annual crops suitable for the climatic conditions. In case of sloping land, the area is further classified into sub-classes according to the slopes. Intensive farming will accelerate the possibility of soil erosion. On the other hand, a risk of flood is the major limitation of this class of area in the plain land.

Class IV: Land only used for cropping in a short period of time and not used for crop production continuously over years. The soil fertility is low to medium and clay content in soil texture is 15~60%. The soils are generally deep and rather well drained.

Class V: Land suitable for perennial crops, pasture, and trees, but not for annual crop. The soils are rather shallow (less than 1.2 m) and have gravel fraction (less than 5 % gravel content). The area is rather dried.

Class VI: Land in which perennial crops, pasture and trees can be grown but no annual crop can grow. The soils are infertile, well drained, and with 5~10 % gravel content, although the area is flat with rather deep soils (more than 2 m).

Class VII: Land in which perennial crops and trees may not grow well. Like the area categorized as Class VI, the area needs to introduce appropriate soil conservation measures and other land management practices to minimize the soil erosion/degradation potentials. The soils

[9] Developed by Brazilian Association of Technical Standards (ABNT)

extending flat to gently rolling terrain are infertile, well-drained, and rather shallow (less than 0.5 m). The area is dried.

Class VIII: Land not suitable for crop production or afforestation/reforestation. Consequently, the area can be used only for habitat for wild animals, sites for recreation, and water storage or harvesting facilities. Inundation area, mangrove forest, and barren or rocky area are calssified as this class.

Even if the area is owned by Navy, the same procedures for appraisal shall be followed. A simplified estimation is not allowed for the land owned by Navy.

If any floras of native species exist in the remaining unused area, the value of such floras shall be appraised and compensated along with other properties. However, those in permanent preservation area (APP) shall be kept untouched and maintained as they are. The value can be appraised but any alternation is not allowed.

Compensation for short-term crops will not be made if the notice of the date of resettlement is made more than six months before. On the other hand, if the notice is made less than six months before and short-term crops can not be harvested by the time of resettlement due to time constraints, the value of short-term crops shall be compensated.

Roads, wells, water supply systems, and electric lines in the affected areas shall be compensated by rebuilding/reconstructing the same based on the cost evaluation method.

h) Administrative Technical Reports

An administrative technical report, which is to be used for the reference for compensation, shall be prepared for the respective properties. The report describes i) the expected values of land/property, ii) the potential effects caused by a project, and iii) the amount of compensation.

i) Negotiations

The negotiations for property acquisition shall not involve anyone who might envision obtaining economic or political benefits from the negotiations, but be made through a direct communication with each owner of property

Compensation shall be based on the administrative technical reports on the respective affected properties. A proponent for a project shall be responsible for issuance of a deed of transfer and registration of the lands to be transferred to the affected families/people in the recording office. The final payment of compensation shall be adjusted by deducting the expenses for registration of new properties for the affected families/people.

j) Payment

A proponent shall make a payment within 30 days, on the condition of the submission of an ownership certificate, from the date of the mutual contract on the amount of compensation. In the cases of Individual Resettlement (CC) and Special Cases (CE), a part of the final payment might be used for procurement of new properties.

k) Deadline for Transfer of Properties

In case that the payment of compensation is made or Individual Resettlement (CC) is selected as the method for acquisition, the owner shall transfer the occupied land to a proponent by the deadline for transfer. The deadline shall be determined by a proponent in principle, but it should be adjusted with the conditions of the owners, especially when buildings/facilities are removed in the affected area.

As long as an implementation schedule of a project is not affected, the deadlines for transfer of the affected lands can be extended within a certain timeframe as an exceptional case. In that case, a proponent shall make an agreement on free use of the acquired land with the affected families/people, so that they could use such areas until the new deadlines set by the agreement.

l) Compulsory acquisition in accordance with Public Utility Declaration Resolution - DUP

Compulsory land acquisition shall be carried out in accordance with the ANEEL Resolution No. 279/2007 otherwise known as the Public Utility Declaratory Resolution. DUP would be applied in case the amicable land acquisition can not be made due the breakdown of the negotiations on compensation or the defect in the documents on land ownership, which are the bases for a proponent to pay compensation. In some projects, compulsory compensation might be undertaken at the state or municipal level.

In the early stage of the project, sufficient deliberation on whether or not the Resolution can be applied to a flood control dam project shall be made in consideration of the nature of the project. In fact, the Resolution stipulates the legitimacy of land acquisition for a hydropower project, and therefore, the same is considered applicable to a flood control dam as its nature is similar to a hydropower dam.

m) Granting of Ownership

In case the legal process (or compulsory acquisition) for granting of ownership is required due to the breakdown of the negotiations or disputes over the conveyance of estate, an expert report relevant to the issue shall be prepared for granting of ownership at least six months before the start of impounding.

n) Prioritization of Properties to be acquired

The land acquisition of the inundation areas shall be carried out in both river banks, from the downstream to upstream if possible. Furthermore, the following lands should be prioritized.

- Construction site and access roads to the site
- Areas to be fully affected or fully acquired
- Areas to be partly affected and whose owners prefer to have partial compensation
- Areas identified as partially affected

o) Criteria to Examine the Possibility of Continuation of Livelihood Activities in the Remaining Areas

The existing livelihood activities in the remaining areas shall be assessed to examine the possibility of the continuation of them. If the assessment reveals that i) the cost incurred for basic infrastructure necessary for the existing livelihood activities in the remaining areas will be higher than that for resettlement or ii) the remaining areas are too remote from basic infrastructure to maintain the existing livelihoods, the continuation of the livelihood activities would be judged impossible. In addition, in case the remaining areas are susceptible to landslide due to its slopes or geological characteristics, the continuation of the livelihood activities would not be allowed.

In case any investment have been made for agricultural development even in the area where no agricultural activity had been undertaken before a project, the possibility of continuation of the agricultural activities in such areas shall be deliberated.

If the existing agricultural activities, namely livelihood activities, can be continued in the remaining area, a proponent shall only acquire the areas to be inundated/impounded and its surrounding areas for protective vegetation strips (APP).

On the other hand, if the continuation of the existing activities is considered impossible or infeasible to support the livelihoods of families, a proponent shall acquire the whole area including the remaining area unless the owners of the areas officially request the exclusion of the remaining areas from land acquisition.

9.3.5 Typical Resettlement Monitoring Program in Brazil

(1) Introduction

Due consideration should be given to: i) agricultural production and economic activities (e.g., agricultural activities, any complementary activities, market supply, and commercialization); ii) social interaction (e.g., resumption of community activities and reformation/restructuring of social structure); and iii) arrangement of basic infrastructure (e.g., houses, education facilities, health facilities, and transportation facilities) during the process of resettling the affected families/people. To this end, a systematic monitoring program needs to be implemented during the process of resettlement, so as to ensure the transparency of the process and remedy the resettlement activities when necessary.

(2) Justification

The main aim of the monitoring program is to identify the positive and negative aspects of the various measures (monetary compensation, commitment letter, resettlement in the remaining areas, individual resettlement, and special arrangements/cases) taken for development of new communities in the course of resettlement

The monitoring program is to target thee families/people resettled/relocated ("resettled/relocated families/people"). Having analyzed the negative aspects identified, the monitoring program is to provide effective alternatives and means to minimize the negative factors, such as provision of technical and social guidance.

Forcing people to change the living environment by any reasons other than personal interest might cause social disruption or seriously threaten the basis of civil society. It is therefore important to restore the lifestyle of the affected families/people, provide necessary support for restoration, and continue monitoring of the resettled/relocated families/people in new areas. The monitoring program would be helpful in having the feedbacks from the resettled/relocated families/people and identifying the needs of technical and social assistance for them.

(3) Objectives

The main objective of the monitoring program is to collect the information relevant to the resettled/relocated families/people in the different stages of a resettlement program to evaluate the process of resettlement from the economic and financial viewpoints and to propose any improvement when necessary. Specifically, the program aims to:

- evaluate the changes in lifestyle of families/people living in the areas directly or indirectly affected by a project in the different stages of a resettlement program
- validate the effectiveness and validity of a resettlement program
- monitor the families who recognize the discrepancy between the plan of a resettlement program and the results of the same or who propose revising the guidelines adopted for resettlement

(4) Goals

The goal of the monitoring program is to propose the necessary activities for improvement of a resettlement program as described above. The milestones to be achieved by the monitoring program are to monitor and survey all the resettled/relocated families in different locations at the respective stages (i.e., T0, T1, T2, and T3 stages) within three years from resettlement.

