7.4.2 Findings of Alternatives

Cost estimation was made for the river channel improvement works, drainage facilities and/or detention facilities to be provided for the respective river basins to identify the combination with the least cost. Land acquisition and house evacuation have also been studied to recognize the social problems possible to take place due to project implementation in the respective river basins. The findings of these studies are summarized in Tables 7-1 and 7-2.

7.5 Optimum Plan

7.5.1 Principles of Planning

The principles of planning the Master Plan are basically the same as those of the Basic Plan, except for the design discharge.

The project scale was determined at the 3-year return period as mentioned in Section 7.3, and the design discharge in each river basin is presented in Table 7-3.

7.5.2 Proposed Storm Water Control System

Selection of the Proposed System

(1) Improvement Objectives

In selecting the Optimum Plan, financial constraints may first have to be taken into account. Further investigation is also necessary for its social, technical and economical aspects. In view of the following considerations, it is concluded that Case II is the optimum one for the improvement objectives.

- Financial Consideration

The financial considerations for project implementation are quite strict. The maximum realizable financial allocation for this purpose, even upon the assumption of the assistance from other government authorities concerned, including increased taxation for purposes of storm water control, will not go beyond the amount between 5,000 million Guaranies and 6,000 million Guaranies a year.

On the other hand, the required construction costs per annum for the execution of this project range from approximately 2,000 million Guaranies to 20,000 million Guaranies, as shown in Table 7-4. Assuming that all the project cost is assured by a loan at an interest rate of 3.5% per annum and repayment period of 30 years including 10-year grace period, the total expenditure will still reach a considerable amount depending on the study case, as shown also in Table 7-4.

In this context, Case I may present some problems in project execution.

- Social Consideration

It is desirable that infrastructure projects such as improvement works of storm water control facilities are executed over areas as wide as practically possible. Therefore, Case I or Case II are deemed practical to meet the above condition.

- Technical Consideration

In Case I and Case II, there is no problem as far as technical aspects are concerned. With regard to Case III, improvement work is locally executed and there is a strong possibility that an adverse influence will appear in the downstream basin. In this context, Case III, though advantageous in terms of cost, should be proposed as the second alternative.

- Economic Consideration

The present study includes 26 basins for which the reliability of available data is not quite even; thus, precluding the possibility of economic evaluation of the effect of project implementation at an even pace.

The evaluation of the project from the economic point of view is, therefore, conducted on two selected basins having sufficient data but with contrasting features, i.e., Mburicao and Ferreira river basins. Internal rates of return (IRRs) of the combination of storm water control facilities in both basins, which can be representative for the purpose of merely comparing the combinations, are summarized hereunder:

Study Case	Internal Rate of Return (%)	
	Mburicao	Ferreira
Case I	1.2	3.7
Case II	9.1	11.4
Case III	11.0	-

Note: Since no important trunk road exists in Ferreira River Basin, IRR of Case III was not calculated.

Case III has the highest internal rate of return (IRR), followed by Case II. There is not much difference in the IRRs of Case III and Case II, and they are both viable from the viewpoint of economics. In the case of Case I, IRR is very low because of the substantially high construction cost; hence, uneconomical.

(2) Optimum Combination of Proposed Facilities

All sub-projects in each basin cannot be implemented at the same time, but it is difficult to decide at this moment the detailed timing of project implementation in each basin. Therefore, it may be reasonable to divide the whole scheme into two groups, and priorities are placed on some of the basins suffering from serious flood damage, as described below.

- River Basins with High Priority

  In the river basins on which priorities of implementation are placed, projects are supposed to be put into implementation in the early stage. These are the three (3) basins of Itay (upper stream area of Aviadores del Chaco Avenue), Mburicao and Lambare.

- Remaining River Basins

  There are twenty-three (23) basins, except the above three, and the projects will be implemented in the second half.

With regard to the optimum combination for Itay, Mburicao and Lambare which are given high priority considerations, the storm discharge of the basin condition in the early stage will be confined in the river channels to be improved, and incremental runoff discharge due to further urbanization in the second half will be dealt with through the provision of detention facilities in view of completing the work urgently within a reasonable range of investment.

As to execution and administration aspects for the detention facilities, no statutory measure to encourage residents' participation in the project has been worked out. Therefore, it is not preferable to expect participation of the residents in the storm water control operation and maintenance for the time being (Case II-2).

In connection with the remaining river basins, the projects will be formulated by means of least cost method, based on the proper combination of river channel improvement works, drainage facilities and detention facilities, as a result of which, the combination of river channel improvement works and drainage facilities (Case II-1) is justified as the optimum one. (Even if the design discharge is controlled by only river channel and drainage improvement works, no large number of forced house evacuation and no extensive land acquisition may be required, as shown in Table 7-2; hence, there will be no social problem to be solved.)

Features of the Proposed System

The Optimum Plan covers the improvement of areas that have suffered from repeated heavy flood damage and areas where heavy inundation damage is anticipated with the progress of development.

Storm water control works of Mburicao, Itay (upstream of Aviadores del Chaco Avenue), and Lambare are planned by river channels, drainage facilities, and detention facilities, and the design discharge is controlled by the combination of these facilities, while those of the remaining basins are planned by the improvement of river channels and drainage facilities, and the entire discharge is confined in the proposed river channels through the proposed drainage facilities.

The alloted shares of the design discharge to drainage systems and detention facilities of the above three basins are as shown in the following table.

Name of Basin	Design Discharge (m3/s)		
	Entire Basin	River Channel	Detention Facilities
Mburicao	190	175	15
Itay	430	380	50
Lambare	330	285	45

The overall aspects of the Plan are tabulated as follows:

River Structures

River Improvement	:	89.4 km in length
Revetment	:	205,000 m^3
Groundsill	:	185 places
Retarding Basin	:	1 place, and 350,000 m^3 of regulation capacity
Bridge	:	70 places

Drainage Facilities

Pipe	:	18.7km in length and 1.0m to 2.5m in diameter
Box Culvert	:	10.6 km in length and 2.0m width x 2.0m height to 3.5m width x 2.0m height
Open Channel	:	5.3km in length and 3.0m width x 2.0m heigh to 3.5m width x 2.0m height

Detention Facilities

Storage in Public Compounds	:	148ha
Infiltration Trench	:	561km

Layouts of the drainage system including river channel and drainage facilities are shown in Fig. 7-3 and in Tables 7-5, 7-6 and 7-7. With regard to the three river channels of Mburicao, Itay and Lambare, Figs. 7-4 and 7-5 show the proposed longitudinal profile and cross section, respectively, for reference.

7.5.3 Standard Drawings of Typical Structures

The required structures and facilities for this project are almost the same as those of the Basic Plan except the proposed infiltration trench. (Refer to Figs. 6-4 to 6-7 in the Basic Plan.)

The standard drawing of the typical infiltration trench is as illustrated in Fig. 7-6.

7.6 Implementation Schedule and Cost Estimate

7.6.1 Implementation Schedule

The project which consists of a number of sub-projects is implemented in two groups as mentioned in 7.5.2 - "Proposed Storm water Control System."

Since the target year of the subject Project is 2005 with a period of 20 years between 1986 and 2005, the consutruction period is

divided into two phases of 10-year each for the first and second phases.

(1) Sub-Projects for 1986-1995 Execution

Priorities are placed on the three basins of Itay (upper stream area of Aviadores del Chaco Avenue), Mburicao and Lambare in accordance with the consideration mentioned above. To balance the expenditures in the former and latter 10-year periods, only drainage system improvement works will be provided for these river channels in the former 10 years, and the detention facilities required will be installed in the latter 10 years.

Out of the above-mentioned three basins, flood damage over the Itay and the Mburicao river basins are severer than those in Lambare. It is, therefore, advisable to provide improvement works for these two basins prior to Lambare.

(2) Sub-Projects for 1996-2005 Execution

During this 10-year period, river improvement works and drainage facilities will be provided for the remaining basins. Detention facilities will be installed for the above-mentioned three river basins to cope with the incremental runoff discharge.

7.6.2 Cost Estimate

The construction cost in terms of base cost of the Master Plan is estimated at 59,890 million Guaranies, as shown in Table 7-8, in the same manner and terms of the Basic Plan cost estimation. And the total construction cost for the fund requirements is estimated at 107,720 million Guaranies including price contingencies.

7.7 Project Justification

Economic and financial studies have been conducted for the Master Plan which is assumed to be completed by the year 2005 to solve the major problems in the planning area caused by inundation in the

residential area and floodwaters flowing on the roads. The basic conditions for these studies are as follows:

(1) All the costs and benefits are calculated at the price level of August 1986; and

(2) The project life is fixed at 50 years, considering the life expectancy of the facilities to be installed for the project.

7.7.1 Economic Evaluation

In examining the economic viability of the project, two river basins having different features were selected to represent the whole basin for the reason that all the basins in the planning area do not have detailed maps and sufficient data for the benefit calculation.

Benefit

Project benefit is defined as the difference in damage by storm water between the with- and without-the-project situations. Hence, the damage with and without new storm water control system have to be estimated to quantify the project benefit in monetary terms. Damage caused by storm water are summarized as follows:

(1) Damage due to traffic interruption by storm water, including augmentation of travel cost of vehicles affected by detouring and speed-down as well as loss of productivity of people who may loss their time assigned for economic activities.

(2) Damage due to submergence by storm water, which is inflicted on the assets mainly consisting of private houses and their household effects.

(3) Indirect damage, including maintenance cost for pavements and vehicles, requirements for road clearing, deterioration of sanitary conditions, negative aesthetic effects of flooding, etc.

The average annual benefit (difference in damage between with and without the project) was calculated on the basis of the past rain-

fall records in 29 years. Those in the Mburicao and the Ferreira river basins are estimated at approximately 691 million Guaranies and 164 million Guaranies, respectively (3-year return period).

Project Evaluation

Based on the social requirements and political considerations for the planning area, the project has been formulated on the 3-year return period basis as discussed in Section 7.3.

The internal rate of return (IRR) was calculated by comparing the benefit and the economic cost in order to evaluate the project from the economic viewpoint.

As a matter of practice in international banking facilities, an IRR of 10 to 12% is acceptable as the cut-off point. However, infrastructure projects like flood control works are often accepted despite of low IRRs. The project showing IRRs of 9.1% and 11.4% for Mburicao and Ferreira river basins, respectively, can be assessed to have enough economic viability for implementation.

7.7.2 Financial Consideration for Project Implementation

The most reliable financial source for project implementation is considered to be the revenue from the storm drainage sector of CORPOSANA, because at present this revenue overcomes the cash outflow composed of amortization of the IDB loan and payment of its loan interest with a resultant positive balance, as presented in Table 7-9. The total surplus fund (positive balance) from 1987 to 2005 is estimated at 25,602 million Guaranies at the annual average of 1,347 million Guaranies.

On the other hand, the total cost amounts to 107,717 million Guaranies, and the annual average is 5,669 million Guaranies. If all the said surplus fund is allocated for the implementation of this project, the expenditure will be about 4.2 times as much as the financial capacity with a difference of 4,322 million Guaranies per annum on the average.

Assuming that all the foreign currency portion of the project cost is covered by a loan with an interest rate of 3.5% and a repayment

period of 30 years including a 10-year grace period, and that the local currency portion is loaned at the interest rate of 15% per annum with a repayment period of 10 years, the total expenditure would reach 192,699 million Guaranies, while the surplus fund during the loan amortization period will accumulate to 142,797 million Guaranies resulting in a negative balance of 49,902 million Guaranies in total. However, this difference can be recovered in various ways such as subsidy or financial assistance from the central government, loan from the private sector, and financial assistance on a grant basis from international lending agencies.

7.7.3 Socio-Economic Impacts

Project implementation could exert favorable influences on not only the planning area but also the whole nation. These favorable impacts are summarized as follows:

(1) The trunk roads leading to international and national highways and to the international airport will be released from traffic interruption due to inundation. Therefore, international and nationwide circulation of commodities will be secured resulting in the stabilization of the people's living conditions of the whole country.

(2) Speedy and safe drainage of storm water will enhance social welfare through the improvement of sanitary conditions in the areas where houses suffer from inundation.

(3) A number of engineers, technicians, laborers, etc., will be required for the project implementation, so that the increase of employment opportunities can be expected at least during the construction period.

CHAPTER 8. FORMULATION OF THE FIRST STAGE PROJECT

8.1 Concepts and Premises

The purpose of the study on the First Stage Project is to provide a means to realize immediate flood damage mitigation in the areas currently suffering from serious flood damage.

The First Stage Project which was extracted from the Master Plan was formulated based on concepts and premises as hereinafter described.

Project Scale

A 3-year return period flood, which was estimated by the runoff analysis under the land use patterns in 1995, is adopted as the design discharge.

Target Area

The Mburicao and the Itay river basins were selected as target areas for the First Stage Project in view of the following reasons (refer to Fig. 8-1.).

(1) Flood damage in the planning area has been recognized to be due mainly to traffic interruption and inundation of houses and household effects. The damage caused by traffic interruption is very serious in the Mburicao and the Itay river basins where traffic interruptions occur on roads such as Artigas, Espana, Mariscal Lopez, Ayala, Fernando de la Mora, etc., that connect the central area of Asuncion City to suburban cities, and on the linking circumferencial roads such as Madame Lynch. As to houses and household effects, flood damage takes place most seriously along Itay River. (Refer to Table 3-3.)

(2) Through realization of the First Stage Proejct, flood damage on houses and household effects will be greatly minimized and the smooth flow of traffic on most of the above-said roads will be assured. Correspondingly, the other roads connecting the suburban cities will be relieved from traffic interruption

by detouring traffic into these major roads. (Refer to Fig. 8-2.)

Extent of Improvement Works

Storm drainage system improvement works will be proposed for the trouble spots that suffer from frequent flooding at present and in the future. (Refer to Fig. 8-3.)

Applicable Facilities

The drainage system consisting of river channels and drainage facilities is applicable for this study.

8.2 Alternative Study

8.2.1 Study Cases

Condition for Selection of Possible Case

In the selection of cases for the alternative study, the following points were considered:

(1) River Facilities

River channel improvement works are in general advantageous in terms of cost to drain safely the storm water. However, as many alternative plans as possible should be considered at river stretches where it is possible to replace river channel improvement works by other methods such as short-cut, retarding basins, etc., from the viewpoints of existing conditions of the river channel, topography and conditions of land utilization along the subject rivers as described below.

- The flow capacity of the river section to be improved is extremely smaller than the design discharge;
- River channel improvement works involve difficulties in evacuating houses and acquiring site to widen a river channel;
- The topographic conditions allow the drainage channel or conduit to join the river channel in the downstream of the

improvement section; and

- It is possible from the topographic viewpoint to provide retarding basins and short-cut channels which may be less costly than the river improvement works.

(2) Drainage Facilities

The best route for drainage facilities can be determined by the topographic features in consideration of public utilities installed underground. There is thus no alternative plan for the drainage facilities except the case where their outlets are installed at the position lower than the existing one to decrease the design discharge in the river section where flow capacity is far from sufficient.

Possible Study Case

As tabulated in the following page, alternative study cases are proposed for four (4) river sections of Mburicao and two (2) of Itay in due consideration of the aforementioned conditions. (Refer to Figs. 8-4 and 8-5.)

Alternative methods include river channel improvement works, short-cut or diversion channel, retarding basin, and detouring of drainage route to decrease the design discharge for the river channel. The optimum plan may be determined in a form of combination of these alternative cases, i.e., by sharing the design discharge between the river channel and other works. As for the other river sections, the design discharge will be controlled by only river channel improvement works.

River Basin	Section	Study Case	Applicable Method	Remarks
Mburicao	Mburicao 7.78K to 8.07K	Case A-1	River improvement works.	Discharge capacity of river channel is lower. Existing: 6 m^3/s Proposed: 15 m^3/s
		Case A-2	Detouring of drainage route 1.	
	Mburicao 5.18K to 7.24K	Case B-1	River improvement works.	Discharge capacity of river channel is lower. Existing: 30-115m^3/s Proposed: 60-130m^3/s
		Case B-2	Detouring of drainage route 1.	
		Case B-3	Detouring of drainage route 2.	
		Case B-4	Detouring of drainage route 3.	
	San Martin 0.83K to 1.61K	Case C-1	River improvement works.	Discharge capacity of river channel is lower. Existing: 14 m^3/s Proposed: 35 m^3/s
		Case C-2	Detouring of drainage route.	
	Mburicao 1.96K to 2.53K	Case D-1	River improvement works.	A large number of meanders in river channel.
		Case D-2	Short-cut channel.	
Itay	Madame Lynch 0.00K to 2.61K	Case E-1	River improvement works.	Discharge capacity of river channel is lower. Existing: 20 m^3/s Proposed: 155-170m^3/s
		Case E-2	Diversion channel to San Pablo River.	
		Case E-3	Diversion channel to Santa Teresa River.	
	Itay 0.00K to 3.23K Itay 0.00K to Santa Teresa 1.34K	Case F-1	River improvement works.	Discharge capacity of river channel is lower. Existing: 20-100m^3/s Proposed: 50-250m^3/s
		Case F-2	Retarding basin 1.	
		Case F-3	Retarding basin 2.	

Note: San Martin River is a tributary of Mburicao River; Madame Lynch and Santa Teresa are of Itay River.

8.2.2 Findings of Alternatives

The distribution of the design discharge between the river channel and the drainage facilities is dependent on the catchment area of

each alternative plan, which may alter through detouring of the drainage route or provision of diversion channels.

The design discharge of each river section between reference points is summarized in Table 8-1, together with the discharge shared by the drainage facilities. It is also shown in Fig. 8-6.

On the basis of the above, the construction costs and the required land acquisition areas and number of houses to be evacuated were estimated for the selection of the Optimum Plan, as tabulated in Table 8-2.

8.3 Optimum Plan

8.3.1 Principles of Planning

The other principles of planning aside from the design discharge and the detention facilities are the same as those of the Basic Plan and the Master Plan formulation. The design discharge was computed under the conditions of land utilization in the year 1995. The design discharges of both Mburicao and Itay rivers are shown in Table 8-3 and in Fig. 8-7.

8.3.2 Proposed Storm Water Drainage System

Selection of the Proposed System

The features of the project will be presented after the study on the proposed drainage system and the optimum structural type of the required facilities are discussed. With regard to the sections in question along the channels of the main river course and the tributaries, various study cases have been compared from the economic and social viewpoints as mentioned below, and it is concluded that the river channel improvement is the optimum alternative.

(1) Consideration from Economic Viewpoint

As shown in the Table 8-2, the river channel improvement case is more economical than the other cases, as in Cases A-1, B-1, C-1 and D-1 on the Mburicao river basin, and E-1 and F-1 on the Itay river basin.

(2) Consideration from Social Viewpoint

Since the area of land acquisition and number of house under the execution of Cases A-1, B-1, C-1, D-1, E-1 and F-1 is only slightly greater than that of the other cases, the advantage over social problems caused by land acquisition and house evacuation seems to be about the same. (Refer to Table 8-2.)

Based on the above study, the storm water control works will be carried out by means of river channel improvement and the installation of drainage facilities for the whole stretches of both Mburicao and Itay rivers, except the retarding basin which will be constructed at the downstream end of the improved section of the Itay River to cope with the anticipated increase of discharge due to the proposed improvement works in the upper reaches of Aviadores del Chaco Avenue in accordance with the results of the Master Plan.

Study on Optimum Structural Type

The structural types of river channel and drainage facilities were studied and the results are described hereinafter. As for the retarding basin, the alternative structural types may be considered as protection works for bank slopes, in case that land is difficult to acquire. In this connection, the optimum structural type would be of non-protection bank slope for the proposed site of the retarding basin where land can be obtained cheaper and hence, no study on structural form is necessary.

(1) River Channel

All river channels are of single section and excavated channel in accordance with the reason mentioned in the Basic Plan and the Master Plan. The structural type of river channel will be selected for each river improvement section from the three types; namely, (1) channel without any protection works, (2) channel with revetments, and (3) channel with revetment and invert. The selection is subject to the construction cost, possibility of land acquisition and house evacuation, etc. (Refer to Table 8-4.)

The optimum structural types of river channel in each section are shown in Table 8-5.

(2) Drainage Facilities

The structural types of drainage facilities include open channel and underground conduit. In general, the former is less costly and it is maintained more easily than the latter, but it is difficult to be adopted in the following cases:

- There is no sufficient open space to provide an open channel.
- Provision of an open channel may involve difficulties because of underground utilities such as water supply pipeline, power cable, sewerage pipe, etc.

The optimum structural types of the improvement section under the foregoing conditions, including the reasons for adoption, are shown in Table 8-6.

Features of the Proposed System

(1) River Channel

The river channel improvement plan covers alignment, longitudinal section planning and cross sectional planning of the river channel. In the alignment, the required land acquisition and number of house evacuation were reduced to the minimum as far as practicable, and the alignment of the river course was made as mild as possible. The longitudinal and cross sectional planning were executed in line with the concept described under Subsection 6.5.1, Principles of Planning.

The section to be improved, and longitudinal and cross sectional planning are shown in Figs. 8-8, 8-9 and 8-10, respectively. The findings of the study on the plan of river channel are summarized below. (Refer to Table 8-7.)

Particulars	Mburicao River	Itay River	Total
Existing Channel Length (including Tributaries)	11.0 km	15.6 km	26.6 km
Channel Length to be Improved	5.6 km	15.6 km	21.2 km
Channel without any Protection	0	2.7	2.7
Channel with Revetment	4.0	10.4	14.4
Channel with Revetment plus Invert	1.6	0	1.6
Culvert	0.2	2.5 *	2.7
Retarding Basin	0	1 pc. (350,000 m^3)	1 pc. (350,000 m^3)
Land Acquisition	26,800 m^2	127,100 m^2	153,900 m^2
House Evacuation (Number of Household)	17	60	77

Note: * In the upstream section of the Madame Lynch River, the installation of box culverts is presently ongoing under the jurisdiction of the municipal office, therefore, the same improvement method is taken up in this section.

There are the revetment, invert, groundsill with head and the bridges as incidental facilities of the rivers. Their respective locations are shown in Fig. 8-11. The purpose of constructing the revetments is to protect the river banks from erosion and to reduce the number of house evacuation and land acquisition.

Generally speaking, the existing riverbed gradient of the subject rivers are very steep, resulting in the bank erosion due to high velocity of the flow in the channel. To reduce the flow velocity, groundsills with head are proposed in both Mburicao and Itay rivers to make the longitudinal gradient milder.

At present, a number of road bridges and a railroad bridge span across the subject rivers. All the bridges at the site where the river improvement works are applied will be reconstructed in this project. The width and height of bridges is principally the same as those of the respective existing bridges.

The findings of the study on the incidental facilities are as shown below.

Particulars	Mburicao River	Itay River	Total
Revetment	38,900 m^2	58,100 m^2	97,000 m^2
Invert	7,800 m^2	0	7,800 m^2
Groundsill with Head	12 units	27 units	39 units
Bridge	16 units*	32 units	48 units

Note: * Including one railroad bridge.

