3.3 Estimation of Cost

Two kinds of project costs are estimated, i.e., economic cost and financial cost. The economic cost is used for comparative studies of alternative schemes and evaluation of the project from an economic view point. The financial cost is devided into local and foreign currency portions. All of these costs shall be expressed in peso currency at the price level as of December 1985.

The project cost consists of those for channel works and dam works. Constitution of the project cost is as follows:

Channel Works

1) Main works cost
   - Preparatory works: Assumed to be 8 % of direct construction work cost
   - Direct construction works: Actual cost basis
   - Miscellaneous works: Assumed to be 15 % of preparatory and direct construction work costs
2) Compensation cost: Actual cost basis
3) Engineering and administration costs
   - Engineering: Assumed to be 10 % of main work cost
   - Administration: Assumed to be 5 % of main work cost
4) Contingency: Assumed to be 15 % of main work, compensation, engineering and administration costs

Dam Works

5) Main work cost
   - Preparatory works: Actual cost basis
   - River diversion works: Actual cost basis
   - Dam: Actual cost basis
   - Spilway: Actual cost basis
6) Compensation cost: Actual cost basis
7) Engineering and administration costs

- Engineering: Assumed to be 10 % of main work cost
- Administration: Assumed to be 5 % of main work cost

8) Contingency: Assumed to be 20 % of main work, compensation, engineering and administration costs

The construction costs shall be estimated using standard unit construction costs. The standard unit construction costs for flood control facilities are shown in Table 3.1 on financial basis and Table 3.2 on economic basis. The unit construction costs for dam works are mentioned in ANNEX DA.

The financial unit costs were estimated based on those of the previous studies. Unit work costs of the similar projects by MPWH are also referred. The economic unit costs except land costs were estimated based on the financial costs deducting 18 % of local portions considering transfer costs and shadow rate. The economic unit land costs were evaluated based on the production foregone.

Principal figures used for or referred to cost estimates are as follows:

- Exchange rates among U.S. dollar, peso, and yen currencies:

(year)	(U.S.$ 1 is equivalent to)	
1980	₱ 7.51	¥ 228
1981	₱ 7.90	¥ 222
1982	₱ 8.54	¥ 250
1983	₱11.11	¥ 239
1984	₱16.70	¥ 239
1985	₱18.73	¥ 240
Dec. 1985	₱18.89(say ₱19)	¥ 203(say ¥200)

- Annual average escalation rate of labor cost: 8.4% during 5 years from 1981 to 1986.

- Annual average escalation rate of local construction materials: 12.6% during 5 years from 1981 to 1986.
- Price indexes of imported construction materials (Imat) and equipment (Ieq):

(Year)	(Imat:%)	(Ieq:%)
1980	105.3	90.1
1981	122.1	90.8
1982	125.6	98.8
1983	99.2	92.1
1984	100.5	96.0
1985	100.	100.

Note: According to FOB prices in Japan

3.4 Assessment of Flood Damages

Flood damages are assessed for the evaluation of flood control benefit resulting from reduction in damages. The flood damages in the basin are classified into two flooding damages and bank erosion damages which are assessed in different methods. Constitution of these damages is shown in Table 3.3.

(1) Flooding Damages

Assessment method of the flooding damage is outlined as follows:

1) The flooding damages consist of direct and indirect damages.

2) Direct damages such as those to buildings and agricultural crops are estimated from damageable value of properties multiplied by damage ratio. The damage ratios depending on the flooding condition are shown in Table 3.4.

3) Unit damageable value of buildings: Average values of residential and non-residential buildings were estimated as shown below in consideration of their constitution. Unit value of each type of building was assessed by the sampling surveys of our economist.

- Building: ₱ 31,000/bldg.
- Movables: ₱ 25,000/bldg.

4) Unit damageable value of agricultural crops: Unit area damageable value of agricultural crop was sestimated by the unit value multiplied by the unit yield for each crop:

- Irrigated paddy: 2.70 ton/ha x ₱10,300/ha
- Rainfed paddy : 2.40 ton/ha x ₱ 9,200/ha
- Upland crop : ₱ 4,200/ha
  Corn : 1.10 ton/ha x ₱ 2,700/ton x 88 % = ₱ 2.600/ha
  Tabacco : 0.70 ton/ha x ₱18,100/ton x 12 % = ₱ 1,600/ha

5) Other direct damages such as those to livestocks and infrastructure are estimated by the constant ratios to other damages

- Livestocks: Assumed at 12.6 % of damages to agricultural crops
- Infrastructure: Assumed at 86 % of damages to buildings including movables according to the past flood damage records

6) Indrect damages including income loss and emergency costs due to flooding are estimated by the constant ratio to the total direct damages. The ratio is assumed at 5 %.

(2) Bank Erosion Damages

Regarding the bank erosion damages, standardized assessment method has not been developed yet, since the bank erosion phenomena are difficult to be treated statistically and the evaluation of damages in monetary term are difficult. In the present study, an attempt was made to assess the damages introducing some bold assumptions as follows:

1) The following damages due to bank erosion are considered for the properties in the possible damaged area:

   - Building damages
   - Agricultural damages
   - Highway damages
   - Loss of residential land

2) The possible damaged area is defined as an area possibly subject to bank erosion damages during the project life under consideration if the bank protection works are not implemented (refer to Fig.3.4). Two types of bank erosion are considered, i.e., continuous bank erosion and river course change.

   - Continuous bank erosion: The possible damaged areas of this type are assumed based on the bank erosion rate in the past.
   - River course change: The possible damaged area of this type are assumed to be the areas enclosed by the existing river course and the possible river course. The possible river course is assumed based on topographic and geomorphological nature of the existing channels.

3) Average annual bank erosion damages are estimated by the following equations:

Annual damages (DAVE):

DAVE = (DB + DA + DH + DL)(1 + DI)/PL

DI = Indirect damage ratio (assumed to be 100 %)

PL = Project life (assumed to be 50 years)

Building damages (DB):

DB = VB x (1.0 + OF)

VB = Damageable value of buildings (excluding movables) in the possible damaged area

OF = Damage ratio for outdoor facilities, garden, tree, etc. (assumed to be 100 %)

Agricultural damages (DA):

DA = VA x (RP + FF)

VA = Damageable value of agricultural crops

RP = Recovery period of new agricultural lands which are assumed to be created on the opposit side of the eroded bank (assumed to be 5 years)

FF = Damage ratio for farm land facilities (assumed to be 100 %)

Highway damages (DH):

DH = CH x LR (1.0 + AP)

CH = Unit reconstruction cost of highway (₱2,260/m for 6.7 meter wide concrete paved road)

LR = Length of reconstruction

AP = Cost ratio for appurtenant facilities of highway

Loss of residential land (DR):

DR = CR x AR

CR = Unit cost of residential land (₱30/m^2)

AR = Area of residential land in the possible damaged area

4) Unit damageable value of building and agricultural crops are assumed to be same with those for the estimation of flooding damages.

(3) Intangible damages

Other than the flooding and bank protection damages mentioned above, the floods badly affect the people's social life and economic activities to a vast extent. Relationship between direct and indirect damages is shown in Fig.3.5. The indirect damages are in general hard to assess in monetary term and intangible. The following damages fall under this category:

1) Damages to people's livelifood
2) Damages to traffic and transportation
3) Damages to business activities in commercial and industrial sectors
4) Loss of lifes and injury

3.5 Economic Evaluation

The benefit of flood control project is brought on by the reduction of damages due to flooding and bank erosion.

For the estimation of flood reduction benefit, probable flood damages for different return periods such as 2, 5, 10, 25, 50 and 100-years are calculated. The lowest flood magnitude which would cause substantial damages is assumed considering the existing channel capacity for each block of inundation.

The bank protection benefit is estimated separately from the flood reduction benefit based on the annual bank erosion damages.

The benefit is estimated under constant and variable property conditions of the basin.

- Constant property condition(CPC): The properties in the basin are assumed to be constant in future at the existing condition of the end of 1985.
- Variable property condition(VPC): The properties in the basin are assumed to vary year by year depending on the basin's development and enhancement of people's livelihood.

The following assumptions are introduced to estimate the properties in future:

- Damageable values of buildings including movables are assumed to increase at the same rate with the projected per capita GRDP (index) in Region II.

Year	1985	1995	2005	2020	2040
Index(%)	100	169	240	499	955

- Damageable values of agricultural crops are assumed to increase linearly up to the year 2005 and keep constant level afterwards. The agricultural property in 2005 are estimated based on the proposed master plan for agricultural development in ANNEX IR.

IV. FRAMEWORK PLAN

4.1 Development of Alternative Plans

4.1.1 Diking System

Diking system is a fundamental component of the alternative flood control plans to complement other flood control measures such as narrow improvement and flood control dams. In order to grasp the hydrological effects of the diking system, runoff calculations for 100-year frequency flood were conducted under the existing basin condition with and without diking system. The process of the flood runoff analyses are presented in ANNEX HY. The results of calculation are shown below.

Reaches	Existing (m^3/s) (1)	W/dike (m^3/s) (2)	Ratio (2)/(1)
Mouth to Chico jct.	21,600	27,400	1.27
Chico jct. to Siffu jct.	26,600	28,800	1.08
Siffu jct. to Ilagan jct.	25,600	27,500	1.07
Ilagan jct. to Magat jct.	23,900	25,900	1.08
Magat jct. to Addalam jct.	16,000	16,300	1.02
Chico R.	8,700	8,700	1.00
Siffu R.	3,300	3,300	1.00
Ilagan R.	9,400	9,900	1.05
Magat R.	10,600	13,800	1.30
Addalam R.	4,800	4,800	1.00
Upper Cagayan R.	12,100	12,100	1.00

With the continuous diking system along the Cagayan river, the flood runoff was estimated to increase up to 127 % of the existing runoff. The flood runoff for the case with diking system would be a basic value for

planning flood control measures. The runoff is called as basic flood discharge.

4.1.2 Improvement of Magapit Narrows

The improvement of Magapit narrows by channel excavation were studied in the following procedures:

1) Establishment of narrow model for flow calculation
2) Study on complete narrow improvement scheme
3) Study on partial narrow improvement scheme

The narrow improvement schemes were studied based on the basic flood discharge, i.e., 100-year flood runoff with diking system.

(1) Establishment of Narrow Model

Surveyed sections of the Cagayan river are available at the intervals of about 5 km. Channel flow calculations with such a long interval were not able to simulate the flood water profile obtained by the flood mark survey in the narrow reaches. For the conveniences of flow calculation for the improvement of Magapit narrows, narrow model was established in the following manners:

1) Based on the river survey results and topographic maps (1/25,000), the existing river widths were measured along the stretches of gorge sections.
2) Existing average river bed elevation for the given river width were estimated by trial and error method so that the surface profile calculated by non-uniform flow may accord with the flood marks at 1980-flood for the channel roughness n = 0.040.

(2) Complete Narrow Improvement Scheme

As an ideal scheme, channel excavation scheme for the entire stretch of narrows from Sta.30 km to 65 km were studied so that the backwater

effects of narrows may be eliminated.

Excavation works by channel widening was studied on the sections of narrow model established in the above. Alignments for channel widening were designed on the topographic maps (scale : 1/25,000). The excavation depth was designed up to about average low water level considering the conveniences of excavation works in dry condition. Following water levels calculated for 75 % dependable discharge were adopted for the average low water level:

- El. 0.37 m for Magapit section
- El. 1.00 to 1.19 m for Nassiping section

According to the study excavation works were necessary at Magapit section (Site-M), Nassiping section (Site-N), and upstream channel from Nassiping (Site-UN). For the Nassiping section two alternative sites were considered, i.e., site along the existing river course (Site-N1) and site including cut-off channel at Nassiping (Site-N2).

Outline of these narrow improvement schemes and longitudinal profile for them are shown in Figs.4.1 though 4.3 and Fig.4.4. Quantities of excavation works are summarized as follows:

Site	Stretch (from - to)	Excavation volume (m^3)
M	Sta.30.0 km - 33.3 km	68,228,000
N	Sta.52.0 km - 59.0 km	43,194,000
N2	Sta.52.0 km - 59.0 km	43,321,000
UN	Sta.59.0 km - 66.0 km	32,718,000

As seen in the above table, excavation volume of Site-N2 is larger than that of Site-N to lower the water level to the same level. Therefore, Site-N is taken up for the improvement of Nassiping section.

The total excavation volume for the complete narrow improvement amounts to 144,140,000 m^3.

(3) Partial Narrow Improvement Scheme

Since the excavation volume for the complete narrow improvement scheme was huge, partial improvement schemes were studied. For the partial improvement, the following alternative schemes were considered:

1) Alt. 1 : Sites-M + N + UN (Complete improvement)
2) Alt. 2 : Sites-N + UN
3) Alt. 3 : Site-UN
4) Alt. 4 : Site-N

For each scheme, flood water level was calculated based on 100-year basic flood discharge. Calculated surface profile is shown in Fig.4.4.

Taking a reference point at Sta.65 km near Alcala, effects of alternative schemes are compared as follows:

Scheme	Excavation volume(m^3) (1)	WL at Sta.65 km (m,MSL)	Reduction in WL(m) (2)	Effect (cm/mil.m^3) (2)/(1)
Existing	-	23.02	-	-
Alt. 1	144,140,000	18.33	4.69	3.3
Alt. 2	76,039,000	19,44	3.58	4.7
Alt. 3	32,718,000	22.43	0.59	1.8
Alt. 4	43,194,000	19.94	3.08	7.1

Channel excavation for Alt.4 is by far effective to lower the flood water level at Sta.65 km comparing to other schemes. The Alt.4, a scheme to improve only Nassiping section, was selected as a component of the alternative flood control plans.

4.1.3 Flood Control Dams

Fourteen potential dam sites have been selected for hydro-power, irrigation and flood control purposes through the screening works in the previous stage of the study. Out of the 14 dams, 8 dams at the lowest site of each tributaries were selected for the flood control study, since they were nearest to the areas to be protected and expected to have direct effects of flood peak reduction. They are Cagayan No.1, Mallig No.2, Siffu No.1(A), Ilagan No.1, Pinukpuk, Addalam (A), Chico No.4, and Disabungan dams (refer to Fig.3.1). According to the previous study, Cagayan No.1, Mallig No.2, Siffu No.1 (A) and Ilagan No.1 dams have been evaluated as class-A dams of higher efficiency for flood control.

The existing Magat dam situates at the suitable site for the flood control dam, although the reservoir has no flood control space. The dam is located at the outlet from the mountainous areas covering 81% of whole Magat river basin. It is worthy to study a scheme to provide flood control space for the existing Magat reservoir. In this scheme Alimit No.1(A) dam will be constructed in order to complement the water supply space of Magat reservoir ceded to the flood control purpose.

Therefore, 9 dams consisting of 8 selected dams and Magat dam with Alimit dam were taken in the alternative flood control plans.

For the Magat dam with flood control space, studies are carried out in combination with the existing Magat dam and Alimit No.1(A). According to the preliminary water balance study on the flow duration at Alimit No.1(A) site, the capacity of about 240 MCM of Magat reservoir could be replaced by Alimit No.1(A) dam. Therefore, Magat reservoir was assumed that to have 200 MCM of effective flood control space by constructing Alimit No.1(A) dam with storage capacity of 240 MCM.

Principal features of the flood control dams are shown in Table 4.1. The effective flood control space except for Cagayan No.1, Addalam (A) and Alimit No.1(A) in the table was calculated based on the flood runoff

hydrograph estimated for 100-year 4-day rainfall adopting the outflow ratio Rout = 0.1. The capacities of Cagayan No.1 and Addalam (A) dams were limited by the topographic site condition and Alimit No.1(A) dam by the possible replenishment for Magat dam. For these dams, outflow ratios corresponding to given capacities were calculated by trial and error method. Sediment space was estimated based on the sediment yeild for 100 years. The sediment yield rate from the upper basin was assumed to be 1,500 $m^3/km^2/year$.

4.1.4 Alternative Plans

Among the flood control measures mentioned above, the diking systems, improvement of Magapit narrows and flood control dams are the alternative measures for the flood prevention. Two cases of Magapit narrows are conceivable i.e., existing and improved Magapit narrows. Three cases of dam schemes were also considered for the framework plan study, i.e., no dam scheme, 5-dam scheme consisting of 4 class-A dams and Magat dam with Alimit dam, and 9-dam scheme consisting of selected 8 dams and Magat dam with Alimit dam. Therefore, following alternative plans were set up for comparative studies of the framework plan putting together the above cases and diking system (Fig.4.5).

1) Alternative plan-OD: A plan consisting of diking system only with existing Magapit narrows.
2) Alternative plan-5D: A plan consisting of 5 flood control dams and diking system with existing Magapit narrows. The 5-dams taken up are Cagayan No.1, Mallig No.2, Siffu No.1(A), and Ilagan No.1 dams and Magat dam with Alimit No.1(A) dam.
3) Alternative plan-9D: A plan consisting of 9 flood control dams and diking system with existing Magapit narrows. The 9-dams taken up are Pinukpuk, Addalam (A), Chico No.4 and Disabungan dams in addition to the above 5 dams.
4) Alternative plan-ODM: A plan consisting of diking system only with improved Magapit narrows.
5) Alternative plan-5DM: A plan consisting of 5 dams and diking system with improved Magapit narrows.

6) Alternative plan-9DM: A plan consiting of 9 dams and diking system with improved Magapit narrows.

4.2 Comparative Studies

4.2.1 Design Flood Discharges

Runoff analyses under the respective alternative schemes are discussed in ANNEX HY. According to the analyses, 100-year design discharge distribution for each alternative plan was determined as shown in Table 4.2.

4.2.2 Preliminary Design

The flood control framework plan includes the channel works and dam works as follows:

I. Channel Works

1) Dike embankment works
2) Revetment works
3) Narrow improvement works
4) Cut-off channel works
5) Bank protection works
6) Drainage sluice works
7) Appurtenant facility works

II. Dam Works

1) River diversion works
2) Dam works
3) Spillway works

Preliminary designs of these channel and dam works were carried out and economic project costs for respective alternative plans were estimated. The project costs for the channel works were shown in Table

4.3 and for dam works in Table 4.4. The project cost includes those of main works, compensation, engineering and administration, and contingency.

The preliminary design of channel works was carried out as presented in the ensuing paragraphs. The preliminary design of concrete dams for flood control purposes was carried out based on the structural design criteria mentioned in ANNEX DA.

(1) Dike Embankment Works

Design high water levels (DHWL) of alternative plans were decided based on the non-uniform flow calculation for design flood discharges. Design high water level at each point of surface slope change is summarized below comparing alternative plans one another.

Station	DHWL for alternative plans (m,MSL)					
	0D	5D	9D	0DM	5DM	9DM
1.0k	5.41	4.90	4.83	5.25	4.92	4.85
30.0k(L)	12.66	11.81	11.74	12.33	11.83	11.76
30.0k(U)	15.06	14.56	14.43	15.41	14.78	14.66
65.0k	23.08	22.01	21.88	20.56	19.78	19.66
160.0k+400m	-	-	29.93	-	-	-
160.0k+1500m	-	30.26	-	-	-	-
160.0k+6000m	32.20	-	-	-	-	-
167.0k+3500m	-	-	-	-	-	32.02
170.6k+100m	-	-	-	-	32.17	-
170.6k+3600m	-	-	-	33.83	-	-
254.3k+700m	50.75	49.74	49.64	50.67	49.74	49.63

Diking systems along the main river and major tributaries were designed based on the design high water levels discussed above. Quantity of works were then estimated.

(2) Revetment Works

Revetment works for dikes were designed where the river course came closer to the dike. Proposed sites were selected on the topographic maps of scale 1/25,000.

(3) Narrow Excavation Works

Only the Nassiping section is subject to the excavation for the Magapit narrow improvement. According to the preliminary design in the preceeding section (4.1.2), excavation volume was estimated to be 43,194,000 m^3 consisting of 21,970,000 m^3 on the left side bank and 21,220,000 m^3 on the right side bank (refer to Fig. 4.2). The excavated materials could be used to reclaim adjacent lowlying lands along the main Cagayan and the Chico rivers to create settlement areas or lands for public facilities free from floodings. Study for effective usage of the excavated materials should be included in the next stage works.

(4) Cut-off Channel Works

In order to accelerate the smooth flood flow and to economize the channel works, cut-off channel works were designed in the markedly meandering reaches as shown in Table 4.5.

Two cut-off channels extending over 7.50 km long in total were designed in the main Cagayan at Gabut and San Isidro. The 0.9 km long cut-off channel was designed for the Magat river near its junction to the main Cagayan.

The Siffu-Mallig river meanders significantly in the entire stretches in the plain area. The cut-off channel works in such a river may stabilize the river course by straightening and steepening the channel. Total length of about 14 km long cut-off channel in the Siffu river will reduce the existing channel length to about 49 %. Total length of about 12 km long cut-off channel will reduce the existing

Mallig river length to about 54 %.

(5) Bank Protection Works

Bank protection works were designed for stabilizing the river course and preventing the bank erosion. River training works in braided river were also included in these works.

The following sites were selected for bank protection works:

1) Existing critical bank erosion sites and sites susceptible to bank erosion.
2) Sites necessary for channel normalization and river training.
3) Sites near towns, village, highway and other important public facilities.

The proposed sites were selected based on the findings during site reconnaissance, results of river bank shifting survey, and topographic maps. The selected sites are listed in Table 4.6. Total length of bank protection works amounts to 112.3 km in total length. For the estimation of cost, assumed were two types of bank protection works, i.e., gabion revetment and wooden pile groyne. One third of total length of bank protection sites were assumed to be protected by the revetment and the remaining by the groyne.

(6) Drainage Sluice Works

Drainage sluice shall be provided for dikes for the interior drainage of the areas protected by dikes of the main Cagayan and major tributaries. In the present study it was assumed, as a rule of thumb, that one sluice of size 1.5 m x 1.5 m x 2 gates would be installed for 4 km^2 of drainage area, or 3 sluices for 2 km long of dike considering the average drainage basin width.

(7) Appurtenant Facility Works

Four bridges crossing over the main Cagayan river need compensation works for the project. They are Magapit, Buntun, Gamu and Naguilian bridges. Three bridges except Magapit bridge need reconstruction for all the alternatives because of the channel improvement by diking systems. Existing bridge conditions and their improvement works are summarized below.

Item	Magapit	Buntun	Gamu	Naguilian
a) Existing condition				
Year built	1980	1968	1972	1953
Length(m)	376	1098	442	668
Width(m)	7.32	7.32	6.75	(6.75)
b) Improvement works				
Improvement	-	Reconst.	Reconst.	Reconst.
Length(m)	376	1,500	1,200	850
Work quantity(m^2)	-	10,980	8,100	5,740

4.2.3 Selection of Optimum Plan

On the basis of the preliminary design including estimates of work quantity and costs in the previous sections, total costs of channel works and dam works are summarized below comparatively for respective schemes.

Alternative scheme	Cost (₱ mil.)			Order
	Channel works	Dam works	Total	
Alt. OD	35,688	0	35,688	2
Alt. 5D	30,268	6,198	36,466	3
Alt. 9D	28,162	17,634	45,796	6
Alt. ODM	38,278	0	38,278	4
Alt. 5DM	28,196	6,198	34,394	1
Alt. 9DM	27,969	17,634	45,603	5

As seen in the above table, alternative plan 5DM which consists of 5 flood control dams and Magapit narrow improvement is the lowest in its cost of all the alternatives. The second and third least cost plans, Alt. OD and Alt. 5D, include long high-dikes which may need more scrupulous maintenance works for their entire service period. The alternative plan 5DM was selected as the framework plan.

4.3 Principal Features of Framework Plan

According to the studies in the preceeding sections, principal features of the flood control framework plan are summarized in Table 4.7, and economic project cost for the plan is shown in Table 4.8.

General location map and longitudinal profile of the flood control framework plan are shown in Figs.4.6 and 4.7.

V. LONG-TERM PLAN

Flood control long-term plan is a basinwide flood control plan based on 25-year frequency flood scaled down from the framework plan. The plan is a target scheme for partial improvement plans such as master and short-term plans. The long-term plan is economically evaluated under two different property conditions of the basin, i.e., constant and variable property conditions.

Major sub-projects are picked up from those included in the long-term plan and priority ranks as candidate sub-projects for master plan are given based on their economic viabilities. Economic viability for priority ranking is assessed under the constant property condition as of 2005 just after the completion of the master plan project.

5.1 Preliminary Design

Design flood discharge was calculated based on 25-year flood under the condition with diking system, 5 flood control dams selected for the framework plan, and improved Magapit narrows. Dimensions and operation rules of the flood control dams are same with those of framework plan. The excavation volume of Magapit narrows and alignment of diking systems were also taken as in the framework plan.

The design discharge distribution for the long-term plan is shown in Fig.5.1. The design flood discharge at river mouth was estimated to be 17,900 m^3/s which corresponded to 70.5 % of that of framework plan.

Longitudinal profile are shown in Fig.5.2. The diking systems were designed based on it in the same manner as in the framework plan study.

Regarding the flood control measures of the major tributaries, following consideration was given:

- Chico and Ilagan rivers: Existing channel retardation function is to be maintained. In addition, bank protection works to prevent bank erosion and to stabilize river course should be executed.
- Siffu-Mallig river: Channel retardation function was not considered, since both the Siffu and Mallig rivers had proposed flood control dams in the upper watersheds. The remarkablly meandered river channels should be improved by the cut-off channels to accelerate flood drainage and to stabilize river channels.
- Magat river: There are two dams in the Magat river, proposed Matuno dam in the upper reaches and existing Magat dam in the middle reaches. The channel retardation function was not considered in the Magat river. Bank protection works to prevent bank erosion and to stabilize river course should be executed.

Quantities of major works such as dike embankment, revetment and land acquisition are shown in Table 5.1. Economic project costs were then estimated as shown in Table 5.2. The project cost for the long-term plan amounts to ₱27,543,000,000.

5.2 Economic Evaluation

The benefit of the flood control long-term plan is brought on by the reduction of damages due to flooding (flood reduction benefit) and bank erosion (bank protection benefit). The benefit is estimated under the constant and variable property conditions of the basin.

5.2.1 Benefit under Constant Property Condition

Probable flood discharges of the present river condition (without project) were calculated for the different magnitudes of rainfall. The results are shown in Table 5.3.

Damages without project were estimated for the respective floods and annual flood damages were then estimated deviding the inundated areas

into several blocks. The flood damages thus estimated are shown in Tables 5.4 and 5.5. Average annual flood without project were estimated at ₱3,793,000,000 over the basin based on the probable damages up to 100-year flood.

For the river condition with improved narrow and dams, probable flood discharges and their damages were also calculated. the results are shown in the said Tables 5.3 and 5.4.

The flood damages for the condition without project will be eliminated up to 25-year floods by the combined effect of Magapit narrow improvement, 5 flood control dams, and diking system. In addition to these, effects of narrow improvement and dam works are expected up to 100-year floods.

The residual damages after completion of the diking system along the main Cagayan river were assumed to be 20% of the damages without diking system. The effects of diking system are not extended to the river basins of upper Cagayan, upper Magat, Ilagan, Siffu, Mallig, Tuguegarao, and Chico. Flood reduction benefit of the long-term plan was estimated as shown in Table 5.6.

On the other hand, annual benefit of the bank protection was estimated as reduction in bank erosion damages mentioned in the section 3.4. Results are shown in Table 5.7. Total bank protection benefit was estimated to be ₱73,000,000/year.

Accordingly, annual benefit under the constant property condition was estimated as follows including the flood reduction and bank protection benefits:

- Flood reduction benefit: ₱ 1,564 mil/yr.
- Bank protection benefit: ₱ 73 mil/yr.

Total: ₱ 1,637 mil/yr.

5.2.2 Benefit under Variable Property Condition

Under the variable property condition, hydrological condition was assumed to be same with that of constant property condition. However, the benefit was assumed to vary year by year depending upon the accumulation of properties in the basin.

Damages with and without project were estimated in the similar manner as in the constant property condition for six return periods of floods and for respective reference years.

The annual benefit for each reference year was estimated as shown in the said Table 5.6. The average annual benefits of the long-term plan are estimated under the variable property condition as shown below.

Year	Annual average benefit (₱ mil./yr)		
	Flood reduction	Bank protection	Total
1985	1,564	73	1,637
1995	2,619	104	2,723
2005	3,699	135	3,834
2020	7,549	232	7,781
2040	14,328	400	14,728

5.2.3 Economic Evaluation

For the cost-benefit analysis, the following assumptions were introduced:

1) The main works will be carried out for 15 years from 1991 to 2005, the target year for the Master Plan.
2) The engineering and administration for the project will continue from the year 1990 until 2005.

3) The compensation will be carried out one year earlier than the main works, i.e., from 1990 to 2004.
4) The project costs are assumed to be disbursed uniformly whole through the work periods.
5) Project life is assumed to be 50 years from the beginning of works in 1991 to the year 2040.
6) Benefit by the project is assumed to be propotional to the cumulative construction cost disbursed by the year under consideration.
7) As an annual operation and maintenance cost, 0.5 percent of cumulative construction cost disbursed by the year under consideration is assumed.
8) Base year for the cost-benefit analysis is taken at the end of 1985.

Cost and benefit cash flows used for the economic evaluation are shown in Table 5.8. Internal rate of return (IRR) of the long-term plan was estimated for the both constant and variable property conditions as follows.

- Constant property condition : 4.8 %
- Variable property condition : 14.2 %

As a result of studies in the previous sections, general location map for the long-term plan is shown in Fig.5.3. The principal features of the long-term plan are summarized in Table 5.9.

5.3 Priority Ranking of Schemes

The execution of the long-term plan needs huge amount of fund and is deemed difficult to complete by the target year of the Master Plan, 2005. Therefore, several schemes included in the long-term plan are selected for the Master Plan based on the economic viability.

5.3.1 Selection of Candidate Schemes

(1) Dike Schemes

The continuous diking system will not be implemented at an early stage, since the system may induce concentration of flood runoff in the lower reaches and worsen the situation against flooding.

In order to nominate the promissing dike schemes among the diking system, quantities of dike works and properties to be protected by dike were compared. As indexes for the dike works and properties to be protected, used were dike embankment volume and number of inundated houses for 100-year flood under the existing basin and channel conditions. The screening of dike schemes is shown in Table 5.10.

