付　　図

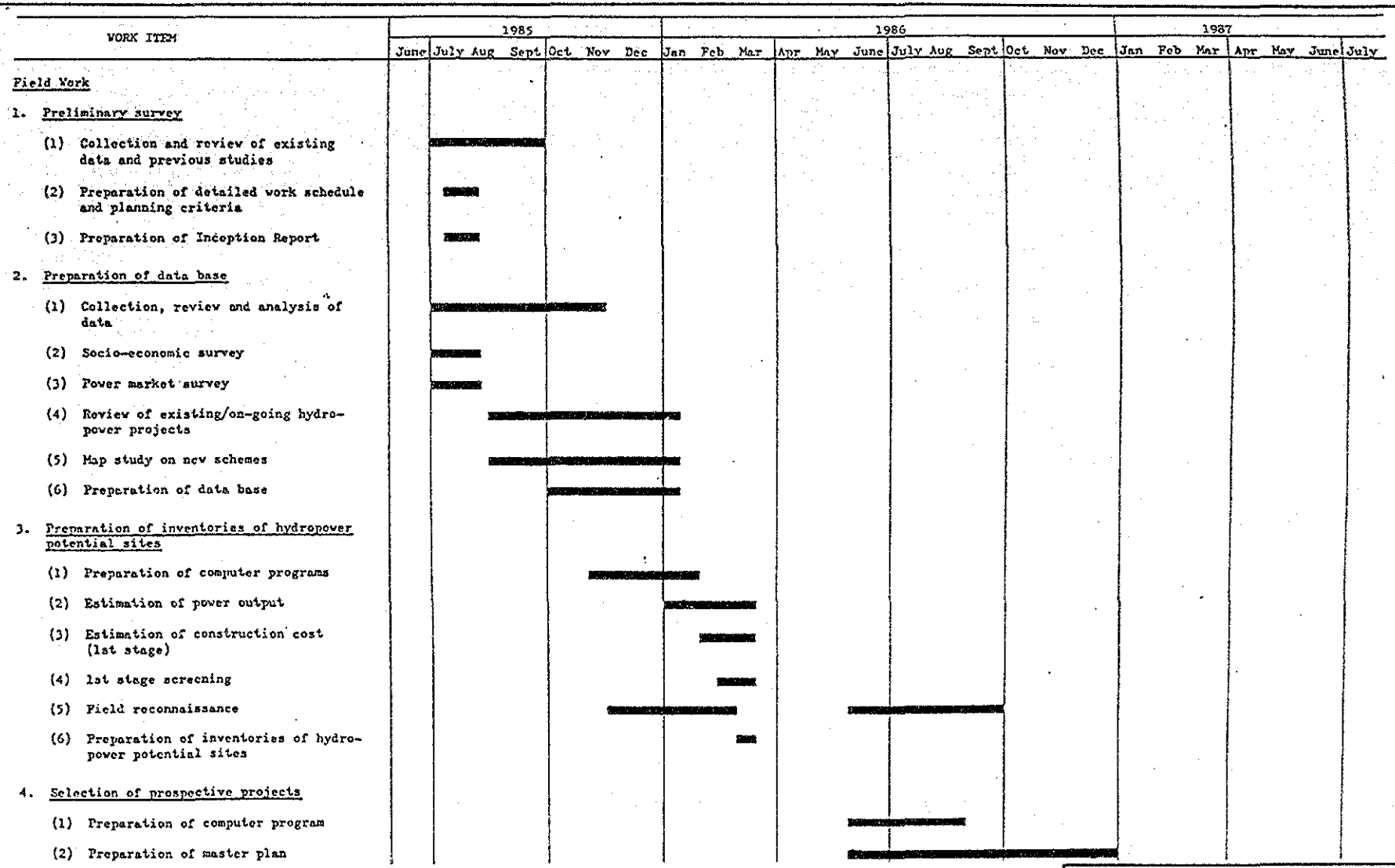

図 1.1　作業工程 (1/2)

