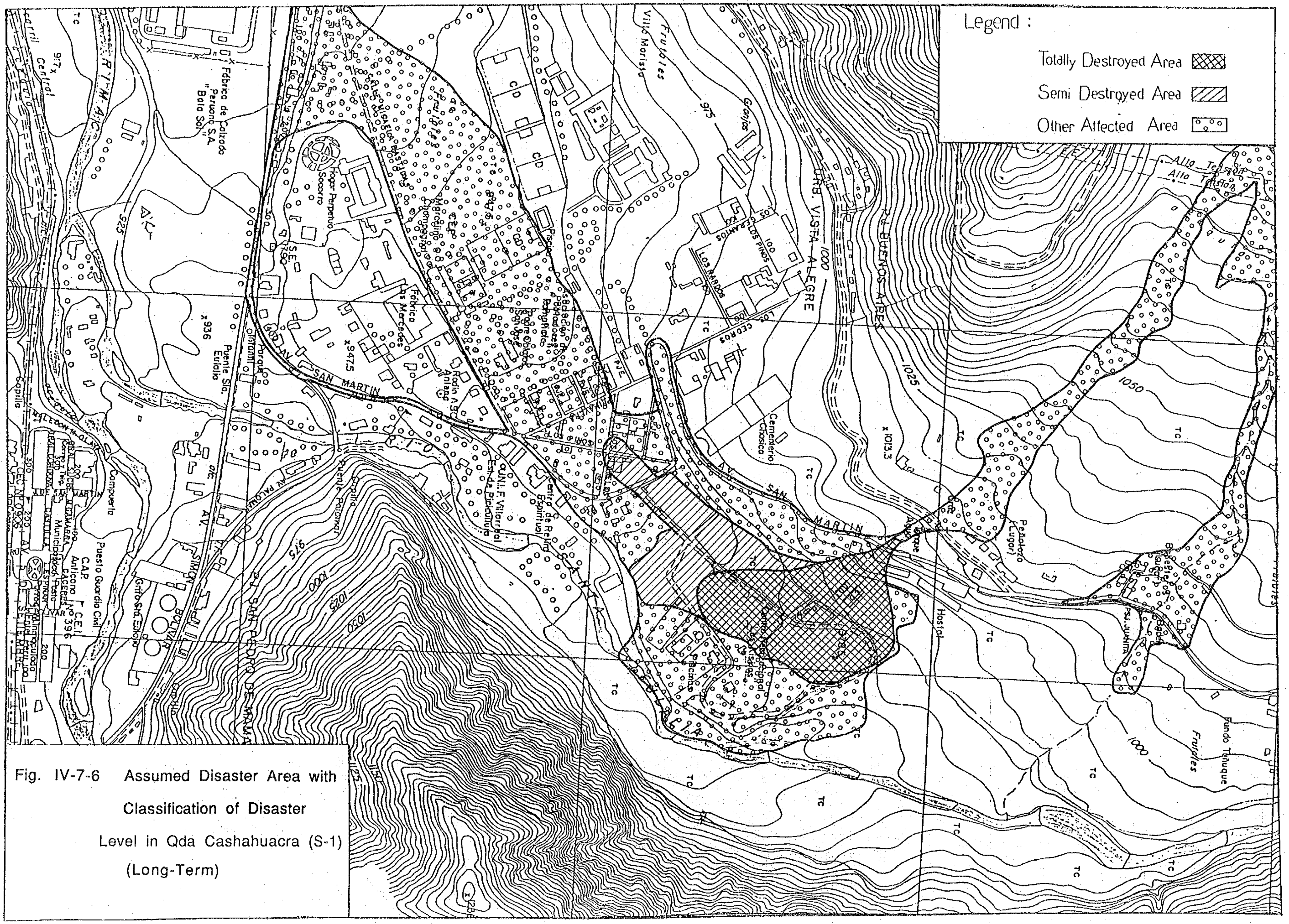

Fig. IV-7-6 Assumed Disaster Area with Classification of Disaster Level in Qda Cashahuacra (S-1) (Long-Term)

Chapter V

V. STRUCTURAL PLAN FOR INUNDATION DISASTER PREVENTION

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CHAPTER V STRUCTURAL PLAN FOR INUNDATION DISASTER PREVENTION

1. GENERAL

The Rimac river flows through the Capital city of Peru, Lima. The surrounding area developed so extensively is highly susceptible to the flood inundation disaster.

On the one hand, the river has various defects against the flood, requiring a radical improvement on them.

This chapter examines the most desirable structural plan for preventing the inundation disaster through the comparative study from the technical, economical and social aspects on the conceivable alternative structural plans.

2. DIVISION OF STUDY AREA

Respective reaches in the Rimac river basin has a different degree of danger for flood inundation and properties to be protected, requiring a division and classification of study area for giving the priority.

The division of study area is made in due consideration of the degree of danger and properties to be protected in each area as follows;

(1) Rimac river

(a) Upper reaches (Upstream of Matucana)

(b) Upper middle reaches (Matsucana to confluence with Santa Eulalia river)

(c) Lower middle reaches (Confluence with Santa Eulalia river to Atarjea weir)

(d) Lower reaches (Atarjea weir to river mouth)

(2) Santa Eulalia river

(a) Upper reaches (Upstream of Autisha dam)

(b) Lower reaches (Autisha to confluence with Rimac river)

(3) Jicamarca river

(a) Upper reaches

(b) Lower reaches (Up to about 4 km from the river mouth)

3. FEATURES OF EACH DIVIDED AREA

3.1 General

The division of study area is made as mentioned in the previous section. The situation of each divided area, based on which the division and classification of study area are made, is as given hereunder.

3.2 Upper Reaches of the Rimac River (Upstream of Matucana)

The area consists mostly of the mountainous slopes which are used as the farm land. The flat areas are scarcely distributed along the river. In the upper-most area, most of lands are not used substantially except the plateau where the cattle breeding is made.

Several residential houses are found in limited flat areas. The traffic road also passes through along the river. However, those are not subject to the flood inundation, since those are mostly situated enough higher than the flooding level. As such, the degree of danger and protective properties for the flood inundation is very low.

3.3 Upper Middle Reaches of the Rimac River (Matucana to the Confluence with the Santa Eulalia river)

The reaches are of a full mature V-shaped valley, of which river beds are commonly covered with thick alluvial deposits. The slopes of valley are very steep and have bluffs in many places. There are some flat areas along the river where residential houses and farm lands exist.

Major protective properties in the area for the flood inundation are the town in Matucana having several hundreds in population, the flat land in Tornamesa with several tens of residential houses, and the traffic road and railway passing through the area.

The inundation in the area is characterized by the cause of inundation as follows: that is, the inundation in the area is mainly caused by the interruption of river flow due to the debris flow from the quebradas.

3.4 Lower Middle Reaches of the Rimac River (Confluence with the Santa Eulalia river to Atarjea weir)

The town of Chosica, which is densely populated, extends in the downstream of the confluence of the Rimac and Santa Eulalia rivers. A lot of residential houses get into the river area, making the river channel width narrow.

Thus, the river stretch of about 12 km long in the downstream of the confluence is seriously narrowed artificially. The river width in the stretch is reduced to 20 to 30 m despite a width of 50 to 60 m at least is considered necessary there in a common sense, threatening to a flood inundation disaster for the inhabitants gathered in the river banks.

On the other hand, the river is as wide as 300 to 400 m in the upstream reaches of the Atarjea Weir, where the sedimentation and turbulence of river flow are remarkable. The turbulence of river flow frequently attacks the dike, breaking it and causing the disaster in highly developed areas in the further downstream.

As mentioned, the level of danger and protective properties for the flood inundation is very high in the area.

3.5 Lower Reaches of the Rimac River (Atarjea weir to the river mouth)

In the lower reaches, the Rimac river flows down in the northern part of the Lima city. The river width is about 60 m in average. However, there is a narrow gorge at 9 to 10.5 km from the river mouth where the width is reduced to 15 to 20 m. The height of bank at the narrow gorge is as high as 20 to 30 m.

The area is protected with the parapet wall or dike. Those, however, will easily be overtopped by the flood with a magnitude of 50 to 100 year recurrence, seriously threatening to the inundation disaster since the area including a large part situated at a lower elevation is so extensively developed.

Besides the above, a lot of residential houses crowding on the river banks of the said narrow gorge are exposed to the danger of bank collapse which may occur due to a large flood discharge.

It can be said that the level of danger and protective properties for the inundation disaster is extremely high in this lower reaches of the Rimac river, requiring an urgent countermeasure.

3.6 Santa Eulalia River

The Santa Eulalia river basin is composed of a full mature V-shaped valley, similar to the upper middle reaches of Rimac river.

The land use in the basin consists mostly of the ravine and hillside agriculture. Some residential houses are seen in the right bank. A traffic road also passes along the right bank. However, those are all located at an elevation higher enough not to be affected by the flood. Although some ravine agricultural lands may suffer the flood inundation, the damage may be minor, requiring no special structural measure for flooding.

3.7 Jicamarca River

In the upper reaches of Jicamarca river, any noteworthy land use is not recognized, implying the protective properties against the flood inundation would negligibly be minor.

In the lower reaches, some flood inundation due to the unsatisfactory provision of culvert under the traffic road is experienced. The surrounding area is composed mostly of the agricultural lands. However, the flood inundation from the river attacks the downstream area along the right bank of Rimac river where the residential houses and various facilities are extensively distributed. It is considered that the same flood damage as experienced will surely occur again in the event that the basin is visited by a heavy rainfall.

4. CLASSIFICATION OF EACH DIVIDED AREA

As stated in the previous section, there is a large difference in the priority level among the respective study areas. Then, for an effective formulation of the master plan, the classification of study level is made in accordance with the priority level.

In the classification, each of the study areas is classified into three groups of Group (A), (B) and (C) in accordance with the priority level based on the situation of each area described in the previous section.

The study for each of Group A, B and C is made as follows;

Group A

Group A has a high urgency of countermeasure, requiring a formulation of definitive plan. Then, the countermeasure for preventing the flood inundation will be established through a comparative study on the conceivable alternative plans.

Group B

The degree of danger and protective properties in Group B is relatively lower without such a high urgency as Group A. As such, a countermeasure to be considered most suitable will be provided where necessary based on the result of hydraulic analysis without a particular comparative study on the alternative plans.

Group C

Group C has very less or no danger of protective properties. Thus, no countermeasure will be examined in this master plan study.

The following is the summary of classification. Fig. V-4-1 visually shows the classification of study area.

Area Division		Classification
(1)	Rimac river:	
(a)	Upper reaches	Group (C)
(b)	Upper middle reaches	" (B)
(c)	Lower middle reaches	" (A)
(d)	Lower reaches	" (A)
(2)	Santa Eulalia river:	
(a)	Upper reaches	Group (C)
(b)	Lower reaches	" (C)
(3)	Jicamarca river:	
(a)	Upper reaches	Group (C)
(b)	Lower reaches	" (A)

5. STRUCTURAL PLAN AGAINST INUNDATION DISASTER FOR GROUP (A)

5.1 General

The main stream of Rimac river between the confluence with the Santa Eulalia river and the river mouth, and the lower reaches of Jicamarca river are classified as Group (A) which has the highest priority for countermeasure, requiring a detailed study on its planning.

Then, the conclusion of structural plan for Group (A) is made through the technical, economical and social comparative studies on the conceivable alternative plans, which should duly meet the design criteria that the plans have to withstand the 100-year probable flood. River stretch having capacity less than the design flood (660 m3/sec) is indicated in Fig. V-5-1. Further, distribution of flood discharge of the Rimac and Santa Eulalia rivers is determined in the hydrological study as illustrated in Fig. V-5-2.

This section presents all the details of comparative studies as well as the final conclusion for the structural plan.

5.2 Alternative Plans

5.2.1 Main Stream (Confluence with Santa Eulalia river to river mouth)

Outline of alternative river improvement plan in each stretch is illustrated in Fig. V-5-3.

(A) Alternative Plans for Upper Reaches (Confluence with Santa Eulalia river to Huampani bridge)

The river stretch of about 12 km long in the downstream of the confluence with the Santa Eulalia river is remarkably narrowed artificially. The river width in the stretch is reduced to 20 m in average despite a width of 50 to 60 m at least is considered necessary. Some countermeasures are essential in view of so high susceptibility to the serious disaster.

As for the countermeasure, two measures are conceivable as follows:

CASE (A-1): The case that the river channel is planned in accordance with the existing river width as much as possible, protecting with the parapet wall or dike.

In this case, the planning is inevitable to include several unreasonable alignments and designs. However, its implementation will become easier since the necessary removal of residential houses and facilities are smaller compared with the alternative mentioned in (A-2) below.

CASE (A-2): The case that the river channel has a reasonable width and alignment for the design flood.

The case requires a considerable amount of removal of residential houses as well as a heavy construction work. However, the case is much more desirable from the aspect of safety of the river passing through a big city and favorable development of the area.

Thus, the above two conceivable cases are taken into consideration for examination. Fig. V-5-4 comparatively indicates the general plan of both cases.

(B) Alternative Plans for Middle Reaches
(Huampani Bridge and Atarjea Weir)

In the upstream reaches of Atarjea weir, there are several portions, where the river is largely widened, having a retarding effect on the floods of the Rimac river. This retarding effect is considered to serve a reduction of flood peak in the downstream reaches, increasing the safety in the area. It is also considered to effectively prevent various sizes of gravels from flowing down to the downstream reaches.

On the other hand, the river channel is not fixed there, disturbing a smooth river flow. The disturbed river flow attacks the river banks, causing an inundation due to the damage of dike.

Therefore, the advantageousness between the following two cases should be examined:

CASE (B-1): The case that the present river width is secured in the portion where the river is largely widened.

CASE (B-2): The case that the river is provided with a smooth channel without such a wide portion.

Then, the above two alternative plans are taken up for the comparative study. Fig. V-5-5 also shows the above two cases of plan.

(c) Alternative Plans for Lower Reaches
(Atarjea weir to the river mouth)

There is a narrow gorge with a sharp bend and high banks at 9 to 10.5 km from the river mouth, originating various inconveniences such as the erosion and sedimentation due to the accelerated river flow, the danger of bank collapse for the inhabitants on both banks or raising up of flood water level in the upstream reaches.

Some improvement on the above condition is essential, and two countermeasures are conceivable as follows:

CASE (C-1): The case that the narrow gorge is widened along the present river course.

CASE (C-2): The case that a short-cut is provided in the portion of sharp bend.

The comparative study is made on the above two conceivable cases for selection.

Fig. V-5-6 shows the layout of the said two cases.

(D) Discussion on Flood Way Plan

The construction of a separate flood way is conceivable in general as a measure for preventing the flood inundation. However, this measure is judged not to be applicable in the basin as explained below: that is, the construction of the flood way which requires a huge amount of compensation and construction cost due to the highly developed condition in the downstream areas will not be practical.

Thus, the plan of flood way is not taken as an alternative plan for the examination.

(E) Discussion on Flood Control Dam Plan

The construction of flood control dam is also conceivable as a countermeasure for mitigating the flood peak.

The damsite for constructing the flood control dam is found in the Santa Eulalia river and in the upper middle reaches of the Rimac river. Therefore, the plan with the flood control dam is preliminarily examined as attached in Appendix XI, Supporting Report III.

The above preliminary examination reveals the following:

(i) In view of the remarkable sedimentation in the basin, the flood control dam should be planned in consideration that the reservoir storage up to the spillway crest level will be filled up with sediments during a short period. Further, it should be considered that the sedimentation will occur from the spillway crest level in the form of a channel with the original river bed slope and the same width as the spillway for which the same width as the original river is usually given.

(ii) The height of spillway gate is assumed to be 15 m in consideration that the technically possible height is approximately 20 m at maximum.

(iii) Taking into consideration the said conditions of sedimentation and spillway gate, the available storage capacity of the two dams for flood control will approximately be 733×10^3 m^3.

(iv) With the above available storage capacity for flood control, the 100-year flood peak of 660 m^3/s can be mitigated to 550 m^3/s.

(v) The cost reduction for the necessary river improvement by the above mitigation of flood peak discharge will approximately be only US$10~20 x 10^6.

On the other hand, the cost increase due to the dam construction is as remarkable as US$86 x 10^6, indicating that the flood control dam plan will not be justifiable evidently.

