INTERIM REPORT
OF
FEASIBILITY STUDY
ON
DIDUYON HYDROELECTRIC DEVELOPMENT PROJECT
UPPER CAGAYAN RIVER
THE REPUBLIC OF THE PHILIPPINES

MARCH, 1979

JAPAN INTERNATIONAL COOPERATION AGENCY

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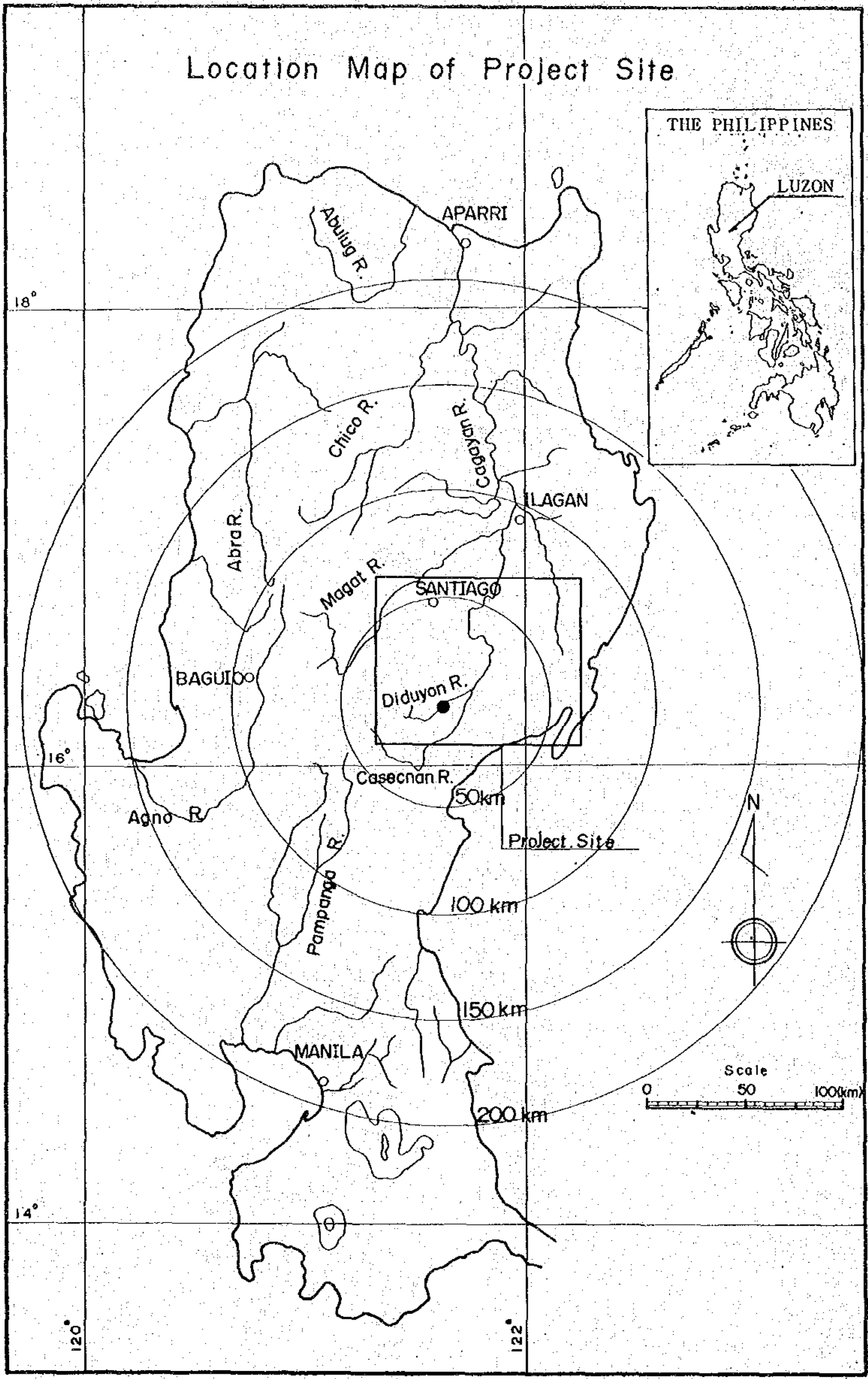
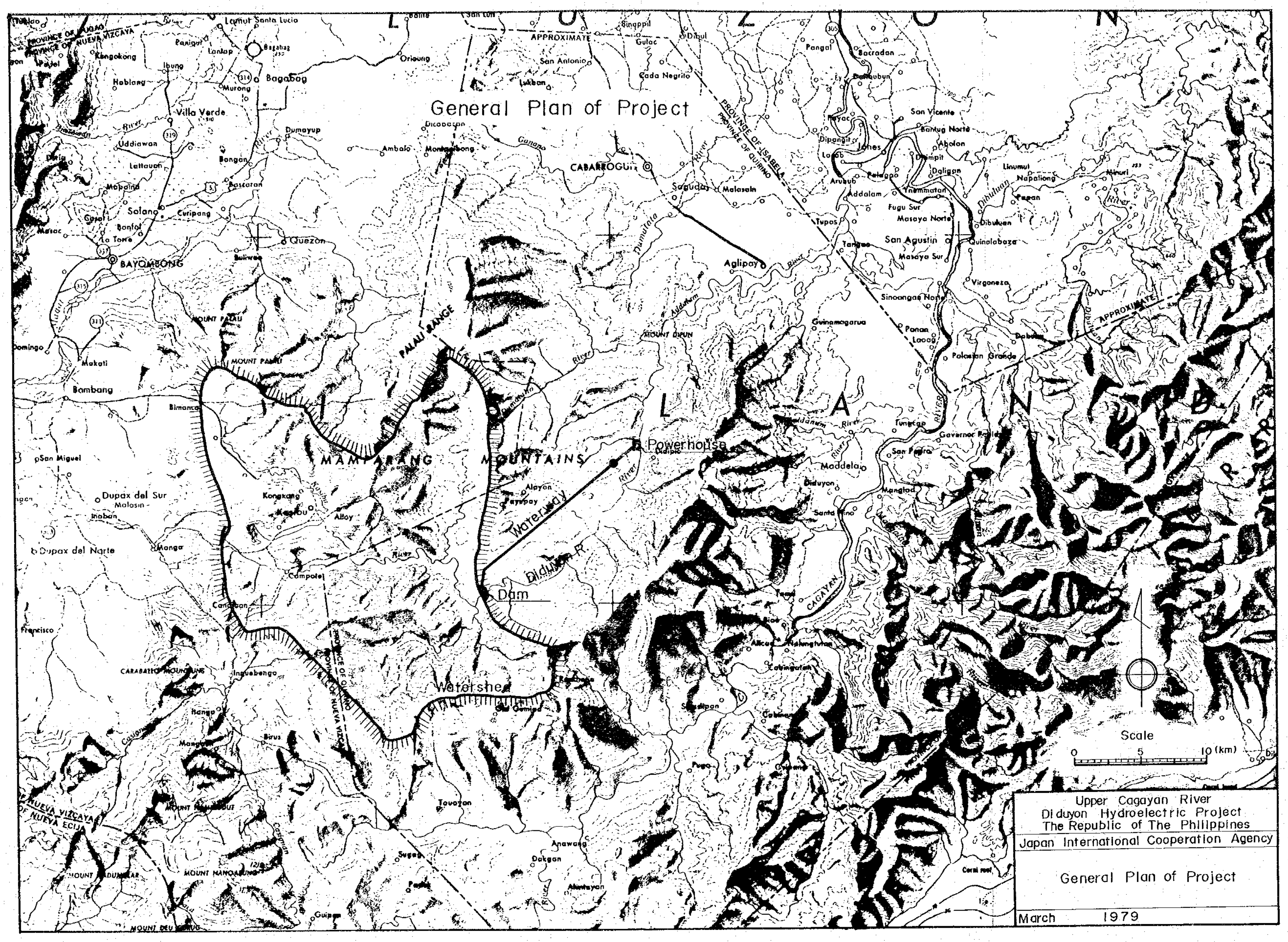
Location Map of Project Site




General Plan of Project
Powerhouse
Waterway
Diduyon R.
Dam
Watershed
MAMPARANG MOUNTAINS
PALALI RANGE
MOUNT PALALI
CARABALLO MOUNTAINS
PROVINCE OF ISABELA
PROVINCE OF QUIRINO
PROVINCE OF NUEVA VIZCAYA
PROVINCE OF NUEVA ECIJA
APPROXIMATE
BAYOMBONG
CABARROGUIS
Bagabag
Villa Verde
Solano
Quezon
Bambang
Dupax del Sur
Dupax del Norte
Aglipay
Saguday
Jones
San Agustin
Maddela
CAGAYAN RIVER
Scale
0 5 10 (km)
Upper Cagayan River
Diduyon Hydroelectric Project
The Republic of The Philippines
Japan International Cooperation Agency
General Plan of Project
March 1979

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U N I T S

mm	millimeter
cm	centimeter
m	meter
km	kilometer
m^2	square meter
km^2	square kilometer
ha	hectare
kg	kilogram
m^3	cubit meter
s or sec	second
t or ton	metric ton
kW	kilowatt
kWh	kilowatt-hour
MW	megawatt
MWH	megawatt-hour
GWH	gigawatt-hour
kV	kilovolt
kVA	kilovolt-ampere
MV	megavolt
MVA	megavolt-ampere
MCM	thousand circular mils
°	degree of angle
°C	centigrade (celsius)
mill	U.S. mill
$	U.S. dollar
₱	Philippine Peso
EL	the height above mean sea level
H.W.L.	high water level
L.W.L.	low water level
T.W.L.	tail water level
kPh	kilometer per hour
ppm	part(s) per million

1. Introduction

1.1. Authorization

Early in 1978, the Government of the Philippines requested from the Japanese Government technical assistance to carry out the feasibility study of the Upper Cagayan River Hydroelectric Power Project focussed on the Diduyon Site.

In response to the request, the Japanese Government has decided to provide the technical assistance, and the Japan International Cooperation Agency (JICA), the official agency responsible for the implementation of technical cooperation programs of the Japanese Government, has organized a study team to carry out the proposed study.

1.2. Objective and Scope of the Study

1.2.1. Objective of the Study

The Diduyon Site is located accross the Diduyon River which constitutes the upper stream of the Addalam River, a tributary of the Cagayan River, the largest river in Luzon Island flowing south to north in Northern Luzon.

The objective of the study is to define the optimum development plan of the Diduyon Site and prepare the feasibility design thereof.

1.2.2. Scope of the Study

The feasibility study of the Diduyon Project is to be carried out into the three (3) stages:

a) 1st Stage

i) Field reconnaissance, gathering of relevant data and discussions with the authorities concerned of the

Philippine Government.

ii) Examinations of gathered data and information.

iii) Comparative analyses of project development plans based on the ii).

iv) Programming of geological explorations.

v) Production of aerographic survey maps.

vi) Installation of hydrologic observation stations and start of hydrologic observations.

b) <u>2nd Stage</u>

i) Execution of geologic explorations.

ii) Production of ground survey maps.

iii) Continuation of hydrological observations.

c) <u>3rd Stage</u>

i) Review of comparative analyses of development plans based on the topographic maps, geologic explorations and hydrologic data completed at the previous stages.

ii) Feasibility design of the optimum development plan of the project including project development programming and cost estimates.

iii) Financial and economic analyses and environmental study of the optimum plan of the project.