NATIONAL POWER CORPORATION

STUDY ON HYDROPOWER POTENTIALS IN LUZON ISLAND

JAPAN INTERNATIONAL COOPERATION AGENCY

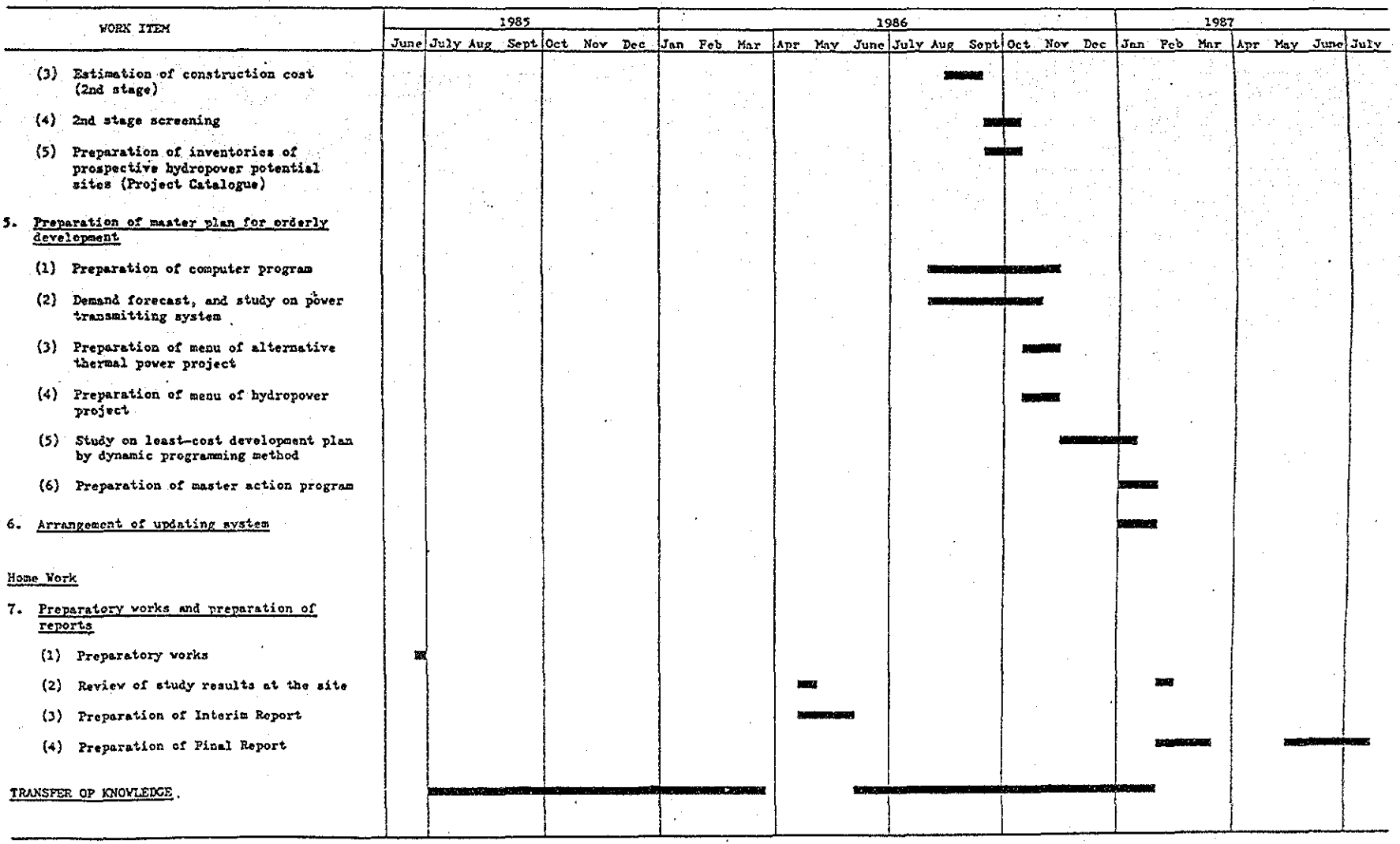

図 1.1　作業工程（2/2）

NATIONAL POWER CORPORATION

STUDY ON HYDROPOWER POTENTIALS IN LUZON ISLAND

JAPAN INTERNATIONAL COOPERATION AGENCY

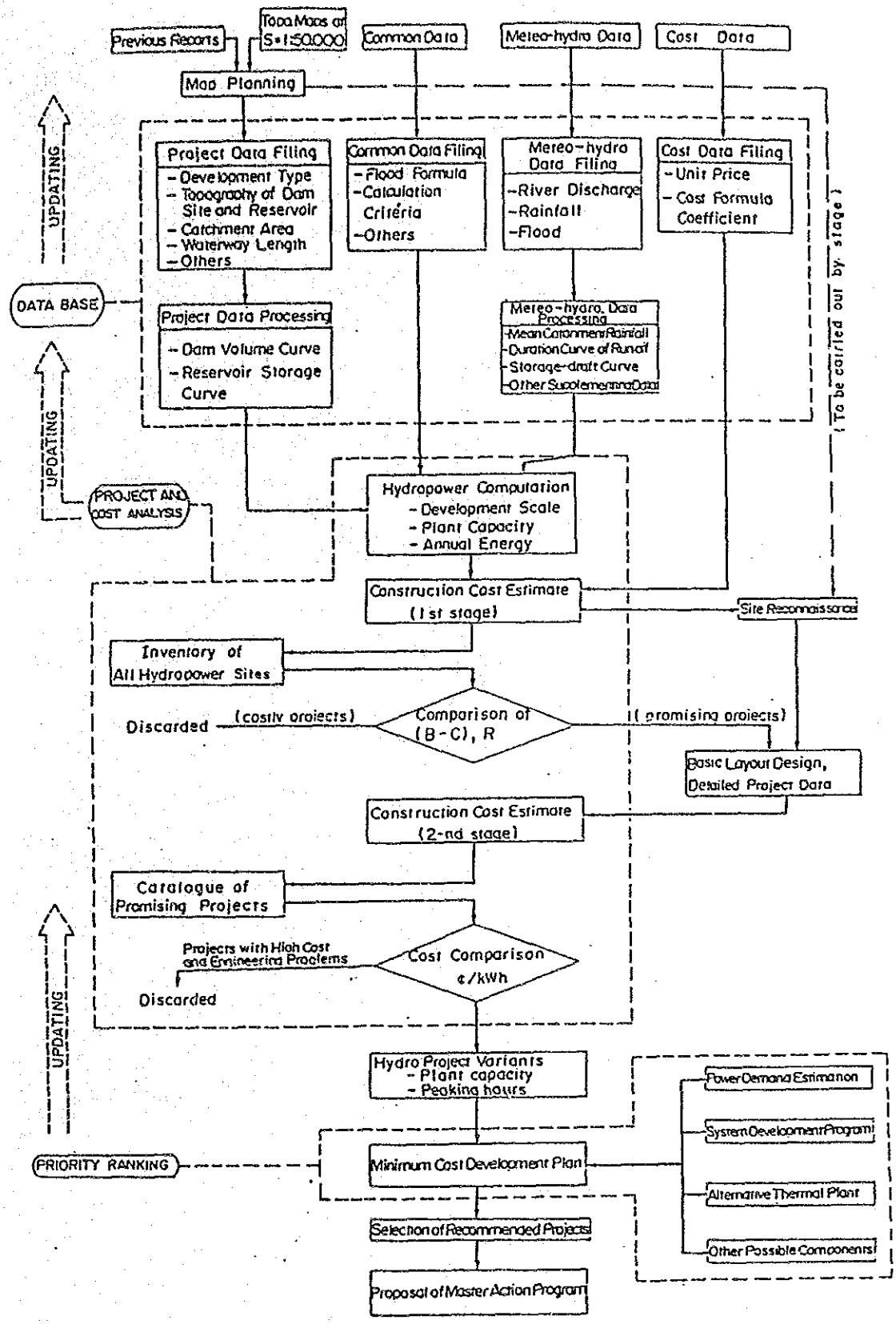

図 2.1　全体作業の流れ図

NATIONAL POWER CORPORATION
STUDY ON HYDROPOWER POTENTIALS IN LUZON ISLAND
JAPAN INTERNATIONAL COOPERATION AGENCY

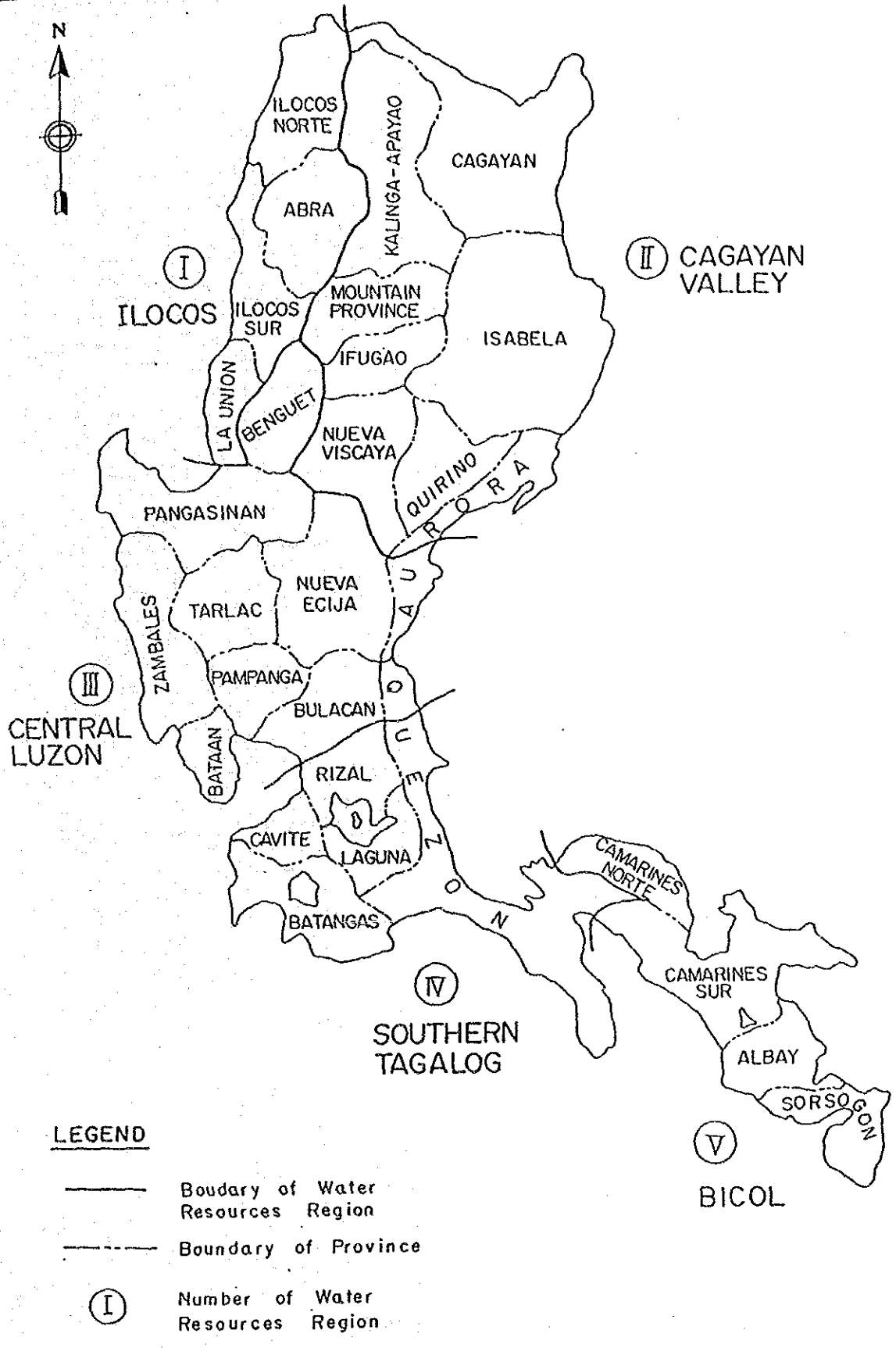

図 2.2　スタディ・エリアの区分図

NATIONAL POWER CORPORATION
STUDY ON HYDROPOWER POTENTIALS IN LUZON ISLAND
JAPAN INTERNATIONAL COOPERATION AGENCY

LEGEND

: Boundary of Water Resources Region

: Boundary of River Basin

: River / Stream

005(029) : Newly Identified Basin Code Number-005
NWRC/NPC Basin Code. Number -(029)

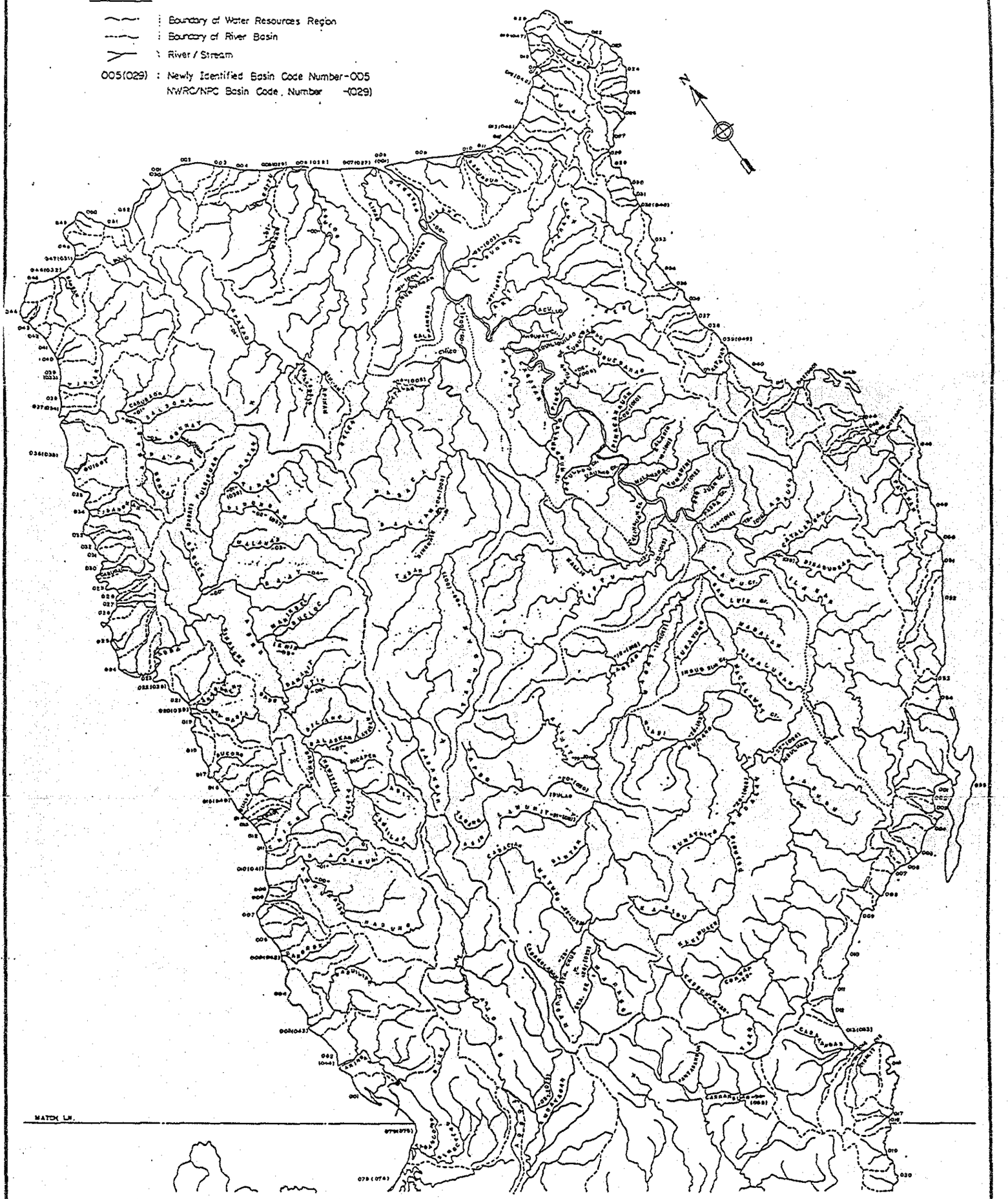

図 2.3　ルソン島の流域･河川の区分図 (1/3)