(5) Environmental indicators

Information to be monitored are: i) the level of satisfaction, ii) the level of family income, and iii) the level of solidarity of new communities of the resettled/relocated families. Furthermore, the following environmental indicators shall be monitored for three years.

- Opposition movement of resettled families/people against the results of the resettlement program;
- Proportion (Percentage) of resettled families/people satisfied with the effectiveness of resettlement;
- Proportion (Percentage) of resettled families/people who remove to other places in a short period of time;
- Degree of crop diversification;
- Proportion (Percentage) of resettled families/people who are able to engage in a job/occupation that enable them to enhance their standard of living;
- Level of increase of crop productivities
- Changes in average family income
- State of adaptation of resettled families/people to the respective new locations
- Level of improvement of social indicators
- Degree of discrepancy between the plan and results of the program
- Degree of introduction of new technologies in agricultural production.

(6) Target groups

The monitoring program is to target: i) directly-affected people, ii) people forced to relocate, iii) people without house or employment, and iv) people who are not able to obtain property compensation.

(7) Basic concepts

The resettled families/people should be followed up and the resettlement measures and their process shall be evaluatd in the different stages of a resettlement program. The results of CSE/socio-economic survey will be used for evaluation.

Stage	Aims of monitoring
T0-T0 Stage (when the monitoring activity starts):	Survey and grasp the socio-economic conditions of the affected families/people prior to resettlement through CSE.
T1- T1 Stage (six months after resettlement):	Evaluate the current situations of the resettled/relocated families.
T2- T2 Stag (18 months after resettlement):	Assess the socio-economic conditions of the resettled/relocated families.
T3- T3 Stage (30 months after resettlement):	Evaluate the stability of the resettled/relocated families

(8) Methodological procedures

The monitoring program is to employ quantitative and qualitative surveys, a questionnaire survey using a set of questionnaires, and a semi-structured interview survey to grasp the feelings and sentiments of the ressetled/relocated families. A quantitative survey can reveal the level of satisfaction/dissatisfaction and other qualitative socio-economic aspects before and after resettlement, while the quantitative survey can measure the inter-annual changes in the pre-determined milestones and environmental indicators. Those surveys to be employed shall encompass different approaches that have the respective pre-determined timeframe, interrelate each other, and have the respective clear aims and methodologies.

The results of CSE shall be used as the baseline data to clarify the changes in socio-economic conditions of the resettled families/people through periodical monitoring activities.

Monitoring activities will be carried out in accordance with the following timeframe:

T0: Before resettlement of families
T1: Six months after resettlement
T2: One year after T1
T3: another one year after T2, when the life of the resettled/relocated families would become stable

(9) Development of program

The monitoring program is to be developed in consideration of its timeframe and methodologies required.

a) “T0” STAGE – Before resettlement

An interview survey will be carried out to determine the baseline of the ressetled/relocated families before resettlement. Hence, the families to be affected by a project will be targeted by this monitoring activity. The changes in the socio-economic conditions will be assessed on the basis of the data collected in this stage.

b) “T1” STAGE – Six months after resettlement

A semi-structured interview using questionnaires will be conducted six month after resettlement to assess if the resettled/relocated families are adaptable to their new environment and evaluate if the unification of the resettled/relocated families as a new community progress as planned. Feelings and sentiments of resettled/relocated families along with good and bad points of the results of resettlement will be grasped through such an interview survey.

c) “T2” STAGE – One year after “T1”

The survey at this stage aims to grasp the socio-economic conditions of the resettled/relocated families considering the vulnerability of the respective families. Data on the second year cropping, such as area cultivated, crop yields, and sales of products, will be collected and analyzed for this purpose. The same questionnaires used in T0 Stage will be used in this stage.

d) “T3” STAGE – One year after “T2”

This stage aims to assess the degree of social stabilization of the resettled/relocated families by evaluating the effect of compensation payment on the household economy at the third year.

Hence, a structured questionnaire survey, which would enables a quantitative economic and financial analyses with cross-checking and social interaction analysis of the resettled/relocated families, will be carried out in this stage.

9.3.6 Environmental Management and Monitoring Programs

All the activities relating to envrionmental management, supervision and monitoring in the construction and operation phases shall be planned in EIA/RIMA as the environmental management and monitoring programs in accordance with the methods/procedures defined by the relevant environmental legislation in Brazil. Contents and composition of envoironmental management and monitoring programs will be determined and finalized in consulation with the relevant organizations in the process of the preparation of EIA/RIMA.

The following items shall be included in the envoironmental management and monitoring programs.

i) Environmental Lisence:	It shall describe the environmental impact assessment study and the proposed measures to avoid and mitigate the expected impact.
ii) Environmental Management and Control:	It shall include the descriptions about environmental training for laborers, health management of laborers, and pollution preventive measures (e.g., dust, traffic, noise, and vibration).
iii) Enviromental Monitoring:	It describes a monitoring plan in the construction and operttaion phases.

A proponent shall be responsible for environmental monitoring, but its implementation (e.g., field monitoring activities) is generally contracted out to a consulting firm/consultants or university.

CHAPTER 10 COST AND IMPLEMENTATION PLAN

10.1 Total Project Cost

The total project cost of first phase implementation is of R$ 202.9 million, being direct cost of R$ 193.9 million in loam concept, R$ 7.8 million of administrative expenses, R$ 1.2 million for the land compensation.

Table 10.1.1 Project Cost Project Cost of Phase 1

Unit: R$ 1,000

Item		Direct Cost (Loan)	Administration Expenses	Expropriation	Subtotal
I. Direct Cost of Measure					
(1) Basin Storage Measures	Water storage in paddy fields	18,000	3,600		21,600
	Heightening of dams (Oeste)	27,200	800	1,110	29,110
	Heightening of dams (Sul)	22,500	700		23,200
(2) River Improvement Measures	Floodgates in Itajaí Mirim River (Upper stream)	17,800	500	10	18,310
	Floodgates in Itajaí Mirim River (Lower stream)	14,000	400		14,400
(3) Structural Measures for Sediment Disaster Prevention		25,800	800	50	26,650
(4) Strengthening of the Existing Flood Forecasting and Warning System (FFWS)		4,000	120		4,120
(5) Formation of Early Warning System for Sediment Disaster and Flash Flood		4,000	120		4,120
II. Subtotal		133,300	7,040	1,170	141,510
III. Engineering Services		25,100	750		25,850
IV. II+III		158,400	7,790	1,170	167,360
V. Physical Contingency (10% of IV)		15,800			15,800
VI. Price Escalation		19,700		70	19,770
VII. Project Cost		**193,900**	**7,790**	**1,240**	**202,930**

Source: JICA Survey Team

Cost estimate was made based on the annual disbursement cost according to the project implementation schedule taking into account annual price escalation.

10.2 Base of Cost Estimation

The base cost is on the price of 06/2011 (exchange rate R$ 1.0 = JPY 50.71 = US$ 0.63). The unit cost used for the estimation of the project is of prices applied in the DNIT.(National Department of Transport Infrastructure).or the DEINFRA.

10.2.1 Civil Work

The base of cost estimation is as follow;

i) Work = Quantity of each work x unit price

ii) Temporary works; according to each project

iii) Compensation ; Resettlement and compensation

The applied main unit costs are of DEINFRA's data, being calculated on the basis of labor 20 days per month. In a unit cost, taxes and administrative expenses are included. The details of the quantity of works, unit costs and cost of the temporary works are in the supporting report document.

10.2.2 Water Storage in Paddy Fields by Heightening of Paddy Ridge

The water storage in paddy fields project that consider as a basin storage measure, will be implemented directly by the participations of the rice producers. In this project, followings items are included;

i) Purchase of machinery

ii) Cost for installation of nursery plants and fence facilities

10.2.3 Expropriation

As a expense relative to the expropriations, the expenses were counted for the compensations originating from of the Oeste Dam heightening, identifying the areas to be impacted.

10.2.4 Others Costs

For the estimation of engineering cost, the values equivalent to 10% of the direct cost of the work was applied, excluding the services that require the special attentions, such as of training, system development, etc. These special services were counted in the special form in accordance with their characteristics. The relative expenses for the project administration were applied of 5% of direct cost. In the case of the Project "Water storage in paddy fields", the special forms were counted being considered that require different characteristics of the measure in the State Government. The cost for physical contingencies was applied 10% of the direct cost of the work. Price escalation is discussed in sub-section 10.6.2.

