stage. Rio do Sul is the center of the municipalities and its economy comprises substantial farming textile industry and small scale establishments.

11.3 Identification of Significative Potential Impacts

11.3.1 Physical Environment due to Project Activity

(1) Scenic resources

It is expected that degradation of the landscape is of middle importance due mainly to the effects caused by the construction of the surge tank, the possible exploitation of quarry A and the effects of the river flow reduction to the island tourist resort at 8 km downstream of the damsite.

The quarry A is located in the opposite side of the river in front of the Paraiso camping lodge at about 1 km upstream of the damsite. The exploitation of this quarry will entail degradation of the landscape directly across the camp site. These effects are considered as long term actions and negative for the development of activities.

The construction of the surge tank will need open excavation of the mountain slope where the vegetation is well reserved.

The reduction of the river flow will have a potential impact in the water level surrounding the island tourist resort. It is expected that a decrease in the river turbulence due to reduction of flow will enhance the use of the water resource by the tourists, because the strong current does not allow major use of this resource at present. This impact is considered irreversible, although it is possible to mitigate the impact and to make positive for the existing touristic facility.

(2) Topography and landscape

The proposed place for the project does not compose a typical scenery when compared with the traditional landscape of the Itajaí valley which is made up of small rural establishments, spots of preserved forest, cultivated land and pasture areas. There are several quarries over the hillside located in parallel with the river and these will cause degradation of the slope. The proposed reservoir will only have 0.16 km^2, and the extent of the impounded water level will only reach to about 0.8 km upstream of the damsite. This impoundment is considered very small with a very fast turnover rate for the impounded water and only a few properties are to be submerged.

The environmental impact is mainly represented by the number of houses and acreage of land to be affected by the creation of reservoir and construction of dam, intake, demanding basin and other of project facilities. The area of submerged land is estimated at 4 ha and the total number of affected properties is considered minimum.

(3) Soils

Most of the soils in the reservoir area are of hilly topography restricting annual crops with good aptitude for reforestation and pasture. It is estimated that there is no land suitable for annual crops. The potential impact on the soils of this area is considered to be no significant The powerhouse area comprises majority of the soils with aptitude of restrictions to annual crops, and the potential impact for the soils of this area due to the project activities are considered no significant. In the soil bank areas, the soils are dedicated to pasture and grasses. The topography of the areas have a steep gradient, and no species of commercial or scientific interest are found or reported. Besides, these areas represent no significant subsistence of economic activities.

(4) Water quality

During implementation of the project, the main effect on the water quality is the increase in the water turbulence, and the consequent effect to the river downstream. This effect is considered to be of medium importance due to he fact that the turbulence of the river is already high throughout the year and the associated communities are already adapted to this condition.

For the specific case of the reservoir area in terms of its physical and operational characteristics, it is considered that the water mass will be well mixed, avoiding stratification, and the absence of stagnation of the water mass will not provide deleterious effects on the water quality derived from an eutrophic condition.

No industrial activity or urban settlement exists in the stretch between the damsite and the Itajaí do Norte confluence, no water use for industry, agriculture or other human uses are detected and no pollutant sewage, sanitary, agricultural or industrial are recorded or found to be in the river.

(5) Surface water hydrology

The most significant impact on the surface water hydrology is the expected reduction on the river maintenance flow between the damsite and the Itajaí do Norte confluence for the stretch of 10.2 km.

(6) Mineral resources

No mineral resources are foreseen to be affected by the project activities. The mineral resources found in the area are only clay for ceramics and kaolin for masonry stone, and these have low economic importance.

Only in the hills of the powerhouse site, mineral deposits such as granite blocks are exploited. The impact on the mineral resources of the powerhouse site due to the project activities is considered of little importance due to the small extent of the area to be affected. This impact is possible to be mitigated.

(7) Roads

There are 18 access roads to be utilized for the implementation of the project (AR-1 to AR-18) as shown in Fig.11.3. All of them except two (AR-1 and AR-17) are existing rural roads that must be reinforced and / or widened to accept the continuous traffic of vehicles as well as the heavy weight of the materials to be transported.

The action of road improvement will not cause the negative impact on the environment since these are existing road and no new areas will be opened through the construction of new roads. The exception is the road leading to the surge tank (AR-1), and to the penstock drainage adit (AR-17) which need to be constructed to access the project area, and some deforestation is required, non the less these areas are minimum and the extent of the road is very short.

11.3.2 Biological Environment due to Project Activity

(1) Flora

This project site is located in an area which is neither nucleus nor buffer zone of the Atlantic forest ecosystem. All the vegetation in the direct affected area is secondary type vegetation in several stages of regeneration.

In the reservoir area, most of the arboreal vegetation has been already removed. The vegetation to be removed for creation of the reservoir exists only on the river banks and on the islands located in the reservoir. This impact is considered irreversible, but of little importance, due to the small area to be affected.

The vegetation cover at the sides of the river in the stretch between the damsite and the do Norte confluence has been highly degraded due to deforestation and more recent

burning by locals for the purpose of clearing bush, and exposition of the possible rocks that will give an indication of granite quarries to be exploited.

In the powerhouse area, the slopes are very steep and rocky, and the vegetation is secondary. In the surge tank area the clearing of the vegetation is more conspicuous. The probable area to be cleared consisting of 1.1 ha including the access road is considered small, and the impact is considered of middle importance and reversible through a restoration plan for degraded areas.

Vegetation in the spoil banks is limited to grasses and bush and all the spoil banks chosen are degraded. The impacts on the flora are not considered significant.

There is no aquatic flora of economic or scientific interest reported for the river stretch between the damsite and Itajaí do Norte confluence. The suspended solids in the water column is high and there is low light penetration. Due to this reason, the aquatic flora is poor.

(2) Fauna

The region is characterized by a considerable degradation. Due to this degradation and the small dimensions of the project area, it can be said that the project will have a weak impact on the fauna which is still existing. The almost complete absence of forest in the directly affected area restrains to a large extent impacts on the terrestrial fauna. This impact is considered reversible and of little importance.

The construction of the dam implies the transformation from fast moving water environment to a slower water movement environment and alteration such as an increase in the preying rate, and alimentary habit change can be foreseen in the reservoir area. Since only 800 m stretch is the longitudinal length of the created reservoir where fast moving is changed to slow moving waters, no thermal stratification is foreseen in the reservoir. The eutrophic conditions to be expected in the reservoir will not cause deterioration of the water quality because of the absence of stratification. There is no evidence to infer that the fish species existing in the river require migration to fulfill any of their vital functions.

In the downstream area, the possible impact could entail a reduction in the submersible area, alterations on the habitat, increase in water transparency and fish concentration near the damsite. As for the upstream impacts, an increase in the slow moving waters species will be foreseen.

The strongest impact on the ichthyofauna will be the flow reduction between the damsite and the Itajaí do Norte confluence, causing organisms to become more vulnerable to climatic, hydrologic and ecological conditions. This impact is considered irreversible.

The bird species in the project area are common and usually found in degraded areas. Since the project will not affect the forest areas and the extent of the project area is relatively small, the impact on the avian fauna is considered no significant.

(3) Endangered and protected species

Since the project area is located at outside of buffer and nucleus zones and has been highly degraded, no species in the category of endangered or protected species are found or reported in the project area.

(4) Sensitive habitats

Due to the same situations mentioned in the above, no sensitive habitats are encountered in the proposed project area.

(5) Significant wild lands

Due to also the same situations in the above, there are no significant wild lands to be affected within the project area.

(6) Species of commercial importance

The species of commercial importance found within the project area are fish species, which are an attraction for sport fishermen upstream of the damsite. It is foreseen that the creation of the reservoir will enhance the population of fish, and also increase the population of the sport fishermen. The impact crated by the reservoir is considered positive.

11.3.3 Socio-cultural Environment due to Project Activity

(1) Land

In the reservoir area, the areas to be submerged are minimal and do not involve important agricultural activities. The areas are mainly dedicated to non permanent leisure dwellings belonging to urban inhabitants. No major impact in farming or agricultural activities is foreseen in the reservoir area.

There is no farming activity along the river stretch between the damsite and the Itajaí do Norte confluence. Because of the steep slopes of the river banks, the soils

downstream of the damsite have high risk for degradation, strong limitations for annual crops with rocky and hilly topography and high susceptibility for erosion.

Some cattle raising has been carried out in the upper portion of the river stretch between the damsite and Itajaí do Norte confluence. The activity does not dependent on the river since the pronounced slopes present an obstacle for the animals to reach the water. No impact for the live stock due to the project activity is foreseen.

CONAMA regulation requests to provide protection belts of 100 m horizontally measured from the highest level of the reservoir. In the reservoir area including 100 m wide buffer area along the reservoir margin, 3 houses are expected to be relocated. The house owners will receive indemnities for their losses, including relocation costs of facilities and infrastructure. This impact is considered reversible. In the damsite area including intake, desanding basin and headrace culvert, there is no local dweller to be affected by the project.

In the powerhouse site, the construction works will cause a disturbance in the economic basis of the community, and the risk of accidents because of the increased traffic of vehicles, dislocation of rocks caused by blasting with noise and dust. The relocation of the houses will probably be the option to reduce these impacts. This action will then become the most serious socio-economic impact in the project implementation. This impact is considered of great magnitude, as the relocation will not only be physical, but it will also involve the alteration in the socio-economic dynamics.

The environmental impact is mainly represented by the number of households and acreage of land to be affected by the construction of project facilities. These are estimated as shown in Table 11.1.

The public infrastructures will be affected by the works of the project and the municipalities relating to the project such as Lontras, Ibirama and Apiúna will have the right to indemnity deriving from the development of water resources with the purpose of generating electricity. This impacts are considered significant in the case of Lontras, medium significance for Ibirama and low significance for Apiúna.

In the reservoir site, the public use for recreational purposes will probably increase, especially for port fishermen. This pole of attraction could be enhanced by the historical patrimony rehabilitation, providing a second pole of attraction for tourism in the vicinity area of the reservoir. This impact is considered positive for the community of the area CELESC ,however, must take the necessary precautions to avoid possible use of the impoundment area for recreational purpose that may cause accidents.

No touristic or recreational use of the river stretch between the damsite and the Itajaí do Norte confluence exists except for the island tourist resort located at about 8 km downstream of the damsite. The potential impact expected is a reduction of the river flow, and this action is considered irreversible but possible to mitigate. The reduction of the water turbulence is expected and it will enhance the use of the river by the local tourists approaching the island.

There is no forest use in the project area because the project is located outside of buffer and nucleus zones for the Atlantic forest ecosystem. Isolated patches of forest will present in the gulches where runoff water drains to the river. This patches are important as the last source of endemic material for reforestation. It is important to preserve this vegetation patches especially for the ones adjacent to quarry C.

(2) Population

The job availability during construction phase will generate about 400 new jobs. This impact is considered non permanent and reversible in its consequences.

The population of the village of Subida will be subject to the most significant impact due to displacement because of the family and economic relationships and they will also be subject to the intense traffic activity in the area while construction is going on.

The population of the different municipalities such as Ibirama, Lontras and Apiúna will get benefit from the indemnification due to water use of hydroelectric power. This is considered a positive impact for the community.

(3) Historical-cultural patrimony sites

There are no patrimony except that represented by the stretch of railroad. It is desirable that the existing tunnel in the selected place for the quarry is maintained and this element will constitute the nucleus for a historical park of the region.

(4) Water uses

The water use for agricultural purposes in the project area is incipient or non existing except for some uses for irrigation in the upstream stretch of the damsite along the surroundings of the left bank for cultivations onion crops. There is no farming activity along the river stretch between the damsite and the Itajaí do Norte confluence because of the high slopes of the river banks with rocky areas and poor drainage. No impact is expected on the agricultural sector in the project area because of no water use.

Most of the households in the upstream of the damsite depend on water from water wells and water treatment is considered substandard. In the directly affected area which is the rural zone of the municipalities, Ibirama, Lontras and Apiúna, the water use is incipient. There are no populations in the vicinity of the river banks along the river stretch between the damsite and the Itajaí do Norte confluence . The few isolated houses in the upper portions of the slopes do not use the river water for their subsistence, and the potable water is extracted from water wells. There is no impact expected because of the interference of the project actions on the municipal water use in the project affected area.

There is no communal water use in the area, which is related to the project actions. The potable water in the different areas along the river stretch affected by the project activities is obtained from water wells with a water recharge not associated with the river hydrology. There are no impacts foreseen by the project on the communal water use of the river waters.

The usual concerns related to water related diseases in dam projects are focused mainly on the reservoir formation, its entrophication, water quality deterioration and eventual development of water related disease. In this project, the reservoir volume and surface area are very small with a very fast turnover rate and so with a minimum stratification probability. Then the water quality in the reservoir is not expected to deteriorate. Because of these reasons, the water born diseases are not considered as a significant possibility in the actual project scheme and no major impact is expected in the area.

(5) Directly affected areas

The Itajaí river at the dam area forms the boundary of two municipalities; Lontras (right bank) and Ibirama (left bank). The directly affected area in both banks including 100 m wide buffer zone for the reservoir is as follows:

- Right bank, municipality of Lontras, 11.1 ha must be expropriated for the buffer zone, and other 2.4 ha will be submerged.
- Left bank, municipality of Ibirama, 8.9 ha must be expropriated for the buffer zone, and other 1.1 ha will be submerged

The area is composed of 6 houses including temporary facilities in both municipalities: 5 of them in the municipality of Lontras and 1 in Ibirama. Four of them are used by the owners themselves for their own subsistence, and the food for their family comes out of the cultivation of the land. The remaining 2 houses are used temporarily by the owners.

The impact caused by the project is considered of middle importance, and not affecting the basic economic subsistence structure of the dwellers. The permanent inhabitant and directly related to their subsistence means to the other occasional dwellers, and their relocation will probably be associated with the new recreational allocation for the occasional dwellers. An increase in the municipal budget by financial compensation by the project will become a significant positive impact for the municipalities. An increase in job availability for the area will bring positive. An overload of the existing roads in the area is a significant impact.

The powerhouse area belongs to the municipality of Apiúna. The rural estates in the directly affected area of Apiúna will not be affected by submergence of the reservoir formation, but by the construction of the powerhouse, tailrace, substation, surge tank and construction facilities. The community of Subida will be affected, and this impact though it is small scale will be the most significant related to the relocation of people by the project, reflecting to socio-economic relationships of the dwellers.

(6) Influence area

Blumenau and Rio du Sul are considered to be second degree area of influence due to their politic influence and their available infrastructure in commerce and services. No direct effect of the project action is foreseen in these communities.

(7) Alteration of the existing roads

The circulation of heavy vehicles is expected to be of medium intensity for Lontras-Subida road. It is expected that the linear distribution of houses located in about 500 m stretch adjacent to soil bank #11 will be affected by dust during the dry season and mud during the rainy season. Due to this reason, it is advisable that this stretch of road be covered with asphalt to avoid the disturbance to the house dwellers, and traffic signs and demarcation are also advisable in the sector to prevent accidents.

Main highway (BR-470) will serve to communicate the powerhouse site and spoil banks #18 and 19 as well as with the concrete bathing plant as shown in Fig.11.3. It will also serve as alternative access to and from the powerhouse site, instead of using the south end section of the Subida community, where the density of housing, and the narrow road may cause accidents if heavy trucks are continuously circulating. In the village of Subida, the traffic will become extremely complicated due to the width of the road, and proximate of road to the houses. Some houses will have to be removed. The entrance to Subida through the bridge will require traffic light and proper signs for safe circulation of vehicles to and from the powerhouse site.

Access road AR-1 will serve as the access road to the surge tank and it has about 800 m in length. Since the region is of steep declivity covered with secondary forest, some deforestation will be required.

Access road AR-11 of about 3 km long road will access to the BR-470, spoil banks #5 and #16, and the damsite. There is a linear concentration of houses along the road for 500 m to the BR-470 intersection, and proper traffic signs and demarcations are advisable to avoid accidents in this sector.

Access road AR-14 of about 700 m long will communicate quarry C with the BR-470. The last 400 m before reaching the highway intersection are heavily populated with houses scattered along the road. It is recommendable that this stretch provides an asphalt cover to avoid dust and mud to the local residents as well as proper traffic signs and demarcations are advisable to avoid accidents.

11.4 Consideration of Necessary Countermeasures

11.4.1 Physical Environment

(1) Restoration program for degraded areas

Areas which are suffered from degradation due to the construction works of the project will be subject to a restoration program. For the areas to be considered are those around the damsite, quarries, borrow area, spoil banks, surge tank and powerhouse, vegetation works should be started after completion of the project works.

After the end of project activities, the opened quarry used for construction could be utilized as a centralized quarry for the local residents of the area dedicated to this activity. The centralized quarry would allow the local authorities to control the exploitation, and it will also diminish the scattered deterioration of the landscape by small individual quarry operators. This action will entail the organization of the isolated quarry workers into an group and the participation of the environmental authorities in the organization process.

Further study on the effects of the river flow reduction upon the landscape value of the Cotia island near Ibirama should be undertaken to evaluate and possibly mitigate this impact. The study should look into the expected water level around the island after the dam construction and evaluate the effect of this flow reduction, the scenic and touristic resources of the area. It may be required to provide dike across river channel to maintain adequate water level around the island and to avoid the drying out of rive areas with water sports and recreational potential.

(2) River maintenance flow

A river maintenance flow is needed for the maintenance of aquatic life in the river stretch between the damsite and the Itajaí do Norte confluence. The analysis offered that the flow discharge of 3 m^3/sec to be released from the dam will be enough for the aquatic life. However, the river maintenance flow was finally increased to 7.2 m^3/sec which corresponds to 80% of the minimum monthly discharge at the damsite so as to satisfy the DNAEE's rule.

(3) Geological impacts

A monitoring program of the geological impacts of the project works to control vibrations induced by blasting in the quarry, tunnel, powerhouse and damsite is advisable. The program will determine the effects of the blasts and observe the stability of the hillside. Institutions such as CELESC and IPT (Technological Research Institute) should be involved in the program.

11.4.2 Biological Environment

(1) Ecological station and protection zone for reservoir

CONAMA resolution requests the implementation of an ecological reserve area or station. For definition of this area, the protection areas of the Atlantic forest to maintain the environmental continuity should be contemplated. The budget estimated by the law for the ecological station should be allowed for the restoration of the degraded slopes of the river stretch between the damsite and Itajaí do Norte confluence. This area could be reforested with native species coming out of the scattered forest patches located in the gulches. With this measure, the project will not only be a low environmental impact project but also contribute to the regeneration of the degraded area of influence. The institutions that will be involved in this action are IBAMA, FATMA, UFSC and FURB.

(2) Conservation of ichthyofauna resources

The conservation of the ichthyofauna resources is directly related to the river maintenance flow. Since the scientific data on the existing populations is scarce, an ichthyological program designed to obtain more knowledge of the existing species will contribute to establish repopulation programs in areas where this resource is being depleted.

Water effluents from the concrete bathing plant should be pre-settled to minimize the suspended solids and the liquid effluent should be treated to reduce the pH to a range of 6-8, according to concrete batching plant regulations in Brazil.

11.4.3 Socio-cultural Environment

(1) Resettlement of population

The community of Subida will probably require resettlement, reorganization of the physical standard of living of the community. The predisposition and expectations of the community should be evaluated and committee of the local inhabitants should keep up with the relocation process. The decomposition of the productive basis and economic structure of the community should be determined by socio-economy study.

For resettlement of the families living in the reservoir area and on spoil bank #1, access to another rural establishment should be contemplated. It will be necessary to contact with the families, explain the need and detect their disposition and expectations, evaluate another rural establishment selected in accordance with their needs and to provide the infrastructure of the new location as well as schedule of the relocation with the families affected.

For the leisure houses adjacent to the dam, indemnification price evaluation and negotiation with the owners will be needed. Preliminary contacts with these people indicate a good disposition to come to an agreement.

(2) Public communication regarding flood stigma

The flood stigma associated with the dam construction is an important aspect to be considered, especially for the concerned groups of the communities of Lontras and Rio do Sul. In a lesser degree, community of Blumenau is important to obtain support in the question. A series of talks and explanations should be carried out with the organized groups of these communities such as municipal prefectures, environmental groups and municipal associations with the purpose of clarifying the fact that the future dam will not have any detrimental effect on the occurrence of floods.

(3) Manpower qualification program

Manpower qualification in the areas of Subida, Lontras and Ibirama will provide the conditions for the local inhabitants to take advantage of the job availability to be generated by the construction works of the project. The allocation of jobs for qualified people of the village of Subida is considered important. This action can be considered as an added value to the compensation of resettlement. The qualification and recruitment of the workers should entail interview and data collection.

(4) Public health control program

The implementation of actions for sanitary vigilance in the project area is essential. Basic sanitary precautions, epidemiological vigilance, permanent research on transmissible diseases and public awareness through different information procedures are countermeasures to be considered.

The sewage treatment originated by the construction camp is highly advisable to avoid a focus of disease vector reproduction. The sewage system is to be constructed according to sound sanitary engineering criteria.

(5) Road signal and surface covering

The overload of the road net infrastructure especially for the Lontras-Subica road and the village of Subida will require a well designed traffic signal system to minimize the accident probabilities. The program will be designed by the local transportation department (DNER) by cooperation of CELESC with a previous briefing of the expected.

It is advisable to avoid the traffic of construction vehicles along the southern sector of the Subida community road. This action will prevent accidents and disturbance to the local population.

It is also advisable to shut off the road stretch directly in front of the powerhouse site, allowing transit of vehicles and persons only with previous authorization of a permanent post guard in this location. This will avoid injuries of people passing at any time in front of the project, where blasting and use of heavy equipment will take place. The alternate use of the bridge communicating powerhouse site with the BR-470 will require proper traffic signs and lights for trucks coming in and out the power house site.

The intersections of the BR-470 with the secondary roads leading to the quarry C site and the damsite will require proper traffic signs, to alert the users of BR-470 for transportation of heavy loaded trucks to access the highway.

Sectors of secondary roads where rural settlements are linearly dispersed along the road and regular transit of construction vehicles is expected should be protected with asphalt or another adequate surface covering to avoid dust during the dry season and muddy conditions during the rainy season.

(6) Reservoir protection fence and establishment of buffer area

It is possible that visitors to the reservoir area will try to use it as a swimming place. This activity may cause accidents, and CELESC would be legally responsible for such happening. Consideration of countermeasures for this impact includes the expropriation of a buffer zone of 100 m around the reservoir area and the fencing of this area to limit access. Proper signs of warning and transit prohibition will be effective for preventiong the accident and release CELESC from legal consequences.

A buffer area has to be defined around the blasting area in the powerhouse site. The possibility of cracking walls in the adjacent brick houses may take place. To mitigate this possibility, a buffer zone must be identified according to sound engineering parameters.

11.5 Management and Monitoring Plan

11.5.1 Environmental Control Actions of Engineering Works

It is prerequisite for implementation of the project to take measures of environmental control including the following:

- The construction process of the access roads should be carried on to minimize erosion. The roads should have proper drainage specially at steep locations.
- The exploitation plan for the quarries, specially for the quarry A, should be compatible with the future restoration and landscape preservation in the context of the surroundings, specially for the case of landscape of the Paraiso camping area.
- Allocation of drainage for the spoil banks and adequate surface finishing should be compatible with the adjacent landscape.
- Sewage treatment at the construction camp and the establishing of health care for periodic visits will be need especially for relationship with transmissible diseases.
- The offices to be involved will be CELESC, FATMA, contractors, the local health department and the consulting company.

11.5.2 Promotion of Various Programs

The following programs should be prepared and promoted under cooperation of offices and agencies concerned;

Reservoir cleaning program

Cleaning of the area to be submerged, and detachment of branches and trunks which are hazardous to the operation of the power plant will be needed. Elimination of foci due to pollytions such as cesspits is desirable before submerging the reservoir area. This actions will be carried out by CELESC.

Monitoring program for geological impacts

The observation of the stability of the hillsides, mainly at the powerhouse site, surge tank and penstock line are recommended. The offices to be involved are CELESC and the IPT-Technological Research Institute.

Restoration program for degraded areas

For the restoration program for the degraded areas, offices such as CELESC, IBAMA and the associated town halls will be engaged in such program implementation.

Implementation program for the ecological areas

The implementation program for the ecological area including selection of the ecological area, topographic survey of the selected area and land acquisition is the basic steps for the implementation of the project. The institutions to be involved will be IBAMA, FATMA, UFSC and FURB.