1.3. Contributions of Both Governments of the Philippines and Japan

1.3.1. Division of Technical Undertakings in Carrying out the Study

The division of technical undertakings by the Governments of the Philippines and Japan was discussed between the executing agency of the Philippine Government, National Power Corporation (NAPOCOR) and the JICA Study Team on July 10, 1978 in Manila and was agreed on as per Table 1-1.

1.3.2. Contribution of the Philippine Government

For the smooth execution of field studies, the JICA Study Team will be provided with the following facilities and assistance;

a) Providing data and information for the study, including data to be obtained from other authorities concerned.

b) Assuring freedom and safety for the study

c) Office space

  i) Manila

    1. permission to use the Manila Office of the New Japan Engineering Consultants, Inc. (NEWJEC) for the Abulug Project

  ii) Site

    1. provision of office with floor space of 30 m^2 at the dam site

    2. provision of similar office on the powerhouse site

d) Lodging accommodation

  i) initial field investigation for 45 days and surveying for 4 months provision of temporary houses adequate to accommodate about 8 persons of Japanese experts each at the dam site and the powerhouse site including free services of cooking and washing, supply of kitchen utensils, lavatory and furniture.

ii) second field investigations for a period of 4th to 8th month;

provision of lodging houses to accommodate 4 persons of Japanese experts each at the dam site and the powerhouse site at the rate of one for each person with kitchen, lavatory, bathroom, furnitures and refrigerator including free services of cooking, washing and assistance in procurement of food.

e) Local transport in the Philippines during the period of field investigations

i) provision of transport facilities in Manila, between Manila and the site, and at the site

ii) provision of helicopter services between Manila and the site for total estimated days of use (6 days) for emergency use

iii) Arrangement of boats at the site as and when needed

f) Temporary warehouse at the site

i) second field investigations;

provision of temporary warehouse of 35 m^2 space near the site office for storage of seismic prospecting devices, surveying instruments and other necessary goods for investigations.

g) Temporary facilities for field investigations

i) provision of temporary facilities for field investigations such as magazine

h) Free access and use of land required by the JICA Study Team in performing the study

i) free access and use of lands at seismic prospecting area, boring site, places for sampling of soil materials, and surveying area.

i) Installation of Xerox machine at the Manila office of NEWJEC

i) Installation of Xerox machine at the Manila Office of NEWJEC

j) Radio-phone facilities from NAPOCOR to the project site

i) provision of radio-phone facilities from NAPOCOR to the project site during the periods of initial and second field investigations.

ii) provision of messenger boys instead of radio-phone facilities only in the period of initial field investigations in case the radio-phone facilities are not ready in time.

k) Customs clearance, etc.

i) customs clearance, handling and storage at the port/ airport and inland transportation in the Philippines of equipment, machines, instruments, tools and other articles brought into the Philippines for performance of the study and personal use.

l) Support by NAPOCOR counterpart personnel

1 project coordinator
2 civil engineers
1 surveyor
1 geologist
1 expert in environment
1 agronomist

1 transmission engineer

1 economist

1 assistant supervisor for seismic prospecting

1 drilling supervisor

1 test aditting supervisor

1 soil expert

1.4. Formation of the JICA Study Team

a)	Mr. Masatoki Ikeda (Team Leader)	Manager, Civil Engineering Dept. the New Japan Engineering Consultants, Inc.(NEWJEC), Osaka, Japan
b)	Mr. Mitsuru Suemori (Coordinator)	Staff Member, Natural Resources Survey Division, Japan International Cooperation Agency (JICA), Japan
c)	Mr. Yoshihiro Chiaki (Civil Work)	Hydro Power Civil Engineer, NEWJEC, Osaka, Japan
d)	Mr. Motoyuki Doi (Civil Work)	Hydro Power Civil Engineer, NEWJEC, Osaka, Japan
e)	Mr. Takumi Kochi (Transport)	Civil Engineer, NEWJEC, Osaka, Japan
f)	Mr. Hideo Yugeta (Geology)	Geologist, NEWJEC, Osaka, Japan
g)	Mr. Taikichi Shuku (System Planning & Economics)	Power System Planner, NEWJEC, Osaka, Japan
h)	Mr. Yoshiro Sekimura (Transmission)	Transmission Engineer, NEWJEC, Osaka, Japan
i)	Mr. Naohiko Deguchi (Environment)	Ecologist, NEWJEC, Osaka, Japan
j)	Mr. Zenzaburo Yamaguchi (Agriculture)	Agronomist, NEWJEC, Osaka, Japan
k)	Mr. Yasuo Yoshino (Aerographic Survey Supervision)	Surveyor, NEWJEC, Osaka, Japan
l)	Mr. Tadashi Shibata (Drilling Supervision)	Drilling Supervisor, NEWJEC, Osaka, Japan

m) Mr. Satoru Murakami (Material Test Supervision) — Soil Expert, NEWJEC, Osaka, Japan

n) Mr. Shinsuke Kawazato (Seismic Prospecting Supervision) — Seismic Prospecting Expert, NEWJEC, Osaka, Japan

Table 1-1 Division of Undertakings by the Philippines and Japan

Working Item	Japan	Philippines (thru NAPOCOR)
1. Drilling work and permeability test	1. Selection of drilling locations 2. Preparation of drilling spec. 3. Supervision of drilling works 4. Geological assessment of boring cores	1. Procurement, transport and erection of drilling machines 2. Drilling work and permeability test 3. Removal of drilling machines after finish of field operations 4. Arrangement of core and preparation of boring log
2. Seismic prospecting	1. Programming 2. Identification of locations and areas for seismic prospecting on maps and in the field 3. Free lending of devices 4. Field supervision 5. Analysis of seismic exploration	1. Carrying out of seismic prospecting including provision of technicians and laborers and explosives and necessary topographic surveying 2. Recording of measurement results
3. Test aditting	1. Programming 2. Identification of locations on maps and in the field 3. Preparation of spec. 4. Geological assessment	1. Carrying out of test aditting including provisions of explosives, necessary survey, selection of contractor, supply of consumables, maintenance and repairs, supply of spare parts, disposal of spoil and supply of timbering

Working Item	Japan	Philippines (thru NAPOCOR)
4. Laboratory soil test	1. Programming 2. Identification of locations for sampling on maps and in the field 3. Preparation of spec. 4. Supervision of soil test 5. Analysis of data	1. Sampling and transport of sampled materials to the laboratory. 2. Carrying out of laboratory test 3. Recording of test results 4. Transmittal of test results to the JICA Study Team
5. Preparation of geological maps	1. Determination of area to be included in geological maps on maps and in the field 2. Preparation of spec. for geological maps 3. Geological assessment based on geological maps 4. Additional field reconnaissance 5. Final geological assessment after finish of field geological explorations	1. Detailed field reconnaissance 2. Preparation of geological maps
6. Aerographic survey and mapping (1/10,000, 1/1,000)	1. Programming 2. Determination of area 3. Preparation of spec. 4. Decision of control points and important points by dispatch of one expert for 4 months 5. Supervision of aerographic survey and mapping	1. Preparation of working plan 2. Collection of available aerophotos 3. Survey of control points 4. Management of progress of survey of control points 5. Setting of control points 6. Photographing 7. Aerial triangulation 8. Mapping

Working Item	Japan	Philippines (thru NAPOCOR)
7. Trench excavation	1. Programming 2. Determination of locations 3. Preparation of spec. 4. Geological assessment after finish of trench excavation	1. Carrying out and supervision of trench excavation
8. Ground survey	1. Programming 2. Determination of locations 3. Preparation of spec.	1. Carrying out of ground survey 2. Production of survey maps
9. Additional hydrological observations	1. Selevtion of site for installation of water level recorder 2. Selection of five sites for installation of railfall gauge 3. Preparation of discharge gauging (sites, method and time interval) 4. Planning of sediment discharge measurement	1. Procurement and installation of water level recorder and railfall gauge 2. Observation and recording of water level and railfall 3. Discharge observation 4. Survey of river cross section 5. Preparation of rating curve 6. Measurement of sediment discharge
10. Agricultural investigation	1. Field survey on agricultural activities in the proposed reservoir area 2. Preliminary plan on resettlement program 3. Feasibility on expansion of irrigable area by utilizing the droughty year discharge increased by the dam construction of the Project 4. Field survey on irrigable area 5. Investigations on benefits of irrigation	1. Assistance in collection of necessary data and information 2. Execution of soil tests for agricultural investigation

Working Item	Japan	Philippines (thru NAPOCOR)
11. Environmental assessment	1. To clarify environmental impacts arising from the development of the Project 2. Study on unfavorable environmental impacts 3. Countermeasures against the avoidable impacts from among unfavorable environmental impacts 4. Study on unavoidable environmental impacts 5. Data collection required for environmental assessment 6. Study and analysis	1. Assistance in collection of necessary data and information 2. Execution of water quality tests sampled by the JICA Study Team

2. Summary of 1st Stage of the Study Achieved by the End of March, 1979

In carrying out the study, JICA entrusted NEWJEC with the organization of the Study Team. The first mission of the Study Team consisting of eleven (11) experts was dispatched to the Philippines for a period of fortyfive (45) days from July 6, 1978 to August 19, 1978 and made field reconnaissance and gathered relevant data and information during their stay in the Philippines.

After their return to Japan, the Study Team carried out preliminary office comparative analyses of project development plans based on the field reconnaissance and the gathered data and information and formulated a program for the subsequent field investigations of viable plans of the project screened out by the preliminary office analyses.

The second mission of the Study Team consisting of five (5) field investigation supervisors was dispatched to the Philippines in January 16, 1979 to supervise the field investigations which are carried out by the local people in accordance with the program of the field investigations worked out by the Study Team. The field investigations will include the hydrological observations, topographic surveys, seismic prospecting, drilling explorations, test aditting, and material tests for the viable plans of the project.

This interim report discusses the outcome of the 1st Stage of the Study achieved by the Study Team by the end of March, 1979.

2.1. Result of Field Reconnaissance

a) The No.2 Dam Site was recommended to be given priority for the implementation of the project in the Report on Reconnaissance Study of Upper Cagayan River Hydroelectric Development Project prepared by NEWJEC in March, 1978. The reconnaissance of the riverbed gradient, topography and geology on the No.3 Dam Site indicates that this dam site is also viable as the alternative dam site.

b) The logging roads in the project area have been developed more than expected. The field investigation crew will have access to the project sites through the roads, if it is improved adequately.

c) The Study Team could gather information and data concerning the transport plan, transmission line, environmental problems, and agriculture related to the Project, with full supports of NAPOCOR and the authorities concerned of the Philippine Government. Our preliminary study based on the gathered information and data indicates that there are no adverse factors which are serious enough to justify the proposed project being discontinued.

d) The approach, method and assumption to be used for the economic and financial analyses of the Project were discussed between NAPOCOR and the Study Team and were agreed upon each other. And the Study Team could gather basic data necessary for the economic and financial analyses.

e) The aerophotos of the project area which were taken before were found available by the Study Team. Accordingly, the aerophotographing of the project area originally planned was cancelled. Instead, the 1/5,000-scale topographic maps of the sites for the main component structures and adjacent areas to them and the 1/10,000-scale maps of the project area are being produced by the local surveyors employed by NAPOCOR, using the existing aerophotos.