Following two dikes were picked up through the screening works in consideration of properties to be protected by dikes.

- Tuguegarao dike
- Cabagan dike

The dikes are designed based on the high water level for 25-year flood under the present basin condition. Revetment works to strengthen the dikes were included in the candidate dike schemes mentioned above. Outline of these dike schmes are illustrated in Figs.5.4 and 5.5. Project costs of these dike schmes are shown in Table 5.11.

(2) Narrow Improvement Schmes

The selected Nassiping site was devided into three work sites, i.e., left side bank of lower portion (Site-NLL), right side bank of lower portion (Site-NLR), and upper portion (Site-NUP) of Nassiping section as shown in Fig.4.2. These three sites were taken up as candidate schemes for the Master Plan. Surface profile for each excavation work is shown in Fig.5.6. The work quantites and hydraulic effects are summarized below.

Scheme	Excavation volume(m^3) (1)	WL at Sta.65km (m,MSL)	Reduction in WL(m) (2)	Effect (cm/mil.m^3) (2)/(1)
Site-N(whole)	43,194,000	19.94	3.08	7.1
Site-NLL	5,828,000	21.67	1.19	20.4
Site-NLR	17,624,000	20.92	2.10	11.9
Site-NUP	19,742,000	22.61	0.52	2.4

The project costs of these narrow improvement schmes are shown in Table 5.12.

(3) Flood Control Dam Scheme

All the dams included in the long-term plan were taken up. Costs of these dam projects are shown in Table 5.13.

- Cagayan No.1 dam
- Magat/Alimit No.1 dam
- Ilagan No.1 dam
- Siffu No.1(A) dam
- Mallig No.2 dam

(4) Bank Protection Schemes

All the bank protection schemes included in the long-term plan were taken up. Project cost of these bank protection works is shown in Table 5.14.

5.3.2 Priority Ranking

Priority ranks as candidate schemes for Master Plan were given to each of the selected schemes based on the economic viability. The economic viability were examined according to the following assumptions:

1) Project cost including main works, engineering and administration, and compensation is assumed to be disbursed uniformly for 5 years from 1991 to 1995 years except for dam works. As for the dam work disbursement schedule of project cost was assumed to be 3%, 15%, 25%, 32%, and 25% for respective years from 1991 to 1995.

2) Benefit is assessed independently for each candidate work comparing with the conditions with and without project. The benefit is estimated under the constant and variable property conditions of the basin.

3) Benefit by the dam works is assumed to be realized next year of the completion of the works, while the benefit of the channel works is in propotional to progress of the works.

4) Other conditions adopted for the study are same as in the evaluation of the long-term plan.

Result of study on the priority ranking of these candidate schemes is shown in Table 5.14, which is summarized below.

Rank	Candidate scheme	IRR.CPC	IRR.VPC
1	Tuguegarao dike	11.6%	23.1%
2	Narrow imp.(Site-NLL)	8.9	18.9
3	Bank protection	7.3	13.7
4	Cabagan dike	5.3	13.6
5	Narrow imp.(Site-NLR)	5.2	13.5
6	Magat/Alimit No.1 dam	5.1	13.1
7	Siffu No.1(A) dam	5.1	12.8
8	Cagayan No.1 dam	3.8	11.6
9	Mallig No.2 dam	2.2	9.3
10	Ilagan No.1 dam	-	5.4
11	Narrow imp.(Site-NUP)	-	-

Note 1. IRR.CPC: IRR under constant property condition
2. IRR.VPC: IRR under variable property condition

5.4 Intersectoral Adjustment

The priority ranks of the candidate schemes discussed in the previous section are adjusted from intersectoral viewpoint as multipurpose projects. Magat/Alimit No 1, Siffu No. 1 and Mallig No. 2 dam schemes were subject to the intersectoral adjustment using the allocated cost. The allocation of costs was presented in ANNEX DA.

(1) Magat/Alimit No.1 Dam Scheme

In consideration of a multipurpose project for irrigation and flood control, capacity and cost of Alimit No. 1 dam allocated for the flood componenet are as follows:

1) Effective flood control capacity: 116 MCM considering safety factor (20%) based on the allocated storage capacity of 139 MCM for Alimit No. 1 dam reservoir.
2) Allocated economic cost: ₱904.7 mil.
3) Allocated negative benefit: ₱0.02 mil./yr
4) Flood control benefit: Interporated from benefits for capacities of 100 MCM and 200 MCM as follows

Year	1985	1995	2005	2020	2040
Benefit(₱mil./yr)	55.33	92.51	128.42	263.36	500.92

(2) Siffu No. 1 Dam Scheme

Siffu No. 1 dam multipurpose project with irrigation and flood control purposes was considered. Full capacity required for the flood control was available. The allocated cost and other principal values are as follows:

1) Effective flood control capacity: 96.1 MCM same as the long-term plan
2) Allocated economic cost: ₱279.3 mil.
3) Allocated negative benefit: ₱0.71 mil./yr
4) Flood control benefit: Same as the long-term plan

Year	1985	1995	2005	2020	2040
Benefit(₱mil./yr)	32.28	53.43	72.66	146.85	277.47

(3) Mallig No. 2 Dam Scheme

Irrigation and flood control purposes were considered for Mallig No. 2 dam. Full capacity required for the flood control was available. The allocated cost and other principal values are as follows:

1) Effective flood control capacity: 93.4 MCM same as the long-term plan
2) Allocated economic cost: ₱343.4 mil.
3) Allocated negative benefit: ₱0.46 mil./yr
4) Flood control benefit: Same as the long-term plan

Year	1985	1995	2005	2020	2040
Benefit(₱mil./yr)	16.71	27.64	37.39	75.65	143.02

(4) Adjustment of Project Ranking

Based on the allocated cost, economic viability of the dam schemes were restudied in the same way as in the previous section. Result of restudy is shown in Table 5.21, which is summarized as follows:

Rank	Candidate scheme	IRR.CPC	IRR.VPC
1	Tuguegarao dike	11.6%	23.1%
2	Narrow imp.(Site-NLL)	8.9	18.9
3	Siffu No.1(A) dam	9.3	18.6(14.5)
4	Bank protection	7.3	13.7
5	Cabagan dike	5.3	13.6
6	Narrow imp.(Site-NLR)	5.2	13.5
7	Magat/Alimit No.1 dam	4.6	12.5(12.1)
8	Cagayan No.1 dam	3.8	11.6
9	Mallig No.2 dam	3.0	10.3(15.2)
10	Ilagan No.1 dam	-	5.4
11	Narrow imp.(Site-NUP)	-	-

Note 1. IRR.CPC: IRR under constant property condition
2. IRR.VPC: IRR under variable property condition
3. IRR.VPC in () shows the evaluation as multipurpose dam project.

Table 1.1 Present Basin Condition (RDP-II)

Item	Unit	Cagayan
1. Location	-	Northern Luzon Island
2. Basin area	km^2	27,280
3. River length	km^2	505
4. Flood prona area	ha	154,900
a. Affected river reach	km	234
b. River slope	-	1/9400 to 1/3200
c. Major land use	-	Rice
d. Carrying capacity	m^3/sec	5,000 (1,900 to 9,000)
e. Present 2-yr. runoff	m^3/sec	5,400 to 6,300
5. Forest in mountainous area	-	Almost denuded
6. Geology	-	Tertiary sedimentary rocks, Alluvium
7. Population		
a. Basin total	pers.	2,194,300/2
b. Flood prone area	pers.	469,000
8. GDP	₱10^6	6,794
	₱/capita/1	3,096
9. Annual flood damage	₱10^6	883

Remarks: /1 : Five-Year Philippine Development Plan 1983 - 1987 values are changed into 1980 prices.

/2 : By average population density of Cagayan and Isabela provinces in 1980 (80.4 pers./km^2). Philippine Statistiscal Year Book 1981.

Table 1.2 Summary of RDP-II Plans

I. Basic Plan : 100-year basinwide plan

I-1. Work Quantity

Item	Quantity
Excavation, common	132,946,000 m^3
Embankment	106,357,000 m^3
Revetment (L.W.C)	1,844,000 m^2
Revetment (H.W.C)	467,000 m^2
Drainage sluice	173 units
Backwater levee	31,021,000 m^3
Bridge	15,209 m^2
Compensation	
Land	15,515 ha
Building	3,890 nos

I-2. Project Cost : ₱8,098 mil. in end 1981 price (economic cost)

II. First Phase Plan : 25-year basinwide plan

II-1. Work Quantity

Item	Quantity
Excavation, common	112,125,000 m^3
Embankment	89,703,000 m^3
Revetment (H.W.C)	1,844,020 m^2
Revetment (L.W.C)	404,920 m^2
Drainage sluice	173 units
Backwater levee	25,461,000 m^3
Bridge	15,209 m^2
Compensation	
Land	15,345 ha
Houses	3,840 nos

II-2. Project Cost : ₱7,102 mil. (economic) or ₱9,499 mil. (financial) in end 1981 price

III. First Step Works

III-1. Work Quantity

Item	Unit	Confining dike	Cutoff channel	Bank protection	Total
Main Works					
Excavation	m^3	14,043,000	6,840,000	-	20,883,000
Embankment	m^3	16,706,000	-	-	16,706,000
Revetment (L.W.C)	m^2	476,700	-	157,300	634,000
Revetment (H.W.C)	m^2	257,540	-	-	257,540
Drainage sluice	nos	9	-	-	9
Backwater levee	m^3	3,216,000	-	-	3,216,000
Compensation					
Land	m^2	7,888,000	1,500,000	90,000	9,478,000
Building	nos	200	40	-	240

III-2. Project cost : ₱2,774 mil. (financial) in end 1981 price

VI. Urgent Works

VI-1. Work Quantity

Site	Facilities to be protected	Length (km)	Revetment ($10^3/m^2$) Wet masonry	Gabion
Apari	Aparri town	1.0	4,500	-
Catayuan	Village, houses and national highway	6.0	43,200	60,600
Gattaran	Village, houses and national highway	1.0	7,200	-
Tuguegarao	Tuguegarao town	4.5	32,400	49,500
Balug	National highway	1.0	7,200	-

IV-2. Project Cost: ₱320.8 mil. (financial) in end 1981 price

Table 2.1 Carrying Capacity of Existing Channels

Station (No.)	Distance (m)	Capacity (m^3/s)	Width (m)	Depth (m)
Cagayan River				
1.0 K	0	-	1,588	4.35
5.0 K	4,000	5,880	1,638	3.60
10.0 K	9,000	9,230	1,520	5.10
15.0 K	14,000	7,560	819	6.73
20.0 K	19,000	9,607	814	9.18
23.0 K	22,000	14,068	1,515	6.73
25.0 K	24,000	13,689	867	8.86
30.0 K	29,000	36,620	410	19.43
33.0 K	32,000	12,160	597	13.30
35.0 K	34,000	7,340	659	7.80
40.0 K	39,000	13,000	455	12.57
43.0 K	42,000	10,500	882	9.77
50.0 K	49,000	11,200	926	10.88
54.5 K	53,500	11,170	581	13.55
59.0 K	58,000	12,500	299	20.94
62.0 K	61,000	9,290	384	15.36
69.5 K	68,500	3,720	1,025	7.02
76.5 K	75,500	5,720	543	9.23
86.0 K	85,000	2,490	526	4.98
90.0 K	89,000	3,550	553	6.54
94.0 K	93,000	3,780	708	7.99
100.5 K	99,500	3,480	803	5.91
108.0 K	107,000	4,610	501	8.01
115.8 K	114,800	5,680	733	6.72
123.0 K	122,000	7,010	764	9.85
128.0 K	127,000	5,510	869	7.53
132.0 K	131,000	6,320	1,648	6.05
135.6 K	134,600	4,160	416	9.02
137.0 K	136,000	4,420	678	6.70
138.0 K	137,000	7,220	706	8.08
140.3 K	139,300	4,740	754	6.58
145.0 K	144,000	8,920	1,046	9.19
149.5 K	148,500	2,030	633	4.81
154.5 K	153,500	6,280	1,007	6.20
160.0 K	159,000	6,020	1,108	5.56
167.0 K	166,000	4,640	561	6.42
170.6 K	169,600	9,140	655	8.25
178.0 K	177,000	3,860	908	5.83
185.0 K	184,000	7,390	1,179	6.78
190.0 K	189,000	11,430	300	12.81
192.0 K	191,000	7,280	1,212	7.88
195.0 K	194,000	8,910	854	8.70
201.0 K	200,000	6,910	306	14.06
206.3 K	205,300	6,550	1,061	8.29
211.0 K	210,000	5,790	762	6.93
215.0 K	214,000	7,960	516	11.63
217.0 K	216,000	9,310	879	9.21
221.0 K	220,000	10,380	535	13.01
226.5 K	225,500	14,580	471	20.69
228.0 K	227,000	11,600	539	13.25
233.5 K	232,500	2,070	593	4.41
237.0 K	236,000	2,820	350	8.34
244.0 K	243,000	4,280	539	5.67
248.0 K	247,000	5,320	620	7.41
251.5 K	250,500	4,670	566	8.77
254.3 K	253,300	6,950	1,201	6.30
258.4 K	257,400	11,750	370	18.90
267.5 K	266,500	5,620	311	12.64
276.5 K	275,500	5,300	474	7.28
288.0 K	287,000	10,100	391	14.57
295.0 K	294,000	7,780	344	7.53
304.0 K	303,000	9,600	451	10.66
311.5 K	310,500	15,300	434	15.06
318.0 K	317,000	7,470	355	9.71

Station (No.)	Distance (m)	Capacity (m^3/s)	Width (m)	Depth (m)
Chico River				
0.0 K	0	1,070	341	8.19
2.0 K	2,000	2,730	439	9.51
4.0 K	4,000	2,950	342	11.28
6.0 K	6,000	3,900	337	11.11
16.0 K	16,000	5,670	709	6.81
25.0 K	25,000	1,540	317	4.70
35.0 K	35,000	1,810	1,068	4.74
44.0 K	44,000	3,140	413	3.31
55.5 K	55,500	6,100	572	4.24
64.3 K	64,300	8,390	357	8.21
75.0 K	75,000	3,320	846	1.39
85.6 K	85,600	2,960	2,597	1.90
94.0 K	94,000	8,690	293	4.72
Tuguegarao River				
0.0 K	0	160	785	3.59
2.0 K	2,000	180	364	4.23
3.6 K	3,600	350	284	4.69
6.0 K	6,000	450	320	4.74
8.0 K	8,000	460	216	5.42
Siffu River				
0.0 K	0	2,080	135	7.48
2.0 K	2,000	1,790	114	6.60
5.0 K	5,000	920	134	7.14
6.5 K	6,500	440	73	3.84
8.0 K	8,000	1,100	161	6.38
Mallig River				
2.0 K	2,000	670	170	5.53
3.5 K	3,500	1,070	91	6.29
5.5 K	5,500	490	60	5.10
Ilagan River				
0.0 K	0	580	667	4.03
2.0 K	2,000	810	529	5.06
3.8 K	3,800	820	490	3.20
6.0 K	6,000	3,470	589	13.91
11.8 K	11,800	3,700	446	4.57
21.5 K	21,500	4,830	304	6.23
36.0 K	36,000	4,750	257	8.92
Magat River				
0.0 K	0	920	259	3.08
4.0 K	4,000	1,300	184	4.66
6.0 K	6,000	1,020	227	3.40
10.0 K	10,000	1,900	656	2.63
15.5 K	15,500	1,060	415	1.76
21.0 K	21,000	1,820	216	1.93
25.5 K	25,500	3,880	623	2.48
31.0 K	31,000	1,330	2,158	1.16
34.0 K	34,000	7,480	1,327	2.21
40.0 K	40,000	4,330	837	2.44
45.0 K	45,000	5,740	917	3.64
50.0 K	50,000	9,070	556	5.92
52.5 K	52,500	(35,120) -	(304) -	(13.45) -

Remarks: 1. Distance : from river mouth
2. Capacity : bankfull

Table 2.2 Flood Damages due to Typhoon in Region II

Year	Date	Name of Typhoon	Affected Area	Damage (₱1,000)	Casualties		
					Dead	Injured	Missing
1970	Oct.10-15	Sening	Nueva-Vizcaya	373	NO	NO	NO
1971	Jul.22-26	Sisang	No effect in Region II except 1 dead in Batanes				
1972	Jun.24-25	Konching	No effect in Region II				
1973	Nov.23-26	Openg	No detailed damage data				
	Oct. 2- 9	Luming	Batanes	195	-	-	-
			Cagayan	4,500			
			Isabela	663			
			K-Apayao	950			
			N-Vizcaya	748			
1974	Jan.10-11	Basiang	Quirino	252			
			N-Vizcaya				
			(Solano)	550			
			(Bayombong)	951			
	Jul.18-21	Iliang	Isabela	3,010			
	Oct. 8-12	Susang	Cagayan	5,474			
			K-Apayao	291			
			Isabela	12,059			
	Oct.14-17	Tering	Isabela	1,744			
			Cagayan	3,549			
	Oct.28-Nov. 1	Wening	Cagayan	394			
			K-Apayao	21,997			
			N-Vizcaya	8,544			
			Isabela	12,851			
			Quirino	492			
1975	Oct. 9-13	Mameng	Batanes	2,710			
1976	Jun.22-Jul. 2	Huaning	Batanes	3,550			
			Ifugao	274			
			N-Vizcaya	513			
			K-Apayao	25			
			Quirino	150			
1977	Sep.14-23	Openg	Cagayan	5,310		-	6
			Isabela		1	-	-
	Nov.10-17	Unding	Quirino	1,128			
			N-Vizcaya	1,150			
1978	Oct.25-27	Kading	Cagayan	3,656	22	10	9
			Quirino	17,055	1	-	13
			Isabela	3,623	2	-	5
			K-Apayao	525	9	-	-
			Ifugao	427	5	-	5
			N-Vizcaya	1,418	14	-	-
1979	Aug. 9-15	Mameng	Cagayan	-	-	-	-
			Isabela	-	-	-	-
			Batanes	500	-	-	-
	Aug. 3- 6	Luding	Northern Luzon				
	Jul.29-Aug. 2	Ising	Batanes, Cagayan & Isabela	3,980			
1980	Nov. 1- 7	Aring	Cagayan	343,792	26		
			Isabela	83,893	16		11
			N-Vizcaya	69,450	27		12
			Quirino	63,596	4		
			K-Apayao	5,165			
			Ifugao	23,073			
			Batanes	600			
1981	Jul. 3- 5	Elang	N-Vizcaya	783	1		
			Quirino	5,253			
	Sep.16-21	Rubing	Cagayan	64,003	3	-	-
			K-Apayao	7,812			
			Quirino	1,308			
			Isabela	370			
			N-Vizcaya	420			
			Batanes	184			
	Nov.22-27	Anding	Isabela	-	1		
			N-Vizcaya	1,040			
			Quirino	11,884			
1982	Oct.12-15	Weling	Cagayan	37,243	12	15	-
			Isabela	14,159	71	144	21
			K-Apayao	10,672	13	24	9
1983	Sep. 3- 8	Herming	Sta. Ana	6,895			
			Gonzaga	205			
			Aparri	1,500			
			Lallo	40			
			Isabela		2		
1984	Aug.27-31	Maring	Cagayan	20,676	25	-	8
			Isabela	1,560	1	-	-
			Quirino	55			
			K-Apayao	40,198	-	-	-
			Ifugao		1		
1985	Jun.20-24	Kuring	Batanes	4,150		-	
			Ifugao	1,400			
			Isabela	13,407			
			Quirino	2,740			
			K-Apayao	2,549	11		
			N-Vizcaya	4,858	3	69	
			Cagayan		1		
	Oct.16-19	Saling	K-Apayao	32			
			Quirino	670			
			Ifugao	30			
			N-Vizcaya	12,305	1		
			Isabela	3,080			

- Based on data from Office of Civil Defence.

Table 2.3 Result of Flood Mark Survey

Location	Distance from mouth (km)	Station	Elevation of Flood Marks (m, MSL) Nov. 1973	Nov. 1980
Details of Magapit narrow				
Side of Rip-Rap Magapit	28.8		-	7.809
Magapit Bridge	29.0	30.0 K	-	9.095
Magapit	29.6		-	8.621
Aguigican	30.3		-	7.829
Magapit	30.5		-	9.677
Aguigican	30.8		12.390	11.187
Aguigican	31.2		12.480	11.230
Aguigican	31.7		-	10.012
Aguigican	32.5		11.240	9.740
Casicalan Norte	33.6		-	10.871
Casicalan Norte	34.2		12.147	11.447
Casicalan Elem. School	35.3		12.811	11.071
Casicalan Sur	35.9		13.262	11.422
Orlando Jose	36.6		12.415	10.355
Gattaran Centro Nor.	37.3		11.509	9.855
Gattaran Centro	37.7		11.756	10.643
Gattaran Centro	38.1		12.693	-
Gattaran Centro Sur	38.3		12.974	10.974
Gattaran Centro Sur	38.7		-	11.832
Gattaran Centro Sur	39.0	40.0 K	13.760	12.090
Dummon	39.4		15.009	-
Dummon	39.7		11.996	10.396
Dummon	39.9		12.505	-
Dummon	40.3		13.964	12.014
Dummon	40.7		17.269	15.269
Sta. Maria	41.1		12.936	10.886
Sta. Maria	41.7		13.130	12.130
Sta. Maria	42.2		12.630	10.530
Guising	42.7		13.368	11.868
Guising	43.5		13.476	12.376
Guising	44.1		13.695	11.695
Guising	44.7		13.891	12.351
Lapogan	45.3		13.489	11.939
Lapogan	45.8		13.384	11.884
Lapogan	46.1		13.789	12.039
Lapogan	46.6		13.822	-
Lapogan	47.3		14.703	12.603
San Vicente	48.2		-	11.989
San Vicente	49.0	50.0 K	-	12.832
San Vicente	50.0		15.016	13.166
San Vicente	50.5		14.832	13.232
Nassipping	51.7		14.744	11.072
Nassipping	52.5		16.163	14.186
Nassipping	53.2		16.983	14.183
Maraburab	57.0		18.142	16.133
Maraburab	57.5		17.560	-
Maraburab	58.0	59.0 K	17.372	15.410
Maraburab	59.1		17.626	16.396
Tupang, Alcala	60.4		18.478	-
Tupang, Alcala	61.6		17.088	-
Tupang, Alcala	62.4		18.495	16.495
Tupang, Alcala	63.1		18.373	16.973
Tupang, Alcala	63.5		19.384	-
Tupang, Alcala	63.9		18.986	-
Tupang	64.0		19.715	-
Cagayan main stream				
Toran	5.0		-	2.4
Alilinu	8.5		-	3.9
Lal-lo	19.0	20.0 K	7.1	-
Bagumbayan	20.0		7.6	6.6
Magapit Br.	29.0	30.0 K	-	8.5
Magapit	30.5		-	9.7
Dummon Br.	41.0		13.7	13.2
Maraburab Br.	57.0		18.2	-
Pared Br.	65.5		19.7	18.3
Baculud	81.5		-	18.2
Minanga	107.0	108.0 K	-	19.2
Solana	129.5		-	21.1
Tuguegarao	137.5		-	23.2
San Pablo Br.	156.5		25.9	-
Cabagan	165.0		-	27.6
Balasig Br.	172.5		-	29.2
Tumauini	189.0		-	32.6
Arcon Br.	193.0		-	32.9
Malalam Br.	211.0		-	35.8

Table 2.4 Existing Flood Control Facilities

Location	Component	Length (m)	Remarks
Cagayan R.			
1. Aparri, Cagayan	jetty	780	
	revetment	300	
2. Agusi, Cagayan	revetment	40	
3. Catayuan, Cagayan	revetment	358	extention of 28 m is on-going.
4. Magapit, Cagayan	revetment	200	
5. Amulung, Cagayan	revetment	438	Amulung P/S.
6. Minanga, Cagayan	revetment	188	Iguig P/S, on-going
7. Namabbalan, Cagayan	revetment	45	on-going
8. Sta. Maria, Isabela	revetment	70	extention of 80 m is on-going.
9. Cabagan, Isabela	revetment	1,790	
10. Reina Mercedes, Isabela	revetment	140	
11. Baringin, Isabela	revetment	200	
12. Dessimpit, Isabela	cut-off channel	660	almost filled up, re-location of the site is being studied.
13. Maddela, Quirino	earth dike	200	
Chico R.			
14. Gobgob, K. Apayao	revetment	827	
	spur dike	200	2 units
Chico-Agoyo R.			
15. Bontoc, Mountain	earth dike	460	
Bayugan R.			
16. Bauko, Mountain	cut-off channel	120	
Pared R.			
17. Baybayog, Cagayan	revetment	150	
Tuguegarao R.			
18. Tuguegarao, Cagayan	revetment	83	partially damaged
Siffu R.			
19. Roxas, Isabela	cut-off chanel	500	almost filled up
	revetment	150	
Mallig R.			
20. Mallig, Isabela	cut-off channel	-	almost filled up
	revetment	-	mostly damaged

Location	Component	Length (m)	Remarks
Ilagan R.			
21. Ilagan, Isabela	revetment	110	extention will be on-going
Magat R.			
22. San Mateo, Isabela	earth dike	8,850	middle portion of 1,400 m was broken, and still be open
	cut-off channel	2,540	partially filled up
23. Bayombong, N.V.	earth dike w/ revetment	2,000	
	spur dike	-	2 units
24. Cabarroguis, N.V.	revetment	-	
25. Batu Ferry, N.V.	revetment	830	partially damaged
26. Abian, N.V.	revetment	-	partially damaged
27. Makate, N.V.	spur dike	-	12 units, partially damaged
28. Bambang, N.V.	earth dike	80	
	cut-off channel	100	
Sta. Fe R.			
29. Indiana, N.V.	revetment	380	
30. Almaguer Mangayang, N.V.	revetment	475	
31. Indiana, N.V.	spur dike	-	4 unit
32. Pugung Buaya, N.V.	revetment	-	
33. Magasawang Kahog, N.V.	revetment	-	
34. Baliling, N.V.	revetment	-	
35. Sta. Fe, N.V.	revetment	155	
Lamut R.			
36. Lamut, Ifugao	revetment	400	
Benay R.			
37. Dupax del Sur, N.V.	revetment	240	
38. Palabotan, N.V.	revetment	340	
39. Nabitangan, N.V.	check dam	102	earth fill dam of 12 m high w/ conc. spill way
Baliling R.			
40. Baliling, N.V.	revetment	248	

Table 2.5 Existing Drainage Systems

Location	Length (m)	Structure
1. Aparri, Cagayan	54	pipes
2. Tuguegarao, Cagayan	1,690	pipes
3. Cabagan, Isabela	300	CHB cells /1
4. Naguilian, Isabela	400	CHB cells
5. Santiago, Isabela	602	open channel box
6. Bagabag, Nueva Vizcaya	1,110	open channel box

Note : /1 : Concrete Hollow Blocks

Table 2.6 Flood Control Budget

(₱ 10^6)

Year	Infrastructure (Total)	Flood control (Total)		Flood control (Reg.-II)	
	(1)	Amount (2)	(2)/(1) (3)	Amount (4)	(4)/(2) (5)
1981	2,420.2	481.2	0.199	30.3	0.063
1982	7,027.5	675.0	0.096	16.3	0.024
1983	7,400.0	694.2	0.094	27.0	0.039
1984	4,292.5	301.0	0.070	5.1	0.017
1985	3,325.8	240.5	0.072	4.3	0.018
1986	3,819.2	484.0	0.127	8.2	0.017
Average	4,714.2	479.3	0.102	15.2	0.017

Remarks

1. Above amounts do not include budget Set-III for programs of attached corporations.
2. Source: MPW/HPWH Infrastructure programs for 1981 through 1986.

Table 2.7 Principal Features of Magat and Maris Dams

I.	Magat Dam	
	Location : Oscariz, Ramon, Isabela	
	Completion: October, 1982	
	1. Dam	
	(1) Type	Zoned Earth-Rock Fill Dam
	(2) Height	114 m
	(3) Crest Elevation	200 El.m
	(4) Crest Length	4,160 m
	2. Spillway	
	(1) Width	164 m
	(2) Length	500 m
	(3) Radial Gate	7 sets
	(4) Orifice Gate	2 sets
	(5) Discharge Capacity	30,600 m^3/sec
	3. Diversion Tunnel	
	(1) Number	2 units
	(2) Diameter	12 m
	(3) Average Length	630 m
	4. Reservoir	
	(1) Live Storage Capacity (FSL)	1,250 x 10^6 m^3
	(2) Area of FSL	45 km^2
	5. Power Facilities	
	(1) Installed Capacity	360 MW
	(2) Additional Capacity	180 MW
II.	Maris Dam (Diversion Weir)	
	Location : Oscariz, Ramon, Isabela	
	Completion: August, 1982	
	1. Dam	
	(1) Type	Ogee Type Concrete Dam
	(2) Height	10.5 m
	(3) Crest Elevation	102 El.m
	(4) Crest Length	215.25 m
	2. Scouring Sluice	
	(1) Sluice Gate	2 sets
	(2) Stoplog Gate	16 sets
	3. Sluiceway	
	(1) North Gate	2 sets
	(2) South Gate	2 sets

Table 2.8 Principal Features of Chico Diversion Weir

Location : Bo. Ngipen, Tabuk
Completion : December, 1983

1.	Weir	
	(1) Type	Ogee Type Concerete Weir
	(2) Height	3.65 - 7.00 m
	(3) Crest Elevation	204.50 El.m
	(4) Crest Length	759.34 m
	(5) Probable Afflux Elevation	207.55 El.m
2.	Scouring Sluice	
	(1) Sluice Gate	2 sets
3.	Sluice way	
	(1) Left Sluiceway (at weir site)	4 Bays w/ 2 Steel Sluice Gates of 2.50 m x 3.80 m each
	(2) Right Sluiceway (downstream of weir)	1 Bay w/ Steel Sluice Gate of 2057 mm x 1315 mm
4.	Siphon	
	(1) Length	732.84 m
	(2) Diameter of Conduit	3.0 - 3.8 m

Note : Crest of weir will be raised by 4 m for stage II.