Monitoring and conservation program for the ichthyofauna

A field investigation during summer, autumn and winter to survey the natural history of the ichthyofauna is desirable. The investigation should include physical and chemical characterization of the water, specially in the areas conformed as ponds. These data are related to the climatic data such as rainfall, river flow and river level to assess the efficacy of the river maintenance flow in sustaining life in the river stretch. The institutions that will be involved in this program are UFSC, FURB, and FUNPIVI.

Climatic condition observation plan

This program is directly associated with the monitoring of the climatic conditions such as determination of the flood possibility. The main parameters to be monitored should reflect the rainfall, river flows and river water levels. This program should start at least one year before the beginning of the construction works.

Water quality control program

To observe the effects of the creation of reservoir and the reduction of river flow in the stretch between the damsite and the Itajaí do Norte, water quality control program will provide data to evaluate the effects of the project on the water quality of the river. FATMA will be engaged in the task provided with adequate equipment to carry on the analysis.

Public health control program

Sanitary and epidemiological vigilance in the working areas is desirable to avoid outburst and transmission of diseases. The program will be established in accordance with the regulation of health department of the municipalities which includes basic sanitation and lodging as well as sewage treatment of the workers camp. The periodic visit and checkup of transmissible diseases by the qualified health personnel are desirable.

Manpower qualification program

The manpower qualification program will be implemented by CELESC, and SENAI and related town halls of the communities interested.

Supporting program for the municipalities

This program is to give technical support to the municipalities of Apiúna, Lontras and Ibirama through the formation of a technical commission. The definition of the financial opportunities for project implementation will be made available. This action will be implemented by CELESC and the interested town halls.

For estimated road length of 1000 m adjacent to populated areas, asphalt covering should be provided. This measure will avoid dust and mud in the populated areas where traffic is expected to be regular. The responsible offices involved will be the road department of the Ministry of Transportation DNER and CELESC.

Population transference program

The transference of population from the community of Subida will be handled by CELESC, in accordance with committee of local inhabitants.

Social communication program

The social communication program will be implemented through the organization of a group by CELESC and other groups of interest in the community. Various means of

communication such as booklets, videos, folders, meetings and round tables will be utilized.

Monitoring of the traffic regulations

The periodic vigilance of the traffic law enforcement in the affected areas by heavy traffic, especially for traffic in the village of Subida and related intersections with the BR-470 is recommended to avoid accidents. The control measures will be enforced by traffic signals, lights and permanent presence of traffic official in critical traffic points. The implementation of this measures can be achieved through the cooperation of the local branch of the Ministry of Transportation.

Prevention of reservoir use by swimmers

A buffer area of 100 m with a fence and signs should be provided to avoid possible accidents, and to alert tourists the possible danger of swimming in the reservoir area. The responsible offices involved will be CELESC and a contractor to install the fence and signs.

Chapter 12 PROJECT EVALUATION

12.1 General

This Chapter deals with the examination on both economic and financial viabilities of the selected scheme of the Salto Pilão project and further discusses on loan repayability, competitiveness of the project in term of the unit cost of generation and the unitary cost of installation. Finally, this Chapter discusses the overall evaluation of the project.

12.2 Economic Evaluation

Economic viability of the project was assessed in terms of the economic internal rate of return (EIRR). The EIRR is presented by a rate of interest (or discount) by which the both sums in the present worths of economic costs and economic benefits during the project life are equalized.

Economic Cost

The economic cost was expressed by the economic value of costs such as the investment cost and the operation and maintenance cost estimated in Chapter 10 and equipment replacing cost needed in the project life. Besides, as the costs estimated in Chapter 10 are denoted in market prices which includes excise and taxes not relating to substantial economic activities, those costs are converted to the economic costs by applying the economic conversion factors estimated by analysis of national economy. The economic costs are thus calculated as follows:

	Market Price (mill. US$)	Conversion Factor	Economic Value (mill. US$)
• Total investment cost excluding interest	177.2	0.9	159.5
• Annual operation and maintenance cost	0.86	0.86	0.74
• Replacement cost for mechanical and electrical equipment	43.4	0.9	39.1

The replacement cost indicated above was estimated to be 80 % of the investment cost concerning mechanical and electrical components. This cost is assumed to be disbursed for a 2-year replacement work at 26th and 27th years after commissioning of the project. The investment cost was disbursed in 4 years of construction and the O & M cost was disbursed every year after commissioning.

Economic Benefit

The economic benefit was expressed also by economic value of electricity supplyable by the Salto Pilão project. The electricity benefit was valued by the least cost of electricity produced by other power plant alternative. In Brazil, most of electricity required is to be supplied from hydro power plants even in the future. In this circumstance, conceivable alternative is also hydro plant. Therefore, the least cost of electricity by the alternative plant was replaced with the long-run marginal cost for expansion of the power system concerned. The marginal cost defined by ELETROBRAS for the South region power system to which the Salto Pilão plant is to be connected is 51 US$/MWh for firm energy in the case that the plant starts operation up to the year of 2000. The cost of secondary energy, which corresponds to fuel cost of thermal plant, is defined to be 11.92 US$/MWh. The cost of peak power defined is zero. As these costs are based on market prices, they are converted to economic values by multiplying the economic conversion factor of 0.9.

The annual economic benefit is computed as follows:

	Firm energy	Secondary energy	Total
Annual energy (MWy)	70.46	11.08	
Annual benefit (mill. US$)			
- Market price basis	31.48	1.16	
- Economic value	28.33	1.04	29.37

Economic Internal Rate of Return (EIRR)

Flow of the economic costs and benefits in economic project life of 50 years on the constant price values at December 1992 is shown in Table 12.1. In this cash flow pattern, the EIRR is 14.4 %.

The costs and benefits used in the above EIRR analysis involve some uncertainties of prices in their estimation. If actual cost is greatly higher than estimated or contrarily actual benefit is lower, the value of EIRR drops. For checking adverse effect of various variations in cost and benefit, their sensitivities are tested on the same cash flow pattern as shown in Table 12.1. The computed EIRR for each variation is as follows:

	Case	EIRR (%)
1)	Base cost and base benefit	14.4
2)	15 % cost increase	12.7
3)	15 % benefits decrease	12.4
4)	15 % cost increase and 15 % benefit decrease	10.9

Even in the most unfavourable case such as 15 % increase of cost combined with 15 % decrease of benefit, the project still keeps the EIRR as high as 10.9 %. This verifies that the project is economically sound and viable even in unfavourable price variation.

12.3 Financial Evaluation

Financial viability of the project was assessed in terms of the financial internal rate of return (FIRR). The FIRR is a rate of interest by which project revenue is equalized to the project expenditure in their total present worths.

Project Expenditure

The project expenditure comprises the investment cost excluding interest during construction, the operation and maintenance (O & M) cost and replacement cost. Those costs can be expressed in market price without any value conversion. The costs estimated on the December 1992 price basis are as follows:

	Expenditure (mill. US$)
• Total investment cost excluding interest	177.2
• Annual O & M cost	0.86
• Replacement cost (26th to 27th year)	43.4

Project revenue

The project revenue is the earning by energy sale at the Salto Pilão power plant. Unit price of energy at generation point was estimated from the CELESC's energy sale and sales income in 1992.

• Energy sale for consumers	(GWh)	7,223
• Sales income	(Cr$ billion)	5,071
	(equiv. US$ million)	454
• Average tariff rate	(US$/MWh)	62.9

• Unit income by energy sale after paying taxes (23 %)	(US$/MWh)	48.4
• Energy price at generation point after deducting distribution cost (10 %)	(US$/MWh)	43.6

This energy price of 43.6 US$/MWh was regarded as the unit revenue of energy sale at the project. Since the secondary energy is not always possible to sell, annual earning by sale of firm energy was only counted as the project revenue.

Unit energy price:	43.6 US$/MWh
Firm energy:	70.46 MWy = 617.2 GWh/y
Annual revenue:	26.9 million US$

Financial Interal Rate of Return (FIRR)

Flow of expenditure and revenue in the 50-year project life on the December 1992 price basis is shown in Table 12.2. The FIRR computed on this cash flow pattern is 12.1%. This value is rather high in comparison with a hurdle rate of interest; 10 %, which is widely applied by international financing agencies. Thus, the project was judged to be viable in financial terms.

In the above analysis of FIRR, future price variation is not considered because, in principle, the price variation equally affects both expenditure and revenue. However, either increase of expenditure or decrease of revenue adversely affects viability of the project. To examine the adverse effect of the price variations, their sensitivity were tested on FIRR using the same cash flow pattern as shown in Table 12.2. The computed FIRR is as follows:

	Case	FIRR (%)
1)	Base expenditure and base revenue	12.1
2)	15 % increase of expenditure	10.6
3)	15 % decrease of revenue	10.3

Price variation within 15 % of the base estimate still gives the FIRR as high as 10 % or more. Thus, the project was judged to be financially sound enough against price variation.

Loan Repayability

CELESC is financially independent from the state government and no grant aid from the government can be expected for the project implementation. Financial support in the form of loan from domestic and international agency are indispensable.

Financial aspect was also examined in terms of repayment capability of loan for the initial investment cost. The loan conditions will differ by agencies to finance. The following loan conditions on the investment cost were assumed in this study.

- Loan amount: 177.2 million US$
- Interest rate: 10 %
- Loan period: 20 years including 4-year grace period

Loan repayment method assumed is such that the principal is repaid uniformly over the 16-year period after the grace period and the interest on outstanding debt is paid annually. As shown in a cash flow in Table 12.3, the project is sound in repayment capability since the accumulated balance becomes positive 12 years after the loan is fully disbursed.

12.4 Generation Cost and Unitary Cost

(1) Mean Cost of Generation

The mean cost of generation expressed by unit cost of firm energy was computed by the equation shown in Chapter 8. Basic parameters applied for the computation are as follows:

• Investment including interest	215.5	mill. US$
• Annualized investment*	21.74	mill. US$
• Annual O & M cost	0.86	mill. US$
• Firm energy	70.46	MWy
• Secondary energy	11.08	MWy
• Reference cost of secondary energy	11.92	US$/MWh
• Reference cost of peak power	0	US$/kW

(*: 50-year life, 10 % discount rate and capital recovery factor of 0.10086)

The mean cost of generation of the project was computed at 34.7 US$/MWh.

The marginal cost of firm energy envisaged by ELETROBRAS for system expansion up to the year of 2000 in the South region is 51 US$/MWh. In comparison with this marginal cost, the mean cost of generation for the Salto Pilão project is smaller. It means that this project is worth developing at a possible earliest stage.

(2) Unitary Cost

In respect of the Salto Pilão project, the unitary cost of installation (CUI = Investment/Installed capacity) was calculated to be 1,518 US$/kW (= US$ 215.5 mill./142 MW). Unitary costs of other hydropower candidate projects planned in 1991 for the South and Southeast regions of Brazil range between 780 US$/kW and 2,600 US$/kW in the case of plant capacity larger than 100 MW. The unitary cost of the Salto Pilão falls on their middle point. Thus, the project is still attractive in view of initial investment burden.

12.5 Overall Evaluation

As examined in the preceding Sections, the Salto Pilão project was assessed viable in both economic and financial terms which are expressed as follows:

- Economic internal rate of return (EIRR) 14.4 %
- Financial internal rate of return (FIRR) 12.1 %
- Mean cost of generation 34.7 US$/MWh
- Unitary cost of installation 1,518 US$/kW

In addition, evaluation on other aspects, namely socio-economic and environmental aspects is discussed below.

Socio-economic Contribution

Hydropower development in the Itajai river basin will enhance socio-economic development in the region in view of two aspects such as stabilization of power supply to local consumers and activation of regional economy owing to creation of job opportunity.

Power consumption in the CELESC system has increased at an annual rate of 6.8 % in the last decade. Of the total consumption in 1992, approximately 50 % was consumed by industrial sector of which growth rate was 5.6 % per annum in the last decade. CELESC has purchased 95 % of the total required energy from ELETROSUL, Itaipu and others in 1992. ELETROSUL is implementing large scale hydropower projects but it is a fact that their progress is behind schedule due to difficulty of financing as well as environmental constraints. This may result in restriction of stable power supply to CELESC in the future. Realization of the Salto Pilão project in the CELESC's own system will greatly contribute to stabilize power supply to consumers in the system. If the project is implemented in the year 2000, degree of the contribution of the project measured by energy sale scale at 2000 is 5.4 % of the CELESC's total requirement or 12.8 % of the industrial sector's requirement.

Furthermore, the implementation work of the project needs many local workers, various kinds of construction materials and supporting services to be supplied in the vicinity of the project site. These supporting businesses will result in creating job opportunity and contribute to activation of the regional economy. It is clear that construction investment will induce new businesses in related economic sectors. It is generally said that total product value of those related businesses is more than or at least equal to the construction investment for the project. Thus, in this aspect, incidental contribution of the project implementation to the regional economy will be an order of US$ 200 million.

Environmental Impact

One of the environmental impact is represented by acreage of land and number of households to be affected by formation of reservoir and construction of project facilities. Those affected by the Salto Pilão project are as follows:

- Area of land to be submerged in reservoir: 5 ha
- Area of lands to be affected by project activities: 94 ha
- Number of households to be resettled: 16 nos
- Number of people to be resettled: 77 persons

As the reservoir is formed almost within the extent of existing river channel, land submergence is limited to very small area. Construction activities for the project are also limited within practicably minimum land area after examining their environmental impacts. These will not cause notable environmental impact. The affected households are also limited in numbers and their resettlement is solvable to their satisfaction.

Another important aspect of environmental impact by the project is reduction of river flow in about 10 km long river stretch between the dam and powerhouse sites due to extraction of water for power generation. The present environmental investigation has revealed however that in this river stretch, there would be no biotic species of scientific or commercial interest, and endangered or to be protected. Thus, the impact by reduction of river flow can be aborted by a river maintenance flow which is equivalent to 80 % of minimum monthly river flow ever recorded.

Overall Evaluation

From the result of economic, financial, socio-economic and environmental evaluations made so far, the Salto Pilão project was judged to be feasible in any aspects. It is therefore recommended to implement the project at the possible earliest time.

Chapter 13 PROJECT IMPLEMENTATION PROGRAM

13.1 Project Organization

The project organization to implement and promote the project is shown in Fig. 13.1

Upon approval of the project fund, compensation of houses and lands will be carried out by CELESC with assistance and cooperation of the provincial offices concerned.

The implementation of the project will be administrated by CELESC. The construction works at site will be entrusted and carried out by Salo Pilão Hydropower Project Management Office (S.P.M.O.), which is the executing agency and responsible for construction and management of the project. SPMO has also responsibility on design and construction supervision including field and laboratory tests and administration of the project.

The construction of the project works will be entrusted to foreign/local contractors which are to be selected by international tendering under supervision of SPMO assisted by the selected foreign consultant.

13.2 Project Implementation Schedule

Overall project implementation schedule is shown in Fig. 13.2.

Following to the feasibility study (F/S), request an approval of F/S to DNAEE and project appraisal to obtain the engineering service loan will be carried out. After obtaining the loan, the detailed design (D/D) works will be carried out by the selected consultant.

The request of approval of D/D to DNAEE and project appraisal to obtain fund for construction works will be commenced immediately after the completion of D/D works. After obtaining the project fund, prequalification and a series of tendering works will be carried out during about one year to select the foreign/local contractors.

The construction works of the project will be executed by dividing into several packages by the selected contractors during the period of 3.5 years as illustrated in Fig. 13.3.

From latter half of first year, preparatory works including land acquisition and compensation of houses, preparation of offices, mobilization of the contractors, construction of access road, etc. will be carried out during about 6 months.

In second year, concrete/rockfill dam, intake/dewatering facility works, about 6 km long headrace tunnel works, surge tank and penstock works and a part of the construction works of the powerhouse will be executed simultaneouly. Among these works, it is expected that the construction of the intake/deveatering facility works and headrace tunnel works will become critical path for this project work. Then these works will be executed continuously even in the wet season.

In third year, concrete work for the dam and intake/dewatering facilities shotcrete and concrete linings for the headrace tunnel will be performed following to the rock excavation works. The substructure works and a part of the superstructure works for the powerhouse and erection works of the generating equipment will be carried out.

In fourth year, the remaining concrete work and rock fill works for the dam, intake/dewatering facilities, headrace tunnel and penstock tunnel, steel lining for the headrace tunnel, construction of superstructure works of the powerhouse and erection work of the generating equipment will be carried out and these works will be completed by 10 months of the fourth year in order to impound the reserver and to complete the testing work for the power generating equipment by the end of the fourth year. The commissioning of the power facilities and commercial operation of the project will be commenced from the beginning of fifth year.

Table

Table 5.1 Monthly Discharges at Damsite

Year	Monthly Mean Discharges (cms)													Annual Runoff
	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sept.	Oct.	Nov.	Dec.	Mean	(mm)
1941	83.2	139.9	128.7	43.5	81.3	115.8	50.3	163.9	90.9	95.3	137.9	77.3	100.4	566
1942	38.4	125.7	86.4	91.8	72.7	72.4	64.0	70.3	67.7	58.8	26.5	34.5	67.0	378
1943	30.3	51.4	22.7	17.9	55.0	185.4	115.6	291.9	138.0	89.0	65.1	36.6	91.8	518
1944	109.4	41.2	100.5	31.8	18.6	21.4	22.0	16.8	26.4	27.8	49.6	16.3	40.2	227
1945	9.0	62.1	28.7	23.1	10.5	16.5	30.6	21.7	55.4	62.9	18.9	28.6	30.4	172
1946	80.2	212.4	160.2	58.3	57.1	137.2	183.0	115.4	67.7	104.0	52.3	62.5	107.0	603
1947	58.3	131.9	79.6	26.7	31.5	52.2	61.5	95.4	244.2	214.1	94.7	82.4	97.4	549
1948	66.7	122.6	114.9	94.5	234.8	57.5	114.3	294.9	56.7	52.7	67.7	23.0	108.7	613
1949	33.3	16.8	38.1	67.2	30.1	87.5	36.5	81.4	100.8	61.7	28.1	27.9	50.8	287
1950	93.7	79.5	110.0	32.9	41.5	34.2	30.8	106.8	71.6	208.9	43.0	61.6	76.5	431
1951	122.9	231.1	134.1	40.0	22.2	20.5	34.8	14.9	15.7	188.1	83.7	48.9	78.9	445
1952	64.2	48.0	22.0	17.8	11.8	57.7	85.4	32.6	146.2	190.0	146.0	50.4	72.6	409
1953	69.1	102.0	55.3	26.9	22.9	18.3	23.6	22.9	67.7	136.3	177.4	76.8	66.2	374
1954	69.8	62.9	112.4	73.0	171.9	154.5	230.2	64.7	177.4	398.3	58.2	25.9	134.0	756
1955	29.8	48.3	52.8	68.1	124.6	102.6	257.0	109.6	137.1	50.3	42.1	72.9	91.7	517
1956	133.1	142.6	54.3	109.0	123.8	55.8	51.2	87.8	228.4	131.7	63.0	53.4	102.5	578
1957	57.4	55.1	71.4	75.9	70.4	51.1	214.1	592.4	446.8	179.6	85.3	46.9	163.1	919
1958	41.8	65.6	212.3	51.3	32.1	86.4	49.0	117.1	214.4	161.9	141.3	117.8	107.8	608
1959	60.9	106.5	48.5	84.2	73.8	38.9	27.7	56.6	173.2	57.8	25.8	29.7	64.8	365
1960	28.8	77.6	76.5	63.7	30.7	26.4	15.0	151.6	97.0	135.5	163.7	84.8	79.2	447
1961	68.5	120.4	156.2	76.3	39.2	46.4	49.5	22.0	366.8	331.4	375.0	158.3	150.4	848
1962	70.4	66.4	84.5	37.3	91.5	54.5	75.6	40.9	148.8	103.7	83.5	48.7	75.5	426
1963	137.8	246.3	223.6	76.2	35.5	20.5	24.5	29.4	168.1	292.1	211.1	73.8	127.4	718
1964	37.0	58.9	38.9	56.9	81.0	44.3	49.8	76.5	113.4	90.6	41.1	41.1	60.8	343
1965	34.2	23.6	51.5	49.3	143.2	53.0	131.5	172.0	205.1	140.4	121.2	182.0	109.6	618
1966	152.4	550.9	176.5	85.9	65.6	119.0	71.3	68.4	187.7	144.9	90.5	134.9	151.1	852
1967	97.6	196.1	125.5	55.2	40.3	67.9	64.5	73.6	201.5	116.8	105.9	108.8	103.7	585
1968	42.9	21.1	23.7	20.9	11.0	15.9	25.0	10.9	63.0	53.2	88.1	79.4	37.9	214
1969	158.2	220.2	124.1	245.2	47.4	140.2	100.9	47.7	58.8	44.6	91.5	35.7	108.4	611
1970	74.0	65.9	67.6	42.2	51.8	130.0	122.9	84.5	101.7	79.2	36.3	112.3	80.9	456
1971	244.7	159.5	241.4	182.3	160.7	207.5	175.1	82.9	100.4	94.6	27.5	17.8	141.2	796
1972	45.1	231.0	94.4	65.2	26.7	95.0	78.6	337.2	265.8	184.8	129.3	112.2	138.3	780
1973	121.0	129.6	70.4	61.1	107.2	167.4	199.5	339.0	271.2	98.7	76.8	59.4	141.8	800
1974	128.4	141.3	153.3	44.4	34.6	52.2	81.8	41.1	119.0	52.3	65.4	28.8	78.1	441
1975	64.4	48.7	132.3	44.7	49.2	63.9	42.9	139.3	358.2	300.0	95.5	294.7	136.8	772
1976	183.6	67.6	133.9	47.3	130.1	189.3	84.3	219.8	118.7	84.8	68.2	193.9	127.3	718
1977	291.0	262.4	129.6	90.8	47.3	30.5	38.3	273.5	93.9	297.1	219.3	81.1	154.2	869
1978	84.0	63.3	85.4	25.5	17.5	21.9	52.4	41.4	112.3	69.6	87.2	118.5	65.0	366
1979	53.6	30.8	41.5	50.6	171.7	65.6	65.1	72.0	87.5	376.2	184.4	169.9	114.9	648
1980	109.3	54.9	197.8	64.0	67.0	58.7	171.6	335.6	270.4	160.9	134.1	334.7	164.2	926
1981	186.6	117.3	49.0	43.1	33.4	33.1	46.0	35.9	74.4	72.9	64.3	102.3	71.3	402
1982	45.8	202.7	105.3	57.3	43.4	93.8	131.7	104.5	61.3	177.9	379.4	149.0	128.5	725
1983	203.4	197.3	250.5	140.7	362.1	361.0	1058.0	384.9	230.9	142.2	133.0	191.0	306.4	1,728
1984	117.8	80.4	112.8	92.7	117.5	219.6	189.5	543.2	169.8	192.2	191.5	106.0	178.4	1,006
1985	61.9	238.5	103.8	118.7	62.4	36.0	63.4	29.8	51.3	54.4	96.4	16.3	76.4	431
1986	23.6	88.9	52.7	44.6	32.8	50.9	30.0	43.4	74.4	134.0	206.9	209.9	82.5	465
1987	248.6	207.7	60.9	59.3	249.4	135.4	119.6	147.2	89.0	274.4	72.4	51.0	143.0	806
1988	61.7	82.0	73.0	78.5	239.2	135.3	62.2	33.4	84.3	86.0	41.5	29.1	83.8	473
1989	181.7	178.7	102.7	115.7	212.5	44.5	60.6	68.0	269.4	89.9	52.2	49.3	118.3	667
1990	367.3	207.8	142.4	154.8	101.1	362.9	243.4	181.8	214.1	353.4	263.4	92.3	223.6	1,261
Mean	99.5	125.7	102.3	68.5	83.8	90.2	108.1	131.8	147.1	146.0	108.1	88.8	108.2	610
Min.	9.0	16.8	22.0	17.8	10.5	15.9	15.0	10.9	15.7	27.8	18.9	16.3	30.4	172
Max.	367.3	550.9	250.5	245.2	362.1	362.9	1058.0	592.4	446.8	398.3	379.4	334.7	306.4	1,728

Table 6.1 List of Present Investigation

(1) Core Drilling

Hole No.	Length (m)	Site
B93 - 1	40	Damsite, Axis-C, Left Bank
2	25	Damsite, Axis-C, Riberbed
3	40	Damsite, Axis-C, Right Bank
4	20	Damsite, Diversion Tunnel
5	45	Surge Tank (Upstream site)
6	40	Penstock (Upstream site)
7	20	Powerhouse (Upstream site)
8-1	25	Quarry site - A
8-2	20	Quarry site - B
8-3	25	Quarry site - B
Total 10 holes	300	

(2) Laboratory Rock Test

Sample No.	Rock Type	Sampling		Item of Rock Test
		Hole No.	Depth	
(a) Dam, Waterway, Tunnel				
Dam 1	Gr	B93-1	38.3m	
2	"	"	38.6m	
3	"	"	39.0m	
4	"	"	39.3m	
5	"	B93-2	22.3m	
6	"	"	24.0m	
7	"	B-93-3	25.0m	
8	"	"	30.0m	
9	"	"	33.0m	-Specific gravity
10	"	"	35.0m	-Water absorption
Tunn -1	"	Outcrop *1	-	-Velocity of supersonic wave
2	"	"	-	-Unconfined compressive
3	"	"	-	strength
4	Ry	B93-6	28.5m	
5	"	"	29.5m	
6	"	"	37.0m	
7	"	B93-5	25.0m	
8	"	"	27.0m	
9	"	"	28.0m	
10	"	"	30.0m	
(b) Quarry - A				
Quar 1	Gr	Outcrop *2		-Specific gravity
Quar 2	"	"		-Water absorption
Quar 3	"	"		-Unconfined comp.strength
				-Los Angeles abrasion
				-Alkari Reaction

Notes : *1 : Existing tunnel of abandoned railway near Hole No. B93-8-1
*2 : Existing quarry at upstream portal of the above existing tunnel.
Gr : Granite
Ry : Rhyolite

Table 6.2. Japanese Rock Classification

Rock Class	Characteristics
A	Hard and fresh rocks. Rock-forming minerals are fresh and not weathered or altered. Joints and cracks are closed tightly, no weathering on their planes. Clear sound is emitted when hammered.
B	Hard and fresh rocks. Rock forming minerals are weathered slightly or partially altered. Joints and cracks are closed tightly, without weathering. Clear sound is emitted when hammered.
CH	Fairly hard and slightly weathered rocks. Rock-forming minerals, except quartz, are weathered or altered. Tightness of joints and cracks is slightly reduced and each block is apt to be exfoliated along joints and cracks which sometimes contain clay and other materials, stained by limonite. Slightly dull sound is emitted when hammered.
CM	Slightly soft and moderately weathered rock. Rock-farming minerals, except quartz, are weathered or altered. Exfoliation occurs along joint and cracks by hammering. Joints and cracks sometimes contain clay and other materials. Slightly dull sound is emitted when hammered.
CL	Soft and weathered rocks. Rock minerals are weathered. Exfoliation occurs easily along joints and cracks by hammering. Joints and cracks contain clay and other materials. Dull sound is emitted when hammered.
D	Very soft, highly weathered, fractured and/or altered rocks. Rock-forming minerals are highly weathered. Joints and cracks are very loose, easily collapse by weak hammering, which contain clay and other materials. Very dull sound is emitted when hammered.