10.3 Direct Cost of Work

10.3.1 Basin Storage Measures

(1) Water storage in paddy fields by heightening of paddy ridge

The direct cost of this project is composed of the heightening of Paddy ridge and the recovering of riprap forest. The details of the costs are;

Table 10.3.1 Water Storage in Paddy Field

Item	Quant.	Unit	Unit Cost (R$)	Cost (R$)
Heightening of Paddy ridge	5,000	ha	3,400	17,000
Recovering of riprap forest	200	ha	5,000	1,000
Total				18,000

Source: JICA Survey Team

The costs related to the formulations of the plans, consensus formation of the producers, necessary costs for the environmental regulations are counted in the engineering services part. A training for PIA shall be carried out the State Government (EPAGRI).

(2) Heightening of Oeste Dam

The project cost of the heightening of the Oeste Dam is shown below. A new discharge conduit will be installed at the left abutment to increase the current discharge releasing capacity.

Table 10.3.2 Direct Cost for Heightening of Oeste Dam

		Unit	Cost (R$)	Oeste dam	
				Quantity	Amount (R$)
Earth Works					
Excavation (Sand)	(DMT up to 5km)	m3	15	59,000	885,000
Excavation (Rock)	(DMT up to 5km)	m3	100	1,650	165,000
Back Filling, Selected Materials	(DMT up to 5km)	m3	40	25,000	1,000,000
Concrete Works					
Concrete (including Batcher plant,Scaffold, etc)	fck=16Mpa	m3	730	12,500	9,125,000
Concrete (including Form, Scaffold, etc)	fck=25Mpa	m3	600	3,500	2,100,000
Reinforcement - deformed bar		t	7,500	140	1,050,000

Demolishing of Existing Concrete Structure	(DMT up to 5km)	m3	540	250	135,000
Consolidation Grout		m	1,250	380	475,000
Road Works					
General Road(including paving)	width=8m,h=3m	m	1,570	1,500	2,355,000
Road Bridge (Including Substructure, ancillary works)		m2	3,000	160	480,000
Other Works					
Main works * 30%					5,331,000
Temporary Work					1,617,000
Cellular Cofferdam	f8.5, h8.5	set	113,000	3	339,000
Cellular Cofferdam	f6.0, h6.0	set	43,000	9	387,000
Cellular Cofferdam (Only move)	f8.5, h8.5	set	57,000	3	171,000
Cellular Cofferdam (Only move)	f6.0, h6.0	set	21,500	8	172,000
Temporary main works * 20%					214,000
(dewatering, site cleaning, etc)					
Civil Works Total					26,001,000
Water gate		t	40,800	29	1,183,000
Metal works Total					1,183,000
Total					**27,184,000**

Source: JICA Survey Team

(3) Heightening of the Sul Dam

The Cost of the heightening of Sul Dam is of the works of heightening of spillway, construction of new tunnel and adjustment works in the lower stream. A new tunnel spillway will be installed to increase the current discharge releasing capacity. The amounts of works and direct cost are as follows:

Table 10.3.3 Direct Cost for Heightening of Sul Dam

		Unit	Cost (R$)	Sul dam spillway	
				Quantity	Amount (R$)
Earth Works					
Excavation (Sand)	(DMT up to 5km)	m3	15	4,400	66,000
Excavation (Rock)	(DMT up to 5km)	m3	100	500	50,000
Concrete Works					
Concrete (including Form, Scaffold, etc)	fck=25Mpa	m3	600	4,050	2,430,000
Reinforcement - deformed bar		t	7,500	70	525,000
Demolishing of Existing Concrete Structure	(DMT up to 5km)	m3	540	800	432,000
Tunnel Works					
Horse Shaped Tunnnel (2R Type)	2R=5m	m	35,000	430	15,050,000
Other Works					
Main works * 30%					1,051,000
Civil Works Total					21,564,000
Water gate		t	40,800	22	898,000
Metal works Total					898,000
Total					**22,462,000**

Source: JICA Survey Team

10.3.2 River Improvement Measures

(1) Installation of Upstream Floodgate of the Itajaí Mirim River

The work of the upper stream floodgate of the Itajai Mirin River will be installed by the complete closing of the river, settling the temporary drainage channel. The amounts of works and direct cost are

Table 10.3.4 Cost of Installation of Upstream Floodgate of the Itajaí Mirim River

	Unit	Cost (R$)	Quantity	Cost (R$)
Earth Works				
Excavation (Sand)	m3	14	4,803	67,914
Back Filling, Selected Materials	m3	35	1,582	55,519
Embankment, Selected Materials	m3	13	7,443	94,669
Concrete Works				
Concrete (including Form, Scaffold, etc)	m3	584	2,149	1,255,560
Reinforcement - deformed bar	t	7,480	172	1,286,176
Substructure Work				
Driving and Furnishing Steel Sheet Pile Type II	sheet	1,374	114	156,663
Driving and Furnishing Steel Sheet Pile Type II	sheet	2,925	128	374,367
Driving and Furnishing Precast Pc Pile	nos	5,450	112	610,425
Driving and Furnishing Precast Pc Pile	nos	4,004	48	192,184
Concrete Block (Production, Installation cost)	m2	282	317	89,455
Revetment Works				
Sodding	m2	1	3,024	3,750
Drainage Channel Works				
Tributary switching channel (Earth type)	m	255	1,000	254,838
Tributary switching channel (Box culvert type)	m	16,009	60	960,520
Drainage channel	m	246	6,000	1,475,460
Road Works				
Macadam Pavement (Crushed Stones(10-40))	m2	14	300	4,110
Super Structure (Including handrail, paving, etc)	m2	1,392	164	227,731
Other Works				
Main works * 30%				2,132,802
Temporary Work				924,214
Cofferdam (Excavation Common / Dredging As Temporary Works)	m3	52	4,968	257,084
Driving Steel Sheet Pile Type II	sheet	653	224	146,212
Stream Diversion Channel (B=30.0*h=2.5)	m	597	120	71,605
Temporary main works * 20%				94,980
Civil Works Total				10,736,236
Water gate	t	40,800	170	6,940,080
Metal works Total				6,940,080
Total				17,676,316
				17,600,000

Source: JICA Survey Team

(2) Installation of downstream floodgate in the Itajaí Mirim River

The floodgate of the (lower stream) Itajaí Mirim River, being considered the effect of high sea and the drainages, the construction will be made by the complete closing of the river. Besides, being considered the existences of the house in the riversides, the riverside work will be made by the concrete sheet pile. The amounts of works and direct cost are;

Table 10.3.5 Cost of Installation of Downstream Floodgate in the Itajaí Mirim River

	Unit	Cost (R$)	Quantity	Cost (R$)
Earth Works				
Excavation (Sand)	m3	14	3,542	50,084
Back Filling, Selected Materials	m3	35	3,399	119,270
Concrete Works			0	0
Concrete (including Form, Scaffold, etc)	m3	584	1,295	756,604
Reinforcement - deformed bar	t	7,480	104	775,054
Substructure Work			0	0
Driving and Furnishing Steel Sheet Pile Type II	sheet	1,110	110	122,109
Driving and Furnishing Precast Pc Pile	nos	2,019	80	161,488
Driving and Furnishing Precast Pc Pile	nos	1,631	48	78,297
Concrete Block (Production, Installation cost)	m2	282	366	103,161
Revetment Works			0	0
Driving and Furnishing Concrete Sheet Pile	m2	358	391	139,949
Driving and Furnishing Concrete Sheet Pile on the Water (Including head cover)	m2	430	5,369	2,309,125
Gabion Box (including geotextile)	m3	287	136	38,963
Sodding	m2	1	176	218
Rubble-mound	m3	78	10,437	817,079
Other Works				
Main works * 30%				1,641,420
Temporary Work				419,054
Cofferdam (Excavation Common / Dredging As Temporary Works)	m3	52	6,081	314,666
Driving Steel Sheet Pile Type II	sheet	653	285	186,028
Temporary main works * 20% (dewatering, site cleaning, etc)			0	100,139
Civil Works Total			0	8,132,707
Water gate	t	40,800	140	5,720,160
Metal works Total			0	5,720,160
Total			0	13,852,867
				13,800,000

Source: JICA Survey Team

10.3.3 Structural Measures for Sediment Disaster Prevention

The structural measures for sediment disaster prevention will be implemented at the 13 priority places (with annual potential loss more of R$ 500.000). In following Table, the direct costs of each works are shown;