Table 2.9 Principal Features of Pumping Stations

Pumping Station	Magapit		Amulung	Iguig	Solana	Tuguegarao
Completion	May '85		June '82	Sept. '83	-	-
Location	Magapit		Baculud	Minanga Sur	Solana	Tuguegarao
Irrigable area (ha)	11,457.27	(H)	1,370.89	775.61	-	-
		(L)	801.19			
Water requirement (m^3/sec)	21.081	(H)	2.523	1.427	-	-
		(L)	1.474			
Water level (El.m)						
HHWL	11.00		20.00	20.00	-	-
MWL (Wet)	1.24		6.30	8.02	-	-
MWL (Dry)	0.46		4.52	7.08	-	-
LWL	0.00		1.40	4.00	-	-
Pumping plant						
Type of pump	Vertical mixed flow pump with volute casing					
No. of pump	4	(H)	3	3	-	-
		(L)	1			
Pump bore (mm)						
Suction	1,800	(H)	700	600	-	-
		(L)	800			
Discharge	1,500	(H)	600	500	-	-
		(L)	800			
Capacity (m^3/min/unit)	340	(H)	70.5	37.60	-	-
		(L)	80.0			
Suction level (El.m)	0.70	(H)	5.21	7.46	-	-
		(L)	5.21			
Discharge level (El.m)	14.00	(H)	23.00	19.50	-	-
		(L)	17.00			
Actual head (m)	13.30	(H)	17.79	12.04	-	-
		(L)	11.79			
Loss head (m)	1.30	(H)	2.71	1.66	-	-
		(L)	1.81			
Total head (m)	14.60	(H)	20.50	13.70	-	-
		(L)	13.60			
Pump Efficiency (%)	88.00	(H)	84.00	80.00	-	-
		(L)	84.50			

Note : (H) : High Line
(L) : Low Line
Tuguegarao P/S has not been operated since 1983.

Table 2.10 Principal Features of Major Bridges

Name of bridge	River	Type of Structure	Year built	No. of span	Total Length (m)	Width (m)	Remarks
Magapit	Cagayan	Suspension RC-I-beam Truss RCDG	1980	1 1 2 2	376.00	7.32	
Buntun	Cagayan	Truss Comp. I-beam	1968	14 3	1,098.00	7.32	
Gamu	Cagayan	Truss Comp. I-beam	1972	3 8	442.00	6.75	
Naguilian	Cagayan	Truss Comp. I-beam	1953	8 5	668.26		
Dalibubon	Cagayan	Pre-cast conc.	1975	30	210.00	5.60	Overflow type
Jones	Cagayan	Pre-cast conc.	1982	22	154.00	3.34	Overflow type Left bank is wash away.
Itawas	Chico	Pre-cast conc.	1984	-	-	-	Overflow type
-	Chico	Pre-cast conc.	1984	-	-	-	Overflow type
Calanan	Chico	Truss	-	5	-	-	
Pinukput		Truss	-	-	-	-	
Dummon	Dummon	Truss RCDG	1945	1 1	97.20	6.30	
Pared	Pared	Truss RCDG	1946	3 1	254.02	7.45	
Pinacanauan	Tuguegarao	Truss Comp. I-beam	-	3 -	-	6.70	
San Pablo	Pinacanauan	Truss Comp. I-beam	1953	4 3	276.10	6.75	
Arcon	Tumauini	Truss	1948	3	121.14	6.75	
Minanga	Tumauini	RCDG	1977	11	339.90	6.75	Piers are being scoured. Left bank is being eroded.
Siffu	Siffu	RCDG	1967	20	300.00	6.75	
Mallig	Mallig	RCDG	1967	14	210.00	6.75	Right bank is eroded.
Mallalam	Ilagan	Truss Comp. I-beam	1953	6 2	472.62	6.75	
Magat Construction	Magat	Truss	1978	-	274.00	12.00	Constructed by NIA.
Baretret	Magat	Truss	-	18	483.90	6.20	New bridge is being constructed.
Batu	Magat	Truss	-	7	345.63	6.20	Piers are being scoured.
Abian	Abian	Comp. I-beam	-	7	108.22	6.75	
Cupas	Sta. Fe	Truss	-	6	279.00	-	Partially damaged
Indiana	Sta. Fe	Truss RCDG	-	3 2	98.40	6.70	
Sta. Fe	Sta. Fe	RCDG	-	1	24.30	6.70	
Ganano	Ganano	Truss	1975	3	73.20	7.32	
Ipil	Ganano	Truss	1975	3	72.00	7.32	
Baluarte	Ganano		-	-	-	-	
Calao	Diaddi	Truss	1975	1	130.00	7.32	

Table 3.1 Standard Unit Construction Costs for Flood Control Facilities (Financial)

Item No.	Work	Unit	Cost (₱) F.C.	L.C.	Total	Remarks
1	Excavation (1)(common)	m3	27	22	49	incl. spoil bank works
2	- do - (2)(coarse material)	m3	31	24	55	- do -
3	- do - (3)(rock)	m3	120	90	210	- do -
4	- do - (4)(rock 33 %, common 67 %)	m3	58	44	102	- do -
5	Dredging	m3	14	16	30	Dredging + piping + spoil bank
6	Embankment (1)(borrowed materials)	m3	34	29	63	incl. exc., embank., sodding
7	- do - (2)(- do -)	m3	65	55	120	High dike (Hd > 10 m)
8	Revetment (1)(masonry, l.w. chan.)	m2	220	730	950	incl. foot protection works
9	- do - (2)(" , h.w. chan.)	m2	130	580	710	- do -
10	- do - (3)(gabion , l.w. chan.)	m2	410	230	640	- do -
11	- do - (4)(" , h.w. chan.)	m2	340	210	540	- do -
12	Wooden pile groyne	unit	7,400	21,300	28,700	
13	Boulder spur dike	m3	60	220	280	
14	Drainage sluice (1)	unit	110,000	428,000	538,000	1.5 m x 1.5 m x 1 gate
15	- do - (2)	unit	146,000	585,000	731,000	1.5 m x 1.5 m x 2 gates
16	Bridge	m2	1,390	5,560	6,950	
101	Land (irrigated)	ha	-	23,000	23,000	
102	" (non-irrigated)	ha	-	10,000	10,000	
103	" (upland crops)	ha	-	8,000	8,000	
104	" (open land)	ha	-	3,000	3,000	
105	" (residential)	m2	-	30	30	
106	Building	nos	-	38,000	38,000	
107	Compensation (average)	m2	-	7.4	7.4	

Remarks : 1. Price level is at the end of December, 1985.
2. Exchange rates referred are US$ 1 = ₱ 19 = ¥ 200.

Table 3.2 Standard Unit Construction Costs for Flood Control Facilities (Economic)

Item No.	Work	Unit	Cost (₱) F.C.	L.C.	Total	Remarks
1	Excavation (1)(common)	m3	27	18	45	incl. spoil bank works
2	- do - (2)(coarse material)	m3	31	20	51	- do -
3	- do - (3)(rock)	m3	120	74	194	- do -
4	- do - (4)(rock 33 %, common 67 %)	m3	58	36	94	- do -
5	Dredging	m3	14	13	27	Dredging + piping + spoil bank
6	Embankment (1)(borrowed materials)	m3	34	24	58	incl. exc., embank., sodding
7	- do - (2)(- do -)	m3	65	45	110	High dike (Hd > 10 m)
8	Revetment (1)(masonry, l.w. chan.)	m2	220	600	820	incl. foot protection works
9	- do - (2)(" , h.w. chan.)	m2	130	480	610	- do -
10	- do - (3)(gabion , l.w. chan.)	m2	410	190	600	- do -
11	- do - (4)(" , h.w. chan.)	m2	340	170	510	- do -
12	Wooden pile groyne	unit	7,400	17,500	24,900	
13	Boulder spur dike	m3	60	180	240	
14	Drainage sluice (1)	unit	110,000	351,000	461,000	1.5 m x 1.5 m x 1 gate
15	- do - (2)	unit	146,000	480,000	626,000	1.5 m x 1.5 m x 2 gates
16	Bridge	m2	1,390	4,560	5,950	
101	Land (irrigated)	ha	-	14,900	14,900	
102	" (non-irrigated)	ha	-	5,060	5,060	
103	" (upland crops)	ha	-	2,800	2,800	
104	" (open land)	ha	-	0	0	
105	" (residential)	m2	-	30	30	
106	Building	nos	-	31,000	31,000	
107	Compensation (average)	m2	-	5.7	5.7	

Remarks : 1. Price level is at the end of December, 1985.
2. Exchange rates referred are US$ 1 = ₱ 19 = ¥ 200.

Table 3.3 Constitution of Flood Damages

- FLOOD DAMAGES
  - Tangible damages
    - Flooding damages
      - Direct damages
        - Damages to buildings (DB): Actual damage basis
          - Residential buildings
            - House
            - Household effects
          - Other buildings
            - Building structures
            - Movables
        - Damages to agricultural crops (DA): Actual damage basis
          - Irrigated paddy
          - Rainfed paddy
          - Corn
          - Other crops
        - Damages to livestocks (DL): 12.6 % of DA
        - Damages to infrastructure (DI): 86 % of DB
      - Indirect damages: 5 % of direct damages
    - Bank erosion damages
      - Direct damages
        - Building damages
        - Agricultural damages
        - Highway damages
        - Loss of residential land
      - Indirect damage: 100 % of direct damages
  - Intangible damages
    - Damages to people's livelyhood
    - Damages to traffic and transportation
    - Damages to business activities
    - Loss of lives and injury
    - Losses for emergency activities for floods

Table 3.4 Damage Ratios

BUILDINGS

Properties	Inundated depth above ground level						Constitution ratio
	- 0.5 m	0.5 to 1.0 m	1.0 to 1.5 m	1.5 to 2.5 m	2.5 to 3.5 m	3.5 m -	
Buildings	0.030	0.053	0.072	0.109	0.152 (0.534)	0.220 (0.571)	-
Movables							
Household	0.043	0.086	0.191	0.331	0.499	0.690	16.8 %
Non-residential	0.077	0.156	0.985	0.399	0.509	0.597	6.5 %
Farmer & fishery	0.089	0.178	0.304	0.394	0.471	0.571	76.7 %
Weighted mean	0.080	0.161	0.284	0.384	0.478 (0.713)	0.593 (0.776)	100.0 %

Notes : 1. For inundated depth more than 2.5 m, 45 % of buildings are assumed to be completely razed (damage ratio = 1.0).
2. Some modifications to the Philippine conditions were made based on Technical Standard for River and Sabo Works, MOC, Japan.

AGRICULTURAL CROPS

Depth (m) :	- 0.5				0.5 to 1				- 1.0			
Duration (day):	1 to 2	3 to 4	5 to 6	7 -	1 to 2	3 to 4	5 to 6	7 -	1 to 2	3 to 4	5 to 6	7 -
Paddy	0.21	0.30	0.36	0.50	0.24	0.44	0.50	0.71	0.37	0.54	0.64	0.74
Upland crops	0.27	0.42	0.54	0.67	0.35	0.48	0.67	0.74	0.51	0.67	0.81	0.91

Note : Based on Technical Standard for River and Sabo Works, MOC, Japan.

Table 4.1 Flood Control Dams

Dam	Drainage area (km2)	Control Starting discharge: Specific discharge (m3/s/km2)	Control Starting discharge: Discharge	Out-flow rate	Capacity (MCM): Effective flood control space	Capacity (MCM): Sediment space	Capacity (MCM): Gross storage capacity	Dam: Maximum W.L. (El.m)	Dam: Dam height (m)
Pinukpuk	856	0.23	200	0.10	196	128	363	115.7	52.7
Chico 4	1,410	0.23	320	0.10	299	211	570	437.5	144.5
Mallig 2	362	0.23	85	0.10	93.4	54	166	148.0	43.0
Siffu 1(A)	656	0.23	150	0.10	96.1	98	213	107.0	44.0
Disabangan	652	0.23	150	0.10	154	98	283	96.0	43.0
Ilagan 1	1,350	0.23	310	0.10	382	203	661	168.0	69.0
Magat	4,143	0.20	830	0.638	200	-	-	-	-
Alimit	559	-	-	-	-	84	324	279.0	84.0
Addalam (A)	864	0.23	200	0.495	153	58	242	162.0	51.0
Cagayan 1	2,364	0.23	540	0.683	318	182	564	158.0	45.0

Remarks : 1. Specific discharge of 0.23 corresponds to average existing channel capacity in the reaches from Alcala to Tuguegarao.

2. Gross storage capacity = 1.2 x (effective space) + sediment space

Table 4.2 Design Discharge Distributions for Alternative Framework Plans

Reaches	Existing	Alt.0D	Alt.5D	Alt.9D	Alt.0DM	Alt.5DM	Alt.9DM
Mouth to Chico jct.	21,600	27,400 (127)	25,300 (117)	25,000 (116)	27,600 (128)	25,400 (118)	25,100 (116)
Chico jct. to Siffu jct.	26,600	28,800 (108)	25,600 (96)	25,200 (95)	28,800 (108)	25,600 (96)	25,200 (95)
Siffu jct. to Ilagan jct.	25,600	27,500 (107)	24,600 (96)	24,300 (95)	27,500 (107)	24,600 (96)	24,300 (95)
Ilagan jct. to Magat jct.	23,900	25,900 (108)	23,100 (97)	22,800 (95)	25,900 (108)	23,100 (97)	22,800 (95)
Magat jct. to Addalam jct.	16,000	16,300 (102)	15,100 (94)	13,500 (84)	16,300 (102)	15,100 (94)	13,500 (84)
Chico R.	8,700	8,700 (100)	8,700 (100)	8,600 (99)	8,700 (100)	8,700 (100)	8,600 (99)
Siffu R.	3,300	3,300 (100)	3,200 (97)	3,200 (97)	3,300 (100)	3,200 (97)	3,200 (97)
Ilagan R.	9,400	9,900 (105)	8,200 (87)	8,000 (85)	9,900 (105)	8,200 (87)	8,000 (85)
Magat R.	10,600	13,800 (130)	9,700 (92)	9,700 (92)	13,800 (130)	9,700 (92)	9,700 (92)
Addalam R.	4,800	4,800 (100)	4,800 (100)	3,100 (65)	4,800 (100)	4,800 (100)	3,100 (65)
Upper Cagayan R.	12,100	12,100 (100)	9,100 (75)	9,100 (75)	12,100 (100)	9,100 (75)	9,100 (75)

Note : 1. Figures without ( ) show design discharge in m3/s and those in ( ) show percentage to the existing runoff.
2. Discharge for Alt.0D with only diking system is called as basic flood discharge.

Table 4.3 Project Cost of Channel Works for Alternative Framework Plans (1/6)

(for Alternative: OD)

Work item	Unit	Work quantity	Unit cost (₱)	Amount (₱ mil.)	Remarks
CHANNEL WORKS					
1. Main Works	-	-	-	(26,765)	
Preparatory w.	l.s.	-	-	1,724	8 % of main w. excl. miscel. w.
Dike embankment w.	km	482	-	15,943	
Embankment (1)	m3	93,100,000	58	5,400	
Embankment (2)	m3	95,850,000	110	10,543	High dike
Revetment w.	km	45.1	-	972	
Revetment (1)	m2	739,000	820	606	for low w. chan.
Revetment (2)	m2	600,000	610	366	for high w. chan.
Narrow excavation w.	m3	0	94	0	
Cut-off channel w.	km	34.5	-	3,487	
Excavation (1)	m3	52,800,000	45	2,376	for main Cagayan
Excavation (1)	m3	17,800,000	45	801	for tributarites
Revetment (3)	m2	516,000	600	310	
Bank protection w.	km	112.3	-	550	
Revetment (3)	m2	838,000	600	503	
Groyne	unit	1,880	24,900	47	unit in total groyne length
Drainage sluice w.	unit	720	626,000	451	
Bridge w.	m2	24,800	5,950	148	
Miscellaneous	l.s.	-	-	3,491	15 % of the above
2. Compensation	m2	-	-	(253)	
Dike	m2	29,000,000	5.7	165	
COC	m2	11,300,000	5.7	64	
Others	m2	4,030,000	5.7	24	10 % of other compensation
3. Engineering & Adm.	-	-	-	(4,015)	
Engineering	l.s.	-	-	2,676	10 % of (1)
Administration	l.s.	-	-	1,338	5 % of (1)
4. Contingency	l.s.	-	-	(4,655)	15 % of (1+2+3)
Total	-	-	-	35,688	

Remarks: Costs are on economic basis.

Table 4.3 Project Cost of Channel Works for Alternative Framework Plans (2/6)

(for Alternative: 5D)

Work item	Unit	Work quantity	Unit cost (₱)	Amount (₱ mil.)	Remarks
CHANNEL WORKS					
1. Main Works	-	-	-	(22,685)	
Preparatory w.	l.s.	-	-	1,461	8 % of main w. excl. miscel. w.
Dike embankment w.	km	482	-	12,705	
Embankment (1)	m3	77,100,000	58	4,471	
Embankment (2)	m3	74,850,000	110	8,234	High dike
Revetment w.	km	45.1	-	925	
Revetment (1)	m2	739,000	820	606	for low w. chan.
Revetment (2)	m2	523,000	610	319	for high w. chan.
Narrow excavation w.	m3	0	94	0	
Cut-off channel w.	km	34.5	-	3,487	
Excavation (1)	m3	52,800,000	45	2,376	for main Cagayan
Excavation (1)	m3	17,800,000	45	801	for tributarites
Revetment (3)	m2	516,000	600	310	
Bank protection w.	km	112.3	-	550	
Revetment (3)	m2	838,000	600	503	
Groyne	unit	1,880	24,900	47	unit in total groyne length
Drainage sluice w.	unit	720	626,000	451	
Bridge w.	m2	24,800	5,950	148	
Miscellaneous	l.s.	-	-	2,959	15 % of the above
2. Compensation	m2	-	-	(232)	
Dike	m2	25,700,000	5.7	146	
COC	m2	11,300,000	5.7	64	
Others	m2	3,700,000	5.7	22	10 % of other compensation
3. Engineering & Adm.	-	-	-	(3,403)	
Engineering	l.s.	-	-	2,268	10 % of (1)
Administration	l.s.	-	-	1,134	5 % of (1)
4. Contingency	l.s.	-	-	(3,948)	15 % of (1+2+3)
Total	-	-	-	30,268	

Remarks: Costs are on economic basis.

Table 4.3 Project Cost of Channel Works for Alternative Framework Plans (3/6)

(for Alternative: 9D)

Work item	Unit	Work quantity	Unit cost (₱)	Amount (₱ mil.)	Remarks
CHANNEL WORKS					
1. Main Works	-	-	-	(21,096)	
Preparatory w.	l.s.	-	-	1,359	8 % of main w. excl. miscel. w.
Dike embankment w.	km	482	-	11,440	
Embankment (1)	m3	84,300,000	58	4,889	
Embankment (2)	m3	59,550,000	110	6,551	High dike
Revetment w.	km	45.1	-	911	
Revetment (1)	m2	739,000	820	606	for low w. chan.
Revetment (2)	m2	500,000	610	305	for high w. chan.
Narrow excavation w.	m3	0	94	0	
Cut-off channel w.	km	34.5	-	3,487	
Excavation (1)	m3	52,800,000	45	2,376	for main Cagayan
Excavation (1)	m3	17,800,000	45	801	for tributarites
Revetment (3)	m2	516,000	600	310	
Bank protection w.	km	112.3	-	550	
Revetment (3)	m2	838,000	600	503	
Groyne	unit	1,880	24,900	47	unit in total groyne length
Drainage sluice w.	unit	720	626,000	451	
Bridge w.	m2	24,800	5,950	148	
Miscellaneous	l.s.	-	-	2,752	15 % of the above
2. Compensation	m2	-	-	(229)	
Dike	m2	25,300,000	5.7	144	
COC	m2	11,300,000	5.7	64	
Others	m2	3,600,000	5.7	21	10 % of other compensation
3. Engineering & Adm.	-	-	-	(3,164)	
Engineering	l.s.	-	-	2,110	10 % of (1)
Administration	l.s.	-	-	1,055	5 % of (1)
4. Contingency	l.s.	-	-	(3,673)	15 % of (1+2+3)
Total	-	-	-	28,162	

Remarks: Costs are on economic basis.

Table 4.3 Project Cost of Channel Works for Alternative Framework Plans (4/6)

(for Alternative: ODM)

Work item	Unit	Work quantity	Unit cost (₱)	Amount (₱ mil.)	Remarks
CHANNEL WORKS					
1. Main Works	-	-	-	(28,732)	
Preparatory w.	l.s.	-	-	1,851	8 % of main w. excl. miscel. w.
Dike embankment w.	km	482	-	13,491	
Embankment (1)	m3	89,800,000	58	5,208	
Embankment (2)	m3	75,300,000	110	8,283	High dike
Revetment w.	km	45.1	-	947	
Revetment (1)	m2	739,000	820	606	for low w. chan.
Revetment (2)	m2	559,000	610	341	for high w. chan.
Narrow excavation w.	m3	43,200,000	94	4,061	
Cut-off channel w.	km	34.5	-	3,487	
Excavation (1)	m3	52,800,000	45	2,376	for main Cagayan
Excavation (1)	m3	17,800,000	45	801	for tributarites
Revetment (3)	m2	516,000	600	310	
Bank protection w.	km	112.3	-	550	
Revetment (3)	m2	838,000	600	503	
Groyne	unit	1,880	24,900	47	unit in total groyne length
Drainage sluice w.	unit	720	626,000	451	
Bridge w.	m2	24,800	5,950	148	
Miscellaneous	l.s.	-	-	3,748	15 % of the above
2. Compensation	m2	-	-	(243)	
Dike	m2	27,500,000	5.7	157	
COC	m2	11,300,000	5.7	64	
Others	m2	3,880,000	5.7	22	10 % of other compensation
3. Engineering & Adm.	-	-	-	(4,310)	
Engineering	l.s.	-	-	2,873	10 % of (1)
Administration	l.s.	-	-	1,437	5 % of (1)
4. Contingency	l.s.	-	-	(4,993)	15 % of (1+2+3)
Total	-	-	-	38,278	

Remarks: Costs are on economic basis.

Table 4.3 Project Cost of Channel Works for Alternative Framework Plans (5/6)

(for Alternative: 5DM)

Work item	Unit	Work quantity	Unit cost (₱)	Amount (₱ mil.)	Remarks
CHANNEL WORKS					
1. Main Works	-	-	-	(21,124)	
Preparatory w.	l.s.	-	-	1,361	8 % of main w. excl. miscel. w.
Dike embankment w.	km	482	-	7,409	
Embankment (1)	m3	102,900,000	58	5,968	
Embankment (2)	m3	13,100,000	110	1,441	High dike
Revetment w.	km	45.1	-	904	
Revetment (1)	m2	739,000	820	606	for low w. chan.
Revetment (2)	m2	488,000	610	298	for high w. chan.
Narrow excavation w.	m3	43,200,000	94	4,061	
Cut-off channel w.	km	34.5	-	3,487	
Excavation (1)	m3	52,800,000	45	2,376	for main Cagayan
Excavation (1)	m3	17,800,000	45	801	for tributarites
Revetment (3)	m2	516,000	600	310	
Bank protection w.	km	112.3	-	550	
Revetment (3)	m2	838,000	600	503	
Groyne	unit	1,880	24,900	47	unit in total groyne length
Drainage sluice w.	unit	720	626,000	451	
Bridge w.	m2	24,800	5,950	148	
Miscellaneous	l.s.	-	-	2,755	15 % of the above
2. Compensation	m2	-	-	(225)	
Dike	m2	24,600,000	5.7	140	
COC	m2	11,300,000	5.7	64	
Others	m2	3,590,000	5.7	21	10 % of other compensation
3. Engineering & Adm.	-	-	-	(3,169)	
Engineering	l.s.	-	-	2,112	10 % of (1)
Administration	l.s.	-	-	1,056	5 % of (1)
4. Contingency	l.s.	-	-	(3,678)	15 % of (1+2+3)
Total	-	-	-	28,196	

Remarks: Costs are on economic basis.

Table 4.3 Project Cost of Channel Works for Alternative Framework Plans (6/6)

(for Alternative: 9DM)

Work item	Unit	Work quantity	Unit cost (₱)	Amount (₱ mil.)	Remarks
CHANNEL WORKS					
1. Main Works	-	-	-	(20,955)	
Preparatory w.	l.s.	-	-	1,350	8 % of main w. excl. miscel. w.
Dike embankment w.	km	482	-	7,278	
Embankment (1)	m3	101,200,000	58	5,870	
Embankment (2)	m3	12,800,000	110	1,408	High dike
Revetment w.	km	45.1	-	899	
Revetment (1)	m2	739,000	820	606	for low w. chan.
Revetment (2)	m2	480,000	610	293	for high w. chan.
Narrow excavation w.	m3	43,200,000	94	4,061	
Cut-off channel w.	km	34.5	-	3,487	
Excavation (1)	m3	52,800,000	45	2,376	for main Cagayan
Excavation (1)	m3	17,800,000	45	801	for tributarites
Revetment (3)	m2	516,000	600	310	
Bank protection w.	km	112.3	-	550	
Revetment (3)	m2	838,000	600	503	
Groyne	unit	1,880	24,900	47	unit in total groyne length
Drainage sluice w.	unit	720	626,000	451	
Bridge w.	m2	24,800	5,950	148	
Miscellaneous	l.s.	-	-	2,733	15 % of the above
2. Compensation	m2	-	-	(223)	
Dike	m2	24,300,000	5.7	139	
COC	m2	11,300,000	5.7	64	
Others	m2	3,560,000	5.7	20	10 % of other compensation
3. Engineering & Adm.	-	-	-	(3,143)	
Engineering	l.s.	-	-	2,095	10 % of (1)
Administration	l.s.	-	-	1,048	5 % of (1)
4. Contingency	l.s.	-	-	(3,648)	15 % of (1+2+3)
Total	-	-	-	27,969	

Remarks: Costs are on economic basis.

Table 4.4 Project Cost of Dam Works for Alternative Framework Plans (1/9)

(Dam: Cagayan No.1)

Work item	Unit	Work quantity	Unit cost (₱)	Amount (₱ mil.)	Remarks
1. Main Works					
1) Preparatory Works				(88.81)	
Access road (1)	km	12	1,379,000	16.55	New
Access road (2)	km	0	276,000	0.00	Improvement
Bridge	m	0	45,100	0.00	
Office, etc.	l.s.		-	72.26	
2) River Div. Works				(376.32)	
Excavation (1)	m^3	28,000	60	1.68	Common
Excavation (2)	m^3	205,300	190	39.01	Rock
Excavation (3)	m^3	138,500	990	137.12	Tunnel
Concrete (1)	m^3	6,510	1,820	11.85	Inlet & outlet
Concrete (2)	m^3	34,450	1,910	65.80	Tunnel lining
Concrete (3)	m^3	6,470	1,560	10.09	Plug
Steel support	ton	680	19,360	13.16	
Rainforcement bar	ton	1,980	14,350	28.41	
Consolidation grout	m	13,870	1,330	18.45	
Coffer dam	m^3	91,900	180	16.54	
Others	l.s.		-	34.21	10 %
3) Dam				(364.12)	
Excavation (1)	m^3	52,200	60	3.13	Common
Excavation (2)	m^3	149,900	190	28.48	Rock
Concrete	m^3	142,100	1,310	186.15	
Curtain grout	m	53,350	1,790	95.50	
Blanket grout	m	13,350	1,330	17.76	
Others	l.s.		-	33.10	10 %
4) Spilway				(161.28)	
Excavation (1)	m^3	68,800	60	4.13	Common
Excavation (2)	m^3	171,500	190	32.59	Rock
Concrete	m^3	57,030	1,640	93.53	
Rainforcement bar	ton	1,141	14,350	16.37	
Others	l.s.		-	14.66	10 %
5) Coyote Blasting	l.s.		-	(-)	
2. Compensation	l.s.		-	100.02	
3. Engineering & Adm.	l.s.		-	148.58	15 % of 1
4. Contingency	l.s.		-	247.83	20 % of (1-3)
Total				1,486.96	

Remarks : Costs are on economic basis.

Table 4.4 Project Cost of Dam Works for Alternative Framework Plans (2/9)

(Dam: Alimit No.1 (A))

Work item	Unit	Work quantity	Unit cost (₱)	Amount (₱ mil.)	Remarks
1. Main Works					
1) Preparatory Works				(139.88)	
Access road (1)	km	30	1,379,000	41.37	New
Access road (2)	km	0	276,000	0.00	Improvement
Bridge	m	50	45,100	2.26	
Office, etc.	l.s.		-	96.25	
2) River Div. Works				(129.00)	
Excavation (1)	m^3	2,400	60	0.14	Common
Excavation (2)	m^3	6,600	190	1.25	Rock
Excavation (3)	m^3	23,900	990	23.66	Tunnel
Concrete (1)	m^3	310	1,820	0.56	Inlet & outlet
Concrete (2)	m^3	8,930	1,910	17.06	Tunnel lining
Concrete (3)	m^3	1,410	1,560	2.20	Plug
Steel support	ton	176	19,360	3.41	
Rainforcement bar	ton	459	14,350	6.59	
Consolidation grout	m	4,350	1,330	5.79	
Coffer dam	m^3	314,500	180	56.61	
Others	l.s.		-	11.73	10 %
3) Dam				(1,005.79)	
Excavation (1)	m^3	20,400	60	1.22	Common
Excavation (2)	m^3	61,500	190	11.69	Rock
Concrete	m^3	646,800	1,310	847.31	
Curtain grout	m	26,300	1,790	47.08	
Blanket grout	m	5,300	1,330	7.05	
Others	l.s.		-	91.44	10 %
4) Spilway				(67.93)	
Excavation (1)	m^3	8,500	60	0.51	Common
Excavation (2)	m^3	55,600	190	10.56	Rock
Concrete	m^3	26,300	1,640	43.13	
Rainforcement bar	ton	526	14,350	7.55	
Others	l.s.		-	6.18	10 %
5) Coyote Blasting	l.s.		-	(-)	
2. Compensation	l.s.		-	0.04	
3. Engineering & Adm.	l.s.		-	201.39	15 % of 1
4. Contingency	l.s.		-	308.81	20 % of (1-3)
Total				1,852.84	

Remarks : Costs are on economic basis.