(2) Retarding Basin

Since the subject basin is located upstream of the Aviadores del Chaco Avenue, to control the anticipated discharge increase over the subject downstream basin upon completion of the storm drainage improvement works in the basin, a retarding basin will be constructed at the downstream of the Aviadores del Chaco Avenue. Hereunder are the major features of the retarding basin. (Refer to Fig. 8-11.)

Volume : 350,000 m^3
Area : 150,000 m^2
Depth : 2.3 m

(3) Drainage Facilities

The drainage facilities under the proposed plan consist of pipe, box culvert, open channel and incidental facilities, as briefly described hereunder.

Drainage routes in the Mburicao river basin consist of 14 routes with a total length of 9.3 km and service area of 910 ha. The location and dimensional data of the cross sections of the drainage conduit are shown in Fig. 8-12 and in Table 8-8. Since the subject basin is one of the advanced

urbanized ones, there is almost no chance for the construction of open channel; hence, most of the routes are planned to be embedded below the road.

The drainage routes in the Itay river basin consist of 10 routes with a total length of 9.6 km and service area of 1,570 ha. The dimensional data of its cross sections are shown in Fig. 8-12 and in Table 8-8. Since the subject basin is at present not fully urbanized and hence, plenty of open spaces, there are a number of routes which allow the planning of open channels. The existing drainage channels along Aviadores del Chaco Avenue are running in parallel with the road; therefore, open channels are planned along the said road. Underground conduit is planned for the routes that do not satisfy the said conditions.

The findings of the study on the facilities located in the two rivers are tabulated as follows:

Particulars	Mburicao River Basin	Itay River Basin	Total
Pipe	5.54 km	0.44 km	5.98 km
Box Culvert	3.59 km	2.64 km	6.23 km
Open Channel	0.18 km	6.56 km	6.74 km
(Total)	(9.31 km)	(9.64 km)	(18.95 km)
Land Acquisition	800 m^2	9,100 m^2	9,900 m^2

Incidental facilities consist of manholes, inlets, outlets, etc. Taking maintenance and administration into consideration, manholes are located at intersections and one at every 200 m along straight portions of the road. Inlets are located in accordance with catchment areas enough to take care of storm water on the road into drainage conduit. Construction of bed protection and revetment works in the length of 10 m are planned up and downstream of the location of outlets to protect the riverbed and river bank in the neighborhood of the outlet.

The findings of the study on the incidental facilities are as shown below.

Particulars	Mburicao River Basin	Itay River Basin	Total
Manhole	92 pc.	32 pc.	124 pc.
Independent Type Inlet	224 pc.	54 pc.	278 pc.
Continuous Type Inlet	1,310 m	2,240 m	3,550 m
Outlet	14 pc.	10 pc.	24 pc.

8.4 Preliminary Design of Required Facilities

The structures specified in the First Stage Project, consisting of revetment, groundsill with head, box culvert, pipe, bridge, etc., as shown in Fig. 8-13, are as described hereinafter.

Revetment

In view of economical reasons and abundance of materials in the project site, wet masonry which is widely accepted in Paraguay is adopted. The revetment is 0.4 to 0.5 m wide, and the front slope is 1:0.2. The height of the revetment is 1.5 to 4.0 m. To protect the revetment from scouring of the riverbed, its foundation is embedded to a depth varying between 0.4 m and 1.0 m depending on the design discharge.

Groundsill with Head

For the same reasons as the foregoing, wet masonry is also adopted. The crown width is 0.5 m and the front face is perpendicular. The height of the groundsill with head is between 0.2 m and 3.7 m. Embedment of the foundation varies between 0.4 m and 1.0 m in depth. An apron of wet masonry is constructed at the downstream of the groundsill, and at the downstream of the apron, a gabion mattress is installed. The length of the apron is between 2 m and 11 m and the thickness is 0.4 m to 1.0 m.

Box Culvert

For construction of box culvert, reinforced concrete is adopted taking easier workability, longer durability and easier procurement of materials into consideration. The cross section of the smallest culvert is one box of 2.0 m wide and 2.0 m high, and the largest is 3-box culvert of 4.1 m wide and 3.6 m high each. Their minimum wall thickness is 0.3 m. The foundation of the box culvert is

directly placed on the ground because of sound and solid geological conditions.

Pipe

For pipes, centrifugal reinforced concrete pipe is adopted, taking the large cross section and the heavy earth covering load. Pipes planned in this study are between 1.0 and 2.2 m in diameter, and the anticipated earth covering load is 4.5 m on maximum. The sand foundation is adopted because the ground conditions are sound and solid.

Bridge

For the same reason as the foregoing, bridges are all reinforced concrete structures. The width of the bridges varies between 4.5 and 24.0 m depending on the width of the respective existing bridges. The span is between 4.5 and 22 m. The types of bridges are either floor slab (span less than 10 m) or T-Girder (span over 10 m). Either spread or pile foundation will be taken depending on the geological conditions of the site.

Other Facilities

Manholes, inlets and outlets are proposed in the drainage facilities. The first two items are composites of brick and reinforced concrete and the other is wet masonry.

8.5 Implementation Plan

8.5.1 Construction Period

The suitable construction period of execution of this First Stage Project is fixed at 4 years due to the findings of the study mentioned below.

(1) Construction Period by Target Year

As mentioned elsewhere in the foregoing, the river improvement and drainage facilities installation for the three rivers of Mburicao, Itay and Lambare are scheduled to be completed by

the year 1995. In case this project is implemented with financial assistance from a foreign source, the execution of the construction works cannot be commenced by the end of the year 1989 due to the three (3) years/1 required for the preparation of loan application and the procurement of the contractor. Therefore, only six (6) years is available for the completion of the river and drainage facilities improvement works in the above three rivers.

When the six years is proportionately divided according to the ratio of the construction costs allocated to the respective works of the three rivers, it is estimated that four (4) years is adequate for the construction period of this project.

(2) Construction Period from Economic Viewpoint

The sooner the completion of construction, the lesser the chance of damage caused by floods. Therefore, the soonest possible completion period is desirable. However, when the construction cost is considered, completion of the works in a too short period makes the cost higher. Therefore, there must be a certain construction period economically justifiable depending on the work volume.

The most suitable construction period for this project, taking both the relationship between construction cost and period into consideration, is shown in Fig. 8-14. The construction period of 4 years is the most economically advisable.

/1 Note: Supposing that this project is executed through a loan under a foreign aid program, the completion of the Feasibility Study will be in early 1987; then it will require the processes and time as follows:

Loan Commitment and Agreement	:	12 months
Contract for Engineering Services	:	6 months
Detail Design and Tender Documents	:	12 months
Pre-Construction Phase	:	6 months

8.5.2 Priority of Project Components

The project is scheduled to be divided into several components and be executed on annual or by stage basis. The order of the execution of the respective components were studied based on two concepts as described below. (Refer to Table 8-9 and Fig. 8-15.)

(1) In full consideration of the investment efficiency, execution of the component with the higher priority is started disregarding adverse effects on the downstream basin which may be caused by an upstream channel improvement, unless the adverse effect is serious.

(2) Contrary to the foregoing, execution starts from the downstream to avoid shift of possible storm water damage.

The order of execution of the respective components in the above two procedures is as shown in Tables 8-10. The results shown in Fig. 8-16 give the procedure of (2) where the resulting benefit comes considerably later than in the case of (1).

The execution of this project is a matter of great urgency since the area is still suffering much from damage caused by annual floods. Therefore, the priority is given to the procedure (1) which proves an earlier realization of much desired effects.

8.5.3 Implementation Plan

In the case where the implementation of proposed construction works is four (4) years starting in early 1990 and completing in 1993, it is desirable that the volume of work be divided annually as evenly as possible. Accordingly, taking the priority fixed for the project components into consideration, the conclusion as tabulated below was reached after going over the annual construction cost. Also shown below are the benefits derived from the implementation of the annual works. (Construction Schedule of the First Stage Project is shown in Fig. 8-17.)

Year	Work Item	Construction Cost (₲ Million)	Benefit (₲ Million)
First Year (1990)	Improvement works of the drainage system along Artigas, Espana and Mariscal Lopez avenues and construction of retarding basin.	2,859*	688
Second Year (1991)	Improvement works of the dainage system along Madame Lynch Avenue.	5,271	605
Third Year (1992)	Improvement works of Mburicao River channel and improvement works of the drainage system along Ayala Avenue.	4,774	508
Fourth Year (1993)	Improvement works of river channels of tributaries and provision of the related drainage facilities in Mburicao and Itay river basins and remaining works.	3,293	307

Note: * Since the preparatory work including mobilization is conducted in the first year, the volume of work to be implemented in the first year is planned to be less than that of the other years.

8.6 Cost Estimate

8.6.1 Construction Cost

Cost estimation of the First Stage Project was carried out in exactly the same manner as in the case of the Master Plan. This project calls for construction materials such as cement, structural steel, steel bar, lumber, stone aggregates, concrete pipe, etc.; and construction equipment such as bulldozer, back hoe, dump truck, mobile crane, and others. Almost all of the foregoing materials are locally available; however, structural steel and construction equipment may have to be imported.

The construction cost includes direct construction cost, indirect construction cost (equivalent to 30% of the direct construction cost), land acquisition cost, house evacuation compensation, engineering services for the detailed design and construction supervision, and contingencies. The cost estimation was based on the market prices as of August 1986 at the foreign currency conversion rate of US$1.00 = 650 Guaranies = ¥155. Construction is to be carried out on contract basis.

The total construction cost for fund requirement of the First Stage Project is estimated at 27,500 million Guaranies composed of the foreign currency component of 13,100 million Guaranies and the local currency component equivalent to 14,400 million Guaranies. The breakdown and annual disbursement of the construction cost for fund requirement are presented in Tables 8-11 and 8-12, respectively.

8.6.2 Maintenance and Administration Costs

The maintenance and administration costs consist of labor cost; operation cost of construction machinery, equipment and vehicles; and other miscellaneous expenses. The amount of 83.0 million Guaranies is estimated for the annual maintenance and administration costs of facilities during the entire life of the project.

8.7 Project Justification

Economic and financial studies were conducted for the First Stage Project on the same basic conditions as the Master Plan.

8.7.1 Economic Evaluation

Project Benefit

The benefits derived from the First Stage Project, which are basically the same as those in the Master Plan, are given as the difference in damage by storm water between the with- and without-the-project situations. Therefore, storm damage in both the Mburicao and the Itay river basins have to be estimated under the above-said two situations to define the project benefits in monetary terms.

Direct damage in both basins, which are due to traffic interruption and submergence of assets, takes place at the trouble spots described hereunder.

(1) Mburicao River Basin

Flood characteristics in the Mburicao river basin can be classified into two types; namely, (1) water flowing on the roads developed lengthwise and crosswise throughout the basin, and (2) inundation along the river due to insufficient flow capacity.

Although flood durations are relatively short, floods take place frequently on the roads at the portions having a small catchment area and flow down toward the uppermost end of tributaries, or into the nearest river channel.

Traffic interruption takes place frequently on the main roads of Artigas, Generalisimo Franco, Mariscal Lopez, Eusebio Ayala, Monsignor Bogarin and Sacramento avenues, and on several streets, as shown in Fig. 8-18 together with the hourly average traffic volumes. Among these main roads, seriously damaged are Generalisimo Franco, Mariscal Lopez and Eusebio avenues because of their big traffic volumes and the longer duration of floods. The inundated areas are observed mainly at the following points:

- The upper reaches of the bridge located at the crossing point of Mburicao River and Generalisimo Franco Avenue, the extention of España Avenue; and

- The upper and lower reaches of the railway bridge crossing Mburicao River.

(2) Itay River Basin

Flooding water spreads widely along most of the river courses and the existing drainage channels, because the channel flow capacities are extremely small in relation to the runoff discharge volume and the geographical gradient of this basin

especially in the immediate upper reaches of Aviadores del Chaco Avenue which is rather gentle. On the other hand, water flowing on the roads which was observed at many spots in Mburicao river basin was recognized only at a few spots in Itay river basin.

Although the total traffic volume in Itay river basin is smaller than that in Mburicao river basin, damage due to traffic interruption, likewise, reaches to a considerable amount because of the long duration of floods. Traffic interruption takes place mainly on the main roads of Madame Lynch, Aviadores del Chaco, Mariscal Lopez and Eusebio Ayala avenues, and on some streets, as shown in Fig. 8-18. Among these main roads, seriously damaged are the intersections of Madame Lynch and Mariscal Lopez avenues and of Eusebio Ayala and Boggiani avenues.

The areas where inundation frequently occur are as follows:

- Grupo Habitacional Aeropuerto area;
- The vicinity of the intersection of Boggiani and Esusebio Ayala avenues; and
- The area along Madame Lynch Avenue.

The average annual benefits from the First Stage Project, which were calculated in the same manner as the those of the Master Plan, are 599 million Guaranies and 1,509 million Guaranies in the Mburicao and the Itay river basins, respectively.

Internal Rate of Return

The economic viability of the First Stage Project was examined by calculating the internal rate of return (IRR) to decide on whether or not the project will be put into implementation. IRRs were calculated for the Mburicao and the Itay river basins on the basis of the cost-benefit flow presented in Table 8-13, with the following results:

Mburicao River Basin	:	11.2%
Itay River Basin	:	11.8%

The First Stage Project : 11.6%

Infrastructure projects like this project are generally accepted despite of low IRRs. In this context, the First Stage Project which gives an IRR of 11.6% is assessed to have enough economic viability for implementation.

8.7.2 Financial Consideration for Project Implementation

Assuming that the foreign currency portion of the project cost is covered by a loan with an interest rate of 3.5% and a repayment period of 30 years including a 10-year grace period, the amortization for the foreign currency portion and the repayment of the local currency portion would be 36,907 million Guaranies with an annual average of 1,025 million Guaranies. The total expenditure including the operation and maintenance cost during the amortization period amounts to 42,264 million Guaranies.

The most reliable financial source for project implementation is the revenue from the storm drainage sector of CORPOSANA, as described in Subsection 7.7.2. The amount possible to be earmarked for the project implementation is estimated at 2,387 million Guaranies on an annual average during the same period given above. (Refer to Table 7-9.)

The financial source overcomes the expenditure amount to 43,666 million Guaranies in total and 1,213 million Guaranies on an annual average, as shown in Table 8-14. Hence, it follows that the First Stage Project can be implemented within the financial capacity of CORPOSANA.

8.7.3 Socio-Economic Impacts

In addition to the direct benefit estimated by counting the tangible damages, project implementation of the storm drainage improvement works in the Mburicao and the Itay river basins could result in the stabilization of the people's living condition in the aspects summarized as follows:

(1) The circulation of commodities and the movement of people will be secured as most of the trunk roads linking Metropolitan

Asuncion and other major cities in the country will be released from the traffic interruption caused by flood. The roads and their function are as follows:

- Artigas Avenue: extends to Poso Colorado City through Mariano R. Alonso City after connecting with Route 9.
- Espana Avenue (Generalisimo Franco, General Genes, Aviadores del Chaco): extends to Aregua City through the International Airport and Luque City.
- Mariscal Lopez Avenue: connected at San Lorenzo City to Route 1 which reaches up to Stroesner City.
- Eusebio Ayala Avenue: connected to Route 1 and Route 2 at San Lorenzo City, as well as to Mariscal Lopez Avenue.
- Madame Lynch Avenue: links the above-said important roads as lateral circumferencial road.

(2) Speedy and safe drainage of storm water will enhance social welfare in the area where houses suffer from inundation and where they are constructed along the inundated roads. Some of the habitually inundated portions in the Mburicao and the Itay river basins are as follows:

- The upper portion from the bridge at the crossing point of Mburicao River and Artigas Avenue.
- The upper portion from Caido Bridge at the crossing point of Mburicao River and Generalisimo Franco Avenue.
- Along Madame Linch Avenue, especially in the area of Grupo Habitacional Aeropuerto.
- The vicinity of the intersection between Boggiani Avenue and Eusebio Ayala Avenue.

CHAPTER 9. ORGANIZATION AND MANAGEMENT OF THE STORM WATER DRAINAGE SYSTEM

9.1 General

As mentioned in Section 3.3, there is no central or national organization founded solely for flood control and water resources development. Although studies have been made on laws, rules and regulations to comprehensively administer and rationally exploit natural resources such as rivers, land and forests, they have not yet been enacted.

As far as management of storm water drainage systems is concerned, CORPOSANA has been authorized under Law 405 and Decree 29697. The agency is making every endeavor to exercise this function; however, several problems have arisen in the study area. This chapter will focus on the study of the problems related to the storm water drainage system, together with the necessary organization and management.

9.2 Problems on the Storm Water Drainage System

The cause of the problems on the storm water drainage system may be emphasized with the lack of coordination among the several agencies concerned, although CORPOSANA should naturally be responsible.

Problems Due to Lack of Coordination

In the study area, it was noted that several projects concerned in storm water drainage system are executed without appropriate coordination with CORPOSANA, so that the problems regarding storm water drainage system such as deterioration or demolition of existing systems, increment of flood damage, and others become worse.

The problems may be due to the causes emphasized hereunder:

(1) Present Problems

- Several drainage channels have been reclaimed for road construction.

- Storm water drainage facilities have been independently provided by other agencies or the private sector without due consideration on the adverse effects to outlying areas or other facilities.

- Land development have converted flood-prone areas into residential areas, and riparian areas have also been utilized for land development.

(2) Future Problems

In the future, several city development projects may be executed resulting in the increment of flood discharge due to loss of permeable area. To cope with the increment of flood discharge, the proposed storm water drainage system will include detention facilities such as infiltration facilities and storage using public places and house lots. To install the detention facilities, the understanding and cooperation of the agencies concerned are indispensable, because problems may arise due to the installation of these facilities without them.

Problems Under the Responsibility of CORPOSANA

The following problems which may be under the responsibility of CORPOSANA are pointed out as the causes of flood damage increment:

(1) Present Problems

- Since the area or stretch presently managed by the managing agency is not clarified, riparian areas are proliferating with facilities installed for some other purposes.

- As for the maintenance of the drainage channel, garbage dumped on the channel bed are allowed to stay without being cleared, and some drainage facilities and structures damaged by floods remain without any rehabilitation works.

- Although it is necessary to arrange the relevant flood protection works during flood time through the collection of flood information, such works are rarely executed.

(2) Future Problems

With regard to problems expected in the future, houses and other structures may be constructed close to the existing riparian area, so that the extension of the river channel to cope with the increment of runoff discharge will hardly be executed.

9.3 Necessary Organization

The necessary organization to cope with the problems mentioned in Section 9.2 may be categorized under two (2) organizations: the coordinating organization and the implementing agency, as hereinafter described.

9.3.1 Coordinating Organization

Among the problems to be coordinated by the coordinating organization include various items that may be classified into two (2): the problems that need to be discussed among several agencies concerned and the problems that need to be resolved by only a few agencies.

In line with the above categories, the following organizations may be necessary:

(1) Overall Coordinating Group

The Overall Coordinating Group should be organized by all agencies concerned. The group shall coordinate overall problems related to the various agencies such as city planning, large-scale road improvement projects and others. It should be composed of representatives from all the agencies concerned which may involve the municipal government, the Ministry of Public Works, the Ministry of the Interior, SENASA, etc.

Since issues to be discussed may seldom evolve, the group shall convene only as necessary in accordance with the request of its members. A secretariat consisting of a general affairs section, a financial section, a legal section, etc., should be provided to deal with the issues brought out in meetings.

(2) Specific Problem Coordinating Group

This group will be organized by a few agencies only to coordinate problems on storm water drainage that are expected to evolve through the daily activities. It should be composed of personnel who are familiar with such problems and be responsible to their solution. A responsible person should be assigned to take charge of the management of group and it is also desirable that it convenens at least once a month or from time to time as the need arises. As in the Overall Coordinating Group, the Specific Problem Coordinating Group should also be provided with a secretariat.

9.3.2 Implementing Agency

The functions of the implementing agency for the storm drainage system should basically cover the following items: (1) planning of the project, (2) project execution and maintenance, (3) flood prevention and rehabilitation works, and (4) preparation of finance, etc. In this regard, the following sections may be created to strengthen its functions: (1) General Affairs Section, (2) Planning Section, (3) Flood Prevention Section, (4) Construction, Maintenance and Rehabilitation Works Section, (5) Financial Management Section, and (6) Legal Section.

9.4 Necessary Laws and Regulations on Storm Water Drainage System

The functions and responsibilities of the agencies can be consolidated by the enactment of laws and regulations. In this connection, the laws and regulations should be prepared for the creation of the foregoing agencies, and it is also desirable for the related agencies to provide additional legislations or items in their own laws and regulations in cooperation with the implementing agency.

The items to be provided may be as follows:

Coordinating Organization

The necessary laws and regulations may include the following items: (1) purpose of the organization; (2) composition and members of the organization; (3) functions, responsibilities, and authority of the organization; (4) manner and frequency of conducting meetings; and (5) others.

Implementing Agency

The laws and regulations for the implementing agency may stipulate the following: (1) stretch and facility to be managed, (2) function of project planning, (3) function of execution of the project, (4) function of maintenance of the project, (5) function of creating the program of emergency countermeasures against floods, (6) function of rehabilitation works, (7) function of permission and prohibition, and (8) function of collection of management funds.

Agencies Concerned

The following items may be stipulated in the laws, rules and regulations for the agencies concerned to secure the function of the storm water drainage system:

(1) Obligation in Urban Development

Urban development that may result in the increment of runoff discharge should be adjusted so as not to increase the flood damage potential in the developed area. For this purpose, it should be made obligatory for the execution body of the urban development project to provide countermeasures for the increment of flood damage potential, in consultation with the implementing agency.

(2) Obligation in the Construction of Buildings and Houses

Construction of buildings and houses which will deteriorate the infiltration and detention capacity due to decrease of permeable area will result in the increment of runoff discharge. In case of construction of buildings and houses,

it should be made obligatory to install necessary detention facilities so as to maintain the current runoff discharge condition of the area.

(3) Utilization of Public Places as Detention Facilities

Public places can be useful as detention facilities aside from their original purposes. The regulation for their use should be arranged so that the public places can be readily used as detention facilities.

(4) Inspection for Illegal dumping of garbage

Dumping of garbage onto the channel remarkably deteriorates the flow capacity of the channel. In this context, the inspection to control illegal dumping of garbage should be strengthened in the regulation.

9.5 Action Plan

The establishment of the storm water drainage system could hardly be promoted without any concrete action, even if the necessary organization, laws, rules and regulations are provided. In this connection, an action plan is herein presented for the full consideration of the agencies concerned including CORPOSANA to forward the establishment of the appropriate system. This action plan may be broadly categorized into short and long term plans, as shown in Table 9-1, to successfully accomplish this Project.

CHAPTER 10. RECOMMENDATIONS

1. The Basic Plan for the proposed Storm Water Drainage System Project which consists of river channel improvement and installation of drainage and detention facilities is formulated on a 10-year return period basis from the long term point of view. In the context of the Basic Plan, the Master Plan which is scheduled to be completed by the year 2005 is formulated on a 3-year return period. It has been confirmed that the project is technically feasible and economically viable.