Table 10.3.6 Direct Cost of Structural Measure for Landslide Disaster Mitigation

Priority	Local	Direct Cost R$ (x 10^3)
1	Road SC 302 Taio-Passo Manso-5	387
2	Road SC470 Gaspar River Bank	2,062
3	Blumenau- Av. Pres Casrelo Branco	2,849
4	Road SC418 Blumenau – Pomerode	1,851
5	Road SC474 Blumenau-Massaranduba 2	3,724
6	Road Gaspar - Luiz Alves, Gaspar 9	3,399
7	Road Gaspar - Luiz Alves, Luiz Alves 6	1,448
8	Road SC470 Gaspar Bypass	2,768
9	Road SC477 Benedito Novo - Doutor Pedrinho 1	1,026
10	Road SC418 Pomerode - Jaraguá do Sul 1	878
11	Road Gaspar - Luiz Alves, Luiz Alves 4	3,726
12	Road SC474 Blumenau-Massaranduba 1	515
13	Road SC 302 Taio-Passo Manso 4	1,173
Total		**25,806**

Source: JICA Survey Team

10.3.4 Strengthening the Existing Flood Forecasting and Warning System (FFWS)

The cost for Strengthening the existing flood forecasting and warning system (FFWS) is composed by followings items;

- Rain gage, water lever gage, CCTV, equipment for communication
- River inventory (topographic survey)

In a following table, detailed cost is shown;

Table 10.3.7 Cost of Strengthening the Existing FFWS

Item	Direct cost R$ (x 10^3)
Acquisition/installation of monitoring and data transmitting equipment	2,535
River inventory	1,500
Total	**4,035**

Source: JICA Survey Team

10.3.5 Early Warning System for Sediment Disaster and Flush Flood

The direct cost of this project is as follow;

- Acquisition and installation of rain gage, transmission of GPRS and VHF antenna
- Acquisition and installation of radio, data transmitting by VHF

In a following table, the direct cost is shown;

Table 10.3.8 Equipment and Installation Cost for Early Warning System for Landslide and Flush Flood

	Equipamento	Unit Cost (R$)	Quant.	Cost (R$)
1	Datalogger (cada município)	3,000	53	159,000
2	Modem GPRS	800	53	42,400
3	Radio modem	1,600	53	84,800
4	Antena GPRS	120	53	6,360
5	Antena VHF	350	53	18,550
6	Caixa protetora Ambiental	500	53	26,500
7	Bateria	100	53	5,300
8	Controlador de Carga	250	53	13,250
9	Painel Solar 20W	650	53	34,450
10	Pluviômetro	3,500	53	185,500
11	Suportes e acessórios necessários para montagem da estação em campo	1,800	53	95,400
12	Cercado para Estações	1,000	53	53,000
13	Instalação das Estações em Campo	1,500	53	79,500
14	Computadores	4,600	53	243,800
15	Servidores de Dados	32,800	1	32,800
16	Licenças de Banco de Dados	29,520	1	29,520
		Total		**1,110,130**

Source: JICA Survey Team

Table 10.3.9 Transmitting Equipment/ Installation of Early Warning System for Landslide Disaster and Flush Flood

	Discrimination of expenses	Unit Cost (R$)	Quant	Cost (R$)
		48,500	10	485,000
1	Enlace de rádio (pares) com proteções , cabos, conectores	25,000	10	250,000
2	Radio Base- Recepção das estações	2,500	10	25,000
3	Conjunto de baterias 300 Ah	8,000	10	80,000
4	Painéis Solares 450w c suporte	2,000	20	40,000
5	Antenas para enlace com cabo	1,500	10	15,000
6	Antenas para radiobase com cabo	3,000	10	30,000
7	Sistema de Gerenciamento de energia	5,000	10	50,000
8	Rack padrão	7,000	10	70,000
9	Torre 18 metros com para-raios	6,000	3	18,000
10	Servidores para link com internet	2,000	3	6,000
11	Sistema de Internet via satélite	9,000	10	90,000
		Total		**1,159,000**

Source: JICA Survey Team

Table10.3.10 Cost of Engineering Service of Strengthening of FFWS

	Item	unit	Unit Cost (R$)	Quant	Cost (R$)
1	Project Leader	hour	164	960	157,440
2	System Engineer	hour	115	3.840	441,600
3	System Developerr	hour	82	9.600	787,200
4	Databank Expert	hour	115	960	110,400
5	Network Expert	hour	115	960	110,400
6	Support Enginerr	hour	66	800	52,800
7	Other Work	hour	197	120	23,640
	Total				**1.683.480**

Source: JICA Survey Team

10.3.6 Engineering Services Cost

The cost for engineering services was estimated based on the direct cost and associated indirect cost. The direct cost was estimated applying the average monthly billing rate of consultant engineers and respective assignment period (total months to be assigned). The indirect cost consists of airfare, accommodation, office expenses, vehicle expenses, supporting staff, etc. In

Brazil, since there is no distinction between international consultant and Brazilian consultant engineers, flat monthly billing rate of R$ 50,000 was applied for estimation of engineering services cost. This monthly billing rate assumed to include the indirect cost. Table 10.3.11 shows the assignment schedule of consulting engineers. The estimated cost for engineering services is composed by following activities;

Table 10.3.12 Cost of Engineering Services

Services	Cost(R$)
(1) Project management	1,400,000
(2) Project formation and detailed design of water storage in paddy fields	8,000,000
(3) Detailed design and supervision of heightening of dams	4,000,000
(4) Detailed design and supervision of flood gate of Itajai Mirim River and training	5,200,000
(5) Detailed design and supervision of Structural Measures for Sediment Disaster Prevention	2,600,000
(6) Detailed design and installation of strengthening the existing flood forecasting and warning system (FFWS)	3,000,000
(7) Detailed design and installation of early warning system for landslide and flush flood	900,000
sub-total	**25,100,000**

Source: JICA Survey Team

The details of the services are the following ones;

(1) Project management

This project, being composed of different characteristic of measures, with objective of implementing the measure in the efficient and effective forms, the following activities will be accomplished:

i) Formulation of strategic implementation plan
ii) Support for environmental license
iii) General arrangements of implementation schedule
iv) Support for the preparation of bidding documents
v) Preparation of application documents for the financial transfer and fund managements
vi) Institutional Coordination and financial institution

(2) Project formation and detailed design of water storage in paddy fields

The cost estimation of this project “Water storage in paddy fields” was accomplished in the conditions that to develop in the paddy expanded in the Itajai river basin. This service is composed by different kinds of services from motivation of the participant producers, support for the formation of the construction implementation associations, support for establishments of participants' activities regulation, production of nursery plants and support for the environmental legalization, etc. The cost of this service is listed below.

i) Plan formulation for the heightening of paddy ridge and recovering of riprap forest
ii) Formation of project implementation
iii) Topographic survey
iv) Overall management of project implementation
v) Support for environmental legalization
vi) Support for environmental license
vii) Support for administration of the machineries in CIDASC
viii) Support for FDR administration

(3) Detailed design and supervision of heightening of dam

This service is composed by detailed design and supervision of the heightening of Oeste & Sul Dam and preparation of operation manuals.

(4) Detailed design and supervision of flood gate of Itajai Mirim River and training

This service is composed by the detailed design of floodgate installation/civil works, respective supervisions of construction/installation works, preparation of the floodgate operation manual and the trainings for floodgate operation.

(5) Detailed design and supervision of Structural Measures for Sediment Disaster Prevention

This service will develop followings activities such as detailed design, construction supervision and preparation of maintenance manual of structures.

(6) Detailed design and supervision of Strengthening the existing flood forecasting and warning system (FFWS)

This service is composed of revision of the existent system of flood forecasting and warning system, development of drainage simulation model, supervision of the acquisitions of the meteorological observations equipments, and elaborations of the operation manuals.

(7) Detailed design and installation of Early Warning System for Landslide and Flush Flood

This service will cover to accomplish the studies of system establishments of the Early Warning System for Landslide and Flush Flood, preparations of the specifications for acquisition of necessary equipments and the necessary trainings.