Rock Class	Compressive Strength (qu : kg/cm^2)	Modulus of Elasticity (Es:kg/cm^2)	Modulus of Deformation (Ed: kg/cm^2)	Seismic Velocity (km/sec)	Poisson's Ratio
A & B	more than 800	more than 80,000	more than 50,000	more than 3.7	less than 0.2
CH	800 to 200	80,000 to 40,000	50,000 to 20,000	3.7 to 3	0.2 to 0.3
CM	400 to 200	40,000 to 15,000	20,000 to 5,000	3 to 1.5	0.2 to 0.3
CL	less than 200	less than 15,000	less than 5,000	less than 1.5	more than 0.3
D	less than 100	less than 5,000	less than 5,000	less than 1.5	more than 0.3

Rock Class	Cohesion (kg/cm^2)	Internal Friction Angle (degree)	Borehole test	
			Modulus of Deformation (kg/cm^2)	Modulus of Elasticity: ES (kg/cm^2)
A & B	more than 40	55 to 65	more than 50,000	more than 100,000
CH	40 to 20	40 to 55	60,000 to 15,000	150,000 to 60,000
CM	20 to 10	30 to 45	20,000 to 3,000	60,000 to 10,000
CL & D	less than 10	15 to 35	less than 6,000	less than 15,000

Notes ;

(1) Compressive strength shows the result of rock piece test.

(2) Modulus of elasticity and deformation show the results of in-situ plate loading tests.

(3) Es means static modulus of elasticity.

Source :Standard of Central Research Institute of Electric Power Industry of Japan

Table 6.3 Brazilian Rock Classification

Hardness			Alteration	Fractureness		Fractures			
						Orientation		Conditions	
H1	Very Hard	A1	Solid Rock	F1	0 to 1 no Fissured	H	0° Horizontal	S1	Rough
H2	Hard	A2	Little Altered	F2	2 to 5 Little Fissured	SH	0° to 20° Sub Horizontal	S2	Little Rough
H3	Moderately Hard	A3	Moderately Altered	F3	6 to 10 Moderately Fissured	I	20° to 70° Inclined	S3	Smooth
H4	Soft	A4	Very Altered	F4	11 to 20 Very Fissured	SV	70° to 90° Sub Vertical	S4	Granular Filling
H5	Very Soft	A5	Saprolite	F5	20 Extremely Fissured	V	Vertical	S5	Clayey Filling

Table 6.4 Result of Laboratory Rock Test

Sample No.	Site	Depth (m)	Rock Type	Specific Gravity (g/cm3)	Water Absorption (%)	Void Ratio (%)	Dynamic Elastic Modulus (GPa)	Unconfined Compressive Strength (MPa)	Los Angeles Abrasion (%)	Potential Alkali Reactivity		
										Dissolved Silica (m Mole/L)	Reduction of Alkalinity (m Mole/L)	Result
Dam-1	B93-1	38.3	Gr	2.596	0.07	0.19	66.37	144.84	-	-	-	-
Dam-2	B93-1	38.6	Gr	2.602	0.07	0.19	68.92	155.13	-	-	-	-
Dam-3	B93-1	39.0	Gr	2.602	0.07	0.17	64.61	175.03	-	-	-	-
Dam-4	B93-1	39.3	Gr	2.588	0.10	0.25	61.62	168.27	-	-	-	-
Dam-5	B93-2	22.3	Gr	2.604	0.08	0.20	67.98	195.31	-	-	-	-
Dam-6	B93-2	24.0	Gr	2.582	0.12	0.31	63.23	42.53	-	-	-	-
Dam-7	B93-3	25.0	Gr	2.599	0.09	0.22	60.17	188.06	-	-	-	-
Dam-8	B93-3	30.0	Gr	2.601	0.09	0.25	55.49	186.00	-	-	-	-
Dam-9	B93-3	33.0	Gr	2.591	0.14	0.36	60.88	140.04	-	-	-	-
Dam-10	B93-3	35.0	Gr	2.572	0.28	0.72	58.68	209.23	-	-	-	-
Tunnel-1	Outcrop (Tunnel)*	-	Gr	2.570	0.32	0.82	64.01	137.30	-	-	-	-
Tunnel-2	Outcrop (Tunnel)*	-	Gr	2.581	0.23	0.59	59.05	166.31	-	-	-	-
Tunnel-3	Outcrop (Tunnel)*	-	Gr	2.604	0.22	0.58	61.69	144.84	-	-	-	-
Tunnel-4	B93-6	28.5	Db	2.699	0.06	0.15	68.76	191.98	-	-	-	-
Tunnel-5	B93-6	29.5	Ry	2.660	0.21	0.56	69.93	206.68	-	-	-	-
Tunnel-6	B93-6	37.0	Db	2.734	0.17	0.47	72.29	141.51	-	-	-	-
Tunnel-7	B93-5	25.0	Db	2.752	0.06	0.17	69.10	241.96	-	-	-	-
Tunnel-8	B93-5	27.0	Db	2.756	0.07	0.20	65.73	148.96	-	-	-	-
Tunnel-9	B-93-5	28.0	Ry	2.730	0.14	0.39	66.88	190.61	-	-	-	-
Tunnel-10	B93-5	30.0	Ry	2.745	0.10	0.29	66.78	71.93	-	-	-	-
Quarry-1	Outcrop (Quarry)**	-	Gr	2.588	0.22	0.56	61.50	154.84	32	2.50	75.25	Inoffensive
Quarry-2	Outcrop (Quarry)**	-	Gr	2.598	0.10	0.26	60.70	164.54	32	16.79	37.65	Inoffensive
Quarry-3	Outcrop (Quarry)**	-	Gr	2.590	0.16	0.41	59.81	150.53	32	9.16	37.65	Inoffensive

* : Inside of existing tunnel of abandoned railway near Drill hole B93-8-1.

** : Existing quarry at upstream portal of the above existing tunnel.

Gr : Granite

Ry : Rhyolite

Db : Diabase

Table 8.1 List of Alternative Options for First Screening

Case No.	Dam Axis	Maximum Plant Discharge (cms)	Reservoir Level			Reservoir Volume			Tail Water Level (m)	Static Gross Head (m)	Rated Head Loss (m)	Rated Effect. Head (m)	Design Efficiency	Installed Capacity (MW)	Nos. of Unit	Unit Capacity (MW)
			FSL (m)	MOL (m)	Draw-Down (m)	FSL (TCM)	MOL (TCM)	Active (TCM)								
B319- 1	B	30	319	319	0	280	280	0	110.91	208.09	12.98	195.11	0.883	50.6	2	25.30
2		45	319	319	0	280	280	0	111.07	207.93	12.98	194.94	0.887	76.2	2	38.10
3		60	319	319	0	280	280	0	111.23	207.77	12.98	194.79	0.890	102.0	2	51.00
4		75	319	319	0	280	280	0	111.38	207.62	12.98	194.63	0.894	127.9	2	63.95
5		90	319	319	0	280	280	0	111.53	207.47	12.98	194.48	0.897	154.0	2	77.00
6		105	319	319	0	280	280	0	111.67	207.33	12.98	194.34	0.901	180.2	2	90.10
B324- 1	B	30	324	323.56	0.44	1,473	1,343	130	110.91	213.09	12.98	200.11	0.883	52.0	2	26.00
2		45	324	323.34	0.66	1,473	1,279	194	111.07	212.93	12.98	199.94	0.887	78.2	2	39.10
3		60	324	323.11	0.89	1,473	1,214	259	111.23	212.77	12.98	199.79	0.891	104.6	2	52.30
4		75	324	322.89	1.11	1,473	1,149	324	111.38	212.62	12.98	199.63	0.894	131.2	2	65.60
5		90	324	322.67	1.33	1,473	1,084	389	111.53	212.47	12.98	199.48	0.898	158.0	2	79.00
6		105	324	322.45	1.55	1,473	1,019	454	111.67	212.33	12.98	199.34	0.902	185.0	2	92.50
C310- 1	C	30	310	310	0	600	600	0	110.91	199.09	12.80	186.29	0.883	48.3	2	24.15
2		45	310	310	0	600	600	0	111.07	198.93	12.80	186.13	0.886	72.7	2	36.35
3		60	310	310	0	600	600	0	111.23	198.77	12.80	185.97	0.889	97.3	2	48.65
4		75	310	310	0	600	600	0	111.38	198.62	12.80	185.82	0.893	122.0	2	61.00
5		90	310	310	0	600	600	0	111.53	198.47	12.80	185.67	0.896	146.8	2	73.40
6		105	310	310	0	600	600	0	111.67	198.33	12.80	185.53	0.900	171.8	2	85.90
C315- 1	C	30	315	314.38	0.62	1,449	1,319	130	110.91	204.09	12.80	191.29	0.883	49.6	2	24.80
2		45	315	314.06	0.94	1,449	1,255	194	111.07	203.93	12.80	191.13	0.886	74.7	2	37.35
3		60	315	313.74	1.26	1,449	1,190	259	111.23	203.77	12.80	190.97	0.890	99.9	2	49.95
4		75	315	313.40	1.60	1,449	1,125	324	111.38	203.62	12.80	190.82	0.893	125.3	2	62.65
5		90	315	313.04	1.96	1,449	1,060	389	111.53	203.47	12.80	190.67	0.897	150.9	2	75.45
6		105	315	312.68	2.32	1,449	995	454	111.67	203.33	12.80	190.53	0.901	176.6	2	88.30
C319- 1	C	30	319	318.55	0.45	2,457	2,327	130	110.91	208.09	12.80	195.29	0.883	50.7	2	25.35
2		45	319	318.32	0.68	2,457	2,263	194	111.07	207.93	12.80	195.13	0.887	76.3	2	38.15
3		60	319	318.09	0.91	2,457	2,198	259	111.23	207.77	12.80	194.97	0.890	102.0	2	51.00
4		75	319	317.85	1.15	2,457	2,133	324	111.38	207.62	12.80	194.82	0.894	128.0	2	64.00
5		90	319	317.60	1.40	2,457	2,068	389	111.53	207.47	12.80	194.67	0.898	154.1	2	77.05
6		105	319	317.35	1.65	2,457	2,003	454	111.67	207.33	12.80	194.53	0.901	180.4	2	90.20
D305- 1	D	30	305	305	0	1,150	1,150	0	110.91	194.09	12.25	181.85	0.882	47.2	2	23.60
2		45	305	305	0	1,150	1,150	0	111.07	193.93	12.25	181.68	0.886	71.0	2	35.50
3		60	305	305	0	1,150	1,150	0	111.23	193.77	12.25	181.52	0.889	94.9	2	47.45
4		75	305	305	0	1,150	1,150	0	111.38	193.62	12.25	181.37	0.893	119.0	2	59.50
5		90	305	305	0	1,150	1,150	0	111.53	193.47	12.25	181.22	0.896	143.2	2	71.60
6		105	305	305	0	1,150	1,150	0	111.67	193.33	12.25	181.08	0.899	167.6	2	83.80
D310- 1	D	30	310	309.69	0.31	2,804	2,674	130	110.91	199.09	12.25	186.85	0.883	48.5	2	24.25
2		45	310	309.53	0.47	2,804	2,610	194	111.07	198.93	12.25	186.68	0.886	72.9	2	36.45
3		60	310	309.37	0.63	2,804	2,545	259	111.23	198.77	12.25	186.52	0.890	97.6	2	48.80
4		75	310	309.21	0.79	2,804	2,480	324	111.38	198.62	12.25	186.37	0.893	122.3	2	61.15
5		90	310	309.04	0.96	2,804	2,415	389	111.53	198.47	12.25	186.22	0.897	147.3	2	73.65
6		105	310	308.87	1.13	2,804	2,350	454	111.67	198.33	12.25	186.08	0.900	172.3	2	86.15
D315- 1	D	30	315	314.75	0.25	5,211	5,081	130	110.91	204.09	12.25	191.85	0.883	49.8	2	24.90
2		45	315	314.62	0.38	5,211	5,017	194	111.07	203.93	12.25	191.68	0.886	74.9	2	37.45
3		60	315	314.49	0.51	5,211	4,952	259	111.23	203.77	12.25	191.52	0.890	100.2	2	50.10
4		75	315	314.36	0.64	5,211	4,887	324	111.38	203.62	12.25	191.37	0.894	125.7	2	62.85
5		90	315	314.23	0.77	5,211	4,822	389	111.53	203.47	12.25	191.22	0.897	151.3	2	75.65
6		105	315	314.11	0.89	5,211	4,757	454	111.67	203.33	12.25	191.08	0.901	177.1	2	88.55

Note: FSL = Full Supply Level
MOL = Minimum Water Level
TCM = Thousand cubic meter

Table 8.2 Plant Capacity and Energy Output

Case	Dam Axis	Reserv. FSL (m)	Max. Plant Discharge (cms)	Installed Capacity (MW)	Energy Producible		Effective Energy		Remarks
					Firm (MWy)	Secondary (MWy)	Firm (MWy)	Secondary (MWy)	
B319- 1	B	319	30	50.6	42.86	2.28	39.99	2.13	
2			45	76.2	57.33	4.61	51.48	4.14	
3			60	102.0	67.96	7.60	61.03	6.82	
4			75	127.9	75.79	10.77	68.06	9.68	
5			90	154.0	82.41	13.49	74.00	12.12	
6			105	180.2	87.22	15.83	78.33	14.22	
B324- 1	B	324	30	52.0	44.09	2.31	41.13	2.15	With Daily Regulation
2			45	78.2	59.23	4.61	53.19	4.14	- do -
3			60	104.6	70.55	7.54	63.35	6.77	- do -
4			75	131.2	79.60	10.36	71.48	9.30	- do -
5			90	158.0	87.18	12.84	78.29	11.53	- do -
6			105	185.0	93.55	14.98	84.01	13.45	- do -
C310- 1	C	310	30	48.3	40.91	2.18	38.17	2.03	
2			45	72.7	54.72	4.39	49.14	3.95	
3			60	97.3	64.87	7.24	58.26	6.50	
4			75	122.0	72.33	10.27	64.96	9.22	
5			90	146.8	78.64	12.86	70.62	11.55	
6			105	171.8	83.22	15.09	74.74	13.55	
C315- 1	C	315	30	49.6	42.14	2.20	39.31	2.05	With Daily Regulation
2			45	74.7	56.60	4.40	50.83	3.95	- do -
3			60	99.9	67.40	7.19	60.53	6.46	- do -
4			75	125.3	76.03	9.89	68.28	8.88	- do -
5			90	150.9	83.24	12.25	74.75	11.00	- do -
6			105	176.6	89.30	14.29	80.19	12.83	- do -
C319- 1	C	319	30	50.7	43.02	2.25	40.14	2.10	- do -
2			45	76.3	57.79	4.49	51.90	4.03	- do -
3			60	102.0	68.83	7.35	61.81	6.60	- do -
4			75	128.0	77.66	10.10	69.73	9.07	- do -
5			90	154.1	85.03	12.52	76.36	11.24	- do -
6			105	180.4	91.24	14.60	81.93	13.11	- do -
D305- 1	D	305	30	47.2	39.92	2.12	37.25	1.98	
2			45	71.0	53.39	4.29	47.94	3.85	
3			60	94.9	63.27	7.07	56.82	6.35	
4			75	119.0	70.54	10.02	63.35	9.00	
5			90	143.2	76.68	12.55	68.86	11.27	
6			105	167.6	81.13	14.72	72.86	13.22	
D310- 1	D	310	30	48.5	41.15	2.15	38.39	2.01	With Daily Regulation
2			45	72.9	55.27	4.29	49.63	3.86	- do -
3			60	97.6	65.81	7.02	59.10	6.31	- do -
4			75	122.3	74.24	9.65	66.67	8.67	- do -
5			90	147.3	81.29	11.96	73.00	10.74	- do -
6			105	172.3	87.21	13.95	78.31	12.53	- do -
D315- 1	D	315	30	49.8	42.25	2.21	39.42	2.06	- do -
2			45	74.9	56.75	4.41	50.96	3.96	- do -
3			60	100.2	67.58	7.22	60.69	6.48	- do -
4			75	125.7	76.24	9.92	68.47	8.91	- do -
5			90	151.3	83.49	12.29	74.97	11.04	- do -
6			105	177.1	89.58	14.34	80.44	12.88	- do -

Table 8.3 Economic Comparison of Full Supply Levels

Dam Axis	FSL	Installed Capacity	Const. Cost	Without Regulation						With Regulation					
				O & M Cost	Total Cost C	Firm Energy	Second. Energy	Energy Benefit B	Net Benefit B-C	O & M Cost	Total Cost C	Firm Energy	Second. Energy	Energy Benefit B	Net Benefit B-C
	(m)	(MW)	($M)	($M)	($M)	(MWy)	(MWy)	($M)	($M)	($M)	($M)	(MWy)	(MWy)	($M)	($M)
	319	154	218.2	9.2	227.4	74.00	12.12	340.3	112.9						
B	322	156	229.0	9.3	238.3	75.14	12.31	345.6	107.3						
	324	158	236.3	9.4	245.7	75.91	12.43	349.1	103.4	20.2	256.5	78.29	11.53	358.7	102.2
	310	147	221.0	8.7	229.7	70.62	11.55	324.8	95.1						
	313	149	230.3	9.0	239.3	71.76	11.75	330.0	90.8						
C	315	151	236.5	9.1	245.6	72.52	11.00	332.6	87.1	19.8	256.3	74.75	11.00	342.5	86.2
	317	153	243.5							20.0	263.5	75.56	11.13	346.2	82.8
	319	154	250.5							20.0	270.5	76.36	11.24	349.9	79.4
	305	143	221.3	8.6	229.9	68.86	11.27	316.7	86.8						
	307	145	227.1	8.6	235.7	69.61	11.40	320.1	84.4						
D	310	147	236.2	8.9	245.1	70.75	11.91	325.7	80.7	19.6	255.8	73.00	10.74	334.5	78.6
	313	149	245.7							19.7	265.4	74.18	10.92	339.9	74.4
	315	151	252.2							19.8	272.0	74.97	11.04	343.5	71.5

Remarks, $M : US$ million

Unit benefit : 51 US$/MWh for firm energy and 11.92 US$/MWh for secondary energy

O & M cost for "with Regulation" includes cost for annual reservoir dredging (1.08 million US$/year).

Costs and benefits shown are total present values.