   Within the framework of the Master Plan, the First Stage Project which narrows down the target area to the Mburicao and the Itay river basins is also formulated on the same project scale as that of the Master Plan, aiming at the early realization of the storm water drainage system project. Studies so far made have shown that the First Stage Project is technically feasible, financially affordable and economically viable with an Internal Rate of Return (IRR) of 11.6%. Through the realization of the project, enhancement of social welfare and stabilization of economic activities not only in the planning area but in the whole of Paraguay, together with the development of the Asuncion metropolitan area, is highly expected.

   Therefore, it is strongly recommended that the project be forwarded to the next stage at the earliest possible opportunity.

2. During this study period, a tentative coordinating group composed of representatives from CORPOSANA, the municipality, the MOPC, the ANDE, and the other related agencies of the government was formed to deliberate on the problems concerning the storm drainage system in the study area. It is desirable that through the discussions of the representatives in the tentative coordinating group, the necessary organization and regulations would be drafted as early as possible in consideration of the action plan prepared in this report.

3. The storm drainage facilities should be maintained to assure their functions through daily maintenance works. Illegal actions such as dumping of garbage on drainage channels and construction of facilities

in the riparian area resulting in the deterioration of flow capacity of the river channel should be discouraged through daily inspection. In this connection, the organization for the maintenance and inspection should be consolidated.

4. Detention facilities, compared with other storm water control facilities, can be locally installed in a small scale. Storage facilities, one of the detention facilities, can be easily provided in private house lots with the cooperation of the residents. It is, therefore, advisable that the agencies concerned encourage the residents to actively participate in storm water control and if necessary, go through the legal procedure to enact appropriate laws and regulations. This will quickly contribute much to the mitigation of flood damage.

5. Large scale projects such as land development, building construction and highway construction will certainly increase runoff discharge in the areas concerned. It is one of the recommendable ideas to make it obligatory that storm water control facilities be provided by the contractors or developers when such projects are put into implementation.

6. Urbanization will make it more difficult to acquire land required for the establishment of an appropriate storm water drainage system. In this connection, CORPOSANA should define the riparian area and the river stretch to be managed by it and implement the necessary improvement works as early as possible. It is desirable that the land proposed for the riparian area in the Basic Plan be acquired for implementation of future storm water control works.

7. The unlimited cooperation of the inhabitants is essential to establish the storm water control system, through a deeper understanding and recognition of its importance. In this connection, it is advisable that the functions of the infiltration facilities provided at the CORPOSANA office and the meteorology office for the infiltration tests conducted during this study period be demonstrated to the residents as often as possible.

8. Basic data and information such as rainfall records, topographic maps and survey results on river channels which are required for analyses

and studies are at present very limited in quantity and poor in quality. It is, therefore, necessary that such basic data be collected for use in the further analyses and design works in the next stage.

TABLES

Table 1-1. MEMBERS OF THE ADVISORY COMMITTEE AND THE STUDY TEAM

Name	Designation
ADVISORY COMMITTEE	
Dr. Katsuyoshi Ishizaki	Chairman of the Committee
Mr. Eiichi Nakamura	Member (Urban Planning/Drainage Planning)
Mr. Katsuhide Yoshikawa	Member (Hydrology/Hydraulics)
Mr. Noboru Yamaguchi	Member (Facility Planning)
Mr. Tohru Take	Member (Coordination)
STUDY TEAM	
Mr. Katsuhisa Abe	Team Leader
Mr. Yoshiyuki Tomioka	Assistant Team Leader (River Planning Engineer)
Mr. Yoshiharu Matsumoto	Hydrologist
Mr. Iwao Irie	Geologist
Mr. Motonori Yoshii	Drainage Planning Engineer
Mr. Junji Kamata	Flood Analyst
Mr. Hiroaki Sakamoto	Urban Planner
Mr. Akio Shichijugari	Drainage Structural Engineer
Mr. Iwao Chikaraishi	Structural Engineer/Cost Estimator
Mr. Teru Sasaki	Institutional Expert
Mr. Kimio Shimomura	Project Economist
Mr. Shinichi Kono	Surveying Engineer

Table 2-1. GROSS DOMESTIC PRODUCT IN THE SECOND FIVE-YEAR DEVELOPMENT PLAN (1977-1981)

Year	Current Price (₲10^6)	1982's Constant Price (₲10^6)	Growth Rate (%)
1977	263,612	495,493	10.9
1978	322,542	551,732	11.4
1979	430,514	614,392	11.4
1980	560,459	684,686	11.4
1981	708,689	744,361	8.7

Source: Central Bank of Paraguay

Table 2-2. GROSS DOMESTIC PRODUCT PROJECTED IN THE THIRD FIVE-YEAR DEVELOPMENT PLAN (1985-1989)

Year	1982's Constant Price (₲10^6)	Growth Rate (%)
1985	772,445	5.0
1986	818,792	6.0
1987	872,013	6.5
1988	928,694	6.5
1989	989,059	6.5

Source: Technical Planning Secretariat

Table 2-3 POPULATION GROWTH IN THE NATION AND IN METROPOLITAN ASUNCION

Location	1950		1962		1972		1982		Average Annual Growth Rate (%)		
	Population (Persons)	Rate (%)	Population (Persons)	Rate (%)	Population (Persons)	Rate (%)	Population (Persons)	Rate (%)	1950-62	1962-72	1972-82
1. Asuncion	26,634	76.0	288,882	70.6	388,958	67.2	457,210	57.2	2.83	3.10	1.63
2. F. de la Mora	5,253	2.0	14,519	3.5	36,892	6.4	66,450	8.3	8.84	10.04	6.06
3. Lambare	-	-	20,778	5.1	31,732	5.5	67,180	8.4	-	4.44	7.79
4. Limpio	8,473	3.1	10,126	2.5	12,767	2.2	16,650	2.1	1.50	2.41	2.69
5. Luque	22,361	8.2	30,834	7.5	40,677	7.0	63,210	7.9	2.71	2.88	4.51
6. M. R. Alonso	4,043	1.5	5,686	1.4	7,388	1.3	14,520	1.8	2.88	2.72	6.99
7. Nemby	4,974	1.8	5,984	1.5	6,899	1.2	12,310	1.5	1.55	1.47	5.96
8. San Antonio	4,698	1.7	5,965	1.5	7,321	1.3	8,110	1.0	2.01	2.12	1.03
9. San Lorenzo	13,100	4.8	18,573	4.5	36,811	6.3	74,240	9.3	2.95	7.27	7.27
10. Villa Elisa	2,365	0.9	3,214	0.8	4,774	0.8	11,600	1.5	2.59	4.14	9.28
11. Villa Hayes	-	-	4,712	1.1	4,795	0.8	7,660	1.0	-	0.18	4.80
Metropolitan Area (Total)	271,901	100.0	409,273	100.0	579,014	100.0	799,140	100.0	3.47	3.62	3.27
Paraguay	1,328,452		1,819,103		2,357,955		3,035,360		2.65	2.70	2.56

Source: Censo Nacional de Poblacion y Viviendas 1982

Table 2-4. GROSS DOMESTIC PRODUCT BY ECONOMIC SECTOR
(AT CONSTANT PRICE OF 1982)

(Unit: Billion Guaranies)

Economic Sector	1979	1980	1981	1982	1983
Agriculture	90.4	99.3	113.9	114.7	111.4
	14.7%	14.5%	15.3%	15.6%	15.6%
Livestock	51.7	53.8	55.4	56.5	55.5
	8.4%	7.9%	7.4%	7.7%	7.8%
Forestry	15.9	18.4	19.5	18.4	18.0
	2.6%	2.7%	2.6%	2.5%	2.5%
Hunting and Fishing	0.9	1.0	1.1	1.1	1.0
	0.1%	0.1%	0.2%	0.1%	0.2%
Mining	2.1	2.7	3.1	3.1	2.9
	0.3%	0.3%	0.4%	0.4%	0.4%
Manufacturing	106.3	120.4	125.6	121.0	115.9
	17.3%	17.6%	16.8%	16.4%	16.2%
Construction	35.8	45.2	52.7	49.5	46.7
	5.9%	6.6%	7.1%	6.7%	6.5%
Electricity	10.1	12.1	12.6	15.8	15.0
	1.6%	1.8%	1.7%	2.2%	2.1%
Water and Sanitary Services	1.7	1.9	2.1	2.3	2.8
	0.3%	0.3%	0.3%	0.3%	0.4%
Transportation and Communications	26.4	29.6	30.5	31.1	30.7
	4.4%	4.3%	4.1%	4.2%	4.3%
Commerce and Finance	167.4	185.0	200.6	196.2	190.2
	27.3%	27.0%	27.0%	26.6%	26.6%
General Government	24.0	25.7	31.6	32.9	32.2
	3.9%	3.8%	4.2%	4.5%	4.5%
Housing	19.7	21.5	23.0	22.5	21.4
	3.2%	3.1%	3.1%	3.0%	3.0%
Other Services	61.2	68.1	72.7	72.0	71.1
	10.0%	10.0%	9.8%	9.8%	9.9%
Total	613.8	684.7	744.4	737.1	714.8
	100.0%	100.0%	100.0%	100.0%	100.0%

Source: Central Bank of Paraguay

Table 2-5. ACTIVE POPULATION BY ECONOMIC SECTOR (1982)

Economic Sector	Population (person)	Distribution (%)
Agriculture	429,230	41.7
Livestock	14,230	1.4
Forestry, Fishing, Etc.	2,260	0.2
Mining	1,130	0.1
Industrial Manufacturing	124,840	12.1
Construction	67,170	6.5
Electricity, Water/Sewage	2,540	0.2
Transportation/Communications	26,230	2.5
Commerce	78,650	7.6
Hotels and Restaurants	6,560	0.6
Housing and Finance	17,120	1.7
Other Services	168,980	16.4
Others	90,740	8.8
Total	1,029,680	100.0

Source: General Direction of Statistics and Census

Table 2-6. MAJOR ONGOING PROJECTS IN ASUNCION CITY

Item		Particulars	Stage	Undertaken By	Financial Source
Road Network	(1)	Improvement of Eusebio Ayala Ave., including Parking Lot (PRODEMA)	Planning Stage	Municipal Government	Not decided
	(2)	Improvement of Fernando de la Mora Ave.	-ditto-	-ditto-	-ditto-
	(3)	Widening of Road and Improvement of Drainage Along Avenue Madame Lynch Avenue	Under construction	-ditto-	Municipal Budget (for 1985)
	(4)	Improvement of Santa Teresa Avenue and Aviadores del Chaco Ave.	-ditto-	-ditto-	Municipal Government
Land Use	(1)	Urban Waste Disposal Facility (PRODEMA)	Planning Stage	-ditto-	-ditto-
	(2)	Construction of New Municipal Building	Under construction	-ditto-	-ditto-
	(3)	Improvement of Recreation Area (Plaza Palacio de Justicia)	Under construction	Private enterprise	
	(4)	Road Improvement for Pedestrians' Exclusive Use of Palma Street and Estrella Street (PRODEMA)	Planning Stage	Municipal Government	Municipal Government
	(5)	Rehabilitation of Slum Area Along Paraguay River	-ditto-	-ditto-	Not decided
	(6)	Construction of New Cemetery	-ditto-	-ditto-	-ditto-
	(7)	Expansion of Green Space Near Palacio de Govierno	-ditto-	-ditto-	-ditto-

Table 3-1. FEATURES OF RIVERS IN THE STUDY AREA

Basin Number	Name of Basin	River Length (km)	Longitudinal /1 Gradient	Catchment Area (ha)	Subbasin Number	Existing Flow Capacity (m^3/s)	Flow Capacity Per Catchment Area ($m^3/s/km^2$)	Remarks
Basins With River Channels								
Group I								
B-4	Jaen	1.90	1/79	247	-	30	12	
B-6	Salamanca	1.83	1/46	143	-	15	13	
B-7	Zanja Moroti	2.35	1/43	161	1	60	85	
					2	90	76	
B-8	Ferreira	3.34	1/68	400	1	170	59	
					2	190	48	
B-19	Lambare	7.03	1/107	2,566	1	10	3	
					2	15	6	
					3	150	11	
					4	35	2	
					7	150	6	
					5	210	43	
					6	200	28	
B-21	Villa Elisa	5.20	1/68	1,153	1	20	7	
					3	75	7	
B-22	Nemby	7.55	1/101	4,417	1	85	15	
					2	20	2	
					3	25	2	
					4	260	28	
					5	25	1	
Group II								
B-2	Jardin	0.78	1/46	60	-	30	50	
B-10	Las Mercedes	1.35	1/45	212	-	20	9	
B-12	Bella Vista	0.86	1/34	75	-	30	40	
B-14	Mburicao	11.04	1/100	1,645	1	20	5	
					2	35	6	
					4	130	11	
					6	120	7	
					3	30	8	
					5	20	9	
B-15	Ycua Carrillo	3.00	1/78	401	1	20	11	
					2	30	7	
B-16	Santa Rosa	2.40	1/87	313	-	20	6	
B-17	Tres Puentes Cue	5.99	1/171	680	-	10	1.5	
B-18	Itay	25.50	1/318	13,613	3-1	3	0.9	
					5	5	0.7	
					2-2	15	1.3	
					6	60	1.4	
					3-2	3	0.9	
					4	5	1.2	
					1	30	2.2	
					2-1	15	0.9	
					7-2	10	2.1	
					7-1	5	0.4	
					7-3	5	1.8	
					8	23	1.2	
					9	-	-	
					10	20	0.5	
B-26	Zeballos Cue	1.23	1/68	213	-	10	5	
B-27	Paso Cai	4.00	1/129	549	-	10	2	
Group III								
B-23	San Lorenzo	9.60	1/142	3,369	1	5	0.3	
					2-1	5	0.2	
					2-3	10	0.3	
					2-2	10	1.3	
B-24	Tayazuape	8.80	1/163	3,013	1	55	4	
					3	15	0.5	
					2	25	5	
B-25	Ycua Dure	4.50	1/113	1,257	-	42	3	
Basins Without River Channels								
B-1	Varadero	-	-	325	-	-	-	No river
B-3	Centro	-	-	724	-	-	-	-do-
B-5	Tacumbu	-	-	170	-	-	-	-do-
B-9	Villa Universitaria	-	-	240	-	-	-	-do-
B-11	Mariscal Lopez	-	-	66	-	-	-	-do-
B-13	Tablada	-	-	103	-	-	-	-do-
B-20	Valle Apua	-	-	1,063	-	-	-	-do-
B-28	Mariano Alonso	-	-	1,565	-	-	-	-do-
B-29	Villa Hayes	-	-	895	-	-	-	-do-
B-30	Petropar	-	-	523	-	-	-	-do-
B-31	Achucarro	-	-	1,335	-	-	-	-do-

Note: /1 Longitudinal gradient is the ratio of the height difference between beginning and end points and the total river length.

Table 3-2. FLOOD DAMAGE IN FIFTEEN BASINS DURING THE RECORDED MAXIMUM FLOOD IN 1982

Name of Basin	Catchment Area (ha)	Inundated Area (ha)	Inundated Houses (houses)	Inundated Trunk Roads (points)	Inundated Street Junctions (points)	Affected Vehicles At Trunk Roads (10^3 units)
Varadero	325	2.1	8	-	13	-
Jardin	60	0.2	-	-	3	-
Jaen	247	1.4	8	-	8	-
Salamanca	143	2.7	31	-	1	-
Zanja Moroti	161	1.3	11	-	5	-
Ferreira	400	4.3	18	1	17	1
Las Mercedes	212	1.0	-	2(1)	2	3
Mariscal Lopez	66	0.7	-	-	5	-
Bella Vista	75	2.0	14	1	6	1.3
Tablada	103	1.0	6	1	5	1
Mburicao	1,645	46.6	100	8(4)	67	28
Ycua Carrillo	401	1.6	22	-	2	-
Santa Rosa	313	2.7	44	1(1)	8	2.5
Itay	5,455 /1	283.9	1,800	13(6)	243	17
Lambare	2,566	39.9	189	6(3)	69	8

Note:

/1 Excluding the area downstream of Aviadores del Chaco Avenue.
( ) Number of spots on habitually inundated trunk roads.

Table 3-3. DEGREE OF FLOOD DAMAGE PER BASIN

Name of Basin	Inundated Area	Inundated Houses	Influence To Traffic	Flood Frequency and Duration	Evaluation
Varadero	*	*	*	*	*
Jardin	*	*	*	*	*
Jaen	*	*	*	*	*
Salamanca	*	**	*	*	**
Zanja Moroti	*	**	*	*	*
Ferreira	*	**	*	**	**
Las Mercedes	*	*	*	*	*
Mariscal Lopez	*	*	*	*	*
Bella Vista	*	**	*	*	*
Tablada	*	*	*	**	**
Mburicao	**	***	****	****	****
Ycua Carrillo	*	**	*	*	*
Santa Rosa	*	**	*	**	**
Itay	****	****	****	****	****
Lambare	**	***	**	***	***

Note: * Less Serious *** Very Serious
** Serious **** Extremely Serious

Table 3-4. FLOOD DAMAGE AT TRUNK ROADS DURING THE RECORDED MAXIMUM FLOOD IN 1982

Name of Road	Number of Spots on Inundated Trunk Road	Affected Vehicles At Trunk Roads (10^3 units)
Artigas Avenue	3	5
Espana Avenue	3	10
Mariscal Lopez Avenue	5	22
Eusebio Ayala Avenue	4	28
Fernando de la Mora Avenue	2	5
Feneral Maximo Santos Avenue	3	2
Madame Lynch Avenue	6	17

Table 5-1. LAND USE IN YEAR 2005

(Unit: ha)

Basin Number	Name of Basin	Commercial	Residential				Industrial	Public	Recreational	Farmland	Grand Total
			High	Medium	Low	Total					
B-1	Varadero	19	199	54	-	253	4	35	14	-	325
B-2	Jardin	-	51	-	-	51	7	2	-	-	60
B-3	Centro	380	108	96	-	204	108	32	-	-	724
B-4	Jaen	49	27	159	-	186	5	7		-	247
B-5	Tacumbu	-	-	112	-	112	55	3	-	-	170
B-6	Salamanca	10	-	105	-	105	-	10	18	-	143
B-7	Zanja Morotí	6	-	151	-	151	-	3	1	-	161
B-8	Ferreira	56	-	330	-	330	-	10	4	-	400
B-9	V. Universitaria	3	-	198	-	198	8	28	3	-	240
B-10	Las Mercedes	19	-	166	-	166	-	16	11	-	212
B-11	Mariscal Lopez	3	-	56	-	56	6	1	-	-	66
B-12	Bella Vista	5	-	64	-	64	5	1	-	-	75
B-13	Tablada	7	-	86	-	86	7	1	2	-	103
B-14	Nburicao	175	27	864	287	1,178	26	209	52	5	1,645
B-15	Ycua Carrillo	20	-	341	-	341	14	11	15	-	401
B-16	Santa Rosa	5	97	119	-	216	1	7	76	8	313
B-17	Tres Puentes Cue	61	144	19	-	163	-	188	230	38	680
B-18	Itay	568	367	1,421	2,984	4,772	66	922	150	7,135	13,613
B-19	Lambare	322	523	1,614	-	2,137	33	37	37	-	2,566
B-20	Valle Apua	17	-	325	615	940	7	4	95	-	1,063
B-21	Villa Elisa	36	-	262	827	1,089	23	3	2	-	1,153
B-22	Nemby	106	-	204	1,046	1,250	23	17	33	2,988	4,417
B-23	San Lorenzo	148	-	131	1,456	1,587	14	256	119	1,245	3,369
B-24	Tayazuape	76	-	11	602	613	-	7	5	2,312	3,013
B-25	Ycua Dure	16	-	-	446	446	2	4	3	786	1,257
B-26	Zeballos Cue	14	-	-	102	102	1	80	-	16	213
B-27	Paso Cai	35	-	277	61	338	-	36	2	138	549
B-28	Mariano Alonso	28	-	-	321	321	5	5	2	1,204	1,565
B-29	Villa Hayes	47	-	-	267	267	93	30	10	448	895
B-30	Petropar	-	-	14	167	181	10	-	2	330	523
B-31	Achucarro	19	-	-	535	535	37	4	5	735	1,335

NOTE : "Residential" is classified into high, medium and low densities.

Table 5-2. BUILDING-TO-LAND RATIO

Classification	Unit	Roof	Interspace		Roads	Total	Building-to-Land Ratio
			Hard/1	Soft/2			
Commercial	ha	13.6	3.2	1.8	6.4	25.0	
	%	54.4	12.8	7.2	25.6	100.0	73.0
High Density Residential	ha	9.1	5.3	4.1	6.5	25.0	
	%	36.4	21.2	16.4	26.0	100.0	49.1
Medium Density Residential	ha	4.8	6.7	7.5	6.0	25.0	
	%	19.2	26.8	30.0	24.0	100.0	25.1
Low Density Residential	ha	2.8	1.6	14.9	5.7	25.0	
	%	11.2	6.4	59.6	22.8	100.0	14.4
Industrial	ha	9.8	9.0	36.0	9.9	64.7	
	%	15.1	13.9	55.7	15.3	100.0	17.9
Public (Hospitals)	ha	6.6	4.3	80.4	-	91.3	
	%	7.2	4.7	88.1	-	100.0	7.2
Public (Schools)	ha	1.1	0.5	4.6	-	6.2	
	%	17.7	8.1	74.2	-	100.0	17.7
Public (Military)	ha	3.3	2.8	48.8	-	54.9	
	%	6.0	5.1	88.9	-	100.0	6.0

Note:

/1 : Impermeable areas due to pavement.
/2 : Permeable areas where rainfall may infiltrate to some degree.