NATIONAL POWER CORPORATION

STUDY ON HYDROPOWER POTENTIALS IN LUZON ISLAND

JAPAN INTERNATIONAL COOPERATION AGENCY

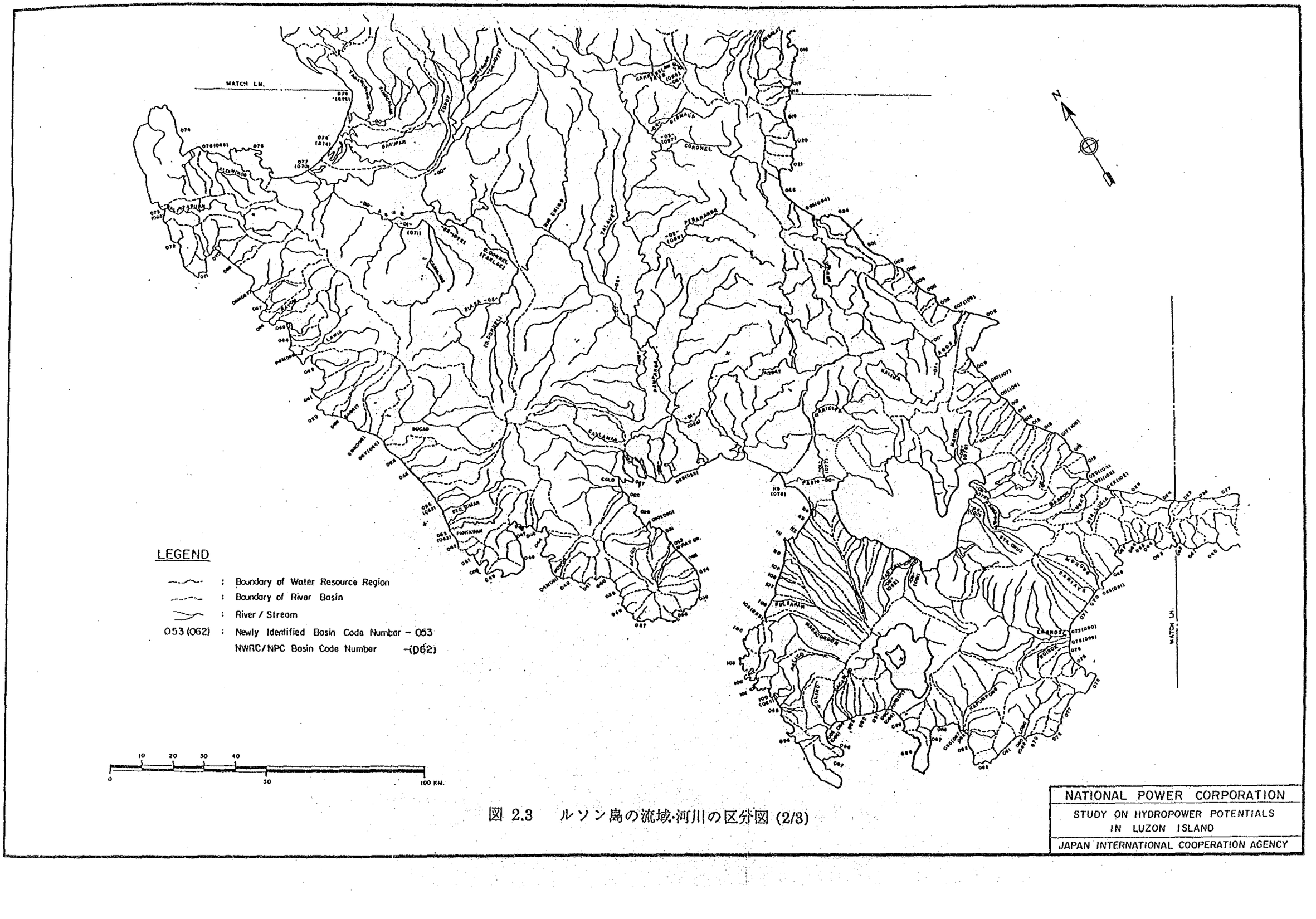

図 2.3　ルソン島の流域･河川の区分図 (2/3)

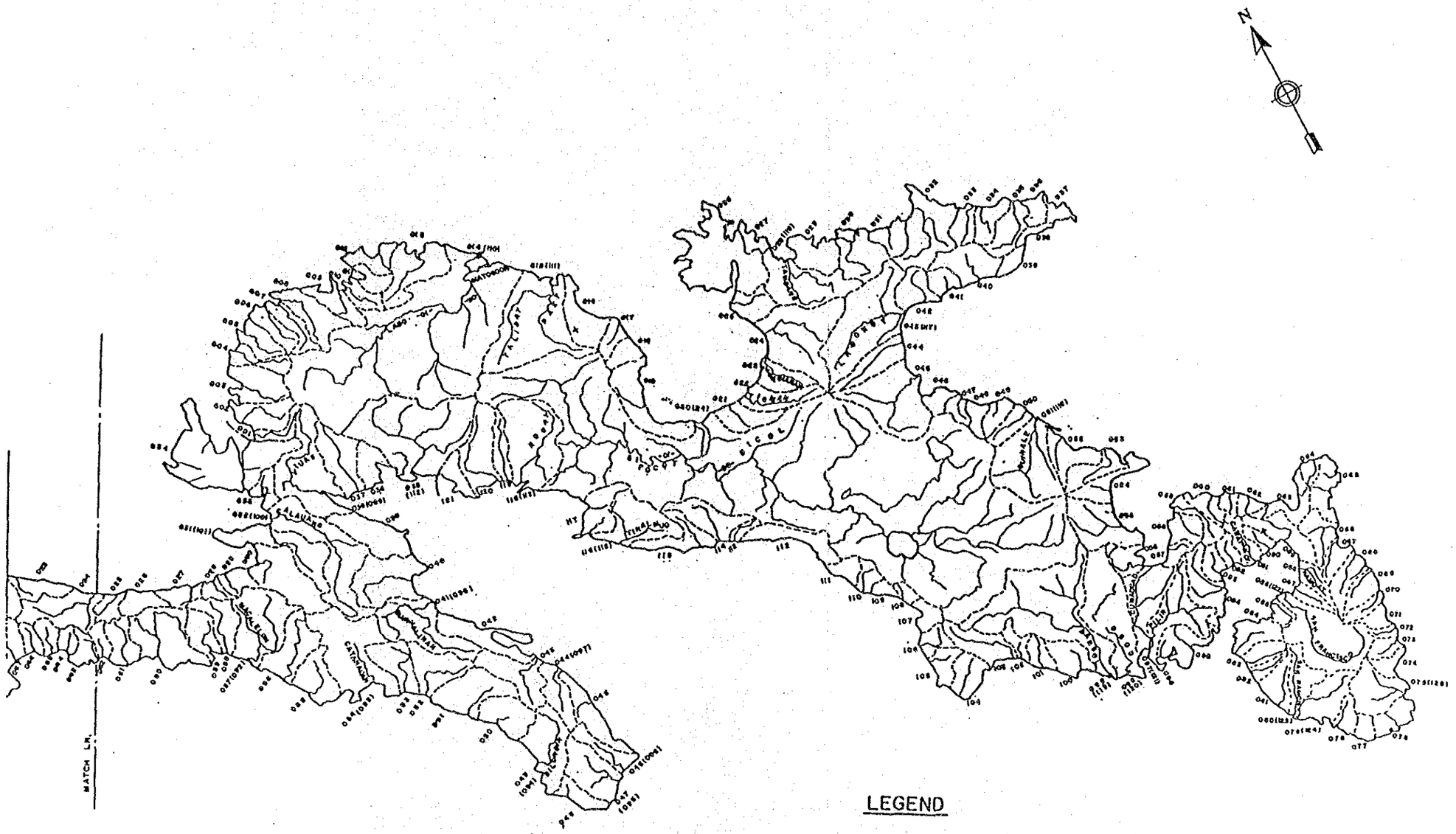

図 2.3　ルソン島の流域･河川の区分図 (3/3)

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JAPAN INTERNATIONAL COOPERATION AGENCY