Table 8.4 Estimated Cost for 2nd Screening

Dam Axis B, FSL = 319 m

Unit ; 1,000US$

ACCOUNT No.	WORK ITEM	MAXIMUM PLANT DISCHARGE (M3/SEC) 30	45	60	75	90	105
10	LAND AND FACILITIES	407	407	407	407	407	407
11	STRUCTURES & OTHER IMPROVEMENT	3,888	5,399	7,122	9,031	11,069	12,941
12	RESERVOIR, DAM & WATERWAYS	49,757	60,893	70,893	77,903	83,702	88,535
13	TURBINES & GENERATORS	9,013	13,228	16,969	20,238	23,406	26,978
14	ACCESSORY ELECTRICAL EQUIPMENT	6,978	8,066	9,010	9,805	10,535	11,269
15	OTHER EQUIPMENT	3,125	4,116	4,888	5,417	6,148	6,895
16	ACCESS ROAD/RAILWAY & BRIDGES	2,110	2,110	2,110	2,110	2,110	2,110
	Total of 10. to 16.	75,278	94,220	111,399	124,911	137,377	149,134
17	INDIRECT COST	21,830	27,324	32,306	36,224	39,839	43,249
	TOTAL COST WITHOUT INTEREST	97,108	121,543	143,705	161,135	177,216	192,382
	INTEREST DURING CONSTRUCTION	20,954	26,227	31,009	34,770	38,239	41,512
	TOTAL COST WITH INTEREST	118,062	147,770	174,713	195,905	215,455	233,894

Table 10.1 Acquisition of Land & Improvement Cost

No.	Item	Unit	Quantity	Unit price (US$)	Amount (US$)
1. Dam & Reservoir					
(i) Left Bank and Island					
Flat area					
	Reservoir Area	ha	0.5	1500	750
	Buffer Area	ha	1.3	1500	1,950
	Quarry (Q.C.)	ha	2.0	1500	3,000
	Spoilbank (SB-5)	ha	3.1	1500	4,650
Mountain area					
	Reservoir Area	ha	1.1	1000	1,100
	Buffer Area	ha	7.6	1000	7,600
	Diversion & Dam	ha	1.9	1000	1,900
	Access road (AR-11)	ha	0.4	1000	400
	Spoilbank (SB-16)	ha	6.8	1000	6,800
Island (5.3ha)		L.S.			15,000
Resort Area (Camping Area)		L.S.			50,000
House L-1		nos	1.0	3000	3,000
	Sub-Total				96,150
(ii) Right Bank					
Flat area					
	Crushing Plant (CP-1)	ha	2.0	500	1,000
	Concrete Plant (BP-1)	ha	0.5	1000	500
	Office & Work Shop (O.S)	ha	8.0	1000	8,000
	Construction Camp (C.C)	ha	10.5	1000	10,500
Mountain area					
	Reservoir Area	ha	2.4	800	1,920
	Buffer Area	ha	11.1	800	8,880
	Diversinon & Dam	ha	0.5	800	400
	Intake & Desanding basin	ha	2.1	800	1,680
	Open Culvert	ha	1.6	800	1,280
	Access road (AR-4,9)	ha	0.9	800	720
	Quarry (Q.A)	ha	2.6	500	1,300
	Spoilbank (SB-1)	ha	3.6	650	2,340
	Spoilbank (SB-8,9)	ha	10.6	800	8,480
House R-1 (Reservoir)		nos	1.0	1500	1,500
House R-2 (")		nos	1.0	7000	7,000
House R-3 (SB-1)		nos	1.0	750	750
House R-4 (C.C)		nos	2.0	7000	14,000
	Sub-Total				70,250
2. Powerhouse & Surgetank					
Powerhouse		m	280.0	100	28,000
- do -		ha	5.9	1000	5,900
Surgetank		ha	1.1	1000	1,100
Work adit No.1		ha	0.7	1000	700
Access road (AR-1,17)		ha	1.3	1000	1,300
Spoilbank (SB-12)		ha	2.2	800	1,760
Spoilbank (SB-18,19)		ha	6.0	1500	9,000
Concrete Plant (BP-2)		ha	0.6	1000	600
Office & Work Shop (O.S)		ha	1.3	1000	1,300
House (powerhouse)		nos	10.0	9000	90,000
House (BP-2)		nos	3.0	9000	27,000
House (SB-18,19)		nos	2.0	9000	18,000
Sheds		nos	2.0	1500	3,000
	Sub-Total				187,660
	Total				354,060

Table 10.2 Environmental Manegement Cost

(US$)

No.	Item	unit	Cost
1.	Reservoir Cleaning Program	L.S.	13,000
2.	Physic-Biotic Programs		
	Environmental Control Actions of the Engineering Works	L.S.	27,000
	Monitoring Program for Geological Impacts	L.S.	42,000
	Restoration Program for Degraded Areas	L.S.	212,500
	Monitoring and Conservation Program for the Ictiofauna	L.S.	21,000
	Climatic Condition Observation Plan	L.S.	82,500
	Water Quality Control Program	L.S.	40,000
	Sub-total		425,000
3.	Socio-Economic Cultural Programs		
	Public Health Control Program	L.S.	149,500
	Manpower Qualification Program	L.S.	7,500
	Supporting Program for the Municipalities	L.S.	66,000
	Population Transference Program	L.S.	8,000
	Social Communication Program	L.S.	26,000
	Resevoir Protection Fence & Establishment of Buffer Area for Powerhouse	L.S.	48,000
	Sub-total		305,000
4.	Center of Environmental Preservation	L.S.	1,100,000
	Total		1,843,000

Table 10.3 Contents of Other Costs

11. STRUCTURES & OTHER IMPROVEMENT		
11. 13. Powerhouse	Other Costs (11.13.00.17)	- Clearing and stripping - Slope protection - Backfilling - Maintenance of existing road - Improvement of existing road - Miscellaneous Cost
12. RESERVOIR, DAM & WATERWAYS		
12. 15. Reservoir	Other Costs (12.16.24.17)	- Miscellaneous Cost
12. 16. Rever Diversion		
16. 24. Diversion Channel	Other Costs (12.16.24.17)	- Clearing and stripping - Miscellaneous Cost
12. 17. Dam & Embankment		
17. 25. Rockfill Dam	Other Costs (12.17.25.17)	- Miscellaneous Cost
17. 26. Concrete Dam	Other Costs (12.17.26.17)	- Clearing and stripping - Maintenance of existing road - Improvement of existing road - New construction road - Miscellaneous Cost
12. 18. Spillway		
18. 28. Main Spillway	Other Costs (12.18.28.17)	- Miscellaneous Cost
12. 19. Intake & Headrace		
19. 30. Intake & Desanding Basin	Other Costs (12.19.30.17)	- Clearing and stripping - Backfilling - Maintenance of existing road - Improvement of existing road - New construction road - Miscellaneous Cost
19. 32. Headrace Culvert & Tunnel	Other Costs (12.19.32.17)	- Clearing and stripping - Backfilling - Embankment of Rock - Embankment of Filter - Consolidation Grouting - Work adit No.2 - Improvement of existing road - New construction road - Miscellaneous Cost
19. 33. Surge Tank	Other Costs (12.19.33.17)	- Clearing and stripping - Consolidation Grouting - Improvement of existing road - New construction road - Miscellaneous Cost
19. 34. Penstock Tunnel & Penstock Lane	Other Costs (12.19.34.17)	- Consolidation Grouting - Penstock drain works - Work adit No.3 - Connection adit work - Miscellaneous Cost
19. 35. Tailrace Channel	Other Costs (12.19.35.17)	- Clearing and stripping - Backfilling - Tailrace cofferdam - Miscellaneous Cost

Table 10.4 Project Cost in US$

- Salto Pilão Hydropower Scheme
- Price Level : December 1992
- Installed capacity : 142 MW
- 1US$=11,163.33Cr$

(unit : US$)

Account No.	Work Item	Unit	Quantity	Unit Price	Ammount
10.	**LAND AND FACILITIES**				
10. 10.	**Acquisition of Land & Improvement**				
10. 10. 11.	Rural Land & Properties				
10. 10. 11. 10.	Land Areas	L.S.			354,060
10. 10. 12.	Legal Charges & Purchase	L.S.			52,940
10. 27.	**Contingence of Account 10**				
	TOTAL OF ACCOUNT 10				407,000
11.	**STRUCTURES & OTHER IMPROVEMENT**				
11. 12.	**Improvement in Powerhouse Area**	L.S.			770,815
11. 13.	**Powerhouse**				
11. 13. 00. 12.	Excavation for Powerhouse				
11. 13. 00. 12. 10.	Common Excavation	m3	248,000	5.8	1,438,400
11. 13. 00. 12. 11.	Open-air Excavation in Rock	m3	35,600	12.8	455,680
11. 13. 00. 14.	Concrete for Powerhouse				
11. 13. 00. 14. 13.	Cement	t	6,728	189.9	1,277,647
11. 13. 00. 14. 14.	Concrete (Cement cost excluded)	m3	24,310	136.2	3,311,022
11. 13. 00. 14. 15.	Reinforcement bar	t	861	1,426.9	1,228,561
11. 13. 00. 15.	Interior Finish Work	L.S.			190,722
11. 13. 00. 17.	Other Costs	L.S.			958,141
11. 27.	**Contingence of Account 11**				1,438,012
	TOTAL OF ACCOUNT 11				11,069,000
12.	**RESERVOIR, DAM & WATERWAYS**				
12. 15.	**RESEVOIR**				
12. 15. 00 18.	Cleaning of Reservoir	ha			13,000
12. 15. 21.	Environment	L.S.			730,000
12. 15. 13.	Other Costs	L.S.			37,150
12. 16.	**RIVER DIVERSION**				
12. 16. 22.	Cofferdams				
12. 16. 22. 19.	Rock & Earth Fill Cofferdam	m3	71,000	9.2	653,200
12. 16. 22. 21.	Removal of Cofferdams	L.S.			184,600
12. 16. 22. 22.	Dewatering & Other Costs	L.S.			125,096
12. 16. 24.	Diversion Channel				
12. 16. 24. 12.	Excavation				
12. 16. 24. 12. 10.	Common Excavation	m3	155,800	5.8	903,640
12. 16. 24. 12. 11.	Open-air Excavation in Rock	m3	8,200	12.8	104,960
12. 16. 24. 17.	Other Cost	L.S.			67,538
12. 17.	**DAM & EMBANKMENT**				
12. 17. 25.	Rockfill Dam				
12. 17. 25. 25.	Rockfill & Filter	m3	7,600	18.7	142,120
12. 17. 25. 26.	Soil Core	m3	6,000	11.0	66,000
12. 17. 25. 17.	Other Costs	L.S.			10,406
12. 17. 26.	Concrete Dam				
12. 17. 26. 12.	Excavation				
12. 17. 26. 12. 11.	Open-air Excavation in Rock	m3	10,000	12.8	128,000
12. 17. 26. 13.	Cleaning & Foundation Treatment	L.S.			110,550
12. 17. 26. 14.	Concrete				
12. 17. 26. 14. 13.	Cement	t	5,622	189.9	1,067,618
12. 17. 26. 14. 14.	Concrete (cement cost excluded)	m3	35,400	104.7	3,706,380
12. 17. 26. 14. 15.	Reinforcement Bars	t	280	1,426.9	399,532
12. 17. 26. 17.	Other Costs	L.S.			845,333
12. 18.	**SPILLWAY**				
12. 18. 28.	Main Spillway (Sand flush)				
12. 18. 28. 23.	Equipment				
12. 18. 28. 23. 16.	Gates & Winches (ha = 12.8 m)				
12. 18. 28. 23. 16. 10.	FOB Cost (L= 5.0 m)	unit	1	305,900.0	305,900
12. 18. 28. 23. 16. 11.	Transport & Securities (H = 7.3 m)	L.S.			18,354
12. 18. 28. 23. 16. 12.	Erection & Test	L.S.			48,944

(unit : US$)

Account No.	Work Item	Unit	Quantity	Unit Price	Ammount
12. 18. 28. 23. 17.	Stoplogs (p= 4 ; t= 0.5 m)				
12. 18. 28. 23. 17. 10.	FOB Cost (ha = 1.8 m)	L.S.			194,876
12. 18. 28. 23. 17. 11.	Transport & Securities (L= 5 m)	L.S.			11,693
12. 18. 28. 23. 17. 12.	Erection & Test (H = 7.2 m)	L.S.			31,180
12. 18. 28. 23. 20.	Winch (C= 8 t)				
12. 18. 28. 23. 20. 10.	FOB Cost (L= m)	unit			25,500
12. 18. 28. 23. 20. 11.	Transport & Securities (H = m)	L.S.			1,530
12. 18. 28. 23. 20. 12.	Erection & Test	L.S.			4,080
12. 18. 28. 17.	Other Costs	L.S.			32,103
12. 19.	**INTAKE & HEADRACE**				
12. 19. 30.	**Intake & Desanding Basin**				
12. 19. 30. 12.	Excavation				
12. 19. 30. 12. 10.	Common Excavation	m3	140,000	5.8	812,000
12. 19. 30. 12. 11.	Open-air Excavation in Rock	m3	170,000	12.8	2,176,000
12. 19. 30. 14.	Concrete				
12. 19. 30. 14. 13.	Cement	t	16,821	189.9	3,194,308
12. 19. 30. 14. 14.	Concrete (cement cost excluded)	m3	62,300	136.2	8,485,260
12. 19. 30. 14. 15.	Reinforcement Bars	t	2,492	1,426.9	3,555,835
12. 19. 30. 23.	Equipment				
12. 19. 30. 23. 16.	Inlet Gates & Winches (ha = 4.3 m)				
12. 19. 30. 23. 16. 10.	FOB Cost (L= 3.7 m)	unit			859,900
12. 19. 30. 23. 16. 11.	Transport & Securities (H = 4.4 m)	L.S.			51,594
12. 19. 30. 23. 16. 12.	Erection & Test	L.S.			137,584
12. 19. 30. 23. 17.	Stoplogs (p= 3 ; t= 0.4 m)				
12. 19. 30. 23. 17. 10.	FOB Cost (ha = 1.5 m)	L.S.			160,000
12. 19. 30. 23. 17. 11.	Transport & Securities (L= 3.7 m)	L.S.			9,600
12. 19. 30. 23. 17. 12.	Erection & Test (H = 4.5 m)	L.S.			25,600
12. 19. 30. 23. 21.	Screens & Rakes (Cpf =)				
12. 19. 30. 23. 21. 10.	FOB Cost	L.S.			782,720
12. 19. 30. 23. 21. 11.	Transport & Securities (L = 5.7 m)	L.S.			46,963
12. 19. 30. 23. 21. 12.	Erection & Test (H= 9.8 m)	L.S.			125,236
12. 19. 30. 16.	Monitoring Apparatus	L.S.			
12. 19. 30. 17.	Other Costs	L.S.			1,880,371
12. 19. 32.	**Headrace Culvert & Tunnel**				
12. 19. 32. 12.	Excavation				
12. 19. 32. 12. 10.	Common Excavation	m3	105,000	5.8	609,000
12. 19. 32. 12. 11.	Open-air Excavation in Rock	m3	11,900	12.8	152,320
12. 19. 32. 12. 12.	Underground Excavation in Rock	m3	167,400	74.9	12,538,260
12. 19. 32. 14a	Concrete for structure				
12. 19. 32. 14a 13.	Cement	t	8,596	189.9	1,632,380
12. 19. 32. 14a 14.	Concrete (cement cost excluded)	m3	28,400	156.5	4,444,600
12. 19. 32. 14a 15.	Reinforcement Bars	t	332	1,426.9	473,731
12. 19. 32. 23. 22.	Steel Culvert				
12. 19. 32. 23. 22. 10.	FOB Cost	L.S.			1,022,430
12. 19. 32. 23. 22. 11.	Transport & Securities	L.S.			224,935
12. 19. 32. 23. 22. 12.	Erection & Test	L.S.			715,701
12. 19. 32. 17.	Other Costs	L.S.			2,307,974
12. 19. 33.	**Surge Tank**				
12. 19. 33. 12.	Excavation				
12. 19. 33. 12. 10.	Common Excavation	m3	70,600	5.8	409,480
12. 19. 33. 12. 11.	Open-air Excavation in Rock	m3	29,700	12.8	380,160
12. 19. 33. 12. 12.	Underground Excavation in Rock	m3	12,000	99.5	1,194,000
12. 19. 33. 14.	Concrete				
12. 19. 33. 14. 13.	Cement	t	600	189.9	113,940
12. 19. 33. 14. 14.	Concrete (cement cost excluded)	m3	2,400	149.3	358,320
12. 19. 33. 14. 15.	Reinforcement Bars	t	1	1,426.9	1,427
12. 19. 33. 17.	Other Costs	L.S.			551,790
12. 19. 34.	**Penstock Tunnel & Penstock Lane**				
12. 19. 34. 12.	Excavation				
12. 19. 34. 12. 12.	Underground Excavation in Rock	m3	19,700	99.0	1,950,300

(unit : US$)

Account No.	Work Item	Unit	Quantity	Unit Price	Ammount
12. 19. 34. 14.	Concrete				
12. 19. 34. 14. 13.	Cement	t	2,550	189.9	484,245
12. 19. 34. 14. 14.	Concrete (cement cost excluded)	m3	10,200	140.5	1,433,100
12. 19. 34. 14. 15.	Reinforcement Bars	t	98	1,426.9	139,836
12. 19. 34. 23. 23.	Steel Lining				
12. 19. 34. 23. 23. 10.	FOB Cost	L.S.			2,984,250
12. 19. 34. 23. 23. 11.	Transport & Securities	L.S.			656,535
12. 19. 34. 23. 23. 12.	Erection & Test	L.S.			2,088,975
12. 19. 34. 17.	Other Costs	L.S			2,177,247
12. 19. 35.	**Tailrace Channel & Tunnel**				
12. 19. 35. 12.	Excavation				
12. 19. 35. 12. 10.	Common Excavation	m3	20,300	5.8	117,740
12. 19. 35. 12. 11.	Open-air Excavation in Rock	m3	8,800	12.8	112,640
12. 19. 35. 14.	Concrete				
12. 19. 35. 14. 13.	Cement	t	484	189.9	91,912
12. 19. 35. 14. 14.	Concrete (cement cost excluded)	m3	2,200	136.2	299,640
12. 19. 35. 14. 15.	Reinforcement Bars	t	44	1,426.9	62,784
12. 19. 35. 17.	Other Costs	L.S.			138,083
12. 20.	**SPECIAL WORK**				
12. 20. 37.	Other Special Works	L.S.			1,100,000
12. 27.	**Contingence of Account 12**				10,462,011
	TOTAL OF ACCOUNT 12				83,702,000
13.	**TURBINES & GENERATORS**				
13. 13. 00. 23. 28.	Turbines (Type : Francis)				
13. 13. 00. 23. 28. 10.	FOB Cost (P= 72,600 kw)	unit	2	3,600,500.0	7,201,000
13. 13. 00. 23. 28. 11.	Transportation & Security (n=327.3 rpm)	L.S.			288,040
13. 13. 00. 23. 28. 12.	Erection & Test (Hl = 207.5 m)	L.S.			1,440,200
13. 13. 00. 23. 28. 13.	Other Costs	L.S.			446,462
13. 13. 00. 23. 16.	Draft Tube Gate (p = 2.0)				
13. 13. 00. 23. 16. 10.	FOB Cost (t = 0.4 m)	unit	2	178,900.0	357,800
13. 13. 00. 23. 16. 11.	Transportation & Security (ha = 23 m)	L.S.			21,468
13. 13. 00. 23. 16. 12.	Erection & Test (L = 3.4 m)	L.S.			57,248
13. 13. 00. 23. 16. 13.	Other Costs (H = 3.1 m)	L.S.			21,881
13. 13. 00. 23. 20.	Winch of Draft Tube (C= 18 t)				
13. 13. 00. 23. 20. 10.	FOB Cost (L = 7.0 m)	unit	1	321,600.0	321,600
13. 13. 00. 23. 20. 11.	Transportation & Security (H= 6.7 m)	L.S.			12,864
13. 13. 00. 23. 20. 12.	Erection & Test	L.S.			64,320
13. 13. 00. 23. 20. 13.	Other Costs	L.S.			19,939
13. 13. 00. 23. 29.	Generator n= 327.3 (P= 78,900 kVA)				
13. 13. 00. 23. 29. 10.	FOB Cost	unit	2	4,234,000.0	8,468,000
13. 13. 00. 23. 29. 11.	Transportation & Security	L.S.			338,720
13. 13. 00. 23. 29. 12.	Erection & Test	L.S.			1,693,600
13. 13. 00. 23. 29. 13.	Other Costs	L.S.			525,016
13. 27.	**Contingence of Account 13**				2,127,842
	TOTAL OF ACCOUNT 13				23,406,000
14.	**ACCESSORY ELECTRICAL EQUIPMENT**				
14. 00. 00. 23. 30.	Accessory Electrical Equipment				
14. 00. 00. 23. 30. 10.	FOB Cost	L.S.			7,356,000
14. 00. 00. 23. 30. 11.	Transportation & Security	L.S.			294,240
14. 00. 00. 23. 30. 12.	Erection & Test	L.S.			1,471,200
14. 00. 00. 23. 30. 13.	Other Costs	L.S.			456,072
14. 27.	**Contingence of Account 14**				957,488
	TOTAL OF ACCOUNT 14				10,535,000

(unit : US$)

Account No.	Work Item	Unit	Quantity	Unit Price	Ammount
15.	OTHER EQUIPMENT OF POWERHOUSE				
15. 13. 00 23. 20.	Overhead Traveling Crane (C= 160 t)				
15. 13. 00 23. 20. 10.	FOB Cost (L= 16.0 m)	unit	1	910,000.0	910,000
15. 13. 00 23. 20. 11.	Transportation & Security (H = m)	L.S.			36,400
15. 13. 00 23. 20. 12.	Erection & Test	L.S.			182,000
15. 13. 00 23. 20. 13.	Other Costs	L.S.			56,420
15. 00 00 23. 21.	Other Equipment				
15. 00 00 23. 21. 10.	FOB Cost	L.S.			3,383,000
15. 00 00 23. 21. 11.	Transportation & Security	L.S.			135,320
15. 00 00 23. 21. 12.	Erection & Test	L.S.			676,600
15. 00 00 23. 21. 13.	Other Costs	L.S.			209,746
15. 27.	Contingence of Account 15				558,514
	TOTAL OF ACCOUNT 15				6,148,000
16.	ACCESS ROAD/RAILWAY & BRIDGES				
16. 00. 14.	Roadways	km	4	371,250.0	1,485,000
16. 00. 16.	Bridges	m	50	7,000.0	350,000
16. 27.	Contingence of Account 16				275,000
	TOTAL OF ACCOUNT 16				2,110,000
	TOTAL OF ACCOUNT 10 to 16 (CDT)				137,377,000
17.	INDIRECT COST				
17. 21.	Construction Site & Camping				
17. 21. 38.	Works of Construction Site & Camping	L.S.	CDT (7%)		9,616,000
17. 21. 38. 33.	Residential Units	L.S.			
17. 21. 38. 34.	Community Plant	L.S.			
17. 21. 38. 35.	Infra-structure				
17. 21. 38. 35. 32.	Edifications	L.S.			
17. 21. 38. 35. 33.	Systems	L.S.			
17. 21. 38. 17.	Other Cost	L.S.			
17. 21. 39.	Maintenance & Operation of Works/Camps	L.S.			
17. 22.	Engineering & Administration of Proprietor				
17. 22. 40.	Engineering				
17. 22. 40. 36.	Basic Engineering	L.S.	CDT (7%)		9,616,000
17. 22. 40. 37.	Special Works of Engineering	L.S.			
17. 22. 41.	Administration of Properties	L.S	CDT (15%)		20,607,000
17. 22. 41. 38.	Administration of Works	L.S.			
17. 22. 41. 39.	General Administration	L.S.			
17. 27.	Contingence of Account 17				
	TOTAL OF ACCOUNT 17				39,839,000
.10 to .17	TOTAL COST WITHOUT INTEREST				177,216,000
	TOTAL COST WITHOUT INTEREST (Cr$x10^6 equivalent)				1,978,321
18.	INTEREST DURING CONSTRUCTION				38,239,000
.10 to .18	TOTAL COST WITH INTEREST				215,455,000
	TOTAL COST WITH INTEREST (Cr$x10^6 equivalent)				2,405,195

Attachment

Contents of Account No. 12.19.30.23.16 Inlet Gates & Wintches contains are as follow :

Account No.	Work Item	Unit	Quantity	Unit Price (US$)	Amount (US$)
12. 19. 30. 23. 16.	Inlet gates & winches (ha =10.3 m)				
12. 19. 30. 23. 16. 10a	FOB (L= 3.7 m)	unit	3	136,700	410,100
12. 19. 30. 23. 16. 11a	Transportation & Securities (H = 4.4 m)	L.S.			24,606
12. 19. 30. 23. 16. 12a	Erection and test	L.S.			65,616
12. 19. 30. 23. 16.	Intake gate & winches (ha = 16.5 m)				
12. 19. 30. 23. 16. 10b	FOB (L= 3.8m)	unit	1	250,000	250,000
12. 19. 30. 23. 16. 11b	Transportation & Securities (H =4.8m)	L.S.			15,000
12. 19. 30. 23. 16. 12b	Erection and test	L.S.			40,000
12. 19. 30. 23. 16.	Sand drain gates and winches (ha=14.3 m)				
12. 19. 30. 23. 16. 10c	FOB (L= 2.5 m)	unit	9	22,200	199,800
12. 19. 30. 23. 16. 11c	Transportation & Securities (H = 1.0 m)	L.S.			11,988
12. 19. 30. 23. 16. 12c	Erection and test	L.S.			31,968

Table 10.5 Allocation of Unit Cost to Foreign and Local Components

No.	Items	Foreign Currency (%)	Local Currency (%)
1.	Labor	0	100
2.	Materials		
	Portland cement	60	40
	Reinforcing steel bars	60	40
	Timber, plank	20	80
	Plywood (t = 200 mm)	20	80
	Steel, shape	70	30
	Steel plate	70	30
	Steel pipe (gas pipe)	70	30
	Diesel oil	80	20
	Gasoline	80	20
	Engine oil	80	20
	Grease	80	20
	Dynamite	30	70
	Detonator	30	70
	Asphalt	30	70
	Metal form (0.3 x 1.5)	70	30
	Electricity	30	70
	Tire (consumable)	50	50
3.	Equipment for civil work		
	a) depreciation and spare part cost		
	- Earth work equipment (Buldozer, dump truck, etc.)	65	35
	- Concrete work equipment	70	30
	- Drainage equipment	80	20
	- Crane	80	20
	b) Inland transportation	40	60
	c) Operators	0	100
4.	Contractor's overhead (civil work)	60	40
5.	Metal Work		
	a) Gate, Penstrock		
	• Ex-factory	70	30
	• Transportation & insurance	40	60
	• Erection & test	50	50
	b) Penstrock		
	• Ex-factory	70	30
	• Transportation & insurance	40	60
	• Erection & test	60	40
	c) Hoist (winch)		
	• Ex-factory	70	30
	• Transportation & insurance	40	60
	• Erection & Test	50	50
6.	Electrical Equipment		
	• Ex-factory	70	30
	• Transportation & Insurance	40	60
	• Erection & test	50	50
7.	Engineering service (Design & supervision)	15	85
8.	Administration (by CELESC)	0	100