Table 5-3. INCREMENT OF RUNOFF COEFFICIENT BY URBANIZATION

River Basin	Name of River	Runoff Coefficient		
		1965	1984	2005
B-1	Varadero	0.54	0.62	0.66
B-2	Jardin	0.65	0.68	0.68
B-3	Centro	0.59	0.62	0.67
B-4	Jaen	0.57	0.65	0.67
B-5	Tacumbu	0.48	0.53	0.53
B-6	Salamanca	0.52	0.57	0.58
B-7	Zanja Moroti	0.63	0.64	0.65
B-8	Ferreira	0.50	0.63	0.66
B-9	Villa Universitaria	0.32	0.44	0.60
B-10	Las Mercedes	0.48	0.59	0.62
B-11	Mariscal Lopez	0.56	0.62	0.63
B-12	Bella Vista	0.50	0.63	0.65
B-13	Tablada	0.45	0.62	0.63
B-14	Mburicao	0.42	0.50	0.57
B-15	Ycua Carrillo	0.37	0.44	0.63
B-16	Santa Rosa	0.33	0.41	0.56
B-17	Tres Puentes Cue	0.30	0.35	0.41
B-18	Itay	0.33	0.41	0.50
B-19	Lambare	0.36	0.51	0.67
B-20	Valle Apua	0.30	0.38	0.40
B-21	Villa Elisa	0.31	0.40	0.51
B-22	Nemby	0.30	0.36	0.44
B-23	San Lorenzo	0.30	0.32	0.35
B-24	Tayazuape	0.30	0.32	0.35
B-26	Zeballos Cue	0.32	0.35	0.41
B-27	Paso Cai	0.32	0.34	0.52

Table 5-4. COEFFICIENT FOR ESTIMATION OF CONCENTRATION TIME

River Basin Condition	Coefficient
Past (1965)	120
Present (1984)	100 or 120
Future (2005, Without Drainage Facilities)	100
Future (2000, With Drainage Facilities)	80

Table 5-5. EFFECT OF DETENTION FACILITIES

Type of Facilities	Return Period	Size of Facility	Maximum Discharge (m3/s) Inflow	Outflow	Regulation Effect (m^3/s)
Storage in House Lots	3-year	1 m^2	0.00381	0.00260	0.00121
	10-year	1 m^2	0.00510	0.00390	0.00120
	3-year	2 m^2	0.00381	0.00181	0.00200
	10-year	2 m^2	0.00510	0.00308	0.00202
Infiltration Facilities	3-year	10 m	0.00381	0.00305	0.00076
	10-year	10 m	0.00510	0.00434	0.00076
	3-year	20 m	0.00381	0.00229	0.00152
	10-year	20 m	0.00510	0.00358	0.00152

Table 5-6 (1/2). PROBABLE DISCHARGE (WITHOUT DETENTION FACILITIES)

RIVER BASIN	CATCHMENT AREA (km^2)	CASE NO.	RUNOFF COEFFICIENT	PROBABLE DISCHARGE 1.1-yr Tc	1.1-yr Q	2-yr Tc	2-yr Q	3-yr Tc	3-yr Q	5-yr Tc	5-yr Q	10-yr Tc	10-yr Q
				min	m^3/s	min	m^3/s	min	m^3/s	min	m^3/s	min	m^3/s
B-2	0.6	1	0.65	35	4.7	25	9.5	25	11.1	25	12.9	20	16.5
Jardin		2	0.68	25	5.9	20	10.8	20	12.7	20	14.7	15	18.9
		3	0.68	25	5.9	20	10.8	20	12.7	20	14.7	15	18.9
		4	0.68	20	6.6	15	11.9	15	13.9	15	16.1	10	20.5
B-4	2.47	1	0.57	50	13.6	40	27.3	40	32.2	35	40.3	35	47.6
Jaen		2	0.65	40	17.9	30	36.0	30	42.3	25	53.3	25	62.7
		3	0.67	40	18.5	30	37.1	30	43.6	25	54.9	25	64.7
		4	0.67	30	21.8	25	40.2	20	47.6	20	59.7	20	70.1
B-6	1.17	1	0.52	45	6.3	35	12.6	30	16.0	30	18.7	30	22.1
Salamanca		2	0.57	35	8.1	25	16.2	25	19.0	25	22.1	20	28.3
		3	0.58	35	8.2	25	16.5	25	19.3	25	22.5	20	28.8
		4	0.58	25	9.8	20	18.0	20	21.1	20	24.5	15	31.4
B-7	1.18	1	0.63	40	8.3	30	16.6	30	19.6	30	22.9	25	29.1
Zanja Moroti		2	0.64	30	10.0	25	18.3	25	21.5	20	27.2	20	32.0
		3	0.65	30	10.1	25	18.6	25	21.9	20	27.6	20	32.5
		4	0.65	25	11.1	20	20.3	20	23.8	15	30.3	15	35.5
B-8	4.0	1	0.5	65	16.2	50	34.2	45	43.0	40	53.6	40	63.4
Ferreira		2	0.63	45	26.2	35	52.4	35	61.8	30	77.5	30	91.4
		3	0.66	45	27.4	35	54.9	30	64.7	30	81.2	30	95.7
		4	0.66	35	31.9	25	64.1	25	75.2	25	93.3	20	111.9
B-10	2.12	1	0.48	55	9.2	40	19.7	40	23.3	35	29.2	35	34.4
Las Mercedes		2	0.59	40	14.0	30	28.0	30	33.0	25	41.5	25	48.9
		3	0.62	40	14.7	30	29.4	30	34.6	25	43.6	25	51.4
		4	0.62	30	17.3	25	31.9	20	37.2	20	47.4	20	55.7
B-12	0.75	1	0.5	40	4.2	30	8.4	30	9.9	25	12.4	25	14.7
Bella Vista		2	0.63	30	6.2	25	11.5	20	14.7	20	17.0	20	20.0
		3	0.65	30	6.4	20	11.8	20	15.1	20	17.6	20	20.7
		4	0.65	20	7.8	15	13.3	15	16.6	15	19.2	15	22.6
B-14	16.45	1	0.42	105	38.7	80	87.2	75	108.5	70	133.9	65	166.5
Mburicao		2	0.5	75	59.8	55	132.7	55	157.5	50	195.5	45	245.3
		3	0.57	70	71.8	55	151.3	50	189.9	45	236.3	45	279.6
		4	0.57	55	85.2	40	181.8	40	214.8	35	268.7	35	326.5
B-15	4.01	1	0.37	75	10.8	55	23.9	50	30.1	50	35.3	45	44.2
Ycua Carrillo		2	0.44	55	16.0	40	34.2	40	40.4	35	50.6	35	59.7
		3	0.63	45	26.2	35	52.5	35	61.9	30	77.7	30	91.6
		4	0.63	35	30.6	25	61.3	25	72.0	25	83.9	20	107.0
B-16	3.13	1	0.33	70	7.9	55	16.7	50	20.9	45	26.0	45	30.8
Santa Rosa		2	0.41	50	12.4	40	24.9	35	31.5	35	36.8	30	46.5
		3	0.56	45	18.2	35	36.4	30	46.2	30	53.9	30	63.6
		4	0.56	35	21.2	25	42.6	25	50.0	25	58.2	20	74.3
B-17	6.8	1	0.3	95	12.4	70	28.2	65	35.2	60	43.6	55	54.4
Tres Puentes		2	0.35	70	18.2	55	38.4	50	48.2	45	60.0	40	75.4
		3	0.41	65	22.5	50	47.7	45	59.9	45	73.8	40	88.4
		4	0.41	50	27.0	35	57.9	35	68.3	30	85.7	30	105.7
B-18	54.55	1	0.33	170	67.3	125	163.0	115	208.1	105	263.5	100	325.0
Itay		2	0.41	120	112.4	90	259.5	80	336.3	75	414.2	70	514.5
		3	0.5	110	147.2	80	344.0	75	428.5	70	528.5	65	657.5
		4	0.5	80	189.1	60	416.9	55	522.2	50	648.4	50	767.8

NOTE
Tc : Concentration Time (min)
Q : Run off Discharge (m3/s)

Case 1 : Under past river basin condition in 1965.
Case 2 : Under present river basin condition in 1984.
Case 3 : Under future river basin condition in 2005, without provision of drainage facilities.
Case 4 : Under future river basin condition in 2005, with provision of drainage facilities.

Table 5-6 (2/2). PROBABLE DESCHARGE (WITHOUT DETENTION FACILITIES)

RIVER BASIN	CATCHMENT AREA (km^2)	CASE NO.	RUNOFF COEFFICIENT	PROBABLE DISCHARGE									
				1.1-yr		2-yr		3-yr		5-yr		10-yr	
				Tc	Q	Tc	Q	Tc	Q	Tc	Q	Tc	Q
				min	m^3/s	min	m^3/s	min	m^3/s	min	m^3/s	min	m^3/s
B-19	25.66	1	0.36	130	43.4	95	103.0	90	127.9	80	163.8	75	203.2
Lambare		2	0.51	85	86.6	65	190.0	60	237.6	55	294.4	50	368.4
		3	0.67	75	125.1	55	277.4	55	329.2	50	408.7	45	512.6
		4	0.67	55	156.2	45	312.4	40	393.8	40	461.1	35	581.5
B-21	11.53	1	0.31	10	19.3	80	45.1	75	56.1	70	69.3	65	86.2
Villa Elisa		2	0.4	75	33.6	55	74.4	55	88.3	50	109.6	45	137.5
		3	0.51	65	47.5	50	100.5	50	119.1	45	148.2	40	186.4
		4	0.51	50	57.0	40	114.0	35	144.1	35	168.5	30	213.2
B-22	5.58	1	0.3	90	10.6	65	24.3	60	30.4	60	35.7	55	44.6
Nemby		2	0.36	80	13.9	60	30.7	55	38.5	55	45.2	50	56.5
		3	0.44	60	21.0	45	44.6	40	56.2	40	65.8	35	83.1
		4	0.44	45	25.5	35	51.0	30	64.7	30	75.5	30	91.2
B-23	33.69	1	0.32	150	44.9	110	107.8	100	138.3	95	169.6	85	218.1
San Lorenzo		2	0.37	140	55.1	105	129.1	95	166.0	90	203.8	80	262.7
		3	0.4	105	75.5	80	170.0	70	221.6	65	273.8	60	341.2
		4	0.4	75	98.1	60	206.0	55	258.0	50	320.4	45	401.8
B-24	30.13	1	0.3	150	37.6	110	90.4	100	116.0	95	142.2	85	182.9
Tayazuape		2	0.32	145	41.3	105	99.8	100	123.7	90	157.6	85	195.1
		3	0.35	105	59.1	80	128.5	75	165.7	70	204.3	65	254.2
		4	0.35	80	73.1	60	161.2	55	201.9	50	247.7	50	296.9
B-26	0.96	1	0.32	50	3.0	40	6.0	35	7.5	35	8.8	35	10.4
Zeballos Cue		2	0.35	50	3.3	40	6.5	35	8.2	35	9.6	30	11.7
		3	0.41	35	4.8	30	8.8	25	11.2	25	13.1	25	15.4
		4	0.41	30	5.2	20	10.4	20	12.2	20	14.2	20	16.7
B-27	5.49	1	0.32	85	11.6	65	25.5	60	31.9	55	39.5	50	49.5
Paso Cai		2	0.34	85	12.4	65	27.1	60	33.9	55	42.0	50	52.5
		3	0.52	55	25.9	40	55.4	40	65.4	35	81.8	35	96.6
		4	0.52	40	31.9	30	63.9	30	75.2	30	87.8	25	111.6

Table 5-7(1/3). PROBABLE DISCHARGE (WITH DETENTION FACILITIES AND WITHOUT DRAINAGE FACILITIES)

RIVER BASIN	CATCHMENT AREA (km^2)	RUNOFF COEFFICIENT	CASE NO.	PROBABLE DISCHARGE (m^3/s)				
				1.1-yr	2-yr	3-yr	5-yr	10-yr
B-2	0.6	0.68	1	5.9	10.8	12.7	14.7	18.9
Jardin			2	5.1	9.9	11.7	13.8	16.3
			3	3.9	8.9	10.8	12.9	15.4
			4	4.8	9.7	11.6	13.6	17.8
			5	4.0	8.9	10.8	12.8	17.0
			6	5.1	10.0	11.9	13.9	16.5
			7	3.8	9.3	11.1	13.1	15.7
B-4	2.47	0.67	1	18.5	37.1	43.6	54.9	64.7
Jaen			2	16.1	33.9	40.5	51.5	61.1
			3	13.6	30.7	37.3	44.6	57.6
			4	15.5	34.1	40.6	51.9	61.7
			5	13.4	31.9	38.5	49.8	59.5
			6	16.4	34.9	41.5	52.8	62.5
			7	12.9	32.8	39.3	50.7	60.4
B-6	1.17	0.58	1	8.2	16.5	19.3	22.5	28.8
Salamanca			2	6.9	14.8	17.7	20.9	26.9
			3	5.7	12.2	16.1	19.3	25.1
			4	6.9	15.2	18.1	21.3	27.5
			5	6.0	14.3	17.2	20.4	26.6
			6	7.3	15.6	18.4	21.6	27.9
			7	6.4	13.4	17.5	20.7	27.0
B-7	1.18	0.65	1	10.1	18.6	21.9	27.6	32.5
Zanja Moroti			2	8.0	16.9	20.2	23.8	30.6
			3	6.7	15.3	18.5	22.2	28.8
			4	8.5	17.0	20.2	26.0	30.8
			5	6.4	15.8	19.0	24.8	29.7
			6	8.1	17.4	20.7	24.3	31.3
			7	6.9	16.3	19.5	23.1	30.1
B-8	4.0	0.66	1	27.4	54.9	64.7	81.2	95.7
Ferreira			2	23.8	50.2	60.1	76.1	90.5
			3	19.1	45.5	55.4	71.1	85.3
			4	22.4	49.9	64.6	76.2	90.7
			5	18.8	46.3	61.0	72.6	87.2
			6	23.8	51.3	61.1	77.6	92.2
			7	18.4	47.7	57.6	74.0	88.6
B-10	2.12	0.62	1	14.7	29.4	34.6	43.6	51.4
Las Mercedes			2	12.6	26.7	31.9	40.7	48.3
			3	10.5	24.0	29.2	37.7	45.3
			4	12.2	26.9	32.1	41.1	48.8
			5	10.4	25.1	30.3	39.3	47.0
			6	12.9	27.6	32.8	41.8	49.6
			7	10.0	25.8	31.0	40.0	47.8
B-12	0.75	0.65	1	6.4	11.8	15.1	17.6	20.7
Bella Vista			2	5.5	10.8	14.0	16.4	19.5
			3	4.6	9.7	12.8	15.3	18.3
			4	5.5	11.9	14.2	16.6	19.7
			5	4.8	11.3	13.5	15.9	19.0
			6	5.7	11.1	14.4	16.9	20.0
			7	5.0	10.4	13.7	16.2	19.3
B-14	16.45	0.57	1	71.8	151.3	189.9	236.3	279.6
Mburicao			2	59.6	137.6	175.0	208.0	262.9
			3	49.0	123.8	152.0	193.1	246.1
			4	56.1	135.6	174.2	220.6	263.9
			5	41.3	124.4	163.0	209.4	252.7
			6	53.8	140.1	178.7	211.7	268.4
			7	39.6	120.9	157.1	200.5	257.2

Note:

Case 1 : Without detention facilities.
Case 2 : Storage facilities in public compound utilizing 2.5% of river basin area.
Case 3 : Storage facilities in public compound utilizing 5% of river basin area.
Case 4 : Storage facilities in house lots with capacity of 1.0 m^3.
Case 5 : Storage facilities in house lots with capacity of 2.0 m^3.
Case 6 : Infiltration facilities with the length of 10 m.
Case 7 : Infiltration facilities with the length of 20 m.

Table 5-7 (2/3). PROBABLE DISCHARGE (WITH DETENTION FACILITIES AND WITHOUT DRAINAGE FACILITIES)

RIVER BASIN	CATCHMENT AREA (km^2)	RUNOFF COEFFICIENT	CASE NO.	PROBABLE DISCHARGE (m^3/s)				
				1.1-yr	2-yr	3-yr	5-yr	10-yr
B-15	4.01	0.63	1	26.2	52.5	61.9	77.7	91.6
Ycua Carrillo			2	22.7	47.8	57.3	72.6	86.4
			3	18.0	43.1	52.6	67.5	81.1
			4	21.0	47.3	56.7	72.5	86.4
			5	17.3	43.6	53.0	68.8	82.7
			6	20.8	48.8	58.2	74.0	87.9
			7	15.6	41.6	54.5	70.3	84.2
B-16	3.13	0.56	1	18.2	36.4	46.2	53.9	63.6
Santa Rosa			2	15.4	32.8	39.3	49.9	59.5
			3	11.9	29.1	35.7	46.0	55.4
			4	14.3	32.6	42.3	50.0	59.7
			5	11.6	29.8	39.6	47.3	56.9
			6	14.2	33.7	40.2	51.1	60.8
			7	10.3	30.9	37.4	48.4	58.0
B-17	6.8	0.41	1	22.5	47.7	59.9	73.8	88.4
Tres Puentes Cue			2	18.3	41.5	53.3	63.6	80.9
			3	13.6	35.3	44.2	57.0	73.4
			4	19.2	44.3	56.6	66.9	85.0
			5	16.8	41.9	54.2	64.5	82.6
			6	20.1	45.3	57.5	67.9	86.0
			7	16.5	42.8	55.1	65.5	83.6
B-18	54.55	0.5	1	147.2	344.0	428.5	528.5	657.5
Itay			2	126.4	299.9	394.1	491.5	616.0
			3	108.4	270.2	345.9	454.5	574.6
			4	102.4	299.4	383.7	483.7	612.8
			5	70.5	267.4	351.8	451.8	580.8
			6	100.5	297.7	378.1	496.5	625.5
			7	64.2	252.5	346.2	441.2	593.6
B-19	25.66	0.67	1	125.1	277.4	329.2	408.7	512.6
Lambare			2	106.7	242.9	307.7	385.5	486.6
			3	94.2	223.0	286.2	362.3	435.6
			4	89.4	241.8	293.5	373.1	477.0
			5	58.0	216.3	268.0	347.6	451.5
			6	88.3	237.3	303.7	383.2	487.2
			7	57.9	198.6	278.2	357.8	433.0
B-21	11.53	0.51	1	47.5	100.5	119.1	148.2	186.4
Villa Elisa			2	38.4	85.3	108.7	136.9	173.7
			3	30.7	75.6	98.2	125.6	151.9
			4	34.0	89.5	108.1	137.2	175.3
			5	26.1	81.6	100.2	129.3	167.4
			6	34.9	87.0	111.2	140.3	178.5
			7	25.0	79.1	103.3	132.4	159.6
B-22	5.58	0.44	1	21.0	44.6	56.2	65.8	83.1
Nemby			2	17.2	39.1	47.3	59.9	76.4
			3	12.9	31.9	41.8	54.0	65.5
			4	17.6	41.2	52.8	62.4	79.6
			5	15.2	38.8	50.4	60.0	77.2
			6	18.6	42.2	50.3	63.4	80.6
			7	15.0	39.7	47.9	61.0	78.2
B-23	33.69	0.4	1	75.5	170.0	221.6	273.8	341.2
San Lorenzo			2	62.4	150.4	190.5	238.3	299.3
			3	51.0	126.1	169.3	215.4	273.7
			4	61.1	155.6	207.2	259.3	326.7
			5	50.7	145.2	196.9	249.0	316.4
			6	62.4	159.7	201.4	250.8	314.5
			7	44.8	142.3	191.1	240.5	304.2

Table 5-7 (3/3). PROBABLE DISCHARGE (WITH DETENTION FACILITIES AND WITHOUT DRAONAGE FACILITIES)

RIVER BASIN	CATCHMENT AREA (km^2)	RUNOFF COEFFICIENT	CASE NO.	PROBABLE DISCHARGE (m^3/s)				
				1.1-yr	2-yr	3-yr	5-yr	10-yr
B-24	30.13	0.35	1	59.1	128.5	165.7	204.3	254.2
Tayazuape			2	46.3	111.0	146.7	183.9	231.3
			3	37.1	94.6	123.1	163.5	208.4
			4	51.6	127.7	160.3	199.0	248.9
			5	47.8	123.9	156.5	195.2	245.1
			6	53.1	129.2	161.9	200.5	250.4
			7	47.3	119.9	158.1	196.7	246.6
B-26	0.96	0.41	1	4.8	8.8	11.2	13.1	15.4
Zeballos Cue			2	3.5	7.6	9.1	11.7	14.0
			3	2.5	6.3	7.9	10.4	12.6
			4	4.5	8.5	10.9	12.8	15.1
			5	4.2	8.3	10.7	12.6	14.9
			6	4.5	8.6	11.0	12.9	15.2
			7	4.0	8.4	9.9	12.6	15.0
B-27	5.49	0.52	1	25.9	55.4	65.4	81.8	96.6
Paso Cai			2	21.9	46.5	59.5	75.4	90.0
			3	17.0	41.1	53.7	64.9	83.4
			4	21.2	50.6	60.7	77.1	91.9
			5	17.9	47.3	57.3	73.7	88.5
			6	22.6	48.5	62.0	78.4	93.2
			7	17.7	45.1	58.7	69.8	89.8

Table 5-8(1/3). PROBABLE DISCHARGE (WITH DETENTION AND DRAINAGE FACILITIES)

RIVER BASIN	CATCHMENT AREA (km^2)	RUNOFF COEFFICIENT	CASE NO.	PROBABLE DISCHARGE (m3/s)				
				1.1-yr	2-yr	3-yr	5-yr	10-yr
B-2	0.6	0.68	1	6.6	11.9	13.9	16.1	20.5
Jardin			2	5.6	10.8	12.8	15.1	17.8
			3	4.7	9.8	11.8	14.0	16.8
			4	5.5	10.8	12.8	15.0	17.8
			5	4.7	10.0	12.0	14.2	17.0
			6	5.8	11.1	13.1	15.3	18.1
			7	5.0	10.3	12.3	14.5	17.3
B-4	2.47	0.67	1	21.8	40.2	47.6	59.7	70.1
Jaen			2	18.8	36.7	47.5	55.9	66.2
			3	15.8	33.1	40.2	52.0	62.3
			4	18.8	37.2	48.4	56.7	67.1
			5	16.7	35.1	46.2	54.5	65.0
			6	19.7	38.0	49.2	57.5	68.0
			7	17.6	35.9	42.9	55.4	65.8
B-6	1.17	0.58	1	9.8	18.0	21.1	24.5	31.4
Salamanca			2	8.2	16.1	19.2	22.7	29.3
			3	6.6	14.3	17.4	20.9	27.3
			4	8.6	16.7	19.8	23.2	30.1
			5	7.7	15.8	18.9	22.3	29.2
			6	8.9	17.1	20.2	23.6	30.5
			7	7.2	16.2	19.3	22.7	29.6
B-7	1.18	0.65	1	11.1	20.3	23.8	30.3	35.5
Zanja Moroti			2	9.5	18.5	22.0	25.8	33.4
			3	7.9	16.6	20.1	24.0	31.3
			4	9.5	18.7	22.1	28.6	33.8
			5	8.3	17.5	21.0	27.4	32.6
			6	9.9	19.1	22.6	26.5	34.3
			7	8.8	18.0	21.4	25.3	33.1
B-8	4.0	0.66	1	31.9	64.1	75.2	93.3	111.9
Ferreira			2	27.6	58.4	69.6	82.1	105.5
			3	23.2	48.8	64.0	76.5	91.7
			4	26.9	59.1	70.2	82.6	106.8
			5	23.4	55.5	66.7	79.0	103.3
			6	28.4	60.5	71.7	84.1	108.3
			7	24.8	52.0	68.1	80.5	104.7
B-10	2.12	0.62	1	17.3	31.9	37.2	47.4	55.7
Las Mercedes			2	14.8	28.9	37.5	44.1	52.3
			3	12.2	25.9	31.5	40.9	49.0
			4	14.8	29.4	38.3	44.9	53.2
			5	13.0	27.6	36.5	43.1	51.4
			6	15.5	30.1	39.0	45.6	53.9
			7	13.7	28.3	37.2	43.8	52.1
B-12	0.75	0.65	1	7.8	13.3	16.6	19.2	22.6
Bella Vista			2	6.7	11.7	15.3	17.9	21.2
			3	5.0	10.5	14.0	16.7	19.9
			4	6.9	13.3	15.6	18.3	21.6
			5	6.2	12.6	14.9	17.6	20.1
			6	7.2	12.2	15.9	18.5	21.9
			7	5.7	11.5	15.2	17.8	21.2
B-14	16.45	0.57	1	85.2	181.8	214.8	268.7	326.5
Mburicao			2	73.1	164.2	197.2	249.6	297.5
			3	58.0	138.0	179.7	230.6	277.8
			4	69.5	166.1	199.1	253.0	301.5
			5	58.3	154.9	187.9	241.8	290.3
			6	74.0	170.6	203.6	257.4	306.0
			7	57.8	148.0	192.4	246.2	294.8

Note:

Case 1 : Without detention facilities.
Case 2 : Storage facilities in public compound utilizing 2.5% of river basin area.
Case 3 : Storage facilities in public compound utilizing 5% of river basin area.
Case 4 : Storage facilities in house lots with capacity of 1.0 m^3.
Case 5 : Storage facilities in house lots with capacity of 2.0 m^3.
Case 6 : Infiltration facilities with the length of 10 m.
Case 7 : Infiltration facilities with the length of 20 m.