Since the flood control dam plan will not be effective evidently as mentioned above, the idea is not taken up as an alternative plan for the comparative study.

5.2.2 Lower Reaches of Jicamarca River

The cause of disaster due to the flood inundation from the Jicamarca river is not in the shortage of flow capacity or alignment of river channel itself but in the unsatisfactory structures provided artificially; that is, the flow capacity at the mouth of Jicamarca river is extremely lessened due to the culvert provided for the traffic road, which causes a serious flood inundation in the downstream area along the right bank of Rimac river.

Thus, only the improvement of culvert to augment the flow capacity is a conceivable way of countermeasure, requiring no examination on other particular alternative plans.

5.2.3 Summary of Alternative Plans for Group (A)

The alternative plans for the comparative study as discussed are summarized below:

The comparative study for determining the structural plan is made for eight (8) cases, i.e. all combination of the conceivable alternative plans in the respective reaches as follows;

Items	Alternative Cases of Combinations for Comparative Study							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
1. Main Stream :								
- Plan for upper reaches (Confluence to Huampani bridge)	A-1	A-1	A-1	A-1	A-2	A-2	A-2	A-2
- Plan for middle reaches (Huampani bridge to Atarjea weir)	B-1	B-1	B-2	B-2	B-1	B-1	B-2	B-2
- Plan for lower reaches (Atarjea weir to river mouth)	C-1	C-2	C-1	C-2	C-1	C-2	C-1	C-2
2. Lower Reaches of : Jicamarca River	The improvement of culvert at the mouth of Jicamarca river is made without any other alternative.							

Note: (i) The necessary measures such as the removal of garbage, dredging of river bed, revetment and groyne, etc. where necessary are taken into consideration in the respective case of alternative plans.

(ii) Regarding (A-1), (A-2), (B-1), (B-2), (C-1) and (C-2), reference is made to Clause 5.2.1 of this Section 5.

6. DISASTER AND DAMAGE AT PROBABLE FLOOD

6.1 General

The structural measure for the flood inundation disaster will mitigate the flood damage. The flood damage study is made to evaluate the flood damage reduction with the structural measure.

It is desirable for the study of flood damage to depict a damage frequency curve. However, the preparation of the damage frequency curve requires sufficient records of actual flood damages which are not available unfortunately. Therefore, the study is made with the following procedure:

- Firstly, the flood prone area to be inundated by the various probable floods has to be estimated on the basis of hydraulic simulation under the present river condition. The extent of flooding area is delineated by considering the topographic conditions and water levels simulated with the non-uniform flow analysis.

- Secondly, the flood prone area delineated in the topographic map with the scale of 1:5,000 is divided by meshes, each having an interval of 500 m being equivalent to 25 ha. The elevations of ground surface and land use are read out by mesh.

- Thirdly, the value of properties is estimated based on the land use survey by mesh. The value of damageable properties is assessed by the number or area of them and unit value of them at 1987 price level.

The water level, inundation area and depth and damage estimate analyzed on the basis of the hydraulic simulation for various probable flood magnitudes are given hereunder.

6.2 Flood Discharge and Water Level

6.2.1 Main Stream (Confluence to river mouth)

Fig. V-6-1 gives the various probable flood hydrographs at Chosica. The water levels for these probable flood discharges are calculated through the non-uniform flow analysis.

Table V-6-1 tabulates the results of the above analysis at the cross sections available from the confluence to the river mouth. The cross sections and their location is attached in Data Book.

Fig.V-6-2 visually shows the relationship between the flood water levels and the elevation of existing river banks.

6.2.2 Main Stream (Confluence to Matucana)

In order to assess the flood damage in the stretch between the confluence and Matucana, the carrying capacity of discharge was estimated. Although river cross sections at particular points in this stretch is not available, flow capacity was checked based on the typical sections prepared by P&V Ingenieros in 1983 (ref. Appendix IV in Supporting Report I).

As a result of the hydraulic calculation by uniform flow theory, it was clarified that the present river channel has enough capacity to flow the 100 year probable flood peak discharge.

6.3 Inundation Area and Depth

Inundation areas were worked out for various probable floods through the non-uniform flow analysis. Inundation depth in each mesh is shown dividing into six (6) ranks as follows, since the flood damage in each mesh is estimated by applying the damage rates to be determined for each of the above ranks.

Rank	Inundation Depth (m)
0	0 m
1	0 to 0.5 m
2	0.5 to 1.0 m
3	1.0 to 2.0 m
4	2.0 to 3.0 m
5	Deeper than 3.0 m

Inundation area and range of depth in each mesh due to 10, 50 and 100 year probable flood are shown in Figs. V-6-3 to V-6-5.

6.4 Damage Estimate

The flood damage in each mesh is estimated by applying the damage rate to the damageable value (the whole assets) in each mesh.

The standard rate in accordance with the inundation depth, which was developed by the Ministry of Construction in Japan, is taken as the damage rate as follows:

	Rank of Inundation Depth					
	(0)	(1)	(2)	(3)	(4)	(5)
Kinds of Properties	0m	0-0.5m	0.5-1.0m	1.0-2.0m	2.0-3.0m	Over 3.0m
1. Residential houses	0	0.124	0.210	0.308	0.439	0.572
2. Household effects	0	0.086	0.191	0.331	0.499	0.690
3. Public buildings	0	0.154	0.295	0.399	0.509	0.597
4. Agricultural crops	0	0.270	0.350	0.510	0.510	0.510

The damageable value in each mesh is counted for several magnitude of probable floods. Table V-6-2 shows the flood damage for four kinds of damageable assets. The result is further summarized by return periods as follows.

Summary of Estimated Flood Damage

Unit: 10^3 US$

River Reaches	Return Period (Year) 2	5	10	25	50	100
1. Main Stream						
- Upper Reaches (Confluence to Huampani Bridge)	0	9,760	11,757	13,577	17,520	19,653
- Middle Reaches (Huampani Bridge to Atarjea Weir)	0	4,280	5,550	7,377	10,897	11,720
- Lower Reaches (Atarjea Weir to river mouth)	0	9,187	10,960	16,360	27,957	43,263
Sub-Total	0	23,227	28,267	37,314	56,383	74,636
2. Confluence to - Matucana	0	0	0	0	0	0
Total	0	23,227	28,267	37,314	56,383	74,636

The flood damage estimated in each mesh are given in Appendix XI, Supporting Report III.

7. EVALUATION AND SELECTION OF STRUCTURAL PLAN

7.1 Economic Evaluation

7.1.1 General

As one of indicators for selecting the structural plan the economic evaluation is made for all the alternative plans, assessing the project cost, the benefit (the damage reduction) to be obtained by the provision of countermeasure, and the economic internal rate of return (EIRR).

This section summarizes the results of the economic analysis and evaluation. All the details are presented in Appendix XI, Supporting Report III.

7.1.2 Project Cost

The project investment cost is estimated in terms of the economic cost for the economic evaluation.

Table V-7-1 presents the project investment cost with work quantities estimated at June 1987 price level for the alternative plans in the respective river reaches.

The project investment cost for all combinations of the above alternative plans, for which the comparative study is made, can be summarized as follows:

Project Investment Cost of Alternative Combinations for Comparative Study

Unit: 10^3 US$

River reaches	Alternative plans in respective reaches	Alternative cases of combination for comparative study							
		(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
1. Main Stream:									
- Upper reaches	A-1	13,643	13,643	13,643	13,643				
	A-2					16,920	16,920	16,920	16,920
- Middle reaches	B-1	12,547	12,547			12,547	12,547		
	B-2			46,572	46,572			46,572	46,572
- Lower reaches	C-1	17,166		17,166		17,166	17,166		
	C-2		24,369		24,369		24,369		24,369
2. Lower Reaches of Jicamarca River:		599	599	599	599	599	599	599	599
Total		43,955	51,158	77,980	85,183	47,232	54,435	81,257	88,460

The project cost includes the operation and maintenance cost (O & M cost) in addition to the above investment cost. The annual O & M cost is assumed to be 0.5% of the investment cost for the main works, referring to the O & M cost experienced in other similar projects.

7.1.3 Project Benefit

The project benefit is defined as the damage reduction by the provision of countermeasure, i.e. the damage without project less the damage with project.

The damage without project (the damage under the present condition) is worked out based on the hydraulic analysis which simulates the inundation for various probable flood magnitudes under the present river condition. Table V-7-2 calculates the damage without project in terms of the annual average damage. Table V-7-3 calculates the damage with project in terms of the annual average damage. Table V-7-4 shows the damage at lower reaches of Qda. Jicamarca in case of without and with project condition.

The estimate of the damage with project is made with the following considerations: that is, the structural measure is planned to withstand the 100-year probable flood magnitude, and therefore, no damage is caused by the flood less than the 100-year probable flood. On the other hand, the flood larger than the 100-year probable flood will overtop the dike, wholly washing away the dike. The inundation in this case will be similar to the state without project.

The damages without and with project, and the project benefit worked out by the damage without project less the damage with project are summarized below :

Unit: 10^3 US$

Flood Inundation Damage

River Reaches	Without Project	With Project	Project Benefit
1. Main Stream :			
- Upper Reaches	3,980	187	3,793
- Middle Reaches	1,953	113	1,840
- Lower Reaches	4,480	420	4,060
Sub-total	10,413	720	9,693
2. Lower Reaches of Jicamarca River :			
Sub-total	713	73	640
Total	11,126	793	10,333

7.1.4 Economic Analysis

The economic internal rate of return (EIRR) is assessed for all the combinations of alternative plans in the respective river reaches in Tables V-7-5 to V-7-12.

The analysis is made on the following assumptions:

- The construction work will take seven (7) years in total.
- The construction work will be implemented from the downstream reaches to upstream reaches.
- The investment cost in each year will accrue at the middle of the year.
- The annual O & M cost and benefit will partially accrue at the completion of construction work in each of upper, middle and lower reaches, and reach the full amount at the eighth year.
- The economic life is assumed at 50 years in accordance with the usual practice.
- No replacement cost will be required during the above economic life of 50 years.

The result of the economic analysis is summarized below:

Alternative Case of Combination		EIRR (%)
(1)	(A-1, B-1, C-1)	16.6
(2)	(A-1, B-1, C-2)	15.9
(3)	(A-1, B-2, C-1)	10.5
(4)	(A-1, B-2, C-2)	9.5
(5)	(A-2, B-1, C-1)	15.9
(6)	(A-2, B-1, C-2)	13.8
(7)	(A-2, B-2, C-1)	10.1
(8)	(A-2, B-2, C-2)	9.2

7.2 Technical and Social Evaluations

7.2.1 Alternative Plans for Upper Reaches of Main Stream

Two alternative cases of plans, i.e. CASE (A-1) and (A-2), are selected as conceivable for the upper reaches of main stream as mentioned in Section 5.2.1.

The two alternative cases are repeated below:

CASE (A-1): The case that the river channel is planned in accordance with the existing river width as much as possible, protecting with the parapet wall or dike.

CASE (A-2): The case that the river channel has a reasonable width and alignment for the design flood.

The evaluation on the above two alternative cases is made from the technical and social aspects as follows;

(1) CASE (A-1)

In CASE (A-1), assuming the river width of 20 m and river bed slope of 1/50, the river flow depth and flow velocity are estimated to reach approximately 5.0 m and 7.0 m/s respectively when the design flood of 660 m^3/s will occur.

Even if the surrounding areas are protected with the parapet wall or dike, a large area to be situated lower than the flood water level of river will be exposed to a high danger, since a small defect in the parapet wall or dike will immediately result in a serious damage. Further, the protection will be vulnerable to the damage due to the erosion and impulse by such a violent flow, especially at the bends which are inevitable at many points in CASE (A-1).

The necessary maintenance works are considered to increase much more since the protection will be subject to such violent flows as mentioned. It is also considered that CASE (A-1) is not favorable from the aspect of the implementation of work as compared with CASE (A-2) because CASE (A-1) makes the mechanized construction work difficult.

From the social aspect, CASE (A-1) will be more favorable in view of its less social constraint although the removal of residential houses and facilities is unavoidable to some extent along the protection to be newly constructed.

(2) CASE (A-2)

In CASE (A-2), the river channel will be widened to a reasonable river width of 40 m to 50 m. Besides that, the river alignment will be made smooth. With this river width, the river flow depth and flow velocity will be reduced down to about 2.5 m and 5.0 m/s respectively for the design flood of 660 m^3/s, remarkably increasing the safety compared with CASE (A-1).

For reference, a standard in relation to the river width is shown below:

<u>Standard River Width</u>

Flood (m3/s)	Standard Width (m)
300	40 to 60
500	60 to 80
1,000	90 to 120
2,000	160 to 220
5,000	350 to 450

<u>Standard River Flow Velocity</u>

Riverbed Slope	Velocity (m/s)
Gentle Riverbed Slope	2.0 to 3.0
Steep Riverbed Slope	3.0 to 5.0

The above standard is established to secure the necessary safety against the flood. As compared with the above standard, it can be said that the river width of 40 to 50 m proposed in CASE (A-2) is still insufficient slightly. However, in view that the standard is narrowly met and that the social constraint should be limited to the smallest, the width of 40 to 50 m is considered acceptable. In addition to the increase of durability of protection, the maintenance work will also be much reduced, compared with CASE (A-1).

A problem in CASE (A-2) is the increase of the necessary removal of houses and facilities as well as the social constraint. However, the solution of the problem is considered possible with a satisfactory education on the disaster and arrangements such as the preparation of alternative places for removal.

In view that the safety should primarily be taken into consideration in the disaster prevention plan, CASE (A-2) is much more desirable and recommendable.

7.2.2 Alternative Plans for Middle Reaches of Main Stream

Two alternative cases of plans selected as conceivable in the middle reaches of main stream, i.e. (CASE (B-1) and (B-2) as mentioned in Section 5.2.1, are repeated below:

CASE (B-1): The case that the present river width is secured in the portion where the river is largely widened.

CASE (B-2): The case that the river is provided with a smooth channel without such a wide portion.

The evaluation from the technical and social aspects is made on the above two alternative plans as follows:

(1) CASE (B-1)

It is considered that the wide portion in the middle reaches has a high retarding effect on the floods of the Rimac river, effectively reducing the flood peak discharge in the downstream reaches.

According to a preliminary examination on the retarding effect, the design flood peak of 660 m^3/s at Chosica is reduced to 540 m^3/s. This retarding effect remarkably increases the safety in the downstream reaches where the capital city is extensively developed. Besides that, the wide portion is also considered to efficiently prevent the various sizes of sands and gravels or boulders from flowing down to the downstream reaches, avoiding various troubles in the downstream reaches as well as increasing the safety there. If such a natural condition as mentioned is artificially changed drastically, it appears that various unexpected adverse effects may occur in the downstream reaches, threatening to the flood inundation disaster. Therefore, in view that the safety should not be reduced, it is technically much better to keep the wide portion unchanged.

On the other hand, the river channel is not fixed in the wide portion, disturbing a smooth river flow. The disturbed river flow attacks the river banks, frequently destroying the banks. The problem, however, is possible to be solved at a relatively less expense by providing a satisfactory protection with the revetment and groyne, etc. The continuous maintenance work such as the removal of deposits after floods, will be inevitable to maintain a smooth river flow in the reaches.

The social constraint in implementing the plan will be very small since the necessary removal of residential houses or facilities will be little in the middle reaches.

(2) CASE (B-2)

CASE (B-2) involves some technical uncertainties; that is, the case will artificially change the existing natural condition to a considerable extent, and therefore, it is worried that the various adverse effects as mentioned in (1) above will unexpectedly arise in the downstream reaches. It seems that it is technically desirable to avoid the plan involving such uncertainties.

7.2.3 Alternative Plans for Lower Reaches of Main Stream

Two alternative plans are considered for the countermeasure of the narrow gorge at 9 to 10.5 km from the river mouth. Those are;

CASE (C-1): The case that the narrow gorge is widened along the present river course,

CASE (C-2): The case that a short-cut is provided in the portion of sharp bend.

The evaluation on the two alternative plans from the technical and social aspects is made as follows:

It is needless to say that CASE (C-2) will technically be more desirable since the case will more favorably improve the various inconveniences and danger originating from the forced and strange river course.