Table 11.1 Acquisition of House and Land and Number of People to be Resettled

Item	Unit	Quantity		Item	Unit	Quantity	
1. Dam & Reservoir							
(i) Left Bank and Island							
Flat area				Access road (AR-4,9)	ha	0.9	
Reservoir Area	ha	0.5		Quarry (Q.A)	ha	2.6	
Buffer Area	ha	1.3		Spoilbank (SB-1)	ha	3.6	
Quarry (Q.C.)	ha	2.0		Spoilbank (SB-8,9)	ha	10.6	
Spoilbank (SB-5)	ha	3.1		House R-1 (Reservoir)	nos	1.0	(0)
Mountain area				House R-2 (")	nos	1.0	(12)
Reservoir Area	ha	1.1		House R-3 (SB-1)	nos	1.0	(0)
Buffer Area	ha	7.6		House R-4 (C.C)	nos	2.0	(10)
Diversion & Dam	ha	1.9		Sub-Total			
Access road (AR-11)	ha	0.4					
Spoilbank (SB-16)	ha	6.8		**2.**			
Island (5.3ha)	L.S.			Powerhouse	m	280.0	
Resort Area (Camping Area)	L.S.			- do -	ha	5.9	
House L-1	nos	1.0	(5)	Surgetank	ha	1.1	
Sub-Total				Work adit No.1	ha	0.7	
				Access road (AR-1,17)	ha	1.3	
(ii) Right Bank				Spoilbank (SB-12)	ha	2.2	
Flat area				Spoilbank (SB-18,19)	ha	6.0	
Crushing Plant (CP-1)	ha	2.0		Concrete Plant (BP-2)	ha	0.6	
Concrete Plant (BP-1)	ha	0.5		Office & Work Shop (O.S)	ha	1.3	
Office & Work Shop (O.	ha	8.0		House (powerhouse)	nos	10.0	(40)
Construction Camp (C.C	ha	10.5		House (BP-2)	nos	3.0	(0)
Mountain area				House (SB-18.19)	nos	2.0	(10)
Reservoir Area	ha	2.4		Sheds	nos	2.0	(0)
Buffer Area	ha	11.1					
Diversinon & Dam	ha	0.5					
Intake & Desanding basi	ha	2.1					
Open Culvert	ha	1.6					

( ) : Number of people to be resettled

Total Land : 100 ha
Houses : 23 nos.
(including sheds)
People : 77 persons
Household : 16 families

Table 12.1 Cash Flow for Economic Evaluation

Price level : December 1992 Unit : million US$

Year	Economic Cost			Economic Benefit
	Investment Cost	O,M & R Cost *	Total	
1	31.90		31.90	
2	47.85		47.85	
3	47.85		47.85	
4	31.90		31.90	
5		0.74	0.74	29.37
6		0.74	0.74	29.37
.		.	.	.
.		.	.	.
.		.	.	.
.		.	.	.
28		0.74	0.74	29.37
29		0.74	0.74	29.37
30		19.92	19.92	14.69
31		19.92	19.92	14.69
32		0.74	0.74	29.37
33		0.74	0.74	29.37
.		.	.	.
.		.	.	.
.		.	.	.
.		.	.	.
53		0.74	0.74	29.37
54		0.74	0.74	29.37

* : Operation, maintenance and replacement cost

Table 12.2 Cash Flow for Financial Evaluation

Price level : December 1992 Unit : million US$

Year	Expenditure			Revinue
	Investment Cost	O,M & R Cost *	Total	
1	35.44		35.44	
2	53.16		53.16	
3	53.16		53.16	
4	35.44		35.44	
5		0.86	0.86	26.90
6		0.86	0.86	26.90
.		.	.	.
.		.	.	.
.		.	.	.
.		.	.	.
28		0.86	0.86	26.90
29		0.86	0.86	26.90
30		22.13	22.13	13.45
31		22.13	22.13	13.45
32		0.86	0.86	26.90
33		0.86	0.86	26.90
.		.	.	.
.		.	.	.
.		.	.	.
.		.	.	.
53		0.86	0.86	26.90
54		0.86	0.86	26.90

Table 12.3 Cash Flow for Loan Repayability

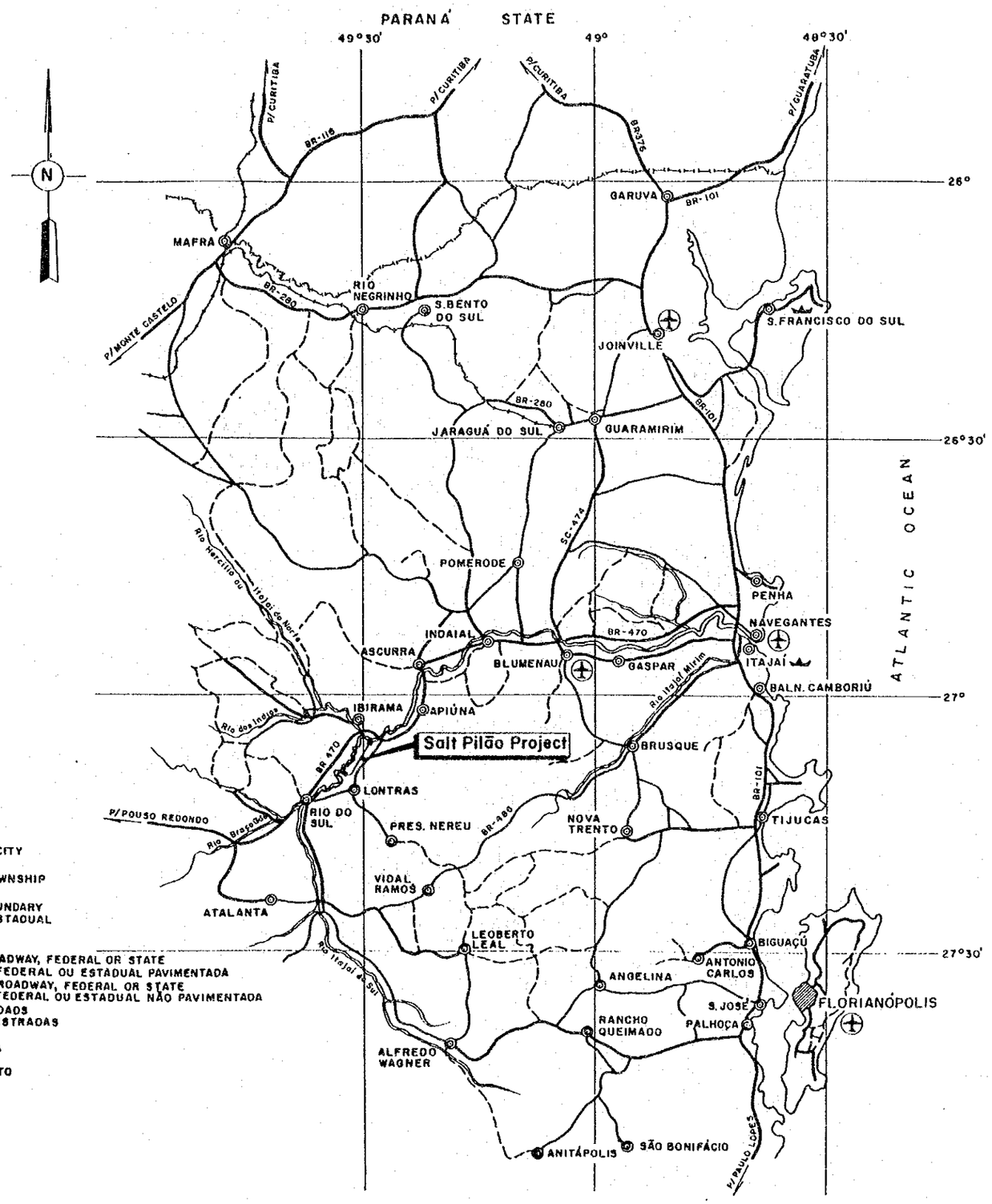
Price level : December 1992 — Unit : million US$

Year	Loan Amount	Payment					Revenue	Annual Balance (e)-(d)	Accum'd Balanse
		Principal	Accum'd Debt	Interest paid	O,M & R Cost	Total (a)+(b)+(c)			
		(a)		(b)	(c)	(d)	(e)		
1	35.44		35.44	1.77		1.77		-1.77	-1.77
2	53.16		88.60	6.20		6.20		-6.20	-7.97
3	53.16		141.76	11.52		11.52		-11.52	-19.49
4	35.44		177.20	15.95		15.95		-15.95	-35.44
5		11.08	166.13	17.72	0.86	29.66	26.90	-2.76	-38.20
6		11.08	155.05	16.61	0.86	28.55	26.90	-1.65	-39.84
7		11.08	143.98	15.51	0.86	27.44	26.90	-0.54	-40.38
8		11.08	132.90	14.40	0.86	26.33	26.90	0.57	-39.82
9		11.08	121.83	13.29	0.86	25.23	26.90	1.68	-38.14
10		11.08	110.75	12.18	0.86	24.12	26.90	2.78	-35.36
11		11.08	99.68	11.08	0.86	23.01	26.90	3.89	-31.47
12		11.08	88.60	9.97	0.86	21.90	26.90	5.00	-26.47
13		11.08	77.53	8.86	0.86	20.80	26.90	6.11	-20.37
14		11.08	66.45	7.75	0.86	19.69	26.90	7.21	-13.15
15		11.08	55.38	6.65	0.86	18.58	26.90	8.32	-4.83
16		11.08	44.30	5.54	0.86	17.47	26.90	9.43	4.59
17		11.08	33.23	4.43	0.86	16.37	26.90	10.54	15.13
18		11.08	22.15	3.32	0.86	15.26	26.90	11.64	26.77
19		11.08	11.08	2.22	0.86	14.15	26.90	12.75	39.52
20		11.08	0.00	1.11	0.86	13.04	26.90	13.86	53.38
21					0.86	0.86	26.90	26.04	79.42
22					0.86	0.86	26.90	26.04	105.46
23					0.86	0.86	26.90	26.04	131.50
24					0.86	0.86	26.90	26.04	157.54
25					0.86	0.86	26.90	26.04	183.58
26					0.86	0.86	26.90	26.04	209.62
27					0.86	0.86	26.90	26.04	235.66
28					0.86	0.86	26.90	26.04	261.70
29					0.86	0.86	26.90	26.04	287.74
30					22.13	22.13	13.45	-8.68	279.06
31					22.13	22.13	13.45	-8.68	270.38
32					0.86	0.86	26.90	26.04	296.42
33					0.86	0.86	26.90	26.04	322.46
34					0.86	0.86	26.90	26.04	348.50
35					0.86	0.86	26.90	26.04	374.54
36					0.86	0.86	26.90	26.04	400.58
37					0.86	0.86	26.90	26.04	426.62
38					0.86	0.86	26.90	26.04	452.66
39					0.86	0.86	26.90	26.04	478.70
40					0.86	0.86	26.90	26.04	504.74
41					0.86	0.86	26.90	26.04	530.78
42					0.86	0.86	26.90	26.04	556.82
43					0.86	0.86	26.90	26.04	582.86
44					0.86	0.86	26.90	26.04	608.90
45					0.86	0.86	26.90	26.04	634.94
46					0.86	0.86	26.90	26.04	660.98
47					0.86	0.86	26.90	26.04	687.02
48					0.86	0.86	26.90	26.04	713.06
49					0.86	0.86	26.90	26.04	739.10
50					0.86	0.86	26.90	26.04	765.14
51					0.86	0.86	26.90	26.04	791.18
52					0.86	0.86	26.90	26.04	817.22
53					0.86	0.86	26.90	26.04	843.26
54					0.86	0.86	26.90	26.04	869.30
Total	177.20	177.20		186.06	85.54	448.80	1318.10		

Notes: (1) Loan with an interest rate of 10% for a loan peariod of 20 years including 4 year grace period.
(2) Principal is repaid uniformly over 16 years.

Figure

PARANÁ STATE



LEGEND
LEGENDA

- CAPITAL/CITY — CAPITAL
- TOWN/TOWNSHIP — CIDADE
- STATE BOUNDARY — LIMITE ESTADUAL
- RIVER — RIO
- PAVED ROADWAY, FEDERAL OR STATE — RODOVIA FEDERAL OU ESTADUAL PAVIMENTADA
- UNPAVED ROADWAY, FEDERAL OR STATE — RODOVIA FEDERAL OU ESTADUAL NÃO PAVIMENTADA
- OTHER ROADS — OUTRAS ESTRADAS
- RAILWAY — FERROVIA
- AIRPORT — AEROPORTO
- HARBOUR — PORTO

São paulo	~ Itajaí	BR-116/376/101	604km
Curitiba	~ Itajaí	BR-376/101	199 km
Joinville	~ Itajaí	BR-101	77 km
Florianopolis	~ Itajaí	BR-101	101 km
Itajaí	~ Blumenau	BR-470	37 km
Blumenau	~ Ibirama	BR-470	73 km
Ibirama	~ Rio do sul	BR-470	25 km
Powerhouse	~ Blumenau	BR-470	65 km
Powerhouse	~ Ibirama	BR-470	8 km
Powerhouse	~ Dam site	Ibirama - Subida	15 km
Dam site	~ Blumenau	BR-470/Ibirama-Subida	67 km
Dam site	~ Rio do sul	Ibirama-Subida/BR-470	18km