Table 5-8 (2/3). PROBABLE DISCHARGE (WITH DETENTION AND DRAINAGE FACILITIES)

RIVER BASIN	CATCHMENT AREA (km^2)	RUNOFF COEFFICIENT	CASE NO.	PROBABLE DISCHARGE (m^3/s)				
				1.1-yr	2-yr	3-yr	5-yr	10-yr
B-15	4.01	0.63	1	30.6	61.3	72.0	83.9	107.0
Ycua Carrillo			2	26.2	51.4	66.4	78.3	93.0
			3	21.8	46.3	60.7	72.7	87.2
			4	25.4	56.1	66.8	78.7	101.8
			5	21.7	52.4	63.1	75.0	98.1
			6	26.9	52.9	68.3	80.1	95.0
			7	20.8	49.2	64.6	76.4	91.3
B-16	3.13	0.56	1	21.2	42.6	50.0	58.2	74.3
Santa Rosa			2	17.8	38.1	45.6	53.8	69.3
			3	14.4	31.2	41.2	49.5	59.5
			4	17.3	38.7	46.1	54.3	70.4
			5	14.6	35.9	43.3	51.6	67.6
			6	18.4	39.8	47.2	55.4	71.5
			7	14.1	33.7	44.4	52.7	63.0
B-17	6.8	0.41	1	27.0	57.9	68.3	85.7	105.7
Tres Puentes Cue			2	21.5	46.8	60.4	72.0	92.2
			3	16.0	39.5	52.5	64.1	83.3
			4	23.6	54.6	65.0	82.4	97.7
			5	21.2	52.2	62.6	80.0	95.3
			6	24.6	51.6	65.9	77.5	98.7
			7	22.2	49.2	63.5	75.1	96.3
B-18	54.55	0.5	1	189.1	416.9	522.2	648.4	767.8
Itay			2	156.0	374.6	476.5	567.8	716.4
			3	127.3	317.4	410.3	522.0	665.1
			4	144.3	372.2	477.5	603.7	723.1
			5	112.4	340.2	445.5	571.7	691.1
			6	140.7	364.0	463.2	581.6	735.9
			7	101.6	332.1	431.2	549.7	703.9
B-19	25.66	0.67	1	156.2	312.4	393.8	461.1	581.5
Lambare			2	129.7	287.1	366.4	433.8	550.8
			3	112.4	261.9	339.1	406.5	520.1
			4	120.6	276.7	358.1	425.4	545.9
			5	85.9	251.2	332.7	399.9	520.4
			6	121.6	286.9	368.3	435.6	556.1
			7	88.0	261.4	318.7	410.1	530.6
B-21	11.53	0.51	1	57.0	114.0	144.1	168.5	213.2
Villa Elisa			2	47.7	101.7	130.7	155.1	198.2
			3	36.4	89.3	110.1	141.8	171.3
			4	45.9	103.0	133.1	157.4	202.2
			5	38.0	95.1	125.2	149.5	194.3
			6	45.5	106.1	136.2	160.6	205.3
			7	34.4	98.2	118.9	152.7	183.1
B-22	5.58	0.44	1	25.5	51.0	64.7	75.5	91.2
Nemby			2	20.5	44.5	53.7	68.4	81.7
			3	14.8	38.0	47.2	61.4	74.4
			4	22.1	47.6	61.3	72.1	85.6
			5	19.6	45.2	58.9	69.7	83.2
			6	23.0	48.6	62.3	73.1	86.6
			7	18.9	46.2	55.3	70.6	84.2
B-23	33.69	0.4	1	98.1	206.0	258.0	320.4	401.8
San Lorenzo			2	77.0	179.9	229.8	289.9	347.6
			3	58.9	153.7	201.5	246.6	315.9
			4	83.6	191.5	243.6	305.9	387.4
			5	68.6	181.2	233.3	295.6	377.1
			6	83.1	195.7	247.7	310.1	391.5
			7	68.5	185.3	237.4	299.7	358.7

Table 5-8 (3/3). PROBABLE DISCHARGE (WITH DETENTION AND DRAINAGE FACILITIES)

RIVER BASIN	CATCHMENT AREA (km^2)	RUNOFF COEFFICIENT	CASE NO.	PROBABLE DISCHARGE (m^3/s)				
				1.1-yr	2-yr	3-yr	5-yr	10-yr
B-24 Tayazuape	30.13	0.35	1	73.1	161.2	201.9	247.7	296.9
			2	56.2	137.8	176.7	212.0	268.5
			3	42.7	109.7	144.6	186.7	240.1
			4	67.8	155.9	196.6	245.4	291.5
			5	64.0	152.1	192.8	241.6	287.7
			6	69.3	157.4	198.1	246.9	293.1
			7	62.2	153.6	194.3	229.6	289.3
B-26 Zeballos Cue	0.96	0.41	1	5.2	10.4	12.2	14.2	16.7
			2	4.0	8.2	10.7	12.7	15.2
			3	2.9	6.8	9.2	11.2	13.6
			4	4.9	10.1	11.9	13.9	16.4
			5	4.7	9.9	11.7	13.7	16.2
			6	5.0	10.2	12.0	14.0	16.5
			7	4.8	9.1	11.8	13.8	16.2
B-27 Paso Cai	5.49	0.52	1	31.9	63.9	75.2	87.8	111.6
			2	26.5	52.9	68.2	80.8	103.7
			3	19.9	46.5	61.2	73.9	95.8
			4	27.2	59.2	70.5	83.1	106.9
			5	23.8	55.9	67.2	79.7	103.5
			6	28.5	56.0	71.9	84.4	108.2
			7	22.9	52.6	68.5	81.1	104.8

Table 5-9. FEATURES OF DETENTION FACILITIES

Type	Facility	Flood Control Effect	Economic Consideration	Maintenance Requirement	Safety Consideration	Legislation Requirement
Storage	Parking Lot Storage	Highly effective in discharge retardation over parking lots	Higher in cost due to shallow depth of storage	No special problem	No danger at the time of collapse due to simple construction	Require legislation for enforcement of installation
	Between-House Storage	Highly effective in discharge retardation in multiple dwelling area	Relatively lower in cost	Require maintenance to eliminate sanitary problems	Require safety measures to keep off small children	-ditto-
	Storage in Park	Good possibilities for discharge retardation only in park but also in vicinities; highly effective	-ditto-	Require precaution against accidents	Require safety measures to prevent accidents and to keep off small children	Problem on legislation may be less because it will be under the control of government authorities
	Storage in Public Compound	Larger compound; discharge retardation over its vicinity can also be expected; highly effective	-ditto-	-ditto-	-ditto-	-ditto-
	Storage in House Lot	Discharge retardation against an increase caused by housing lot development is great	Generally higher in cost, but possible to lower by adoption of different construction method	For maintenance require close cooperation of residents	- - -	Require legislation for enforcement of installation
Infiltration	Infiltration Inlet and Trench	-ditto-	Generally higher in cost when compared with storage type	Require maintenance for clogging prevention	- - -	Require legislation for installation in private lot; installation along roads by governemnt authorities may be simpler in procedure
	Infiltration Well	-ditto-	-ditto-	Difficult to maintain	Possibility of subsidence at fill-up gound	Require legislation for enforcement of installation

Table 6-1. LIST OF BASINS IN THE PLANNING AREA

Basin Number	Name of Basin	Area (ha)	Remarks
B-1	Varadero	325	
B-2	Jardin	60	
B-3	Centro	724	
B-4	Jaen	247	
B-5	Tacumbu	170	
B-6	Salamanca	143	
B-7	Zanja Moroti	161	
B-8	Ferreira	400	
B-9	Villa Universitaria	240	
B-10	Las Mercedes	212	
B-11	Mariscal Lopez	66	
B-12	Bella Vista	75	
B-13	Tablada	103	
B-14	Mburicao	1,645	
B-15	Ycua Carrillo	401	
B-16	Santa Rosa	313	
B-17	Tres Puentes Cue	680	
B-18	Itay	5,455	Subbasin No. 8, No. 9 and No. 10 are excluded.
B-19	Lambare	2,566	
B-20	Valle Apua	1,063	
B-21	Villa Elisa	955	Subbasin No. 2 is excluded.
B-22	Nemby	558	Subbasin No. 2 to No. 5 are excluded.
B-23	San Lorenzo	3,369	
B-24	Tayazuape	2,465	Subbasin No. 2 is excluded.
B-26	Zeballos Cue	213	
B-27	Paso Cai	549	
	Total	23,158	

Table 6-2. CONSTRUCTION COST OF ALTERNATIVES FOR BASIC PLAN

(Unit: ₲ million)

Basin Number	Name of Basin or River	Case I	Case II /2	Case III /2
1. Basins with River Channel				
B-2	Jardin	620	930	790
B-4	Jaen	3,120	3,690	3,410
B-6	Salamanca	1,550	1,990	1,790
B-7	Zanja Moroti	2,470	2,500	2,480
B-8	Ferreira	4,100	5,220	4,710
B-10	Las Mercedes	2,810	3,100	2,850
B-12	Bella Vista	750	900	860
B-14	Mburicao	21,660	24,580	22,980
B-15	Ycua Carrillo	5,640	6,060	5,900
B-16	Santa Rosa	3,500	4,220	3,870
B-17	Tres Puentes Cue	5,020	5,310	5,180
B-18	Itay	61,990	63,460	62,300
B-19	Lambare	34,000	36,610	34,460
B-21	Villa Elisa	9,090	11,670	16,830
B-22	Nemby	4,620	5,440	5,050
B-23	San Lorenzo	20,940	25,820	24,130
B-24	Tayazuape	9,710	13,110	12,120
B-26	Zeballos Cue	980	1,120	1,070
B-27	Paso Cai	4,340	5,640	5,230
	Sub-Total	196,910	221,370	210,010
2. Basins without River Channel /1				
B-1	Varadero	3,220	3,220	3,220
B-3	Centro	7,390	7,390	7,390
B-5	Tacumbu	1,150	1,150	1,150
B-9	Villa Universitaria	2,270	2,270	2,270
B-11	Mariscal Lopez	650	650	650
B-13	Tablada	1,020	1,020	1,020
B-20	Valle Apua	8,330	8,330	8,330
	Sub-Total	24,030	24,030	24,030
	Total	220,940	245,400	234,040

Note:

/1 Only drainage facilities are applied to these basins in all the study cases, because the cost is absolutely less than that of the combination with detention facilities.

/2 Costs of Case II and Case III were estimated on the assumption that about 15% of the design discharge are regulated by detention facilities.

Table 6-3. LAND ACQUISITION AND HOUSE EVACUATION OF ALTERNATIVES FOR BASIC PLAN

Basin Number	Name of Basin	Land Acquisition (m^2)		House Evacuation (No.)		Remarks
		Case I	Case II and III /1	Case I	Case II and III /1	
B-1	Varadero	-	-	-	-	No river
B-2	Jardin	-	-	-	-	River improvement is not required
B-3	Centro	-	-	-	-	No river
B-4	Jaen	9,500	5,900	14	7	
B-5	Tacumbu	-	-	-	-	No river
B-6	Salamanca	3,700	3,700	0	0	
B-7	Zanja Moroti	8,400	7,900	24	12	
B-8	Ferreira	16,800	14,800	20	15	
B-9	Villa Universitaria	-	-	-	-	No river
B-10	Las Mercedes	7,500	4,900	18	11	
B-11	Mariscal Lopez	-	-	-	-	No river
B-12	Bella Vista	-	-	-	-	River improvement is not required
B-13	Tablada	-	-	-	-	No river
B-14	Mburicao	42,300	36,500	40	24	
B-15	Ycua Carrillo	17,500	8,600	26	12	
B-16	Santa Rosa	14,400	7,600	21	10	
B-17	Tres Puentes Cue	6,000	6,000	-	-	
B-18	Itay	354,000	287,800	146	110	
B-19	Lambare	47,700	23,300	51	27	
B-20	Valle Apua	-	-	-	-	No river
B-21	Villa Elisa	62,800	62,800	-	-	
B-22	Nemby	14,200	14,200	-	-	
B-23	San Lorenzo	320,500	320,500	-	-	
B-24	Tayazuape	183,600	183,600	-	-	
B-26	Zeballos Cue	4,000	4,000	-	-	
B-27	Paso Cai	64,000	64,000	-	-	
	Total	1,160,900	1,056,100	360	228	

Note:

/1 : Results of Case II-2 and III-2 are shown.

Table 6-4 (1/2). DESIGN DISCHARGE FOR BASIC PLAN

No. of Basin	Name of Basin	No. of Subbasin	Design Discharge (m^3/s)	Remarks
B-1	Varadero	-	-	No River
B-2	Jardin	-	20	
B-3	Centro	-	-	No River
B-4	Jaen	-	70	
B-5	Tacumbu	-	-	No River
B-6	Salamanca	-	35	
B-7	Zanja Moroti	1	25	
		2	36	
B-8	Ferreira	1	85	
		2	115	
B-9	Villa Universitaria	-	-	No River
B-10	Las Mercedes	-	56	
B-11	Mariscal Lopez	-	-	No River
B-12	Bella Vista	-	25	
B-13	Tablada	-	-	No River
B-14	Mburicao	1	100	
		2	135	
		3	95	
		4	260	
		5	40	
		6	320	
B-15	Ycua Carrillo	1	50	
		2	110	
B-16	Santa Rosa	-	75	
B-17	Tres Puentes Cue	-	105	

Table 6-4 (2/2). DESIGN DISCHARGE FOR BASIC PLAN

No. of Basin	Name of Basin	No. of Subbasin	Design Discharge (m^3/s)	Remarks
B-18	Itay	1	320	
		2-1	360	
		2-2	200	
		3-1	50	
		3-2	50	
		4	95	
		5	110	
		6	670	Subbasins 8 to 10 are outside the Planning area
		7-1	160	
		7-2	60	
		7-3	35	
B-19	Lambare	1	115	
		2	75	
		3	340	
		4	450	
		5	130	
		6	190	
		7	590	
B-20	Valle Apua	-	-	No River
B-21	Villa Elisa	1	70	Subbasin 2 is outside the Planning Area
		3	220	
B-22	Nemby	1	90	Subbasins 2-5 are outside the Planning Area
B-23	San Lorenzo	1	230	
		2-1	290	
		2-2	95	
		2-3	410	
B-24	Tayazuape	1	170	Subbasin 2 is outside the Planning Area
		3	300	
B-26	Zeballos Cue	-	17	
B-27	Paso Cai	-	115	

Table 6-5. DESIGN STANDARD OF RIVER CHANNEL IMPROVEMENT

Type of Channel	Maximum Allowable Velocity (m/s)	Roughness Coefficient	Freeboard /1 $Q>30m^3/s$	Freeboard /1 $Q\leq 30m^3/s$
Channel Without Revetment (Type A)	3.0	0.035	0.6	0.3
Channel With Revetment and Without Invert (Type B)	4.0	0.025	0.6	0.3
Channel With Revetment and Invert (Type C)	5.0	0.020	0.6	0.3
Box Culvert (Type D)	5.0	0.020	0.6	- /2
Channel With Embankment and Revetment (Type E)	4.0	0.025	0.6	- /2

Note:

/1 Q: Design Discharge

/2 : Design discharges of Channel with Embankment and Revetment, and Box Culvert are bigger than 30 m^3/s.

Table 6-6. RUNOFF COEFFICIENT FOR DRAINAGE PLAN

Basin Number	Name of Basin or River	Runoff Coefficient (%) 1984	1995	2005
B-1	Varadero	63	65	67
B-2	Jardin	67	68	68
B-3	Centro	61	64	67
B-4	Jaen	65	66	67
B-5	Tacumbu	63	63	63
B-6	Salamanca	57	58	58
B-7	Zanja Moroti	64	65	65
B-8	Ferreira	63	65	66
B-9	Villa Universitaria	44	52	60
B-10	Las Mercedes	59	61	62
B-11	Mariscal Lopez	64	64	64
B-12	Bella Vista	63	64	65
B-13	Tablada	64	64	64
B-14	Mburicao	50	54	57
B-15	Ycua Carrillo	44	54	63
B-16	Santa Rosa	49	59	68
B-17	Tres Puentes Cue	51	63	75
B-18	Itay	45	51	56
B-19	Lambare	51	59	67
B-20	Valle Apua	42	47	52
B-21	Villa Elisa	42	47	51
B-22	Nemby	41	47	52
B-23	San Lorenzo	43	48	52
B-24	Tayazuape	40	45	49
B-26	Zeballos Cue	40	45	49
B-27	Paso Cai	43	53	63

Table 6-7. ROOFTOP AND IMPERMEABLE AREA IN RESIDENTIAL AREAS

Item	House Lot Average Area (ha)	Rooftop Area (ha)	Impermeable Area (ha)
High Density Residential Area	14.4 (100%)	9.1 (60%)	5.3 (40%)
Medium Density Residential Area	11.5 (100%)	4.8 (40%)	6.7 (60%)
Low Density Residential Area	4.4 (100%)	2.8 (60%)	1.6 (40%)

Table 6-8. CAPACITY OF DETENTION FACILITIES TO CONTROL ONE CUBIC METER OF RUNOFF DISCHARGE

Basin Number	Name of Basin or River	Storage in Public Compounds (ha)	Infiltration Trench (m)	Storage in House Lots (m^3)
With Drainage Facilities				
B-2	Jardin	1.4	12,800	1,000
B-4	Jaen	1.7	12,000	1,000
B-6	Salamanca	1.6	12,300	980
B-7	Zanja Moroti	1.3	9,800	990
B-8	Ferreira	1.7	12,300	1,000
B-10	Las Mercedes	1.7	12,900	1,010
B-12	Bella Vista	1.3	10,000	1,060
B-14	Mburicao	2.3	12,500	1,030
B-15	Ycua Carrillo	1.4	8,300	1,000
B-16	Santa Rosa	1.7	11,100	1,000
B-17	Tres Puentes Cue	1.9	8,400	1,030
B-18	Itay	2.6	8,900	1,010
B-19	Lambare	2.4	11,600	990
B-21	Villa Elisa	2.1	10,700	1,010
B-22	Nemby	2.0	11,800	1,010
B-23	San Lorenzo	2.7	11,000	990
B-24	Tayazuape	2.9	11,100	1,020
B-26	Zeballos Cue	1.6	11,700	1,030
B-27	Paso Cai	1.9	10,200	1,000
Without Drainage Facilities				
B-2	Jardin	1.4	9,700	1,000
B-4	Jaen	1.9	12,700	1,000
B-6	Salamanca	1.8	12,000	980
B-7	Zanja Moroti	1.5	9,300	990
B-8	Ferreira	1.9	10,500	1,000
B-10	Las Mercedes	2.0	12,600	1,010
B-12	Bella Vista	1.5	10,600	1,010
B-14	Mburicao	2.5	9,800	1,020
B-15	Ycua Carrillo	2.2	11,500	1,000
B-16	Santa Rosa	1.9	10,300	1,010
B-17	Tres Puentes Cue	2.7	12,700	1,010
B-18	Itay	2.8	10,100	1,010
B-19	Lambare	2.6	10,400	1,000
B-21	Villa Elisa	2.5	10,200	980
B-22	Nemby	2.3	10,600	1,010
B-23	San Lorenzo	3.2	7,800	1,010
B-24	Tayazuape	4.0	11,100	950
B-26	Zeballos Cue	1.7	11,000	1,030
B-27	Paso Cai	2.1	10,300	1,000

Note: Detention facilities are not employed in basins without rivers.

Table 6-9. COMPARISON OF CONSTRUCTION COST OF DETENTION FACILITIES FOR BASIC PLAN

(Unit: ¢ million)

Basin Number	Name of Basin	Case II	Case III
B-2	Jardin	360	230
B-4	Jaen	860	580
B-6	Salamanca	570	380
B-7	Zanja Moroti	280	260
B-8	Ferreira	1,560	1,050
B-10	Las Mercedes	720	470
B-12	Bella Vista	230	180
B-14	Mburicao	5,340	3,740
B-15	Ycua Carrillo	1,390	1,230
B-16	Santa Rosa	1,250	900
B-17	Tres Puentes Cue	1,320	1,190
B-18	Itay	9,390	8,230
B-19	Lambare	7,920	5,770
B-21	Villa Elisa	3,610	2,770
B-22	Nemby	1,340	950
B-23	San Lorenzo	7,240	5,550
B-24	Tayazuape	4,480	3,490
B-26	Zeballos Cue	190	130
B-27	Paso Cai	1,800	1,390
	Total	49,850	38,490

Note: Only drainage facilities are applied to basins without river in all the study cases, because the cost is absolutely less than that of the combination with detention facilities.

Costs of Case II and Case III have been estimated on the assumption that about 15% of the design discharge is regulated by detention facilities.