However, the area is so crowded with the residential houses. If such a drastic improvement as mentioned in CASE (C-2) is executed, the necessary removal of residential houses will result in a huge increase as well as cause much more severe social constraint.

On the other hand, such a severe social constraint as CASE (C-2) can considerably be mitigated in CASE (C-1), making the implementation of plan easier.

Although the extent of improvement to be made in CASE (C-1) may not be so perfect as CASE (C-2), the problem may mostly be solved since the river flow will favorably become calm with the river channel to be widened.

As such, the technical and social evaluation on the two alternative plans comes to a conclusion that the merit of CASE (C-2) is not so large to such an extent that CASE (C-2) be executed at a sacrifice of so large increase of social constraint.

7.3 Selection of Structural Plan for Group (A)

As discussed, the result of evaluation from the technical and social aspects recommends the plans of (A-2) for the upper reaches, (B-1) for the middle reaches and (C-1) for the lower reaches respectively.

On the other hand, a high economic indicator with the second best EIRR is shown in the combination of (A-2, B-1, C-1), although the highest EIRR is indicated in the combination of (A-1, B-1, C-1) as seen in section 5.3.1(4).

Thus, the comprehensive evaluation from the technical, economical and social aspects reveals that the structural plan with the combination of (A-2, B-1, C-1) should be selected: that is, the structural measure for preventing the flood inundation disaster in the main stream should be planned with the following policies:

(1) The river channel in the upper reaches of main stream will be widened to a reasonable width of 40 to 50 m.

(2) The middle reaches of main stream will be planned, keeping the present wide river width in principle.

(3) The narrow gorge in the lower reaches of main stream will be widened along the present river course.

The proposed river improvement of the above combination is shown in Fig. V-7-1. It is noted that this improvement plan shown in Fig. V-7-1 is just prepared preliminarily at this master plan study stage, requiring further reexaminations on the basis of more detailed investigation and study.

The selected river improvement plan is reviewed in the light of the past actual flood disasters as follows:

<u>Upper Reaches</u>:

A flood inundation due to the narrow river channel is recorded near the town of Chosica in February 1983. The power intake of ELECTROLIMA and surrounding residential houses were inundated by the overtopping of flood water estimated at 200 to 250 m^3/sec. The proposed structural plan will duly widen the river channel and lower the flood water level, exterminating such inundations in the area.

Middle Reaches:

Campoy-Huachipa area has frequently been inundated due to the defects of levee, insufficient revetment in the levee or structure with insufficient flow capacity. The proposed structural plan duly involves the repair of defects in the levee, reinforcement of levee with revetment and improvement of the structure, satisfactorily preventing such disasters in the past as mentioned.

Lower Reaches:

A serious inundation in Callao area including the important military facilities is recorded in February 1984 due to the shortage of flow capacity in the downstream reaches of the narrow gorge, which is mainly caused by the remarkable deposit of sediments.

The proposed structural plan involves the riverbed excavation in the downstream reaches for increasing the flow capacity, and the widening of the narrow gorge which will favorably reduce the production of sediments, preventing the recurrence of such a serious inundation in the area as mentioned.

For reference, the above selected structural plan is reviewed in relation to the actual flood inundation disaster in the part as follows;

8. STRUCTURAL PLAN AGAINST INUNDATION DISASTER FOR GROUP (B)

8.1 General

The Rimac river reaches between the confluence with the Santa Eulalia river and Matucana is classified as Group (B), for which the examination on a special alternative plan is not made in the following view:

The reaches between Matucana and the confluence have some protective properties and experiences of flood inundation. However, the flood inundation in the area is not an usual type of flood inundation, but results mainly from damming up the river flow due to the debris flow from a quebrada, which will be solved by the countermeasures for the debris flow in the quebrada. In addition to less danger for the usual type of flood inundation, the river in the reaches does not have unreasonably less width such as the portions artificially narrowed in the main stream. The river also does not have the extremely wide portion like the main stream. Thus, the river does not require the examination on rearrangement of the present river channel. As such, the conceivable countermeasure in the reaches will be only to provide the means such as the heightening of dike or parapet wall, revetment and groyne, etc. where necessary along the present river bank based on the hydraulic analysis result; that is, there are no other comparable alternative plans for the comparative study.

Then, this section presents the proposed structural measure for the Rimac river reaches between the confluence and Matucana based on the hydraulic analysis, and the evaluations on it.

8.2 Structural Plan for Group B Area

It is reported that there are some portions where the flood inundation has been experienced. Those areas identified through the review on reports of the disaster and interview survey are shown in Fig. XI-6-3 of Appendix XI, Supporting Report III.

On the other hand, the hydraulic analysis carried out based on the available topographic data shows that the present river between Matucana and the confluence has a flow capacity enough to handle the 100-year flood peak discharge of 310 m^3/sec as shown in detail in Appendix V, Supporting Report I, indicating that the river improvement works have been carried out subsequently.

As far as the hydraulic analysis indicates, no structural plan will be required in the river reaches. However, it is found through the field reconnaissance that there are some areas where the safety should be increased, especially in Corcona and Torna Mesa areas which are particularly vulnerable against floodings. Then, the reinforcement of the protection to increase the safety in proposed as the structural plan for the Group (B) area as follows:

(A) Corcona

Corcona is located around 11 km upstream of the confluence with Santa Eulalia river in Chosica. In 1983, this area was inundated due to an overtopping from the left bank. The central highway was also inundated at that time, since the central highway in this area is situated at the nearby same elevation as that of the river bed.

After the inundation, a continuous embankment was urgently constructed to protect Corcona village and the highway. Although the embankment is constructed with about 1 km in length and 4 to 5 m in height, it is still insufficient to protect the area from the rapid torrent due to the steep gradient of the river bed. Since no revetment on the embankment is provided at present, it will be easily eroded, resulting in an inundation such as that once experienced.

Therefore, it is recommended to extend the existing embankment toward up and downstream and to provide the revetment on it. As the right side of the river channel in this area is a skirt of mountain, no protection will be needed. Thus, the structural plan in this area consists of the repair and extension of existing embankment with the revetment work. The area to be provided with the improvement is shown in Fig. V-8-1.

(B) Torna Mesa

This area is located about 1 km upstream from the confluence with Rio Seco on the left side of the stream. At the upstream side of this village where the river width is enlarged considerably, the deposit of gravel transported is remarkable in the river bed. It is considered that the rapid flow separates itself in this area and a part of it attacked the left bank when the water level is high. As a result, the flow may intrude into the village from the low portion of the left bank and cause an inundation. The major assets to be protected against flooding in this area is residential houses (approx. 20 nos.), central highway and railway. Then, the river dredging is required to lower the present river bed. At least, 3 m of depth (from the lowest river bed to the top of bank) is necessary to be secured at the stretch having a width of around 20 m. In addition to the dredging, the revetment work on both banks is needed to protect from erosion. The length of the protective area is about 2.0 km from the upstream end of Torna Mesa village to a little downstream of the confluence with Rio Seco. Since it is unavoidable that the debris flow from Rio Seco will flush out into the main stream, a continuous removal of the debris material is also essential to keep the river bed stable. The location of the protective area is shown in Fig. V-8-1.

The work quantity and construction cost of the necessary structural plan for Group (B) are is summarized as below:

Area	Work Item	Length to be provided	Cost
Corcona	Embankment & revetment work	1,000 m	1,230
Torna Mesa	Dredging & revetment work	2,000 m	850

8.3 Evaluation

The structural plan for Group (B) area is proposed as mentioned above. The necessary cost for the proposed structural plan is estimated at US$2,000 x 10^3. On the other hand, the benefit to be obtained by the proposed structural plan will be zero because no damage arises under the present condition without the structural plan, resulting in a negative figure of EIRR.

However, the necessary cost for the proposed structural plan in Group (B) is relatively minor, having a little effect on the economic viability of the whole structural plan including Group (A). On the other hand, it is much more desirable to ensure the safety from the technical and social aspects. Thus, it is considered the proposed structural plan is necessary and justifiable from an overall view.

Tables

Table V-6-1 WATER LEVEL AT PROBABLE FLOOD DISCHARGE (1/2)

Unit : EL.m

Sec.No.	Elevation of bankfull (m) Left	Right	Return Period 10	50	100
1	13.0	13.0	9.9	10.7	11.0
2	13.0	12.3	12.2	13.0	13.3
3	16.2	16.2	13.8	14.4	14.6
4	16.5	18.7	16.4	16.9	17.1
5	22.2	19.0	17.8	18.3	18.4
6	22.5	19.9	20.2	21.2	21.6
7	21.3	26.2	22.3	23.7	24.2
8	25.4	24.2	23.7	24.6	24.9
9	26.0	25.8	26.1	27.1	27.5
10	28.8	27.0	26.8	27.5	27.8
11	31.1	30.2	28.3	28.4	28.5
12	35.5	33.0	31.8	32.3	32.4
13	38.3	36.3	35.3	35.7	35.8
14	40.1	41.2	37.7	38.2	38.4
15	43.4	42.0	39.5	39.9	40.1
16	47.4	43.1	42.3	43.0	43.3
17	44.7	44.7	45.2	45.6	45.8
18	47.4	47.4	45.0	45.4	45.5
19	49.5	45.8	47.0	47.6	47.9
20	51.3	52.4	49.1	49.9	50.2
21	56.0	53.1	50.8	51.5	51.8
22	55.6	55.7	53.8	54.4	54.6
23	61.3	59.0	57.3	58.3	58.5
24	64.0	62.0	59.2	59.9	60.1
25	67.7	69.7	63.1	64.1	64.5
26	67.0	67.8	65.2	66.2	66.5
27	70.6	70.6	66.8	67.7	68.0
28	71.7	71.1	69.0	69.8	70.1
29	77.2	75.5	71.3	72.3	72.6
30	80.5	80.7	73.8	74.6	74.9
31	83.6	84.0	78.0	78.5	78.6
32	87.9	88.7	80.9	81.8	83.2
33	90.7	90.7	86.0	87.3	88.1
34	98.1	94.1	88.4	89.0	89.2
35	99.5	100.2	96.0	98.6	99.6
36	108.0	103.2	100.6	103.2	104.2
37	105.7	107.4	101.2	103.6	104.2
38	108.5	109.2	101.2	103.6	104.2
39	114.8	114.8	102.8	105.8	106.8
40	115.3	115.3	105.0	106.8	107.5
41	126.8	126.8	109.9	112.4	113.3
42	124.4	124.4	109.7	112.4	113.3
43	127.8	127.8	124.9	125.5	125.7
44	131.6	127.6	128.8	129.9	130.2
45	131.4	131.0	131.3	132.0	132.2
46	135.7	133.6	134.5	135.6	135.9
47	143.3	143.8	138.2	139.3	139.5
48	140.8	144.4	140.1	141.0	141.3
49	141.4	147.2	142.2	143.4	143.9
51	154.3	154.3	148.7	149.4	149.6
52	153.3	153.3	150.7	151.3	151.4
53	158.7	158.7	156.6	157.2	157.4
54	164.8	164.8	158.1	158.8	159.1
55	162.0	164.6	161.3	162.0	162.3
56	168.2	168.2	163.1	163.9	164.3
57	165.8	165.7	163.5	164.1	164.3
58	168.3	173.8	166.2	166.4	166.5
59	172.4	178.1	170.4	170.9	171.1
60	179.0	179.0	174.8	175.4	175.6
61	184.1	189.2	182.1	182.6	182.7
62	188.8	188.3	185.8	186.2	186.3
63	194.1	196.7	192.3	192.7	192.9
64	198.5	200.2	196.4	196.9	197.1
65	202.9	202.9	199.6	200.1	200.3
66	210.5	208.6	203.6	204.1	204.2
67	213.6	214.2	208.9	209.5	209.7
68	212.7	215.0	210.7	211.2	211.3
69	220.0	225.0	214.8	215.5	215.7
70	225.4	226.7	219.5	220.1	220.3
71	230.0	231.4	224.1	224.6	224.7
72	237.0	236.0	229.4	229.9	230.1
73	240.0	238.8	234.9	235.5	235.6
74	242.0	244.5	238.3	238.8	238.9
75	249.0	249.0	244.2	244.5	244.6
76	248.4	249.0	245.3	245.6	245.7
77	249.4	249.1	245.9	246.4	246.6
78	260.7	252.4	247.8	248.2	248.3
79	262.0	252.2	248.7	249.0	249.1
80	257.2	254.8	249.1	249.4	249.6
81	258.0	254.8	250.6	251.0	251.2
82	261.0	258.0	252.9	253.2	253.3
83	264.6	264.6	259.7	260.3	260.5
84	265.0	265.4	260.6	261.3	261.5
85	265.8	264.0	262.4	262.7	262.8
86	275.1	269.5	269.3	269.5	269.6
87	283.6	277.8	276.0	276.2	276.2
88	285.0	285.2	284.1	284.4	284.6
89	291.2	292.0	290.2	290.4	290.5
90	302.0	301.8	299.9	300.1	300.1
91	312.0	308.4	306.6	306.8	306.9
92	323.1	318.2	315.9	316.0	316.1
93	330.1	326.1	323.9	324.1	324.1
94	338.9	331.7	331.5	331.7	331.8
95	341.0	340.2	340.0	340.2	340.3
96	350.0	348.8	349.4	349.5	349.6
97	361.0	360.0	360.4	360.6	360.7
98	368.5	368.5	368.2	368.6	368.7
99	379.0	375.0	274.6	374.9	375.1
100	384.0	383.8	381.9	382.4	383.0

Note : Sec.No.50 is not available.

Table V-6-1 WATER LEVEL AT PROBABLE FLOOD DISCHARGE (2/2)

Unit : EL.m

Sec.No.	Elevation of bankfull (m) Left	Right	Return Period 10	50	100
101	393.0	392.4	390.4	390.9	391.1
102	404.5	399.5	399.3	399.5	399.6
103	410.5	407.3	408.5	408.7	408.7
104	419.7	418.2	417.0	417.3	417.4
105	426.5	426.0	424.6	424.8	424.9
106	439.0	434.0	433.5	433.7	433.7
107	447.8	444.0	442.7	442.9	443.0
108	451.8	452.0	452.7	453.0	453.2
109	463.1	460.0	459.3	459.7	459.8
110	470.0	470.0	467.1	476.3	467.4
111	480.0	476.9	476.7	476.9	477.0
112	489.9	486.6	486.6	486.7	486.8
113	495.9	495.9	495.9	496.1	496.2
114	505.0	505.0	504.2	504.6	504.8
115	510.0	510.0	509.9	510.2	510.3
116	518.1	518.1	518.3	518.7	518.8
117	525.0	524.9	525.6	525.9	526.0
118	535.0	535.0	534.8	535.0	535.1
119	544.7	544.6	544.3	544.6	544.7
120	553.2	560.3	551.2	551.6	551.7
121	561.1	562.9	560.4	560.6	560.7
122	572.5	568.1	570.0	571.0	571.2
123	584.4	587.6	583.5	583.9	584.0
124	589.5	592.4	588.1	588.4	588.5
125	590.7	595.7	591.2	591.5	591.7
126	594.4	599.0	593.6	593.9	594.0
127	597.2	602.0	596.8	597.1	597.2
128	602.7	607.8	602.8	603.1	603.2
129	605.5	609.5	605.4	605.8	605.9
130	609.1	612.6	607.9	608.2	608.3
131	614.5	615.2	613.7	614.0	614.1
132	619.3	619.0	619.0	619.2	619.3
133	623.7	622.8	623.6	623.9	624.1
134	626.5	625.1	625.9	626.2	626.3
135	629.9	628.2	629.1	629.2	629.3
136	635.1	635.4	634.9	635.3	635.4
137	642.5	642.5	643.7	644.0	644.1
138	662.6	665.5	663.5	664.0	664.1
139	666.3	663.1	664.4	664.8	665.1
140	666.5	668.7	667.1	667.4	667.6
141	667.2	668.0	668.8	669.3	669.5
142	681.1	680.2	680.6	680.8	680.9
143	690.0	690.1	690.8	691.1	691.2
144	695.1	695.0	695.7	696.0	696.1
145	699.5	698.0	699.0	699.3	699.4
146	703.4	706.0	704.7	705.1	705.2
147	710.5	710.4	710.4	710.7	710.8
148	717.4	716.3	719.2	720.8	721.5
149	722.4	722.4	723.8	724.2	724.3
150	723.8	724.5	725.3	725.8	725.9