Table 10.3.11 Masnning Schedule of Engineering Services

Stage	Position	2013 1	4	7	10	2014 1	4	7	10	2015 1	4	7	10	2016 1	4	7	10	2017 1	4	7	10	M/M
		J F M A M J J A S O N D J F M A M J J A S O N D J F M A M J J A S O N D J F M A M J J A S O N D J F M A M J J A S O N D																				
Project Management																						
	Project Manager																					28.0
	TOTAL																					28.0
Water Storage in Paddy Fileds																						
	Sector Leader																					53.0
	Procurement Expert / FDR Coordinator																					12.0
	Geodetic Engineer																					12.0
	Irrigation Engineer																					17.0
	Construction Planner																					20.0
	Agronomist																					10.0
	Environmentalist																					12.0
	Training Expert																					24.0
	TOTAL																					160.0
Heightening of Dams																						
Detail Design Stage	Sector Leader / Dam Structural Engineer																					12.0
	Geologist																					3.0
	Geodetic Engineer																					3.0
	Hydraulic Engineer																					2.0
	Design Engineer																					6.0
	Mechanical Engineer																					2.0
	Construction Planner																					4.0
	Cost Estimator / Constructural Planner																					3.0
	Spec Writer																					3.0
Construction Supervision Stage	Sector Leader / Dam Structural Engineer																					15.0
	Tender Evaluator																					2.0
	Construction Engineer																					14.0
	Tunnel Engineer																					7.0
	Mechanical Engineer																					2.0
	O&M Engineer																					2.0
	TOTAL																					80.0
Floodgates in Itajai Mirim River																						
Detail Design Stage	Sector Leader / Civil Engineer																					12.0
	Hydrologist																					6.0
	Geologist																					6.0
	Structure Engineer (River)																					6.0
	Structure Engineer (Bridge)																					3.0
	Mechanical Engineer																					5.0
	Cost Estimator / Construction Planner																					5.0
	Spec Writer																					3.0
Construction Supervision Stage	Sector Leader / Civil Engineer																					27.0
	Tender Evaluator																					4.0
	Construction Engineer																					17.0
	Mechanical Engineer																					6.0
	Electric Engineer																					2.0
	O&M Engineer																					2.0
	TOTAL																					104.0
Strengthening of Existing FFWS																						
	Sector Leader / FFWS																					23.0
	Hydrologist																					8.0
	River Engineer																					8.0
	Telecommunication Engineer																					8.0
	System Enginner																					4.0
	Network Engineer																					4.0
	Database Engineer																					5.0
	TOTAL																					60.0
Installation of Early Warning System for Landslide and Flashflad																						
	Sector Leader / Disaster Prevention																					14.0
	System Engineer																					2.0
	Traomomg Expert																					2.0
	TOTAL																					18.0
Structural Measures for Disaster Prevention																						
Detail Design Stage	Sector Leader / Landslide																					14.0
	Geologist																					4.0
	Geodetic Engineer																					4.0
	Slop Protection Engineer																					6.0
	Cost Estimate / Construction Planner																					2.0
Supervision Stage	Sector Leader / Landslide																					20.0
	O & M Expert																					2.0
	TOTAL																					52.0
	GRAND TOTAL																					502.0

Source: JICA Survey Team

10.4 Implementation Method and Organization Chart

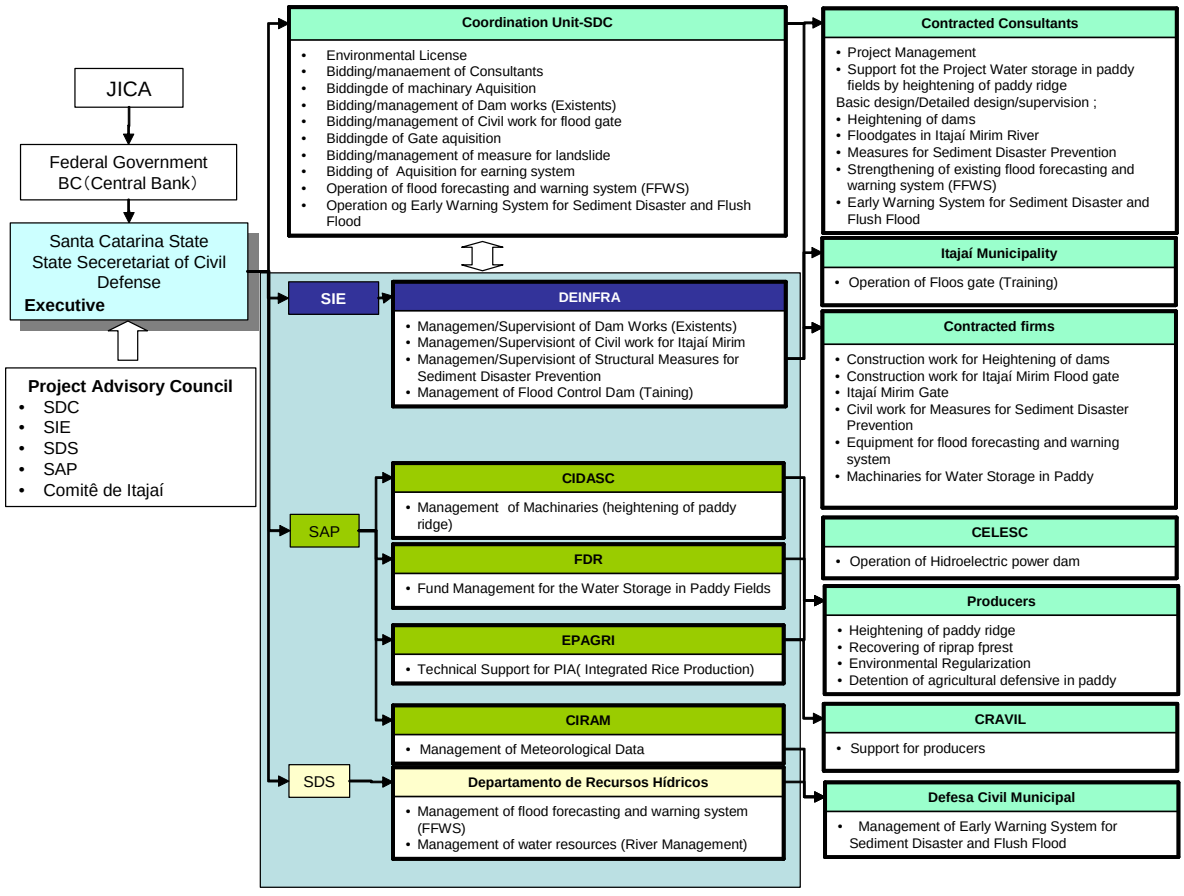
10.4.1 Components of Phase 1 Project

The components of Phase 1 project are;

i) FDR for paddy ridge heightening（Water storage in paddy fields）
ii) Technical Assistance by EPAGRI for the Introduction of PIA（Water storage in paddy fields）(made by the Sate Government)
iii) Heightening of dams（Oeste and Sul dams）
iv) Installation of floodgates in Itajai Mirim River
v) Design and procurement of gates (Itajaí Mirim River)
vi) Structural measures for landslide disaster prevention
vii) Strengthening the existing FFWS
viii) Acquisition of consulting services

10.4.2 Executing Organization and Project Implementation Schedule

The project executing agency is of the State Secretariat of Civil defense (SDC) and the SDC will be creating the Coordination Unit of the Project (UC) that has responsible attribution of the Project Implementation. The Project will be implemented in accordance with the divided project components. The project implementation organization is shown below.



Source: JICA Survey Team

Figure 10.4.1 Executing Agency and Project Implementation Organization

The Project organization chart are composed by Executive agency, Project Advisory Council, Operation agency, beneficiary and contracted.

(1) Project Advisory Council

The definition of the projects contents will be accomplished by the definition of Project advisory Council to be created in the SDC. The Project Advisory Council will be composed by the operative institutions such as of SDC, State Secretariat of Infrastructure (SIE), State secretariat of Agriculture and Fishing (SAP), State secretariat of Sustainable Developments (SDS) and the Itajaí Committee, being composed of the representative of each institutions. This Council, in addition to approve the contents of the projects, will be monitored the progress of the project, and will be prepared of the necessary budgets for implementation of each institutions.