The 1/1,000-scale topographic maps of the sites for the main component structures and adjacent areas to them originally planned by the aerophotographing was changed by the ground photogrammetry in consideration of the survey schedule of this feasibility study.

f) The data and information gathered during the field reconnaissance are listed in Table 2-1.

2.2. Comparative Analyses of Project Development Plans

Based on the result of field reconnaissance and the gathered data and information, the comparative development plans were formulated and the comparative analyses of the plans were carried out. For the comparative analyses of the plans, the existing 1/50,000-scale maps were used instead of the 1/5,000-scale maps of the sites for the main component structures and adjacent areas to them which were planned originally to be used for this purpose but which were not made ready in time.

2.2.1. Dam Sites

After the preliminary layout studies of the possible dam sites, the No.2 Dam Site and the No.3 Dam Site were selected for the preliminary comparative analyses. The economics of both dam sites were compared to each other, changing the dam types and dam heights. The result of the comparative analyses is shown on the following table.

Dam Site	No.2	No.3	No.3
Dam type	Fill type	Fill type	Concrete type
Reservoir H.W.L.	670 ~ 680	670 ~ 680	670 ~ 680
B/C	1.226~1.237~1.231	1.279~1.277~1.282	1.360~1.326
B-C (10^6₱)	59.7 ~ 71.0	78.6 ~ 88.7	95.5 ~ 99.1

This table indicates that the construction of a concrete dam on the No.3 Dam Site is most economical and to make the height of the dam higher will produce more economics.

But the layout studies of the No.3 Dam Site which were used for the above cost-benefit analysis were made on the basis of the existing 1/50,000-scale maps of less accuracy, surface geologic investigations without any sub-surface explorations and incomplete information of the saddle part structure on the No.3 Dam Site. There is a possibility that the economics of the No.3 site may be affected by the result of the ongoing detailed field explorations. Accordingly, it is proposed that the No.2 Dam Site should survive as the alternative dam site.

2.2.2. Layout of Tunnel Route and Powerhouse

After the preliminary layout studies of the various combination plans of tunnel routes and powerhouse types, two (2) plans of open powerhouse construction and two (2) plans of underground powerhouse construction both on the left bank were selected for the preliminary comparative analyses.

The result of the comparative analyses of those plans is shown on the following table.

Type / Item	Open Type				Underground Type	
	One Stage Development	Two Stage Development			Lower Stream Plan	Upper Stream Plan
		Upper Stream P/S	Lower Stream P/S	Total		
B/C	1.326	1.196	1.647	1.294	1.312	1.351
B-C (10^6₱)	99.1	49.1	44.5	93.6	97.1	107.2

This table shows that the most economical plan is the underground powerhouse to be constructed on the Upper Stream Site and the second economical one is the open type powerhouse to be constructed in the one stage. However, the underground powerhouse development contains normally many geologic problems to be solved. Accordingly, it is recommended that the field investigations will be focussed mainly on the open type one-stage development of the powerhouse and the Upper Stream Site underground powerhouse will be investigated as the second alternative plan.

2.3. Recommendations for Field Investigations

The comparative analyses of the project development plans indicate that the following plans will be viable;

a) the construction of the concrete dam on the No.3 Dam Site.

b) the construction of the filltype dam on the No.2 Dam Site.

c) the one-stage construction of the open type powerhouse.

d) the construction of the Upper Stream Site underground powerhouse.

It is recommended to carry out the following field investigations which will provide the basic information and data necessary for the selection of the optimum plan of the dam and powerhouse construction out of the above plans.

2.3.1. Topographic Surveys

a) Production of topographic maps.

b) Longitudinal and cross-sectional surveys necessary for the feasibility design.

c) Preparatory surveys necessary for the execution of the field geologic explorations.

The proposed quantities of the topographic surveys are presented in Table 2-2.

2.3.2. Geologic Explorations

It is proposed to carry out the drilling work (including permeability tests), seismic prospecting and test additing. The proposed quantities of the field geologic explorations are presented in Table 2-3.

2.3.3. Material Tests

The field reconnaissance indicates that both a concrete dam and a filltype dam are possible for the proposed dam sites. Accordingly, it is recommended to carry out the following material tests of core materials for a filltype dam and aggregate materials for a concrete dam.

a) Core Material Tests

Core material tests of materials collected from the intended core quarry sites near the No.2 Dam Site and the No.3 Dam Site.

b) Fine Aggregate Tests

Tests of riverbed materials collected from the Diduyon River and the other neighboring rivers.

2.3.4. Other Investigations

a) Hydrologic Observation

Continuous observations of precipitation and discharge at the rainfall gauging stations and the discharge gauging station which were installed at the 1st Stage of the Study.

b) Measurements of Sediment Discharge

Measurements of the river sediment discharge which will be related closely to the available storage capacity of the reservoir and the environmental problems of the project.

Table 2-1 Data and Information Gathered during Field Reconnaissance

(1) Topography and Geology

1) Topographic Maps

Scale	1 :	50,000
"	1 :	250,000
"	1 :	1,000,000
"	1 :	2,000,000

2) Geological Maps

Scale 1 : 1,000,000 Geological Map Series

(2) Hydrology

1) Rainfall Data

Station : Abaca, Aluntayan, Anawang, Barat Dakgan, Dulao, Dupax, Lagawe Lipuga, Mt. Polis Pass Namulditan, Ponggo, Pugo and Solano

2) Discharge Data

Station	:	Aglipay	(the Addalam River)
	:	Pangat	(the Cagayan River)
	:	Bato	(the Magat River)

(3) Environment and Agriculture

1) Annual Report 1977 Regional Health Office No.II

2) 1975 Integrated Census of the Population and its Economic Activities

: Isabela

: Nueva Vizcaya

: Quirino

3) 1975 Census of the Population and Housing

: Isabela

: Nueva Vizcaya

4) Annual Survey of Establishments 1974

: Manufacturing

: Mining and Quarring

: Electricity, Gas and Water

: Insurance and Real Estate

: Construction

: Wholesaling and Retailing

: Private Services

: Transportation, Communication and Storage

5) Journal of Philippine Statistics : V28 No.3
The Daily Industry

(4) Development Scheme

1) Power System Luzon Generation Expantion Study

: Volume 1 Main Report

: Volume 2 Data Report

: Volume 3 Data Report

2) The National Income Accounts, CY 1976

3) Population Projections for the Philippines by Province
1970 - 2000

4) Population Projections of Cities in the Philippines
1970 - 2000

5) NEDA Journal of Philippine Development, 1st Semester 1976

6) Journal of Philippine Development 2nd Semester 1976

7) NPC Financial Projection 1978 - 1987

8) NPC Financial Statements (for the year ended Dec. 31, 1977)

9) NEDA National Income Series

   : No.1

   : No.4

10) NEA Annual Report CY 1976

11) National Power Corporation System Development Map (Dec. 1977)

12) Transmission Line Expansion Program

13) List of Existing NPC S/S and T/L in operation

14) Statistical Data of NPC Operating Plants

15) Logging Road Map

16) List of Permanent Bridges (D.P.H. Isabela Office)

17) Map of Isabela showing Integrated Road System (D.P.H. Isabela Office)

18) Charts

    a) San Fernando Harbor

       Scale 1 : 15,000

    b) Manila Harbor

       i) Scale 1 : 10,000

       ii) " 1 : 30,000

Table 2-2 Proposed Quantities of Topographic Surveys

Kind of Survey	Quantity	Remarks
1. Production of topographic maps		
1.1. Sites for main structures	5.92 km^2	Dam sites, tunnel route, penstock route and powerhouse site on the scale of 1/5000
1.2. Sites for main structures	5.92 km^2	Dam site, tunnel route, penstock route and powerhouse site on the scale of 1/1000
1.3. Project area	300 km^2	on the scale of 1/10,000
2. Longitudinal and cross-sectional surveys		
2.1. Reservoir area	5 sections 8 km	
2.2. Dam axis	6 sections 4 km	
2.3. Dam site and its vicinity	Longitudinal section: 1 line 3 km Cross section: 29 lines 6 km	
2.4. Powerhouse and its vicinity	Longitudinal section: 1 line 3 km Cross section: 29 lines 6 km	

Kind of Survey	Quantity	Remarks
3. Preparatory surveys for geologic explorations		
3.1. Seismic prospecting line	10 km	Sites for dam, surge tank, tunnel, penstock, powerhouse, quarry and aggregate
3.2. Test adit	6 adits	EL 680, 640 and 600
3.3. Drill hole	33 holes	
3.4. Material sampling site	5 sites	

Table 2-3 Proposed Quantities of Geologic Explorations

Location	Test aditting	Drilling work	Seismic prospecting
1. No.3 Dam Site	6 adits 300 m	13 holes 880 m	5 lines 2,300 m
2. No.2 Dam Site		3 holes 140 m	1 line 1,000 m
3. Headrace tunnel adit for the Open Type Powerhouse One-stage Development Plan		4 holes 160 m	2 lines 800 m
4. Surge tank for the same plan		1 hole 100 m	1 line 300 m
5. Penstock route for the same plan		3 holes 60 m	3 lines 3,400 m
6. Open Type Powerhouse One-stage Development Site		3 holes 120 m	4 lines 1,400 m
7. Upper Stream Underground Type Powerhouse Site		1 hole 400 m	
8. Aggregate Quarry Site		5 holes 250 m	2 lines 800 m
Total	6 adits 300 m	33 holes 2,110 m	18 lines 10,000 m

3. Generation Expansion Plan in Luzon Grid

The existing power stations in Luzon Grid as of 1978 are shown in Table 3-1. The power stations under construction are Magat Hydro (540 MW), PNPP No. 1 Nuclear (620 MW), Kalayan Pumping-up (300 MW), Malaya No. 2 Steam (320 MW), Tiwi Geothermal No. 1 (55 MW), and Mak-Ban Geothermal No. 1 (55 MW).

The latest energy forecast in Luzon Grid prepared in January, 1978 by German consultants, Lahmeyer International, GmbH is presented in Table 3-2 and Fig. 3-1. This energy forecast was made by correlative analyses of energy consumption and growth of GNP, taking account of variations in energy consumption related to changes in fuel cost and power energy tariff, restrictions in power supply due to natural phenomena, and future electrification plan.

In Japan, the Aoki Method is introduced as a macro method for load forecasting. This method is to forecast load by correlative analyses of per capita energy consumption and growth of per capita GNP. The results of our load forecast by the Aoki Method are presented in Fig. 3-1. Our load forecast and Lahmeyer's load forecast are very much close to each other. A difference in the maximum curve and minimum curve is caused by variations with respect to estimates of population concentration in Luzon Island. In view of this, the Lahmeyer's energy forecast adopted by NAPOCOR is adequate to be used for our analyses.