Table 4.4 Project Cost of Dam Works for Alternative Framework Plans (3/9)

(Dam: Ilagan No.1)

Work item	Unit	Work quantity	Unit cost (₱)	Amount (₱ mil.)	Remarks
1. Main Works					
1) Preparatory Works				(122.51)	
Access road (1)	km	11	1,379,000	15.17	New
Access road (2)	km	15	276,000	4.14	Improvement
Bridge	m	0	45,100	0.00	
Office, etc.	l.s.		-	103.20	
2) River Div. Works				(184.66)	
Excavation (1)	m^3	10,500	60	0.63	Common
Excavation (2)	m^3	46,600	190	8.85	Rock
Excavation (3)	m^3	51,800	990	51.28	Tunnel
Concrete (1)	m^3	3,020	1,820	5.50	Inlet & outlet
Concrete (2)	m^3	13,100	1,910	25.02	Tunnel lining
Concrete (3)	m^3	4,260	1,560	6.65	Plug
Steel support	ton	260	19,360	5.03	
Rainforcement bar	ton	776	14,350	11.14	
Consolidation grout	m	5,290	1,330	7.04	
Coffer dam	m^3	259,600	180	46.73	
Others	l.s.		-	16.79	10 %
3) Dam				(951.43)	
Excavation (1)	m^3	25,400	60	1.52	Common
Excavation (2)	m^3	81,500	190	15.49	Rock
Concrete	m^3	598,600	1,310	784.17	
Curtain grout	m	28,300	1,790	50.66	
Blanket grout	m	9,850	1,330	13.10	
Others	l.s.		-	86.49	10 %
4) Spilway				(153.02)	
Excavation (1)	m^3	23,700	60	1.42	Common
Excavation (2)	m^3	136,400	190	25.92	Rock
Concrete	m^3	58,000	1,640	95.12	
Rainforcement bar	ton	1,160	14,350	16.65	
Others	l.s.		-	13.91	10 %
5) Coyote Blasting	l.s.		-	(-)	
2. Compensation	l.s.		-	14.01	
3. Engineering & Adm.	l.s.		-	211.74	15 % of 1
4. Contingency	l.s.		-	327.47	20 % of (1-3)
Total				1,964.84	

Remarks : Costs are on economic basis.

Table 4.4 Project Cost of Dam Works for Alternative Framework Plans (4/9)

(Dam: Siffu No.1 (A))

Work item	Unit	Work quantity	Unit cost (₱)	Amount (₱ mil.)	Remarks
1. Main Works					
1) Preparatory Works				(29.00)	
Access road (1)	km	1	1,379,000	1.38	New
Access road (2)	km	6	276,000	1.66	Improvement
Bridge	m	20	45,100	0.90	
Office, etc.	l.s.		-	25.06	
2) River Div. Works				(70.70)	
Excavation (1)	m^3	2,300	60	0.14	Common
Excavation (2)	m^3	9,400	190	1.79	Rock
Excavation (3)	m^3	14,500	990	14.36	Tunnel
Concrete (1)	m^3	370	1,820	0.67	Inlet & outlet
Concrete (2)	m^3	5,250	1,910	10.03	Tunnel lining
Concrete (3)	m^3	640	1,560	1.00	Plug
Steel support	ton	105	19,360	2.03	
Rainforcement bar	ton	277	14,350	3.97	
Consolidation grout	m	2,600	1,330	3.46	
Coffer dam	m^3	149,000	180	26.82	
Others	l.s.		-	6.43	10 %
3) Dam				(167.63)	
Excavation (1)	m^3	10,300	60	0.62	Common
Excavation (2)	m^3	35,500	190	6.75	Rock
Concrete	m^3	91,600	1,310	120.00	
Curtain grout	m	11,600	1,790	20.76	
Blanket grout	m	3,200	1,330	4.26	
Others	l.s.		-	15.24	10 %
4) Spilway				(75.15)	
Excavation (1)	m^3	12,500	60	0.75	Common
Excavation (2)	m^3	48,300	190	9.18	Rock
Concrete	m^3	30,300	1,640	49.69	
Rainforcement bar	ton	606	14,350	8.70	
Others	l.s.		-	6.83	10 %
5) Coyote Blasting	l.s.		-	(-)	
2. Compensation	l.s.		-	14.24	
3. Engineering & Adm.	l.s.		-	51.37	15 % of 1
4. Contingency	l.s.		-	81.62	20 % of (1-3)
Total				489.71	

Remarks : Costs are on economic basis.

Table 4.4 Project Cost of Dam Works for Alternative Framework Plans (5/9)

(Dam: Mallig No.2)

Work item	Unit	Work quantity	Unit cost (₱)	Amount (₱ mil.)	Remarks
1. Main Works					
1) Preparatory Works				(36.82)	
Access road (1)	km	11	1,379,000	15.17	New
Access road (2)	km	4	276,000	1.10	Improvement
Bridge	m	20	45,100	0.90	
Office, etc.	l.s.		-	19.65	
2) River Div. Works				(40.15)	
Excavation (1)	m^3	1,500	60	0.09	Common
Excavation (2)	m^3	5,900	190	1.12	Rock
Excavation (3)	m^3	8,300	990	8.22	Tunnel
Concrete (1)	m^3	180	1,820	0.33	Inlet & outlet
Concrete (2)	m^3	3,300	1,910	6.30	Tunnel lining
Concrete (3)	m^3	390	1,560	0.61	Plug
Steel support	ton	64	19,360	1.24	
Rainforcement bar	ton	172	14,350	2.47	
Consolidation grout	m	1,700	1,330	2.26	
Coffer dam	m^3	77,000	180	13.86	
Others	l.s.		-	3.65	10 %
3) Dam				(155.27)	
Excavation (1)	m^3	5,300	60	0.32	Common
Excavation (2)	m^3	17,200	190	3.27	Rock
Concrete	m^3	88,900	1,310	116.46	
Curtain grout	m	10,300	1,790	18.44	
Blanket grout	m	2,000	1,330	2.66	
Others	l.s.		-	14.12	10 %
4) Spilway				(50.11)	
Excavation (1)	m^3	9,300	60	0.56	Common
Excavation (2)	m^3	36,000	190	6.84	Rock
Concrete	m^3	19,800	1,640	32.47	
Rainforcement bar	ton	396	14,350	5.68	
Others	l.s.		-	4.56	10 %
5) Coyote Blasting	l.s.		-	(-)	
2. Compensation	l.s.		-	10.46	
3. Engineering & Adm.	l.s.		-	42.35	15 % of 1
4. Contingency	l.s.		-	67.03	20 % of (1-3)
Total				402.19	

Remarks : Costs are on economic basis.

Table 4.4 Project Cost of Dam Works for Alternative Framework Plans (6/9)

(Dam: Addalam (A))

Work item	Unit	Work quantity	Unit cost (₱)	Amount (₱ mil.)	Remarks
1. Main Works					
1) Preparatory Works				(83.36)	
Access road (1)	km	4	1,379,000	5.52	New
Access road (2)	km	0	276,000	0.00	Improvement
Bridge	m	10	45,100	0.45	
Office, etc.	l.s.		-	77.39	
2) River Div. Works				(110.28)	
Excavation (1)	m^3	3,900	60	0.23	Common
Excavation (2)	m^3	15,800	190	3.00	Rock
Excavation (3)	m^3	19,500	990	19.31	Tunnel
Concrete (1)	m^3	790	1,820	1.44	Inlet & outlet
Concrete (2)	m^3	6,250	1,910	11.94	Tunnel lining
Concrete (3)	m^3	1,240	1,560	1.93	Plug
Steel support	ton	126	19,360	2.44	
Rainforcement bar	ton	344	14,350	4.94	
Consolidation grout	m	2,800	1,330	3.72	
Coffer dam	m^3	285,000	180	51.30	
Others	l.s.		-	10.03	10 %
3) Dam				(725.78)	
Excavation (1)	m^3	33,200	60	1.99	Common
Excavation (2)	m^3	73,700	190	14.00	Rock
Concrete	m^3	444,500	1,310	582.30	
Curtain grout	m	27,900	1,790	49.94	
Blanket grout	m	8,700	1,330	11.57	
Others	l.s.		-	65.98	10 %
4) Spilway				(131.03)	
Excavation (1)	m^3	22,300	60	1.34	Common
Excavation (2)	m^3	86,400	190	16.42	Rock
Concrete	m^3	52,600	1,640	86.26	
Rainforcement bar	ton	1,052	14,350	15.10	
Others	l.s.		-	11.91	10 %
5) Coyote Blasting	l.s.		-	(-)	
2. Compensation	l.s.		-	0.70	
3. Engineering & Adm.	l.s.		-	157.57	15 % of 1
4. Contingency	l.s.		-	241.74	20 % of (1-3)
Total				1,450.46	

Remarks : Costs are on economic basis.

Table 4.4 Project Cost of Dam Works for Alternative Framework Plans (7/9)

(Dam: Disabungan)

Work item	Unit	Work quantity	Unit cost (₱)	Amount (₱ mil.)	Remarks
1. Main Works					
1) Preparatory Works				(95.55)	
Access road (1)	km	2	1,379,000	2.76	New
Access road (2)	km	2	276,000	0.55	Improvement
Bridge	m	300	45,100	13.53	
Office, etc.	l.s.		-	78.71	
2) River Div. Works				(110.24)	
Excavation (1)	m^3	6,200	60	0.37	Common
Excavation (2)	m^3	24,700	190	4.69	Rock
Excavation (3)	m^3	29,100	990	28.81	Tunnel
Concrete (1)	m^3	1,560	1,820	2.84	Inlet & outlet
Concrete (2)	m^3	8,280	1,910	15.81	Tunnel lining
Concrete (3)	m^3	1,640	1,560	2.56	Plug
Steel support	ton	167	19,360	3.23	
Rainforcement bar	ton	476	14,350	6.83	
Consolidation grout	m	3,500	1,330	4.66	
Coffer dam	m^3	169,000	180	30.42	
Others	l.s.		-	10.02	10 %
3) Dam				(738.22)	
Excavation (1)	m^3	54,400	60	3.26	Common
Excavation (2)	m^3	182,200	190	34.62	Rock
Concrete	m^3	424,400	1,310	555.96	
Curtain grout	m	34,400	1,790	61.58	
Blanket grout	m	11,800	1,330	15.69	
Others	l.s.		-	67.11	10 %
4) Spilway				(134.17)	
Excavation (1)	m^3	24,400	60	1.46	Common
Excavation (2)	m^3	94,700	190	17.99	Rock
Concrete	m^3	53,200	1,640	87.25	
Rainforcement bar	ton	1,064	14,350	15.27	
Others	l.s.		-	12.20	10 %
5) Coyote Blasting	l.s.		-	(-)	
2. Compensation	l.s.		-	21.45	
3. Engineering & Adm.	l.s.		-	161.73	15 % of 1
4. Contingency	l.s.		-	252.27	20 % of (1-3)
Total				1,513.63	

Remarks : Costs are on economic basis.

Table 4.4 Project Cost of Dam Works for Alternative Framework Plans (8/9)

(Dam: Chico No.4)

Work item	Unit	Work quantity	Unit cost (₱)	Amount (₱ mil.)	Remarks
1. Main Works					
1) Preparatory Works				(385.05)	
Access road (1)	km	0	1,379,000	0.00	New
Access road (2)	km	0	276,000	0.00	Improvement
Bridge	m	0	45,100	0.00	
Office, etc.	l.s.		-	385.05	
2) River Div. Works				(142.86)	
Excavation (1)	m^3	4,400	60	0.26	Common
Excavation (2)	m^3	17,500	190	3.33	Rock
Excavation (3)	m^3	39,200	990	38.81	Tunnel
Concrete (1)	m^3	930	1,820	1.69	Inlet & outlet
Concrete (2)	m^3	12,240	1,910	23.38	Tunnel lining
Concrete (3)	m^3	3,760	1,560	5.87	Plug
Steel support	ton	248	19,360	4.80	
Rainforcement bar	ton	649	14,350	9.31	
Consolidation grout	m	5,500	1,330	7.32	
Coffer dam	m^3	195,000	180	35.10	
Others	l.s.		-	12.99	10 %
3) Dam				(4,277.94)	
Excavation (1)	m^3	230,000	60	13.80	Common
Excavation (2)	m^3	470,000	190	89.30	Rock
Concrete	m^3	2,800,000	1,310	3,668.00	
Curtain grout	m	54,000	1,790	96.66	
Blanket grout	m	16,000	1,330	21.28	
Others	l.s.		-	388.90	10 %
4) Spilway				(268.32)	
Excavation (1)	m^3	27,800	60	1.67	Common
Excavation (2)	m^3	107,850	190	20.49	Rock
Concrete	m^3	115,100	1,640	188.76	
Rainforcement bar	ton	2,300	14,350	33.01	
Others	l.s.		-	24.39	10 %
5) Coyote Blasting	l.s.		-	(116.49)	
2. Compensation	l.s.		-	205.00	
3. Engineering & Adm.	l.s.		-	778.60	15 % of 1
4. Contingency	l.s.		-	1,234.85	20 % of (1-3)
Total				7,409.11	

Remarks : Costs are on economic basis.

Table 4.4 Project Cost of Dam Works for Alternative Framework Plans (9/9)

(Dam: Pinukpuk)

Work item	Unit	Work quantity	Unit cost (₱)	Amount (₱ mil.)	Remarks
1. Main Works					
1) Preparatory Works				(55.38)	
Access road (1)	km	0	1,379,000	0.00	New
Access road (2)	km	0	276,000	0.00	Improvement
Bridge	m	0	45,100	0.00	
Office, etc.	l.s.		-	55.38	
2) River Div. Works				(79.89)	
Excavation (1)	m^3	3,600	60	0.22	Common
Excavation (2)	m^3	14,500	190	2.76	Rock
Excavation (3)	m^3	18,200	990	18.02	Tunnel
Concrete (1)	m^3	700	1,820	1.27	Inlet & outlet
Concrete (2)	m^3	5,990	1,910	11.44	Tunnel lining
Concrete (3)	m^3	1,180	1,560	1.84	Plug
Steel support	ton	120	19,360	2.32	
Rainforcement bar	ton	328	14,350	4.71	
Consolidation grout	m	2,700	1,330	3.59	
Coffer dam	m^3	147,000	180	26.46	
Others	l.s.		-	7.26	10 %
3) Dam				(494.23)	
Excavation (1)	m^3	23,400	60	1.40	Common
Excavation (2)	m^3	70,900	190	13.47	Rock
Concrete	m^3	302,600	1,310	396.41	
Curtain grout	m	17,600	1,790	31.50	
Blanket grout	m	4,900	1,330	6.52	
Others	l.s.		-	44.93	10 %
4) Spilway				(117.55)	
Excavation (1)	m^3	16,800	60	1.01	Common
Excavation (2)	m^3	65,200	190	12.39	Rock
Concrete	m^3	48,500	1,640	79.54	
Rainforcement bar	ton	970	14,350	13.92	
Others	l.s.		-	10.69	10 %
5) Coyote Blasting	l.s.		-	(-)	
2. Compensation	l.s.		-	27.53	
3. Engineering & Adm.	l.s.		-	112.06	15 % of 1
4. Contingency	l.s.		-	177.33	20 % of (1-3)
Total				1,063.97	

Remarks : Costs are on economic basis.

Table 4.5 Sites for Cut-off Channel Works

River	Site	Stretch (Sta.) From	Stretch (Sta.) To	Chan. length (km) COC	Chan. length (km) Existing
Cagayan R.	Gabut	68.7	78.5	2.50	9.3
	San Isidro	88.4	105.6	5.00	17.2
Subtotal		-	-	(7.50)	(26.5)
Magat R.	Lenzon	1.4	4.4	0.90	3.0
Subtotal		-	-	(0.90)	(3.0)
Siffu R.		2.0	3.0	0.55	1.0
		3.2	7.3	0.90	4.1
		8.3	9.8	0.80	1.5
		10.5	11.4	0.45	0.9
		11.5	16.5	0.85	5.0
		16.5	17.3	0.40	0.8
		18.9	21.0	0.75	2.1
		22.2	24.5	0.92	2.3
		24.5	25.8	0.50	1.3
		26.5	27.3	0.30	0.8
		27.5	29.1	0.25	1.6
		31.2	33.0	0.50	1.8
		35.4	36.7	0.40	1.3
		37.9	42.3	0.90	4.4
		44.0	48.0	1.00	4.0
		48.7	51.3	0.40	2.6
		51.5	53.3	0.40	1.8
		54.2	60.0	1.30	5.8
		61.2	62.8	0.50	1.6
		63.6	66.5	0.80	2.9
		67.3	68.5	0.60	1.2
		68.6	70.5	0.40	1.9
Subtotal		-	-	(13.87)	(50.7)
Mallig R.		-1.4	0	0.60	1.4
		2.0	4.5	0.80	2.5
		5.1	6.3	0.40	1.2
		6.9	8.2	0.50	1.3
		8.2	9.3	0.25	1.1
		9.7	10.5	0.25	0.8
		11.3	12.7	0.80	1.4
		14.2	15.8	0.55	1.6
		16.2	21.7	0.75	5.5
		25.0	26.2	0.25	1.2
		27.0	29.7	0.75	2.7
		31.2	32.0	0.20	0.8
		33.9	34.7	0.45	0.8
		35.8	40.2	0.95	4.4
		42.2	43.1	0.25	0.9
		43.8	44.5	0.30	0.7
		45.2	46.3	0.40	1.1
		47.1	48.0	0.35	0.9
		48.9	50.6	0.30	1.7
		50.8	52.1	0.40	1.3
		52.8	53.7	0.50	0.9
		54.1	55.0	0.40	0.9
		55.0	56.1	0.50	1.1
		58.3	59.6	0.60	1.3
		61.2	62.1	0.15	0.9
		65.9	67.2	0.35	1.3
		68.6	70.5	0.20	1.9
Subtotal		-	-	(12.20)	(41.6)
Total		-	-	(34.47)	(92.3)

Remarks:
1. Stretch is indicated by the Station No. along the existing channel.
2. Channel length shows the length of cut-off channel and existing channel corresponding to it.

Table 4.6 Sites for Bank Protection Works

Location			Length (Sta., km)			Kind of work	Object to be protected
River	(R/L)	Site	From	To	Leng.		
Cagayan	(R)	Aparri	1.6	2.3	0.7	R	Aparri, reclamation, dike
	(R)	Agusi	10.0	12.8	2.8	R	Agusi, Camalaniugan, Hwy. No.5, dike
	(R)	Lal-lo	20.1	21.8	1.7	R	Lal-lo, dike
	(R)	Catayauan	24.3	30.0	5.7	R	Catayauan, Sta.Maria, dike
			30.0	31.3	1.3	T	Magapit, Hwy. No.5
	(R)	Gattaran	39.3	40.6	1.3	T	Gattaran, Hwy. No.5
	(R)	Alcala	64.2	65.2	1.0	T	Tupang
	(R)	Amulung	81.0	82.5	1.5	T	Alcala-Amulung P.S.
	(R)	Iguig	105.0	108.0	3.0	T	San Isidro, Sta. Rosa, Minanga
	(L)	Dassun	110.6	113.1	2.5	R	Dike
	(R)	Bayo	115.3	118.3	3.0	R	Dike
			118.3	119.0	0.7	T	
	(L)	Solana	123.0	126.5	3.5	T	Solana
	(L)	Enrile	131.5	133.8	2.3	T	
	(R)	Tuguegarao	135.0	138.5	4.5	R	Catagaman, Tuguegarao, dike
	(L)	Alibago	142.0	144.0	2.0	T	Alibago, prob. road
	(R)	Namabbalan	147.7	149.5	1.8	T	Hwy. No.5
	(R)	San Pablo Br.	-	-	1.0	T	Hwy. No.5, Bridge, Calamagui
	(R)	Cabagan	164.5	167.3	2.8	T	Cabagan
	(R)	Balasig Br.	-	-	1.3	T	Hwy. No.5, Bridge, Balasig
	(L)	Malapagay	175.9	178.6	2.7	R	Malapagay, dike
			178.6	180.0	1.4	T	
	(R)	Sinippil	182.0	184.0	2.0	R	Sinippil, dike
			184.0	185.7	1.7	T	
	(R)	Tumauini	190.8	192.2	1.4	T	Tumauini
	(R)	Balug	193.8	195.0	1.2	T	Balug, Hwy. No.5
	(L)	Sta. Isabel	199.8	201.1	1.3	R	Sta. Isabel, dike
	(R)	Naguilian	234.6	235.9	1.3	T	Naguilian
	(R)	Minanga	240.0	242.0	2.0	T	Minanga, San Luis
	(L)	Cauayan	243.7	246.2	2.5	R	Dike
			246.2	248.6	2.4	T	
	(L)	Baringin Norte	253.2	255.8	2.6	T	Baringin N., barangay road
	(R)	Malasin	273.2	275.0	1.8	T	Paddy field
	(L)	Angadanan	277.7	278.9	1.2	T	Angadanan, paddy field
	(L)	Echague	302.3	307.2	4.9	T	Echague, paddy field
	(L)	Pangal Norte	316.2	317.9	1.7	T	Pangal N., paddy field
	(R)	Jones	336.4	339.0	3.8	T	Prob. road, Jones, S. Vicente, Diarao
Chico	(L)	Niug	13.9	16.2	2.3	T	Niug, rural road, paddy field
	(R)	Piat	38.0	40.9	2.9	T	Piat
	(L)	Cagumitan	41.4	43.7	2.3	T	
	(R)	Sto. Domingo	44.6	46.1	1.5	T	Ferry
	(R)	Pata	48.5	50.2	1.7	T	Pata
	(R)	Villa Laida	51.0	53.0	2.0	T	Villa Laida
	(L)	Lallayug	54.6	56.9	2.3	T	
	(L)	Camalog	72.5	74.2	1.7	T	Paddy field
	(R)	Magaogao	76.0	77.7	1.7	T	"
	(L)	Masablang	78.5	80.1	1.6	T	"
	(R)	Cabaruan	81.2	83.9	2.7	T	" , rural road
	(R)	Tabuk	87.8	90.6	2.8	T	" , Tabuk
	(R)	Bulanao	92.4	96.2	3.8	T	"
	(L)	Gobgob	92.6	94.6	2.0	T	Rural road

(Cont'd)

(Continuation)

Location			Length (Sta., km)			Kind of work	Object to be protected
River (R/L)		Site	From	To	Leng.		
Tuguegarao	(R)	Tanza	2.8	4.6	1.8	R	Tanza, Caggay, dike
	(R)	Penablanca	10.3	11.7	1.4	T	Penablanca
	(L)	Aggugaddan	23.7	25.5	1.8	T	
Ilagan	(R)	Bangag	0.8	2.1	1.3	T	
	(L)	Ilagan	2.2	3.7	1.5	T	Ilagan
	(L)	Malalam	5.0	6.0	1.0	T	Malalam, paddy field
	(R)	Alinguigan	8.0	10.0	2.0	T	Alinguigan
	(L)	San Antonio	16.5	18.5	2.0	R	Rural road, dike
Magat	(L)	Lenzon	-1.0	1.4	2.4	R	Dike
	(L)	Binarzang	12.5	14.0	1.5	R	Binarzang, dike
			14.0	15.0	1.0	T	
	(R)	Pulay	19.6	20.6	1.0	R	Paddy field, dike
			20.6	21.7	1.1	T	
	(L)	Kalabaza	27.0	28.5	1.5	R	Dike
	(L)	Macatal-1	29.6	30.2	0.6	T	Dike
	(L)	Macatal-2	32.0	32.7	0.7	T	Dike
	(L)	San Rafael	34.2	35.3	1.1	R	Dike
	(L)	San Juan	42.8	45.3	2.5	T	
	(R)	Sinaman Norte	48.6	51.0	2.4	R	Dike
	(L)	Bayombong	-	-	3.3	T	Bayonbong
	(L)	Batu Ferry	-	-	5.3	T	National road, bridge
	(R)	Makati	-	-	5.0	T	National road, bridge
P.de Cabagan	(L)	Angancasilian	3.8	5.8	2.0	R	Dike
P.de Tumauini	(R)	Maligaya	2.3	3.9	1.6	T	Maligaya, rice field, Arcon Br.

Remarks: R and T in kind-of-work column denote dike revetment works, and other bank protection and river training works, respectively.

Table 4.7 Principal Features of Framework Plan

1)	Channel Works	
	a) Dike embankment works:	116,000,000 m3
	b) Revetment works (45.1 km long):	1,227,000 m2
	c) Drainage sluice works:	720 units
	d) Narrow excavation works:	43,200,000 m3
	e) Cut-off channel works (34.5 km long):	70,600,000 m3
	f) Bank protection works:	112.3 km
	g) Appurtenant facility works:	3 bridges
	- Buntun bridge:	Reconstruction
	- Gamu bridge:	Reconstruction
	- Naguilian bridge:	Reconstruction

		(Dam height: m)	(F.C.: MCM)
2)	Flood Control dam Works		
	- Cagayan No.1	45.0	318
	- Alimit No.1(A)	84.0	200
	- Ilagan No.1	69.0	382
	- Siffu No.1(A)	44.0	96.1
	- Mallig No.2	43.0	93.4

3)	Compensation	
	a) Channel works:	39,490,000 m2
	b) Dam works:	113,500,000 m2
	- Cagayan No.1 dam	47,700,000 m2
	- Alimit No.1 dam	10,000,000 m2
	- Ilagan No.1 dam	29,100,000 m2
	- Siffu No.1(A) dam	14,400,000 m2
	- Mallig No.2 dam	12,300,000 m2

4)	Project Cost (Economic):	₱34,394,000,000
	a) Channel works:	₱28,196,000,000
	b) Dam works:	₱ 6,198,000,000

Table 4.8 Economic Project Cost for Framework Plan

Work item	Unit	Work quantity	Unit cost (₱)	Amount (₱ mil.)	Remarks
I. CHANNEL WORKS					
1. Main Works	-	-	-	(21,124)	
Preparatory w.	l.s.	-	-	1,361	8 %
Dike embankment w.	km	482	-	7,409	
Embankment (1)	m3	102,900,000	58	5,968	
Embankment (2)	m3	13,100,000	110	1,441	High dike
Revetment w.	km	45.1	-	904	
Revetment (1)	m2	739,000	820	606	for low w. chan.
Revetment (2)	m2	488,000	610	298	for high w. chan.
Narrow excavation w.	m3	43,200,000	94	4,061	
Cut-off channel w.	km	34.5	-	3,487	
Excavation (1)	m3	52,800,000	45	2,376	for main Cagayan
Excavation (1)	m3	17,800,000	45	801	for tributarites
Revetment (3)	m2	516,000	600	310	
Bank protection w.	km	112.3	-	550	
Revetment (3)	m2	838,000	600	503	
Groyne	unit	1,880	24,900	47	
Drainage sluice w.	unit	720	626,000	451	
Bridge w.	m2	24,800	5,950	148	
Miscellaneous	l.s.	-	-	2,755	15 % of the above
2. Compensation	m2	-	-	(225)	
Dike	m2	24,600,000	5.7	140	
COC	m2	11,300,000	5.7	64	
Others	m2	3,590,000	5.7	21	10 %
3. Engineering & Adm.	-	-	-	(3,169)	
Engineering	l.s.	-	-	2,112	10 % of (1)
Administration	l.s.	-	-	1,056	5 % of (1)
4. Contingency	l.s.	-	-	(3,678)	15 % of (1+2+3)
Total	-	-	-	28,196	
II. DAM WORKS					
1. Main Works	l.s.	-	-	(4,370)	
Cagayan No.1	l.s.	-	-	991	
Alimit No.1 (A)	l.s.	-	-	1,343	
Ilagan No.1	l.s.	-	-	1,412	
Siffu No.1 (A)	l.s.	-	-	342	
Mallig No.2	l.s.	-	-	282	
2. Compensation	l.s.	-	-	(139)	
3. Engineering & Adm.	-	-	-	(656)	
Engineering	l.s.	-	-	437	10 % of (1)
Administration	l.s.	-	-	219	5 % of (1)
4. Contingency	l.s.	-	-	(1,033)	20 % of (1+2+3)
Total	-	-	-	6,198	
GRAND TOTAL	-	-	-	34,394	

Table 5.1 Quantities of Dike Works for Long-Term Plan

Stretch	Dike length (km)		Embankment (10^3 m3)		Revetment (10^3 m2)		Land acquisition (10^3 m2)	
	Left	Right	Left	Right	Left	Right	Left	Right
Main Cagayan R.								
Mouth - Alacala	31.4	51.3	4,528	4,731	-	284.6	1,265	1,574
Alcala - Tuguegarao	38.0	47.0	8,382	5,772	101.4	238.6	1,973	1,625
Tuguegarao - Siffu jct.	60.5	58.5	7,574	9,057	119.2	75.8	2,270	2,487
Siffu jct. -	33.4	33.6	2,463	3,510	98.6	-	875	969
Subtotal (1)	163.3	190.4	22,947	23,070	319.2	599.0	6,382	6,654
Backwater levee (2)	19.0	21.7	2,932	2,547	-	52.6	704	569
Subtotal (1)+(2)	182.3	212.1	25,879	25,617	319.2	651.6	7,087	7,224
Tributaries								
Ilagan R.	11.0	7.9	1,010	889	39.4	-	260	246
Magat R.	31.7	34.3	3,871	2,192	-	-	1,142	728
Subtotal (3)	42.7	42.2	4,881	3,081	39.4	-	1,402	974
Total (1)+(2)+(3)	225.0	254.3	30,760	28,698	358.6	651.6	8,489	8,198
Total (Left + Right)	479.3		59,458		1,010.2		16,687	