(2) Executive Agency

The executive agency of this project will be receiving of the loam, and the following activities will be implemented;

i) Management and execution of the Project
ii) Acquisition of Environmental license
iii) Management, supervision of consulting services
iv) Management of the heightening of paddy ridge
v) Management, supervision of acquisition of construction machinery
vi) Management and supervision of the contractor for dam civil works
vii) Management and supervision of the contractor for floodgate civil work
viii) Management and supervision of the manufacturer of floodgate
ix) Management and supervision of the contractor for the structural measures for landslide disaster prevention
x) Management and supervision of the contractor for the structural measures for landslide disaster prevention
xi) Operation and administration of the flood forecasting and warning system (FFWS)
xii) Operation and administration of the Early Warning System for Landslide and Flush Flood

(3) Operation Agency

The operation agencies will be responsible for the execution and the administration of project. The infrastructures works will be responsible of the SIE and the projects related to the “Water storage in paddy fields” will be responsible of the SAP and the operations of the flood forecasting and warning system and Early Warning System for Landslide and Flush Flood will be responsible of the SDS.

1) State secretariat of Infrastructure - Department of infrastructure (SIE-DEINFRA)

The State Secretariat of Infrastructure (SIE) will be responsible institution of the executions of Oeste & Sul Dam heightening, of the floodgates of the river Itajaí Mirim river and the works of Structural Measures for Sediment Disaster Prevention. After the constructions, the SIE will be responsible in the operations of the flood controle dams.

2) SAA-CIDASC

The CIDASC will be responsible of administration of the acquired machineries. The acquired machineries will be made available to the 10 construction units in order to implement the paddy ridge heightening works for the associations of the producers.

3) SAP-FDR

The FDR will be responsible in the administrations of Fund that will be created for loam of the construction costs of paddy ridge heightening for the producers associations. FDR will be financed the necessary resources for the paddy ridge heightening works of the producers associations and the resources financed will be applied the new areas.

4) SAP-EPAGRI

The EMAGRI will be responsible to accomplish the technical assistance to introduce the PIA (Integrated Production of Rice).

5) SAP-CIRAM

The CIRAM will be responsible of administering the transferred data of the flood forecasting and warning system (FFWS) and Early Warning System for Sediment Disaster and Flush Flood

6) SDS-Water resources Departments

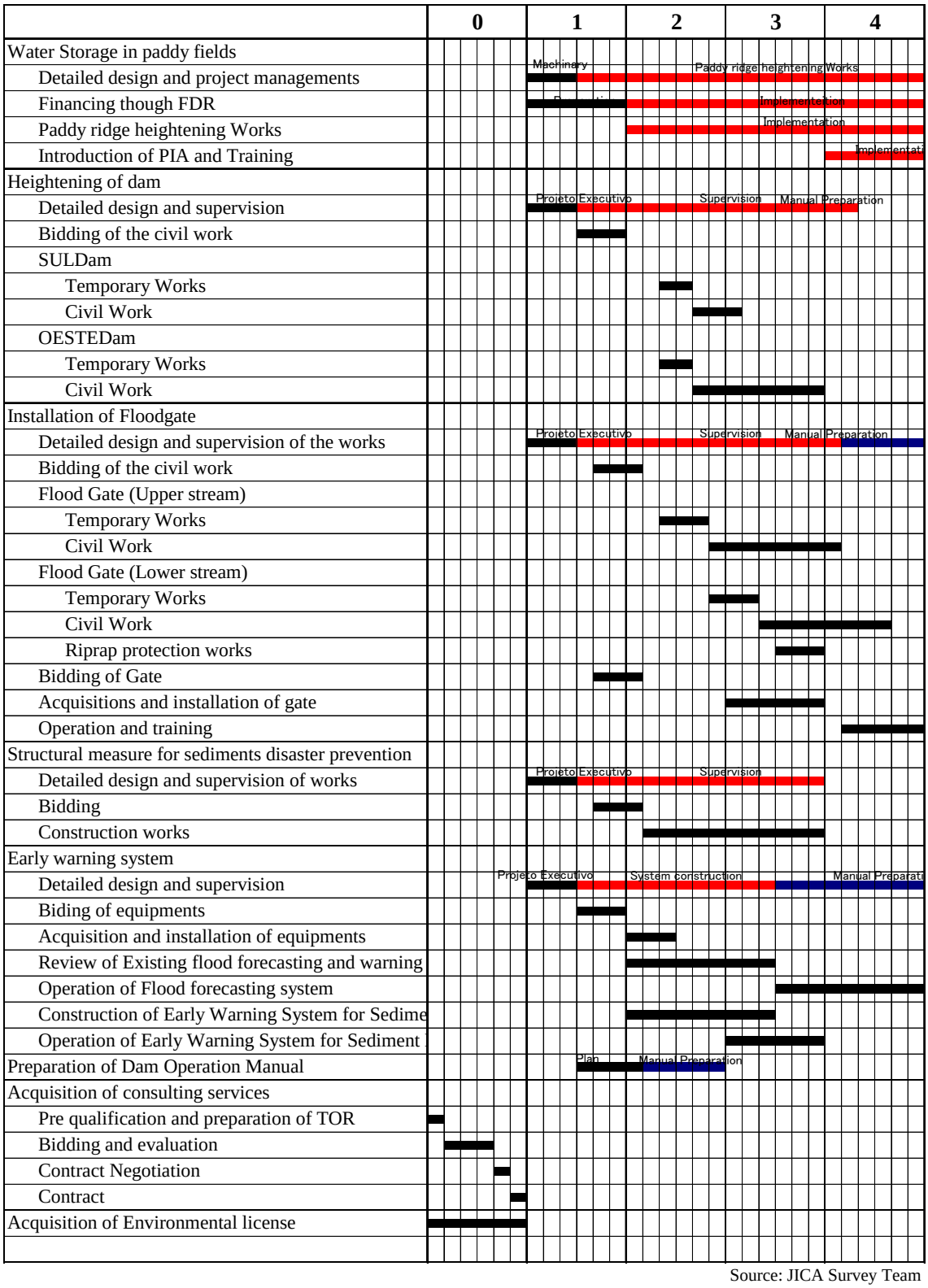
The SDS-department of water resources will be responsible of operation of the flood forecasting and warning system and administration of water resources.

(4) Beneficiary and participant of the Project

As the beneficiaries and participant of the project, there are the rice producer that participate to the project "Water Storage in paddy fields", the CRAVIL (Agricultural Cooperative of Itajaí Valley) that attends the producers, the CELESC as operator of hydroelectric dam, and the municipality of Itajaí. The associations of the rice producers will be implemented the paddy ridge heightening works, using the machineries to be acquired for the project and the FDR (available Resources for the paddy ridge heightening works). Simultaneously, the producers will be received the consultants' technical supports, so much to acquire the environmental license, support for the environmental legalization and the detailed work plan. After the construction, the technical assistances of the EPAGRI will be received to introduce the PIA. The CRAVIL will be accomplished the necessary technical assistance for the implementations of the works and the introductions of the PIA. The CELESC will implement the operations of the hydroelectric dams being used the manuals to be prepared for the consultants. The Municipality of Itajaí will be responsible for the operation of the floodgates, being used the manuals the prepared by the consultants to protect the residents' lives in the riversides of the Itajaí Mirim River.

10.5 Project Implementation Schedule

The Project will be implemented during 4 years after the contract of consultant's services, included of the detailed design, bidding of the works. In following figure, implementation schedule is indicated.



Source: JICA Survey Team

Figure 10.5.1 Project Implementation Schedule

10.6 Cost Estimation of Phase 1 of the Project

10.6.1 Packaging of Phase 1

The following packaging of Phase 1 of the Project is recommended.

Table 10.6.1 Packaging and Procurement Method of Phase 1 of the Project

No.	Package	Executing Organization	Procurement Method
1	Procurement of construction equipment (water storage in paddy field)	CIDASC	ICB (International competitive bidding)
2	Water storage in paddy field	CIDASC/FDR	Budget of FDR
3	Heightening of dams (Sul and Oeste dams)	DEINFRA	ICB
4	Installation of floodgates on the Itajai Mirim River	DEINFRA	ICB
5	Design and installation of gates at the floodgates	DEINFRA	ICB
6	Structural measures for landslide disaster prevention	DEINFRA	ICB
7	Installation of FFWS and Early Warning System for Landslide and Flish Flood	Defesa Civil	ICB
8	Procurement of Consultants	Defesa Civil	ICB

Source: JICA Survey Team

10.6.2 Annual Project Cost of Phase 1

(1) Price Escalation Rate

Annual price escalation rates were assumed to be 1.5% for foreign currency portion and 2.8% for local currency portion, respectively. Table 10.6.2 presents annual inflation rates in Brazil in 2006-2011. The average inflation rate of 2.8% was applied to the annual price escalation rate for local currency portion.