Scale 0 — 50km

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Fig. 1.1
Vicinity Map

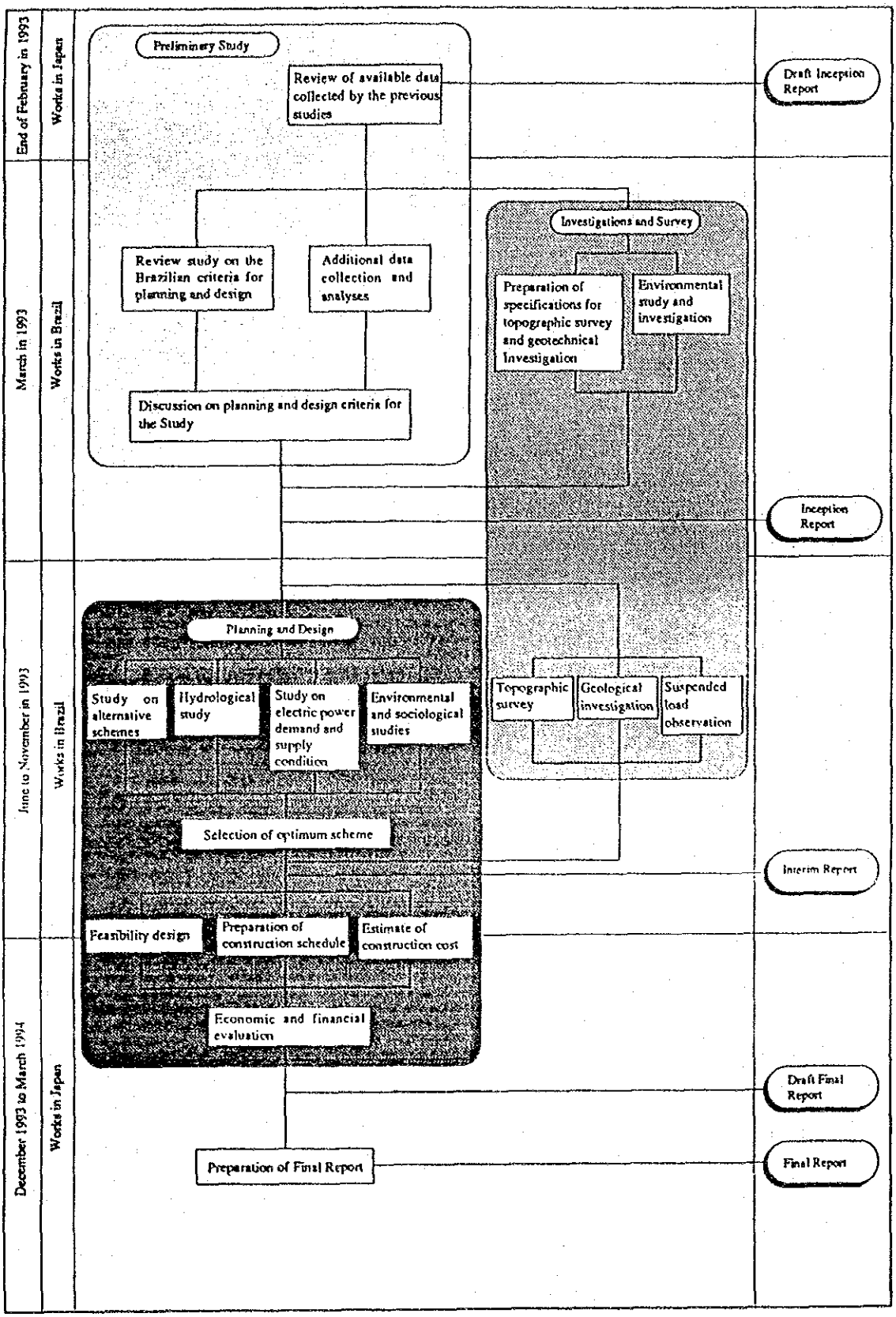

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Fig. 1.2
General Work Flow

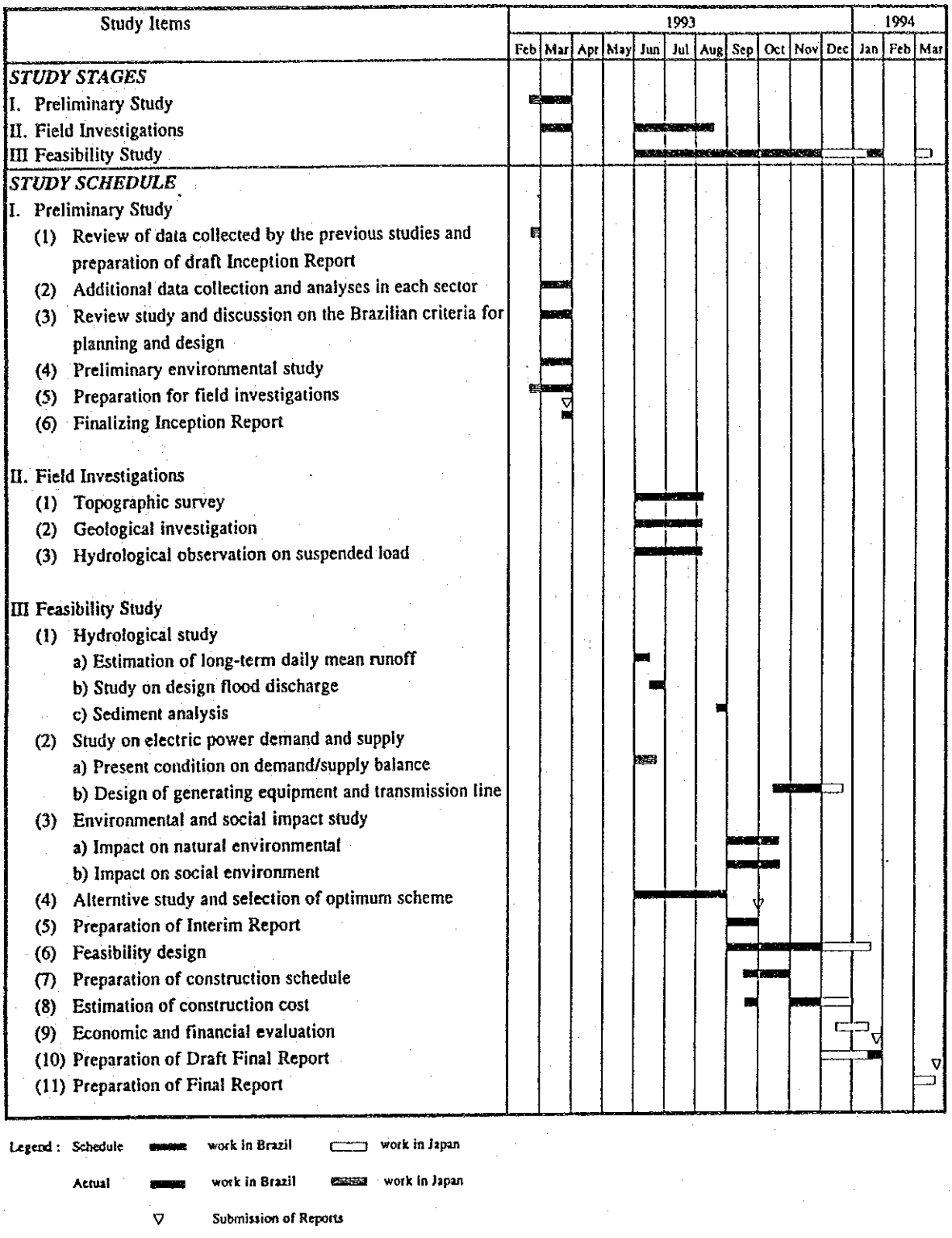

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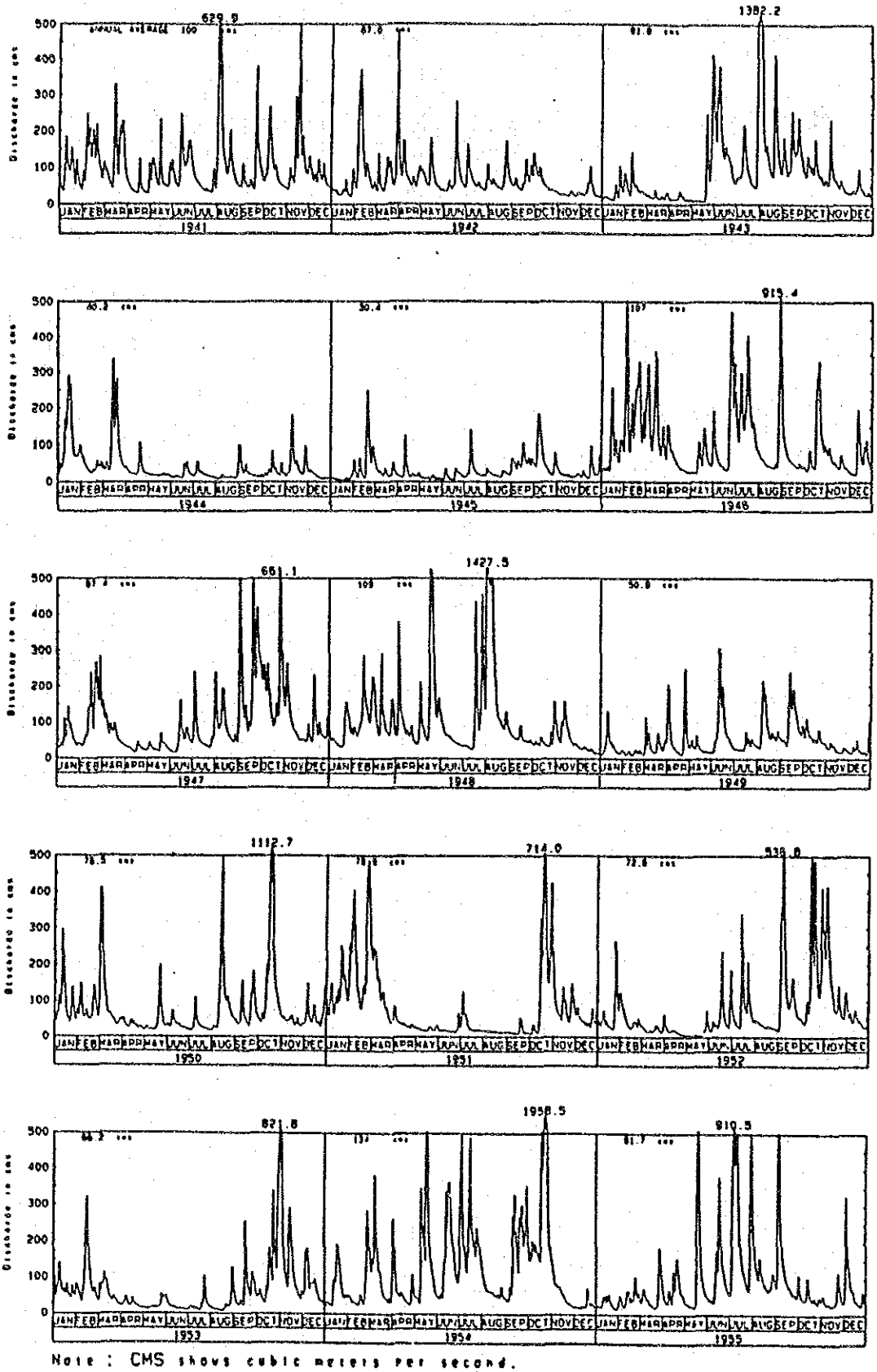
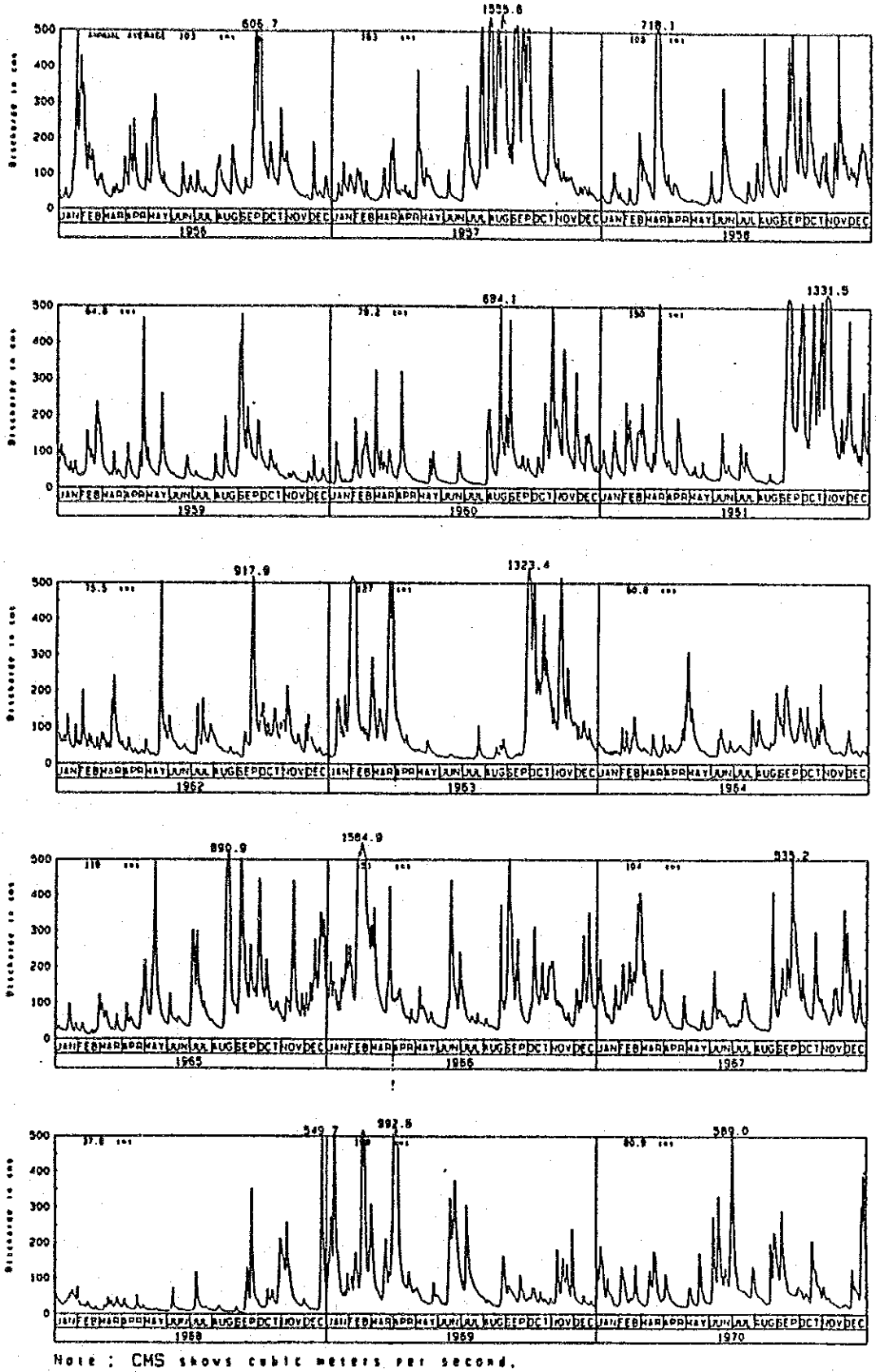
Fig. 1.3
Work Schedule



Note : CMS shows cubic meters per second.

JAPAN INTERNATIONAL COOPERATION AGENCY CENTRAIS ELÉTRICAS DE SANTA CATARINA S.A.,BRAZIL SALTO PILÃO HYDROELECTRIC POWER DEVELOPMENT PROJECT	**Fig. 5.1** **Estimated Daily Mean Discharges at Proposed Dam Site (1/4)**



Note : CMS shows cubic meters per second.

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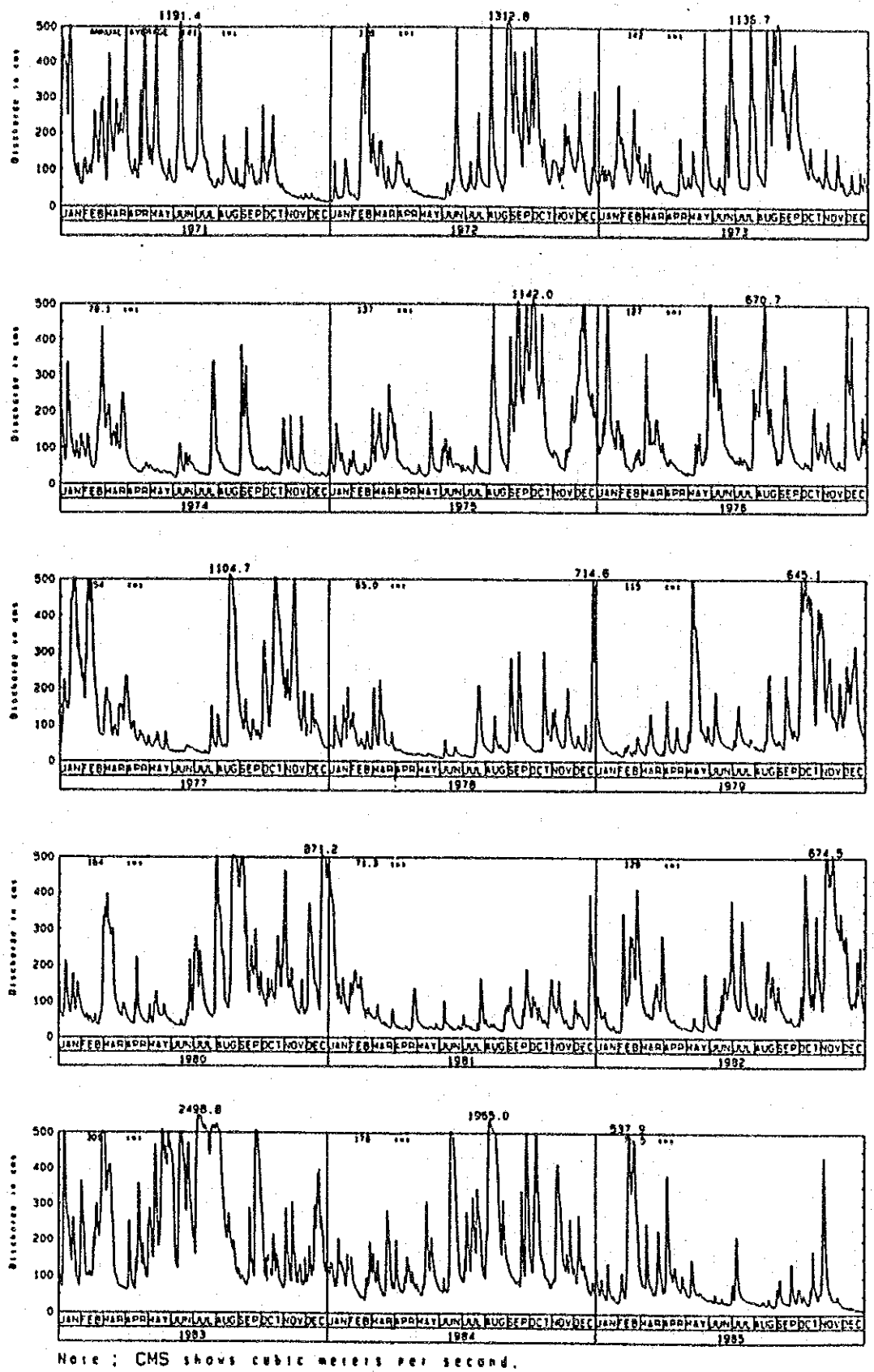
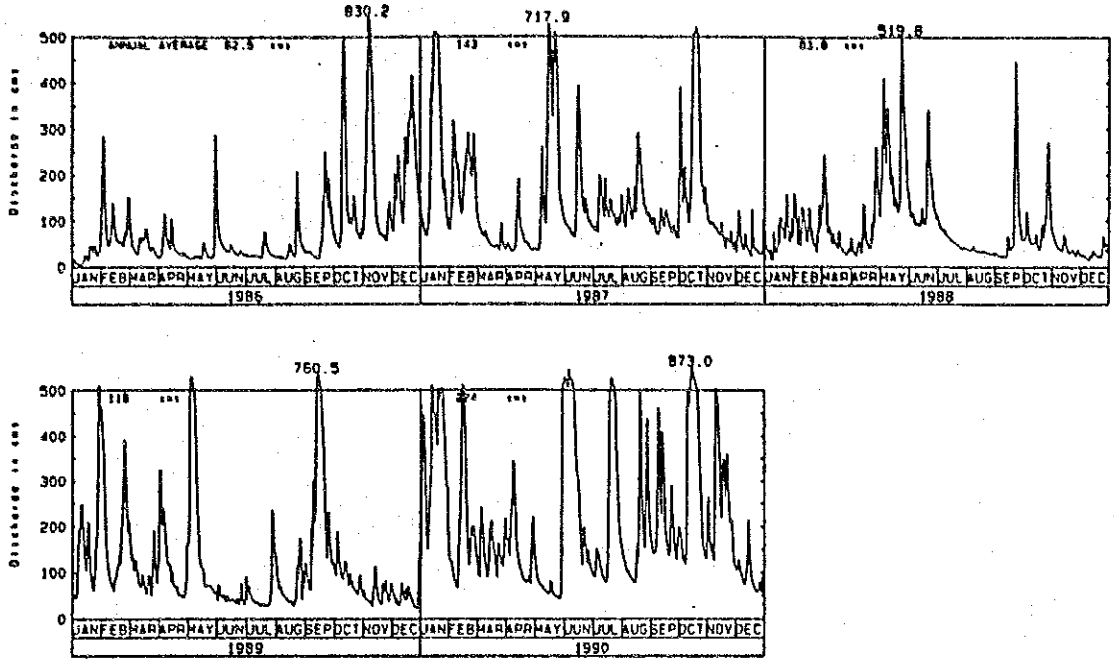
Fig. 5.1
Estimated Daily Mean Discharges at Proposed Dam Site (2/4)



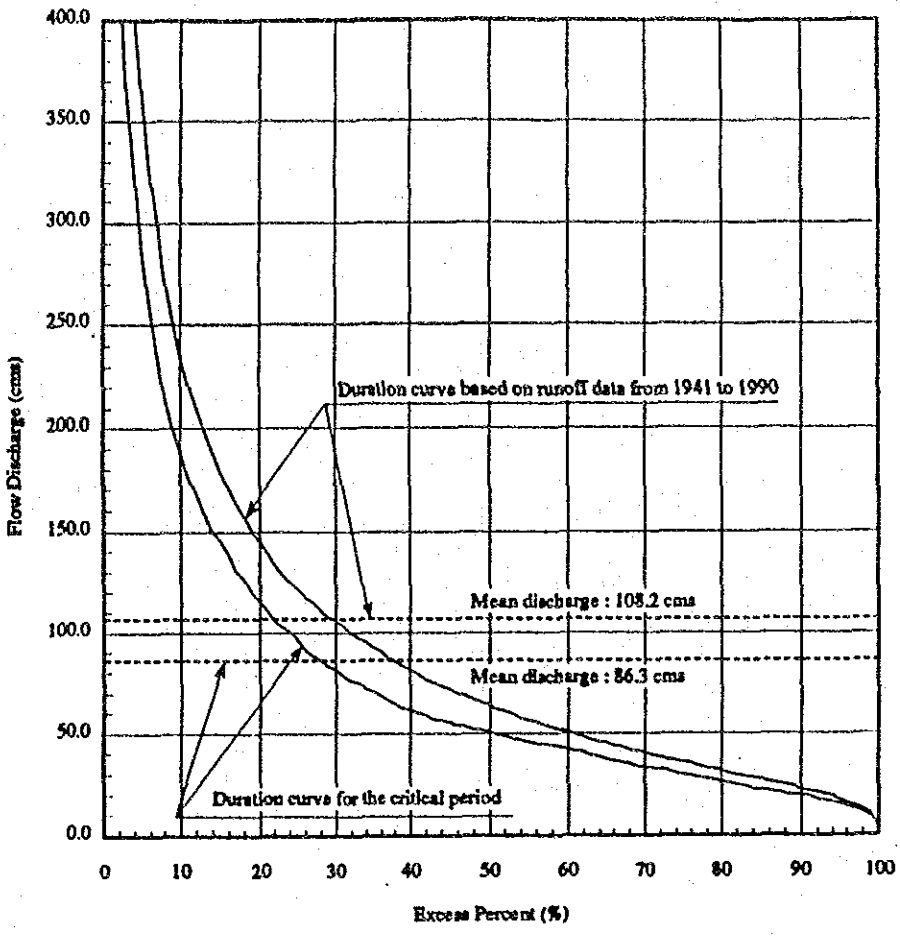
Note ; CMS shows cubic meters per second.

JAPAN INTERNATIONAL COOPERATION AGENCY CENTRAIS ELÉTRICAS DE SANTA CATARINA S.A.,BRAZIL SALTO PILÃO HYDROELECTRIC POWER DEVELOPMENT PROJECT	**Fig. 5.1** **Estimated Daily Mean Discharges at Proposed Dam Site (3/4)**



Note : CMS shows cubic meters per second.

JAPAN INTERNATIONAL COOPERATION AGENCY CENTRAIS ELÉTRICAS DE SANTA CATARINA S.A.,BRAZIL SALTO PILÃO HYDROELECTRIC POWER DEVELOPMENT PROJECT	**Fig. 5.1** **Estimated Daily Mean Discharge at Proposed Dam Site (4/4)**



(1) Duration curve based on runoff data from 1941 to 1990

Excess Percent (%)	Flow Discharge (cms)	Excess Percent (%)	Flow Discharge (cms)	Excess Percent (%)	Flow Discharge (cms)	Excess Percent (%)	Flow Discharge (cms)
1	674.5	26	117.5	51	61.8	76	34.7
2	528.9	27	114.6	52	60.7	77	33.7
3	453.4	28	110.9	53	59.3	78	32.9
4	405.4	29	108.1	54	57.6	79	32.0
5	357.1	30	105.6	55	56.0	80	31.2
6	322.4	31	103.2	56	55.1	81	30.3
7	296.3	32	99.8	57	54.1	82	29.4
8	274.1	33	97.2	58	52.8	83	28.6
9	252.4	34	94.8	59	51.3	84	27.8
10	235.0	35	92.1	60	50.4	85	27.0
11	221.3	36	90.0	61	49.4	86	26.2
12	209.5	37	87.2	62	48.0	87	25.4
13	199.1	38	85.3	63	46.7	88	24.6
14	189.2	39	83.4	64	45.7	89	23.7
15	179.0	40	81.1	65	44.8	90	22.2
16	171.1	41	79.3	66	43.8	91	21.4
17	163.5	42	76.7	67	42.8	92	20.6
18	156.7	43	74.9	68	41.9	93	19.8
19	150.5	44	73.1	69	41.0	94	18.1
20	144.6	45	71.7	70	40.0	95	17.4
21	138.8	46	70.0	71	39.1	96	15.8
22	133.7	47	68.3	72	38.1	97	14.2
23	128.9	48	66.4	73	37.3	98	12.3
24	125.2	49	64.8	74	36.4	99	10.3
25	121.4	50	63.5	75	35.5	100	4.1

(2) Duration curve for the critical period from Apr. 1949 to Nov. 1956

Excess Percent (%)	Flow Discharge (cms)	Excess Percent (%)	Flow Discharge (cms)	Excess Percent (%)	Flow Discharge (cms)	Excess Percent (%)	Flow Discharge (cms)
1	558.2	26	91.9	51	49.4	76	28.6
2	429.5	27	88.2	52	48.5	77	27.8
3	361.3	28	86.2	53	47.5	78	27.0
4	322.4	29	83.4	54	46.6	79	26.5
5	283.7	30	81.5	55	45.7	80	26.2
6	256.5	31	78.7	56	44.7	81	25.4
7	231.8	32	75.8	57	44.7	82	24.6
8	216.6	33	74.9	58	43.8	83	23.8
9	200.2	34	72.0	59	42.8	84	22.5
10	189.2	35	70.1	60	41.9	85	22.2
11	176.6	36	68.5	61	41.0	86	21.4
12	167.6	37	66.4	62	40.0	87	20.6
13	157.8	38	64.5	63	39.1	88	19.8
14	150.0	39	62.5	64	38.1	89	19.0
15	145.2	40	61.7	65	37.3	90	19.0
16	138.4	41	60.1	66	36.4	91	18.1
17	130.9	42	58.8	67	35.5	92	17.4
18	126.2	43	56.9	68	34.7	93	16.7
19	119.4	44	56.0	69	33.7	94	15.8
20	115.7	45	55.1	70	32.9	95	14.9
21	109.9	46	54.1	71	32.5	96	13.3
22	106.2	47	53.2	72	32.0	97	12.6
23	103.3	48	52.2	73	31.2	98	11.0
24	100.4	49	51.3	74	30.3	99	8.8
25	96.7	50	50.4	75	29.4	100	4.1

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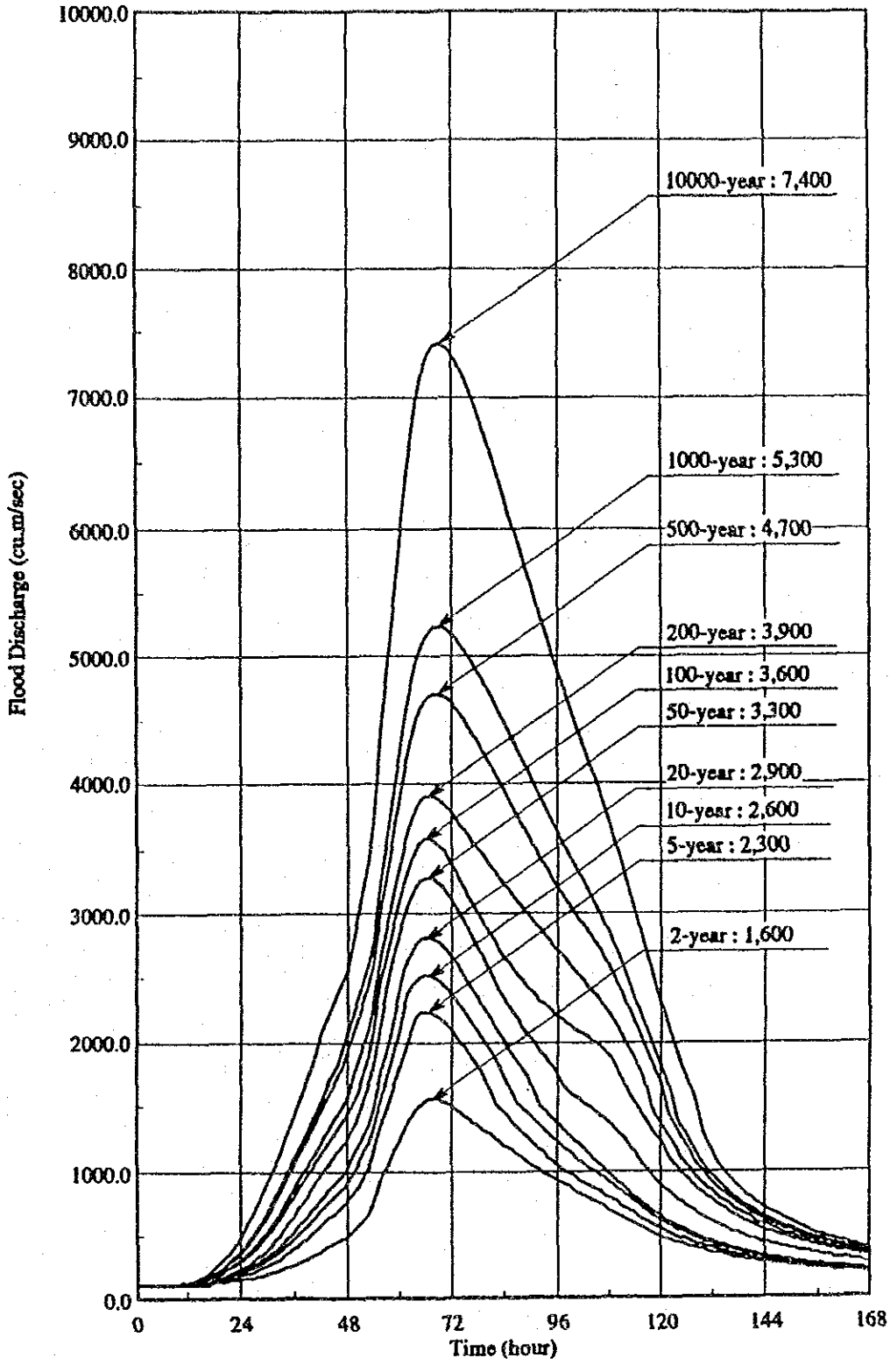
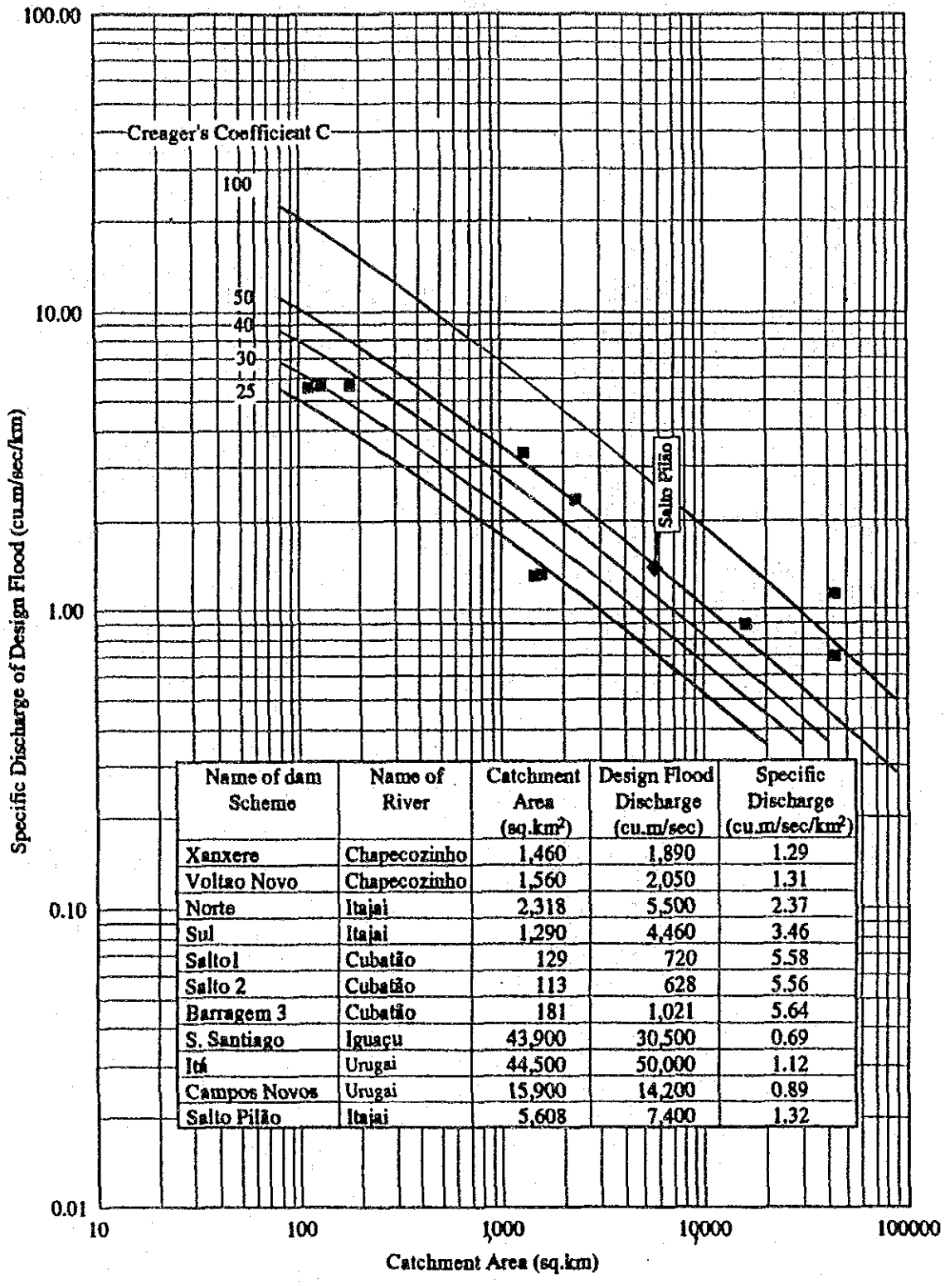
Fig. 5.2
Flow Duration Curve at Proposed Dam Site



Note :
Figures in the above indicate the flood peak discharges in the hydrographs.