Table 5.2 Economic Project Cost for Long-Term Plan

Work item	Unit	Work quantity	Unit cost (₱)	Amount (₱ mil.)	Remarks
I. CHANNEL WORKS					
1. Main Works	-	-	-	(15,987)	
Preparatory w.	l.s.	-	-	1,030	8 %
Dike embankment w.	km	480	-	3,451	
Embankment (1)	m3	59,500,000	58	3,451	
Revetment w.	km	45.1	-	770	
Revetment (1)	m2	734,000	820	602	for low w. chan.
Revetment (2)	m	276,000	610	168	for high w. chan.
Narrow excavation w.	m3	43,200,000	94	4,061	
Cut-off channel w.	km	34.5	-	3,487	
Excavation (1)	m3	52,800,000	45	2,376	for main Cagayan
Excavation (1)	m3	17,800,000	45	801	for tributarites
Revetment (3)	m2	516,000	600	310	
Bank protection w.	km	112.3	-	550	
Revetment (3)	m2	838,000	600	503	
Groyne	unit	1,880	24,900	47	unit in total
Drainage sluice w.	unit	720	626,000	451	
Bridge w.	m2	17,300	5,950	103	
Miscellaneous	l.s.	-	-	2,085	15 % of the above
2. Compensation	m2	-	-	(176)	
Dike	m2	16,700,000	5.7	95	
COC	m2	11,300,000	5.7	64	
Others	m2	2,800,000	5.7	16	10 %
3. Engineering & Adm.	-	-	-	(2,398)	
Engineering	l.s.	-	-	1,599	10 % of (1)
Administration	l.s.	-	-	799	5 % of (1)
4. Contingency	l.s.	-	-	(2,784)	15 % of (1+2+3)
Total	-	-	-	21,345	
II. DAM WORKS					
1. Main Works	l.s.	-	-	(4,370)	
Cagayan No.1	l.s.	-	-	991	
Alimit No.1 (A)	l.s.	-	-	1,343	
Ilagan No.1	l.s.	-	-	1,412	
Siffu No.1 (A)	l.s.	-	-	342	
Mallig No.2	l.s.	-	-	282	
2. Compensation	l.s.	-	-	(139)	
3. Engineering & Adm.	-	-	-	(656)	
Engineering	l.s.	-	-	437	10 % of (1)
Administration	l.s.	-	-	219	5 % of (1)
4. Contingency	l.s.	-	-	(1,033)	20 % of (1+2+3)
Total	-	-	-	6,198	
GRAND TOTAL	-	-	-	27,543	

Table 5.3 Probable Flood Discharges (Long-term Plan)

(Without Project) (m3/s)

Stretch	Return Period (year)					
	2	5	10	25	50	100
1	6,300	10,000	12,100	15,900	18,300	21,600
2	6,400	11,000	13,700	18,700	22,000	26,600
3	6,100	10,300	12,900	17,800	21,100	25,600
4	5,400	9,400	11,700	16,300	19,500	23,900
5	3,300	6,000	7,400	10,700	13,400	16,000
6	2,000	3,000	3,800	5,200	7,500	8,700
7	1,200	1,600	2,000	2,700	3,000	3,300
8	2,000	3,400	4,700	6,700	7,600	9,400
9	2,700	4,500	6,000	7,200	9,500	10,600

(With Improved Narrows and Dams) (m3/s)

Stretch	Return Period (year)					
	2	5	10	25	50	100
1	6,200	9,700	11,600	15,100	17,500	20,700
2	6,500	10,400	12,700	17,100	20,200	24,500
3	6,100	9,800	12,000	16,300	19,400	23,700
4	5,400	8,900	11,000	15,100	18,100	22,200
5	3,100	5,500	6,700	9,800	12,300	14,700
6	2,000	3,000	3,800	5,200	7,500	8,700
7	1,200	1,600	2,000	2,700	3,000	3,200
8	1,800	2,800	3,700	5,700	6,500	8,200
9	2,500	4,000	5,300	6,400	8,300	9,300

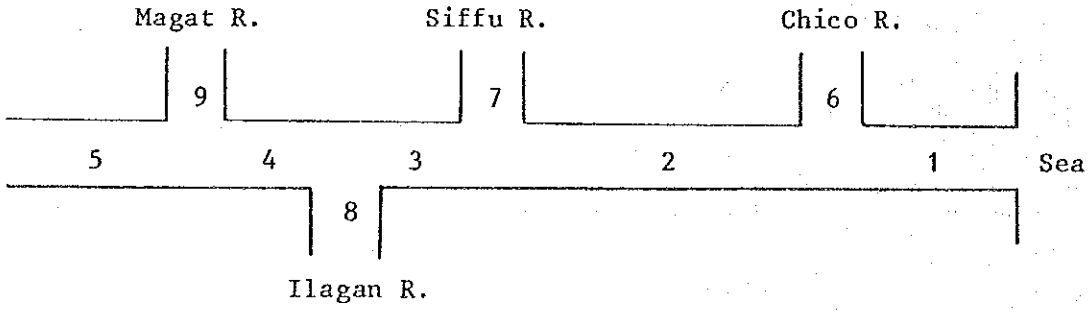


Table 5.4 Probable Flood Damage (Long-Term Plan)

(Unit: ₱ 10^6)

Item	2 year	5 year	10 year	25 year	50 year	100 year
(Without Project: Constant Property Condition)						
Buildings	1,754	3,000	3,863	5,161	5,809	6,402
Agricultural crops	130	231	286	347	380	424
Livestocks	16	29	36	44	48	53
Infrastructure	1,508	2,580	3,322	4,438	4,996	5,506
Sub-total	3,408	5,840	7,507	9,990	11,233	12,385
Indirect damages	170	292	375	500	562	619
Total damages	3,578	6,132	7,882	10,490	11,795	13,004
(With Improved Narrows and Dams: Constant Property Condition)						
Buildings	1,529	2,542	3,176	4,264	5,063	5,785
Agricultural crops	99	192	242	305	341	384
Livestocks	12	24	30	38	43	48
Infrastructure	1,315	2,186	2,731	3,667	4,354	4,975
Sub-total	2,955	4,944	6,179	8,274	9,801	11,192
Indirect damages	148	247	309	414	490	560
Total damages	3,103	5,191	6,489	8,688	10,291	11,752

Table 5.5 Annual Flood Damages (Without Project)

Stretch	Return period of no-damage (year)	Damages (₱ mil.) 2-year	5-year	10-year	25-year	50-year	100-year	Annual average damages (₱ mil./yr)
Main Cagayan R.								
Mouth - Chico	2.56	-	340.1	478.5	733.9	916.3	1,173.6	136.6
Chico - Tuguegarao	1.06	1,298.5	2,164.2	2,965.5	4,172.2	4,521.1	4,760.7	1,409.0
Tuguegarao - Siffu	1.05	689.3	1,498.3	1,935.4	2,377.1	2,524.4	2,681.2	859.3
Siffu - Ilagan	1.05	16.2	32.6	45.8	68.6	84.0	101.8	20.8
Ilagan - Magat	1.10	27.6	79.7	99.7	152.8	168.7	238.2	43.5
Magat - Upstream	1.35	118.6	291.4	389.7	720.1	1,018.1	1,256.6	171.8
Tributaries								
Siffu	0.82	34.4	63.4	81.8	117.4	138.3	158.4	37.4
Mallig	1.75	40.7	52.6	73.0	94.0	107.3	111.1	29.8
Ilagan	1.04	33.1	115.9	144.5	201.3	222.3	311.8	60.3
Lower Magat	1.03	364.3	546.6	663.7	771.1	922.6	900.4	352.3
Upper Magat	1.03	872.5	945.4	1,002.9	1,079.8	1,175.8	1,218.4	672.2
Total	-	-	-	-	-	-	-	3,793.0

Table 5.6 Estimation of Flood Reduction Benefit (Long-term Plan)

Stretch	Annual damages (₱ mil./yr)					Benefit (₱ mil./yr)
	W/o pro. Up to 100 yr	Up to 25 yr		25 yr to 100 yr		
		W/o pro.	W/pro.	W/o pro.	W/pro.	
	(1)	(2)	(3)	(4)	(5)	(6)
Main Cagayan R.						
Mouth-Chico	136.6	109.6	21.9	27.0	25.1	89.6
Chico-Tuguegarao	772.2	677.5	135.5	94.7	73.1	563.6
Tuguegarao-Siffu	799.9	733.2	146.6	66.7	63.8	589.5
Siffu-Ilagan	20.8	18.3	3.7	2.5	2.2	14.9
Ilagan-Magat	43.6	38.3	7.7	5.3	4.9	31.0
Magat-Upstream	171.7	143.1	143.1	28.8	25.4	3.4
Subtotal	1,945.0	1,720.0	458.5	225.0	194.5	1,292.0
Tributaries						
Chico R.	636.8	598.2	598.2	38.6	38.6	0
Tuguegarao R.	59.4	51.1	51.1	8.3	8.3	0
Siffu R.	37.4	33.4	33.4	4.0	1.5	2.5
Mallig R.	29.8	26.7	26.7	3.1	2.1	1.0
Ilagan R.	60.3	53.4	53.4	6.9	5.0	1.9
Lower Magat R.	352.3	325.8	65.2	26.5	20.4	266.7
Upper Magat R.	672.1	637.6	637.6	34.5	34.5	0
Subtotal	1,848.1	1,726.2	1,465.6	121.9	110.4	272.1
Total	3,793.1	3,446.2	1,924.1	346.9	304.9	1,564.1

Notes: 1. (3) includes narrow imp., dam, and diking system works.
2. (5) includes narrow imp. and dam works.
3. Benefit = (2) - (3) + (4) - (5)

Table 5.7 Estimation of Bank Protection Benefit

Stretch	Bank erosion damages (₱ 1,000/yr)					Benefit (Total)
	Bldg.	Agricul.	Highway	Resi.land	Indirect	
1. Main Cagayan R.	10,960	1,897	4,880	2,654	20,391	40,782
2. Chico R.	4,477	2,442	954	1,083	8,956	17,912
3. Tuguegarao R.	1,374	124	572	332	2,402	4,804
4. P.D. Cabagan R.	49	38	0	12	99	198
5. P.D. Tumauini R.	41	28	175	10	254	508
6. Ilagan R.	705	132	330	170	1,337	2,674
7. Magat R.	1,499	609	714	215	3,037	6,074
Total	19,105	5,270	7,625	4,476	36,476	72,952

Table 5.8 Cost and Benefit Flow (Long-Term Plan)

IRR FOR LONG-TERM PLAN

INPUT: CH C.MAIN = 15,987.00 B.1985 = 1,637.00
C.COMP = 176.00 B.1995 = 2,723.20
DAM C.MAIN = 4,370.00 B.2005 = 3,834.10
C.COMP = 139.00 B.2020 = 7,780.90
B.2040 = 14,728.50

IRR.CPC = 0.0480 NPV-CPC = (24.0218)
IRR.VPC = 0.1420 NPV-VPC = 15.0196

YEAR	MAIN W.	COMPEN.	ENG.ADM.	CONTIN.	O & M	T.COST	B.CPC	B.CPC-C	B.VPC	B.VPC-C
TOTAL	20,357.0	315.0	3,053.6	3,817.6	4,275.0	31,818.1	68,754.0	36,935.9	341,124.3	309,306.2
1985	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1986	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1987	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1988	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1989	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1990	0.0	21.0	190.8	34.1	0.0	245.9	0.0	(245.9)	0.0	(245.9)
1991	1,357.1	21.0	190.8	252.5	0.0	1,821.4	0.0	(1,821.4)	0.0	(1,821.4)
1992	1,357.1	21.0	190.8	252.5	6.8	1,828.2	109.1	(1,719.1)	159.8	(1,668.4)
1993	1,357.1	21.0	190.8	252.5	13.6	1,835.0	218.3	(1,616.7)	334.1	(1,500.9)
1994	1,357.1	21.0	190.8	252.5	20.4	1,841.8	327.4	(1,514.4)	522.9	(1,318.9)
1995	1,357.1	21.0	190.8	252.5	27.1	1,848.6	436.5	(1,412.0)	726.2	(1,122.4)
1996	1,357.1	21.0	190.8	252.5	33.9	1,855.4	545.7	(1,309.7)	944.8	(910.6)
1997	1,357.1	21.0	190.8	252.5	40.7	1,862.2	654.8	(1,207.4)	1,178.2	(684.0)
1998	1,357.1	21.0	190.8	252.5	47.5	1,868.9	763.9	(1,105.0)	1,426.4	(442.6)
1999	1,357.1	21.0	190.8	252.5	54.3	1,875.7	873.1	(1,002.7)	1,689.4	(186.4)
2000	1,357.1	21.0	190.8	252.5	61.1	1,882.5	982.2	(900.3)	1,967.2	84.7
2001	1,357.1	21.0	190.8	252.5	67.9	1,889.3	1,091.3	(798.0)	2,259.8	370.5
2002	1,357.1	21.0	190.8	252.5	74.6	1,896.1	1,200.5	(695.6)	2,567.3	671.2
2003	1,357.1	21.0	190.8	252.5	81.4	1,902.9	1,309.6	(593.3)	2,889.5	986.7
2004	1,357.1	21.0	190.8	252.5	88.2	1,909.7	1,418.7	(490.9)	3,226.6	1,317.0
2005	1,357.1	0.0	190.8	249.1	95.0	1,892.1	1,527.9	(364.2)	3,578.5	1,686.4
2006	0.0	0.0	0.0	0.0	101.8	101.8	1,637.0	1,535.2	4,097.2	3,995.4
2007	0.0	0.0	0.0	0.0	101.8	101.8	1,637.0	1,535.2	4,360.3	4,258.6
2008	0.0	0.0	0.0	0.0	101.8	101.8	1,637.0	1,535.2	4,623.5	4,521.7
2009	0.0	0.0	0.0	0.0	101.8	101.8	1,637.0	1,535.2	4,886.6	4,784.8
2010	0.0	0.0	0.0	0.0	101.8	101.8	1,637.0	1,535.2	5,149.7	5,047.9
2011	0.0	0.0	0.0	0.0	101.8	101.8	1,637.0	1,535.2	5,412.8	5,311.0
2012	0.0	0.0	0.0	0.0	101.8	101.8	1,637.0	1,535.2	5,675.9	5,574.2
2013	0.0	0.0	0.0	0.0	101.8	101.8	1,637.0	1,535.2	5,939.1	5,837.3
2014	0.0	0.0	0.0	0.0	101.8	101.8	1,637.0	1,535.2	6,202.2	6,100.4
2015	0.0	0.0	0.0	0.0	101.8	101.8	1,637.0	1,535.2	6,465.3	6,363.5
2016	0.0	0.0	0.0	0.0	101.8	101.8	1,637.0	1,535.2	6,728.4	6,626.6
2017	0.0	0.0	0.0	0.0	101.8	101.8	1,637.0	1,535.2	6,991.5	6,889.8
2018	0.0	0.0	0.0	0.0	101.8	101.8	1,637.0	1,535.2	7,254.7	7,152.9
2019	0.0	0.0	0.0	0.0	101.8	101.8	1,637.0	1,535.2	7,517.8	7,416.0
2020	0.0	0.0	0.0	0.0	101.8	101.8	1,637.0	1,535.2	7,780.9	7,679.1
2021	0.0	0.0	0.0	0.0	101.8	101.8	1,637.0	1,535.2	8,128.3	8,026.5
2022	0.0	0.0	0.0	0.0	101.8	101.8	1,637.0	1,535.2	8,475.7	8,373.9
2023	0.0	0.0	0.0	0.0	101.8	101.8	1,637.0	1,535.2	8,823.0	8,721.3
2024	0.0	0.0	0.0	0.0	101.8	101.8	1,637.0	1,535.2	9,170.4	9,068.6
2025	0.0	0.0	0.0	0.0	101.8	101.8	1,637.0	1,535.2	9,517.8	9,416.0
2026	0.0	0.0	0.0	0.0	101.8	101.8	1,637.0	1,535.2	9,865.2	9,763.4
2027	0.0	0.0	0.0	0.0	101.8	101.8	1,637.0	1,535.2	10,212.6	10,110.8
2028	0.0	0.0	0.0	0.0	101.8	101.8	1,637.0	1,535.2	10,559.9	10,458.2
2029	0.0	0.0	0.0	0.0	101.8	101.8	1,637.0	1,535.2	10,907.3	10,805.5
2030	0.0	0.0	0.0	0.0	101.8	101.8	1,637.0	1,535.2	11,254.7	11,152.9
2031	0.0	0.0	0.0	0.0	101.8	101.8	1,637.0	1,535.2	11,602.1	11,500.3
2032	0.0	0.0	0.0	0.0	101.8	101.8	1,637.0	1,535.2	11,949.5	11,847.7
2033	0.0	0.0	0.0	0.0	101.8	101.8	1,637.0	1,535.2	12,296.8	12,195.1
2034	0.0	0.0	0.0	0.0	101.8	101.8	1,637.0	1,535.2	12,644.2	12,542.4
2035	0.0	0.0	0.0	0.0	101.8	101.8	1,637.0	1,535.2	12,991.6	12,889.8
2036	0.0	0.0	0.0	0.0	101.8	101.8	1,637.0	1,535.2	13,339.0	13,237.2
2037	0.0	0.0	0.0	0.0	101.8	101.8	1,637.0	1,535.2	13,686.4	13,584.6
2038	0.0	0.0	0.0	0.0	101.8	101.8	1,637.0	1,535.2	14,033.7	13,932.0
2039	0.0	0.0	0.0	0.0	101.8	101.8	1,637.0	1,535.2	14,381.1	14,279.3
2040	0.0	0.0	0.0	0.0	101.8	101.8	1,637.0	1,535.2	14,728.5	14,626.7

Remarks:
1. Figures in ( ) show negative values.
2. All unit in million pesos

Table 5.9 Principal Features of Long-Term Plan

1)	Channel Works		
	a) Dike embankment works:		59,500,000 m3
	b) Revetment works (45.1 km long):		1,010,000 m2
	c) Drainage sluice works:		720 units
	d) Narrow excavation works:		43,200,000 m3
	e) Cut-off channel works (34.5 km long):		70,600,000 m3
	f) Bank protection works:		112.3 km
	g) Appurtenant facility works:		3 bridges
	- Buntun bridge:		Reconstruction
	- Gamu bridge:		Extension
	- Naguilian bridge:		Extension
2)	Flood Control Dam Works	(Dam height: m)	(F.C.: MCM)
	- Cagayan No.1	45.0	318
	- Alimit No.1(A)	84.0	200
	- Ilagan No.1	69.0	382
	- Siffu No.1(A)	44.0	96.1
	- Mallig No.2	43.0	93.4
3)	Compensation		
	a) Channel works:		30,800,000 m2
	b) Dam works:		113,500,000 m2
	- Cagayan No.1 dam		47,700,000 m2
	- Alimit No.1 dam		10,000,000 m2
	- Ilagan No.1 dam		29,100,000 m2
	- Siffu No.1(A) dam		14,400,000 m2
	- Mallig No.2 dam		12,300,000 m2
4)	Project Cost (Economic):		₱27,543,000,000
	a) Channel works:		₱21,345,000,000
	b) Dam works:		₱ 6,198,000,000
5)	Economic Evaluation	(Const. propertry)	(Vari. property)
	a) Benefit (₱mil./yr)	1,637.0	3,834.1 /1
	- Flood reduction	1,564.0	3,698.6 /1
	- Bank protection	73.0	135.5
	b) IRR (%)	7.0	17.3

/1 Annual benefit for variable property: as of 2005

Table 5.10 Screening of Dike Schemes

Dike	Location From (km)	Location To (km)	Dike volume (1000 m3) (1)	Inundated building (nos) (2)	Efficiency (1000 m3/bldg.) (1)/(2)	Remarks
MOUTH...ALCALA (LEFT)						
MAL-1	1.0 - 2.590	10.0 + 1.540	1,962	733	2.7	
MAL-2	23.0 + 0.380	25.0 +2.000	557	245	2.3	
MAL-3	35.0 - 0.280	43.0 + 5.000	6,578	2,507	2.6	
ALCALA...TUGUEGARAO (LEFT)						
ATL-1	62.0 + 2.750	123.0 + 4.860	21,975	11,934	1.8	
TUGUEGARAO...SIFFU R. JCT. (LEFT)						
TSL-1	132.0 + 0.420	160.0 + 0.370	9,509	5,609	1.7	
TSL-2	160.0 + 0.420	195.0 + 3.700	9,684	5,933	1.6	Incl. Siffu Left
SIFFU R. JCT....UPSTREAM (LEFT)						
SUL-1	195.0 + 4.840	201.0 - 0.300	293	75	3.9	Incl. Siffu Right
SUL-2	201.0 + 0.150	221.0 + 1.770	3,681	619	5.9	
SUL-3	221.0 + 3.550	233.5 - 0.700	8,714	3,964	2.2	Incl. Magat Left
SUL-4	233.5 + 1.280	244.0 - 6.650	4,214	2,296	1.8	Incl. Magat Right
MOUTH...ALCALA (RIGHT)						
MAR-1	1.0	15.0 + 0.110	2,142	730	2.9	
MAR-2	15.0 + 2.030	30.0 + 0.140	1,554	726	2.1	
MAR-3	33.0 + 0.240	35.0 + 0.480	372	130	2.9	
MAR-4	40.0 + 0.570	54.0	4,764	2,995	1.6	
MAR-5	54.5 + 2.200	62.0 + 2.850	8,472	900	9.4	Incl. Pared Right
ALCALA...TUGUEGARAO (RIGHT)						
ATR-1	62.0 + 5.600	115.8 + 0.570	16,394	4,262	3.8	Incl. Pared Left
ATR-2	115.8 + 0.650	138.0 + 0.500	7,389	13,459	0.5	Incl. Tuguegarao Right
TUGUEGARAO...SIFFU R. JCT. (RIGHT)						
TSR-1	138.0 + 0.500	149.5 + 2.730	7,581	2,114	3.6	Incl. Tuguegarao Left
TSR-2	149.5 + 3.030	154.5 + 3.000	3,456	1,187	2.9	Incl.Pinacanauan Right
TSR-3	154.5 + 3.800	167.0 + 2.750	3,887	3,908	1.0	Incl.Pinacanauan Left
TSR-4	167.0 + 2.840	192.0 + 1.300	7,212	4,551	1.6	Incl. Tumauini Right
TSR-5	192.0 + 1.900	201.0 + 3.550	1,701	347	4.9	Incl. Tumauni Left
SIFFU R. JCT....UPSTREAM (RIGHT)						
SUR-1	206.3	211.0 + 1.020	4,199	1,254	3.4	Incl. Ilagan Right
SUR-2	211.0 + 1.870	215.0	2,740	1,364	2.0	Incl. Ilagan Left
SUR-3	217.0 + 3.200	226.5 + 0.530	838	47	17.9	
SUR-4	228.0 + 2.100	233.5 + 2.500	1,297	815	1.6	
SUR-5	233.5 + 2.740	254.3	3.544	1,618	2.2	
ILAGAN (LEFT)						
IL -1	11.8 + 4.900	21.5 + 0.390	409	199	2.1	
MAGAT (RIGHT)						
MA -1	10.0 + 0.230	15.5 + 4.870	2,770	571	4.8	
MA -2	25.5 + 0.980	50.0 + 0.720	627	372	1.7	

Remarks: (1) Dike volume was estimated preliminarily based on 100-year flood without dam and narrow improvement.
(2) Number of inundated buildings was estimated for the condition without dike based on 100-year flood.

Table 5.11 Project Costs of Dike Schemes

Work item	Unit	Work quantity	Unit Cost (₱)	Amount (₱ mil.)
TUGUEGARAO DIKE				
1. Main Works	-	-	-	(374.7)
Preparatory w.	l.s.	-	-	24.1
Dike embankment w.	km	22.1	-	136.3
Embankment	m3	2,350,000	58	136.3
Revetment w.	km	-	-	144.7
Revetment (1)	m2	137,000	820	112.3
Revetment (2)	m2	53,000	610	32.4
Drainage sluice w.	unit	33	626,000	20.7
Miscellaneous	l.s.	-	-	48.8
2. Compensation	m2	-	-	(4.6)
Dike	m2	736,000	5.7	4.2
Others	m2	73,600	5.7	0.4
3. Engineering & Adm.	l.s.	-	-	(56.1)
4. Contingency	l.s.	-	-	(65.2)
Total				500.6
CABAGAN DIKE				
1. Main Works	-	-	-	(186.8)
Preparatory w.	l.s.	-	-	12.0
Dike embankment w.	km	15.4	-	71.9
Embankment	m3	1,240,000	58	71.9
Revetment w.	km	-	-	63.3
Revetment (1)	m2	62,700	820	51.4
Revetment (2)	m2	19,500	610	11.9
Drainage sluice w.	unit	23	626,000	14.4
Miscellaneous	l.s.	-	-	25.2
2. Compensation	m2	-	-	(2.6)
Dike	m2	415,000	5.7	2.4
Others	m2	41,500	5.7	0.2
3. Engineering & Adm.	l.s.	-	-	(28.0)
4. Contingency	l.s.	-	-	(36.1)
Total				276.9

Remarks: Costs are on economic basis.

Table 5.12 Project Costs of Narrow Improvement Schemes

Work item	Unit	Work quantity	Unit cost (₱)	Amount (₱ mil.)
NARROW IMP. (SITE-NLL)				
1. Main Works	-	-	-	(679.7)
Preparatory w.	l.s.	-	-	43.8
Narrow excavation w.	m3	5,830,000	94	548.0
Miscellaneous	l.s.	-	-	87.9
2. Compensation	m2	184,000	5.7	(1.0)
3. Engineering & Adm.	l.s.	-	-	(102.0)
4. Contingency	l.s.	-	-	(117.4)
Total				900.1
NARROW IMP. (SITE -NLR)				
1. Main Works	-	-	-	(2,049.9)
Preparatory w.	l.s.	-	-	132.5
Narrow excavation w.	m3	17,620,000	94	1,656.3
Miscellaneous	l.s.	-	-	261.1
2. Compensation	m2	985,000	5.7	(5.6)
3. Engineering & Adm.	l.s.	-	-	(307.5)
4. Contingency	l.s.	-	-	(354.4)
Total				2,717.4
NARROW IMP. (SITE-NUP)				
1. Main Works	-	-	-	(2,319.1)
Preparatory w.	l.s.	-	-	148.4
Narrow excavation w.	m3	19,740,000	94	1,855.6
Miscellaneous	l.s.	-	-	315.1
2. Compensation	m2	839,000	5.7	(4.8)
3. Engineering & Adm.	l.s.	-	-	(347.9)
4. Contingency	l.s.	-	-	(400.7)
Total				3,072.5

Remarks: Costs are on economic basis.

Table 5.13 Project Costs of Flood Control Dams

(Unit: ₱ mil.)

	Dam scheme	Main works	Compensation	Eng. & adm.	Contingency	Total
1.	Cagayan No.1	990.53	100.02	148.58	247.83	1,486.96
2.	Alimit No.1 (A)	1,342.60	0.04	201.39	308.81	1,852.84
3.	Ilagan No.1	1,411.62	14.01	211.74	327.47	1,964.84
4.	Siffu No.1 (A)	342.48	14.24	51.37	81.62	489.71
5.	Mallig No.2	282.35	10.46	42.35	67.03	402.19

Table 5.14 Project Cost of Bank Protection Works

	Work item	Unit	Work quantity	Unit cost (₱)	Amount (₱ mil.)
1.	Main Works	km	112.3	-	683
	Preparatory	l.s.	-	-	44
	Revetment	m2	838,000	600	503
	Groyne	unit	1,880	24,900	47
	Miscellaneous	l.s.	-	-	89
2.	Eng. & adm.	l.s.	-	-	102
3.	Contingency	l.s.	-	-	118
	Total				903

Table 5.15 Design Discharge for Candidate Schemes

(Unit: m3/s)

Stretch	Existing	Dike	Magapit improve.	Dam				
				Cagayan No.1	Magat /Alimit	Ilagan No.1	Siffu No.1 (A)	Mallig No.2
1	21,600	15,900	22,000	21,300	21,500	21,100	21,600	21,600
2	26,600	18,700	26,600	25,800	26,000	26,000	26,600	26,600
3	25,600	17,800	25,600	24,800	25,000	25,000	25,600	25,600
4	23,900	16,300	23,900	23,100	23,400	23,900	23,900	23,900
5	16,000	10,700	16,000	14,700	16,000	16,000	16,000	16,000
6	8,700	5,200	8,700	8,700	8,700	8,700	8,700	8,700
7	3,300	2,700	3,300	3,300	3,300	3,300	3,200	3,200
8	9,400	6,700	9,400	9,400	9,400	8,200	9,400	9,400
9	10,600	7,200	10,600	10,600	9,300	10,600	10,600	10,600
Return period of flood	100 yr	25 yr	100 yr	100 yr	100 yr	100 yr	100 yr	100 yr

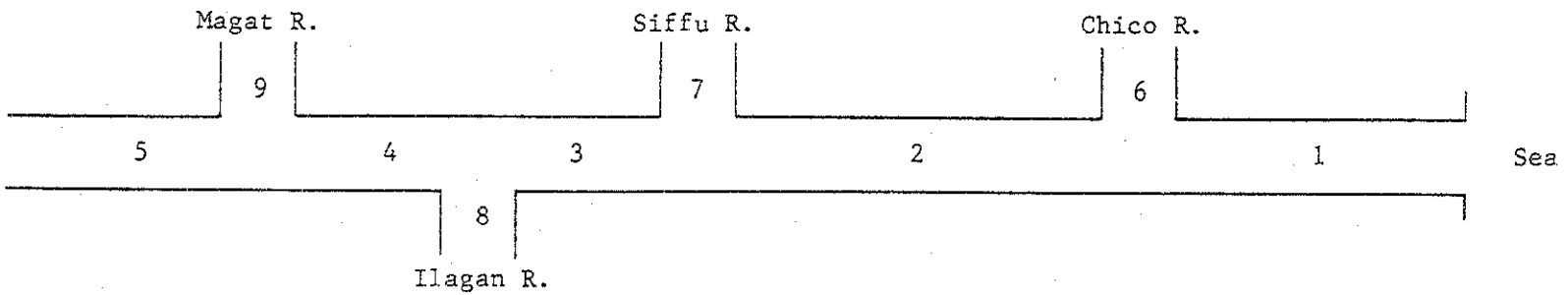


Table 5.16 Annual Flood Damages with Narrow Improvement Schemes

Stretch	Damages (₱ mil./yr) W/O Project	Site-N	Site-NLL	Site-NLR	Site-NUP
Main Cagayan R.					
Mouth - Chico	136.6	139.7	139.7	139.7	139.7
Chico - Tuguegarao	1,409.0	1,209.4	1,319.4	1,237.3	1,401.0
Tuguegarao - Siffu	859.3	859.3	859.3	859.3	859.3
Siffu - Ilagan	20.8	20.8	20.8	20.8	20.8
Ilagan - Magat	43.5	43.5	43.5	43.5	43.5
Magat - Upstream	171.8	171.8	171.8	171.8	171.8
Subtotal	2,641.0	2,444.5	2,544.5	2,472.4	2,636.1
Tributaries					
Siffu	37.4	37.4	37.4	37.4	37.4
Mallig	29.8	29.8	29.8	29.8	29.8
Ilagan	60.3	60.3	60.3	60.3	60.3
Lower Magat	352.3	352.3	352.3	352.3	352.3
Upper Magat	672.2	672.2	672.2	672.2	672.2
Subtotal	1,152.0	1,152.0	1,152.0	1,152.0	1,152.0
Total	3,793.0	3,596.5	3,706.5	3,624.4	3,788.1

Remarks:

1. Chico river is included in the stretch Chico - Tuguegarao.
2. Tuguegarao river is included in the stretch Tuguegarao - Siffu.