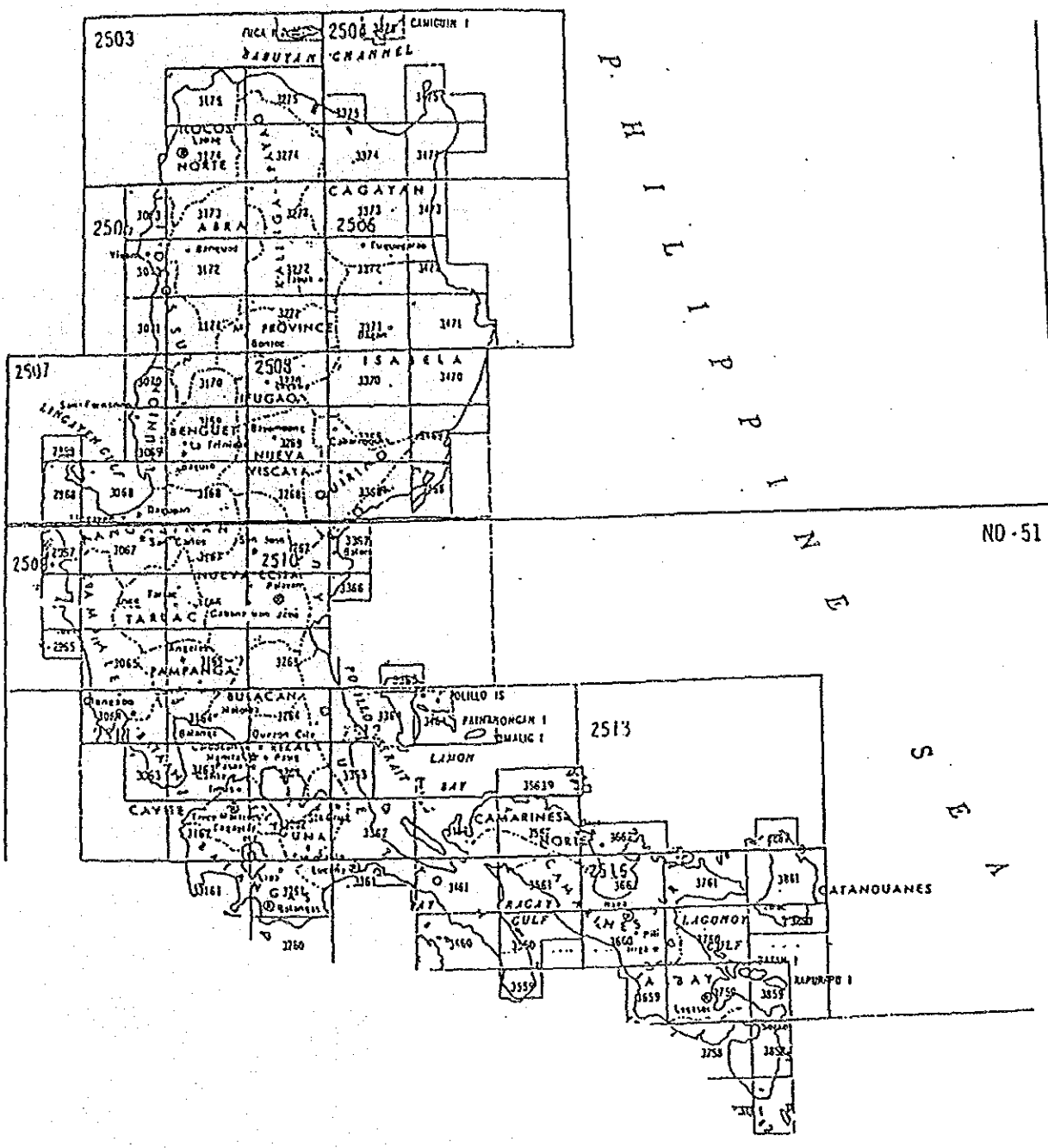

図 3.1　地形図のインデックス・マップ

NATIONAL POWER CORPORATION
STUDY ON HYDROPOWER POTENTIALS IN LUZON ISLAND
JAPAN INTERNATIONAL COOPERATION AGENCY

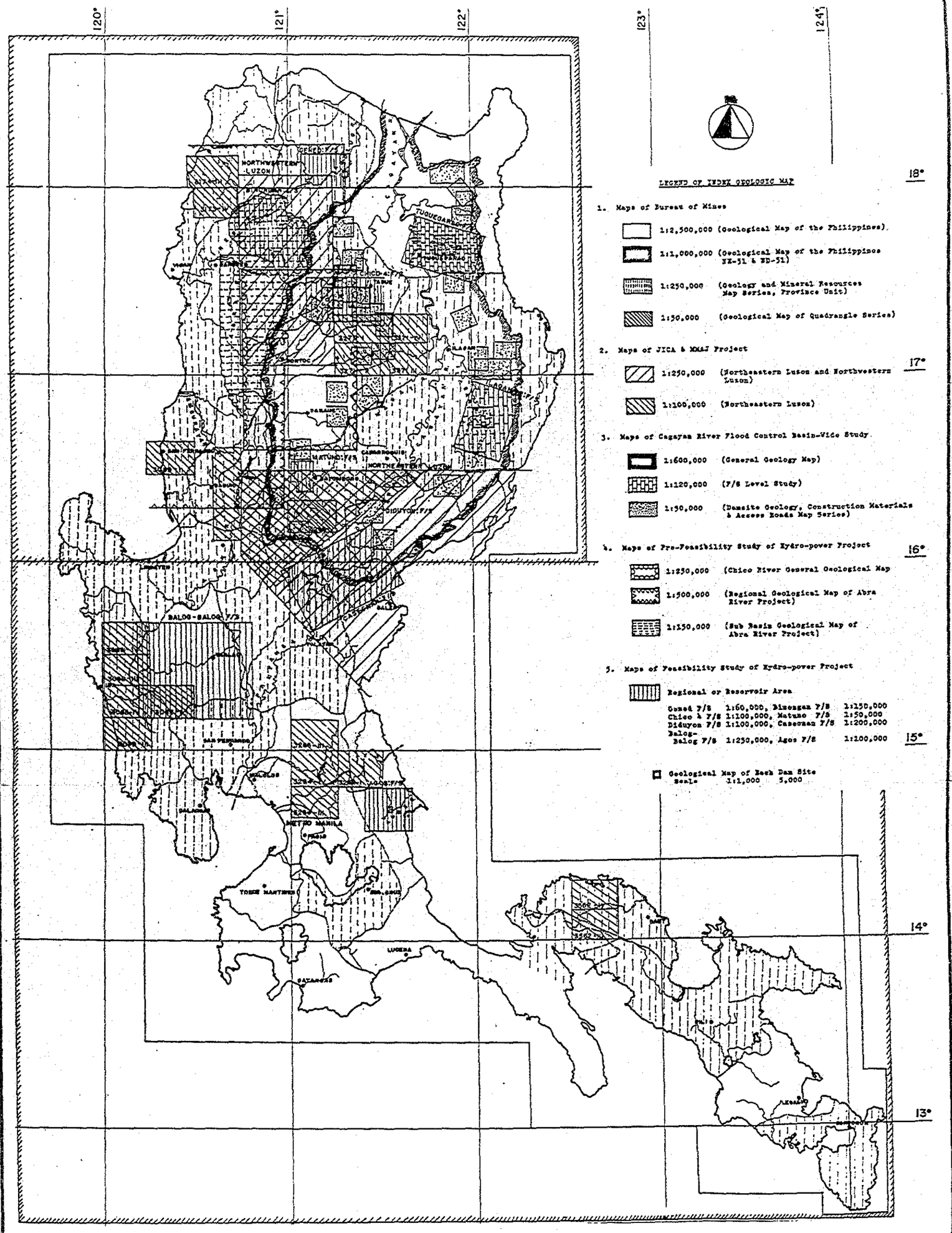

図 3.2　地質図のインデックス・マップ

NATIONAL POWER CORPORATION
STUDY ON HYDROPOWER POTENTIALS IN LUZON ISLAND
JAPAN INTERNATIONAL COOPERATION AGENCY

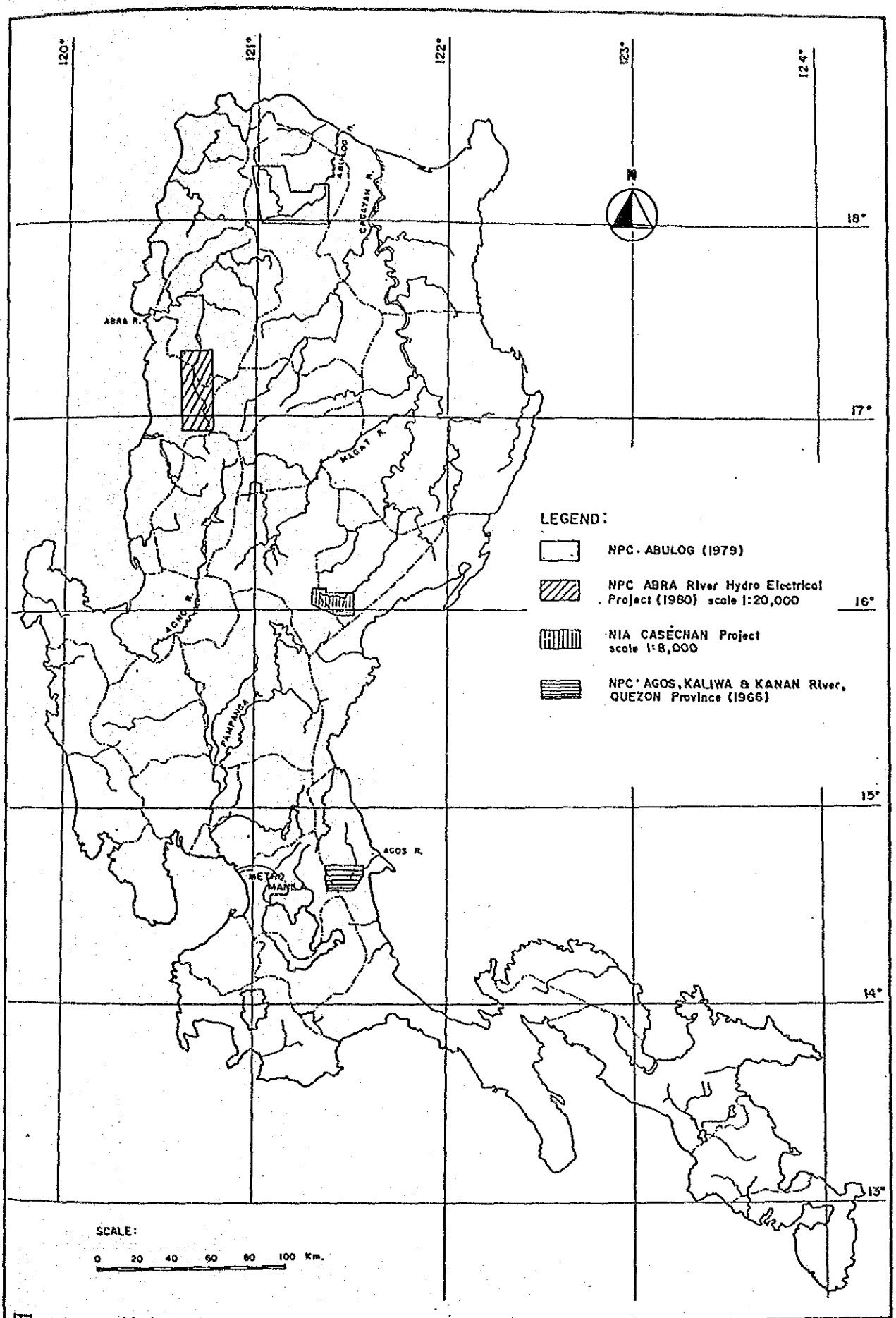

図 3.3　航空写真のインデックス・マップ

NATIONAL POWER CORPORATION
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JAPAN INTERNATIONAL COOPERATION AGENCY

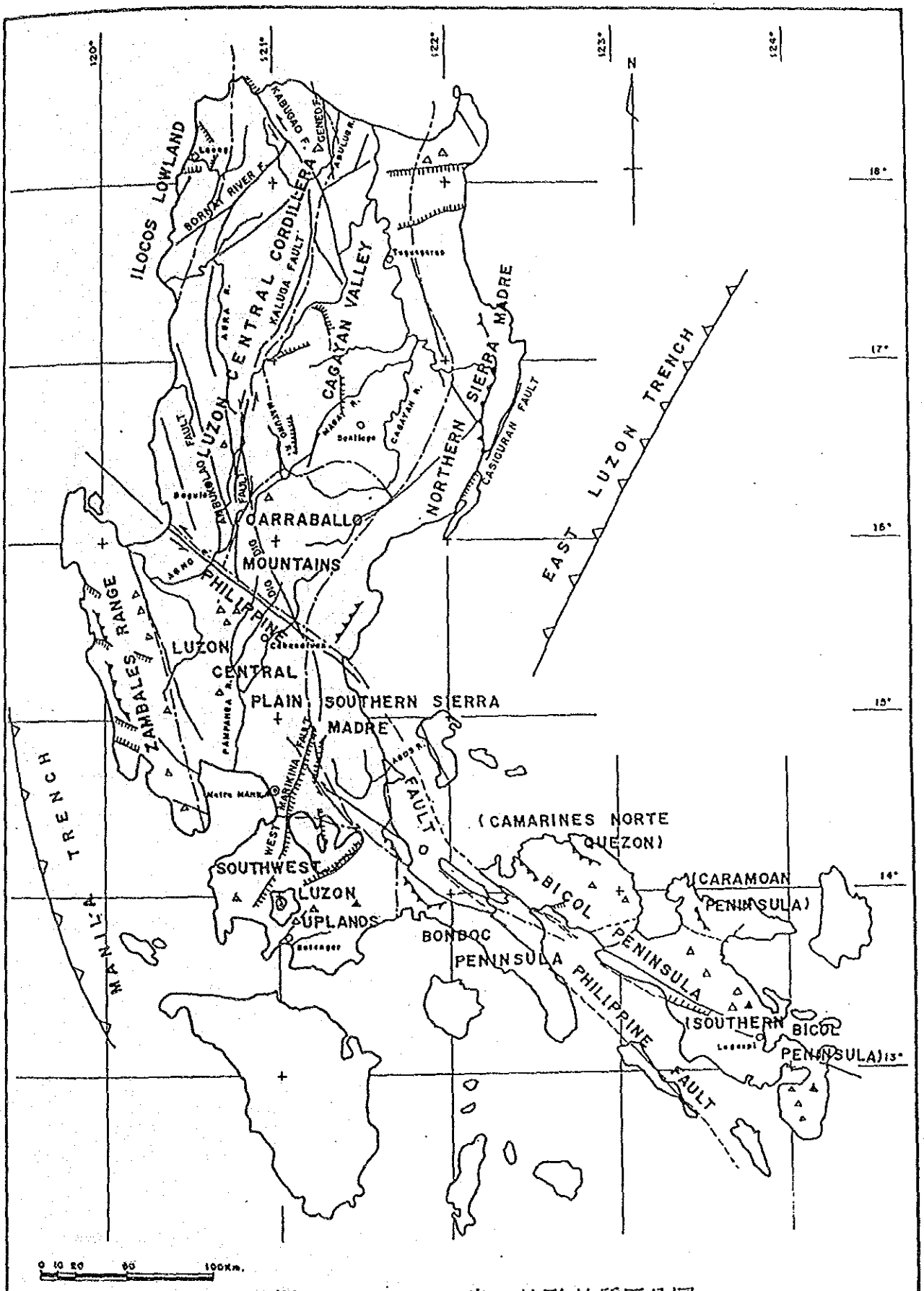

図 3.4　ルソン島の地形･地質区分図

NATIONAL POWER CORPORATION
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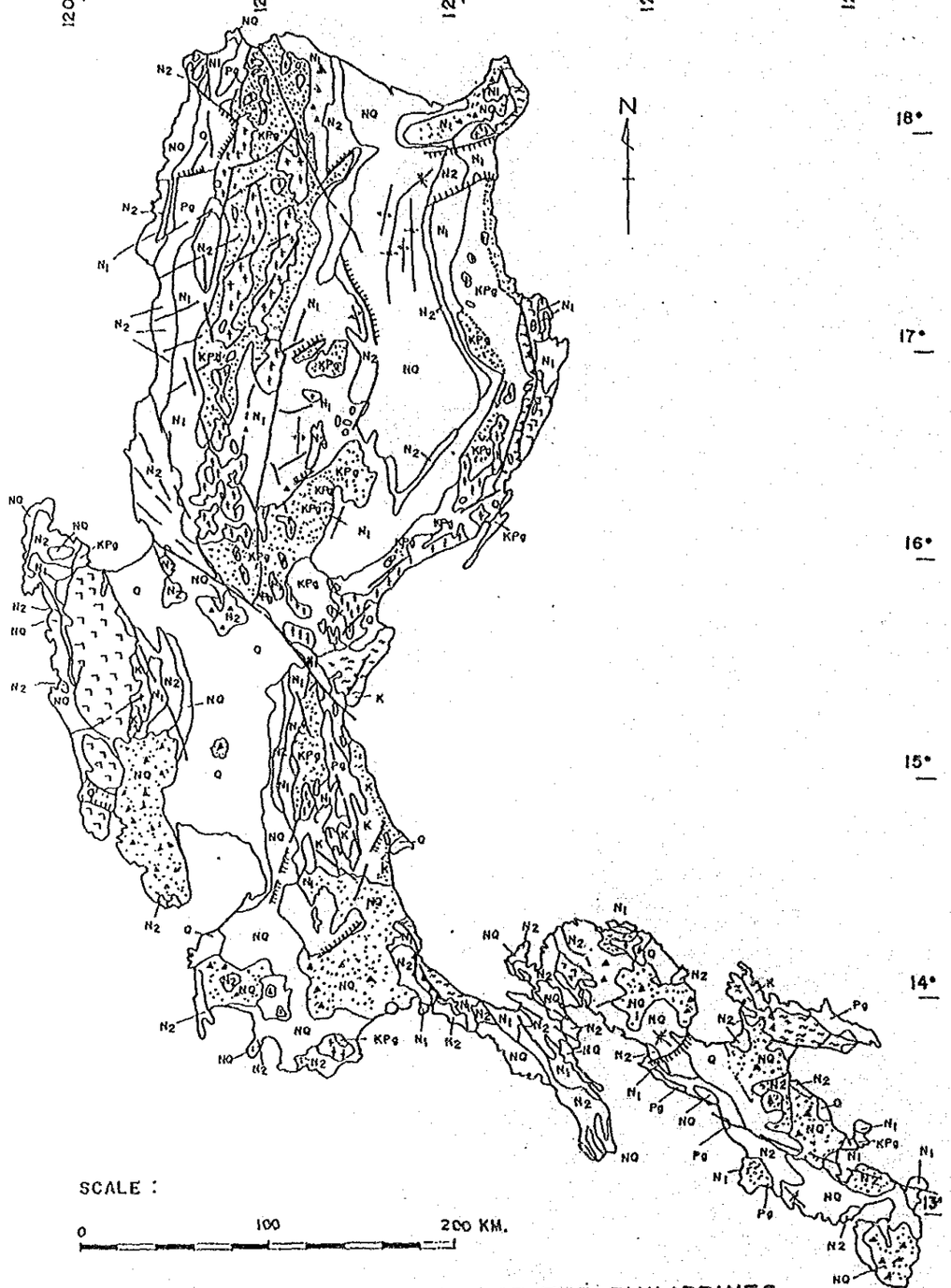

Adopted from : GEOLOGICAL MAP OF THE PHILIPPINES, Bureau of Mines.

LEGEND

		Age	Map Symbol	Sedimentary Rocks	Map Symbol	Volcanic Rocks
CENOZOIC	QUATERNARY	Recent	Q	Quarternary alluvial, lacustrine, beach and residual deposits.	▲	Quarternary volcanics
		Pleistocene	NQ	Marine and terrestial sediments, includes extensive reef limestone and waterlaid pyroclastics	NQ	Volcanic deposits. Mostly andesites and basalts with associated dacites and ryhodacites in places.
	TERTIARY	Pliocene	N2	Largely marine clastics reef limestone.	N2	Andesite-basaltic pyroclastics and lavas, dacite.