Using the above energy forecast, the generation expansion program in Luzon Grid has been reviewed on the condition that the system reserve capability is kept around 18% on an average. The results of this review are summarized in Table 3-3 and Fig. 3-2.

The Diduyon Project is aimed to take the place of the Cabingatan Project (140 MW), the Dakgan Project (120 MW) and the Gadeng Project (150 MW) included in Table 3-3 and Fig. 3-2.

Table 3-1 Existing Power Plants in Luzon Grid (as of June, 1978)

Type	Name	Commission Year	Installed Capacity (MW)
Hydro	Botocan	1928	17
	Caliraya	1945/50	36 (9x4)
	Ambuklao	1956	75 (25x3)
	Binga	1959	100 (25x4)
	Angat	1968	212 (50x4 & 6x2)
	Pantabangan	1978	100 (50x2)
	Hydro Total		540 (21%)
Thermal	Rockwell 1-5	1955	125 (25x5)
	6-8	1963	180 (60x3)
	Tegen 1-2	1965	220 (110x2)
	Gardner 1	1968	165
	Gardner 2	1970	220
	Snyder 1	1971	220
	Snyder 2	1972	330
	Bataan 1	1972	75
	Bataan 2	1978	165
	Malaya 1	1975	330
	Thermal Total		2030 (79%)
	Grand Total		2570 (100%)

Table 3-2 Luzon Grid Load Forecast Energy (Consumption and Generation) and Power 1978-2000

Year	Energy Consumption (in GWH)	Energy Generation (in GWH)	Peak Power Demand (in MW)
1978	10,850	11,660	1,960
1979	12,130	13,050	2,190
1980	13,490	14,510	2,440
1981	15,030	16,160	2,710
1982	16,690	17,950	3,010
1983	18,480	19,870	3,340
1984	20,400	21,930	3,680
1985	22,450	24,140	4,050
1986	24,600	26,450	4,540
1987	26,920	28,950	4,860
1988	29,410	31,620	5,310
1989	32,100	34,520	5,800
1990	34,960	37,600	6,310
1991	37,990	40,850	6,860
1992	41,120	44,220	7,420
1993	44,430	47,780	8,020
1994	47,950	51,560	8,660
1995	51,690	55,580	9,330
1996	55,610	59,800	10,040
1997	59,720	64,220	10,780
1998	64,020	68,830	11,550
1999	68,500	73,650	12,360
2000	73,190	78,700	13,210

Table 3-3 Generation Expansion Program

C.Y.	Peak MW	Plant/Unit Addition	Type	Rated Cap. (MW)	Dependable Cap. (MW)	Total cap. (MW)	Res. Cap. (MW)	Reserve(%)
1978	1960	Existing	Hydro	535	402			
		Existing	Thermal	1847	1755			
		Tiwi #1 (Dec.)	Geo.	55	52	2209	249	13
1979	2190	Malaya 2 (Apr.)	Thermal	320	305			
		Mak-Ban #1 (Apr.)	Geo.	55	52			
		Tiwi #2 (June)	Geo.	55	52			
		Mak-Ban 2 (July)	Geo.	55	52			
		Rehab. of G'ner 1-2	Thermal	-	19	2689	499	23
1980	2440	Tiwi # 3 (Feb.)	Geo.	55	52			
		Mak-Ban # 3 (Mar.)	Geo.	55	52			
		Tiwi # 4 (May)	Geo.	55	52			
		Mak-Ban # 4 (June)	Geo.	55	52			
		Rehab. of S-1 & 2	Thermal	-	-	2897	457	19
1981	2710	Masiway	Hydro	12	12	2909	199	7
1982	3010	Kalayaan 1 & 2	P-Hydro	300	300	3209	199	7
1983	3340	Magat 1-6	Hydro	540	435			
		Dual-fired(Legaspi)	Thermal	225	214	3858	518	16
1984	3680	PNPP #1	Nuclear	620	590	4448	768	21
1985	4050	Kalayaan # 3	P-Hydro	150	150			
		Dual-fired(Batangas)	Thermal	300	285	4883	833	21
1986	4440	San Roque	Hydro	260	195			
		Kanan	Hydro	280	210			
		Tiwi # 5	Geo.	55	52			
		Mak-Ban # 5	Geo.	55	52	5392	952	21
1987	4860	Gened 1-6	Hydro	600	430			
		Tiwi # 6	Geo.	55	52			
		Mak-Ban # 6	Geo.	55	52	5926	1066	22
1988	5310	Chico IV	Hydro	360	270			
		Tabu 1-2	Hydro	110	83			
		PNPP # 2	Nuclear	620	590	6869	1559	29
1989	5800	Chico II	Hydro	250	190			
		Tanudan	Hydro	140	105			
		Cabingatan	Hydro	140	105			
		Dual-fired(Legaspi)	Thermal	300	285	7554	1754	30
1990	6310	Agbulu	Hydro	400	280			
		Dakgan	Hydro	120	90	7924	1614	26
1991	6860	Gadeng	Hydro	150	114			
		Ilagan	Hydro	210	158			
		Dual-fired(Santiago)	Thermal	400	380	8576	1716	25

Fig. 3-1 Luzon Grid Energy Forecast (1975 to 2000)

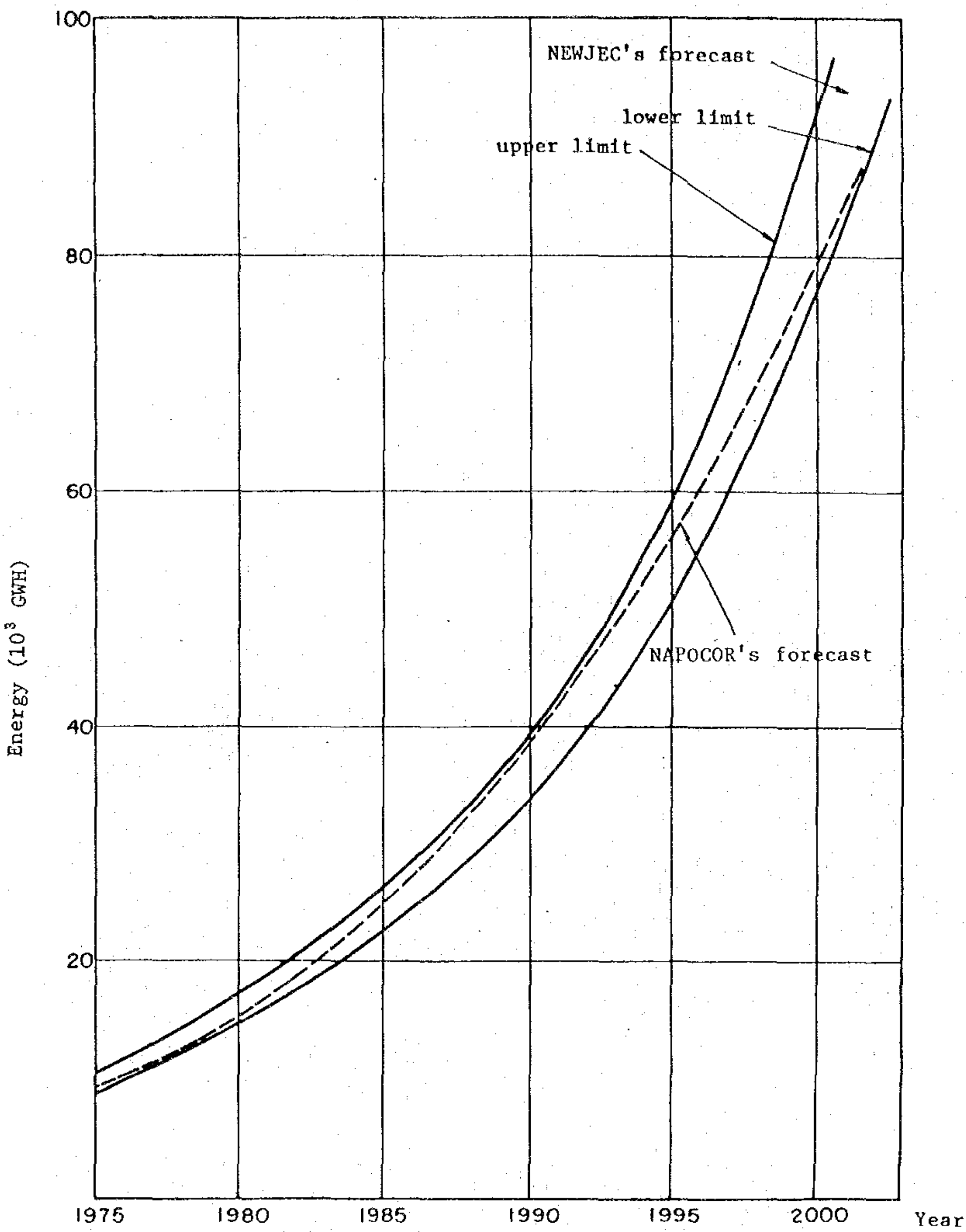
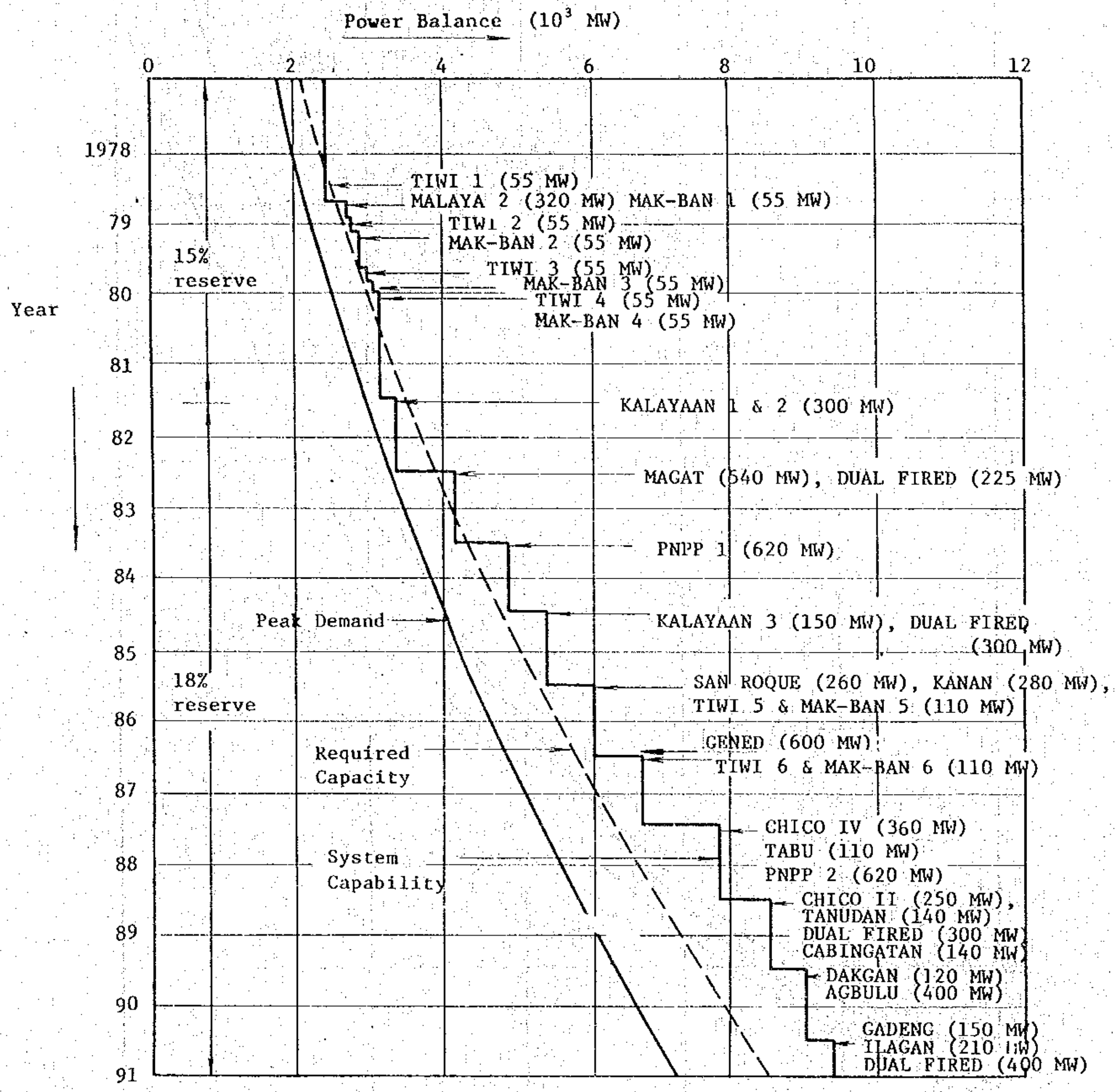