Unit : EL.m

Sec.No.	Elevation of bankfull (m) Left	Right	Return Period 10	50	100
151	731.0	731.3	734.2	735.0	735.4
152	734.8	734.9	736.6	738.0	738.5
153	737.2	737.2	736.5	737.3	737.6
154	738.3	739.1	742.0	743.6	744.1
155	745.4	746.0	744.0	744.4	744.5
156	754.3	752.5	754.2	755.5	756.1
157	756.6	756.6	757.6	758.3	758.5
158	760.8	760.0	761.5	761.8	762.0
159	762.5	762.8	762.5	763.0	763.2
160	763.8	765.5	763.8	764.1	764.2
161	765.8	766.0	765.6	766.1	766.3
162	766.2	767.6	767.5	768.1	768.2
163	767.0	767.6	768.2	768.7	768.9
164	770.5	768.2	768.4	768.8	769.0
165	769.1	770.6	768.6	769.1	769.3
166	770.6	769.1	769.7	770.0	770.1
167	772.0	771.0	771.0	771.4	771.5
168	772.8	771.8	772.4	772.8	772.9
169	772.8	772.8	773.0	773.3	773.4
170	775.3	774.3	774.7	775.0	775.0
171	776.7	775.5	775.8	776.1	776.2
172	778.8	777.3	777.5	777.7	777.8
173	780.4	780.7	779.0	779.3	779.4
174	779.5	779.5	780.0	780.4	780.5
175	781.8	789.6	780.8	781.2	781.3
176	784.3	794.5	780.8	780.9	781.0
177	785.8	785.2	782.1	782.4	782.5
178	784.4	785.3	783.9	784.4	784.5
179	789.5	786.1	785.8	786.3	786.5
180	786.3	787.0	787.5	787.8	787.9
181	788.4	787.7	787.5	788.0	788.2
182	789.3	789.9	789.2	789.7	789.8
183	789.4	788.7	789.6	790.4	790.6
184	789.4	789.0	790.5	791.3	791.6
185	792.4	793.7	790.2	790.7	790.9
186	808.2	808.0	808.6	809.0	809.1
187	816.6	818.4	815.4	815.6	815.7
188	818.3	818.7	819.5	820.5	820.9
189	822.1	822.7	822.4	823.4	823.7
190	825.5	830.2	825.6	825.7	825.8
191	830.6	830.9	830.1	830.6	830.7
192	838.3	837.8	839.8	841.5	842.2
193	849.0	845.9	848.1	849.9	850.4
194	849.5	849.5	852.3	853.7	854.3
195	854.9	853.5	855.7	857.2	857.7
196	859.6	858.1	861.5	862.8	863.3
197	862.6	863.8	868.9	870.1	870.5
198	876.6	878.8	876.6	877.2	877.3
199	887.6	886.4	886.1	886.6	886.7

Table V-6-2 SUMMARY OF PROBABLE FLOOD DAMAGE BY CATEGORY OF DAMAGEABLE ASSETS

Unit : 10^6 Intis (10^3 US $)

	Residentoal houses	Household effects	Public offices	Agricutural crops	Total
10 year					
Upper reaches	282.8	24.2	45.6	0.1	352.7 (11756.7)
Middle reaches	133.5	10.2	21.8	1.1	166.5 (5550.0)
Lower reaches	275.2	21.8	31.7	0.1	328.8 (10960.0)
Total	691.4 (23046.7)	56.2 (1873.3)	99.1 (3303.3)	1.3 (43.3)	848.0 (28266.7)
50 year					
Upper reaches	421.0	40.3	64.4	0.1	525.9 (17530.0)
Middle reaches	264.1	21.3	40.2	1.4	326.9 (10896.7)
Lower reaches	688.7	60.0	88.8	1.2	838.7 (27956.7)
Total	1373.8 (45793.3)	121.7 (4056.7)	193.3 (6443.3)	2.7 (90.0)	1691.5 (56383.3)
100 year					
Upper reaches	471.4	47.4	70.6	0.1	589.6 (19653.3)
Middle reaches	283.6	22.9	43.5	1.5	351.6 (11720.0)
Lower reaches	1045.0	93.6	157.7	1.6	1297.9 (43263.3)
Total	1800.0 (60000.0)	164.0 (5466.7)	271.8 (9060.0)	3.3 (110.0)	2239.1 (74636.7)

Table V-7-1 PROJECT INVESTMENT COST OF RIVER IMPROVEMENT OF ALTERNATIVE PLANS (MAIN STREAM)

Unit : US$ 10^3

No.	Work Items	Unit	Unit Cost (US$)	Upper Reaches A-1 Q'ty		Upper Reaches A-2 Q'ty		Middle Reaches B-1 Q'ty		Middle Reaches B-2 Q'ty		Lower Reaches C-1 Q'ty		Lower Reaches C-2 Q'ty	
				Q'ty	Amount	Q'ty	Amount	Q'ty	Amount	Q'ty	Amount	Q'ty	Amount	Q'ty	Amount
1	Preparatory works /1	L.S.	-	-	522	-	642	-	504	-	1,817	-	639	-	909
2	Main Works				10,447		12,844		10,083		36,339		12,777		18,179
	(1) Excavation														
	- Rock/boulders	cu.m	7.2	90,600	649	141,000	1,011	103,200	740	0	0	176,000	1,261	293,000	2,100
	- Common	cu.m	3.7	93,900	344	150,000	550	44,900	165	1,236,000	4,532	1,582,000	5,801	2,636,100	9,666
	(2) Embankment	cu.m	20.8	238,000	4,958	238,000	4,958	255,200	5,317	1,255,000	26,146	28,200	588	28,200	588
	(3) Backfill														
	- Gravel	cu.m	7.2	46,900		46,900		68,300				72,500		72,500	
	- Random	cu.m	3.7	24,600	90	80,400	295	4,500	17	0	0	187,600	688	187,600	688
	(4) Rienforced concrete	cu.m	100.0	20,500	2,050	28,200	2,820	14,900	1,490	0	0	11,900	1,190	14,200	1,420
	(5) Gabion	pc.	20.0	0	0	0	0	0	0	0	0	0	0	0	0
	(6) Revetment														
	- Wet masonry	sq.m	13.3	77,500	1,033	77,500	1,033	27,500	367	267,000	3,560	155,800	2,077	155,800	2,077
	- Gabion mattress	sq.m	10.0	35,600	356	35,600	356	31,700	317	0	0	0	0	0	0
	(7) Groyne														
	- Wet masonry	cu.m	40.7	0	0	0	0	990	40	0	0	0	0	0	0
	- Concrete	cu.m	83.8	0	0	0	0	0	0	0	0	0	0	0	0
	(8) Ground sill	sq.m	130.0	3,600	468	0	0	6,000	780	0	0	1,125	146	1,125	146
	(9) Bridge	sq.m	1,160.0	0	0	960	1,114	320	371 *	320	371 *	360	418	360	418
	(10) Road	sq.m	22.0	0	0	0	0	0	0	0	0	0	0	9,600	211
	(11) Gate	sq.m	8,010.0	0	0	12	96	0	0	0	0	0	0	0	0
	(12) Miscellaneous (5%)	L.S.	-	-	497	-	612	-	480	-	1,730	-	608	-	866
3	Compensation	Nos.	166.7	400	67	1,200	200	280	47	0	0	2,820	470	3,745	624
4	Engineering service & /2 governmental administration	L.S.	-	-	828	-	1,026	-	798	-	2,862	-	1,041	-	1,478
5	Physical contingency /3	L.S.	-	-	1,780	-	2,207	-	1,715	-	6,153	-	2,239	-	3,179
	Total				13,643		16,920		13,146 (599)		47,171 (599)		17,166		24,369

Note : Plan A-1,Upper reach, heightening the existing river banks
A-2, - do - enlarging the existing river channel
B-1,Middle reach, keeping the existing river width with partial diking
B-2, - do - reducing the existing river width by dike
C-1,Lower reach, enlarging the width of narrow portion along the existing river course
C-2, - do - short-cutting and enlarging the width of narrow portion
* ,Improvement work at the river mouth of Jicamarca river
( ),Total improvement cost for outlet of Qda.Jicamarca
/1, 5% of item 2
/2, 7.5% of item 1 to 3
/3, 15% of item 1 to 4

Table V-7-2 FLOOD INUNDATION DAMAGE WITHOUT PROJECT (1/2)

Return Period (Year)	Expected Frequency (Events/Year)	Damage Amount (10^6 Intis)	Events per Year within Interval	Average Damage per Interval (10^6 Intis)	Annual Average Damage (10^6 Intis)
Upper reaches of main stream					
0.5	2.0	0			
			1.0	0	0
1.0	1.0	0			
			0.5	0	0
2.0	0.5	0			
			0.3	146.4	43.9
5.0	0.2	292.8			
			0.1	322.8	32.3
10.0	0.1	352.7			
			0.067	386.4	25.9
30.0	0.033	420.0			
			0.013	473.0	6.1
50.0	0.020	525.9			
			0.010	557.8	5.6
100.0	0.010	589.6			
			0.005	604.8	3.0
200.0	0.005	620.0			
			0.003	637.5	1.9
500.0	0.002	655.0			
			0.001	662.5	0.7
1,000.0	0.001	670.0			
				Total	119.4 (US$3,980 x 10^3)

Return Period (Year)	Expected Frequency (Events/Year)	Damage Amount (10^6 Intis)	Events per Year within Interval	Average Damage per Interval (10^6 Intis)	Annual Average Damage (10^6 Intis)
Middle reaches of main stream					
0.5	2.0	0			
			1.0	0	0
1.0	1.0	0			
			0.5	0	0
2.0	0.5	0			
			0.3	64.2	19.3
5.0	0.2	128.4			
			0.1	147.5	14.8
10.0	0.1	166.5			
			0.067	208.3	14.0
30.0	0.033	250.0			
			0.013	288.5	3.7
50.0	0.020	326.9			
			0.010	339.3	3.4
100.0	0.010	351.6			
			0.005	363.3	1.8
200.0	0.005	375.0			
			0.003	387.5	1.2
500.0	0.002	400.0			
			0.001	410.0	0.4
1,000.0	0.001	420.0			
				Total	58.6 (US$1,953 x 10^3)

Table V-7-2 FLOOD INUNDATION DAMAGE WITHOUT PROJECT (2/2)

Return Period (Year)	Expected Frequency (Events/Year)	Damage Amount (10^6 Intis)	Events per Year within Interval	Average Damage per Interval (10^6 Intis)	Annual Average Damage (10^6 Intis)
Lower reaches of main stream					
0.5	2.0	0			
			1.0	0	0
1.0	1.0	0			
			0.5	0	0
2.0	0.5	0			
			0.3	137.8	41.3
5.0	0.2	275.6			
			0.1	302.2	30.2
10.0	0.1	328.8			
			0.067	454.4	30.4
30.0	0.033	580.0			
			0.013	709.4	9.2
50.0	0.020	838.7			
			0.010	1,068.3	10.7
100.0	0.010	1,297.9			
			0.005	1,364.0	6.8
200.0	0.005	1,430.0			
			0.003	1,440.0	4.3
500.0	0.002	1,450.0			
			0.001	1,475.0	1.5
1,000.0	0.001	1,500.0			
				Total	134.4 (US$4,480 x 10^3)

Table V-7-3 FLOOD INUNDATION DAMAGE WITH PROJECT (1/2)

Return Period (Year)	Expected Frequency (Events/Year)	Damage Amount (10^6 Intis)	Events per Year within Interval	Average Damage per Interval (10^6 Intis)	Annual Average Damage (10^6 Intis)
Upper reaches of main stream					
0.5	2.0	0			
			1.0	0	0
1.0	1.0	0			
			0.5	0	0
2.0	0.5	0			
			0.3	0	0
5.0	0.2	0			
			0.1	0	0
10.0	0.1	0			
			0.067	0	0
30.0	0.033	0			
			0.013	0	0
50.0	0.020	0			
			0.010	0	0
100.0	0.010	589.6			
			0.005	604.8	3.0
200.0	0.005	620.0			
			0.003	637.5	1.9
500.0	0.002	655.0			
			0.001	662.5	0.7
1,000.0	0.001	670.0			
				Total	5.6 (US$187 x 10^3)
Middle reaches of main stream					
0.5	2.0	0			
			1.0	0	0
1.0	1.0	0			
			0.5	0	0
2.0	0.5	0			
			0.3	0	0
5.0	0.2	0			
			0.1	0	0
10.0	0.1	0			
			0.067	0	0
30.0	0.033	0			
			0.013	0	0
50.0	0.020	0			
			0.010	0	0
100.0	0.010	351.6			
			0.005	363.3	1.8
200.0	0.005	375.0			
			0.003	387.5	1.2
500.0	0.002	400.0			
			0.001	410.0	0.4
1,000.0	0.001	420.0			
				Total	3.4 (US$113 x 10^3)

Table V-7-3 FLOOD INUNDATION DAMAGE WITH PROJECT (2/2)

Return Period (Year)	Expected Frequency (Events/Year)	Damage Amount (10^6 Intis)	Events per Year within Interval	Average Damage per Interval (10^6 Intis)	Annual Average Damage (10^6 Intis)
<u>Lower reaches of main stream</u>					
0.5	2.0	0			
			1.0	0	0
1.0	1.0	0			
			0.5	0	0
2.0	0.5	0			
			0.3	0	0
5.0	0.2	0			
			0.1	0	0
10.0	0.1	0			
			0.067	0	0
30.0	0.033	0			
			0.013	0	0
50.0	0.020	0			
			0.010	0	0
100.0	0.010	1,297.9			
			0.005	1,364.0	6.8
200.0	0.005	1,430.0			
			0.003	1,440.0	4.3
500.0	0.002	1,450.0			
			0.001	1,475.0	1.5
1,000.0	0.001	1,500.0			
				Total	12.4 (US$420 x 10^3)

Table V-7-4 FLOOD INUNDATION DAMAGE AT LOWER REACHES OF JICAMARCA

Return Period (Year)	Expected Frequency (Events/Year)	Damage Amount (10^6 Intis)	Events per Year within Interval	Average Damage per Interval (10^6 Intis)	Annual Average Damage (10^6 Intis)
Without project					
0.5	2.0	0			
			1.0	0	0
1.0	1.0	0			
			0.5	0	0
2.0	0.5	0			
			0.3	0	0
5.0	0.2	0			
			0.1	0	0
10.0	0.1	201.2			
			0.067	209.6	14.0
30.0	0.033	218.0			
			0.013	220.7	2.9
50.0	0.020	223.3			
			0.010	229.6	2.3
100.0	0.010	235.8			
			0.005	238.4	1.2
200.0	0.005	241.0			
			0.003	244.5	0.7
500.0	0.002	248.0			
			0.001	250.0	0.3
1,000.0	0.001	252.0			
				Total	21.4 (US$713 x 10^3)
With project					
0.5	2.0	0			
			1.0	0	0
1.0	1.0	0			
			0.5	0	0
2.0	0.5	0			
			0.3	0	0
5.0	0.2	0			
			0.1	0	0
10.0	0.1	0			
			0.067	0	0
30.0	0.033	0			
			0.013	0	0
50.0	0.020	0			
			0.010	0	0
100.0	0.010	235.8			
			0.005	238.4	1.2
200.0	0.005	241.0			
			0.003	244.5	0.7
500.0	0.002	248.0			
			0.001	250.0	0.3
1,000.0	0.001	252.0			
				Total	2.2 (US$73 x 10^3)

Table V-7-5 CASH FLOW AND ECONOMIC ANALYSIS (ALTERNATIVE CASE OF COMBINATION (1))