Table 5.17 Annual Flood Damages with Magat Dam Schemes

Stretch	Damages (₱ mil./yr)				
	W/O Project	Magapit/Alimit dam			
		100 mcm	200 mcm	300 mcm	400 mcm
Main Cagayan R.					
Mouth - Chico	136.6	136.6	133.8	124.9	112.1
Chico - Tuguegarao	1,409.0	1,404.6	1,403.0	1,323.7	1,237.5
Tuguegarao - Siffu	859.3	857.1	854.8	810.8	759.2
Siffu - Ilagan	20.8	20.7	20.6	19.3	17.8
Ilagan - Magat	43.5	43.5	43.5	40.8	37.4
Magat - Upstream	171.8	171.8	171.8	171.8	160.1
Subtotal	2,641.0	2,634.3	2,627.5	2,491.3	2,324.1
Tributaries					
Siffu	37.4	37.4	37.4	37.4	37.4
Mallig	29.8	29.8	29.8	29.8	29.8
Ilagan	60.3	60.3	60.3	60.3	60.3
Lower Magat	352.3	316.2	243.4	199.0	153.1
Upper Magat	672.2	672.2	672.2	672.2	672.2
Subtotal	1,152.0	1,115.9	1,043.1	998.7	952.8
Total	3,793.0	3,750.2	3,670.6	3,490.0	3,276.9

Remarks:

1. Chico river is included in the stretch Chico - Tuguegarao.
2. Tuguegarao river is included in the stretch Tuguegarao - Siffu.

Table 5.18 Annual Flood Damages with Dam Schemes

Stretch	Damages (₱ mil./yr)				
	W/O Project	Cagayan No.1 dam	Ilagan No.1 dam	Siffu No.1(A) dam	Mallig No.2 dam
Main Cagayan R.					
Mouth - Chico	136.6	130.6	130.1	136.6	136.6
Chico - Tuguegarao	1,409.0	1,380.4	1,402.3	1,409.0	1,409.0
Tuguegarao - Siffu	859.3	839.1	854.9	859.3	859.3
Siffu - Ilagan	20.8	19.9	20.6	20.8	20.8
Ilagan - Magat	43.5	41.4	43.5	43.5	43.5
Magat - Upstream	171.8	149.2	171.8	171.8	171.8
Subtotal	2,641.0	2,560.6	2,623.2	2,641.0	2,641.0
Tributaries					
Siffu	37.4	37.4	37.4	5.2	37.4
Mallig	29.8	29.8	29.8	29.8	13.1
Ilagan	60.3	60.3	39.0	60.3	60.3
Lower Magat	352.3	352.3	352.3	352.3	352.3
Upper Magat	672.2	672.2	672.2	672.2	672.2
Subtotal	1,152.0	1,152.0	1,130.7	1,119.8	1,135.2
Total	3,793.0	3,712.6	3,753.9	3,760.8	3,776.3

Remarks:

1. Chico river is included in the stretch Chico - Tuguegarao.
2. Tuguegarao river is included in the stretch Tuguegarao - Siffu.

Table 5.19 Benefits of Candidate Schemes

Scheme		Damage/Benefit (₱ million)				
		1985	1995	2005	2020	2040
Existing	D	3,793.1	6,361.0	8,998.4	18,410.4	34,981.4
Narrow imp. (Site-NLL)	D	3,706.6	6,216.1	8,793.4	17,992.4	34,188.2
	B	86.5	144.9	205.0	418.0	793.2
- do - (Site-NLR)	D	3,624.5	6,048.4	8,597.7	17,592.1	33,427.8
	B	168.6	282.6	400.7	818.3	1,553.6
- do - (Site-NUP)	D	3,788.2	6,352.8	8,986.8	18,386.6	34,936.1
	B	4.9	8.2	11.6	23.8	45.3
Cagayan No.1 dam	D	3,712.7	6,226.1	8,807.3	18,019.0	34,237.5
	B	80.4	134.9	191.1	391.4	743.9
Magat/Alimit dam (100 MCM)	D	3,750.3	6,289.5	8,899.3	18,207.3	34,595.2
	B	42.8	71.5	99.1	203.1	386.2
- do - (200 MCM)	D	3,670.7	6,156.2	8,713.5	17,825.9	33,869.2
	B	122.4	204.8	284.9	584.5	1,112.2
- do - (300 MCM)	D	3,490.1	5,853.6	8,287.2	16,952.9	32,209.9
	B	303.0	507.4	711.2	1,457.5	2,771.5
- do - (400 MCM)	D	3,277.0	5,496.2	7,783.6	15,921.3	30,248.6
	B	516.1	864.8	1,214.8	2,489.1	4,732.8
Ilagan No.1 dam	D	3,753.9	6,295.3	8,904.7	18,218.9	34,617.7
	B	39.2	65.7	93.7	191.5	363.7
Siffu No.1 (A) dam	D	3,760.8	6,307.5	8,925.7	18,263.6	34,703.9
	B	32.3	53.5	72.7	146.8	277.5
Mallig No.2 dam	D	3,776.4	6,333.3	8,961.0	18,334.7	34,838.4
	B	16.7	27.7	37.4	75.7	143.0

Remarks D: Damages
B: Benefit as decrease in damages with and without project

Table 5.20 Economic Viability of Candidate Schemes for Master Plan

Sub-project	Cost (₱ mil.)		Constant Prop. C.		Variable Prop. C.		Rank
	Const.	Total O & M	Total B (mil.)	IRR (%)	Total B (mil.)	IRR (%)	
Tuguegarao dike	500.6	117.5	2,867.0	11.6	13,718.2	23.1	1
Cabagan dike	276.9	65.1	817.8	5.3	3,865.1	13.6	4
Narrow imp. (Site-NLL)	900.1	211.5	4,065.5	8.9	19,135.6	18.9	2
- do - (Site-NLR)	2,717.4	638.6	7,919.5	5.2	37,453.6	13.5	5
- do - (Site-NUP)	3,072.5	722.0	230.3	-	1,089.8	-	11
Cagayan No.1 dam	1,487.0	334.6	3,616.7	3.8	17,655.8	11.6	8
Magat/Alimit dam	1,852.8	416.9	5,507.6	5.1	26,389.5	13.1	6
Ilagan No.1 dam	1,964.8	442.1	1,760.9	-	8,636.8	5.4	10
Siffu No.1 (A) dam	489.7	110.2	1,452.6	5.1	6,632.0	12.8	7
Mallig No.2 dam	402.2	90.5	752.0	2.2	3,417.3	9.3	9
Bank protection	903.4	212.3	3,431.0	7.3	10,620.5	13.7	3

Note : 1. Constant and variable Prop. C. denote total benefit and IRR under the constant and variable property conditions of basin during project life of 50 years.
2. Regarding dam projects, single purpose for flood control is assumed.

Table 5.21 Priority Ranks after Intersectoral Adjustment

Sub-project	Cost (₱ mil.)		Constant Prop. C.		Variable Prop. C.		Rank
	Const.	Total O & M	Total B (mil.)	IRR (%)	Total B (mil.)	IRR (%)	
Tuguegarao dike	500.6	117.5	2,867.0	11.6	13,718.2	23.1	1
Narrow imp. (Site-NLL)	900.1	211.5	4,065.5	8.9	19,135.6	18.9	2
Siffu No.1 (A) dam	279.3	94.8	1,453.5	9.3	6,631.8	18.6	3
Bank protection	903.4	212.3	3,431.0	7.3	10,620.5	13.7	4
Cabagan dike	276.9	65.1	817.8	5.3	3,865.1	13.6	5
Narrow imp. (Site-NLR)	2,717.4	638.6	7,919.5	5.2	37,453.6	13.5	6
Magat/Alimit dam	904.7	204.5	2,491.0	4.6	11,890.1	12.5	7
Cagayan No.1 dam	1,487.0	334.6	3,616.7	3.8	17,655.8	11.6	8
Mallig No.2 dam	343.4	98.0	751.5	3.0	3,418.0	10.3	9
Ilagan No.1 dam	1,964.8	442.1	1,759.5	-	8,637.0	5.4	10
Narrow imp. (Site-NUP)	3,072.5	722.0	230.3	-	1,089.8	-	11

Note : 1. Constant and variable Prop. C. denote total benefit and IRR under the constant and variable property conditions of basin during project life of 50 years.
2. Regarding dam projects, multipurpose dams are assumed.