Fig.3-2 System Peak and Capability Curves



4. Characteristics of the River Basin

4.1. Topography

The catchment area of the Diduyon Dam is a basin surrounded by more than 1,000 m high mountains on the western part of the Manparang Mountainous Region. The mountainous area with less undulation makes up a greater part of the basin, and the elevation at or near the dam site is about 800 m. Wider plains exist along the Diduyon River and the principal tributaries of the Cagayan River, and the rivers flow gently, meandering over the plains. There are one- and more-stepped terraces at places along the rivers.

The both banks of the Diduyon River downstream of N20°W on the lower reaches of the dam site present steep mountains of more than elevation 1,000 m and a deep gorge with a steep gradient of the riverbed. The tributaries of the Diduyon River represented by the Didipio River join the Diduyon River in hanging valleys.

The west end of the catchment area slopes down to the valley of the Magat River in a steep straight incline which seems to be a fault scarp.

4.2. Geology

The river basin consists of Oligocene pyroclastic rocks and quartz porphyries or porphyrites which penetrate the Oligocene pyroclastic rocks. Generally the pyroclastic rocks are designated as agglomerates and the quartz porphyries as diorites in this area.

The pyroclastic rocks contain a large quantity of gravels or boulders, rather subangular quartz porphyries and porphyrites or andesites in the andesitic matrix. Some of the boulders reach more than 1 m in diameter. Sometimes the pyrocratic rocks intercalate andesite lavas, conglomerates, sandstones and shales. On the left bank 1 km upstream of the powerhouse site there are two (2) layers with the respective thickness of about 1 m and 5 m of the sandstones or pebbly sandstones and their rock facies at this place are recognized to show a slight lateral change. On the left bank about 1 km upstream of the No.3 Dam Site, there are andestic autobrecciated lavas.

The quartz porphyries generally penetrate the pyrocrastic rocks in dykes of thickness of several meters to 10 meters. Some of the quartz porphyries are supposed to be considerably large rock masses. The directions of most of the dykes are not clear, but the prevailing directions of the dykes checked in the field are N20°W.

The general geologic structure of the basin is not clear, but a monoclinic structure inclined at 25 to 30 degrees toward southeast is recognized at the No.3 Dam Site. The geologic structure at the location 1 km upstream of the open type powerhouse site strikes toward N80°E to N70°W 8°S. And the geologic structures at the places 1.5 km, 4 km and 5.5 km downstream of the open type powerhouse site show the dips of 60-70 degrees to the south, 40 degrees to the south and vertical direction respectively with NE-SW strikes. In view of this, the geologic structure from the No.3 Dam Site to Dibibe via the open type powerhouse site, although a little bit folded, can be generally considered to be a monoclinic structure. There is a possiblity that the parts showing a sharp inclination may be affected by faults.

The presence of many faults with strikes toward NW-SE and NE-SW is supposed from the topography of the area. In the field reconnaissance carried out at the 1st Stage of the Study, no large-scale faults which will obstruct the continuation of the Project could be observed, except the fractured diorites in a width of 20 m exposed at the logging road on the left bank 1 km upstream of the No.3 Dam Site. At the upstream end of the outcrop the existence of something like a fault with a strike toward N20°W 30°E is recognized, but any fault clay is not found on the same place.

Generally, the fresh rocks are exposed on the riverbed. But the rocks on the ridges and the mountain slopes are weathered hard and turn almost clayey. The weathering is supposed to reach down to the depth of more than 20 to 30 m beneath the ground surface. The overburdens except on the riverbed range between 1 and 3 m and reach more than 3 m in places. Along the river near Papalongan terrace gravel beds are observed.

Fresh agglomerates and diorites are very hard and are considered available for the embankment materials and the concrete aggregates. But weathered agglomerates and diorites are clayey and have a high water content, which are not suitable for core materials. On the right bank 500 m upstream of the No.3 Dam Site are distributed talus deposits containing much cobble size breccias. But they are considered to be lacking in sandy contents for aggregate use, and the availability of materials of even quality and in a large quantity from the same talus deposits is suspicious at this stage.

5. Topography of the Project Site

5.1. The Diduyon River

The Diduyon River is the lower reaches of the Addalam River belonging to the Cagayan River System. The Addalam River originates from Mt. Palali (1,500 m high) of the Palali Mountain Range in the Mamparang Mountain Mass and changes its name to the Kasibu River after it passes through the Kong Kong Valley. The Kasibu River flows eastsouth in a distance of 40 km with a riverbed gradient of 1/370 and joins the Kakiduguen River at the riverbed elevation 630, joining the Compote River and the Malabing River on the way.

After it joins the Kakiduguen River, the name of the Addalam River is changed into the Diduyon River. The Diduyon River flows down with a steep gradient of 1/30, turns its river course to eastnorth, and flows down to elevation 200 in the Mamparang Mountain Mass. Then, the Diduyon River joins the Dumatalto River at the riverbed elevation 130, joining the Didipio River and the Dibiowan River on the way.

On the lower reaches of the confluence with the Dumatalto River, the river name is changed again into the Addalam River. It flows gently in a distance of 34 km with the riverbed gradient of 1/530 and joins the main stream of the Cagayan River at the riverbed elevation 70.

The Addalam River has a river course length of 106 km, a head of 1,200 m, a gross catchment area of 1,030 km^2, and a hydroelectric power potential of 170 MW (1,490 GWH). The river profile and the river basin area are shown in Fig.5-1.

The Addalam River can be classified distinctly into three sections: the first is the section with a riverbed gradient of 1/370 upstream of the riverbed elevation 600, the second the intermediate section with the steepest riverbed gradient of 1/30, and the third the section with a riverbed gradient of 1/530 downstream of the riverbed elevation 200. This feature provides the best condition for the hydroelectric development; the riverbed gradient which is gentle upstream of the riverbed elevation 600 and steep downstream of it will enable to create the most effective reservoir on the upstream side and to obtain a high head with a short waterway on the downstream side, if the dam is constructed on the bordering point, and the gentle riverbed gradient downstream of the riber-bed elevation 200 limits the downstream terminal for the hydro-electric power development to the point at the riverbed elevation 200 which furnishes the best site for the construction of the powerhouse.

Thus, the profile of the Diduyon River has the optimum feature for the hydroelectric development.

5.2. Dam Site

On the upper reaches of the Diduyon River the Kasibu River and its tributaries, the Compote River, the Malabing River and the Kakiduguen River spread dendritically. The upper reaches of the Diduyon River are a plateau basin surrounded by 1,000 m class high mountains and have a gentle riverbed gradient suitable for the creation of a reservoir.

It is considered the best plan to construct a dam at the down-stream tip of the plateau basin. The river section 2 km long downstream from the confluence with the Kakiduguen River which corresponds to the downstream tip of the plateau basin has the following topographic features.

a) The river meanders.

b) The small tributaries join the main stream alternately from the both banks.

c) The mountains along the river are cut by the valleys and stand out toward the river in the form of ridges.

d) The elevations of the ridges are almost 700 m and many of them have saddle parts.

To design a dam in the river with the above-mentioned features, both abutments are to be placed on the ridges which may have saddle part at least on either bank, and such saddle part will require careful attention in the design. Notwithstanding, this river section is still suitable for the construction of a dam for the reasons mentioned below.

a) Upstream of the river section the riverbed is wide and the mountain slopes on both banks are gentle.

b) Downstream of it the riverbed gradient becomes sharply steep and the riverbed elevation lowers.

After the preliminary layout studies of the various sites in the river section, two dam sites, the No.2 Dam Site and the No.3 Dam Site, have been screened out to be most viable.

5.2.1. No.2 Dam Site

The No.2 Dam Site is located 3 km downstream of the confluence with the Kakiduguen River.

A mountain stream joins the Diduyon River from the left bank just upstream of the dam site. A left bank ridge stands out to the river between the mountain stream and the Diduyon River bending to the left at 500 m downstream of the dam site and this left bank ridge will provide the abutment of the dam. The actual survey during the latest field reconnaissance indicates that the height from the summit of the ridge to the riverbed is 80 m which is lower by 20 m than the height shown on the existing 1/50,000-scale maps.

A 90 to 100 m wide ridge stands out to the river at the elevation 700 on the right bank.

The slopes of the both banks on the site are gentle; the left bank is inclined at about 20 degrees and the right bank at about 30 degrees. The width of the valley at the elevation 670 is about 450 m.

The gradient of the riverbed upstream of the dam site is 1/370, while the gradient of the riverbed from the dam site to the No.3 Dam Site is 1/130.

5.2.2. No.3 Dam Site

The No.3 Dam Site is located about 3.8 km downstream of the No.2 Dam Site. The elevation of the riverbed on the dam site is lower by about 30 m than that of the No.2 Dam Site.

The width of the riverbed on the dam site is about 60 m and exposed rocks rise on the both banks. The width of the valley on the site is narrow, and the slopes of the both banks are steep; the left bank 45 degrees and the right bank 30 degrees. The width of the valley at elevation 680 is about 300 m.

The gradient of the riverbed from the No.2 Dam Site to this dam site is 1/130, but the riverbed gradient downstream of it becomes as steep as 1/30. The elevation of the riverbed on this dam site is lower than that on the No.2 Dam Site. But the narrow width of the valley on the site provides the good site for the dam construction.