Table 6-10. FEATURES OF PROPOSED STORM WATER CONTROL SYSTEM FOR BASIC PLAN

Basin Number	Name of Basin	River			Drainage Facilities Improvement Area (ha)	Detention Facilities		Remarks
		Design Discharge (m^3/s)	Type of /1 Channel	Improvement Length (km)		Storage in Public Compounds (ha)	Storage in House Lots (m^3)	
B-1	Varadero	-	-	-	314	-	-	No river.
B-2	Jardin	20	-	-	60	-	-	Improvement not necessary.
B-3	Centro	-	-	-	706	-	-	No river.
B-4	Jaen	62	B	1.9	247	6.8	4,000	
B-5	Tacumbu	-	-	-	117	-	-	No river.
B-6	Salamanca	35	B	1.8	143	-	-	
B-7	Zanja Moroti	30	E	0.6	161	3.9	3,000	
B-8	Ferreira	100	E	0.7	400	12.8	7,500	
B-9	Villa Universitaria	-	-	-	240	-	-	No river.
B-10	Las Mercedes	48	C	1.4	212	6.8	4,000	
B-11	Mariscal Lopez	-	-	-	66	-	-	No river.
B-12	Bella Vista	25	-	-	75	-	-	Improvement not necessary.
B-13	Tablada	-	-	-	103	-	-	No river.
B-14	Mburicao	270	B	6.5				
			C	2.2				
	Sub-Total			8.7	1,645	57.5	25,800	
B-15	Ycua Carrillo	85	B	3.0	401	17.5	12,500	
B-16	Santa Rosa	64	B	2.4	229	9.4	5,500	
B-17	Tres Puentes Cue	105	B	6.0	224	-	-	
B-18	Itay	650	A	12.6				
			B	10.4				
			D	2.5				
	Sub-Total			25.5	4,064	135.0	50,500	
B-19	Lambare	470	B	6.2				
			C	1.4				
			D	0.8				
	Sub-Total			8.4	2,566	144.0	59,400	
B-20	Valle Apua	-	-	-	968	-	-	No river.
B-21	Villa Elisa	70	A	3.4	955	-	-	
B-22	Nemby	90	A	3.5	371	-	-	
B-23	San Lorenzo	410	A	14.2				
			B	1.6				
	Sub-Total			15.8	1,759	-	-	
B-24	Tayazuape	300	A	8.1	701	-	-	
B-26	Zeballos Cue	17	A	0.4	117	-	-	
B-27	Paso Cai	115	A	4.0	375	-	-	
	Total			95.6	17,219	393.7	172,200	

/1 Type of Channel; A : Channel Without Revetment
B : Channel With Revetment and Without Invert
C : Channel With Revetment and Invert
D : Box Culvert
E : Channel With Embankment

Table 6-11 (1/2). REQUIRED WIDTH OF RIVER IMPROVEMENT FOR BASIC PLAN

Basin Number	Name of Basin	Subbasin Number	Required Width (m)		
			River Width	Maintenance Road /1	Total
B-2	Jardin	- /2	5.3	2.0	7.3
B-4	Jaen	-	9.6	2.0	11.6
B-6	Salamanca	-	7.5	2.0	9.5
B-7	Zanja Moroti	1 /2	5.3	2.0	7.3
		2-1 /2	5.5	2.0	7.5
		2-2	25.1	(6.0)	25.1
B-8	Ferreira	1 /2	9.0	2.0	11.0
		2-1 /2	10.4	2.0	12.4
		2-2	36.1	(6.0)	36.1
B-10	Las Mercedes	1	6.5	2.0	8.5
		2	6.5	2.0	8.0
B-12	Bella Vista	- /2	6.0	2.0	8.0
B-14	Mburicao	1	11.7	2.0	13.7
		2	12.7	2.0	14.7
		3	10.6	2.0	12.6
		4	20.6	2.0	22.6
		5	8.3	2.0	10.3
		6	25.0	2.0	27.0
B-15	Ycua Carrillo	1	6.4	2.0	8.4
		2	10.4	2.0	12.4
B-16	Santa Rosa	-	9.8	2.0	11.8
B-17	Tres Puentes Cue	-	12.2	2.0	14.2
B-18	Itay	1	19.2	-	19.2
		2-1	24.4	1.0	25.4
		2-2	33.0	4.0	37.0
		3-1	7.5	1.0	8.5
		3-2	8.0	4.0	12.0
		4	27.7	4.0	31.7

Note: /1 : Width of the maintenance road depends on the type of channel (refer to Fig. 6-4.)
/2 : River improvement is not required.

Table 6-11 (2/2). REQUIRED WIDTH OF RIVER IMPROVEMENT FOR BASIC PLAN

Basin Number	Name of Basin	Subbasin Number	Required Width (m)		
			River Width	Maintenance Road /1	Total
B-18	Itay (Cont.)	5	12.6	4.0	16.6
		6	51.0	4.0	55.0
		7-1	24.0	4.0	28.0
		7-2	15.9	4.0	19.9
		7-3	13.0	4.0	17.0
B-19	Lambare	1	8.6	2.0	10.6
		2	7.7	2.0	9.7
			8.0	-	8.0
		3	17.7	4.0	21.7
		4	21.3	4.0	25.3
		5 /2	-	-	-
		6 /2	-	-	-
		7	28.0	4.0	32.0
B-21	Villa Elisa	1	19.9	4.0	23.9
		3	31.8	4.0	35.8
B-22	Nemby	1	23.5	4.0	27.5
B-23	San Lorenzo	1	25.2	4.0	29.2
			16.2	4.0	20.2
		2-1	49.0	4.0	53.0
		2-2	25.0	4.0	29.0
		2-3	60.9	4.0	64.9
B-24	Tayazuape	1	29.0	4.0	33.0
		3	52.0	4.0	56.0
B-26	Zeballos Cue	-	14.0	4.0	18.0
B-27	Paso Cai	-	26.0	4.0	30.0

Note: /1 : Width of the maintenance road depends on the type of channel (refer to Fig. 6-4.)
/2 : River improvement is not required.

Table 6-12. CONSTRUCTION COST OF PROPOSED STORM WATER CONTROL SYSTEM FOR BASIC PLAN

(Unit: ¢ Million)

Basin Number	Name of Basin or River	River	Drainage Facilities	Detention Facilities	Total
B-1	Varadero	-	3,220	-	3,220
B-2	Jardin	-	620	-	620
B-3	Centro	-	7,390	-	7,390
B-4	Jaen	550	2,470	440	3,470
B-5	Tacumbu	-	1,150	-	1,150
B-6	Salamanca	230	1,320	-	1,550
B-7	Zanja Moroti	710	1,580	310	2,610
B-8	Ferreira	820	3,140	850	4,810
B-9	Villa Universitaria	-	2,270	-	2,270
B-10	Las Mercedes	570	1,970	460	3,010
B-11	Mariscal Lopez	-	650	-	650
B-12	Bella Vista	-	750	-	750
B-13	Tablada	-	1,020	-	1,020
B-14	Mburicao	3,810	14,850	3,240	21,910
B-15	Ycua Carrillo	1,130	3,510	1,320	5,980
B-16	Santa Rosa	920	2,190	620	3,730
B-17	Tres Puentes Cue	2,540	2,480	-	5,020
B-18	Itay	21,290	34,440	8,280	64,020
B-19	Lambare	5,780	24,000	7,780	37,570
B-20	Valle Apua	-	8,330	-	8,330
B-21	Villa Elisa	1,000	8,090	-	9,090
B-22	Nemby	1,420	3,190	-	4,620
B-23	San Lorenzo	5,880	15,050	-	20,940
B-24	Tayazuape	3,930	5,780	-	9,710
B-26	Zeballos Cue	20	960	-	980
B-27	Paso Cai	660	3,680	-	4,340
	Total	51,260	154,100	23,300	228,760

Table 7-1 (1/3). CONSTRUCTION COST OF ALTERNATIVES FOR MASTER PLAN (RETURN PERIOD: 3-YEAR)

(Unit: ¢ Million)

Basin Number	Name of Basin or River	Case I-1	Case I-2/2	Case I-3/2
1.	Basins With River Channel			
B-2	Jardin	500	610	560
B-4	Jaen	2,560	2,870	2,730
B-6	Salamanca	1,260	1,400	1,340
B-7	Zanja Moroti	1,920	2,010	1,970
B-8	Ferreira	3,330	4,270	3,910
B-10	Las Mercedes	2,100	2,340	2,220
B-12	Bella Vista	620	730	700
B-14	Mburicao	16,220	18,900	17,330
B-15	Ycua Carrillo	4,030	4,720	4,500
B-16	Santa Rosa	2,650	3,510	3,110
B-17	Tres Puentes Cue	3,220	3,800	3,690
B-18	Itay	47,670	50,430	48,640
B-19	Lambare	26,050	35,090	31,320
B-21	Villa Elisa	7,300	10,780	9,750
B-22	Nemby	3,620	5,110	4,470
B-23	San Lorenzo	16,450	22,320	20,420
B-24	Tayazuape	7,470	13,490	11,920
B-26	Zeballos Cue	800	1,090	1,000
B-27	Paso Cai	3,470	5,790	5,080
	Sub-Total	151,240	189,260	174,660
2.	Basins Without River Channel/1			
B-1	Varadero	2,640	2,640	2,640
B-3	Centro	1,820	1,820	1,820
B-5	Tacumbu	940	940	940
B-9	Villa Universitaria	1,860	1,860	1,860
B-11	Mariscal Lopez	540	540	540
B-13	Tablada	840	840	840
B-20	Valle Apua	6,840	6,840	6,840
	Sub-Total	15,480	15,480	15,480
	Total	166,720	204,740	190,140

Note: /1 Only drainage facilities are applied to these basins in all the study cases, because the cost is absolutely less than that of the combination with detention facilities.

/2 Costs have been estimated on the assumption that the runoff discharge under the land use condition as of 1984 is confined by drainage system and the incremental discharge for future urbanization up to 2005 by detention facilities.

Table 7-1 (2/3). CONSTRUCTION COST OF ALTERNATIVES FOR MASTER PLAN (RETURN PERIOD: 3-YEAR)

(Unit: ₲ Million)

Basin Number	Name of Basin or River	Case II-1	Case II-2/2	Case II-3/2
1.	Basins With River Channel			
B-2	Jardin	60	60	60
B-4	Jaen	1,090	1,180	1,130
B-6	Salamanca	210	230	220
B-7	Zanja Moroti	650	660	660
B-8	Ferreira	1,840	2,020	1,960
B-10	Las Mercedes	390	500	460
B-12	Bella Vista	160	180	170
B-14	Mburicao	7,520	8,890	8,400
B-15	Ycua Carrillo	1,160	2,560	2,050
B-16	Santa Rosa	760	1,710	1,470
B-17	Tres Puentes Cue	1,260	2,220	1,870
B-18	Itay	21,790	25,060	23,730
B-19	Lambare	9,420	15,670	14,030
B-21	Villa Elisa	540	2,930	2,380
B-22	Nemby	840	2,070	1,760
B-23	San Lorenzo	3,540	7,550	7,320
B-24	Tayazuape	2,330	6,550	5,560
B-26	Zeballos Cue	10	240	180
B-27	Paso Cai	430	2,790	2,240
	Sub-Total	54,000	83,070	75,650
2.	Basins Without River Channel/1			
B-1	Varadero	520	520	520
B-3	Centro	-	-	-
B-5	Tacumbu	150	150	150
B-9	Villa Universitaria	20	20	20
B-11	Mariscal Lopez	250	250	250
B-13	Tablada	150	150	150
B-20	Valle Apua	-	-	-
	Sub-Total	1,090	1,090	1,090
	Total	55,090	84,160	76,740

Note: /1 Only drainage facilities are applied to these basins in all the study cases, because the cost is absolutely less than that of the combination with detention facilities.

/2 Costs have been estimated on the assumption that the runoff discharge under the land use condition as of 1984 is confined by drainage system and the incremental discharge for future urbanization up to 2005 by detention facilities.

Table 7-1 (3/3). CONSTRUCTION COST OF ALTERNATIVES FOR MASTER PLAN (RETURN PERIOD: 3-YEAR)

(Unit: ¢ Million)

Basin Number	Name of Basin or River	Case III-1	Case III-2/1	Case III-3/1
1.	Basins With River Channel			
B-2	Jardin	-	-	-
B-4	Jaen	-	-	-
B-6	Salamanca	-	-	-
B-7	Zanja Moroti	-	-	-
B-8	Ferreira	-	-	-
B-10	Las Mercedes	20	160	110
B-12	Bella Vista	-	-	-
B-14	Mburicao	4,380	6,590	6,070
B-15	Ycua Carrillo	-	-	-
B-16	Santa Rosa	550	1,400	1,160
B-17	Tres Puentes Cue	-	-	-
B-18	Itay	12,630	18,840	17,310
B-19	Lambare	4,680	11,820	10,170
B-21	Villa Elisa	-	-	-
B-22	Nemby	-	-	-
B-23	San Lorenzo	-	-	-
B-24	Tayazuape	-	-	-
B-26	Zeballos Cue	-	-	-
B-27	Paso Cai	-	-	-
	Sub-Total	22,260	38,810	34,820
2.	Basins Without River Channel			
B-1	Varadero	-	-	-
B-3	Centro	-	-	-
B-5	Tacumbu	-	-	-
B-9	Villa Universitaria	-	-	-
B-11	Mariscal Lopez	-	-	-
B-13	Tablada	-	-	-
B-20	Valle Apua	-	-	-
	Sub-Total	-	-	-
	Total	22,260	38,810	34,820

Note: /1 Costs have been estimated on the assumption that the runoff discharge under the land use condition as of 1984 is controlled by drainage system and the incremental discharge for future urbanization up to 2005 by detention facilities.

Table 7-2. LAND ACQUISITION AND HOUSE EVACUATION OF ALTERNATIVES FOR MASTER PLAN

(Unit: m^2)

Basin Number	Name of Basin	Case I			Case II			Case III		
		I-1	I-2	I-3	II-1	II-2	II-3	III-1	III-2	III-3
Land Acquisition										
B-1	Varadero	-	-	-	-	-	-	-	-	-
B-2	Jardin	-	-	-	-	-	-	-	-	-
B-3	Centro	-	-	-	-	-	-	-	-	-
B-4	Jaen	4,200	3,000	3,000	3,300	3,000	3,000	3,000	3,000	3,000
B-5	Tacumbu	-	-	-	-	-	-	-	-	-
B-6	Salamanca	500	-	-	100	-	-	-	-	-
B-7	Zanja Moroti	7,200	7,000	7,000	7,000	7,000	7,000	7,000	7,000	7,000
B-8	Ferreira	14,600	13,800	13,800	14,000	13,800	13,800	13,800	13,800	13,800
B-9	Villa Universitaria	-	-	-	-	-	-	-	-	-
B-10	Las Mercedes	3,700	2,900	2,900	3,200	2,900	2,900	2,900	2,900	2,900
B-11	Mariscal Lopez	-	-	-	-	-	-	-	-	-
B-12	Bella Vista	-	-	-	-	-	-	-	-	-
B-13	Tablada	-	-	-	-	-	-	-	-	-
B-14	Mburicao	34,400	30,000	30,000	32,500	30,000	30,000	30,000	30,000	30,000
B-15	Ycua Carrillo	10,100	4,000	4,000	8,200	4,000	4,000	4,000	4,000	4,000
B-16	Santa Rosa	8,500	4,100	4,100	7,600	4,100	4,100	4,100	4,100	4,100
B-17	Tres Puentes Cue	2,100	-	-	1,200	-	-	-	-	-
B-18	Itay	276,300	217,900	217,900	246,900	217,900	217,900	217,900	217,900	217,900
B-19	Lambare	26,500	9,600	9,600	19,500	9,600	9,600	9,600	9,600	9,600
B-20	Valle Apua	-	-	-	-	-	-	-	-	-
B-21	Villa Elisa	50,900	42,200	42,200	47,000	42,200	42,200	42,200	42,200	42,200
B-22	Nemby	7,200	-	-	4,900	-	-	-	-	-
B-23	San Lorenzo	228,500	172,800	172,800	206,400	172,800	172,800	172,800	172,800	172,800
B-24	Tayazuape	116,500	62,900	62,900	91,700	62,900	62,900	62,900	62,900	62,900
B-26	Zeballos Cue	3,900	3,800	3,800	3,900	3,800	3,800	3,800	3,800	3,800
B-27	Paso Cai	52,800	41,200	41,200	50,100	41,200	41,200	41,200	41,200	41,200
	Total	847,900	592,700	592,700	747,500	592,700	592,700	592,700	592,700	592,700
House Evacuation										
B-1	Varadero	-	-	-	-	-	-	-	-	-
B-2	Jardin	-	-	-	-	-	-	-	-	-
B-3	Centro	-	-	-	-	-	-	-	-	-
B-4	Jaen	6	4	4	4	4	4	4	4	4
B-5	Tacumbu	-	-	-	-	-	-	-	-	-
B-6	Salamanca	-	-	-	-	-	-	-	-	-
B-7	Zanja Moroti	10	8	8	8	8	8	8	8	8
B-8	Ferreira	13	11	11	11	11	11	11	11	11
B-9	Villa Universitaria	-	-	-	-	-	-	-	-	-
B-10	Las Mercedes	9	7	7	8	7	7	7	7	7
B-11	Mariscal Lopez	-	-	-	-	-	-	-	-	-
B-12	Bella Vista	-	-	-	-	-	-	-	-	-
B-13	Tablada	-	-	-	-	-	-	-	-	-
B-14	Mburicao	26	18	18	23	18	18	18	18	18
B-15	Ycua Carrillo	17	10	10	15	10	10	10	10	10
B-16	Santa Rosa	12	6	6	11	6	6	6	6	6
B-17	Tres Puentes Cue	-	-	-	-	-	-	-	-	-
B-18	Itay	123	101	101	112	101	101	101	101	101
B-19	Lambare	33	21	21	28	21	21	21	21	21
B-20	Valle Apua	-	-	-	-	-	-	-	-	-
B-21	Villa Elisa	-	-	-	-	-	-	-	-	-
B-22	Nemby	-	-	-	-	-	-	-	-	-
B-23	San Lorenzo	-	-	-	-	-	-	-	-	-
B-24	Tayazuape	-	-	-	-	-	-	-	-	-
B-26	Zeballos Cue	-	-	-	-	-	-	-	-	-
B-27	Paso Cai	-	-	-	-	-	-	-	-	-
	Total	249	183	183	220	183	183	183	183	183

Table 7-3 (1/2). DESIGN DISCHARGE FOR MASTER PLAN

No. of Basin	Name of Basin	No. of Subbasin	Design Discharge (m^3/s)	Remarks
B-1	Varadero	-	-	No River
B-2	Jardin	-	15	
B-3	Centro	-	-	No River
B-4	Jaen	-	45	
B-5	Tacumbu	-	-	No River
B-6	Salamanca	-	20	
B-7	Zanja Moroti	1	15	
		2	25	
B-8	Ferreira	1	55	
		2	70	
B-9	Villa Universitaria	-	-	No River
B-10	Las Mercedes	-	35	
B-11	Mariscal Lopez	-	-	No River
B-12	Bella Vista	-	20	
B-13	Tablada	-	-	No River
B-14	Mburicao	1	65	
		2	80	
		3	55	
		4	150	
		5	25	
		6	190	
B-15	Ycua Carrillo	1	35	
		2	65	
B-16	Santa Rosa	-	50	
B-17	Tres Puentes Cue	-	60	

Table 7-3 (2/2). DESIGN DISCHARGE FOR MASTER PLAN

No. of Basin	Name of Basin	No. of Subbasin	Design Discharge (m^3/s)	Remarks
B-18	Itay	1	190	
		2-1	210	
		2-2	110	
		3-1	30	
		3-2	30	
		4	60	
		5	65	
		6	390	Subbasins 8 to 10 are outside the Planning area
		7-1	95	
		7-2	35	
		7-3	25	
B-19	Lambare	1	70	
		2	45	
		3	200	
		4	250	
		5	80	
		6	110	
		7	330	
B-20	Valle Apua	-	-	No River
B-21	Villa Elisa	1	45	Subbasin 2 is outside the Planning Area
		3	120	
B-22	Nemby	1	60	Subbasins 2-5 are outside the Planning Area
B-23	San Lorenzo	1	130	
		2-1	160	
		2-2	45	
		2-3	230	
B-24	Tayazuape	1	95	Subbasin 2 is outside the Planning Area
		3	170	
B-26	Zeballos Cue	-	12	
B-27	Paso Cai	-	70	

Table 7-4. AVERAGE ANNUAL AMORTIZATION OF ALTERNATIVES FOR MASTER PLAN

(Unit: ¢ Million)

Study Case	Without Loan		With Loan	
	Total	Annual Average	Total	Annual Average
Case I-1	297,520	15,660	541,520	11,280
Case I-2	365,370	19,230	664,970	13,850
Case I-3	339,320	17,860	617,600	12,870
Case II-1	98,310	5,170	178,780	3,720
Case II-2	150,190	7,900	273,180	5,690
Case II-3	136,950	7,210	249,320	5,190
Case III-1	39,720	2,090	72,270	1,510
Case III-2	69,260	3,650	126,220	2,630
Case III-3	62,140	3,270	113,080	2,360

Note: The costs mentioned in the second and third subdivisions of each case have been estimated on the assumption that the present discharge is contolled by drainage system and the residual discharge by detention facilities.

Terms and conditions of loan are an annual interest rate of 4% and a repayment period of 30 years including a 10-year grace period.

Table 7-5 (1/2). FEATURES OF PROPOSED RIVER CHANNEL FOR MASTER PLAN

Basin Number	Name of Basin	Subbasin Number	Type of River /1 Channel	Length of River Channel Impv't. (km)	Required Width (m) River Width	Maintenance Road	Total	Remarks
B-2	Jardin	-	-	0	-	-	-	River improvement is not necessary
B-4	Jaen	-	B	1.9	7.7	2.0	9.7	
B-6	Salamanca	-	B	1.3	4.7	2.0	6.7	
B-7	Zanja Moroti	1	-	0	-	-	-	River improvement is not necessary
		2-1	-	0	-	-	-	-do-
		2-2	E	0.6	24.5	(6.0)/2	24.5	
B-8	Ferreira	1	-	0	-	-	-	River improvement is not necessary
		2-1	-	0	-	-	-	-do-
		2-2	E	0.7	33.7	(6.0)/2	33.7	
B-10	Las Mercedes	1	C	1.2	5.4	2.0	7.4	
		2	C	0.2	6.4	2.0	8.4	
	Total -			1.4				
B-12	Bella Vista	-	-	0	-	-	-	River improvement is not necessary
B-14	Mburicao	1	C	0.1	3.6	2.0	5.6	
		2	C	0.4	8.1	2.0	10.1	
		3	C	1.0	7.0	2.0	9.0	
		4	B	1.2	15.7	2.0	17.7	
		5	B	0.4	7.1	2.0	9.1	
		6	B	2.5	19.1	2.0	21.1	
	Total -			5.6				
B-15	Ycua Carrillo	1	B	0.7	6.4	2.0	8.4	
		2	B	1.2	10.1	2.0	12.1	
	Total -			1.9				
B-16	Santa Rosa	-	B	2.4	8.2	2.0	10.2	
B-17	Tres Puentes Cue	-	B	6.0	9.4	2.0	11.4	

Note:
/1 Type of Channel;
A : Channel Without Revetment
B : Channel With Revetment and Without Invert
C : Channel With Revetment and Invert
D : Box Culvert
E : Channel With Embankment
/2 The crown of the embankment will serve as maintenance road.