JAPAN INTERNATIONAL COOPERATION AGENCY CENTRAIS ELÉTRICAS DE SANTA CATARINA S.A.,BRAZIL SALTO PILÃO HYDROELECTRIC POWER DEVELOPMENT PROJECT	Fig. 5.3 **Probable Flood Discharge Hydrographs at Proposed Dam Site**



Name of dam Scheme	Name of River	Catchment Area (sq.km²)	Design Flood Discharge (cu.m/sec)	Specific Discharge (cu.m/sec/km²)
Xanxere	Chapecozinho	1,460	1,890	1.29
Voltao Novo	Chapecozinho	1,560	2,050	1.31
Norte	Itajai	2,318	5,500	2.37
Sul	Itajai	1,290	4,460	3.46
Salto1	Cubatão	129	720	5.58
Salto 2	Cubatão	113	628	5.56
Barragem 3	Cubatão	181	1,021	5.64
S. Santiago	Iguaçu	43,900	30,500	0.69
Itá	Urugai	44,500	50,000	1.12
Campos Novos	Urugai	15,900	14,200	0.89
Salto Pilão	Itajai	5,608	7,400	1.32

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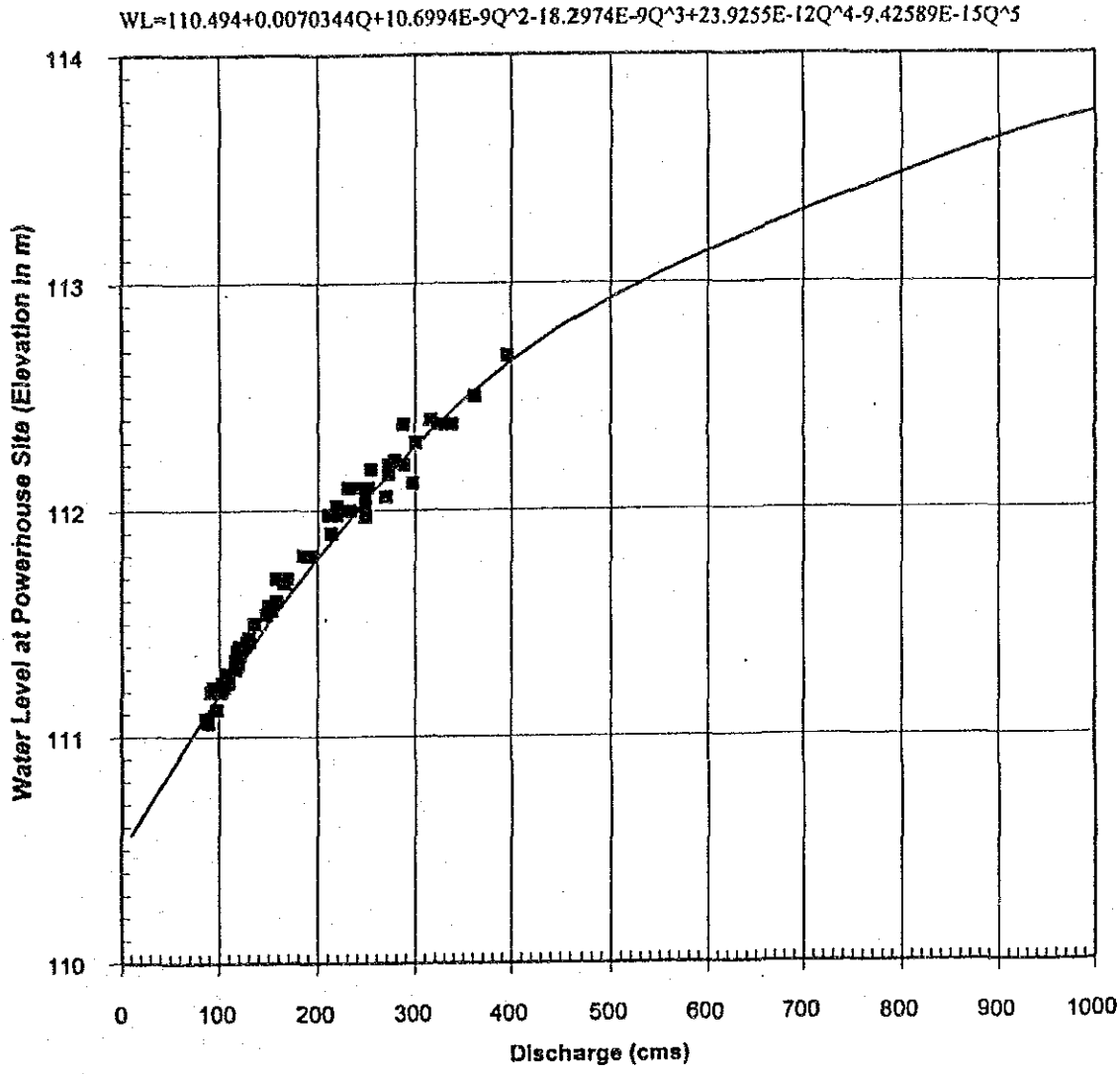
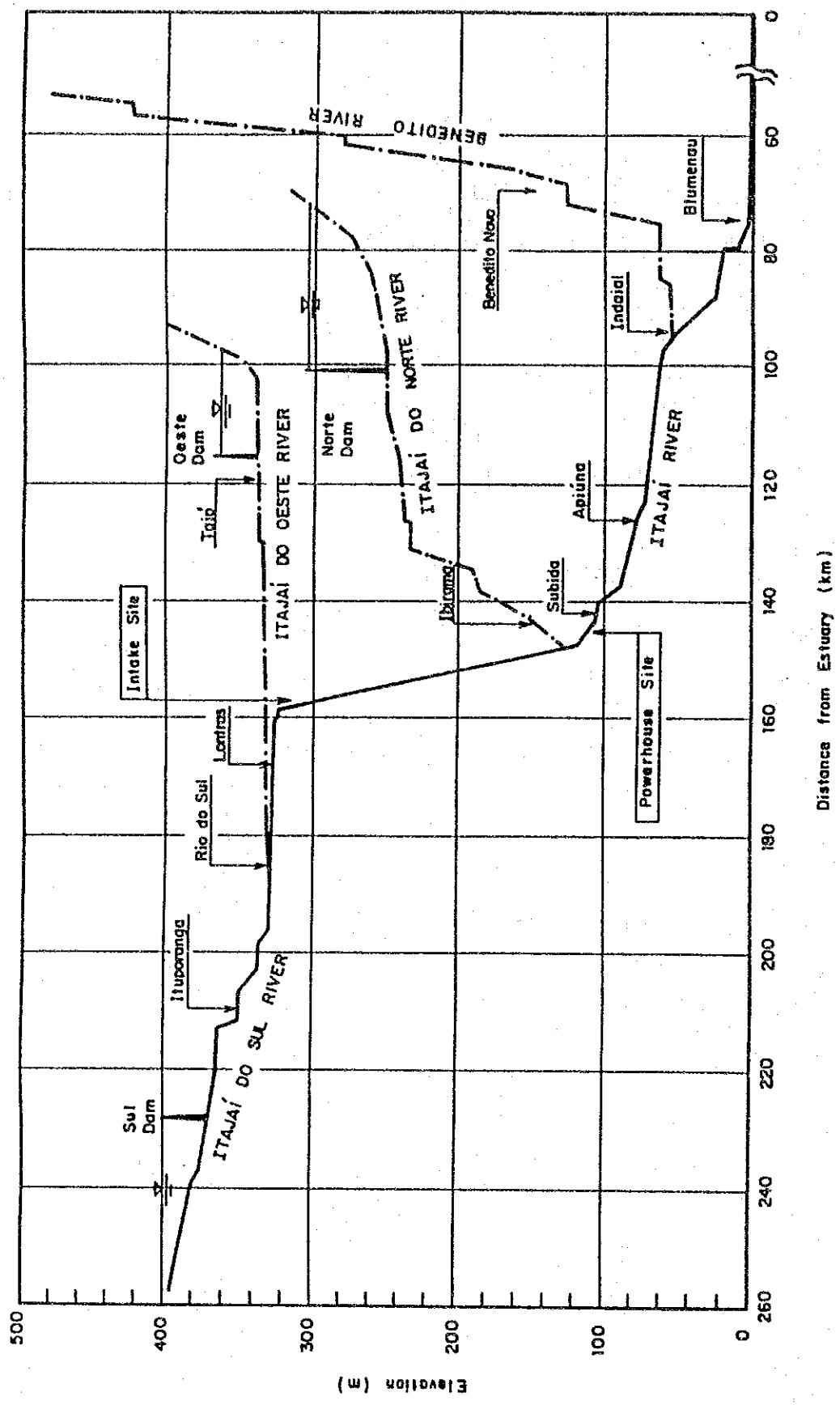
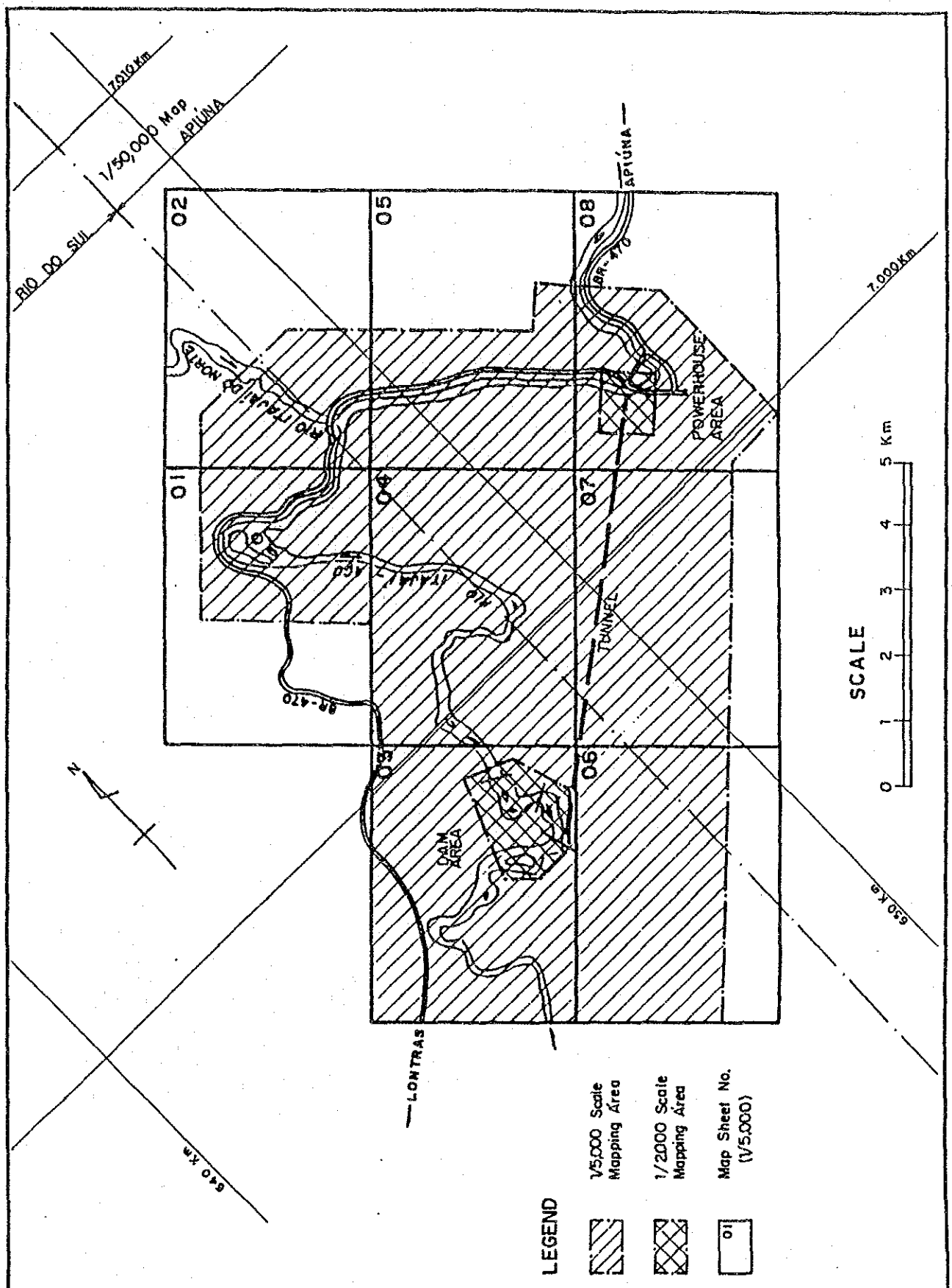
Fig. 5.4
Comparison of Design Flood Discharges in and around Itajaí River Basin



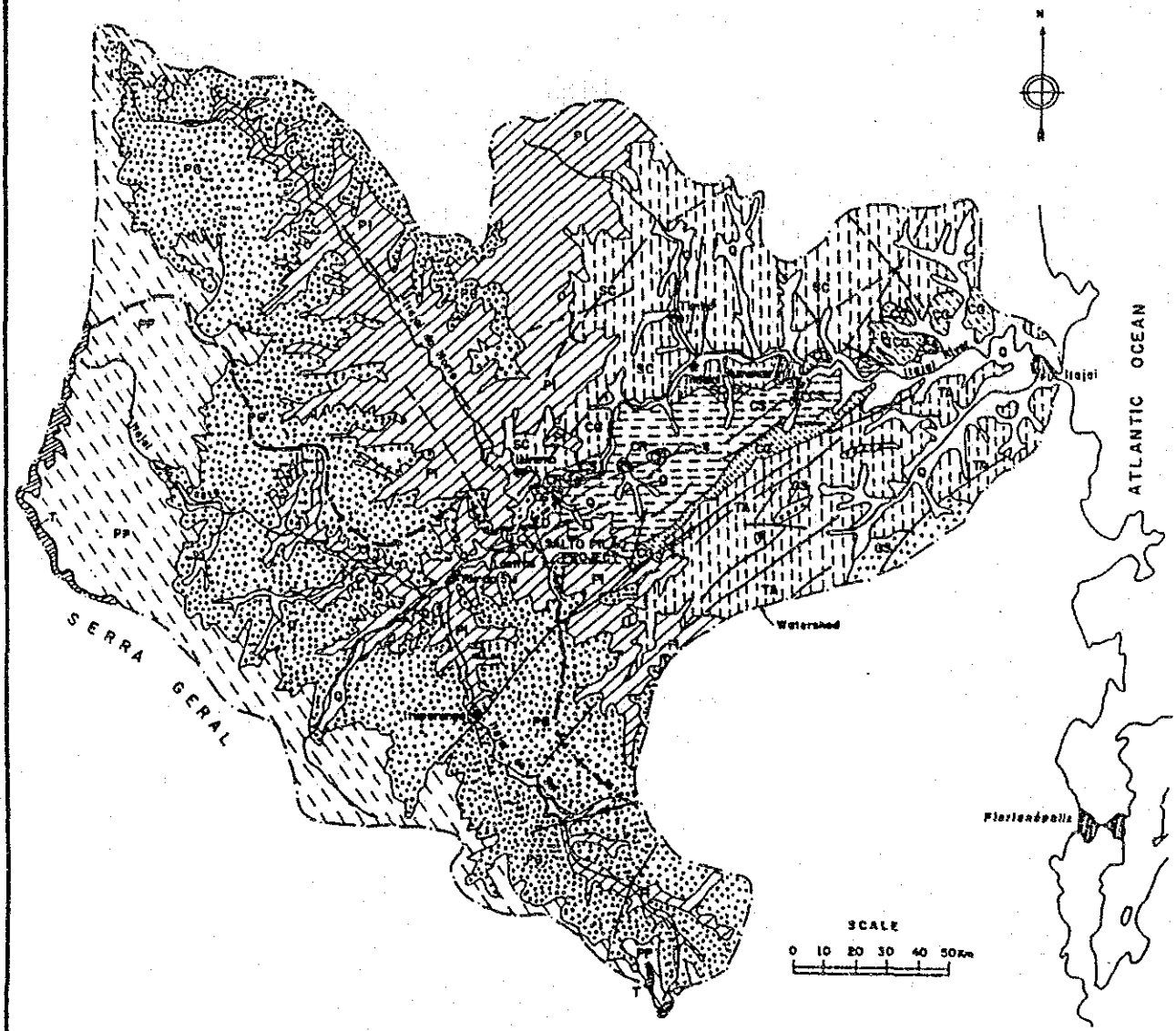
JAPAN INTERNATIONAL COOPERATION AGENCY CENTRAIS ELÉTRICAS DE SANTA CATARINA S.A.,BRAZIL SALTO PILÃO HYDROELECTRIC POWER DEVELOPMENT PROJECT	**Fig. 5.5** **Tailwater Rating Curve at Powerhouse**



JAPAN INTERNATIONAL COOPERATION AGENCY CENTRAIS ELÉTRICAS DE SANTA CATARINA S.A.,BRAZIL SALTO PILÃO HYDROELECTRIC POWER DEVELOPMENT PROJECT	**Fig. 6.1** **Longitudinal Profile of Itajaí River**



JAPAN INTERNATIONAL COOPERATION AGENCY CENTRAIS ELÉTRICAS DE SANTA CATARINA S.A.,BRAZIL SALTO PILÃO HYDROELECTRIC POWER DEVELOPMENT PROJECT	**Fig. 6.2** **Map Coverage of Project Site**



GEOLOGICAL STRATIGRAPHY

Mark	Geological Age	Name of Layer		Lithology
Q	Quaternary / Tertiary	Alluvial and Colluvial Sediment		Clay, sand and gravel
T	MESOZOIC: Triassic	Sao Bento Group	Botucatu Formation	Sandstone
PP	PALEOZOIC: Permian	Passa Dois Group	Rio do Rasto, Terezina, Serra Alta and Irati Formations	Sandstone, mudstone and shale
PG		Guata Group	Palermo and Rio Bonito Formations	Sandstone, mudstone and slate
PI	PALEOZOIC: Carboniferous	Itarare Group	Rio do Sul and Matta Formation	Sandstone, mudstone and shale

Mark	Geological Age	Name of Layer		Lithology
GS	EO-PALEOZOIC: Cambrian	Subida Intrusion Series	Subida and Guabiruba Series	Intrusive granite
CR	PRE-CAMBRIAN	Itajaí Group	Campo Alegre Formation	Intrusive rhyolite associated with diabase
CS				Siltstone with intercalation of sandstone
CG			Gaspar Formation	Sandstone
BR		Brusque Metamorphic Complex		Rhyolite, schist associated with gneiss
TA SC		Taboleiro and Santa Catarina Complexes		Gneiss, granite and diolite

: Tectonic lineament

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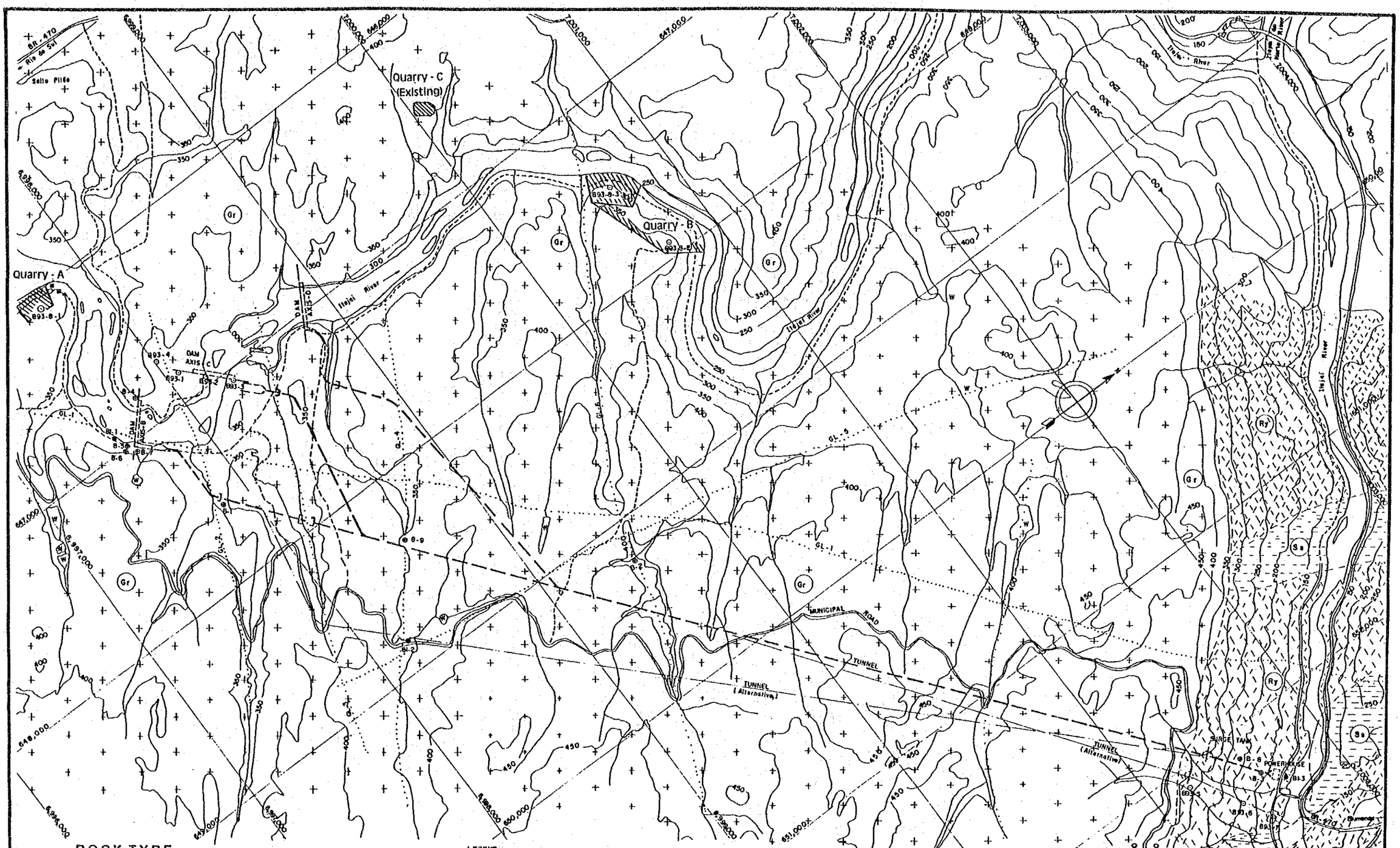
Fig. 6.3

Geological Map of Itajaí River Basin



Mark	Geologic Formation		Rock Type
Gr	Subida Series		Granite
Ry	Itajaí	Campo Alegre Formation	Rhyolite and diabase interbed
Ss	Group	Garcia Formation	Sandstone, slate and partly hornfels