5.3. Waterway Route and Powerhouse Site

The Diduyon River, after it passes the No.3 Dam Site, turns its river course to the eastnorth and flows in a rapid stream with a riverbed gradient of 1/30 down to the powerhouse site.

The catchment area on the right bank in the river section from the No.3 Dam Site to the powerhouse site is so narrow that the watershed on the right bank is only 5 km distant from the river course. The mountain slope of the right bank is 1/2 to 1/3, cut by mountain streams.

The left bank in the same river section is the eastern tip of the Manparang Mountain Range. And the 1,000 m class high mountains come close to the Diduyon River on the left bank. The Didipio River joints the Diduyon River in a hanging valley from the left side near the powerhouse site. The river course in the same river section is narrow and the mountain streams present like hanging valleys.

The valley becomes a little bit wider at the point 3 km downstream of the confluence with the Didipio River. Downstream from the point at the riverbed elevation 200 the mountain slopes of the both banks become as gentle as 1/5, the gradient of the riverbed becomes also 1/120, and its river course bends like an arrow toward the north.

The contour line of 800 m on the left bank come, in the shape of a ridge, close to 2 km distant from the river course at the riverbed elevation 180 m where there is the confluence with the Dibiowan River 13.5 km downstream of the No.3 Dam Site. The ridge stands away from the river course as the river flows farther downstream and the elevation of the summit near the river course becomes as low as 500 m.

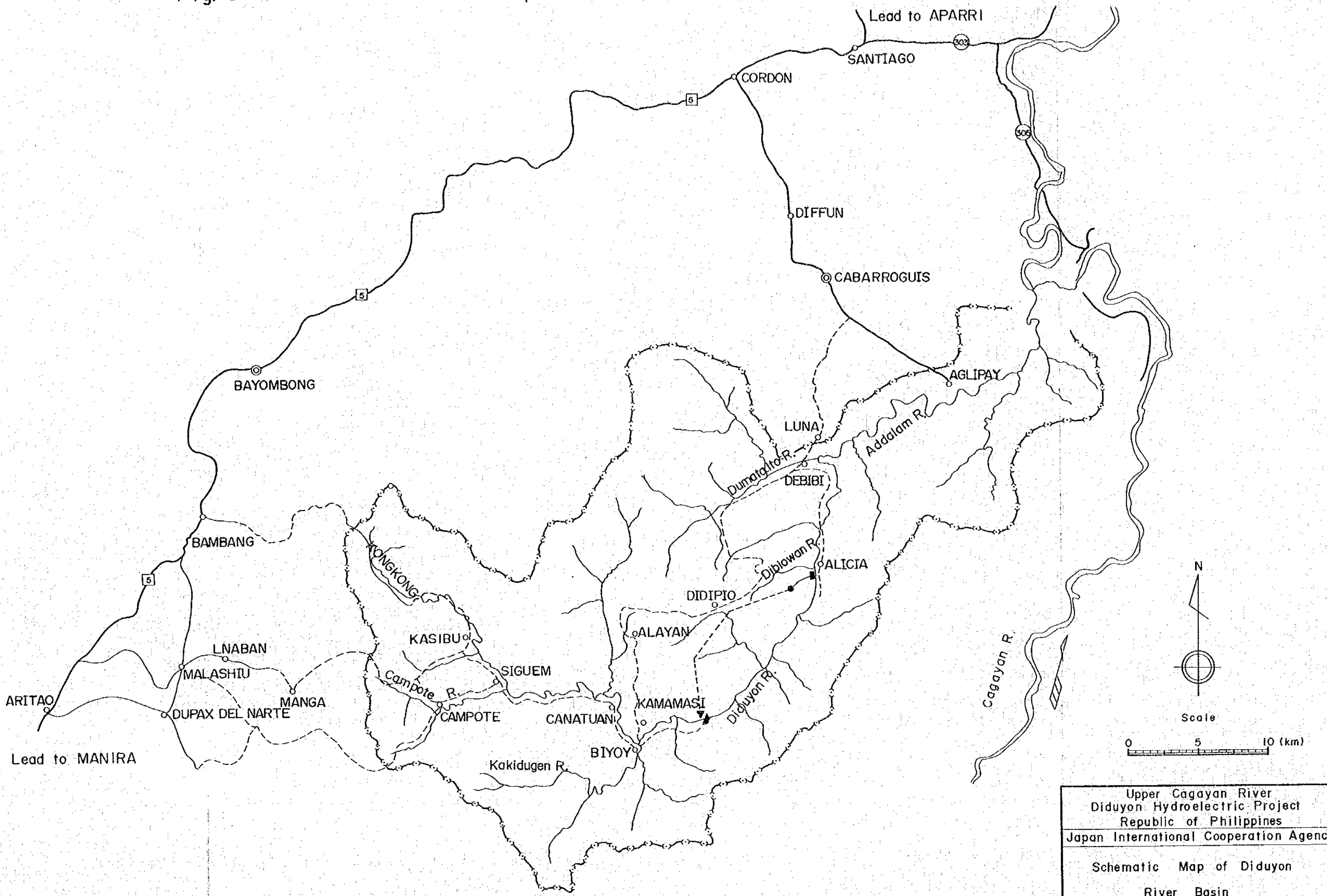
Along the left bank side just upstream of the confluence with the Dibiowan River there is a river terrace 1,000 m long and 100 m wide which will provide enough space for the construction of a powerhouse and a switchyard.

In the river section from the No.3 Dam Site to this river terrace, the mountain slopes of the both banks are adjacent directly to the river. Accordingly, it is difficult to find any adequate space for the construction of a powerhouse.

The right bank has a steep mountain slope and is undulated by the small mountain streams cut on the right bank. Moreover, the right bank is on the outer side of the bending Diduyon River. Accordingly, the alignment of the waterway on the right bank is questionable.

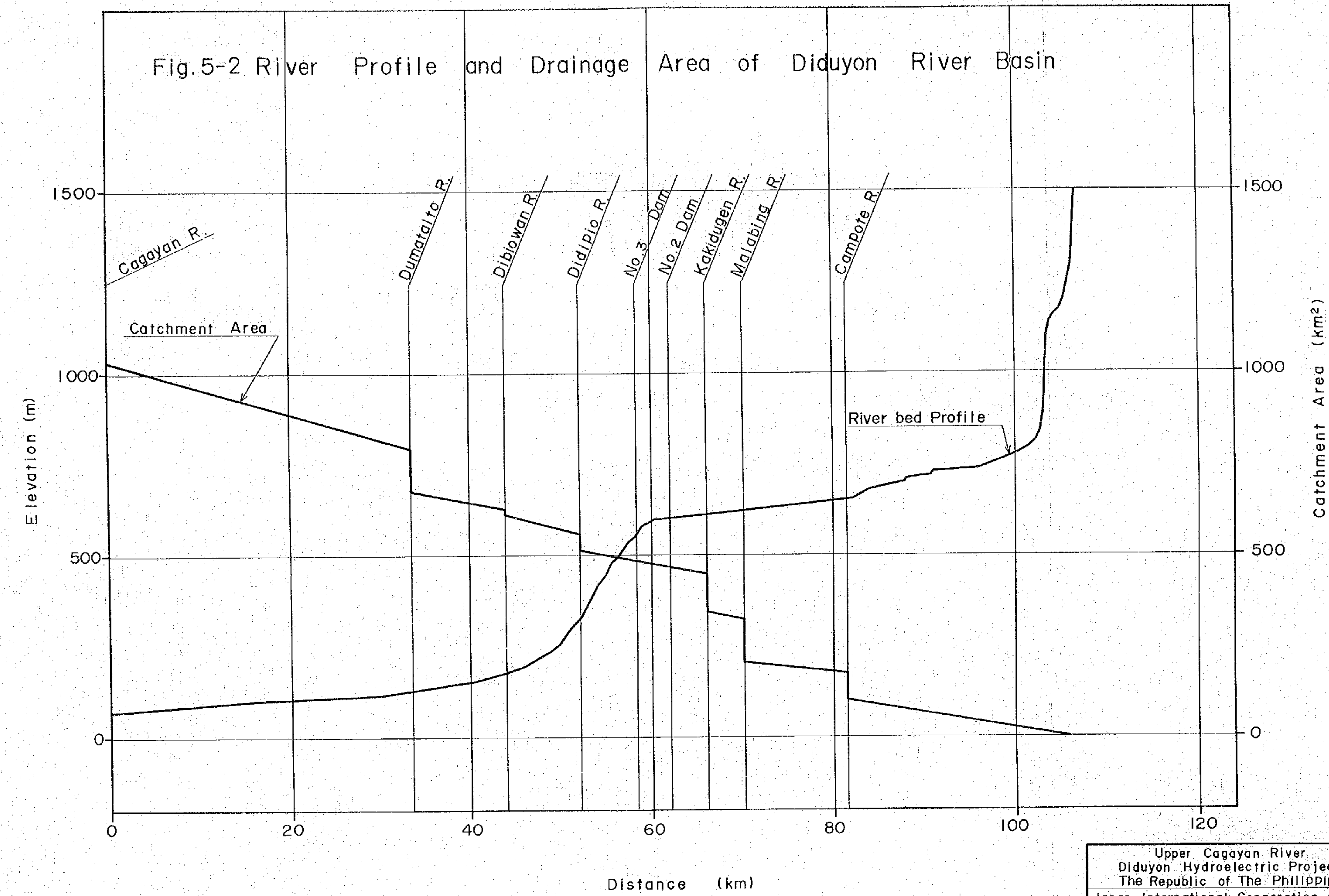
In contrast, the Didipio River flows in a hanging valley on the left bank. In order to keep away from the Didipio River, the waterway route will have to take a little bit roundabout route. But the topography of the waterway route on the left bank is such as construction adits will be able to be excavated every 4 km on the route, which will make it easier to drive tunnels for the waterway. However, an aqueduct bridge may be required to be constructed accross the valley of the Didipio River, depending on the geology of the tunnel route.

Fig. 5-1 Schematic Map of Diduyon River Basin



Upper Cagayan River Diduyon Hydroelectric Project Republic of Philippines
Japan International Cooperation Agency
Schematic Map of Diduyon River Basin
March 1979 Fig. 5-1

Fig.5-2 River Profile and Drainage Area of Diduyon River Basin



Upper Cagayan River Diduyon Hydroelectric Project The Republic of The Philippines		
Japan International Cooperation Agency		
River Profile and Drainage Area of Diduyon River Basin		
March	1979	Fig. 5-2

6. Hydrology

6.1. Climate in Luzon Island

The Philippines is located in the tropic zone. The meteorologic feature of a region in the Philippines is affected largely by the topography peculiar to the region and the direction of winds different by seasons.

In the Philippines the prevailing seasonal winds are the northeast seasonal winds, the trade winds blowing from the east, and the southwest seasonal winds. The northeast seasonal winds are prevailing normally from October to January, the trade winds from February to April, and the southwest seasonal winds from May to September. In the season of the southwest seasonal winds, typhoons causing heavy rains occur very frequently.

The meteorologic characteristic by region is generally classified by the volume of the precipitation because the variation of the temperature by region is very much small and the classification on the basis of the temperature is very difficult but the regional characteristic of the precipitation by region can be distinguished.