Table 10.6.2 Annual Inflation Rate in Brazil by IBGE

Year	Inflation Rate	Year	Inflation Rate
2006	1.73	2009	2.5
2007	2.54	2010	3.5
2008	3.92	2011	2.4
Average			**2.8**

Source: JICA Survey Team

(2) Allocation of Foreign and Local Currency Portions

Since lots of materials and equipment for construction such as steel products, construction materials and construction equipment are produced in Brazil, construction materials and equipment can be procured in Brazil. All of the construction cost of structures is therefore allocated to the local currency portion. Equipments for the strengthening of existing FFWS and early warning system for landslide and flush flood are assumed to be imported materials, allocating to the foreign currency portion. The cost for engineering services is also allocated to foreign currency portion.

(3) Annual Construction Cost

Table 10.6.3 presents the estimated annual construction cost based on the project implementation schedule as shown in Figure 10.5.1 and price escalation rates above.

Table 10.6.3 Annual Project Cost of Phase 1

Item	Base Cost in 2011			2013			2014			2015			2016			2017			Total		
	FC	LC	Total	FC	LC	Total	FC	LC	Total	FC	LC	Total	FC	LC	Total	FC	LC	Total	FC	LC	Total
	R$ 1000			R$ 1000			R$ 1000			R$ 1000			R$ 1000			R$ 1000			R$ 1000		
Procurement of construction equipment (water storage in paddy	100%	0%	100%	80%	0%	80%	20%	0%	20%	0%	0%	0%	0%	0%	0%	0%	0%	0%	100%	0%	100%
	25,000	0	25,000	20,000	0	20,000	5,000	0	5,000	0	0	0	0	0	0	0	0	0	25,000	0	25,000
Water storage in paddy field (FDR Budget)	0%	100%	100%	0%	15%	15%	0%	25%	25%	0%	25%	25%	0%	25%	25%	0%	10%	10%	0%	100%	100%
	0	10,000	10,000	0	1,500	1,500	0	2,500	2,500	0	2,500	2,500	0	2,500	2,500	0	1,000	1,000	0	10,000	10,000
Heightening of dams (Sul and Oeste dams)	0%	100%	100%	0%	0%	0%	0%	5%	5%	0%	5%	5%	0%	55%	55%	0%	35%	35%	0%	100%	100%
	0	49,700	49,700	0	0	0	0	2,485	2,485	0	2,485	2,485	0	27,335	27,335	0	17,395	17,395	0	49,700	49,700
Installation of floodgates on the Itajai Mirim River	0%	100%	100%	0%	0%	0%	0%	10%	10%	0%	15%	15%	0%	60%	60%	0%	15%	15%	0%	100%	100%
	0	31,800	31,800	0	0	0	0	3,180	3,180	0	4,770	4,770	0	19,080	19,080	0	4,770	4,770	0	31,800	31,800
Structural measures for landslide disaster prevention	0%	100%	100%	0%	0%	0%	0%	10%	10%	0%	40%	40%	0%	40%	40%	0%	10%	10%	0%	100%	100%
	0	25,800	25,800	0	0	0	0	2,580	2,580	0	10,320	10,320	0	10,320	10,320	0	2,580	2,580	0	25,800	25,800
Strengtheing of Existing FFWS	100%	0%	100%	0%	0%	0%	90%	0%	90%	10%	0%	10%	0%	0%	0%	0%	0%	0%	100%	0%	100%
	4,000	0	4,000	0	0	0	3,600	0	3,600	400	0	400	0	0	0	0	0	0	4,000	0	4,000
Installation of Early Warning System for Landslide and Flish Flood	100%	0%	100%	0%	0%	0%	90%	0%	90%	10%	0%	10%	0%	0%	0%	0%	0%	0%	100%	0%	100%
	4,000	0	4,000	0	0	0	3,600	0	3,600	400	0	400	0	0	0	0	0	0	4,000	0	4,000
Procurement of Consultants	100%	0%	100%	15%	0%	15%	25%	0%	25%	25%	0%	25%	20%	0%	20%	15%	0%	15%	100%	0%	100%
	25,100	0	25,100	3,765	0	3,765	6,275	0	6,275	6,275	0	6,275	5,020	0	5,020	3,765	0	3,765	25,100	0	25,100
Sub-total	58,100	117,300	175,400	23,765	1,500	25,265	18,475	10,745	29,220	7,075	20,075	27,150	5,020	59,235	64,255	3,765	25,745	29,510	58,100	117,300	175,400
Price Escalation				718	85	803	844	928	1,772	434	2,345	2,779	388	8,770	9,158	352	4,639	4,991	2,736	16,767	19,503
Physical Contingency				2,377	150	2,527	1,848	1,075	2,922	708	2,008	2,715	502	5,924	6,426	377	2,575	2,951	5,810	11,730	17,540
Total				26,860	1,735	28,595	21,167	12,748	33,914	8,217	24,428	32,644	5,910	73,929	79,839	4,494	32,959	37,452	66,646	145,797	212,443
Land Acquisition	0%	100%	100%	0%	80%	80%	0%	20%	20%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	100%	100%
	0	1,170	1,170	0	936	936	0	234	234	0	0	0	0	0	0	0	0	0	0	1,170	1,170
Price Escalation				0	53	53	0	20	20	0	0	0	0	0	0	0	0	0	0	73	73
Sub-total				0	989	989	0	254	254	0	0	0	0	0	0	0	0	0	0	1,243	1,243
Ground Total			176,570	26,860	2,724	29,584	21,167	13,002	34,168	8,217	24,428	32,644	5,910	73,929	79,839	4,494	32,959	37,452	66,646	147,040	213,686

CHAPTER 11 PROJECT EVALUATION

11.1 Methodology of Economic Evaluation

The economic evaluation in this Feasibility Study was carried out for the following projects;

Table 11.1.1 Project Subject to Evaluation

Project	Outlook of Project
Water storage in paddy fields	Paddy fields ridge heightening (5,000ha)
Change of current dam operation method and heightening of the dam（Oeste）	Heightening of dam by 2 m
Change of current dam operation method and heightening of the dam（Sul）	Heightening of dam by 2 m
Utilization of the existing hydropower generation dam for flood control	2 dams
Installation of floodgate and improving Itajai Mirim River in Itajai City	2 floodgates
Structure Measures for landslide disasters	13 locations
Strengthening the existing flood forecasting and warning system	1 unit
Installation of early warning system for landslide and flush flood	1unit

Source; JICA survey team

The evaluation period is of 50 years. Respective benefits are considered that the differences between the potential value of disaster that can be caused by the existent infrastructures and the potential value to be mitigated with the implantation of the project proposed as a mitigation measure. The benefit of structural measures for landslide disasters is separately estimated. The reaches of flood inundation were estimated through hydrological simulation by respective probable floods and it was transformed to damage values. The expected annual average flood mitigation benefit is estimated based on the probability of occurrence of probable flood and probable flood damages. Besides this, there is benefit of valorizations of the lands through improvement of safety. However, this benefit, in this evaluation, was not considered.

11.2 Cost and Benefit

11.2.1 Cost

The project cost proposed in this Study is summarized in the following table. The details of project cost are indicated in Chapter 10.

Table 11.2.1 Proposed Project Cost

Unit; R$ 1,000

Item		Direct Cost（Loan）	Administration Expenses	Expropriation	Subtotal
I. Direct Cost of Measure					
(1) Basin Storage Measures	Water storage in paddy fields	18,000	3,600		21,600
	Heightening of dams（Oeste）	27,200	800	1,110	29,110
	Heightening of dams（Sul）	22,500	700		23,200
(2) River Improvement Measures	Floodgates in Itajaí Mirim River (Upper stream)	17,800	500	10	18,310
	Floodgates in Itajaí Mirim River (Lower stream)	14,000	400		14,400
(3) Structural Measures for Sediment Disaster Prevention		25,800	800	50	26,650
(4) Strengthening of the Existing Flood Forecasting and Warning System (FFWS)		4,000	120		4,120
(5) Installation of Early Warning System for		4,000	120		4,120

Item	Direct Cost (Loan)	Administration Expenses	Expropriation	Subtotal
Sediment Disaster and Flash Flood				
II. Subtotal	133,300	7,040	1,170	141,510
III. Engineering Services	25,100	750		25,850
IV. II+III **Total**	**158,400**	**7,790**	**1,170**	**167,360**

Source; JICA survey team

11.2.2 Benefit

As the result of the implementations of the measure proposed in this FS Study, it is foreseen to obtain the following benefits;