Upper Reaches : A-1 Middle Reaches : B-1 Lower Reaches : C-1 Unit : US$ 10^3

EIRR = 16.5819 %

Year	Fisical year	COST STREAM: Disbursement of Investment: Upper Reaches	Middle Reaches	Lower Reaches	Jicamarca River	Annual O&M Cost	Cost Total	Discounted Total Cost	BENEFIT STREAM: Annual Benefit	Discounted Total Benefit	Net Present Worth
1	1990/1991	10	-	3,433	-	-	3,443	2,953	0	0	(2,953)
2	1991/1992	15	-	6,866	-	-	6,881	5,063	0	0	(5,063)
3	1992/1993	15	-	6,866	-	-	6,881	4,343	0	0	(4,343)
4	1993/1994	15	6,274	-	599	66	6,954	3,764	1,447	783	(2,981)
5	1994/1995	2,718	6,274	-	-	66	9,057	4,206	1,447	672	(3,534)
6	1995/1996	5,435	-	-	-	115	5,550	2,211	2,687	1,070	(1,141)
7	1996/1997	5,435	-	-	-	115	5,550	1,896	2,687	918	(978)
8	1997/1998					130	130	38	10,333	3,028	2,990
9	1998/1999					130	130	33	10,333	2,597	2,565
10	1999/2000					130	130	28	10,333	2,228	2,200
11	2000/2001					130	130	24	10,333	1,911	1,887
12	2001/2002					130	130	21	10,333	1,639	1,619
13	2002/2003					130	130	18	10,333	1,406	1,388
14	2003/2004					130	130	15	10,333	1,206	1,191
15	2004/2005					130	130	13	10,333	1,035	1,022
16	2005/2006					130	130	11	10,333	887	876
17	2006/2007					130	130	10	10,333	761	752
18	2007/2008					130	130	8	10,333	653	645
19	2008/2009					130	130	7	10,333	560	553
20	2009/2010					130	130	6	10,333	480	474
21	2010/2011					130	130	5	10,333	412	407
22	2011/2012					130	130	4	10,333	353	349
23	2012/2013					130	130	4	10,333	303	299
24	2013/2014					130	130	3	10,333	260	257
25	2014/2015					130	130	3	10,333	223	220
26	2015/2016					130	130	2	10,333	191	189
27	2016/2017					130	130	2	10,333	164	162
28	2017/2018					130	130	2	10,333	141	139
29	2018/2019					130	130	2	10,333	121	119
30	2019/2020					130	130	1	10,333	104	102
31	2020/2021					130	130	1	10,333	89	88
32	2021/2022					130	130	1	10,333	76	75
33	2022/2023					130	130	1	10,333	65	65
34	2023/2024					130	130	1	10,333	56	55
35	2024/2025					130	130	1	10,333	48	47
36	2025/2026					130	130	1	10,333	41	41
37	2026/2027					130	130	0	10,333	35	35
38	2027/2028					130	130	0	10,333	30	30
39	2028/2029					130	130	0	10,333	26	26
40	2029/2030					130	130	0	10,333	22	22
41	2030/2031					130	130	0	10,333	19	19
42	2031/2032					130	130	0	10,333	16	16
43	2032/2033					130	130	0	10,333	14	14
44	2033/2034					130	130	0	10,333	12	12
45	2034/2035					130	130	0	10,333	10	10
46	2035/2036					130	130	0	10,333	9	9
47	2036/2037					130	130	0	10,333	8	8
48	2037/2038					130	130	0	10,333	7	6
49	2038/2039					130	130	0	10,333	6	6
50	2039/2040					130	130	0	10,333	5	5
Total		13,643	12,547	17,166	599	5,952	49,907	24,704	452,585	24,704	(0)

Table V-7-6 CASH FLOW AND ECONOMIC ANALYSIS (ALTERNATIVE CASE OF COMBINATION (2))

Upper Reaches : A-1 Middle Reaches : B-1 Lower Reaches : C-2 Unit : US$ 10^3

EIRR = 15.8801 % COST STREAM BENEFIT STREAM

Year	Fisical year	Disbursement of Investment: Upper Reaches	Middle Reaches	Lower Reaches	Jicamarca River	Annual O&M Cost	Cost Total	Discounted Total Cost	Annual Benefit	Discounted Total Benefit	Net Present Worth
1	1990/1991	10	-	4,874	-	-	4,943	4,266	0	0	(4,266)
2	1991/1992	15	-	9,748	-	-	9,881	7,358	0	0	(7,358)
3	1992/1993	15	-	9,748	-	-	9,881	6,350	0	0	(6,350)
4	1993/1994	15	6,274	-	599	92	6,607	3,664	1,447	802	(2,862)
5	1994/1995	2,718	6,274	-	-	92	7,042	3,370	1,447	692	(2,678)
6	1995/1996	5,435	-	-	-	140	1,759	726	2,687	1,110	383
7	1996/1997	5,435	-	-	-	140	1,759	627	2,687	957	331
8	1997/1998					156	156	48	10,333	3,178	3,130
9	1998/1999					156	156	41	10,333	2,743	2,701
10	1999/2000					156	156	36	10,333	2,367	2,331
11	2000/2001					156	156	31	10,333	2,042	2,012
12	2001/2002					156	156	27	10,333	1,762	1,736
13	2002/2003					156	156	23	10,333	1,521	1,498
14	2003/2004					156	156	20	10,333	1,313	1,293
15	2004/2005					156	156	17	10,333	1,133	1,116
16	2005/2006					156	156	15	10,333	977	963
17	2006/2007					156	156	13	10,333	843	831
18	2007/2008					156	156	11	10,333	728	717
19	2008/2009					156	156	9	10,333	628	619
20	2009/2010					156	156	8	10,333	542	534
21	2010/2011					156	156	7	10,333	468	461
22	2011/2012					156	156	6	10,333	404	398
23	2012/2013					156	156	5	10,333	348	343
24	2013/2014					156	156	5	10,333	301	296
25	2014/2015					156	156	4	10,333	259	256
26	2015/2016					156	156	3	10,333	224	220
27	2016/2017					156	156	3	10,333	193	190
28	2017/2018					156	156	3	10,333	167	164
29	2018/2019					156	156	2	10,333	144	142
30	2019/2020					156	156	2	10,333	124	122
31	2020/2021					156	156	2	10,333	107	106
32	2021/2022					156	156	1	10,333	92	91
33	2022/2023					156	156	1	10,333	80	79
34	2023/2024					156	156	1	10,333	69	68
35	2024/2025					156	156	1	10,333	59	59
36	2025/2026					156	156	1	10,333	51	51
37	2026/2027					156	156	1	10,333	44	44
38	2027/2028					156	156	1	10,333	38	38
39	2028/2029					156	156	0	10,333	33	32
40	2029/2030					156	156	0	10,333	28	28
41	2030/2031					156	156	0	10,333	25	24
42	2031/2032					156	156	0	10,333	21	21
43	2032/2033					156	156	0	10,333	18	18
44	2033/2034					156	156	0	10,333	16	16
45	2034/2035					156	156	0	10,333	14	13
46	2035/2036					156	156	0	10,333	12	12
47	2036/2037					156	156	0	10,333	10	10
48	2037/2038					156	156	0	10,333	9	9
49	2038/2039					156	156	0	10,333	8	7
50	2039/2040					156	156	0	10,333	7	6
Total		13,643	12,547	24,369	599	7,172	48,580	26,711	452,585	26,711	0

Table V-7-7 CASH FLOW AND ECONOMIC ANALYSIS (ALTERNATIVE CASE OF COMBINATION (3))

Upper Reaches : A-1 Middle Reaches : B-2 Lower Reaches : C-1 Unit : US$ 10^3

EIRR = 10.5049 %

Year	Fisical year	Upper Reaches	Middle Reaches	Lower Reaches	Jicamarca River	Annual O&M Cost	Cost Total	Discounted Total Cost	Annual Benefit	Discounted Total Benefit	Net Present Worth
		COST STREAM: Disbursement of Investment							BENEFIT STREAM		
1	1990/1991	10	-	3,433	-	-	3,443	3,116	0	0	(3,116)
2	1991/1992	15	-	6,866	-	-	6,881	5,635	0	0	(5,635)
3	1992/1993	15	-	6,866	-	-	6,881	5,100	0	0	(5,100)
4	1993/1994	15	23,286	-	599	66	23,966	16,072	1,447	970	(15,102)
5	1994/1995	2,729	23,286	-	-	66	26,081	15,827	1,447	878	(14,950)
6	1995/1996	5,457	-	-	-	248	5,705	3,133	2,687	1,475	(1,658)
7	1996/1997	5,457	-	-	-	248	5,705	2,835	2,687	1,335	(1,500)
8	1997/1998					248	248	112	10,333	4,647	4,535
9	1998/1999					248	248	101	10,333	4,205	4,104
10	1999/2000					248	248	91	10,333	3,805	3,714
11	2000/2001					248	248	83	10,333	3,444	3,361
12	2001/2002					248	248	75	10,333	3,116	3,042
13	2002/2003					248	248	68	10,333	2,820	2,752
14	2003/2004					248	248	61	10,333	2,552	2,491
15	2004/2005					248	248	55	10,333	2,309	2,254
16	2005/2006					248	248	50	10,333	2,090	2,040
17	2006/2007					248	248	45	10,333	1,891	1,846
18	2007/2008					248	248	41	10,333	1,711	1,670
19	2008/2009					248	248	37	10,333	1,549	1,512
20	2009/2010					248	248	34	10,333	1,402	1,368
21	2010/2011					248	248	30	10,333	1,268	1,238
22	2011/2012					248	248	28	10,333	1,148	1,120
23	2012/2013					248	248	25	10,333	1,039	1,014
24	2013/2014					248	248	23	10,333	940	917
25	2014/2015					248	248	20	10,333	851	830
26	2015/2016					248	248	18	10,333	770	751
27	2016/2017					248	248	17	10,333	697	680
28	2017/2018					248	248	15	10,333	630	615
29	2018/2019					248	248	14	10,333	570	557
30	2019/2020					248	248	12	10,333	516	504
31	2020/2021					248	248	11	10,333	467	456
32	2021/2022					248	248	10	10,333	423	413
33	2022/2023					248	248	9	10,333	383	373
34	2023/2024					248	248	8	10,333	346	338
35	2024/2025					248	248	8	10,333	313	306
36	2025/2026					248	248	7	10,333	283	277
37	2026/2027					248	248	6	10,333	257	250
38	2027/2028					248	248	6	10,333	232	227
39	2028/2029					248	248	5	10,333	210	205
40	2029/2030					248	248	5	10,333	190	186
41	2030/2031					248	248	4	10,333	172	168
42	2031/2032					248	248	4	10,333	156	152
43	2032/2033					248	248	3	10,333	141	137
44	2033/2034					248	248	3	10,333	127	124
45	2034/2035					248	248	3	10,333	115	113
46	2035/2036					248	248	3	10,333	104	102
47	2036/2037					248	248	2	10,333	94	92
48	2037/2038					248	248	2	10,333	85	83
49	2038/2039					248	248	2	10,333	77	76
50	2039/2040					248	248	2	10,333	70	68
Total		13,643	46,572	17,166	599	11,292	89,327	52,876	452,585	52,876	0

Table V-7-8 CASH FLOW AND ECONOMIC ANALYSIS (ALTERNATIVE CASE OF COMBINATION (4))

Upper Reaches : A-1 Middle Reaches : B-2 Lower Reaches : C-2 Unit : US$ 10^3

EIRR = 9.5215 % COST STREAM BENEFIT STREAM

Year	Fisical year	Disbursement of Investment: Upper Reaches	Middle Reaches	Lower Reaches	Jicamarca River	Annual O&M Cost	Cost Total	Discounted Total Cost	Annual Benefit	Discounted Total Benefit	Net Present Worth
1	1990/1991	10	-	4,874	-	-	4,884	4,459	0	0	(4,459)
2	1991/1992	15	-	9,748	-	-	9,763	8,139	0	0	(8,139)
3	1992/1993	15	-	9,748	-	-	9,763	7,431	0	0	(7,431)
4	1993/1994	15	23,286	-	599	92	23,992	16,675	1,447	1,005	(15,670)
5	1994/1995	2,718	23,286	-	-	92	26,096	16,560	1,447	918	(15,642)
6	1995/1996	5,435	-	-	-	274	5,709	3,308	2,687	1,557	(1,751)
7	1996/1997	5,435	-	-	-	274	5,709	3,021	2,687	1,421	(1,599)
8	1997/1998					289	289	140	10,333	4,992	4,852
9	1998/1999					289	289	127	10,333	4,558	4,430
10	1999/2000					289	289	116	10,333	4,161	4,045
11	2000/2001					289	289	106	10,333	3,800	3,693
12	2001/2002					289	289	97	10,333	3,469	3,372
13	2002/2003					289	289	89	10,333	3,168	3,079
14	2003/2004					289	289	81	10,333	2,892	2,811
15	2004/2005					289	289	74	10,333	2,641	2,567
16	2005/2006					289	289	67	10,333	2,411	2,344
17	2006/2007					289	289	62	10,333	2,202	2,140
18	2007/2008					289	289	56	10,333	2,010	1,954
19	2008/2009					289	289	51	10,333	1,835	1,784
20	2009/2010					289	289	47	10,333	1,676	1,629
21	2010/2011					289	289	43	10,333	1,530	1,487
22	2011/2012					289	289	39	10,333	1,397	1,358
23	2012/2013					289	289	36	10,333	1,276	1,240
24	2013/2014					289	289	33	10,333	1,165	1,132
25	2014/2015					289	289	30	10,333	1,064	1,034
26	2015/2016					289	289	27	10,333	971	944
27	2016/2017					289	289	25	10,333	887	862
28	2017/2018					289	289	23	10,333	810	787
29	2018/2019					289	289	21	10,333	739	719
30	2019/2020					289	289	19	10,333	675	656
31	2020/2021					289	289	17	10,333	616	599
32	2021/2022					289	289	16	10,333	563	547
33	2022/2023					289	289	14	10,333	514	499
34	2023/2024					289	289	13	10,333	469	456
35	2024/2025					289	289	12	10,333	428	416
36	2025/2026					289	289	11	10,333	391	380
37	2026/2027					289	289	10	10,333	357	347
38	2027/2028					289	289	9	10,333	326	317
39	2028/2029					289	289	8	10,333	298	289
40	2029/2030					289	289	8	10,333	272	264
41	2030/2031					289	289	7	10,333	248	241
42	2031/2032					289	289	6	10,333	227	220
43	2032/2033					289	289	6	10,333	207	201
44	2033/2034					289	289	5	10,333	189	184
45	2034/2035					289	289	5	10,333	172	168
46	2035/2036					289	289	4	10,333	157	153
47	2036/2037					289	289	4	10,333	144	140
48	2037/2038					289	289	4	10,333	131	128
49	2038/2039					289	289	3	10,333	120	117
50	2039/2040					289	289	3	10,333	109	106
Total		13,643	46,572	24,369	599	13,159	98,342	61,167	452,585	61,167	0

Table V-7-9 CASH FLOW AND ECONOMIC ANALYSIS (ALTERNATIVE CASE OF COMBINATION (5))