Table 7-5 (2/2). FEATURES OF PROPOSED RIVER CHANNEL FOR MASTER PLAN

Basin Number	Name of Basin	Subbasin Number	Type of River /1 Channel	Length of River Channel Impv't. (km)	Required Width (m) River Width	Required Width (m) Maintenance Road	Required Width (m) Total	Remarks
B-18	Itay	1	D	2.5	14.1	-	14.1	
		2-1	B	2.2	17.4	1.0	18.4	
		2-2	A	1.2	26.6	4.0	30.6	
		3-1	B	2.7	9.8	2.0	11.8	
		3-2	B	2.3	7.6	4.0	11.6	
		4	B	0.5	5.1	2.0	7.1	
			B	1.0	9.1	4.0	13.1	
			A	1.2	22.2	4.0	26.2	
		5	B	1.7	10.0	4.0	14.0	
		6	A	3.5	40.5	4.0	44.5	
		7-1	A	2.7	21.0	4.0	25.0	
		7-2	A	2.3	16.0	4.0	20.0	
		7-3	A	1.4	13.0	4.0	17.0	
	Total -			25.5				
B-19	Lambare	1	C	0.8	7.8	2.0	9.8	
		2	C	0.6	6.6	2.0	8.6	
			D	0.8	8.0	-	8.0	
		3	B	0.9	12.6	4.0	16.6	
		4	B	2.7	14.4	4.0	18.4	
		5	-	0	-	-	-	River Improvement is not necessary
		6	-	0	-	-	-	-do-
		7	B	1.1	19.4	4.0	23.4	
	Total -			6.9				
B-21	Villa Elisa	1	A	1.6	15.8	4.0	19.8	
		3	A	1.8	24.3	4.0	28.3	
	Total -			3.4				
B-22	Nemby	1	A	3.5	18.1	4.0	22.1	
B-23	San Lorenzo	1	A	5.7	13.2	4.0	17.2	
		2-1	A	3.5	26.7	4.0	30.7	
		2-2	A	5.1	17.2	4.0	21.2	
		2-3	A	1.5	31.9	4.0	35.9	
	Total -			15.8				
B-24	Tayazuape	1	A	4.1	22.2	4.0	26.2	
		3	A	4.0	28.1	4.0	32.1	
	Total -			8.1				
B-26	Zeballos Cue	-	A	0.4	13.5	4.0	17.5	
B-27	Paso Cai	-	A	4.0	19.8	4.0	23.8	

Table 7-6 (1/2). FEATURES OF PROPOSED DRAINAGE FACILITIES FOR MASTER PLAN

Name of River or Basin	Location No. /1	Drainage Area (ha)	Structural Type	Size /2 (m)	Length (m)
Varadero	1-1	51	Pipe	2.2	490
	1-2	30	-do-	1.6	1,170
Jardin	2-1	29	-do-	1.8	150
Jaen	4-1	34	-do-	1.8	510
	4-2	107	Box Culvert	2.5 x 2.0	710
Tacumbu	5-1	29	Pipe	1.6	550
Salamanca	6-1	48	-do-	2.2	100
Zanja Moroti	7-1	35	-do-	1.8	250
Ferreira	8-1	86	Box Culvert	2.0 x 2.0	800
	8-2	40	Pipe	2.0	620
	8-3	19	-do-	1.4	320
	8-4	49	-do-	2.2	600
	8-5	13	-do-	1.2	200
Villa Universitaria	9-1	11	-do-	1.0	130
Las Mercedes	10-1	10	-do-	1.0	150
Mariscal Lopez	11-1	44	-do-	2.0	730
Bella Vista	12-1	42	-do-	2.0	350
Tablada	13-1	39	-do-	2.0	400
Mburicao	14-1 /3	55	----	-	-
	14-2	205	Box Culvert	3.0 x 2.0	2,370
	14-3	27	Pipe	1.6	305
	14-4	14	-do-	1.2	100
	14-5	42	-do-	1.8	540
	14-6	102	-do-	2.5	1,310
	14-7	66	-do-	2.2	795
	14-8	75	-do-	2.2	310
	14-9	14	-do-	1.2	150
	14-10	38	-do-	1.8	180
	14-11	83	-do-	2.5	655
	14-12	26	-do-	1.6	560
	14-13	101	-do-	2.5	1,490
	14-14	27	-do-	1.6	545
Ycua Carrillo	15-1	145	Box Culvert	3.0 x 2.0	650
Santa Rosa	16-1	34	Pipe	1.8	320
	16-2	20	-do-	1.4	100
Tres Puentes Cue	17-1	51	-do-	2.2	420
Itay	18-1	234	Box Culvert	3.5 x 2.0	100
	18-2	231	-do-	3.5 x 2.0	1,675
	18-3	390	-do-	2.5 x 2.0	1,775
	18-4	24	Pipe	1.4	100
	18-5	11	Pipe	1.0	100
	18-6	39	Pipe	1.8	140
	18-7	139	Box Culvert	2.0 x 2.0	410
	18-8	94	Pipe	2.5	80
	18-9	187	Open Channel	3.0 x 2.0	2,395
	18-10	218	Open Channel	3.5 x 2.0	2,865

Table 7-6 (2/2). FEATURES OF PROPOSED DRAINAGE FACILITIES FOR MASTER PLAN

Name of River or Basin	Location No. /1	Drainage Area (ha)	Structural Type	Size /2 (m)	Length (m)
Lambare	19-1	205	Box Culvert	2.0 x 2.0	580
	19-2	54	Pipe	2.2	340
	19-3	117	Box Culvert	2.5 x 2.0	130
	19-4	29	Pipe	1.6	250
	19-5	37	-do-	1.8	250
	19-6	62	-do-	2.2	1,000
	19-7	153	Box Culvert	3.0 x 2.0	200
	19-8	59	Pipe	2.2	250
	19-9	40	-do-	1.8	590
	19-10	54	-do-	2.2	920
	19-11	21	-do-	1.4	80
	19-12	133	Box Culvert	2.5 x 2.0	470
	19-13	202	Box Culvert	2.0 x 2.0	700
	19-14	37	Pipe	1.8	120

Note

/1 : Location of drainage facilities is shown in Fig. 7-2.

/2 : The first and second figures of Box Culvert and Open Channel types give the bottom width and the height, respectively.

/3 : Improvement works of Location No. 14-1 consist of only inlets.

Table 7-7. FEATURES OF PROPOSED DETENTION FACILITIES FOR MASTER PLAN

River Basin	Storage Facilities in Public Compound (ha)	Infiltration Trench (km)
Mburicao	19	74
Itay	70	253
Lambare	59	234
Total	148	561

Table 7-8. CONSTRUCTION COST OF PROPOSED STORM WATER CONTROL SYSTEM FOR MASTER PLAN

(Unit: ¢ Million)

Basin Number	Name of Basin or River	River	Drainage Facilities	Detention Facilities	Total
1. Sub-Projects for 1986-1995 Execution					
B-14	Mburicao	2,500	4,190	-	6,690
B-18	Itay (Upstream of Aviadores del Chaco Avenue)	10,430	4,420	-	14,850
B-19	Lambare	3,440	4,830	-	8,270
	Sub-Total	16,370	13,440	-	29,810
2. Sub-Projects for 1996-2005 Execution					
B-1	Varadero	-	520	-	520
B-2	Jardin	-	60	-	60
B-3	Centro	-	-		-
B-4	Jaen	410	680	-	1,090
B-5	Tacumbu	-	150	-	150
B-6	Salamanca	160	50	-	210
B-7	Zanja Moroti	560	90	-	650
B-8	Ferreira	730	1,110	-	1,840
B-9	Villa Universitaria	-	20	-	20
B-10	Las Mercedes	370	20	-	390
B-11	Mariscal Lopez	-	250	-	250
B-12	Bella Vista	-	160	-	160
B-13	Tablada	-	150	-	150
B-14	Mburicao	-	-	1,330	1,330
B-15	Ycua Carrillo	610	550	-	1,160
B-16	Santa Rosa	640	120	-	760
B-17	Tres Puentes Cue	1,050	210	-	1,260
B-18	Itay (Downstream of Aviadores del Chaco Avenue	3,530	-	4,680	8,210
B-19	Lambare	-	-	4,180	4,180
B-20	Valle Apua	-	-	-	-
B-21	Villa Elisa	540	-	-	540
B-22	Nemby	840	-	-	840
B-23	San Lorenzo	3,540	-	-	3,540
B-24	Tayazuape	2,330	-	-	2,330
B-26	Zeballos Cue	10	-	-	10
B-27	Paso Cai	430	-	-	430
	Sub-Total	15,750	4,140	10,190	30,080
	Total	32,120	17,580	10,190	59,890

Table 7-9. FUTURE SURPLUS FUND OF CORPOSANA'S DRAINAGE SECTOR

Unit: ¢ million

Year	Revenue /1	Expenditure /2			Surplus Fund	Accumulation
		Interest	Repayment	Total		
1987	720.9	108.3	271.5	379.8	341.1	341.1
1988	829.0	91.3	302.4	393.7	435.3	776.4
1989	953.4	65.2	302.4	367.6	585.8	1,362.2
1990	1,096.4	44.6	104.3	148.9	947.5	2,309.7
1991	1,151.2	41.7	104.3	146.0	1,005.2	3,314.9
1992	1,208.8	39.8	104.3	144.1	1,064.7	4,379.6
1993	1,269.2	35.9	104.3	140.2	1,129.0	5,508.6
1994	1,332.7	32.9	95.5	128.4	1,204.3	6,712.9
1995	1,399.3	30.6	82.7	113.3	1,286.0	7,998.9
1996	1,469.3	28.4	77.2	105.6	1,363.7	9,362.6
1997	1,542.8	26.4	77.2	103.6	1,439.2	10,801.8
1998	1,619.9	24.4	78.8	103.2	1,516.7	12,318.5
1999	1,700.9	22.6	61.9	84.5	1,616.4	13,934.9
2000	1,785.9	21.3	61.9	83.2	1,702.7	15,637.6
2001	1,875.2	20.1	61.9	82.0	1,793.2	17,430.8
2002	1,969.0	18.9	61.9	80.8	1,888.2	19,319.0
2003	2,067.5	17.6	61.9	79.5	1,988.0	21,307.0
2004	2,170.9	16.4	61.9	78.3	2,092.6	23,399.6
2005	2,279.4	15.2	61.9	77.1	2,202.3	25,601.9
2006	2,393.4	13.9	61.9	75.8	2,317.6	27,919.5
2007	2,513.1	12.7	61.9	74.6	2,438.5	30,358.0
2008	2,638.8	11.4	61.9	73.3	2,565.5	32,923.5
2009	2,770.7	10.2	61.9	72.1	2,698.6	35,622.1
2010	2,909.2	9.0	61.9	70.9	2,838.3	38,460.4
2011	3,054.7	7.7	61.9	69.6	2,985.1	41,445.5
2012	3,207.4	6.4	61.9	68.3	3,139.1	44,584.6
2013	3,367.8	5.3	61.9	67.2	3,300.6	47,885.2
2014	3,536.2	4.0	61.9	65.9	3,470.3	51,355.5
2015	3,713.0	2.8	61.9	64.7	3,648.3	55,003.8
2016	3,898.7	1.5	61.9	63.4	3,835.3	58,839.1
2017	4,093.6	0.3	30.9	31.2	4,062.4	62,901.5
2018	4,298.3	-	-	-	4,298.3	67,199.8
2019	4,513.2	-	-	-	4,513.2	71,713.0
2020	4,738.9	-	-	-	4,738.9	76,451.9
2021	4,738.9	-	-	-	4,738.9	81,190.8
2022	4,738.9	-	-	-	4,738.9	85,929.7
2023	4,738.9	-	-	-	4,738.9	90,668.6
2024	4,738.9	-	-	-	4,738.9	95,407.5
2025	4,738.9	-	-	-	4,738.9	100,146.4
2026	4,738.9	-	-	-	4,738.9	104,885.3
2027	4,738.9	-	-	-	4,738.9	109,624.2
2028	4,738.9	-	-	-	4,738.9	114,363.1
2029	4,738.9				4,738.9	119,102.0
2030	4,738.9				4,738.9	123,840.9
2031	4,738.9				4,738.9	128,579.8
2032	4,738.9				4,738.9	133,318.7
2033	4,738.9				4,738.9	138,057.6
2034	4,738.9				4,738.9	142,796.5

NOTE /1 : Annual inrease rates are assumed to be 15% until 1990, 5% from 1991 to 2020 and 0% after 2021.

/2 : Amotization for the loan of IDB, etc.

Table 8-1(1/3). DISCHARGE DISTRIBUTION OF ALTERNATIVES FOR FIRST STAGE PROJECT

Mburicao river 7.78 km (1-3S) to 8.07 km (B.P.)

Alternative Plan		Discharge to be Controlled (m3/s)
(Minimum Flow Capacity)		6
A-1	River	15
A-2	River	6
	Drainage	9

Mburicao river 5.18 km (4-1S) to 7.24 km (1-1S)

Alternative Plan		Discharge to be Controlled (m3/s)			
		1-1S to 1	1 to 2-1S	2-1S to 2	2 to 4-1S
(Minimum Flow Capacity)		43	24	30	100
B-1	River	60	75	80	130
B-2	River	24	35	39	-
	Drainage	36	40	41	-
B-3	River	-	-	73	110
	Draiange	-	-	7	20
B-4	River	-	-	74	111
	Drainage	-	-	6	19
B-2 and B-3	River.	24	35	32	110
	Drainage	36	40	48	20
B-2 and B-4	River	24	35	33	111
	Drainage	36	40	47	19

Table 8-1(2/3). DISCHARGE DISTRIBUTION OF ALTERNATIVES FOR FIRST STAGE PROJECT

San Martin river 0.83 km (3-1S) to 1.61 km (B.P.)

Alternative Plan		Discharge to be Controlled (m3/s)
(Minimum Flow Capacity)		14
C-1	River	35
C-2	River	23
	Drainage	22

Mburicao river 1.96 km to 2.53 km

Alternative Plan		Discharge to be Controlled (m3/s)
(Minimum Flow Capacity)		40
D-1	River	155
D-2	River (Short-cut)	155

Madame Lynch river 0.0 km (2-1) to 2.61 km (1-2-1S)

Alternative Plan		Discharge to be Controlled (m3/s)		
		2-1 to 2-1-1S	2-1-1S to 1-2	1-2 to 1-2-1S
(Minimum Flow Capacity)		9	19	15
E-1	River	170	155	155
E-2	River	30	20	5
	Diversion	-	-	155
E-3	River	15	-	-
	Diversion	155	-	-

Table 8-1(3/3). DISCHARGE DISTRIBUTION OF ALTERNATIVES FOR FIRST STAGE PROJECT

Itay river 0.32 km (2-2) to 1.38km (5)
Santa Teresa river 0.0 km (4-4) to 1.34 km (4-2)
San Pablo river 0.0 (4-3) to 0.67 km (B.P.)

Alternative Plan		Discharge to be Controlled.(m3/s) Santa Teresa River 4-4 to 4-2	San Pablo River 4-3 to B.P.	Itay River 2-2 to 5
(Minimum Flow Capacity)		1	4	4
E-1	River	50	10	110
E-2	River	185	160	230
E-3	River	4-4 to 4-4-1s 185	-	230

Itay river 0.0 km (2-3) to 3.23 km (3-3)
Santa Teresa river 0.15 km(4-4) to 1.34 km (4-2)

Alternative Plan		Discharge to be Controlled (m3/s) Itay River 2-3 to 2-2	2-2 to 5	5 to 3-3	Santa Teresa River 4-4 to 4-2
(Minimum Flow Capacity)		85	4	1	1
F-1	River	250	110	65	50
F-2	River	230	90	65	30
F-3	River	240	100	50	50
F-2 & F-3	River	220	80	50	30

Table 8-2. CONSTRUCTION COST AND HOUSE EVACUATION OF ALTERNATIVES FOR FIRST STAGE PROJECT

Alternative Plan	Cost (in million Guarani)					Land Acquisition (m^2)	House Evacuation (No.)
	River Channel	Diversion Channel	Retarding Basin	Drainage Facilities	Total		
A-1	70	-	-	29	99	200	1
A-2	-	-	-	242	242	0	0
B-1	603	-	-	1,941	2,544	3,500	3
B-2	349	-	-	3,215	3,564	2,900	3
B-3	573	-	-	2,032	2,605	3,100	3
B-4	578	-	-	1,982	2,560	3,200	3
B-2 & B-3	321	-	-	3,306	3,627	1,800	3
B-2 & B-4	325	-	-	3,256	3,581	1,800	3
C-1	295	-	-	928	1,223	1,300	4
C-2	169	-	-	1,218	1,387	1,100	4
D-1	120	-	-	-	120	2,600	1
D-2	187	-	-	-	187	4,800	5
E-1	2,884	-	-	-	2,884	69,500	27
E-2	2,190	710	-	-	2,900	94,600	68
E-3	2,513	838	-	-	3,351	105,200	33
F-1	1,648	-	-	-	1,648	76,500	25
F-2	1,462	-	290	-	1,752	91,200	20
F-3	1,541	-	110	-	1,651	90,200	24
F-2 & F-3	1,348	-	400	-	1,748	104,900	20

Table 8-3 (1/2). DESIGN DISCHARGE FOR FIRST STAGE PROJECT

River	Reference Point		Section Length (m)	Design Discharge (m^3/s)
Mburicao River Basin				
Mburicao River	B.P.	to 1-3S	289	15
	1-3S	to 1-2S	191	20
	1-2S	to 1-1S	354	25
	1-1S	to 1	241	60
	1	to 2-1S	1,169	75
	2-1S	to 2	458	80
	2	to 4-1S	194	130
	4-1S	to 4	1,437	140
	4	to 6-1	1,527	155
	6-1	to 6-3	1,612	175
Sub-Total			7,472	
Jose Lombarde River	B.P.	to 6-2	802	11
Santo Domingo River	B.P.	to 5	1,130	25
San Martin River	B.P.	to 3-1S	779	35
	3-1S	to 3	857	50
Sub-Total			1,636	
Total (Mburicao River Basin)			11,040	
Itay River Basin				
Itay River	B.P.	to 3-1-1S	369	10
	3-1-1S	to 3-1	679	15
	3-1	to 3-3	952	35
	3-3	to 5	1,705	65
	5	to 2-2	1,203	110
	2-2	to 2-3	323	250
Sub-Total			5,231	
Orilla River	B.P.	to 3-2-1S	438	25
	3-2-1S	to 3-2	1,817	30
Sub-Total			2,255	

Table 8-3 (2/2). DESIGN DISCHARGE FOR FIRST STAGE PROJECT

River	Reference Point		Section Length (m)	Design Discharge (m^3/s)
Santa Teresa River	B.P.	to 4-1	482	15
	4-1	to 4-2	1,031	35
	4-2	to 4-4	1,189	50
Sub-Total			2,702	
San Pablo River	B.P.	to 4-3	670	10
Madame Lynch River	B.P.	to 1-1	211	75
	1-1	to 1-2	2,310	155
	1-2	to 2-1-1S	517	155
	2-1-1S	to 2-1	1,707	170
Sub-Total			4,745	
Total (Itay River Basin)			15,603	

Table 8-4 (1/3). TYPE SELECTION OF RIVER CHANNEL OF ENTIRE RIVER SECTION FOR FIRST STAGE PROJECT

Reference Point	Design Discharge (m^3/s)	Improvement Length (m)	Construction Cost (₡10^6)			Land Acquisition (m^2)			House Evacuation (No.)		
			Type A	Type B	Type C	Type A	Type B	Type C	Type A	Type B	Type C
Mburicao River											
B.P. to 1-3S	15	90	100	79	70	800	400	250	0	2	1
1-3S to 1-2S	20	0	-	-	-	-	-	-	-	-	-
1-2S to 1-1S	25	0	-	-	-	-	-	-	-	-	-
1-1S to 1	60	0	-	-	-	-	-	-	-	-	-
1 to 2-1S	75	98	251	213	189	1,200	800	600	4	0	0
2-1S to 2	80	344	211	179	159	5,100	2,900	2,500	2	0	0
2 to 4-1S	130	126	277	255	265	1,500	400	200	7	3	3
4-1S to 4	140	1,079	347	272	294	6,500	4,100	3,200	12	4	3
4 to 6-1	155	1,340	590	393	579	12,600	9,300	7,600	15	1	1
6-1 to 6-3	175	527	492	436	449	5,600	3,100	1,500	10	0	0
Sub-Total		3,604									
Jose Lombarde River											
B.P. to 6-2	11	622	212	143	149	4,200	1,900	1,300	4	1	1
Santo Domingo River											
B.P. to 5	25	355	234	172	181	2,400	1,300	700	4	1	1
San Martin River											
B.P. to 3-1S	35	687	462	325	295	3,600	1,900	1,300	6	4	4
3-1S to 3	50	355	415	292	265	4,100	2,200	1,500	4	2	2
Sub-Total		1,042									
Total	11,040	5,623									

Note; Type A : Excavated Channel without Revetment
Type B : Excavated Channel with Revetment without Invert
Type C : Excavated Channel with Revetment and Invert

Table 8-4 (2/3). TYPE SELECTION OF RIVER CHANNEL OF ENTIRE RIVER SECTION FOR FIRST STAGE PROJECT

Reference Point	Design Discharge (m^3/s)	Improvement Length (m)	Construction Cost ($\phi 10^6$)			Land Acquisition (m^2)			House Evacuation (No.)		
			Type A	Type B	Type C	Type A	Type B	Type C	Type A	Type B	Type C
Itay River											
B.P. to 3-1-1S	10	369	29	25	28	2,400	1,400	1,000	5	0	0
3-1-1S to 3-1	15	679	163	127	140	5,700	3,300	1,800	7	0	0
3-1 to 3-3	35	952	228	223	230	3,900	1,200	900	10	0	0
3-3 to 5	65	1,705	854	692	835	24,000	14,400	9,800	21	5	4
5 to 2-2	110	1,203	346	465	526	25,300	11,500	8,500	9	5	5
2-2 to 2-3	250	323	202	223	235	13,300	6,600	4,700	0	0	0
Sub-Total		5,231									
Orilla River											
B.P. to 3-2-1S	25	438	129	114	117	4,300	1,600	1,300	5	2	2
3-2-1S to 3-2	30	1,817	472	411	429	17,800	6,200	5,200	7	4	4
Sub-Total		2,255									
Santa Teresa River											
B.P. to 4-1	15	482	160	108	115	3,100	1,500	1,100	8	1	1
4-1 to 4-2	35	1,031	476	417	425	15,100	8,800	6,800	8	6	5
4-2 to 4-4	50	1,189	408	489	508	23,000	12,700	10,300	11	7	6
Sub-Total		2,702									
San Pablo River											
B.P. to 4-3	10	670	128	102	104	3,100	1,500	1,200	3	0	0

Note; Type A : Excavated Channel without Revetment
Type B : Excavated Channel with Revetment without Invert
Type C : Excavated Channel with Revetment and Invert

Table 8-4 (3/3). TYPE SELECTION OF RIVER CHANNEL OF ENTIRE RIVER SECTION FOR FIRST STAGE PROJECT

Reference Point	Design Discharge (m^3/s)	Improvement Length (m)	Construction Cost (Ø10^6)			Land Acquisition (m^2)			House Evacuation (No.)		
			Type A	Type B	Type C	Type A	Type B	Type C	Type A	Type B	Type C
Madame Lynch River											
B.P. to 1-1S	75	211	-	-	220 /1	-	-	700 /1	-	-	0 /1
1-1 to 1-2	155	2,310	-	-	4,900 /1	-	-	7,400 /1	-	-	15 /1
1-2 to 2-1-1S	155	517	421	384	411	9,800	3,200	1,600	7	0	0
2-1-1S to 2-1	170	1,707	1,087	850	892	32,700	14,300	7,800	15	7	7
Sub-Total		4,745									
Total		15,603									

Note; /1 : Figures are for Type D (Box Culvert).