		Miocene	N1	Mainly marine sandstone shale and limestone some conglomerate	N1	Mainly dacite and andesite lavas and pyroclastics
		Oligocene	Pg	Mainly marine sandstone graywacke shale and limestone.	Pg	Marine andesite lavas pyroclastics
		Paleocene	KPg	Metasediments consisting mainly of largely graywacke and shale.	KPg	Metavolcanics, largely spilites and basalts.
MESOZOIC		Cretaceous	K	Chert, plagic to hemi-pelagic sediments, turbidites, limestone and graywacke shale.	K	Spilitic to non-spilitic basalt andesite

Intrusive and Basic Rocks

Tertiary — Intermediate to acid; mainly diorite, granodiorite, quartz diorite and monzonite, tonalite, adamellite, gabbro, syenite and granite and localized facies.

Cretaceous-paleogene — Basic and ultrabasic; mainly peridotite, dunite and layered gabbro; peridotite and dunite are generally serpentinized; troctolite, norite, trond; hemite.

Metamorphic Rocks

Pre-Jurassic — Schist, phyllite, gneiss, marple and quartzite ranging from the greenschist to pyroxenite facies.

STRUCTURAL SYMBOLS

- High-angle fault
- Normal fault, hachunes on downthrown side
- Thrust fault, saw-teeth on overriding
- Boundary of lithologic unit
- Anticlimal axis
- Synclimal axis
- ▲ Quaternary volcanic center

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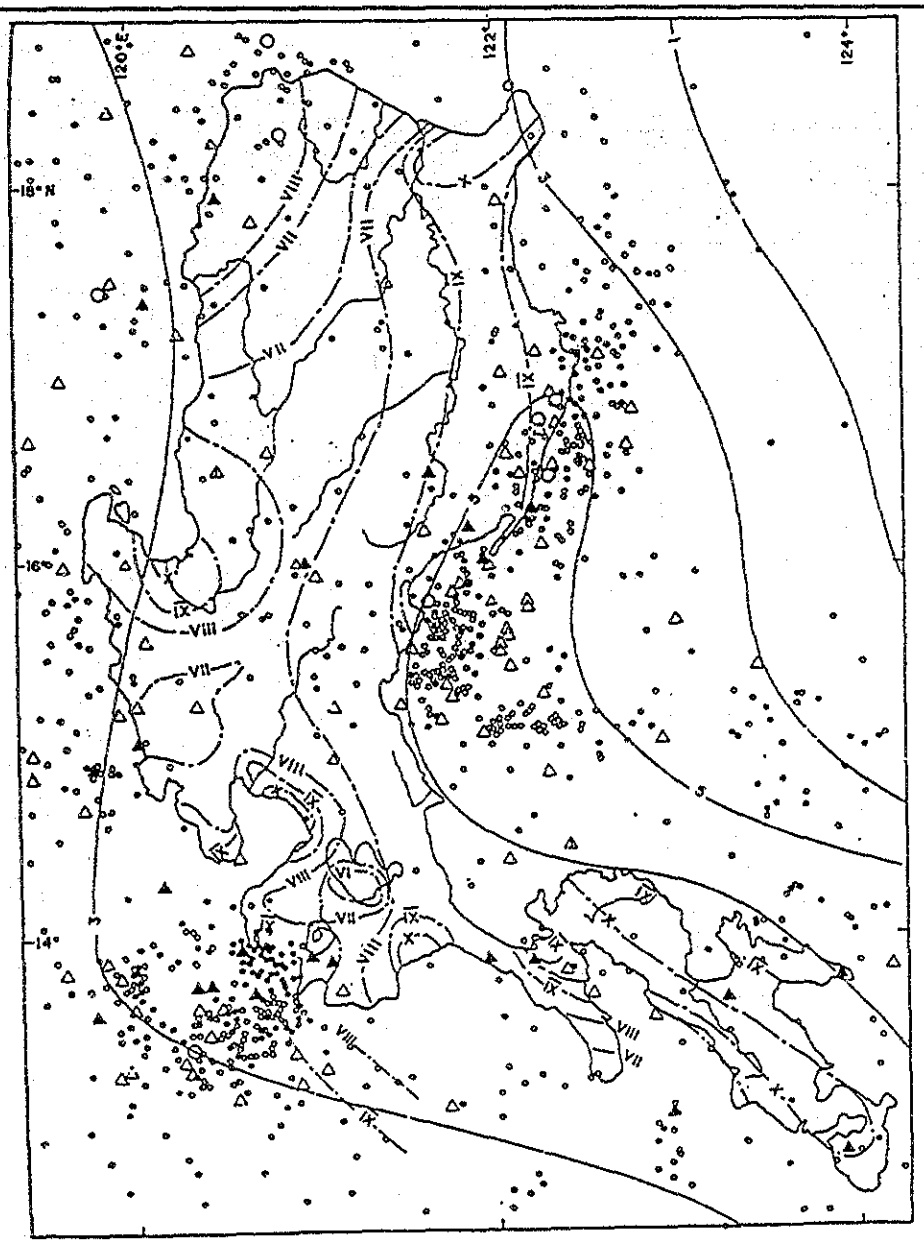
図 3.5　ルソン島の地質図