Upper Reaches : A-2 Middle Reaches : B-1 Lower Reaches : C-1 Unit : US$ 10^3

EIRR = 15.8812 % COST STREAM BENEFIT STREAM

Year	Fisical year	Disbursement of Investment: Upper Reaches	Middle Reaches	Lower Reaches	Jicamarca River	Annual O&M Cost	Cost Total	Discounted Total Cost	Annual Benefit	Discounted Total Benefit	Net Present Worth
1	1990/1991	20	-	3,433	-	-	3,453	2,980	0	0	(2,980)
2	1991/1992	45	-	6,866	-	-	6,911	5,147	0	0	(5,147)
3	1992/1993	45	-	6,866	-	-	6,911	4,441	0	0	(4,441)
4	1993/1994	45	6,274	-	599	66	6,984	3,873	1,447	802	(3,071)
5	1994/1995	3,353	6,274	-	-	66	9,693	4,638	1,447	692	(3,946)
6	1995/1996	6,706	-	-	-	115	6,821	2,817	2,687	1,109	(1,707)
7	1996/1997	6,706	-	-	-	115	6,821	2,431	2,687	957	(1,473)
8	1997/1998					170	170	52	10,333	3,178	3,126
9	1998/1999					170	170	45	10,333	2,742	2,697
10	1999/2000					170	170	39	10,333	2,366	2,328
11	2000/2001					170	170	34	10,333	2,042	2,009
12	2001/2002					170	170	29	10,333	1,762	1,733
13	2002/2003					170	170	25	10,333	1,521	1,496
14	2003/2004					170	170	22	10,333	1,312	1,291
15	2004/2005					170	170	19	10,333	1,132	1,114
16	2005/2006					170	170	16	10,333	977	961
17	2006/2007					170	170	14	10,333	843	829
18	2007/2008					170	170	12	10,333	728	716
19	2008/2009					170	170	10	10,333	628	618
20	2009/2010					170	170	9	10,333	542	533
21	2010/2011					170	170	8	10,333	468	460
22	2011/2012					170	170	7	10,333	404	397
23	2012/2013					170	170	6	10,333	348	343
24	2013/2014					170	170	5	10,333	301	296
25	2014/2015					170	170	4	10,333	259	255
26	2015/2016					170	170	4	10,333	224	220
27	2016/2017					170	170	3	10,333	193	190
28	2017/2018					170	170	3	10,333	167	164
29	2018/2019					170	170	2	10,333	144	141
30	2019/2020					170	170	2	10,333	124	122
31	2020/2021					170	170	2	10,333	107	105
32	2021/2022					170	170	2	10,333	92	91
33	2022/2023					170	170	1	10,333	80	78
34	2023/2024					170	170	1	10,333	69	68
35	2024/2025					170	170	1	10,333	59	58
36	2025/2026					170	170	1	10,333	51	50
37	2026/2027					170	170	1	10,333	44	44
38	2027/2028					170	170	1	10,333	38	38
39	2028/2029					170	170	1	10,333	33	32
40	2029/2030					170	170	0	10,333	28	28
41	2030/2031					170	170	0	10,333	25	24
42	2031/2032					170	170	0	10,333	21	21
43	2032/2033					170	170	0	10,333	18	18
44	2033/2034					170	170	0	10,333	16	16
45	2034/2035					170	170	0	10,333	14	13
46	2035/2036					170	170	0	10,333	12	12
47	2036/2037					170	170	0	10,333	10	10
48	2037/2038					170	170	0	10,333	9	9
49	2038/2039					170	170	0	10,333	8	7
50	2039/2040					170	170	0	10,333	7	6
Total		16,920	12,547	17,166	599	7,672	54,904	26,708	452,585	26,708	(0)

Table V-7-10 CASH FLOW AND ECONOMIC ANALYSIS (ALTERNATIVE CASE OF COMBINATION (6))

Upper Reaches : A-2 Middle Reaches : B-1 Lower Reaches : C-2 Unit : US$ 10^3

EIRR = 13.7510 %

Year	Fisical year	COST STREAM: Disbursement of Investment: Upper Reaches	Middle Reaches	Lower Reaches	Jicamarca River	Annual O&M Cost	Cost Total	Discounted Total Cost	BENEFIT STREAM: Annual Benefit	Discounted Total Benefit	Net Present Worth
1	1990/1991	20	-	4,874	-	-	4,894	4,302	0	0	(4,302)
2	1991/1992	45	-	9,748	-	-	9,793	7,568	0	0	(7,568)
3	1992/1993	45	-	9,748	-	-	9,793	6,653	0	0	(6,653)
4	1993/1994	45	6,274	-	599	92	7,010	4,187	1,447	864	(3,323)
5	1994/1995	3,353	6,274	-	-	92	9,719	5,103	1,447	760	(4,343)
6	1995/1996	6,706	-	-	-	140	6,846	3,160	2,687	1,240	(1,920)
7	1996/1997	6,706	-	-	-	140	6,846	2,778	2,687	1,090	(1,688)
8	1997/1998					196	196	70	10,333	3,686	3,616
9	1998/1999					196	196	61	10,333	3,241	3,179
10	1999/2000					196	196	54	10,333	2,849	2,795
11	2000/2001					196	196	48	10,333	2,504	2,457
12	2001/2002					196	196	42	10,333	2,202	2,160
13	2002/2003					196	196	37	10,333	1,936	1,899
14	2003/2004					196	196	32	10,333	1,702	1,669
15	2004/2005					196	196	28	10,333	1,496	1,468
16	2005/2006					196	196	25	10,333	1,315	1,290
17	2006/2007					196	196	22	10,333	1,156	1,134
18	2007/2008					196	196	19	10,333	1,016	997
19	2008/2009					196	196	17	10,333	893	877
20	2009/2010					196	196	15	10,333	785	771
21	2010/2011					196	196	13	10,333	691	677
22	2011/2012					196	196	12	10,333	607	596
23	2012/2013					196	196	10	10,333	534	524
24	2013/2014					196	196	9	10,333	469	460
25	2014/2015					196	196	8	10,333	412	405
26	2015/2016					196	196	7	10,333	363	356
27	2016/2017					196	196	6	10,333	319	313
28	2017/2018					196	196	5	10,333	280	275
29	2018/2019					196	196	5	10,333	246	242
30	2019/2020					196	196	4	10,333	217	212
31	2020/2021					196	196	4	10,333	190	187
32	2021/2022					196	196	3	10,333	167	164
33	2022/2023					196	196	3	10,333	147	144
34	2023/2024					196	196	2	10,333	129	127
35	2024/2025					196	196	2	10,333	114	112
36	2025/2026					196	196	2	10,333	100	98
37	2026/2027					196	196	2	10,333	88	86
38	2027/2028					196	196	1	10,333	77	76
39	2028/2029					196	196	1	10,333	68	67
40	2029/2030					196	196	1	10,333	60	59
41	2030/2031					196	196	1	10,333	52	51
42	2031/2032					196	196	1	10,333	46	45
43	2032/2033					196	196	1	10,333	41	40
44	2033/2034					196	196	1	10,333	36	35
45	2034/2035					196	196	1	10,333	31	31
46	2035/2036					196	196	1	10,333	28	27
47	2036/2037					196	196	0	10,333	24	24
48	2037/2038					196	196	0	10,333	21	21
49	2038/2039					196	196	0	10,333	19	18
50	2039/2040					196	196	0	10,333	16	16
Total		16,920	12,547	24,369	599	8,892	63,327	34,328	452,585	34,328	0

Table V-7-11 CASH FLOW AND ECONOMIC ANALYSIS (ALTERNATIVE CASE OF COMBINATION (7))

Upper Reaches : A-2 Middle Reaches : B-2 Lower Reaches : C-1 Unit : US$ 10^3

EIRR = 10.1475 % COST STREAM BENEFIT STREAM

Year	Fisical year	Disbursement of Investment: Upper Reaches	Middle Reaches	Lower Reaches	Jicamarca River	Annual O&M Cost	Cost Total	Discounted Total Cost	Annual Benefit	Discounted Total Benefit	Net Present Worth
1	1990/1991	20	-	3,433	-	-	3,453	3,135	0	0	(3,135)
2	1991/1992	45	-	6,866	-	-	6,911	5,697	0	0	(5,697)
3	1992/1993	45	-	6,866	-	-	6,911	5,172	0	0	(5,172)
4	1993/1994	45	23,286	-	599	66	23,996	16,302	1,447	983	(15,319)
5	1994/1995	3,353	23,286	-	-	66	26,705	16,471	1,447	892	(15,579)
6	1995/1996	6,706	-	-	-	248	6,954	3,894	2,687	1,504	(2,390)
7	1996/1997	6,706	-	-	-	248	6,954	3,535	2,687	1,366	(2,169)
8	1997/1998					303	303	140	10,333	4,769	4,629
9	1998/1999					303	303	127	10,333	4,330	4,203
10	1999/2000					303	303	115	10,333	3,931	3,816
11	2000/2001					303	303	105	10,333	3,569	3,464
12	2001/2002					303	303	95	10,333	3,240	3,145
13	2002/2003					303	303	86	10,333	2,941	2,855
14	2003/2004					303	303	78	10,333	2,670	2,592
15	2004/2005					303	303	71	10,333	2,424	2,353
16	2005/2006					303	303	65	10,333	2,201	2,137
17	2006/2007					303	303	59	10,333	1,998	1,940
18	2007/2008					303	303	53	10,333	1,814	1,761
19	2008/2009					303	303	48	10,333	1,647	1,599
20	2009/2010					303	303	44	10,333	1,495	1,451
21	2010/2011					303	303	40	10,333	1,358	1,318
22	2011/2012					303	303	36	10,333	1,232	1,196
23	2012/2013					303	303	33	10,333	1,119	1,086
24	2013/2014					303	303	30	10,333	1,016	986
25	2014/2015					303	303	27	10,333	922	895
26	2015/2016					303	303	25	10,333	837	813
27	2016/2017					303	303	22	10,333	760	738
28	2017/2018					303	303	20	10,333	690	670
29	2018/2019					303	303	18	10,333	627	608
30	2019/2020					303	303	17	10,333	569	552
31	2020/2021					303	303	15	10,333	516	501
32	2021/2022					303	303	14	10,333	469	455
33	2022/2023					303	303	12	10,333	426	413
34	2023/2024					303	303	11	10,333	386	375
35	2024/2025					303	303	10	10,333	351	341
36	2025/2026					303	303	9	10,333	319	309
37	2026/2027					303	303	8	10,333	289	281
38	2027/2028					303	303	8	10,333	263	255
39	2028/2029					303	303	7	10,333	238	231
40	2029/2030					303	303	6	10,333	216	210
41	2030/2031					303	303	6	10,333	196	191
42	2031/2032					303	303	5	10,333	178	173
43	2032/2033					303	303	5	10,333	162	157
44	2033/2034					303	303	4	10,333	147	143
45	2034/2035					303	303	4	10,333	133	130
46	2035/2036					303	303	4	10,333	121	118
47	2036/2037					303	303	3	10,333	110	107
48	2037/2038					303	303	3	10,333	100	97
49	2038/2039					303	303	3	10,333	91	88
50	2039/2040					303	303	2	10,333	82	80
Total		16,920	46,572	17,166	599	13,657	94,914	55,700	452,585	55,700	0

Table V-7-12 CASH FLOW AND ECONOMIC ANALYSIS (ALTERNATIVE CASE OF COMBINATION (8))

Upper Reaches : A-2 Middle Reaches : B-2 Lower Reaches : C-2 Unit : US$ 10^3

EIRR = 9.2228 % COST STREAM BENEFIT STREAM

Year	Fisical year	Disbursement of Investment: Upper Reaches	Middle Reaches	Lower Reaches	Jicamarca River	Annual O&M Cost	Cost Total	Discounted Total Cost	Annual Benefit	Discounted Total Benefit	Net Present Worth
1	1990/1991	20	-	4,874	-	-	4,894	4,481	0	0	(4,481)
2	1991/1992	45	-	9,748	-	-	9,793	8,209	0	0	(8,209)
3	1992/1993	45	-	9,748	-	-	9,793	7,516	0	0	(7,516)
4	1993/1994	45	23,286	-	599	92	24,022	16,879	1,447	1,016	(15,863)
5	1994/1995	3,353	23,286	-	-	92	26,731	17,197	1,447	931	(16,266)
6	1995/1996	6,706	-	-	-	274	6,980	4,111	2,687	1,582	(2,529)
7	1996/1997	6,706	-	-	-	274	6,980	3,764	2,687	1,449	(2,315)
8	1997/1998					329	329	162	10,333	5,102	4,939
9	1998/1999					329	329	149	10,333	4,671	4,522
10	1999/2000					329	329	136	10,333	4,277	4,140
11	2000/2001					329	329	125	10,333	3,915	3,791
12	2001/2002					329	329	114	10,333	3,585	3,471
13	2002/2003					329	329	105	10,333	3,282	3,178
14	2003/2004					329	329	96	10,333	3,005	2,909
15	2004/2005					329	329	88	10,333	2,751	2,664
16	2005/2006					329	329	80	10,333	2,519	2,439
17	2006/2007					329	329	73	10,333	2,306	2,233
18	2007/2008					329	329	67	10,333	2,111	2,044
19	2008/2009					329	329	62	10,333	1,933	1,872
20	2009/2010					329	329	56	10,333	1,770	1,714
21	2010/2011					329	329	52	10,333	1,621	1,569
22	2011/2012					329	329	47	10,333	1,484	1,436
23	2012/2013					329	329	43	10,333	1,358	1,315
24	2013/2014					329	329	40	10,333	1,244	1,204
25	2014/2015					329	329	36	10,333	1,139	1,102
26	2015/2016					329	329	33	10,333	1,043	1,009
27	2016/2017					329	329	30	10,333	954	924
28	2017/2018					329	329	28	10,333	874	846
29	2018/2019					329	329	25	10,333	800	775
30	2019/2020					329	329	23	10,333	733	709
31	2020/2021					329	329	21	10,333	671	649
32	2021/2022					329	329	20	10,333	614	595
33	2022/2023					329	329	18	10,333	562	544
34	2023/2024					329	329	16	10,333	515	498
35	2024/2025					329	329	15	10,333	471	456
36	2025/2026					329	329	14	10,333	431	418
37	2026/2027					329	329	13	10,333	395	382
38	2027/2028					329	329	12	10,333	362	350
39	2028/2029					329	329	11	10,333	331	321
40	2029/2030					329	329	10	10,333	303	294
41	2030/2031					329	329	9	10,333	278	269
42	2031/2032					329	329	8	10,333	254	246
43	2032/2033					329	329	7	10,333	233	225
44	2033/2034					329	329	7	10,333	213	206
45	2034/2035					329	329	6	10,333	195	189
46	2035/2036					329	329	6	10,333	179	173
47	2036/2037					329	329	5	10,333	163	158
48	2037/2038					329	329	5	10,333	150	145
49	2038/2039					329	329	4	10,333	137	133
50	2039/2040					329	329	4	10,333	125	121
Total		16,920	46,572	24,369	599	14,879	103,339	64,037	452,585	64,037	0