The climate in the Philippines can be classified into four types on the basis of the rainfall patterns through a year:

a) Type I : Two distinct seasons; the dry season from November to April, and the wet season from May to October; Mainly the west coast zone of Luzon Island falls in Type I Classification.

b) Type II : No dry season, but a pronounced large rainfall period from November to January; The east coast in Southern Luzon falls in Type II Classification.

c) Type III : No clear distinction of the seasons, but relatively dry from November to April and wet from May to October; The Provinces of Cagayan, Isabela and Nueva Vizcaya fall in Type III Classification.

d) Type IV : Relatively uniform rainfall through a year; The Sierra Madre Mountain Range falls in Type IV Classification.

The project area is located on the border between the Type III region and the Type IV region. The discharge record gauged on the lower reaches of the project site shows the approximation of the rainfall pattern on the project site to Type II.

In addition, it is typhoons that have large influence on the precipitation in the Philippines. For 24 years from 1948 to 1972 483 typhoons occurred in or attacked the territory of the Philippines. About 42% of those typhoons gave influences to or passed through any part of the Philippine Archipelago.

The following table indicates the extreme value and mean value of the past record of each of the meteorologic elements in the Philippines.

Element		Extreme Value	Year of Occurrence	Place
Max. temperature		42.2°C	April 29, 1912	Tuguegarao
Min. temperature		6.3°C	Jan. 11, 1932	Baguio
Max. daily rainfall		1,215.7 mm	Oct.17 to 18, 1967	"
Max. monthly rainfall		1,871.0 mm	Aug. 1964	"
Max. annual rainfall		7,651.8 mm	1956	Surigao
Max. wind velocity		240 kPh	Oct. 13, 1970	Virac
Annual mean humidity		81 %	1970	Luzon
Monthly mean rainfall				
	Min.	19.4 mm	Feb. on an average (1949-1973)	Tuguegarao
	Max.	305.5 mm	Nov. on an average (1949-1973)	"
Monthly mean temperature				
	Min.	24.5°C	Jan. on an average (1951-1970)	"
	Max.	30.5°C	May on an average (1951-1970)	"
Day of rainfall per month				
	Min.	4 days	Feb. on an average (1949-1973)	"
	Max.	15 days	Aug.,Sept. & Nov. on an average (1949-1973)	"

6.2. Available Hydrologic Data in the Diduyon River Basin

The locations of and the period of observations at the existing rainfall gauging stations and the river discharge gauging stations at or near the river basin are shown in Fig. 6-1, Table 6-1 and Table 6-2.

a) Data on River Discharge

The river discharge of the Diduyon River itself had been observed at the Aglipay Gauging Station located at 39 km downstream of the proposed dam site. The river discharge observations relevant to the Diduyon River are those recorded at the Pangal Gauging Station located at 17.5 km downstream from the conjunction of the Cagayan River with the Diduyon (Addalam) River. The records at both stations are the daily discharge records observed at a fixed time every day and they do not include the records on flood hydrograph. The staff gauges are lost and the observations at both stations are now suspended. The periods of observations done at these stations are as below.

Gauging Station	Commencement of Observation	Start of Suspension of Observation	Observation Period
Aglipay	June, 1964	December, 1975	11.5 years
Pangal	January, 1960	December, 1967	8.0 years

The records at both stations show a quite good correlation. Therefore, the discharges in the period of suspension at the one gauging station can be presumed by the existing records for the correponding period at the other gauging station.

b) Data on Railfall

Any railfall gauging station is not installed in the catchment area of the Diduyon River. The rainfall gauging stations adjacent to the Diduyon River are the Consuelo Gauging Station (EL 600 m) on the most upstream of the Magat River, the Salinas Ref. Project Gauging Station (EL 610) and the Magat Ref.

Project Gauging Station (EL 243). The annual mean precipitation recorded at the Consuelo Gauging Station for a period of 1948 to 1963 is about 2,230 mm, the annual maximum precipitation is 3,375 mm in 1948 and the annual minimum precipitation is 1,373 mm in 1959. Most of the railfalls are caused by typhoons and tropical atmospheric pressures. The season of typhoons is from July to November. Likewise, heavy rainfalls accompanying thunders occur from July to November. The maximum daily precipitation ever recorded is 1,216 mm recorded in 1967 at Baguio. Most of the records at those rainfall gauging stations are daily rainfall records. The longest period of the observation at those stations is about 30 years from the end of 1949.

c) Observation Record of Sedimentation

Actual observation records on the river sedimentations of not only the Diduyon River but also the adjacent rivers are not available.

6.3. Finding of Field Reconnaissance

a) High Water Discharge

The observations conducted by the end of March, 1979 indicates that the time of concentration is relatively short and it takes only around 2 hours from the commencement of rainfall to flooding. Accordingly, only the daily rainfall records are insufficient to clarify the flood runoff characteristics of the river basin. And it is necessary to collect the records on a hourly basis, using together ombrographs and automatic water-gauges. The rains occur locally in a specific area. It is, therefore, desirable to install as many rainfall gauging stations as possible in order to extract the representative rainfall in the river basin among from a lot of records measured in the many gauging stations.

b) Low Water Discharge

The records on low flow runoff are available at the Aglipay and Pangal Stations. However, the watersheds for those stations have different topographic features from the watershed for the dam site. Therefore, the discharge at the dam site cannot be presumed simply by the basin area ratio conversion. It is, therefore, necessary to observe simultaneously the discharges both at the dam site and at Aglipay to obtain a correlation between them and to estimate correctly the discharge of the dam site. For this, it is recommendable to resume the discharge observation at the Aglipay Station now under suspension as well as to observe the discharge at the dam site by automatic gauge. It is also recommendable to carry out the observation of flood hydrograph at Aglipay, where only daily water stage observation had been made before.

c) Sedimentation

The bedrocks underlying the basin area of the Diduyon River are generally deeply weathered, and the overburdens 5-10 m deep below the ground surface may be clayey. Furthermore, the forests in the basin are cut broadly. Therefore, the surface condition of the land in the basin area is quite unprotected and land collapses at the mountain slopes are observed in places. Accordingly, heavy rainfalls in any of the tributary basins made the river flow muddy which results in the transport of much soil and sands. Sandbars comprising gravels, pebbles and sands are developed here and there on the river course upstream of the dam site. This fact shows the possibility of bed load transportation being made in a large quantity. In view of this, it is presumed that much sediment transport takes place in the proposed project basin area. The sediment load will badly affect the effective storage capacity of the reservoir. Therefore, the measurements of the concentration of the suspended load and the estimate of the bed load based on the investigation of the riverbed materials should be carried out to estimate the sediment load.

6.4. Installation of Gauging Stations

In order to build up an adequate hydrologic observation system considering the characteristics of the river basin mentioned above, the following gauging stations were recommended to be installed newly:

a) Rainfall gauging station

i) Kasibu Station (with ordinary type gauge)

ii) Siguem Station (with ordinary type gauge and automatic gauge)

iii) Alayan Station (ordinary type)

iv) Biyoy Station (ordinary type)

v) Kamamasi Station (the No.2 Dam Site) (ordinary type)

All the stations except the Siguem Station (with automatic gauge) and the Biyoy Station have already been set up at the 1st Stage of the Study and started the observations.

b) Discharge gauging station

i) Kamamasi Station (the No.2 Dam Site) (with automatic water-gauge and staff gauge)

ii) Aglipay Station (with staff gauge)

A staff gauge has already been installed at Kamamasi at the 1st Stage of the Study and the daily discharge have been observed at a fixed time every day continuously. Installations of an automatic water-gauge at Kamamasi and a staff gauge at Aglipay were completed by the end of August, 1978.

6.5. Estimated Discharge Used for Preliminary Comparative Analyses

The river discharge is observed at the Pangal Site (catchment area: 4,244 km^2), and its observation record for 12 years from 1959 to 1970 is published. Using the observation record at Pangal, the river discharge at the Diduyon Dam Site was computed by the catchment area ratio conversion. The daily mean inflow, high discharge (95 days discharge), mean discharge (185 days discharge), low discharge (275 days discharge) and droughty discharge (355 days discharge) on the dam site which were obtained by the catchment area ratio conversion are 30.7 m^3/sec., 32.9 m^3/sec., 19.2 m^3/sec., 10.5 m^3/sec. and 4.3 m^3/sec. The discharge accumulation curve at the dam site is presented in Fig. 6-2 and the duration curve at the dam site in Fig. 6-3.

Table 6-1 Locations of Rainfall Gauging Stations

	Name of Station	Basin	Elevation	Responsible agency	Period of observation
1	Herald Lumber Company	Abra	204 m	WB	1950 -
2	Buguias	Agno	402	WB	"
3	Adaoay	"	870	"	"
4	Ambuklao	"	995	NPC	"
5	Km. 5 Halsema Rd. Atok	Amburayan	2,280	WB	"
6	Binga Dam Itagan	Agno	500	NPC	1961 -
7	Bobok Sawmill	"	1,525	NPC	1950 -
8	San Roque	"	100	BPW	1957 -
9	Ambayoan RGS, San Nicolas (R.G)	"	200	"	1961 -
10	Baguio City	Aringay	1,500	WB	1947 -
11	Santo Thomas Reservoir	Bued	700	BPW	1957 -
12	Consuelo	Cagayan	600	WB	1949 -
13	Salinas Ref. Project	"	610	"	"
14	Magat Ref. Project	"	243	"	"
15	Casiguran	Quezon	4	"	1950 -
16	Baler	"	6	"	"
17	Cabanatuan City	Pampanga	30	"	"

Table 6-2 Locations of Discharge Gauging Stations

	Name of Station		C.A. (km^2)	Period of observation
A	Cagayan R.	Pangal, Echague, Isabela	4,244	1959 -
B	Addalam R.	Guinalvin, Aglipay, Nueva Viscaya	721	1965 -
C	Dibuluan R.	Minuri, Jones, Isabela	272	1965 -
D	Dabubu R.	Dabubu, Pequino, San Agustin Isabela	162	1965 -
E	Cagayan R.	Dipaddiw Maddela, Nueva Viscava	2,323	1968 -