LEGEND

EARTHQUAKE EPICENTERS

DEPTH OF FOCUS	4 - 5.9	6 - 7.9	UNKNOWN
0-70 km.	•	○	△
70-300 km.	•	●	▲
Unknown	↕	ϕ	⧋

MAXIMUM OBSERVED INTENSITY

ROMAN NUMBER (VII-X) INDICATE INTENSITY

SEISMIC FLUX CONTOUR

5 IN UNITS OF 10^{24} ergs Km^{-2} yr^{-1}

SCALE

0 50 100 150 200 km.

図 3.6 地震図

Adopted from: SEISMOTECTONIC MAP OF THE PHILIPPINES (SOUTHEAST ASIA ASSOCIATION OF SEISMOLOGY AND EARTHQUAKE ENGINEERING, 1985)

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JAPAN INTERNATIONAL COOPERATION AGENCY

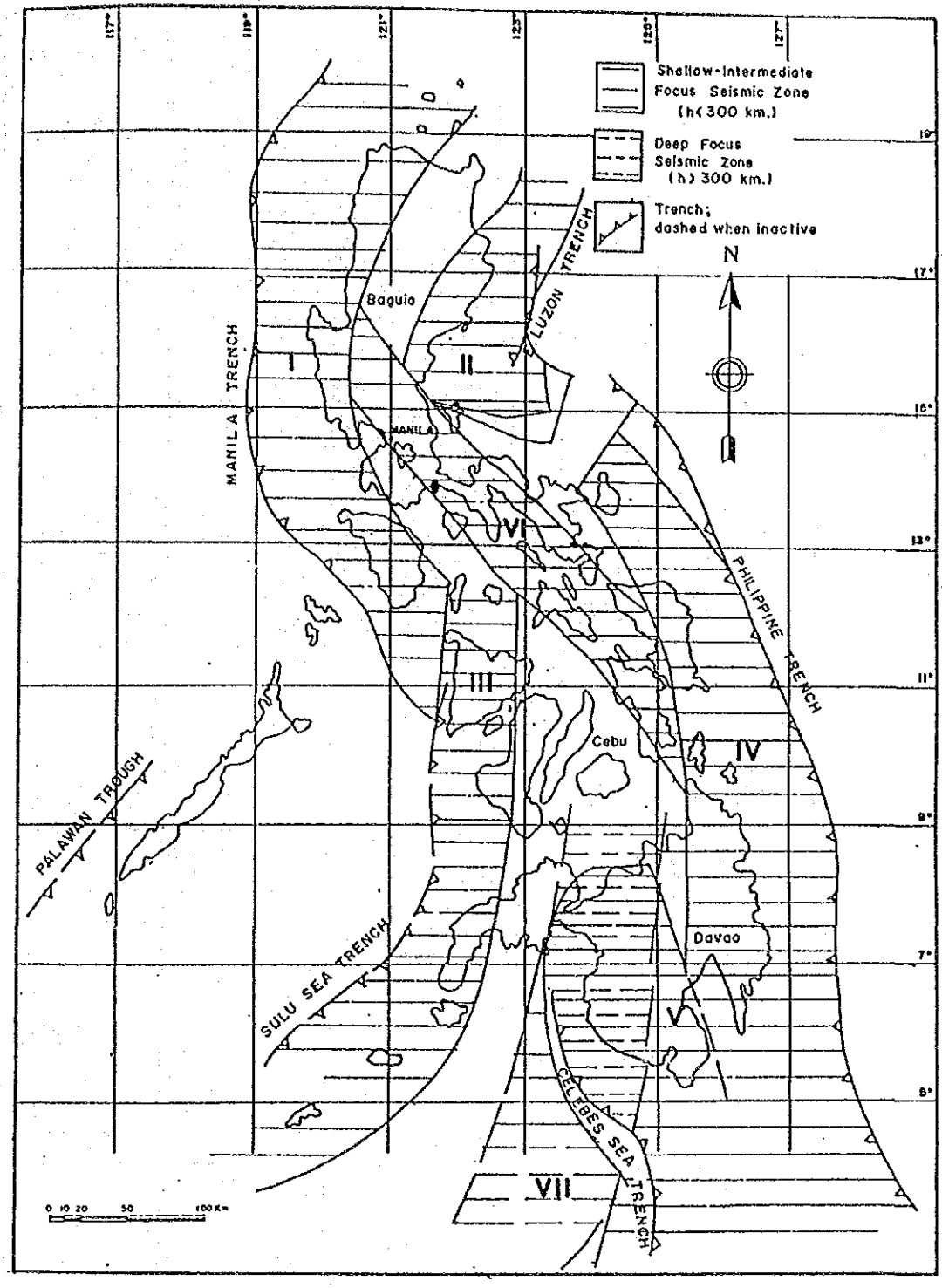

図 3.7　フィリピン全島の震源分布図

From: BMG (1981) GEOLOGY and MINERAL RESOURCES of the PHILIPPINES

NATIONAL POWER CORPORATION
STUDY ON HYDROPOWER POTENTIALS IN LUZON ISLAND
JAPAN INTERNATIONAL COOPERATION AGENCY

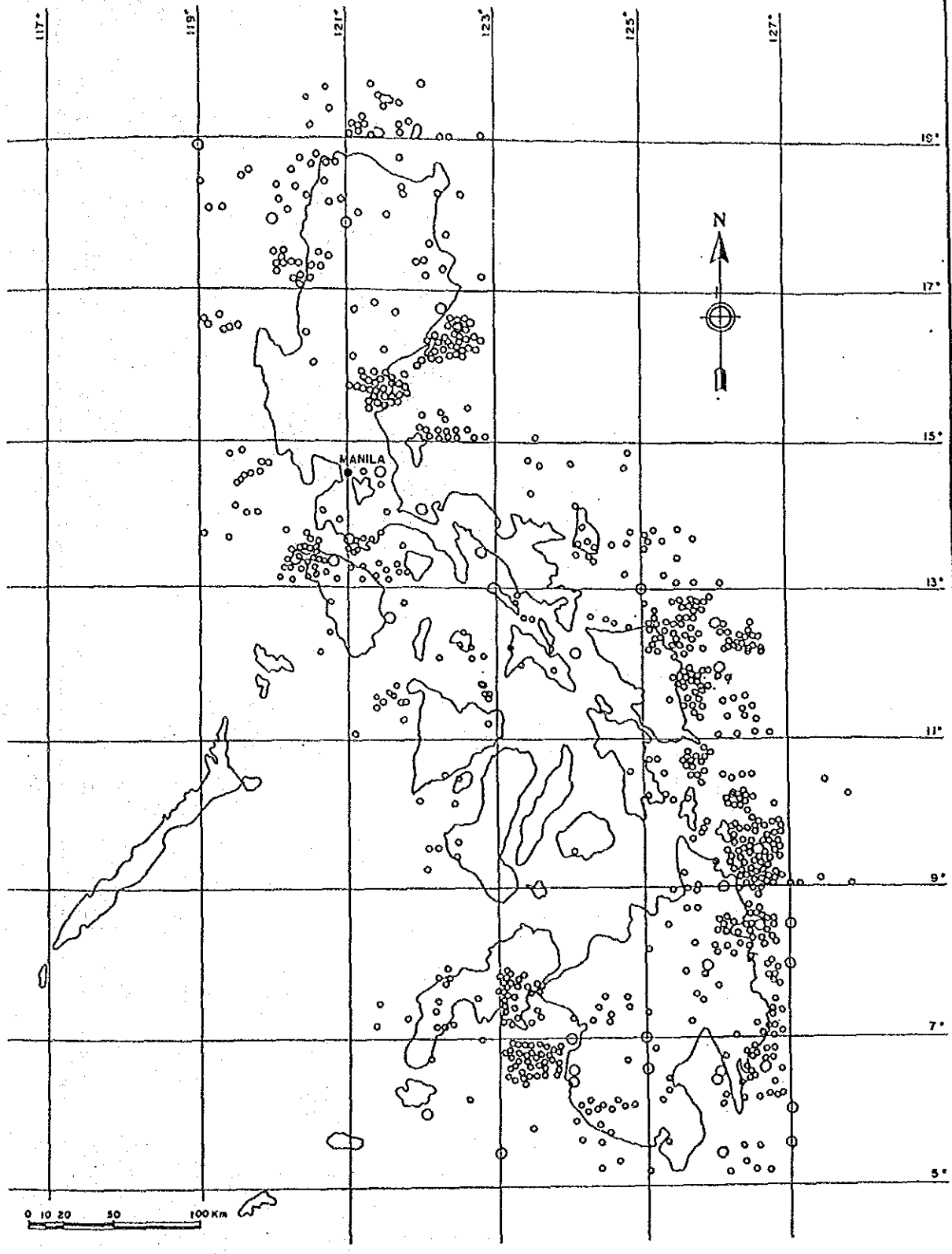

図 3.8　フィリピン全島の地震分布図

Legend :　○ M≧7
　　∘ 7>M≧5

From: NOAA EARTHQUAKE MAGNET TAPE
DATA FILE (1655-1978) M≧5, h<70

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JAPAN INTERNATIONAL COOPERATION AGENCY