Figures

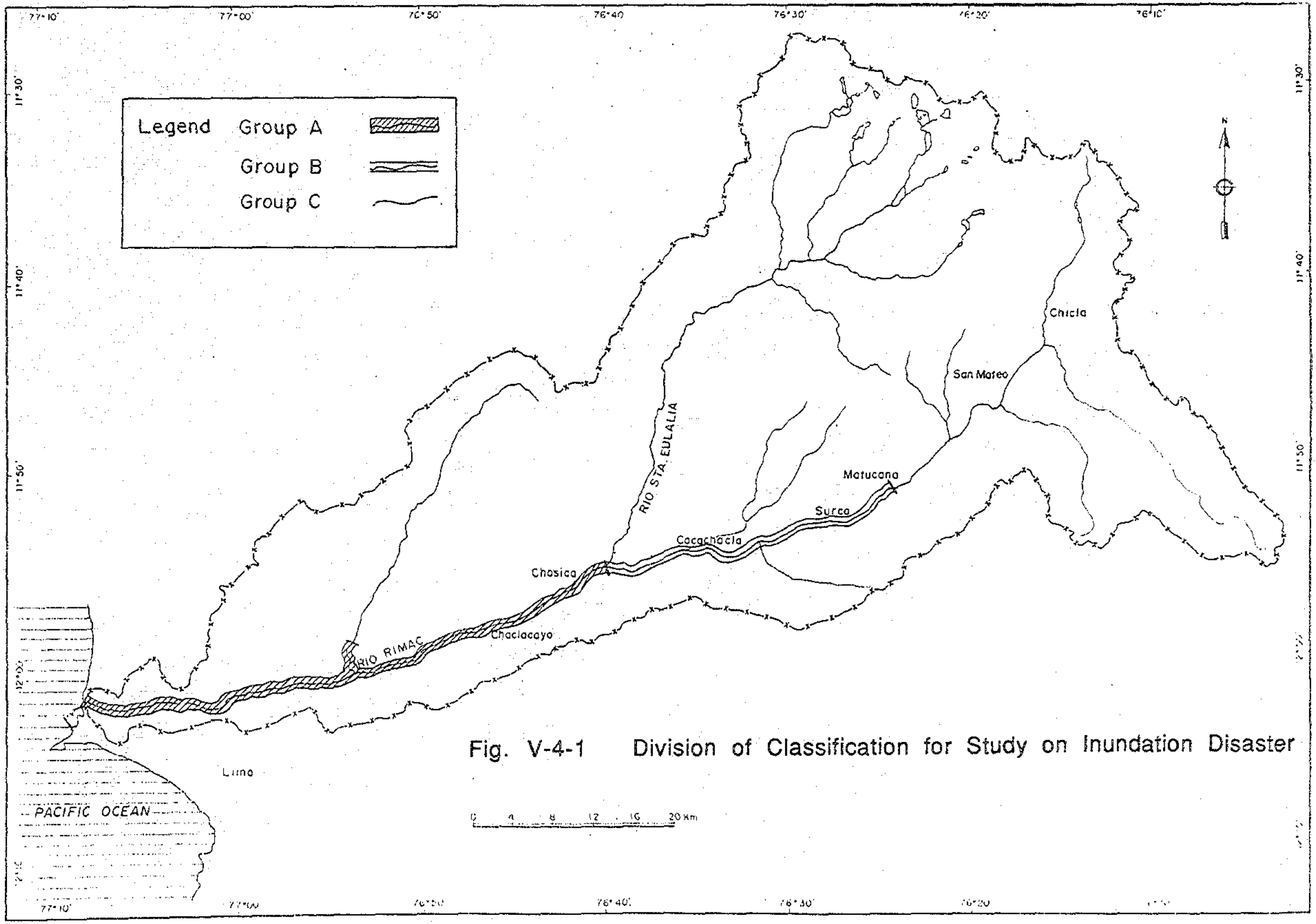


Fig. V-4-1 Division of Classification for Study on Inundation Disaster

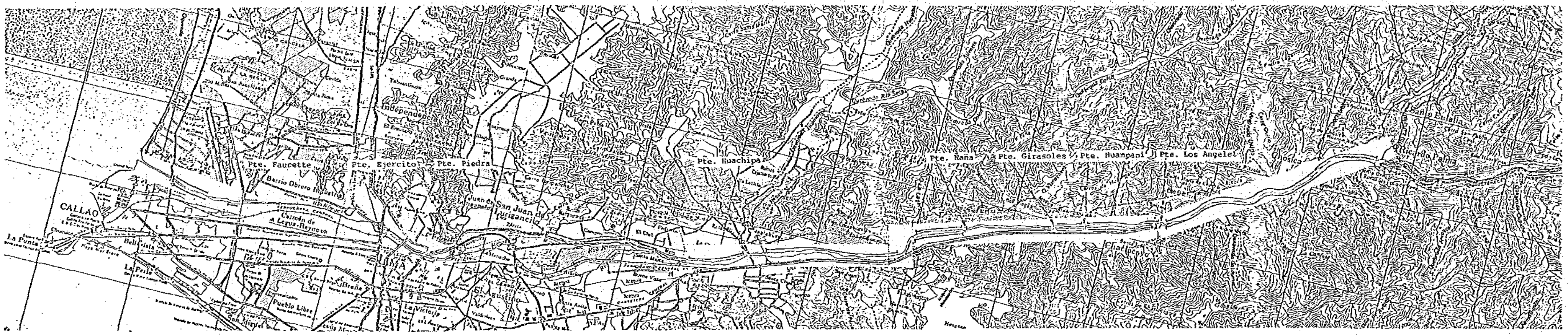


Fig. V-5-1 River Stretch having Capacity less than 660 m³/sec (100 year probable flood)

Remarks: ▭ , River strech having capacity less than 660 m³/sec

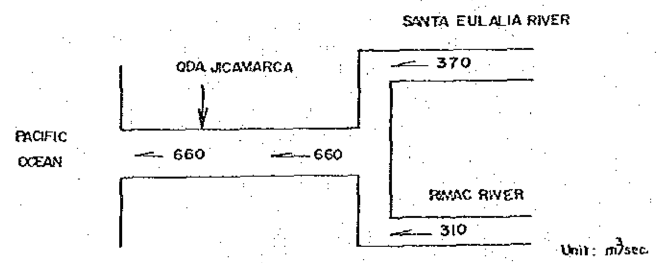


Fig. V-5-2 Distribution of Design Flood Discharge (100 year probable flood)

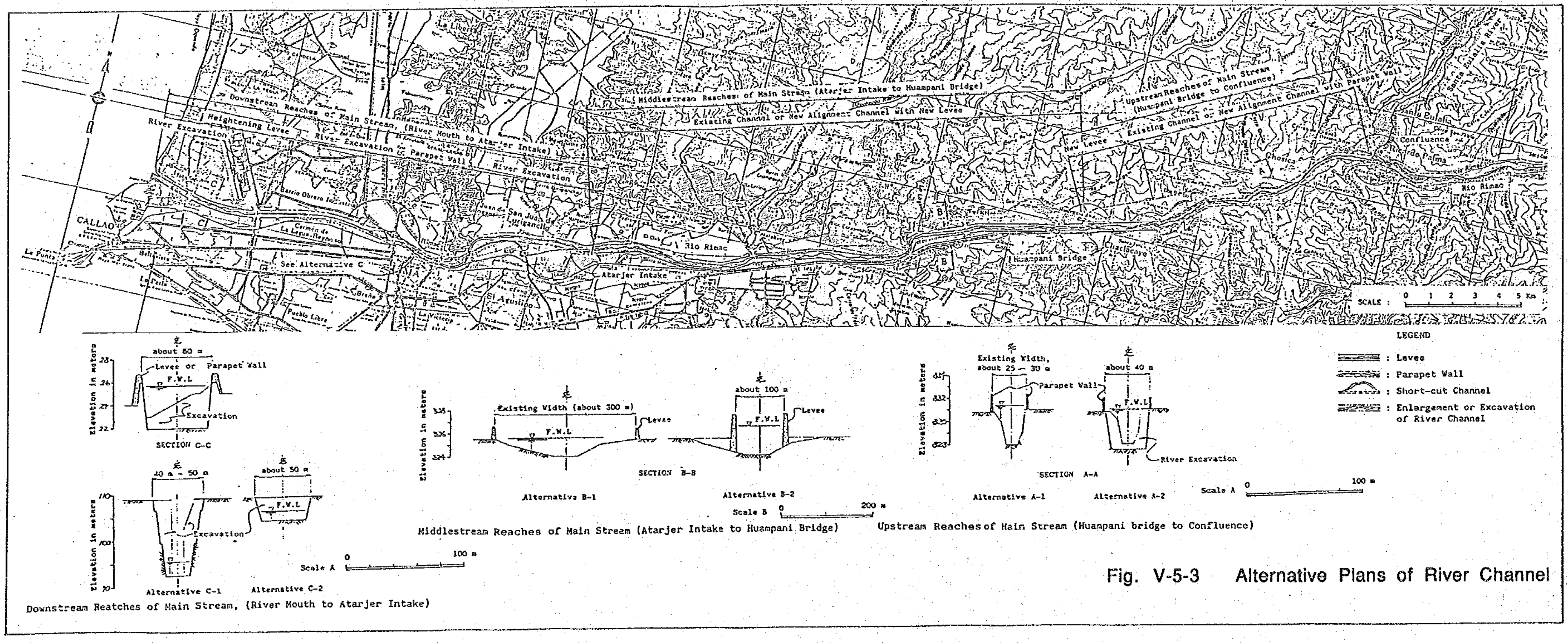


Fig. V-5-3 Alternative Plans of River Channel

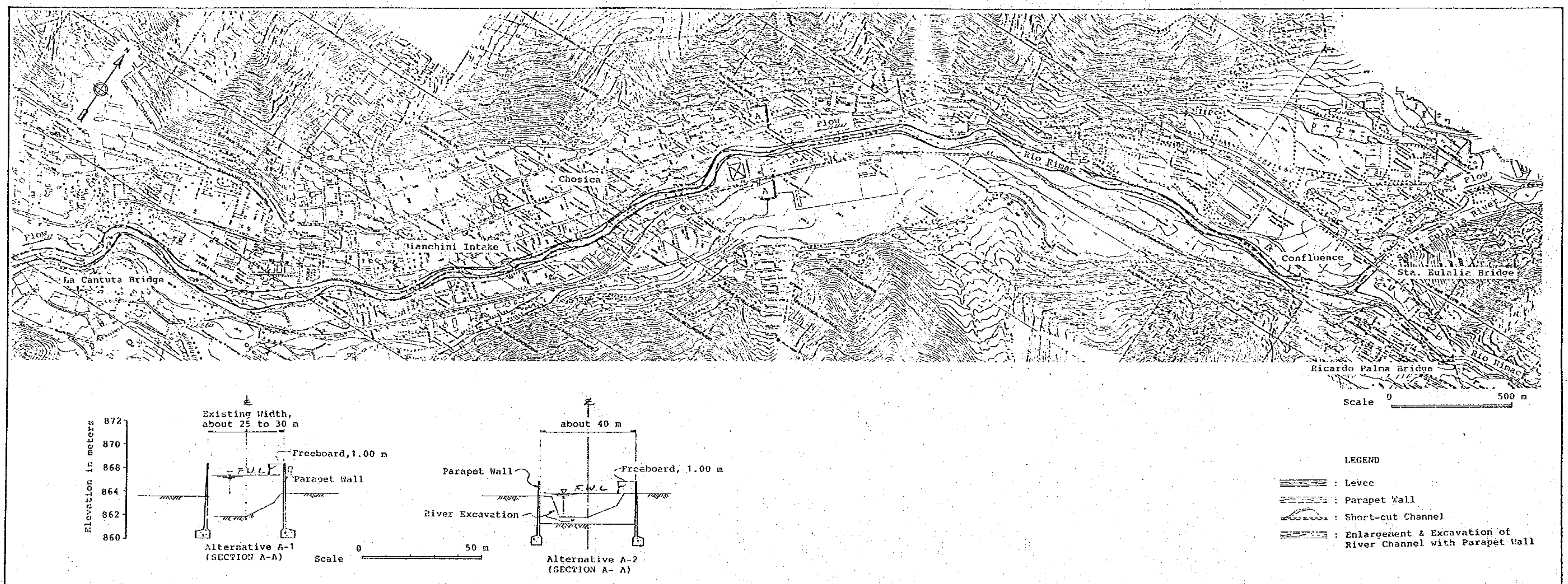
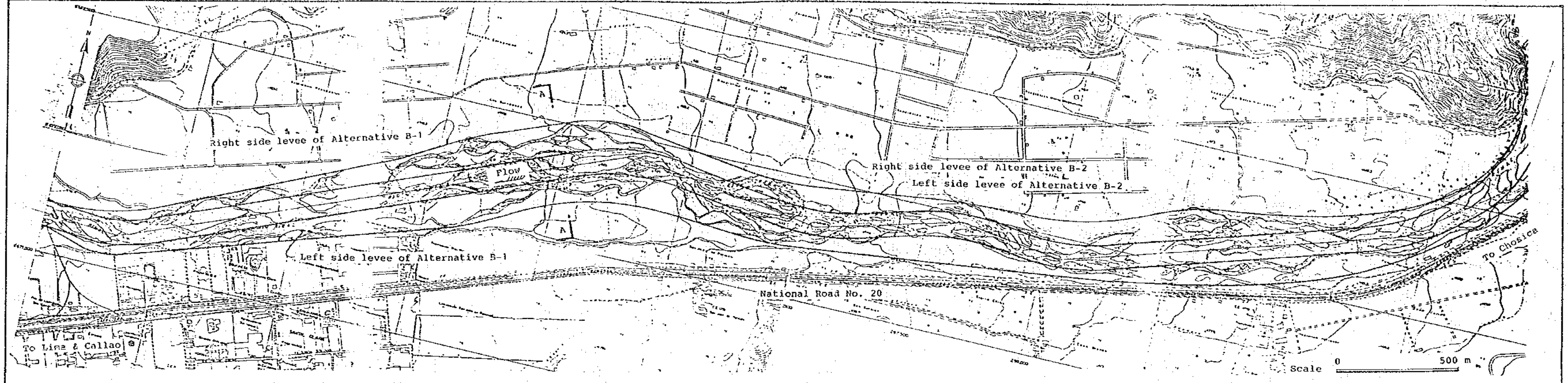
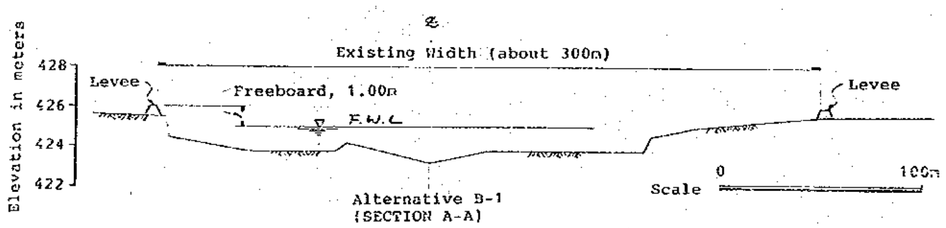


Fig. V-5-4 Detail of Alternative Plans in the Upstream Reaches of Main Stream





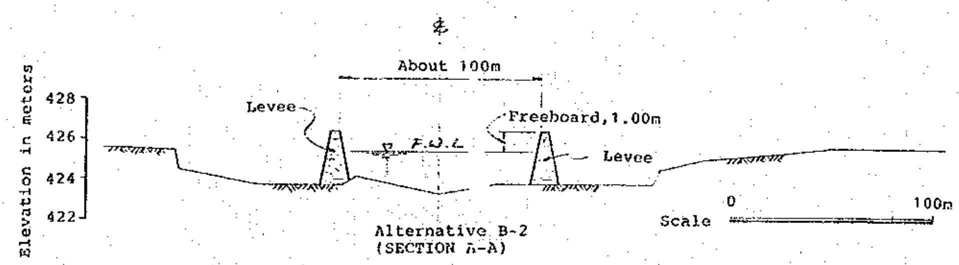


Fig. V-5-5 Detail of Alternative Plans in the Wide Portion in the Middle Reaches of Main Stream

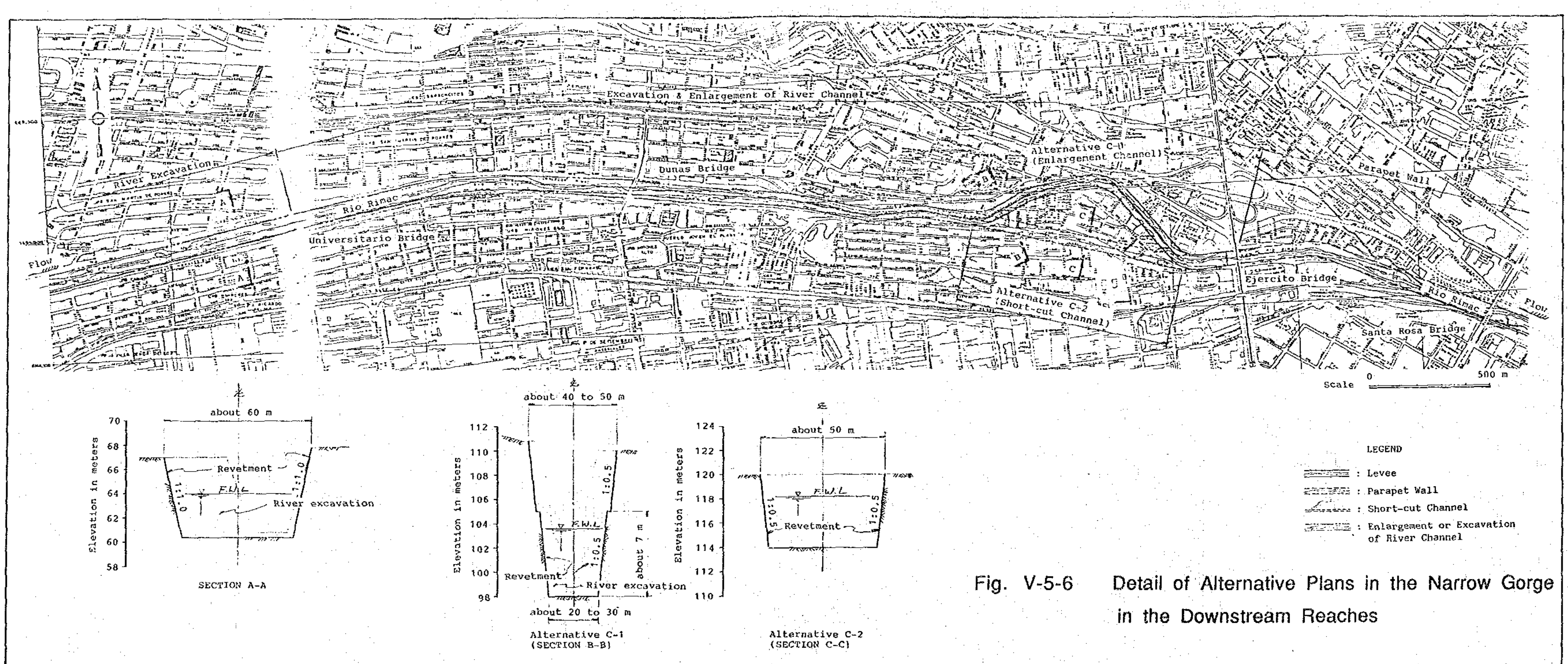


Fig. V-5-6 Detail of Alternative Plans in the Narrow Gorge in the Downstream Reaches