Table 8-5. OPTIMUM STRUCTURAL TYPE OF PROPOSED RIVER CHANNEL FOR FIRST STAGE PROJECT

River Name	Reference Point		Design Discharge (m^3/s)	Improvement Length (m)	Optimum Channel Type /1	Land Acquisition (m^2)	House Evacuation (No.)	Bridge (place)	Groundsill with Head (place)
Mburicao River Basin									
Mburicao	B.P.	to 1-3S	15	90	C	800	1	1	0
	1-3S	to 1-2S	20	0	- /2	-	-	0	0
	1-2S	to 1-1S	25	0	- /2	-	-	0	0
	1-1S	to 1	60	0	- /2	-	-	1	0
	1	to 2-1S	75	98	C	600	0	2	1
	2-1S	to 2	80	344	C	2,500	0	0	2
	2	to 4-1S	130	126	B	400	3	1	0
	4-1S	to 4	140	1,079	B	4,100	4	0	1
	4	to 6-1	155	1,340	B	9,300	1	1	2
	6-1	to 6-3	175	527	B	3,100	0	2	1
Sub-Total				3,604		20,800	9	8	7
Jose Lombarde	B.P.	to 6-2	11	622	B	1,900	1	2	2
Santo Domingo	B.P.	to 5	25	355	B	1,300	1	2	0
San Martin	B.P.	to 3-1S	35	687	C	1,300	4	4	2
	3-1S	to 3	50	355	C	1,500	2	0	1
Sub-Total				1,042		2,800	6	4	3
Total				5,623		26,800	17	16	12
Itay River Basin									
Itay	B.P.	to 3-1-1S	10	369	B	1,400	0	0	1
	3-1-1S	to 3-1	15	679	B	3,300	0	2	1
	3-1	to 3-3	35	952	B	1,200	0	3	4
	3-3	to 5	65	1,705	B	14,400	5	5	5
	5	to 2-2	110	1,203	A	25,300	9	0	0
	2-2	to 2-3	250	323	A	13,300	0	0	0
Sub-Total				5,231		58,900	14	10	11
Orilla	B.P.	to 3-2-1S	25	438	B	1,600	2	2	1
	3-2-1S	to 3-2	30	1,817	B	6,200	4	5	4
Sub-Total				2,255		7,800	6	7	5
Santa Teresa	B.P.	to 4-1	15	482	B	1,500	1	2	3
	4-1	to 4-2	35	1,031	B	8,800	6	3	3
	4-2	to 4-4	50	1,189	A	23,000	11	1	0
Sub-Total				2,702		33,300	18	6	6
San Pablo	B.P.	to 4-3	10	670	B	1,500	0	2	1
Madame Lynch	B.P.	to 1-1S	75	211	D	700	0	0	0
	1-1	to 1-2	155	2,310	D	7,400	15	0	0
	1-2	to 2-1-1S	155	517	B	3,200	0	3	0
	2-1-1S	to 2-1	170	1,707	B	14,300	7	4	4
Sub-total				4,745		25,600	22	7	4
Total				15,603		127,100	60	32	27
Grand Total				21,226		153,900	79	48	39

Note: /1 Channel Type; A : Channel Without Revetment
B : Channel With Revetment and Without Invert
C : Channel With Revetment and Invert
D : Box Culvert
E : Channel With Embankment

/2 River improvement is not necessary.

Table 8-6 (1/2). OPTIMUM STRUCTURAL TYPES OF PROPOSED DRAINAGE FACILITIES FOR FIRST STAGE PROJECT

Location/1 No.	Section	Structural Type	Present Use	Reason for Adoption
Mburicao River Basin				
14-1 /2	-	-	Road	-
14-2	Whole Section	Underground Conduit	Road	No space for open channel; underground utilities existing.
14-3	-do-	-do-	Road	-do-
14-4	-do-	-do-	Road	-do-
14-5	-do-	-do-	Road	-do-
14-6	-do-	-do-	Road	-do-
14-7	-do-	-do-	Road	-do-
14-8	-do-	-do-	Road	-do-
14-9	-do-	-do-	Road	-do-
14-10	-do-	-do-	Road	-do-
14-11	-do-	-do-	Road	-do-
14-12	440m of Upper Section	-do-	Road	-do-
	120m of Lower Section	-do-	Open space	Economically justified.
14-13	Whole Section	-do-	Road	No space for open channel; underground utilities existing.
14-14	365m of Upper Section	-do-	Road	-do-
	180m of Lower Section	Open Channel	Existing channel	Sufficient open space available.

Note

/1 : The location of drainage facilities is shown in Fig. 8-12.
/2 : Improvement works of Location No. 14-1 consist of only inlets.

Table 8-6 (2/2). OPTIMUM STRUCTURAL TYPES OF PROPOSED DRAINAGE FACILITIES FOR FIRST STAGE PROJECT

Location/1 No.	Section	Structural Type	Present Use	Reason for Adoption
Itay River Basin				
18-1	Whole Section	Underground Conduit	Road	No space for open channel.
18-2	190m of Upper Section	Open Channel	Existing channel	Sufficient open space available.
	1,485m of Lower Section	Underground Conduit	Road	No space for open channel.
18-3	915m of Upper and Middle Section	-do-	Road	-do-
	860m of Middle and Lower Section	Open Channel	Existing channel	Sufficient open space available.
18-4	Whole Section	Underground Conduit	Road	No space for open channel.
18-5	-do-	-do-	Road	-do-
18-6	-do-	-do-	Road	-do-
18-7	250m of Upper Section	Open Channel	Existing channel	Sufficient open space available.
	160m of Lower Section	Underground Conduit	Road	No space for open channel.
18-8	Whole Section	-do-	Road	-do-
18-9	-do-	Open Channel	Existing channel	Sufficient open space available.
18-10	-do-	-do-	Existing channel	-do-

Table 8-7(1/2). FEATURES OF PROPOSED RIVER CHANNEL FOR FIRST STAGE PROJECT (MBURICAO RIVER BASIN)

River and Reference Point	Section Length (m)	Design Discharge (m3/s)	Structure Type	Dimension/1 (m)	Cross-sectional Type /2
Mbruricao river					
B.P. to 1-3S	289	15	channel with revetments and Invert	2.0 x 1.4	C
1-3S to 1-2S	191	20	no improvement	-	-
1-2S to 1-1S	354	25	no improvement	-	-
1-1S to 1	241	60	no improvement	-	-
1 to 2-1S	1,169	75	channel with revetments and invert	5.6 x 2.5	C
2-1S to 2	458	80	- ditto -	6.1 x 2.5	C
2 to 4-1S	194	130	channel with revetments	12.7 x 2.5	B
4-1S to 4	1,437	140	- ditto -	13.7 x 2.5	B
4 to 6-1	1,527	155	- ditto -	15.2 x 2.5	B
6-1 to 6-3	1,612	175	- ditto -	17.1 x 2.5	B
Jose Lombarde river					
B.P. to 6-2	802	11	- ditto -	3.3 x 1.0	B
Santo Domingo river					
B.P. to 5	1,130	25	- ditto -	5.6 x 1.1	B
San Martin river					
B.P. to 3-1S	779	35	channel with revetments and invert	4.5 x 1.6	C
3-1S to 3	847	50	- ditto -	5.3 x 1.8	C

NOTE /1 : Breadth x Height
/2 : Types B and C are drawn below.

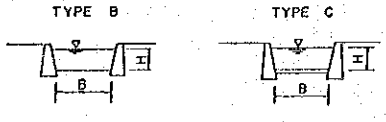

Table 8-7(2/2). FEATURES OF PROPOSED RIVER CHANNEL FOR FIRST STAGE PROJECT (ITAY RIVER BASIN)

River and Reference Point	Section Length (m)	Design Discharge (m3/s)	Structure Type	Dimension/1 (m)	Cross-sectional Type/2
Itay river					
B.P. to 3-1-1S	369	10	channel with revetments	2.7 x 1.0	B
3-1-1S to 3-1	679	15	- ditto -	3.0 x 1.2	B
3-1 to 3-3	952	35	- ditto -	5.6 x 1.5	B
3-3 to 5	1,705	65	- ditto -	8.0 x 2.0	B
5 to 2-2	1,203	110	channel without protection	11.1 x 2.5	A
2-2 to 2-3	323	250	channel without revetments	45.5 x 2.5	A
Orilla river					
B.P. to 3-2-1S	438	25	- ditto -	5.1 x 1.3	B
3-2-1S to 3-2	1,817	30	- ditto -	6.0 x 1.3	B
Santa Teresa					
B.P. to 4-1-1S	482	15	- ditto -	3.6 x 1.0	B
4-1-1S to 4-2	1,032	35	- ditto -	7.4 x 1.5	B
4-2 to 4-4	1,189	50	channel without protection	9.2 x 2.0	A
San Pablo river					
B.P. to 4-3	670	10	channel with revetments	3.7 x 1.0	B
Madame Lynch river					
B.P. to 1-1-S	211	75	underground culvert	3.0 x 2.6 x 2 boxes	D(1)
1-1-S to 1-2	2,310	155	underground culvert	4.1 x 3.0 x 3 boxes	D(2)
1-2 to 2-1-1S	517	155	channel with revetments	12.4 x 3.0	B
2-1-1S to 2-1	1,707	170	- ditto -	13.7 x 3.0	B

NOTE /1 : Breadth x Height
/2 : Types A, B and D are drawn below.

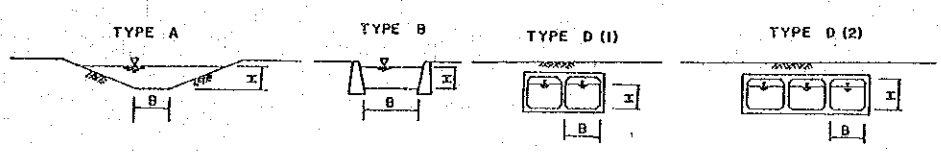

Table 8-8 (1/2). FEATURES OF PROPOSED DRAINAGE FACILITIES FOR FIRST STAGE PROJECT

Location Number /1	Pipe No.	Drainage Area (ha)	Structural Type	Size /2 (m)	Length (m)
MBURICAO RIVER BASIN					
14-1 /3		55.0	----	-	-
14-2	1	67.0	Pipe	2.2	350
	2	95.2	Box Culvert	2.0 x 2.0	175
	3	148.7	-do-	2.4 x 2.0	220
	4	162.7	-do-	2.6 x 2.0	260
	5	176.9	-do-	2.8 x 2.0	315
	6	192.4	-do-	3.0 x 2.0	365
	7	205.0	-do-	3.1 x 2.0	685
14-3	1	27.0	-do-	1.6	305
14-4	1	14.0	-do-	1.2	100
14-5	1	42.0	-do-	1.8	540
14-6	1	47.3	-do-	2.0	125
	2	64.1	-do-	2.2	285
	3	101.7	Box Culvert	2.0 x 2.0	370
	4	40.9	Pipe	1.8	305
	5	58.0	-do-	2.0	210
	6	124.0	Box Culvert	2.0 x 2.0	15
14-7	1	34.4	Pipe	1.8	225
	2	46.2	-do-	2.0	365
	3	66.0	-do-	2.2	205
14-8	1	63.9	-do-	2.0	205
	2	75.0	-do-	2.2	105
14-9	1	14.0	-do-	1.2	150
14-10	1	38.0	-do-	1.8	180
14-11	1	58.8	-do-	2.2	140
	2	83.0	Box Culvert	2.0 x 2.0	515
14-12	1	10.9	Pipe	1.0	440
	2	26.0	-do-	1.6	120
14-13	1	20.4	-do-	1.2	305
	2	41.4	-do-	1.8	300
	3	74.6	-do-	2.2	215
	4	86.7	Box Culvert	2.0 x 2.0	320
	5	101.0	Box Culvert	2.0 x 2.0	350
14-14	1	21.7	Pipe	1.4	365
	2	24.0	Open Channel	1.5 x 1.0	180

Table 8-8 (2/2). FEATURES OF PROPOSED DRAINAGE FACILITIES FOR FIRST STAGE PROJECT

Location Number /1	Pipe No.	Drainage Area (ha)	Structural Type	Size /2 (m)	Length (m)
18-1	1	234.0	Box Culvert	2.5 x 1.4	100
18-2	1	83.0	Open Channel	2.5 x 2.0	190
	2	37.9	Pipe	1.8	100
	3	158.0	Box Culvert	2.5 x 2.0	640
	4	227.5	2-Box Culvert	1.8 x 2.0	505
	5	231.0	-do-	2.2 x 2.0	240
18-3	1	246.2	-do-	1.9 x 2.0	270
	2	250.1	Open Channel	4.2 x 2.0	90
	3	330.4	Open Channel	4.3 x 2.5	500
	4	385.7	2-Box Culvert	2.2 x 2.5	645
	5	390.0	Open Channel	4.9 x 2.5	270
18-4	1	24.0	Pipe	1.4	100
18-5	1	11.0	-do-	1.0	100
18-6	1	39.0	-do-	1.8	140
18-7	1	136.2	Open Channel	2.5 x 2.0	250
	2	139.0	Box Culvert	2.0 x 2.0	160
18-8	1	94.0	-do-	2.0 x 2.0	80
18-9	1	113.2	Open Channel	2.1 x 2.0	500
	2	137.9	-do-	2.5 x 2.0	450
	3	162.1	-do-	2.8 x 2.0	450
	4	182.1	-do-	3.1 x 2.0	675
	5	187.0	-do-	3.4 x 2.0	320
18-10	1	37.5	-do-	2.0 x 1.0	475
	2	108.0	-do-	2.2 x 2.0	455
	3	124.6	-do-	2.3 x 2.0	485
	4	149.4	-do-	2.9 x 2.0	135
	5	191.8	-do-	3.6 x 2.0	500
	6	218.0	-do-	4.0 x 2.0	425
	7	218.0	-do-	4.3 x 2.0	390

Note

/1 : Location of drainage facilities is shown in Fig. 8-12.

/2 : The first and second figures of Box Culvert and Open Channel types give the bottom width and the height, respectively.

/3 : Improvement works of Location No. 14-1 consist of only inlets.

Table 8-9. COMPONENT OF CONSTRUCTION WORKS FOR FIRST STAGE PROJECT

Component	Mburicao River Basin	Itay River Basin
A. Artigas Avenue	Construction of one bridge.	-
B. Espana Avenue	Construction of one bridge and two routes of drainage facilities.	Construction of one groundsill and two routes of drainage facilities.
C. Mariscal Lopez Avenue	Construction of one bridge and two routes of drainage facilities.	Construction of two bridges and one route of drainage facilities.
D. Ayala Avenue	Construction of two routes of drainage facilities.	Construction of three routes of drainage facilities.
E. Madame Lynch (I)	-	River improvements of Itay River (up to confluence with Madame Lynch River) and Madame Lynch River (up to Mariscal Lopez Avenue).
F. Madame Lynch River (II)	-	River improvement of Madame Lynch River (between Mariscal Lopez Avenue and Ayala Avenue).
G. River Channel (I)	River improvement of Mburicao River (between Artigas Avenue and Espana Avenue).	-
H. River Channel (II)	-	River improvements of Itay River (between confluence points with Madame Lynch River and Orilla River) and Orilla River (up to Ayala Avenue).
I. River Channel (III)	River improvement of Mburicao River (between Espana Avenue and Mariscal Lopez Avenue).	-
J. River Channel (IV)	River improvement of Mburicao River (between Mariscal Lopez Avenue and Ayala Avenue).	-
K. River Channel (V)	River improvement of three tributaries and construction of three routes of drainage facilities.	River improvement of four tributaries and construction of four routes of drainage facilities.
L. Drainage Facilities	Construction of five routes of drainage facilities.	-
M. Retarding Basin	-	Construction of retarding basin.

Table 8-10. ACCUMULATED COST AND BENEFIT THROUGH REARRANGEMENT OF IMPLEMENTATION ORDER OF CONSTRUCTION COMPONENTS

Order of Priority	Construction Component	Accumulated Cost (₱10^6)	Accumulated Benefit (₱10^6)
CASE 1	(Based on Economic Consideration)		
1	C. Mariscal Lopez Avenue	559	310
2	A. Artigas Avenue	655	342
3	B. Espana Avenue	2,353	688
4	M. Retarding Basin	2,859	688
5	E. Madame Lynch Avenue (I)	6,642	1,070
6	F. Madame Lynch Avenue (II)	8,130	1,293
7	G. River Channel (I)	8,986	1,327
8	I. River Channel (III)	9,114	1,331
9	J. River Channel (IV)	9,222	1,363
10	D. Ayala Avenue	12,106	1,693
11	H. River Channel (II)	12,904	1,801
12	K. River Channel (V)	15,896	2,016
13	L. Drainage Facilities	16,197	2,108
CASE 2	(Based on Technical Consideration)		
1	A. Artigas Avenue	96	33
2	G. River Channel (I)	956	67
3	M. Retarding Basin	1,461	67
4	B. Espana Avenue	3,159	412
5	E. Madame Lynch Avenue (I)	6,943	794
6	H. River Channel (II)	7,734	902
7	I. River Channel (III)	7,862	906
8	C. Mariscal Lopez Avenue	8,421	1,216
9	F. Madame Lynch Avenue (II)	9,905	1,439
10	J. River Channel (IV)	10,013	1,471
11	D. Ayala Avenue	12,904	1,801
12	K. River Channel (V)	15,896	2,016
13	L. Drainage Facilities	16,197	2,108

Table 8-11. CONSTRUCTION COST OF PROPOSED PLAN FOR FIRST STAGE PROJECT

(Unit: ¢ thousand)

Work Item	Unit	Quantity/1	F.C.	L.C.	Total
1. Civil Works					
River Improvement Works					
- Excavation	m^3	947,600	395,140	163,008	558,148
- Backfilling of Earth	m^3	71,900	10,425	77,787	88,212
- Embankment	m^3	27,100	6,475	1,449	7,924
- Spoil	m^3	848,600	510,692	101,286	611,978
- Revetment	m^3	65,600	615,453	1,047,413	1.662,866
- Gravel Backfilling for Revetment	m^3	36,690	97,098	139,683	236,781
- Invert	m^3	2,470	23,057	36,123	59,180
- Box Culvert	m	2,663	2,733,760	1,258,663	3,992,423
- Groundsill	pc.	39	10,524	12,690	23,214
- Bridge	pc.	48	689,187	267,416	956,603
- Sodding	m^2	28,200	-	37,749	37,749
- Maintenance Road	m^2	37,950	19,809	42,117	61,926
Sub-Total			5,111,620	3,185,385	8,297,005
Drainage Facilities					
- Excavation	m^3	300,700	147,229	252,959	400,188
- Backfilling of Earth	m^3	116,600	43,288	109,920	153,208
- Spoil	m^3	184,100	110,781	21,972	132,753
- Box Culvert	m	6,230	1,475,932	722,789	2,198,721
- Piping	m	5,980	475,231	262,598	737,829
- Open Channel	m	6,740	546,802	657,944	1,204,746
- Manhole	pc.	124	48,682	30,163	78,845
- Inlet (Independent Type)	pc.	278	457,403	356,486	813,889
- Inlet (Continuous Type)	m	3,550	157,808	113,336	271,144
- Outlet	pc.	24	10,096	16,953	27,049
- Restoration of Pavement	m^2	55,170	306,871	12,002	426,873
Sub-Total			3,780,123	2,665,122	6,445,245
Total of 1			8,891,743	5,850,507	14,742,250
2. Compensation					
House Evacuation	pc.	77	-	568,800	568,800
Land Acquisition	m^2	163,800	-	885,946	885,946
3. Engineering Services	l.s.		3,022,000	342,200	3,364,200
Total of 1, 2 and 3			11,913,743	7,647,453	19,561,196
4. Physical Contingency (10% of Total of 1 to 3)	l.s		1,191,374	764,745	1,956,119
Total of 1 to 4			13,105,117	8,412,198	21,517,315
5. Price Contingency (None for F.C.; 10% for L.C.)	l.s		-	5,985,140	5,985,140
Grand Total			13,105,117	14,397,338	27,502,455

Note: The quantities of relative improvement works to secure the transportation alone the Artigas Avenue are also included.

Table 8-12. ANNUAL DISBURSEMENT SCHEDULE FOR FIRST STAGE PROJECT

(Unit: ¢ million)

Item	1988		1989		1990		1991		1992		1993		Grand Total		
	F.C.	L.C.	F.C.	L.C.	F.C.	L.C.	F.C.	L.C.	F.C.	L.C.	F.C.	L.C.	F.C.	L.C.	Total
1. River Improvement Works	-	-	-	-	567	253	3,228	1,686	652	653	665	593	5,112	3,185	8,297
2. Drainage Facility Works	-	-	-	-	1,080	959	-	-	1,802	1,084	898	623	3,780	2,665	6,445
3. House Evacuation	-	-	-	-	-	-	-	158	-	173	-	238	-	569	569
4. Land Acquisition	-	-	-	-	-	-	-	198	-	411	-	277	-	886	886
5. Engineering Services	467	52	467	52	522	60	522	60	522	60	522	60	3,022	342	3,364
Total of 1 to 5	467	52	467	52	2,169	1,271	3,750	2,103	2,975	2,380	2,085	1,790	11,914	7,647	19,561
6. Physical Contingency (10% of Total of 1 to 5)	47	5	47	5	217	127	375	210	298	238	209	179	1,191	765	1,956
Total of 1 to 6	514	57	514	57	2,386	1,399	4,125	2,313	3,273	2,618	2,294	1,968	13,105	14,397	21,517
7. Price Contingency (None for F.C.; 10% for L.C.)	-	12	-	19	-	649	-	1,413	-	2,021	-	1,871	-	5,985	5,985
Total	514	69	514	76	2,386	2,047	4,125	3,726	3,273	4,639	2,294	3,840	13,105	14,397	27,502

Table 8-13. COST-BENEFIT FLOW FOR FIRST STAGE PROJECT

Unit: ¢ million

Year	Economic Cost				Benefit
	Consulting Services	Construction	Operation & Maintenance	Total	
1	571	-	-	571	-
2	571	-	-	571	-
3	640	2,673	-	3,313	-
4	640	4,595	14	5,249	688
5	640	3,918	38	4,596	1,293
6	640	2,598	58	3,296	1,801
7	-	-	71	71	2,108
8	-	-	71	71	2,108
9	-	-	71	71	2,108
10	-	-	71	71	2,108
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41	-	-	71	71	2,108
42	-	-	71	71	2,108
43	-	-	71	71	2,108
44	-	-	71	71	2,108
45	-	-	71	71	2,108
46	-	-	71	71	2,108
47	-	-	71	71	2,108
48	-	-	71	71	2,108
49	-	-	71	71	2,108
50	-	-	71	71	2,108
Total	3,702	13,784	3,234	20,720	96,534