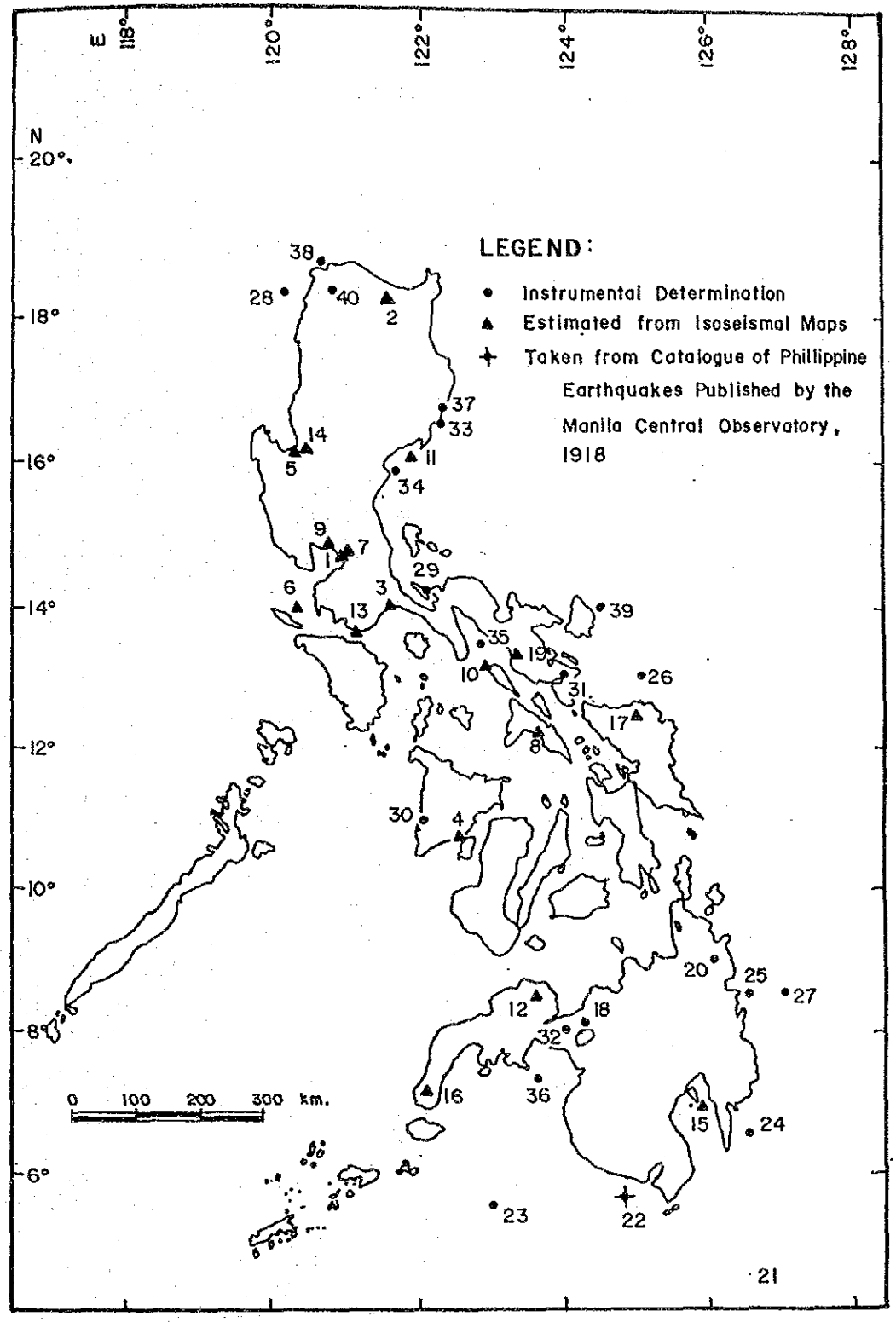


図 3.9　既往大地震の分布図

After L.C. Rolando, et al (SEASEE, Series on Seismology volume IV, Philippines 1985)