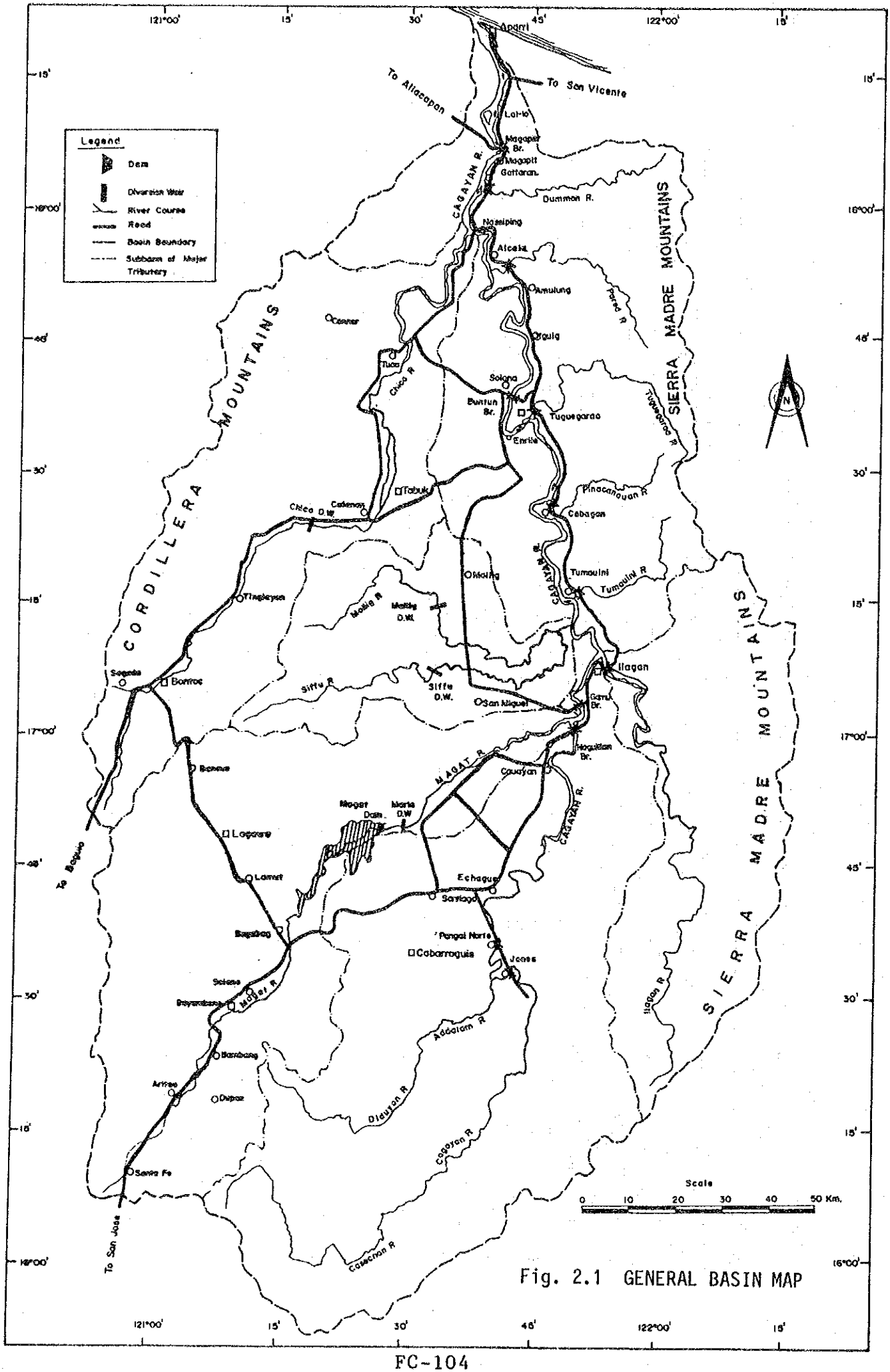


Fig. 2.1 GENERAL BASIN MAP

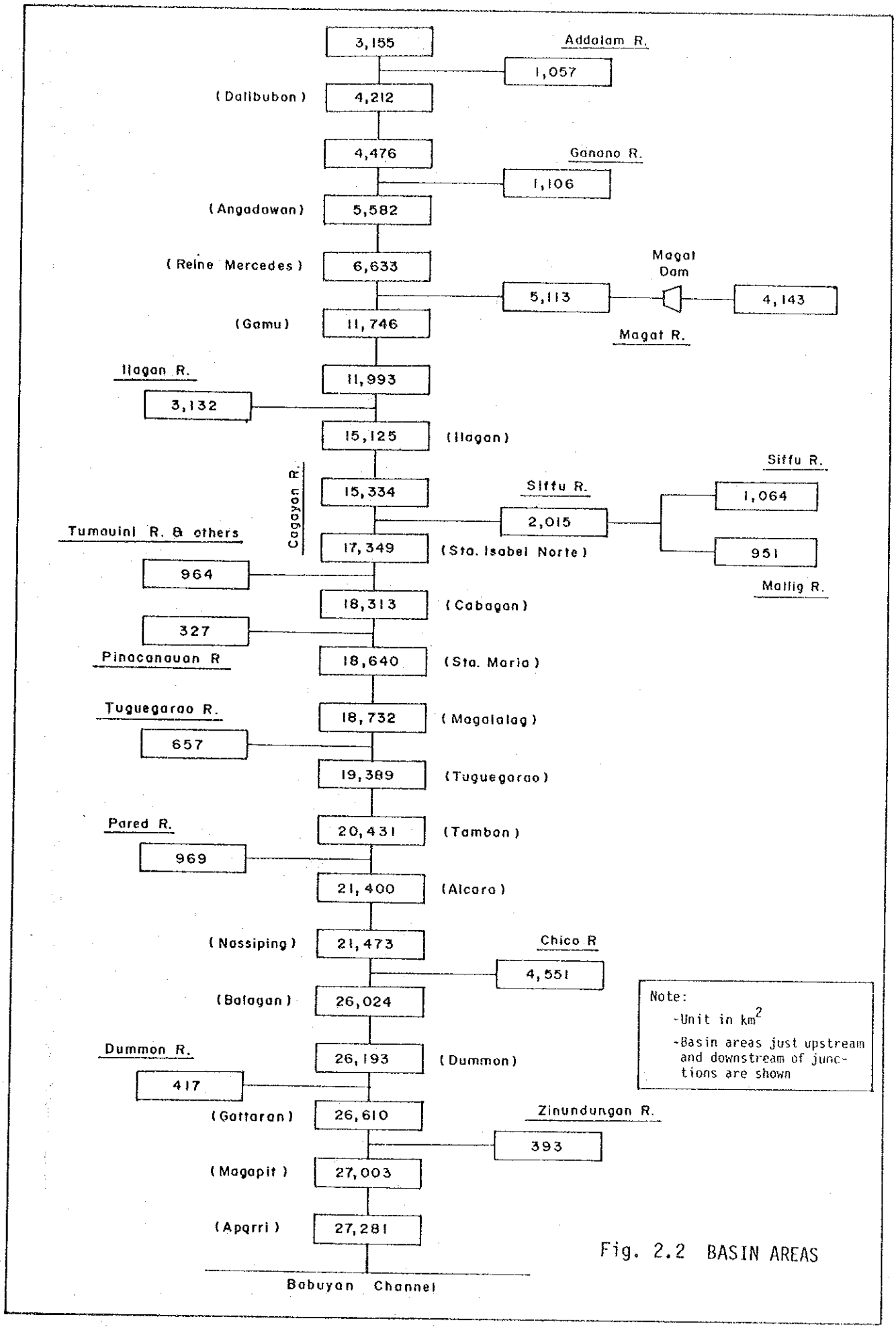


Fig. 2.2 BASIN AREAS

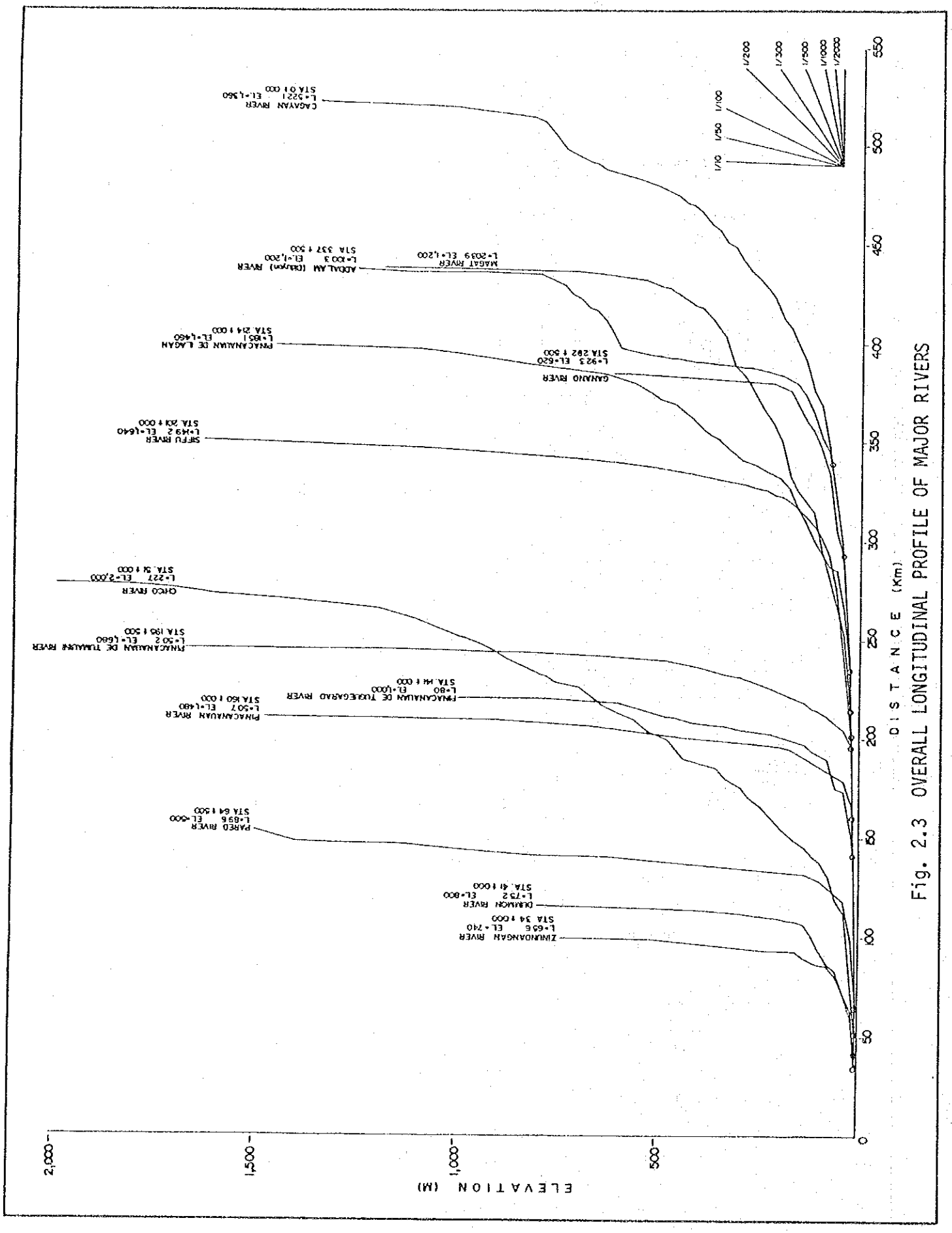


Fig. 2.3 OVERALL LONGITUDINAL PROFILE OF MAJOR RIVERS

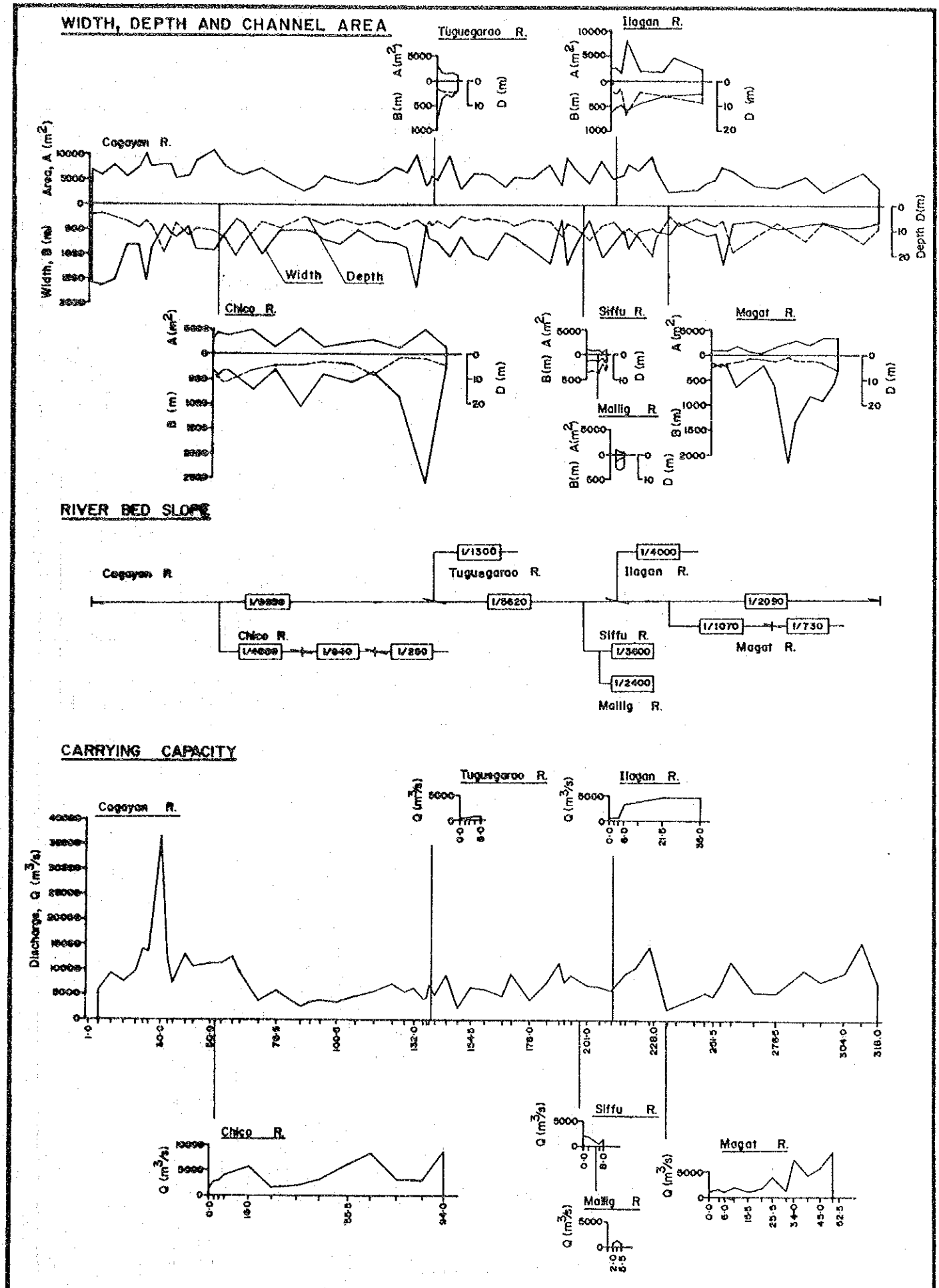


Fig. 2.4 CHARACTERISTICS OF EXISTING RIVER CHANNELS

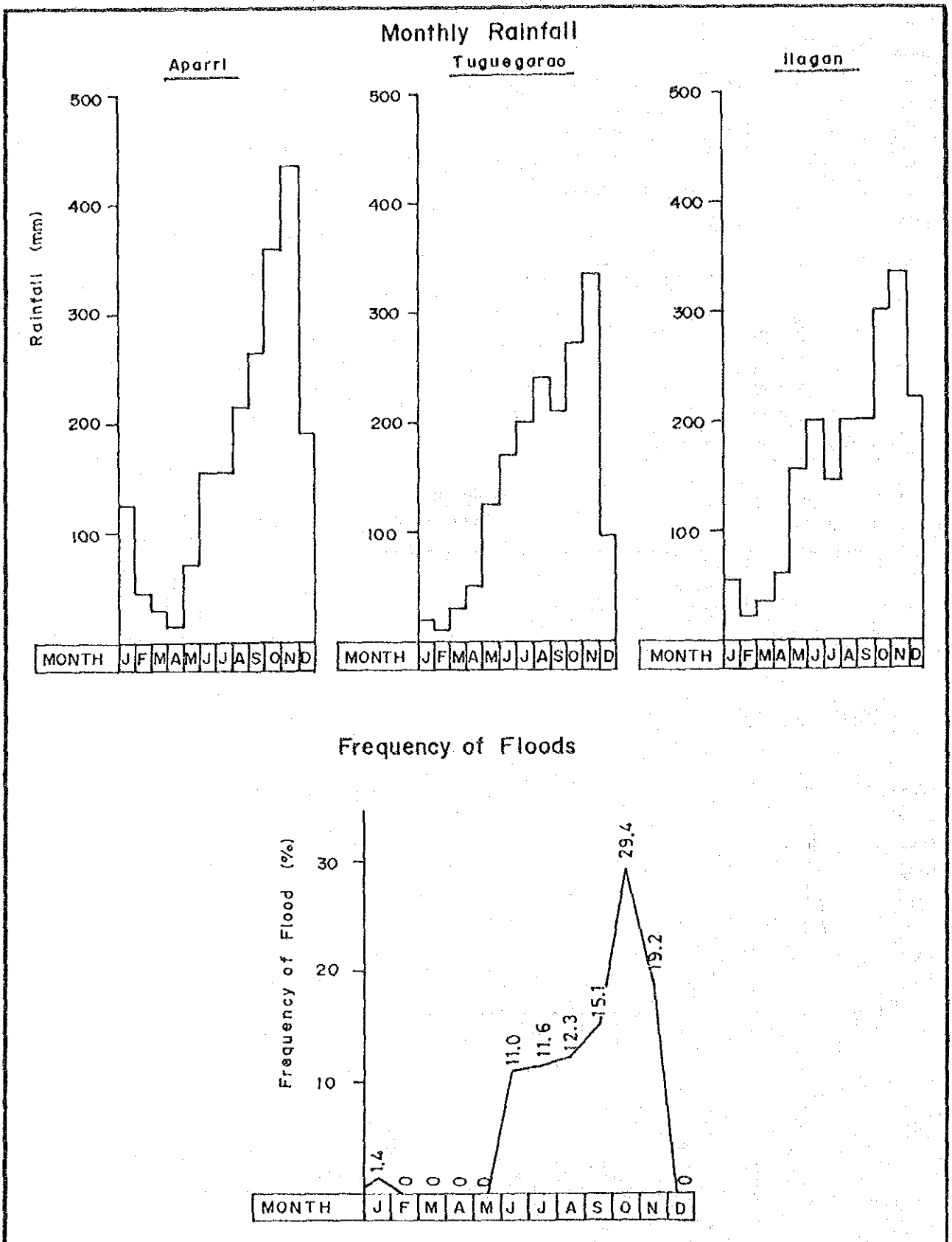


Fig. 2.5 MONTHLY RAINFALL AND FREQUENCY OF FLOODS

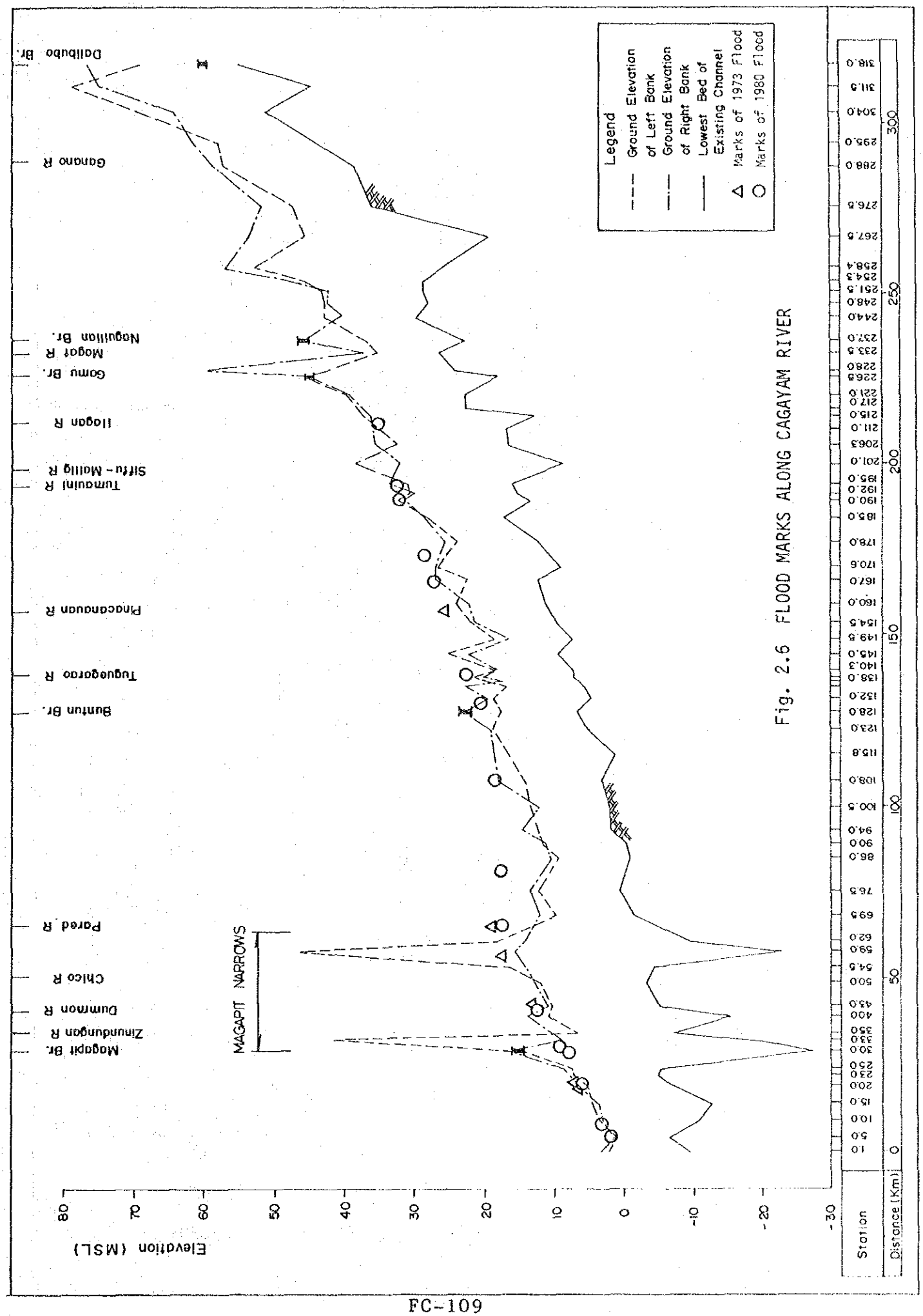


Fig. 2.6 FLOOD MARKS ALONG CAGAYAM RIVER

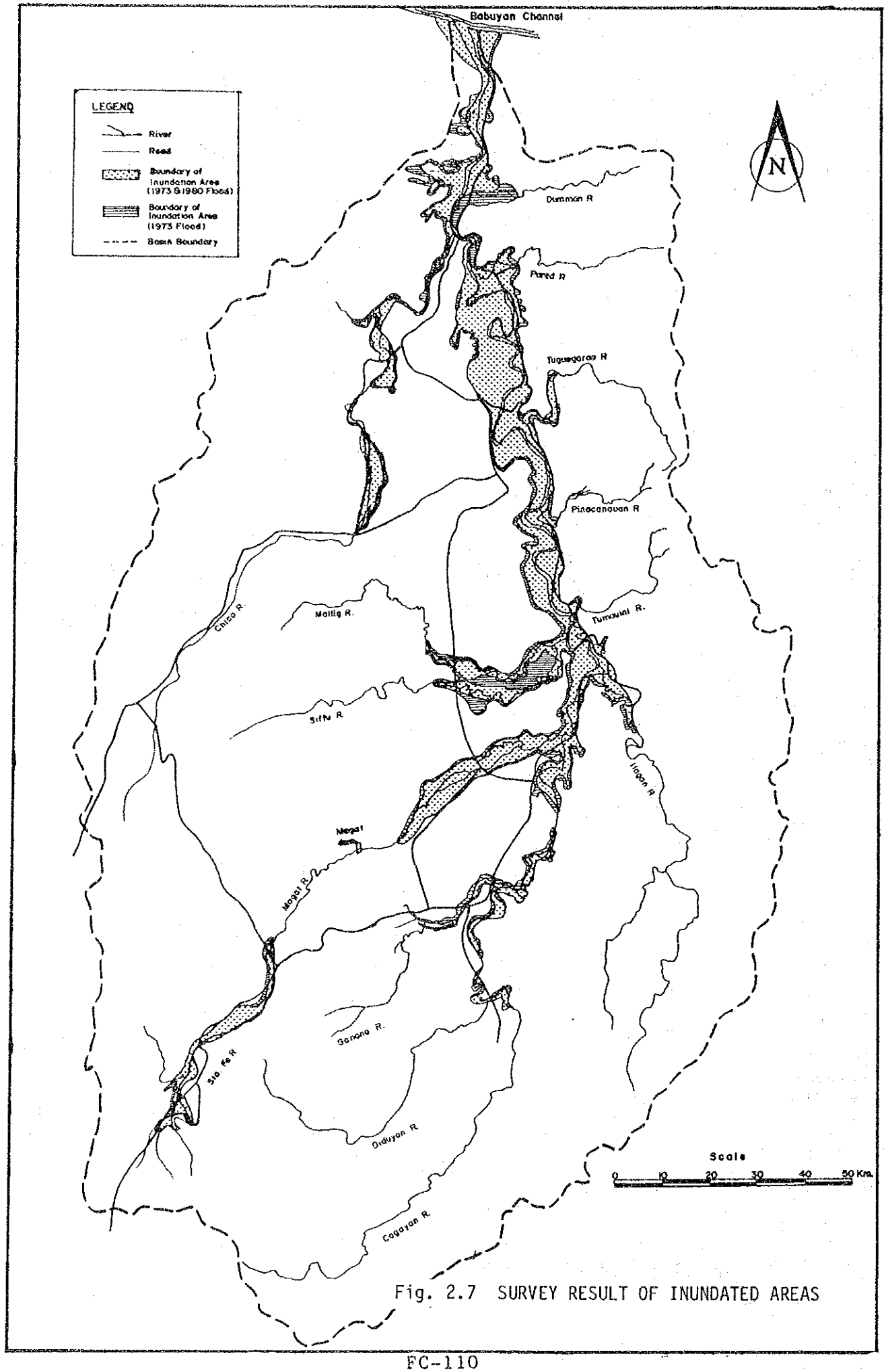


Fig. 2.7 SURVEY RESULT OF INUNDATED AREAS

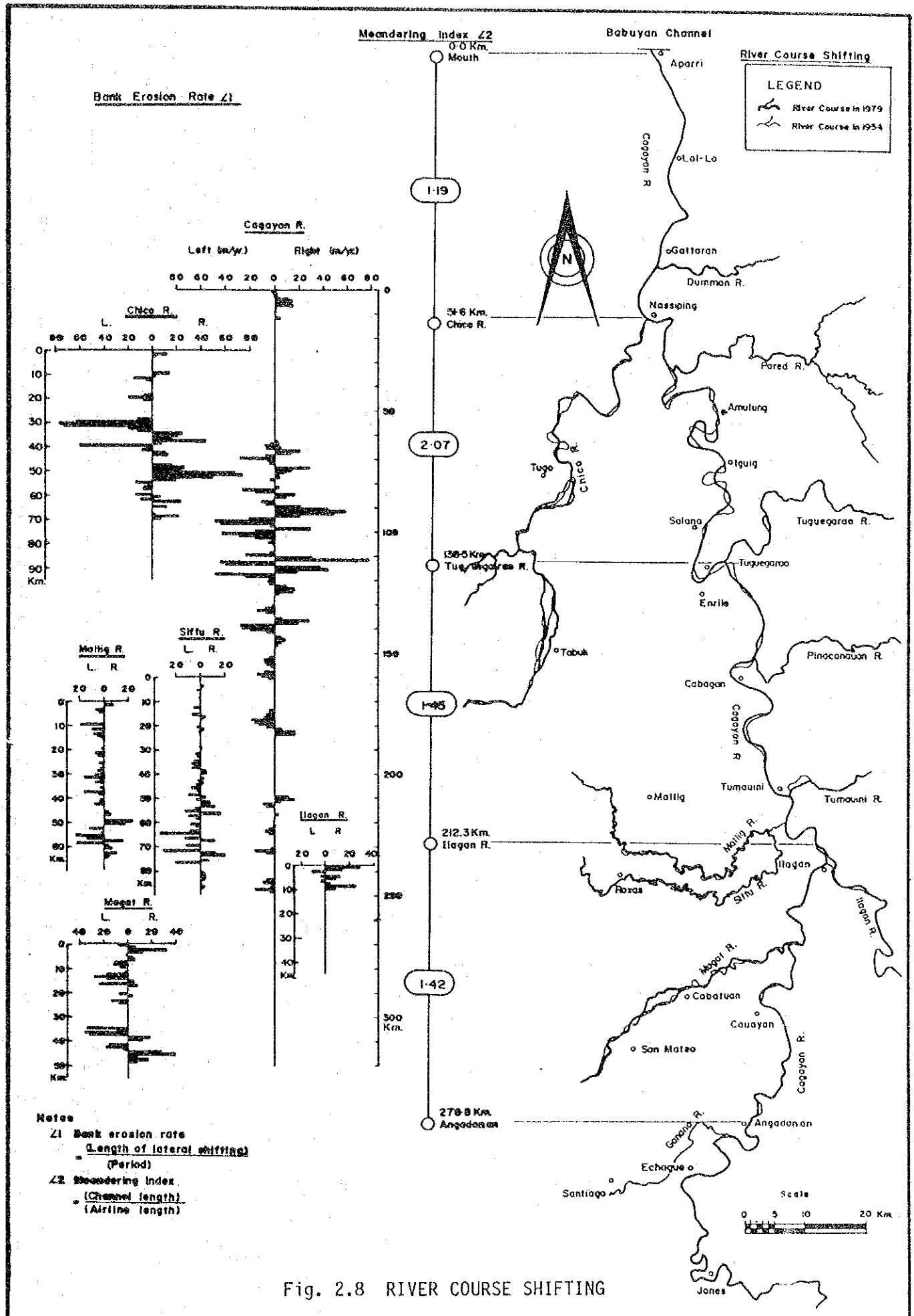


Fig. 2.8 RIVER COURSE SHIFTING

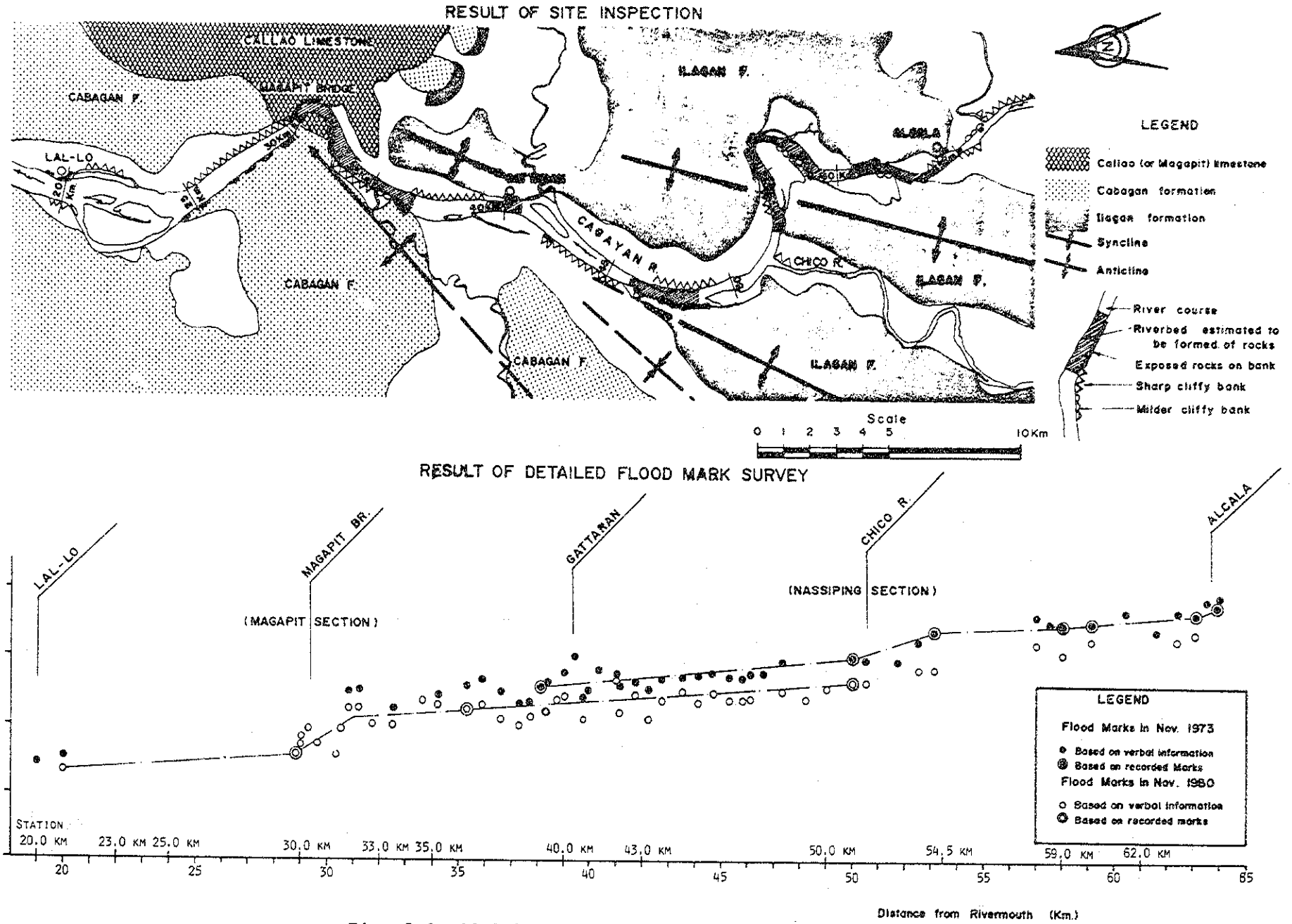


Fig. 2.9 CONDITION OF MAGAPIT NARROWS

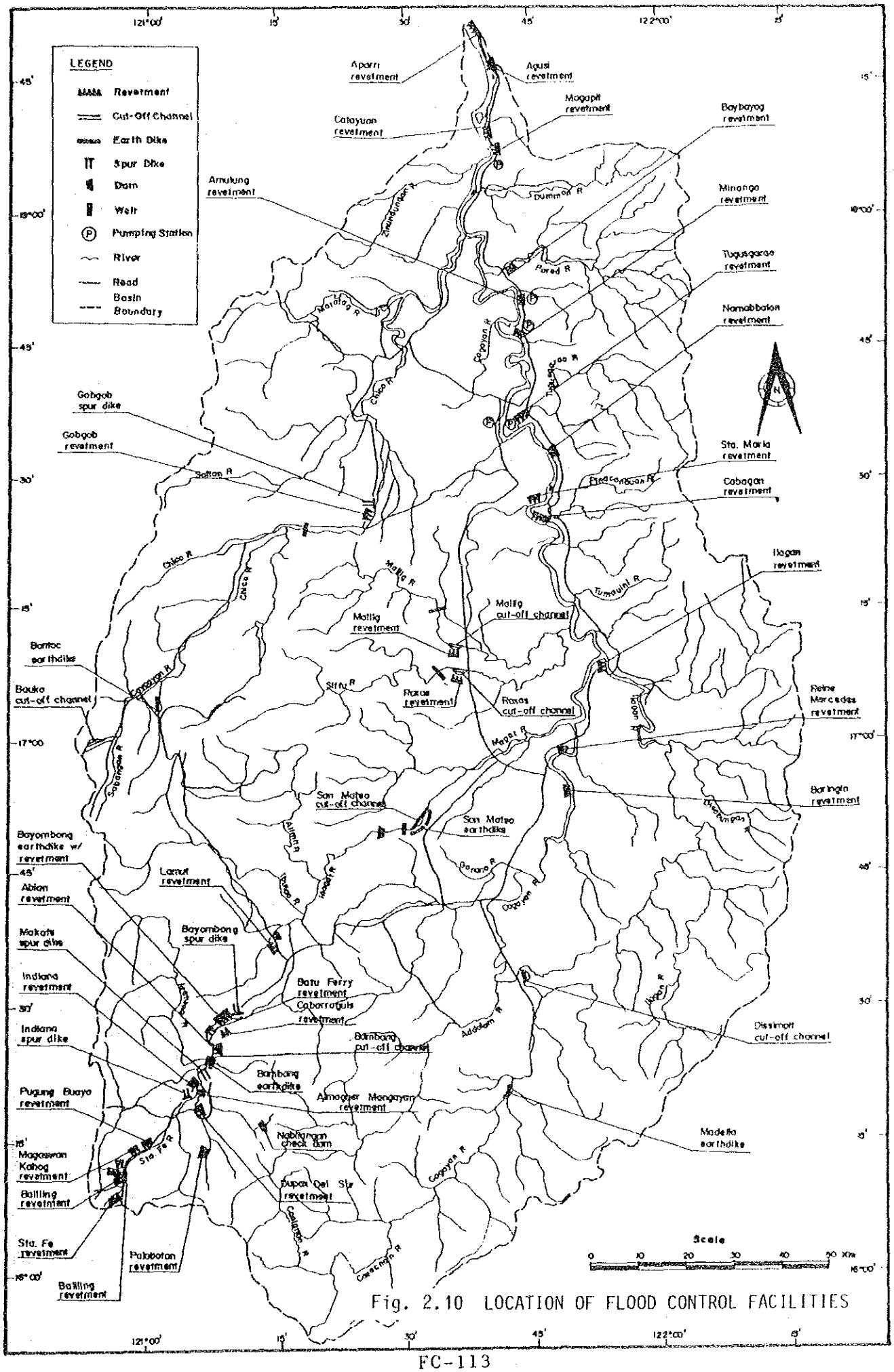


Fig. 2.10 LOCATION OF FLOOD CONTROL FACILITIES

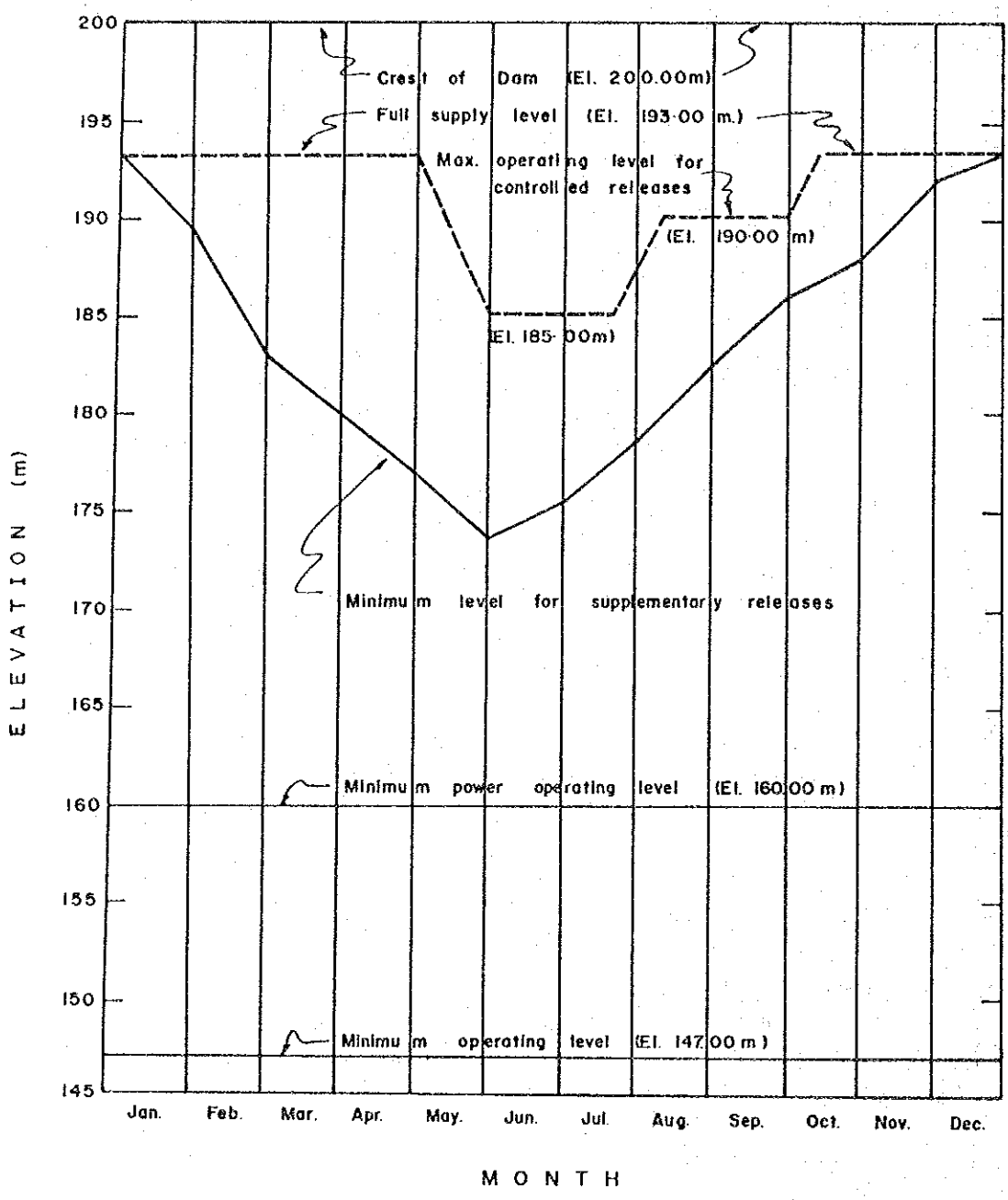


Fig. 2.11 MAGAT RESERVOIR OPERATION RULE CURVE

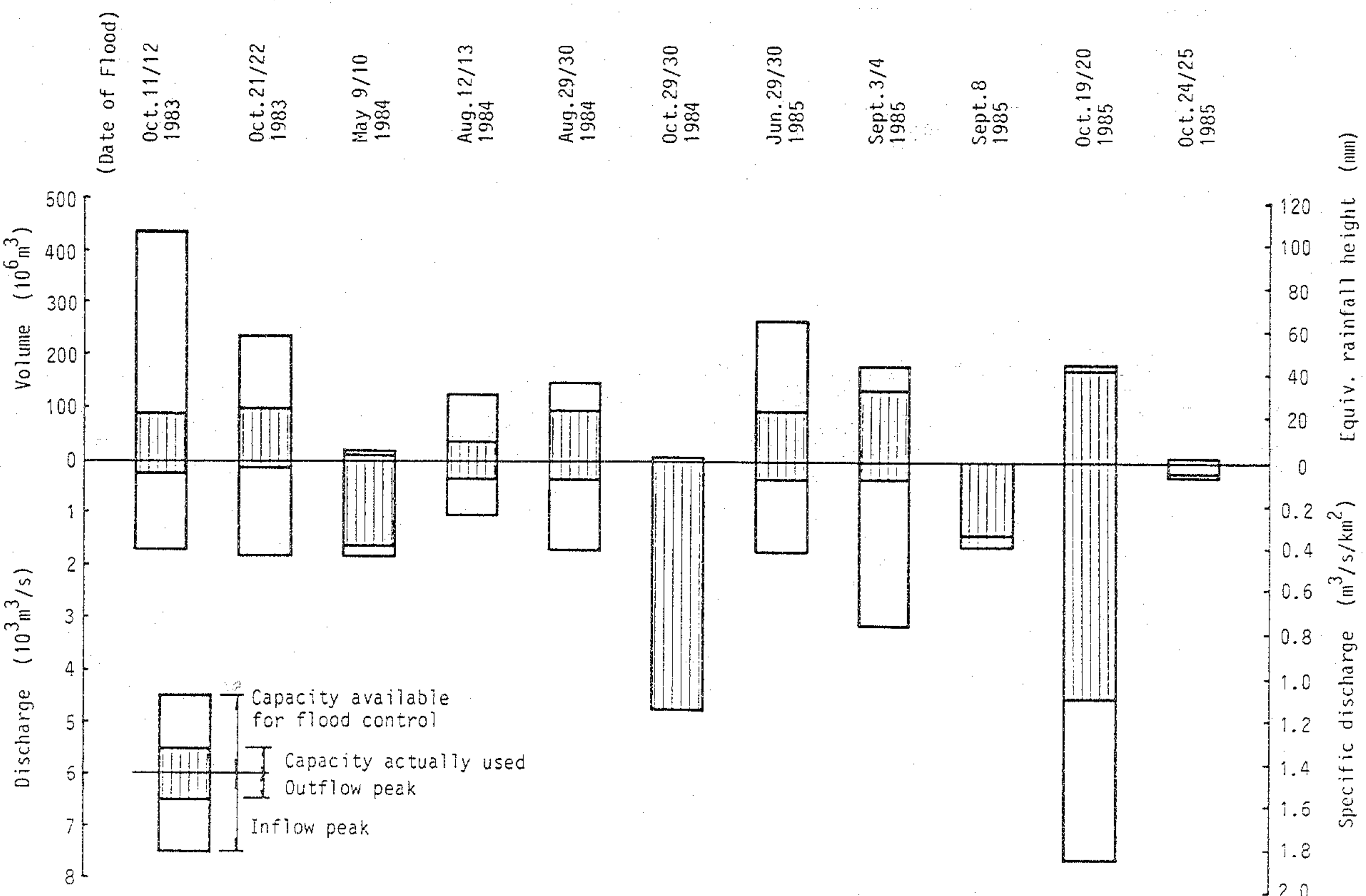


Fig. 2.12 FLOOD CONTROL EFFECTS OF EXISTING MAGAT DAM

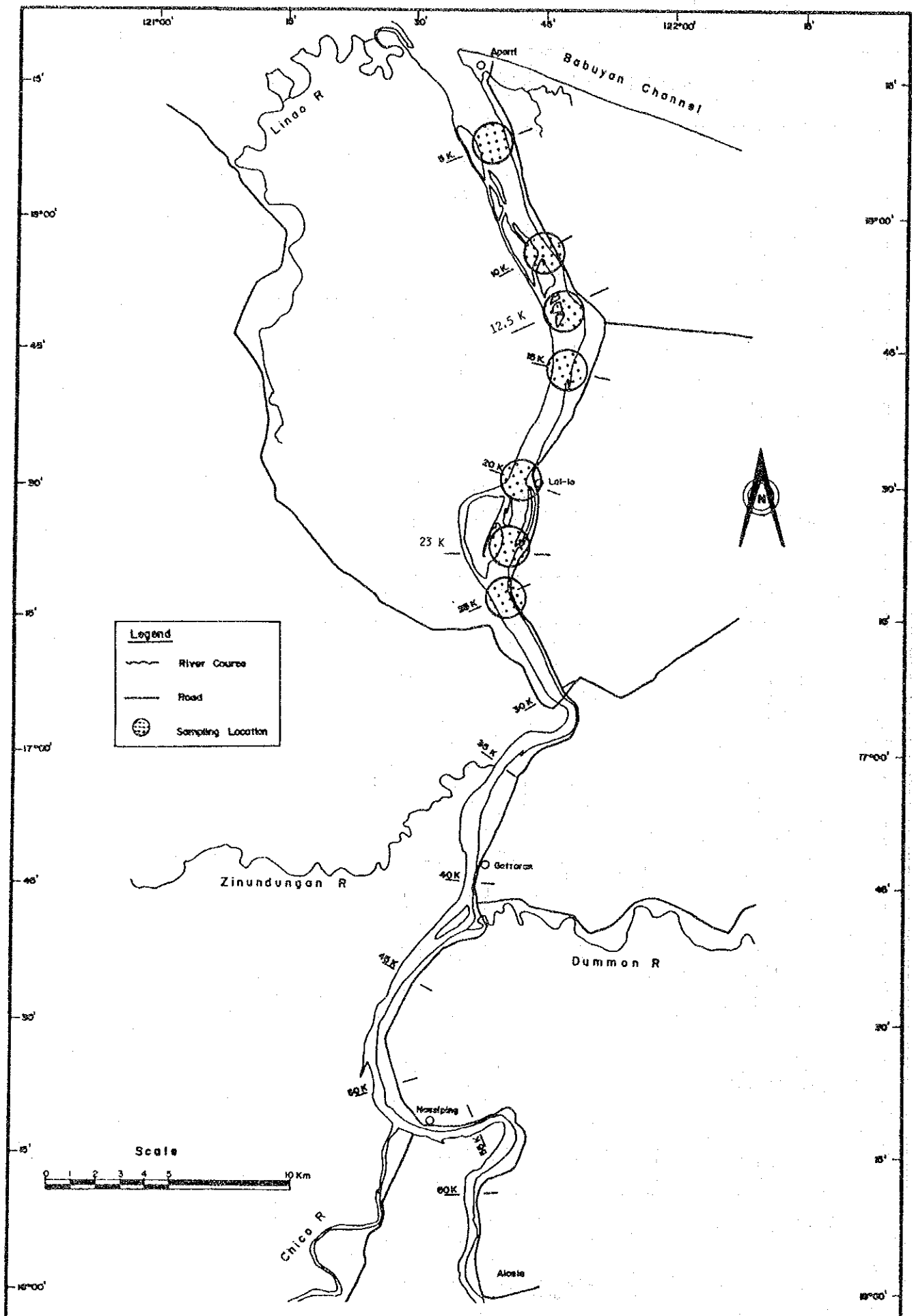


Fig. 2.13 LOCATION MAP OF SALINE WATER INTRUSION SURVEY