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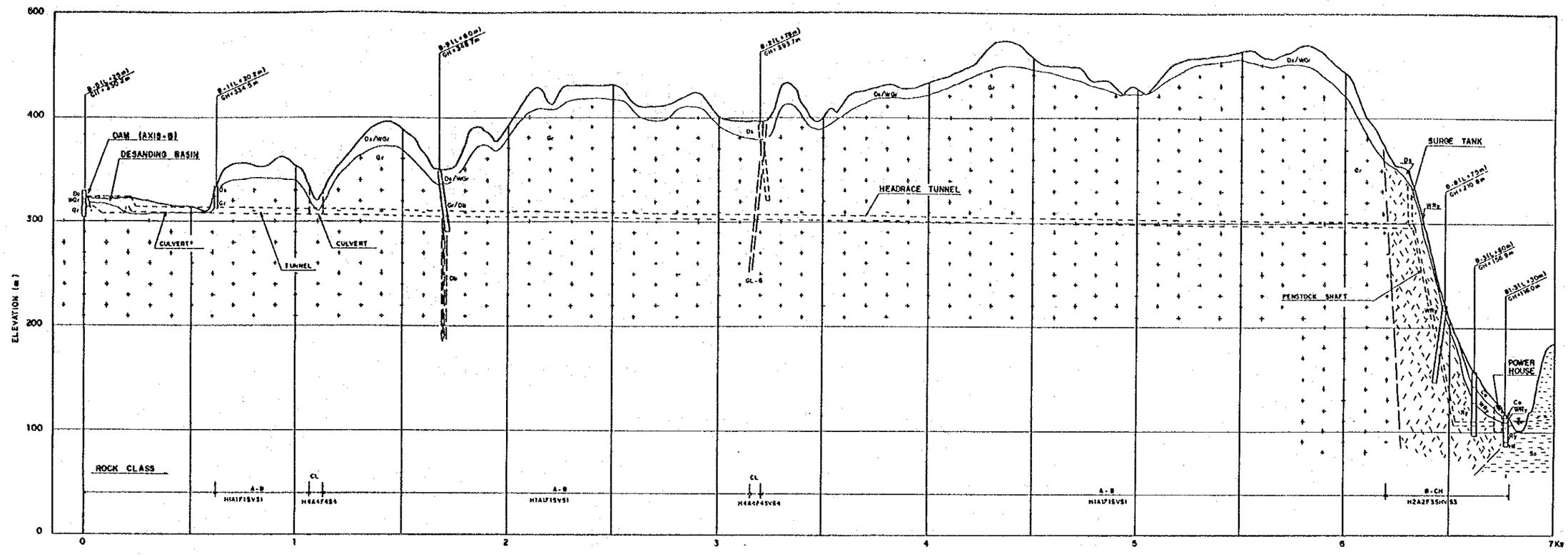
Fig. 6.4
Geological Map of Project Area



LONGITUDINAL SECTION ON TUNNEL ROUTE FROM DAM (AXIS-B) TO POWERHOUSE

LEGEND

- Al: Alluvium, Clayey Soil
- Co: Colluvium, Clayey Soil with Boulders
- Ds: Clay, Soft Decomposed Rock
- Gr: Granite
- Ry: Rhyolite with Diabase Interbed
- Db: Diabase Intrusion
- Ss: Sandstone, Slate, Partly Hornfels

DRILL HOLE

Hole No. (Hole Length) El. of Top of Hole

No.B-□ by Canambra, 1960
No.B1-□ by JICA, 1991
No.B93-□ by JICA, 1993

ROCK PROPERTIES

Mark	Geologic Formation		Rock Type	Rock Classification (1)	Rock Classification (2)	Engineering Properties
Gr	Subida Series		Granite	A - B	H1A1F1SVS1	Very hard. Massive. Joints closed tightly and spaced only with 3 to 5 m.
WGr			Weathered Granite	CL	H3A4F4SVS5	Stained into brown. Fragile and soft.
Ry	Itajaí Group	Campo Alegre . Formation	Rhyolite	B - CH	H1A1F2SVS3	Complex of rhyolite, rhyodacite, interbedded with diabase. Very hard but cracky. Joints develop in some places.
WRy			Weathered Rhyolite	CM - CL	H3A3F4SVS4	Colour altered. Stained. Moderately hard. Many open cracks with clay film.
Db			Diabase	CH	H2A2F3SVS3	Intrusive rock. Hard but cracky.
Hf		Garcia Formation	Hornfels	CH	H2A2F3SVS3	Hard. Thermo-metamorphic. Joints develop with spacing of 10 cm.

Note: Rock Classification (1): Japanese classification
Rock Classification (2): Brazilian Index

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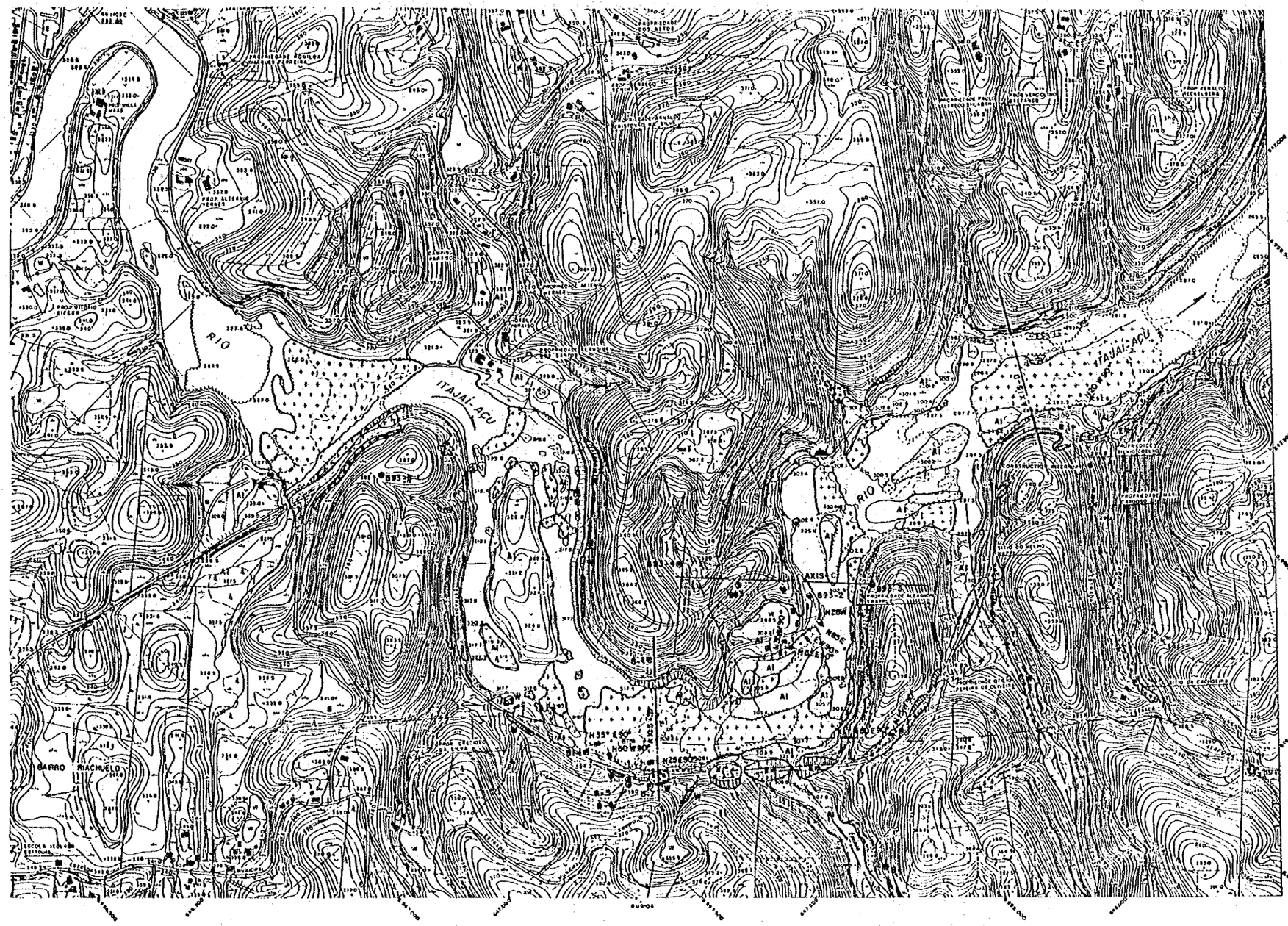
Fig. 6.5
Geological Section along Proposed Tunnel Route



LEGEND

- Al — Alluvium
- Em — Embankment
- Slid Material
- Outcrop, Fresh Granite
- W — Outcrop, Cliff, Weathered Granite
- Outcrop, Cliff, Soft Decomposed Granite
- Boulders, Granite
- Joint Dip
- Geotectonic Lineament
- Drill Hole

SCALE

0 500m

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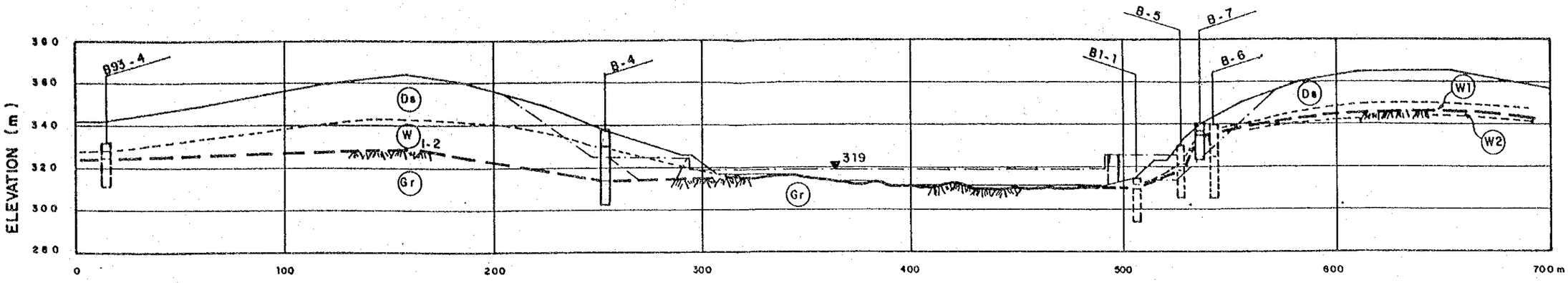
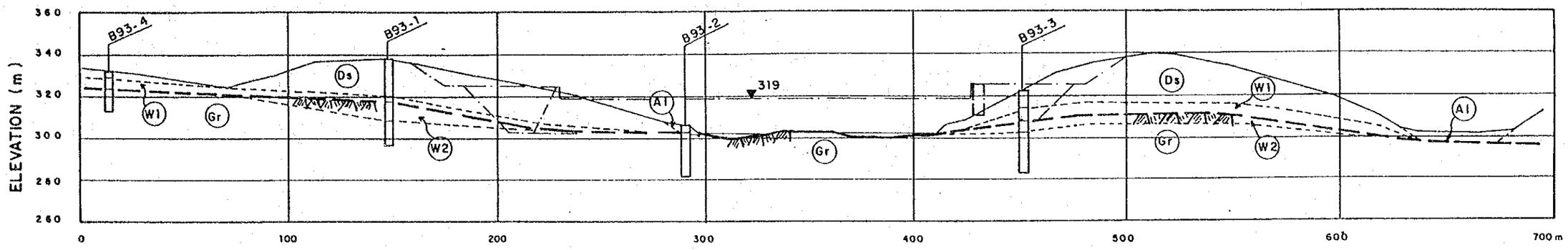
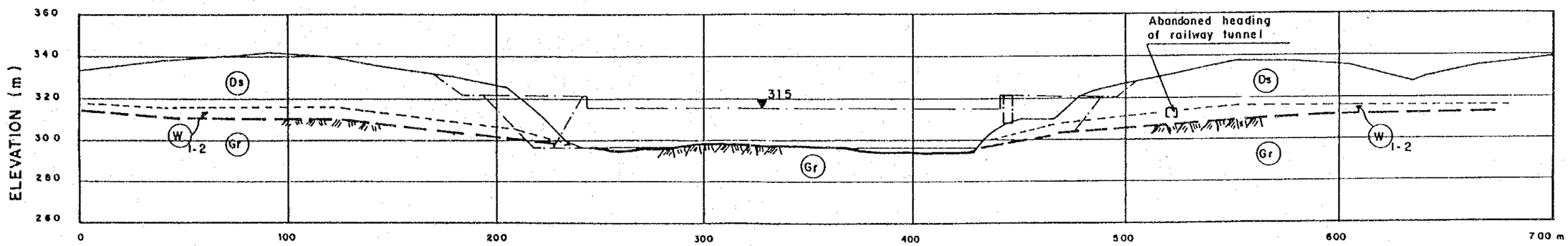
Fig. 6.6
Geological Map of Dam Area



AX IS - B



AXIS - C



AXIS - D

LEGEND

Mark	Rock Type	Rock Classification	
		(1)	(2)
Al	Alluvium	-	-
Ds	Clayey soil and soft decomposed granite	-	-
W1	Highly weathered granite	D	H5A5F5S5
W2	Slightly or moderately weathered granite	CM to CL	H3A3F3S3
Gr	Hard, massive granite	A to B	H1A1F1SV81

Note : W 1-2 means complex of W1 and W2 , boundery not clear.

Drill hole

Drill hole (off section)

Hard rock surface

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Fig. 6.7
Geological Section along Dam Area B,C, and D

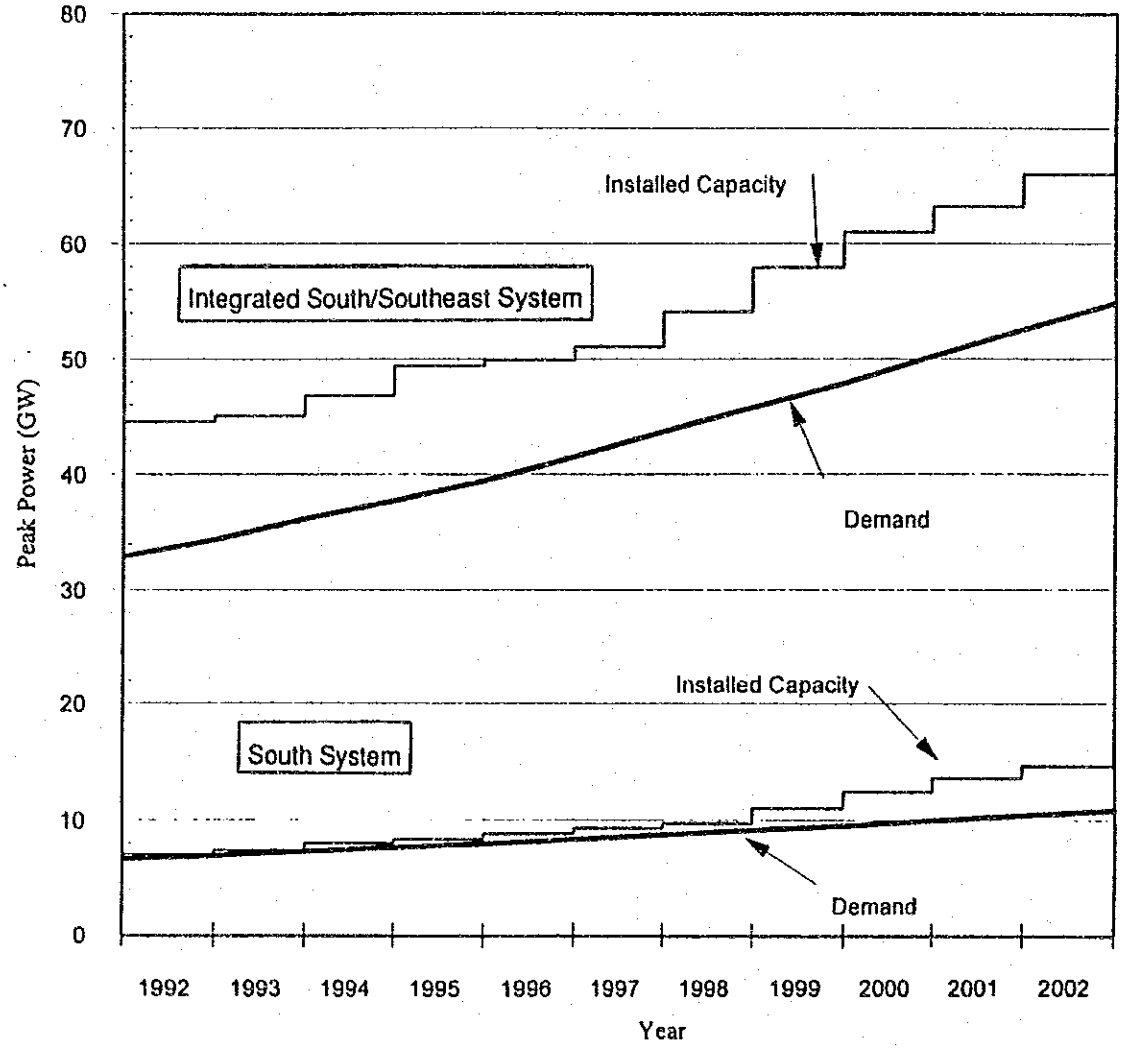

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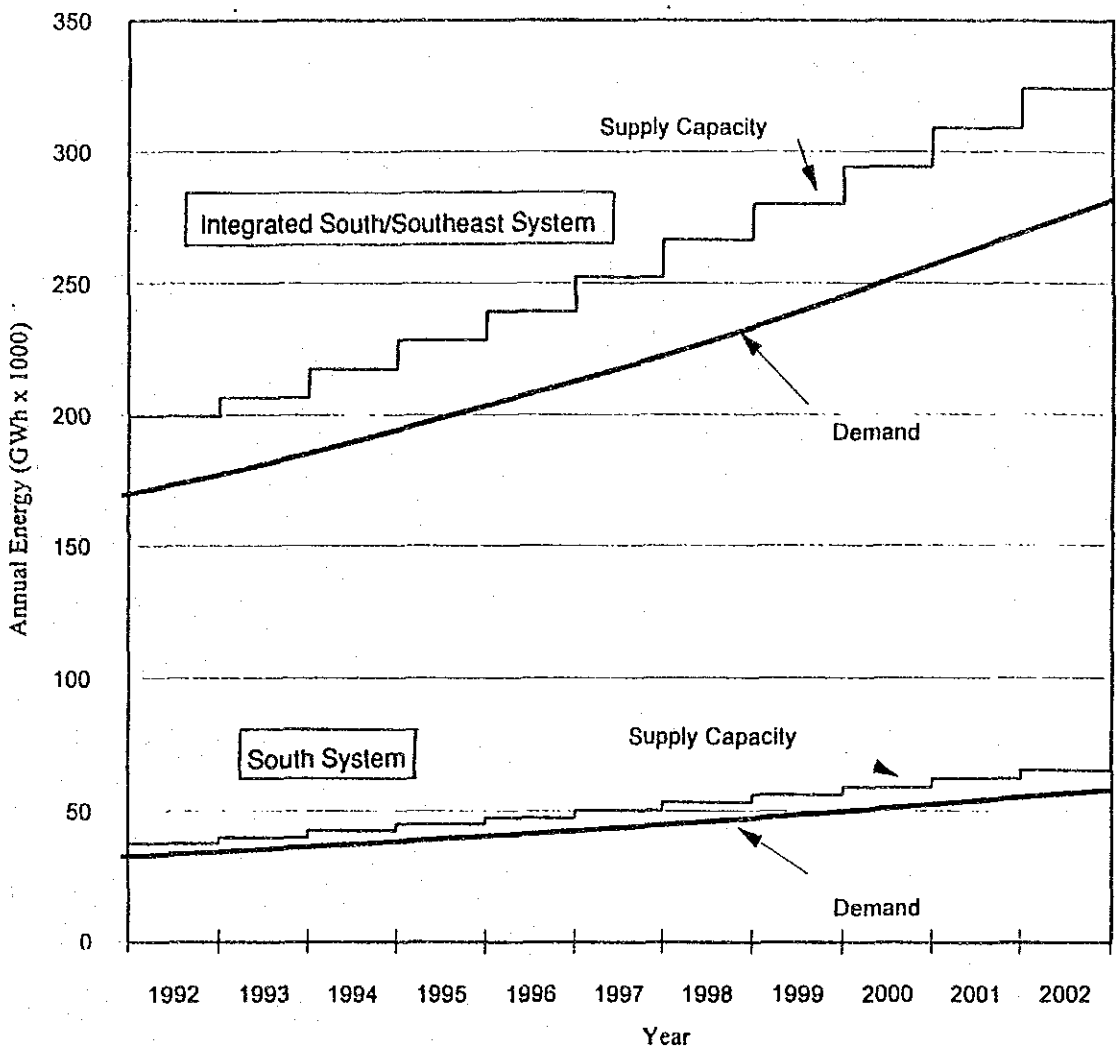
Fig. 7.1
Peak Power Demand and Supply Projection for South/Southeast System



JAPAN INTERNATIONAL COOPERATION AGENCY CENTRAIS ELÉTRICAS DE SANTA CATARINA S.A.,BRAZIL SALTO PILÃO HYDROELECTRIC POWER DEVELOPMENT PROJECT	**Fig. 7.2** **Energy Demand and Supply Projection for South/Southeast System**

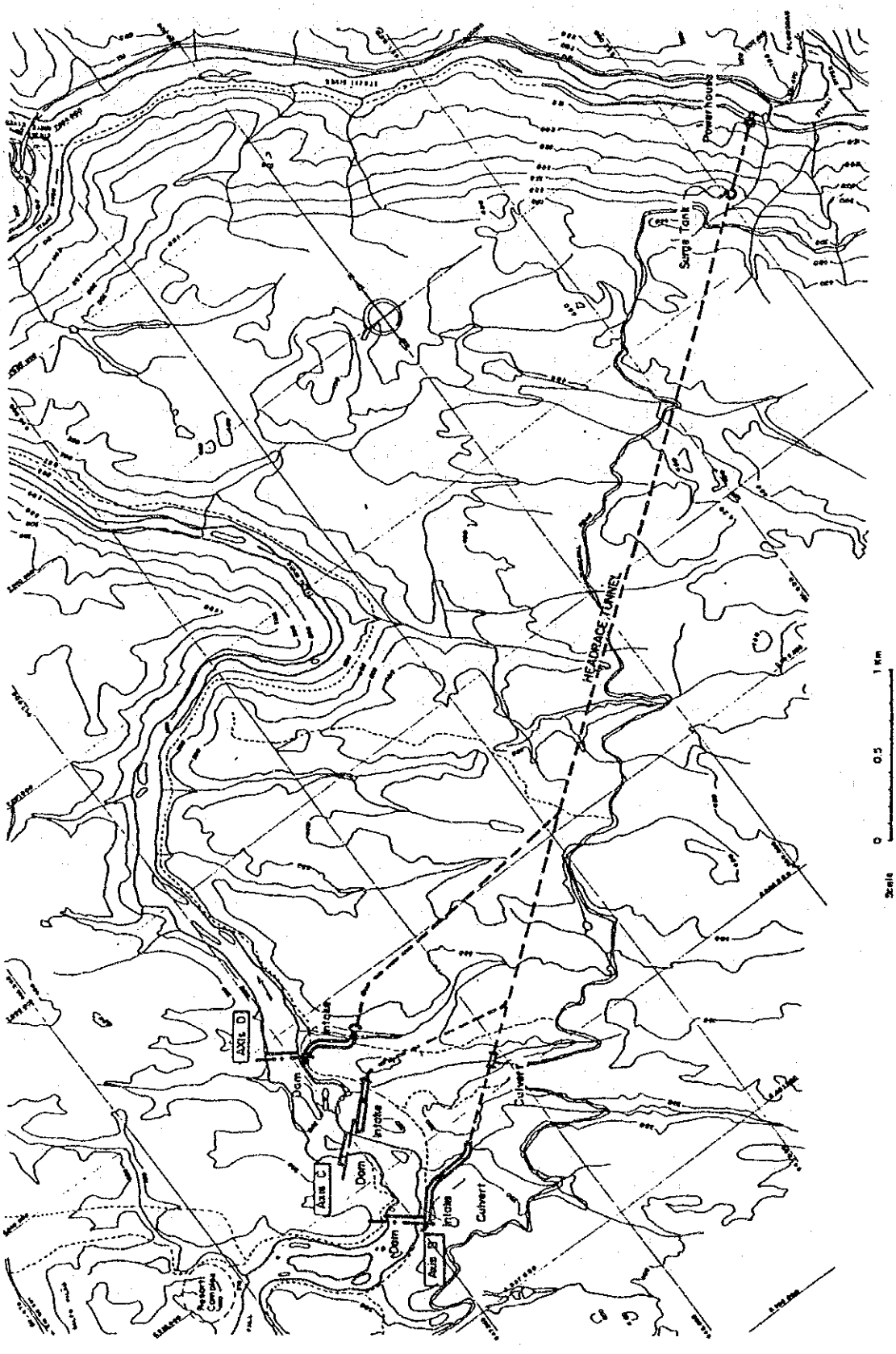


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Fig. 8.1
Overall Alignment of Alternatives