Fig. 6-1 Most Upper Reaches of the Cagayan River

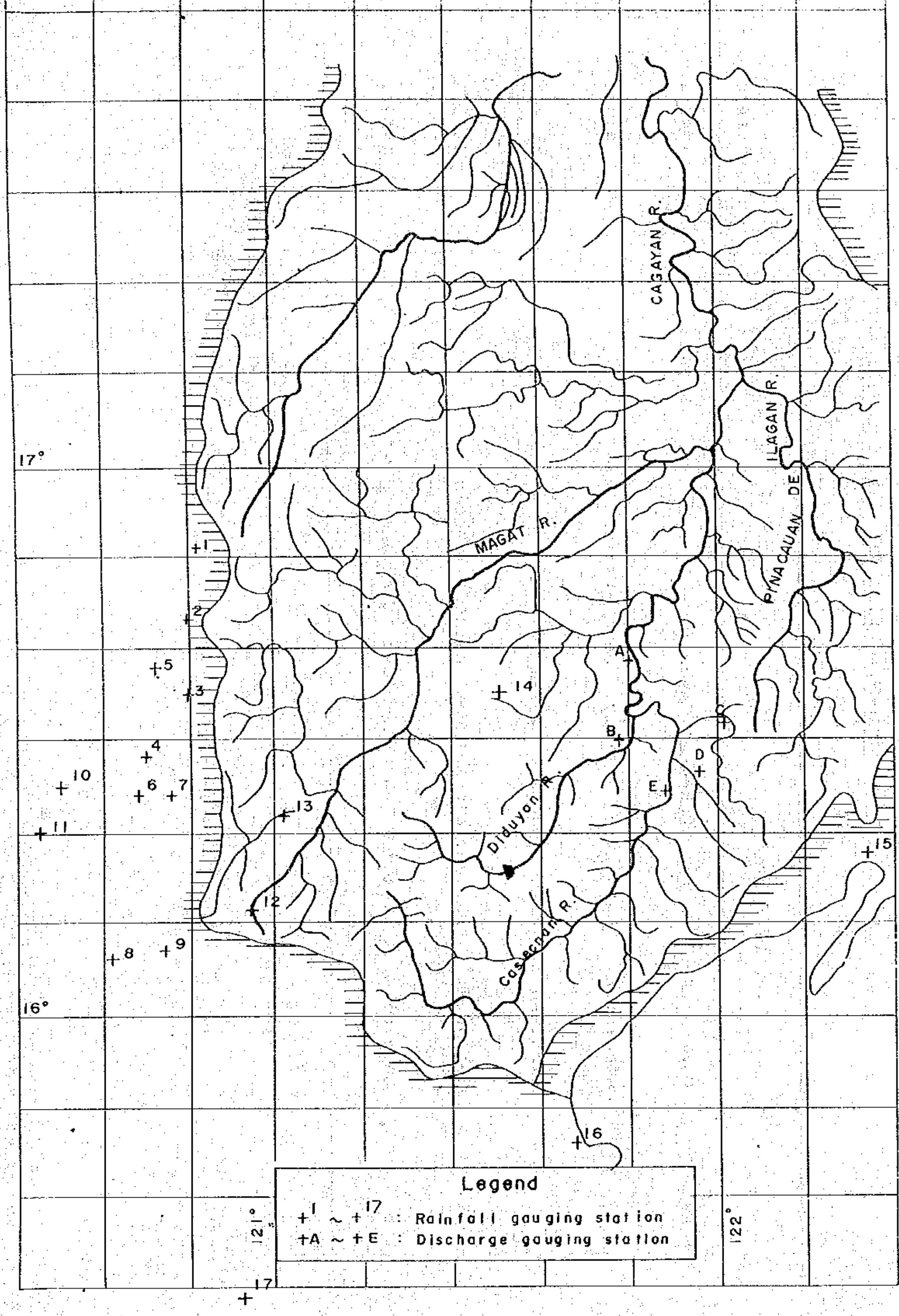
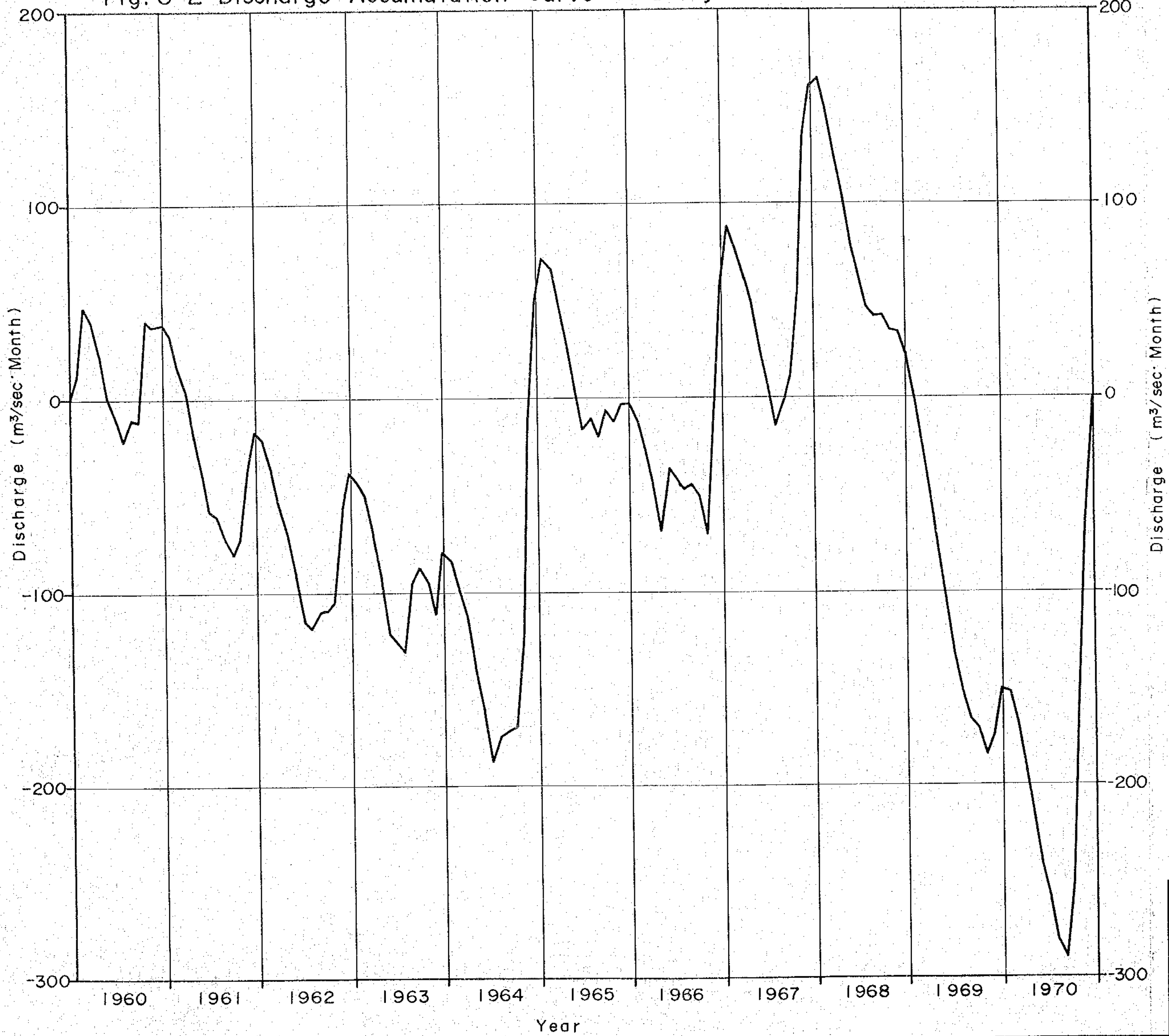
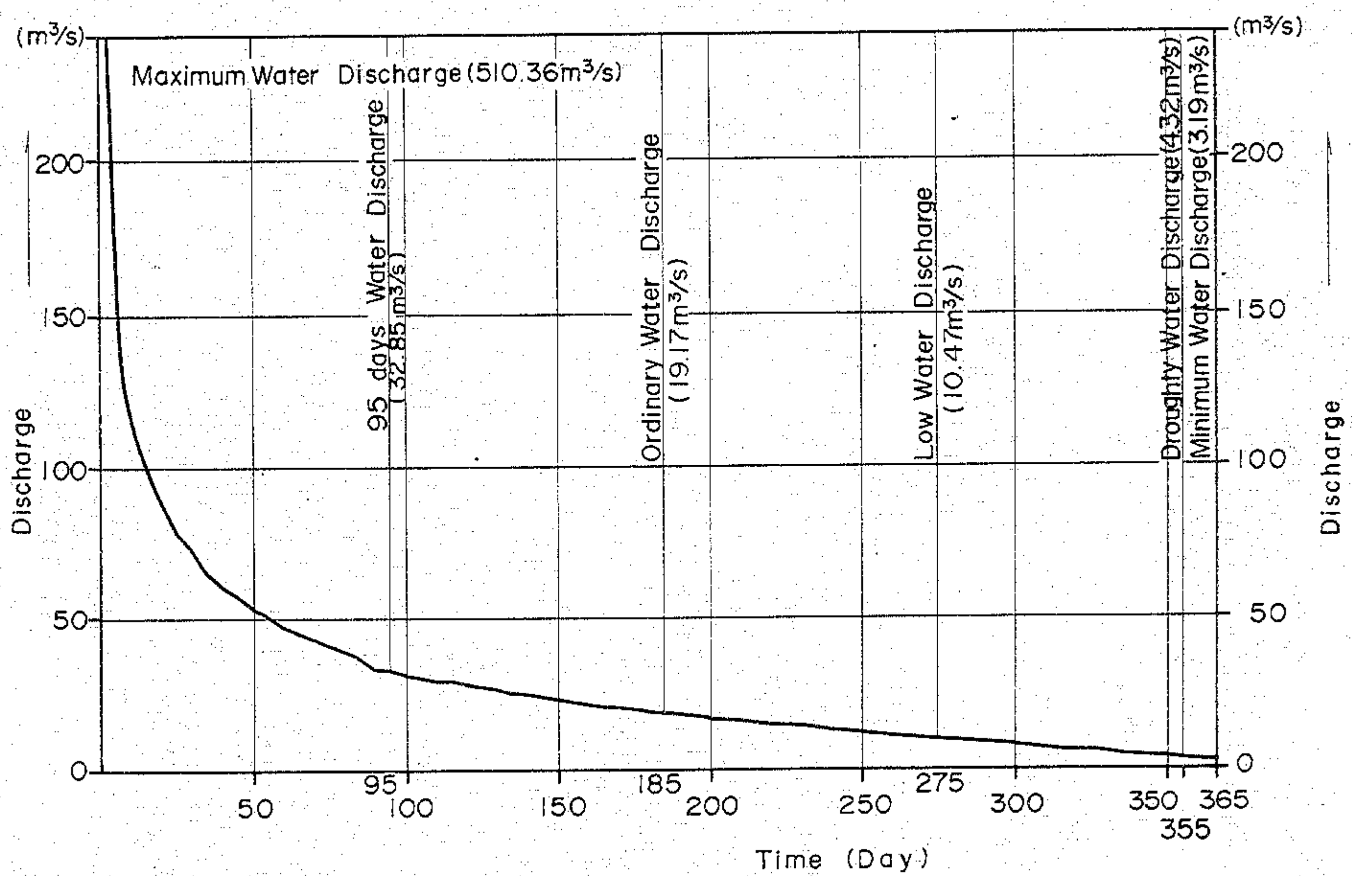


Fig. 6-2 Discharge Accumulation Curve at Diduyon Dam Site (C.A. = 477 km²)



Upper Cagayan River Diduyon Hydroelectric Project The Republic of The Philippines
Japan International Cooperation Agency
Discharge Accumulation Curve at Diduyon Dam Site
March 1979 Fig. 6-2

Fig. 6-3 Discharge Duration Curve at Diduyon Dam Site (C.A.= 477 km^2)



Note: Average Duration Curve for a period of 11 years From 1960 ~ 1970