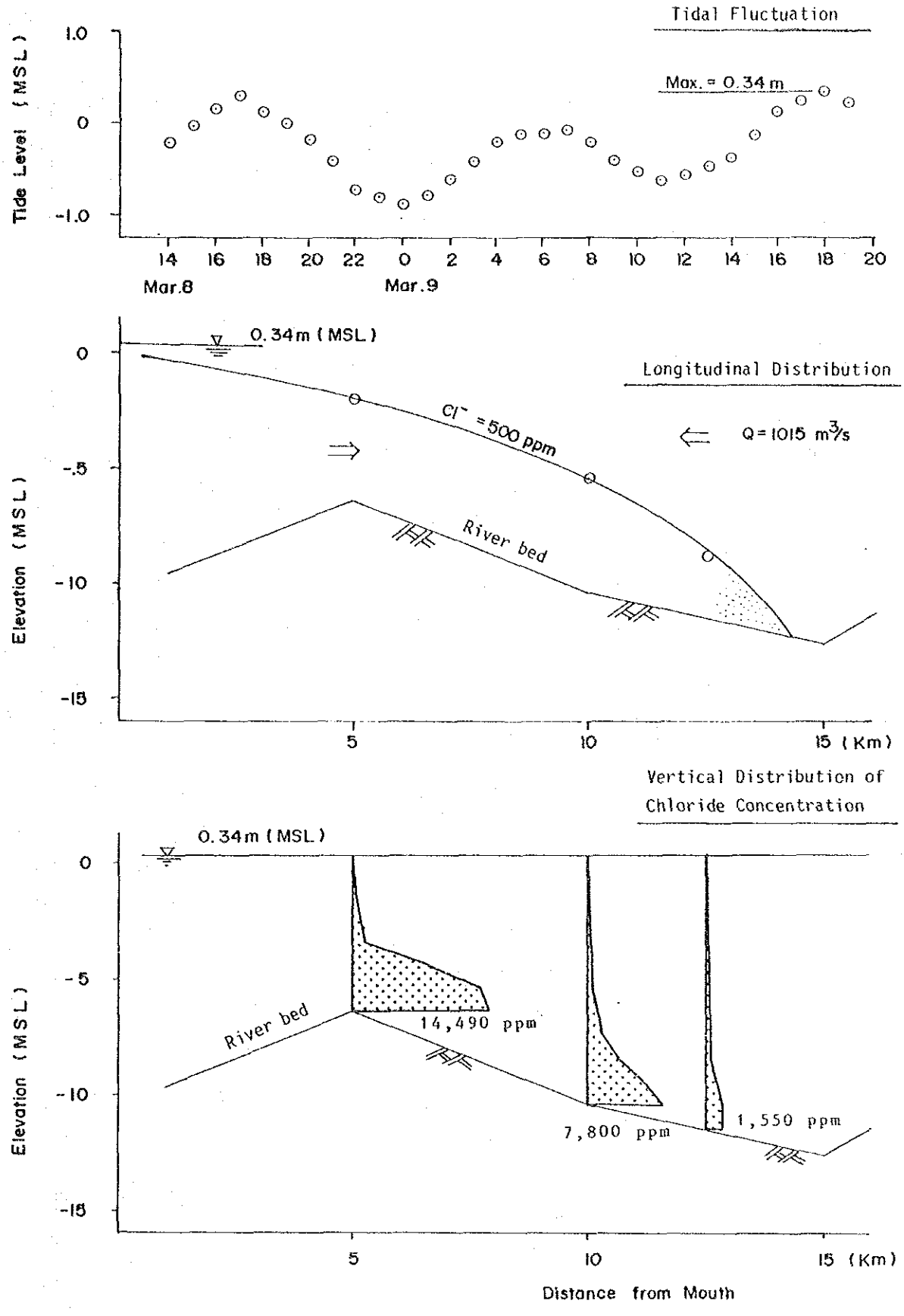


Fig. 2.14 RESULT OF SALINE WATER INTRUSION SURVEY

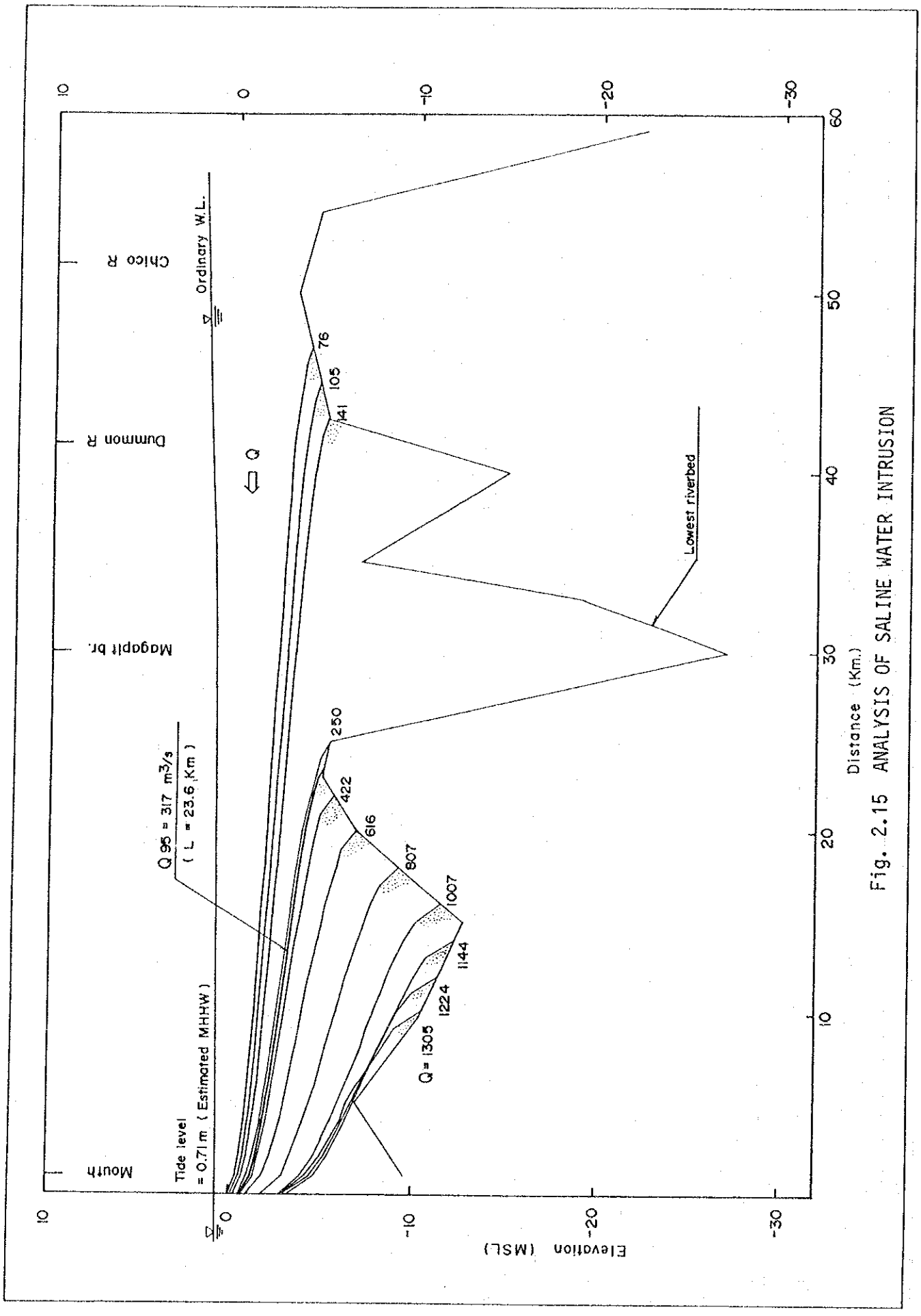


Fig. 2.15 ANALYSIS OF SALINE WATER INTRUSION

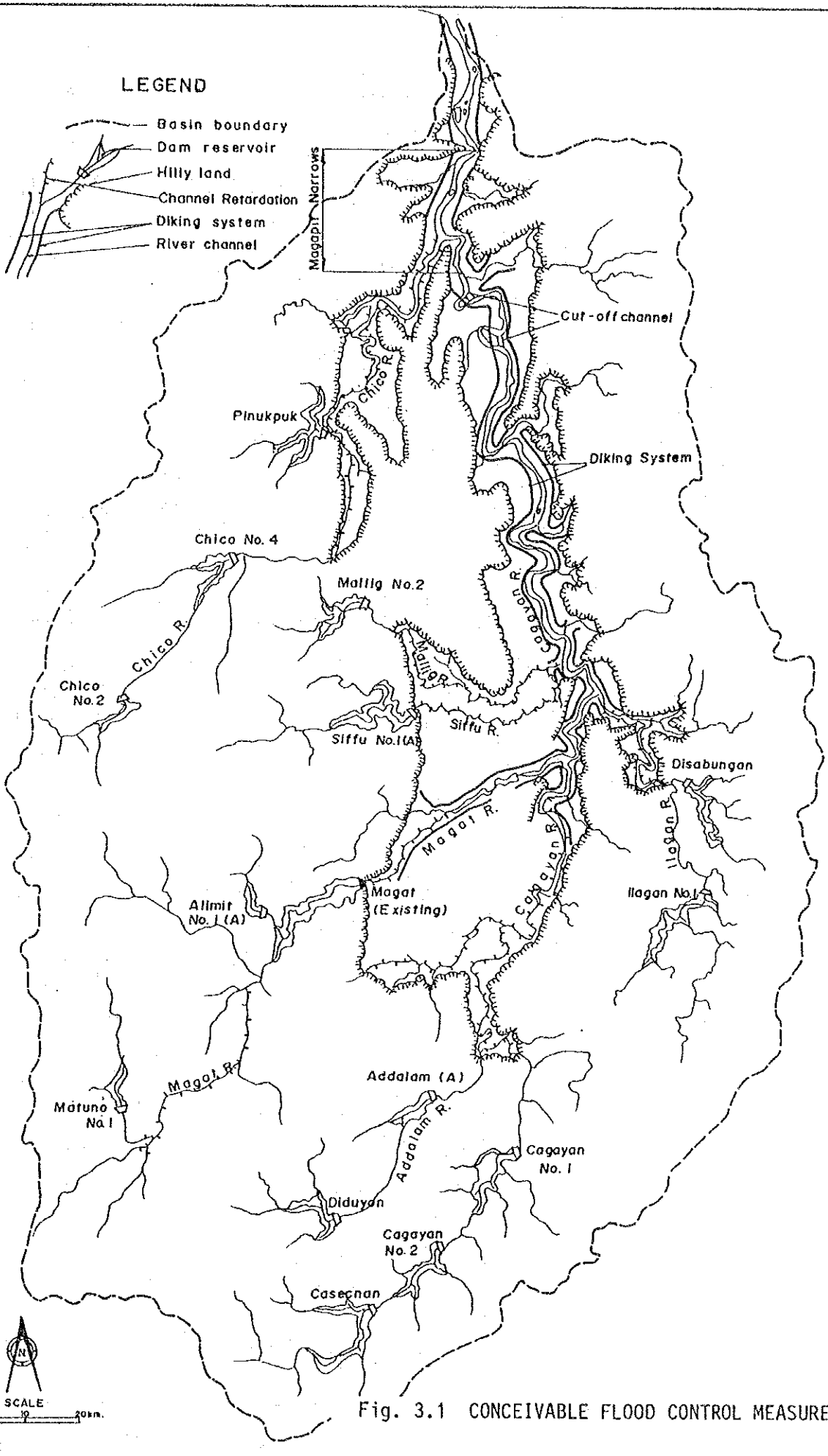


Fig. 3.1 CONCEIVABLE FLOOD CONTROL MEASURES

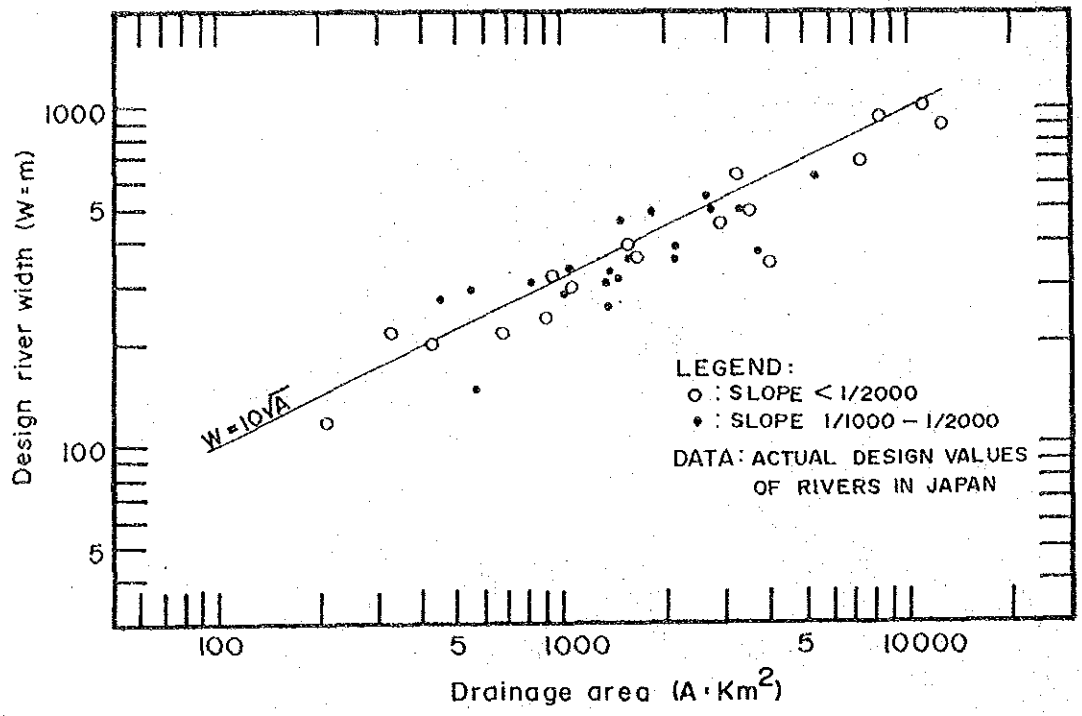
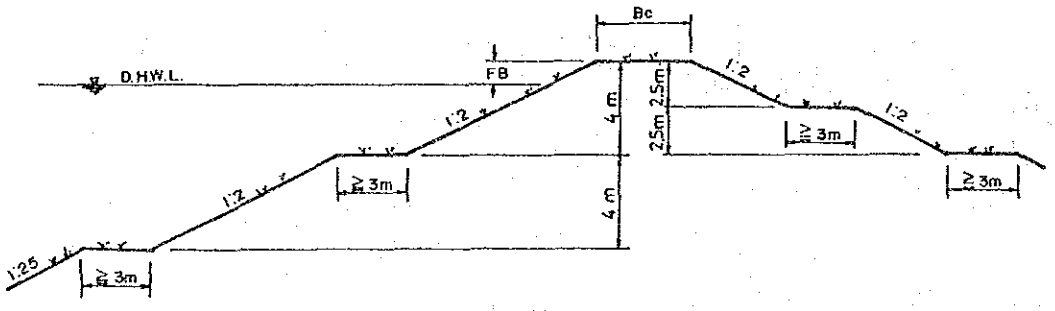


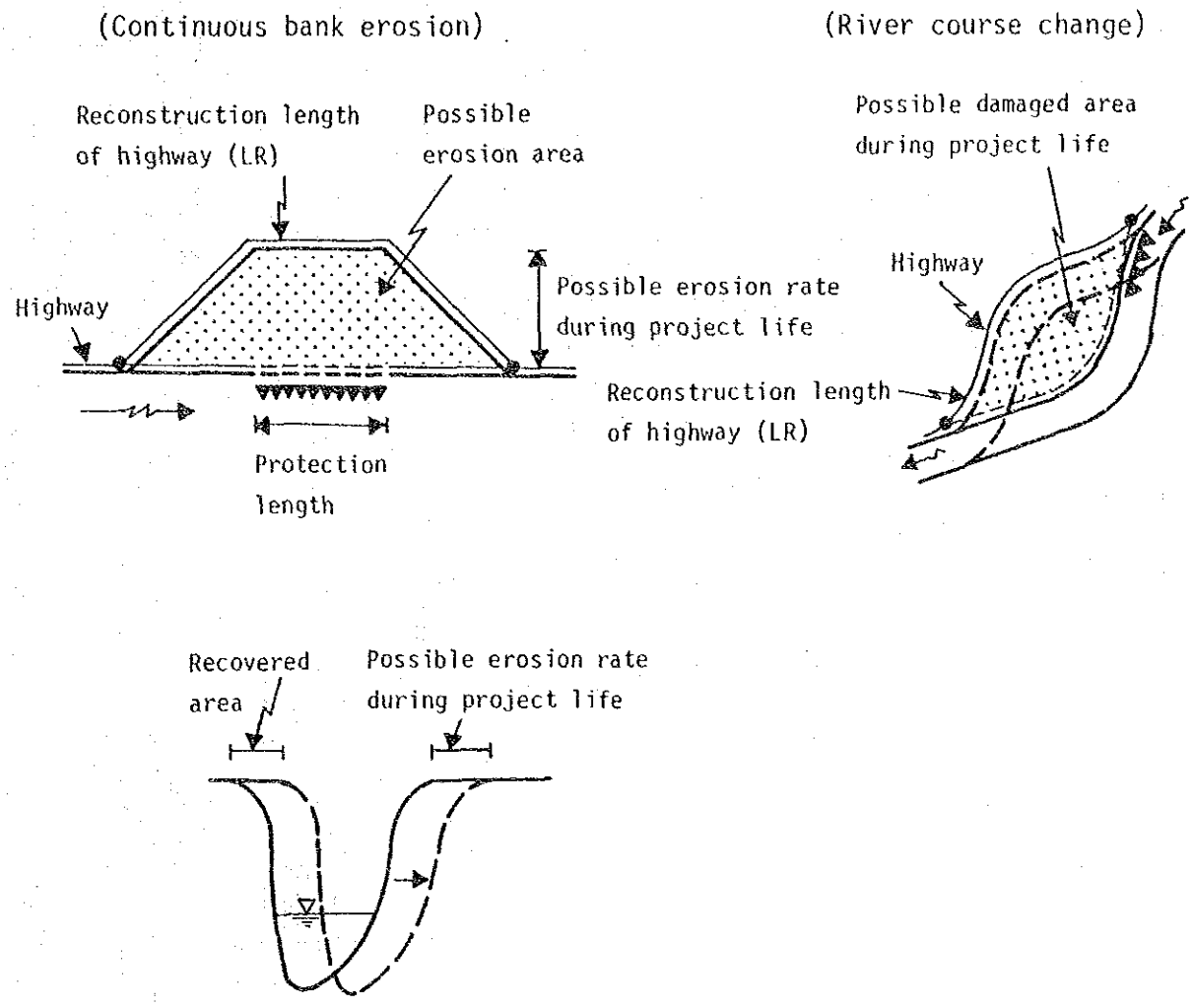
Fig. 3.2 RELATIONSHIP BETWEEN DESIGN RIVER WIDTH AND DRAINAGE AREA



Design Discharge Q (m/3)	Free-board FB (m) not less than	Crown width Bc (m) not less than
< 200	0.6	3
200 to 500	0.8	3
500 to 2,000	1.0	4
2,000 to 5,000	1.2	5
5,000 to 10,000	1.5	6
10,000 <	2.0	7

Fig. 3.3 STANDARD DIKE SECTION

Conseptual Explanation of Terms for
the Assessment of Bank Erosion Damages



Bank erosion damages
- Building damages
- Agricultural damages
- Highway damages
- Loss of residential land

Fig. 3.4 BANK EROSION DAMAGES

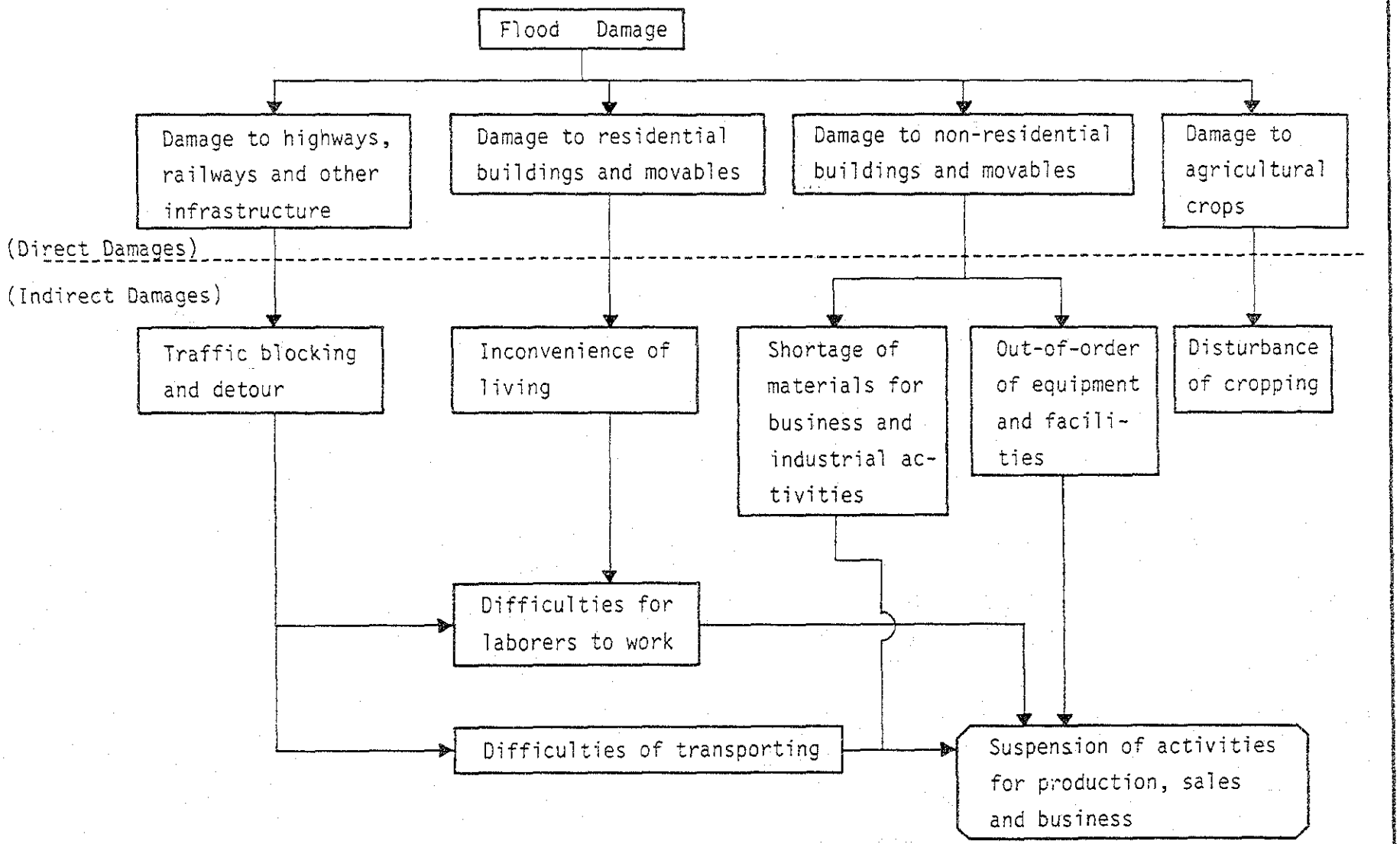


Fig. 3.5 DIRECT AND INDIRECT FLOOD DAMAGES

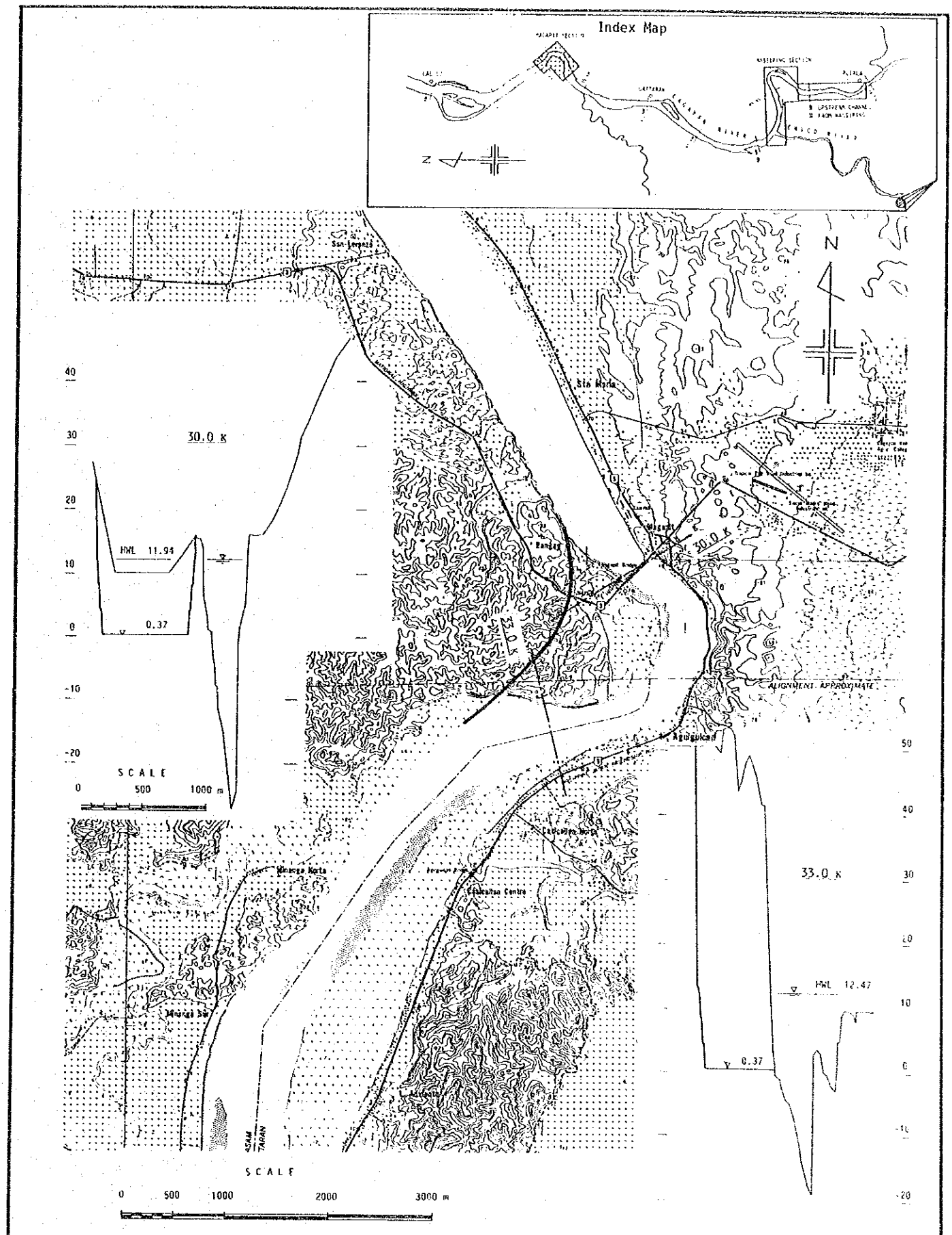


Fig. 4.1 IMPROVEMENT OF MAGAPIT SECTION

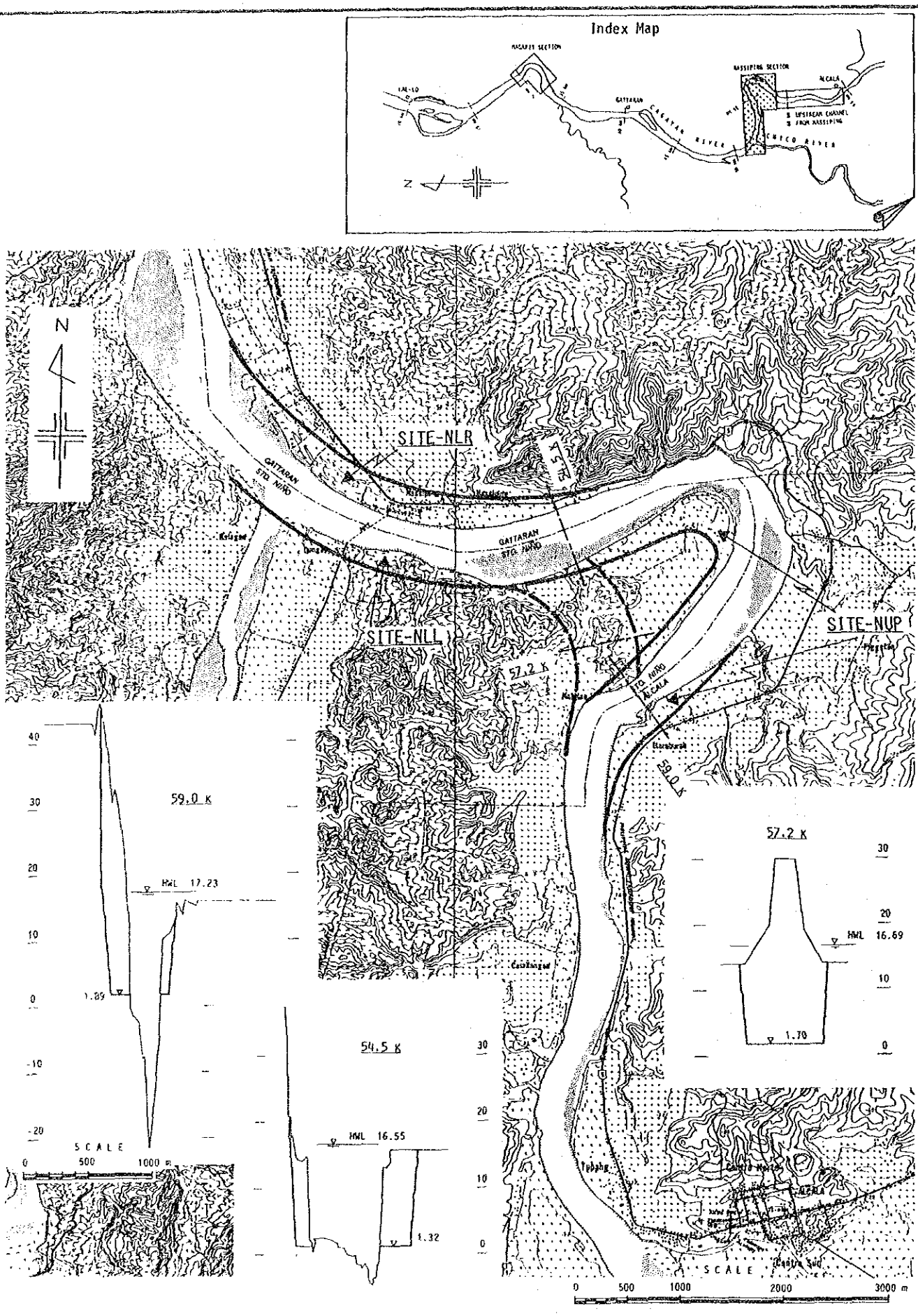


Fig. 4.2 IMPROVEMENT OF NASSIPING SECTION