Table 11.2.2 Expected Benefit of the Project

	Results of Measure
Water storage in paddy fields	・ Increase of rice production (10%)
Heightening of the dam (Oeste) Heightening of the dam (Sul)	・ Flood disaster mitigation in Taio City ・ Flood disaster mitigation in Rio do Sul City
Utilization of the existing hydropower generation dam for flood control	・ Flood disaster mitigation in Timbó city
Installation of floodgate and improving Itajai Mirim River in Itajai City	・ Flood disaster mitigation in Itajaí City ・ Mitigation of Economic loss in Itajaí City
Strengthening the existing flood forecasting and warning system & Installation of Early Warning system for Landslide and Flush flood	・ Mitigation of scarified (Injured and death)

Source; JICA survey team

The benefits counted in the proposed project in this FS study were estimated in the following forms;

(1) Increase of rice production

The benefit of the Project "Water storage in paddy fields" will be expected by the increase of productivities and improvement of quality of the products through the improvement of the paddy fields infrastructures. The expected value of the benefit was estimated R$ 2.0 million/year (Project area x Increase of productivity x Rice price = 5,000 ha x 0.8 t/ha x R$ 500/t). The increase of productivity was estimated to be 10% of the average rice yield of 7.9 t/ha in the period of 2000-2008.

(2) Benefit of the Project "Change of current dam operation method and heightening of the dam"

The effect of flood damage mitigations due to heightening of two dams was roughly estimated based on the available probable flood inundation maps at major cities which were prepared by FURB. The results of estimates were the following ones;

Table 11.2.3 Estimation of Flood Damage Mitigation Benefit by Dam Heightening

City	Number of housing	Number of affected housing (Estimate)			
		5 - year	10 - year	25 - year	50 - year
Taio (present)	2,541	250	300	400	500
Taio (with project)		-		350	500
Timbo (present)	8,297	150	200	250	300
Timbo (with project)		-	-	200	300
Rio do Sul	15,504	100	500	1,000	1,500
Rio do Sul (with project)		50	480	1,000	1,500
Total		500	1,000	1,650	2,300
With project		50	480	1,550	2,300
Effect of project		450	520	0	0

City	Number of housing	Number of affected housing（Estimate）			
		5 - year	10 - year	25 - year	50 - year
Flood damage（R$1,000）		9,000	10,400	0	0
Annual flood damage（R$1,000）		3,600	970	0	0
Expected annual average flood mitigation benefit （R$1,000）					4,570

Source; JICA Survey team

As seen above, the expected annual average flood mitigation benefit was estimated, presupposing of R$ 20,000 of asset for each housing affected by flood disaster. The number of affected houses by the flood was calculated for each safety level, using the existing reports/data in this theme. The expected annual average flood mitigation benefit was estimated R$ 4.6 million.

(3) Benefit by building damage mitigation by floodgates in the Mirim River

The expected annual average benefit was estimated assuming that the asset of house to be affected by flood was R$ 100,000 and damage rates due to flood were 20% with an inundation depth of more than 0.5m and 5% for less than 0.5m. Considering that an installation of two floodgates is expected to protect the 10-year flood, the expected annual average benefit of building damage mitigation was estimated R$ 4.6 million as follows:

Table 11.2.4 Estimation of Building Damage Mitigation Benefit by Floodgates in the Mirim River

		5 year	10 year	25 year	50 year
Number of affected houses	< 0.5m	512	1,552	1,632	1,596
	>0.5	232	940	2,637	3,911
	Subtotal	744	2,492	4,269	5,506
Flood damage (R$ 1,000)	< 0.5m	2,562	7,759	8,161	7,978
	>0.5	4,633	18,795	52,732	78,214
	Subtotal	7,196	26,555	60,894	86,193
Annual average damage (R$ 1,000)		2,878	1,688	2,623	1,471
Expected annual average flood mitigation benefit (R$ 1,000)			4,566	7,189	8,660

Source; JICA Survey team

(4) Benefit by mitigation of economic loss by floodgates in the Mirim River

In addition to the above, the economic loss in the services sector due to flood disaster in the Itajai Mirim River was estimated based on the decrease of ICMS at Itajai City assuming that 20% of the total number of existing companies is located in a beneficiary area and to be protected by floodgate installation. The total amount of ICMS in the State occupies around 5% of the State's GDP. The services sector contributes around 50% of the State's GDP. Thus the economic loss in the services sector is estimated by 10 times of the decrease of ICMS. Considering that an installation of two floodgates is expected to protect the 10-year flood, the expected annual average benefit of economic loss mitigation was estimated R$ 42.0 million as follows:

Table 11.2.5 Estimation of Economic Loss Mitigation Benefit by Floodgates in the Mirim River

		5 year	10 year	25 year	50 year
ICMS (R$ million)	Decrease of ICMS amount	7.9	12.9	24.5	39.9
	Economic loss	79.0	129.0	245.0	399.0
Annual average damage (R$ million)		31.6	10.4	11.2	6.4
Expected annual average flood mitigation benefit (R$ million)			42.0	53.2	59.7

Source; JICA survey team

(5) Benefit by structure measure of landslide

The benefit originated by structure measure of landslide was estimated as follows;

Table 11.2.6 Benefit of the Structure Measure of Landslide

No. of priority order	Site	Potential annual loss (R$ x 10^3/year)	Total cost (direct and indirect) (R$ x 10^3)	Benefit: decrease in potential annual loss (R$ x 10^3/year)
1	Road SC 302 Taio-Passo Manso-5	1,255	551	1,062
2	Road SC470 Gaspar River Bank	1,095	2,810	581
3	Blumenau -Av Pres Castelo Branco	1,021	3,883	654
4	Road SC418 Blumenau - Pomerode	989	2,522	841
5	Road SC474 Blumenau-Massaranduba 2	907	5,077	641
6	Road Gaspar - Luiz Alves, Gaspar 9	774	4,664	653
7	Road Gaspar - Luiz Alves, Luiz Alves 6	700	1,974	591
8	Road SC470 Gaspar Bypass	689	3,772	402
9	Road SC477 Benedito Novo - Doutor Pedrinho 1	680	1,399	575
10	Road SC418 Pomerode- Jaragua do Sul 1	651	1,187	553
11	Road Gaspar - Luiz Alves, Luiz Alves 4	629	5,078	532
12	Road SC474 Blumenau - Massaranduba 1	601	702	425
13	Road SC 302 Taio - Passo Manso 4	526	1,599	446
Total of the 13 risk sites		10,516	35,219	7,956

Source: JICA Survey Team

(6) Benefit of alarm/alert systems

The table below shows the victims by the flood disaster in November 2008. Although reduction of victims is expected by the strengthening of existing FFWS and installation of early warning system of landslide and flashflood, such benefit was not considered in this study due to difficulty of estimation in terms of monetary value.

Table 11.2.7 Victims by the Flood Disaster in November 2008

	Injured	Death
2008/11 Flood	4,637	89
With project	-	-

Source: AVADAMs enviados pelos munincipios á Defesa Civil de Santa Catarina, nos dias 24 e 25 de novembro de 2008.

11.3 Project Economic Evaluation

The results of the economic evaluation are as follows:

Table 11.3.1 Results of Economic Evaluation

Evaluation Index		Indicator
IRR		22.9 %
Discount rate（6%）	B/C	3.03
	ENPV(^10^6)	236.4
Discount Rate（10%）	B/C	2.19
	ENPV(^10^6)	101.6
Discount Rate（12%）	B/C	1.89
	ENPV(^10^6)	67.6

Source; JICA survey team

The economic evaluation was conducted in terms of the EIRR (Economic Internal Rate of Return) on the basis of the economic cost and benefit. The EIRR is indicated 22.9%. The project is considered to be highly economically feasible.

11.4 Grovel Evaluation

This Project, motivated by the extraordinary flood in November, 2008, with the consensus of taking the preventive measures for floods, formulated the Master plan and selected the priority projects for the Feasibility Study.

The economical importance in the basin is being more and more significant inside of the economical scenery of the State, with the tendencies of new investments, especially in the Itajai Port area. Further large quantity of investments is expected more and more inside of the basin, it needs to assure the protection of the installed goods, through the disasters mitigation measure. It is notable that the economical activity in the lower Itajaí River basin had 5 times of economical growth in the 8 years in the period from 1999 to 2008, being significant that the needs to protect the basin from disaster are more and more important.