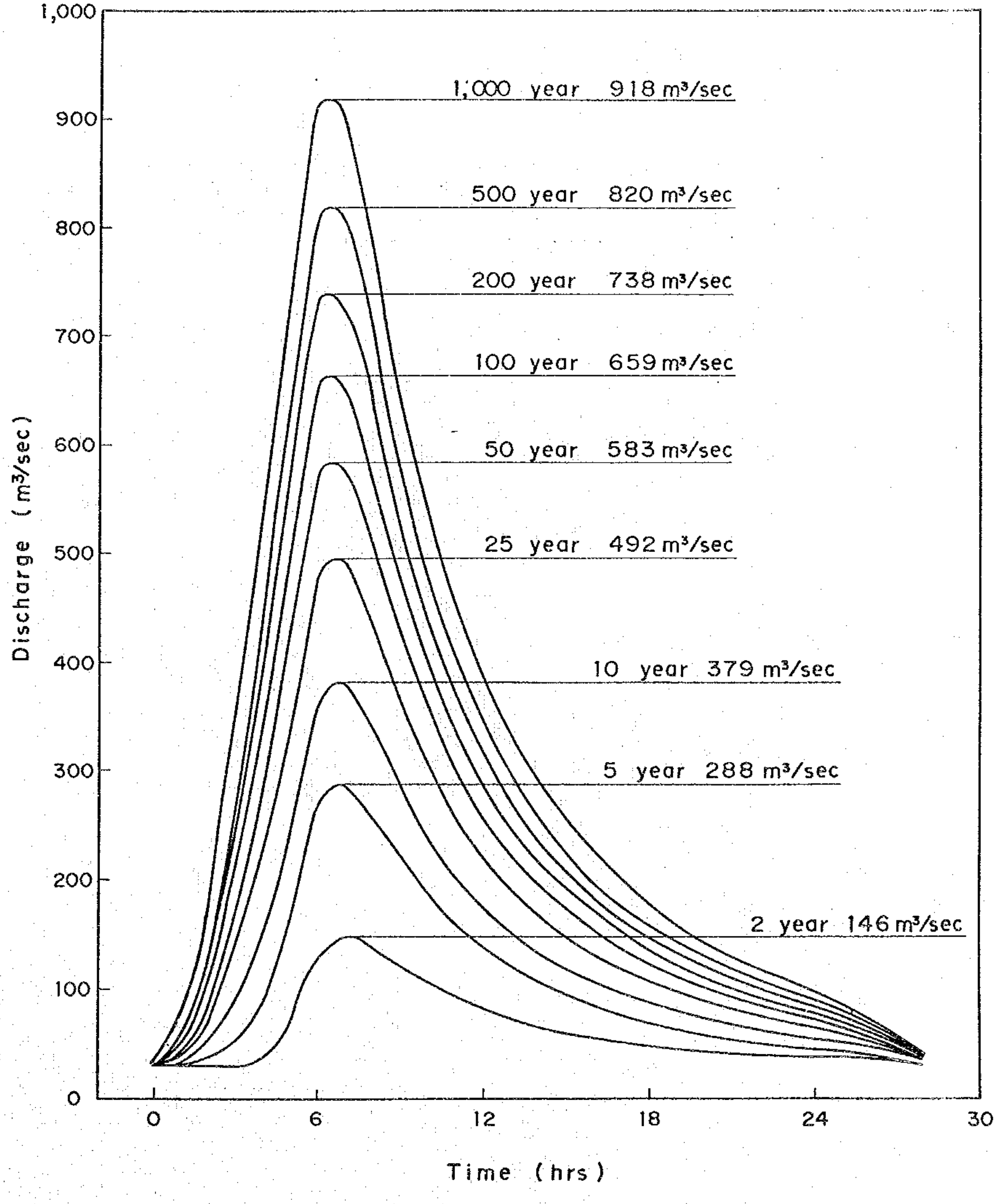


Fig. V-6-1 Flood Hydrograph at Chosica

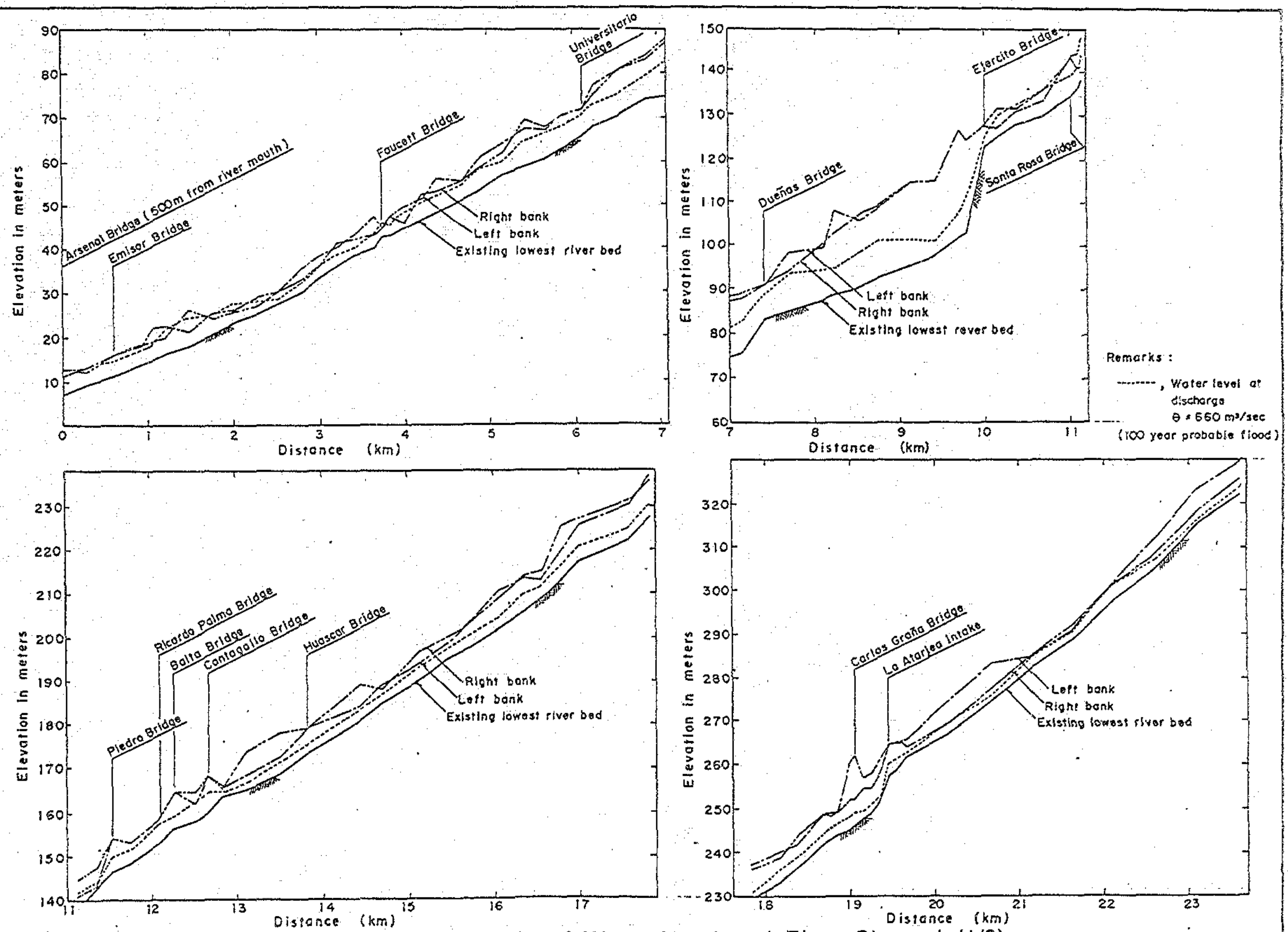


Fig. V-6-2 Longitudinal Profile of Water Level and River Channel (1/3)

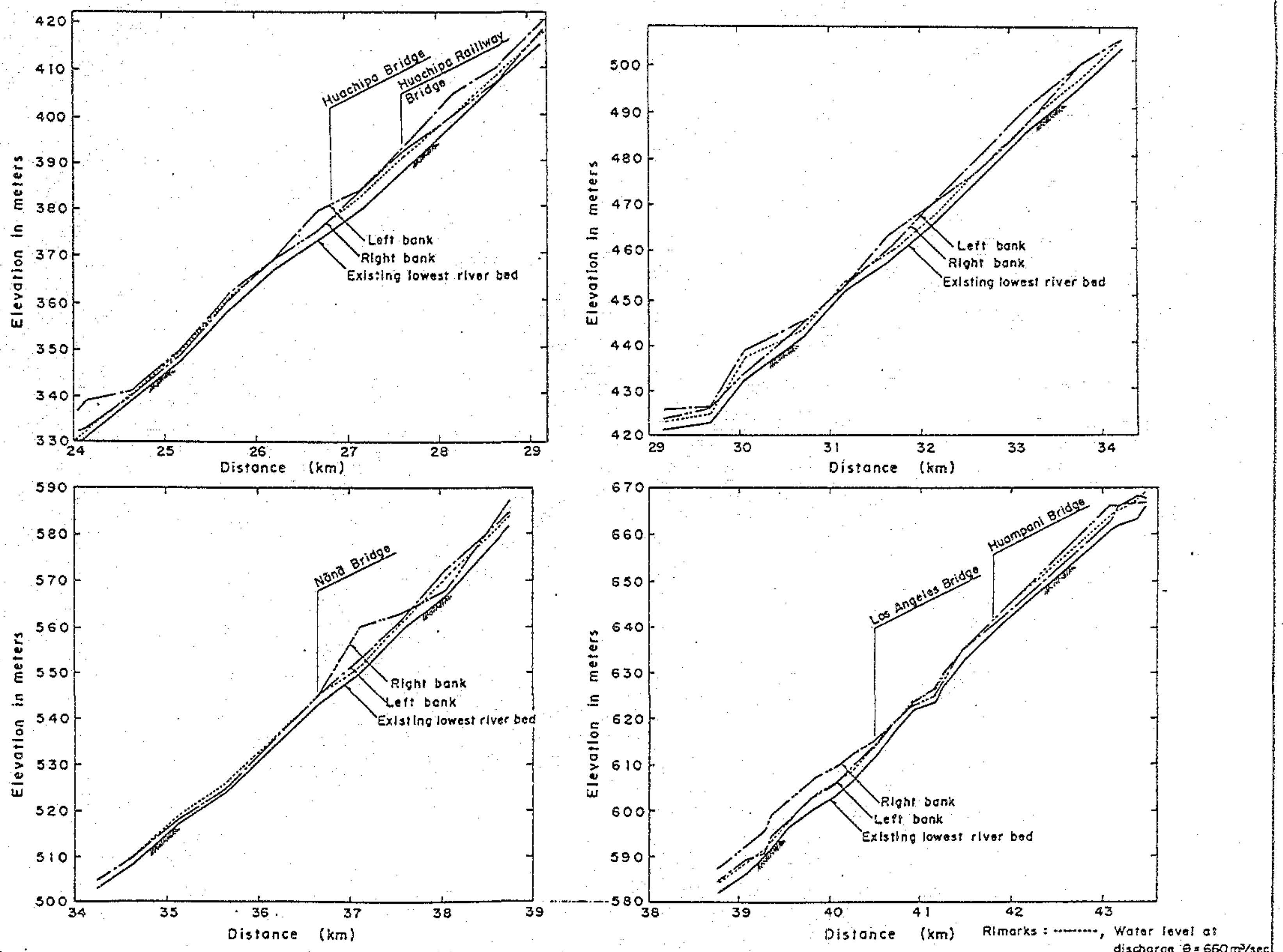


Fig. V-6-2 Longitudinal Profile of Water Level and River Channel (2/3)

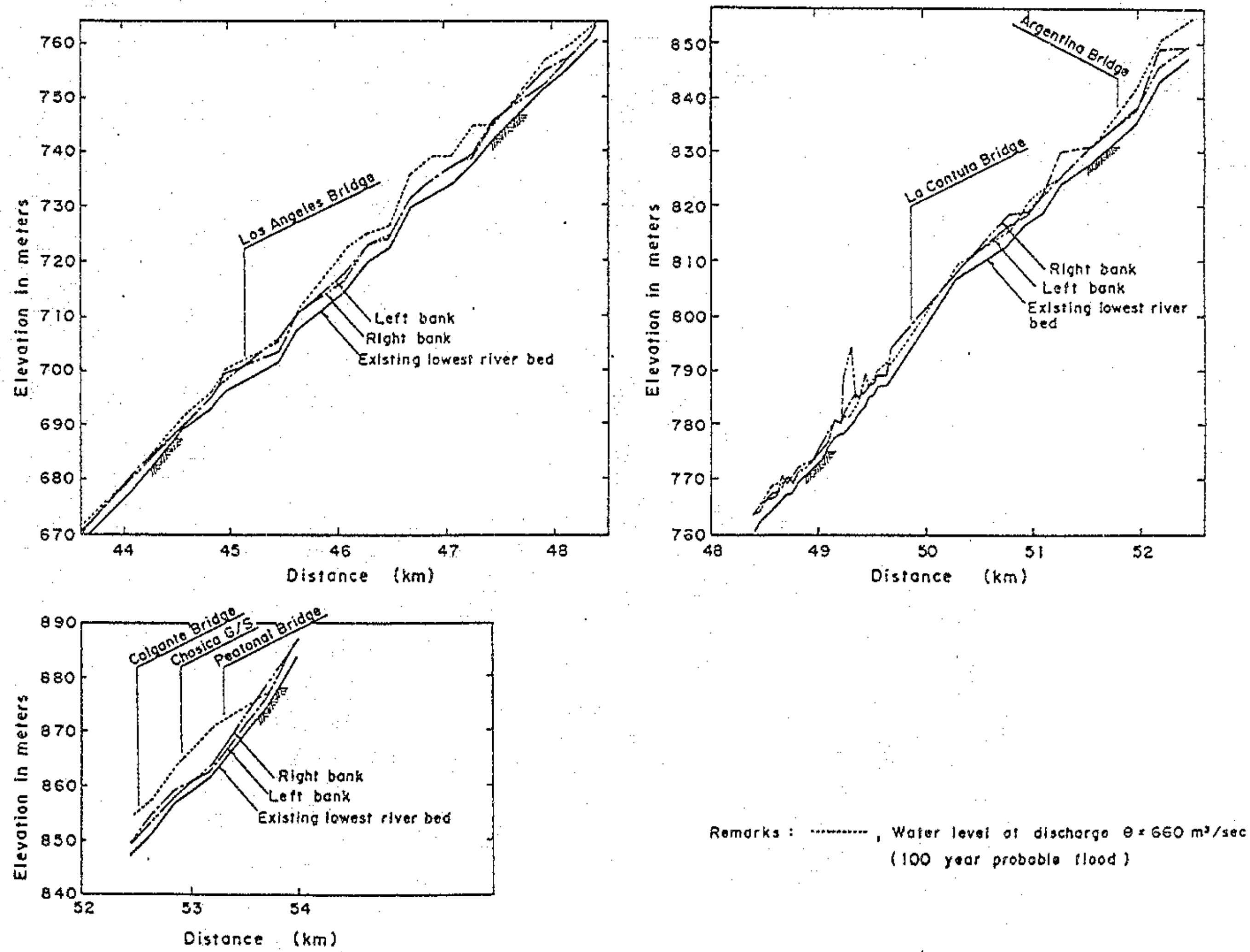


Fig. V-6-2 Longitudinal Profile of Water Level and River Channel (3/3)