NATIONAL POWER CORPORATION
STUDY ON HYDROPOWER POTENTIALS IN LUZON ISLAND
JAPAN INTERNATIONAL COOPERATION AGENCY

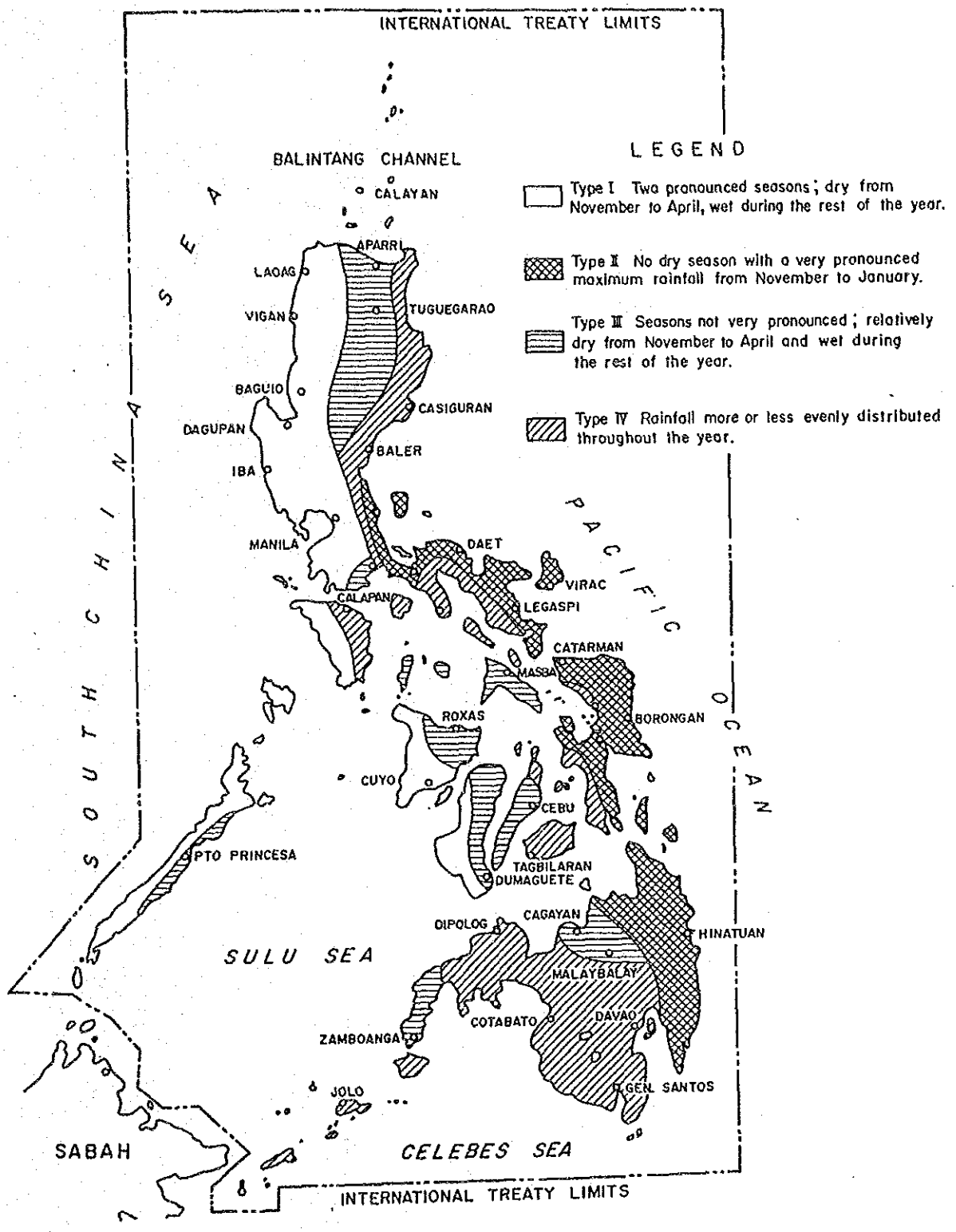


図 4.1　フィリピン気候区分

NATIONAL POWER CORPORATION
STUDY ON HYDROPOWER POTENTIALS IN LUZON ISLAND
JAPAN INTERNATIONAL COOPERATION AGENCY

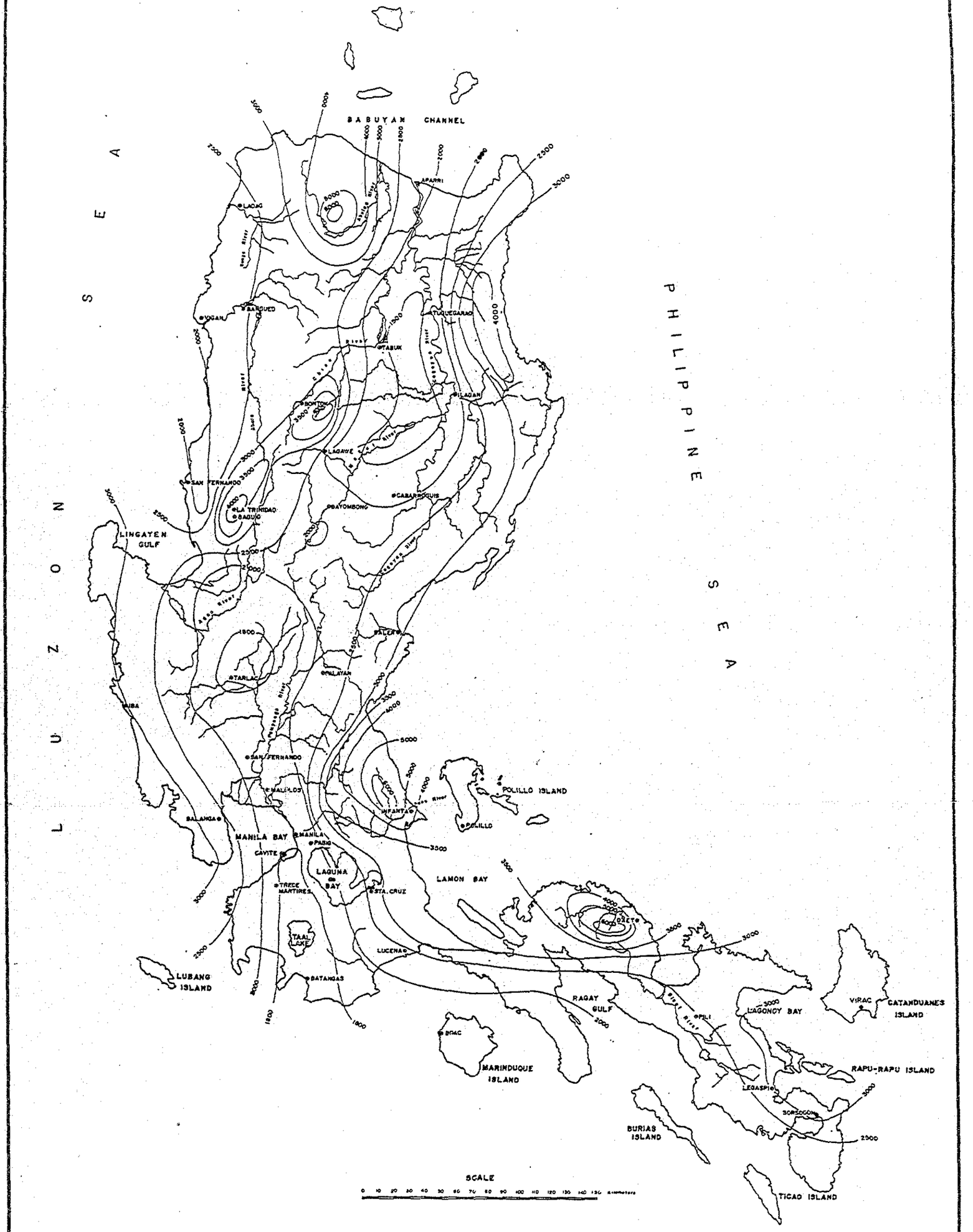


図 4.2　年間降雨等雨量線図

NATIONAL POWER CORPORATION
STUDY ON HYDROPOWER POTENTIALS IN LUZON ISLAND
JAPAN INTERNATIONAL COOPERATION AGENCY

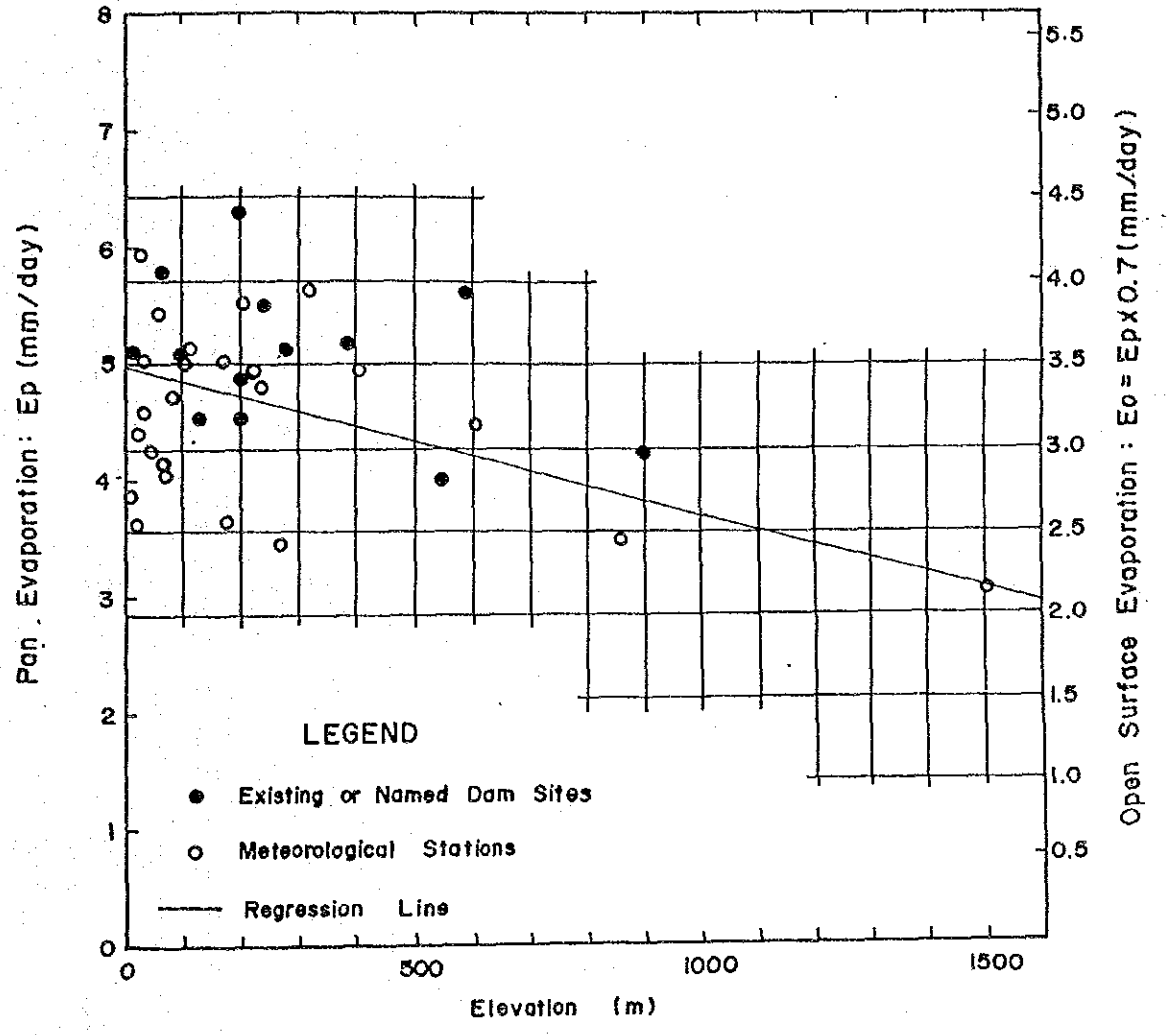
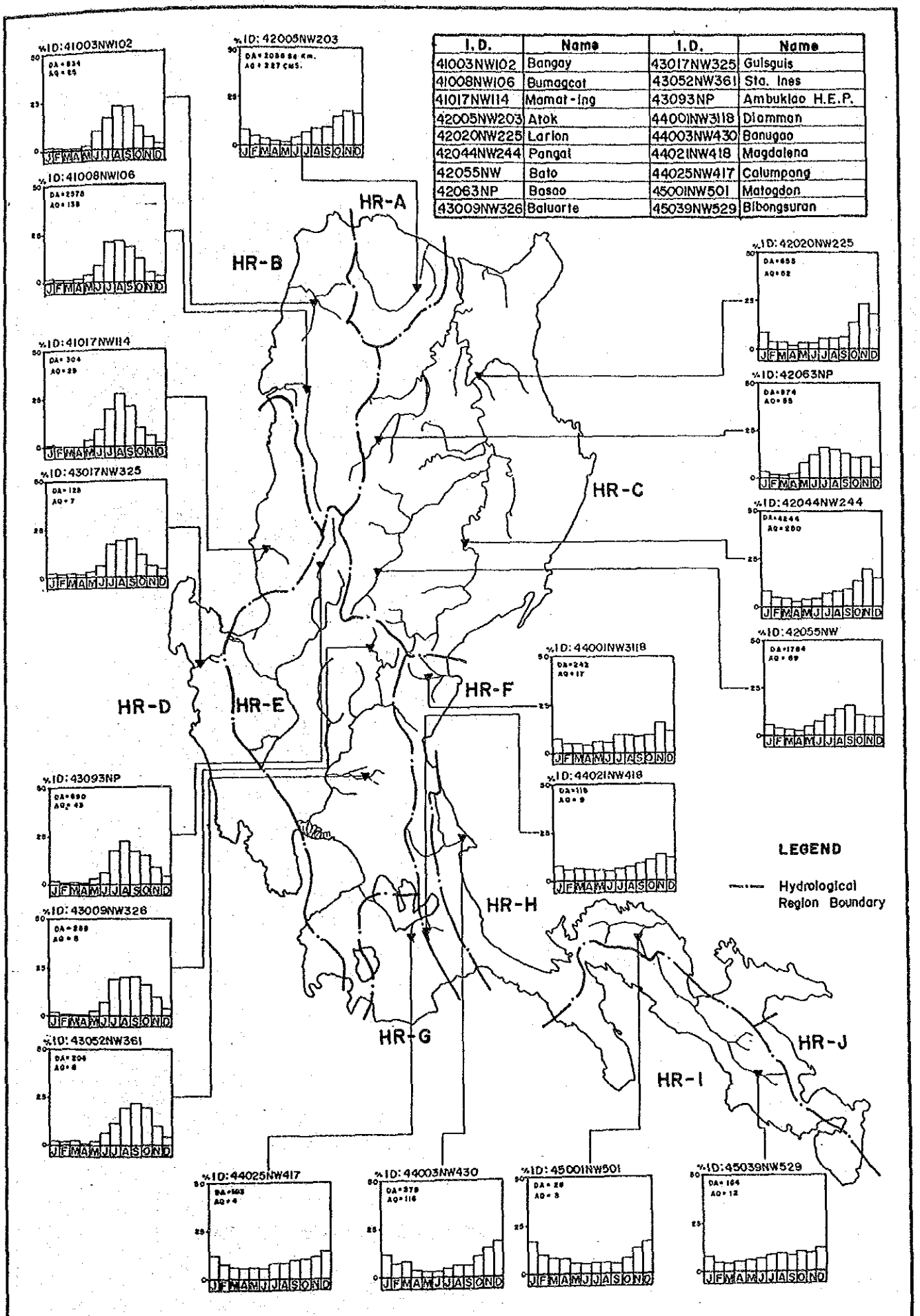


図 4.3　ルソン島内蒸発量

NATIONAL POWER CORPORATION
STUDY ON HYDROPOWER POTENTIALS IN LUZON ISLAND
JAPAN INTERNATIONAL COOPERATION AGENCY



I.D.	Name	I.D.	Name
41003NW102	Bangay	43017NW325	Gulsguis
41008NW106	Bumagcat	43052NW361	Sta. Ines
41017NW114	Mamat-ing	43093NP	Ambuklao H.E.P.
42005NW203	Atok	44001NW3118	Diamman
42020NW225	Larion	44003NW430	Banugao
42044NW244	Pangat	44021NW418	Magdalena
42055NW	Bato	44025NW417	Calumpang
42063NP	Basao	45001NW501	Matogdon
43009NW326	Baluarte	45039NW529	Bibongsuran

図 4.4　基準流量観測所地点月流量ハイドログラフ

NATIONAL POWER CORPORATION
STUDY ON HYDROPOWER POTENTIALS IN LUZON ISLAND
JAPAN INTERNATIONAL COOPERATION AGENCY

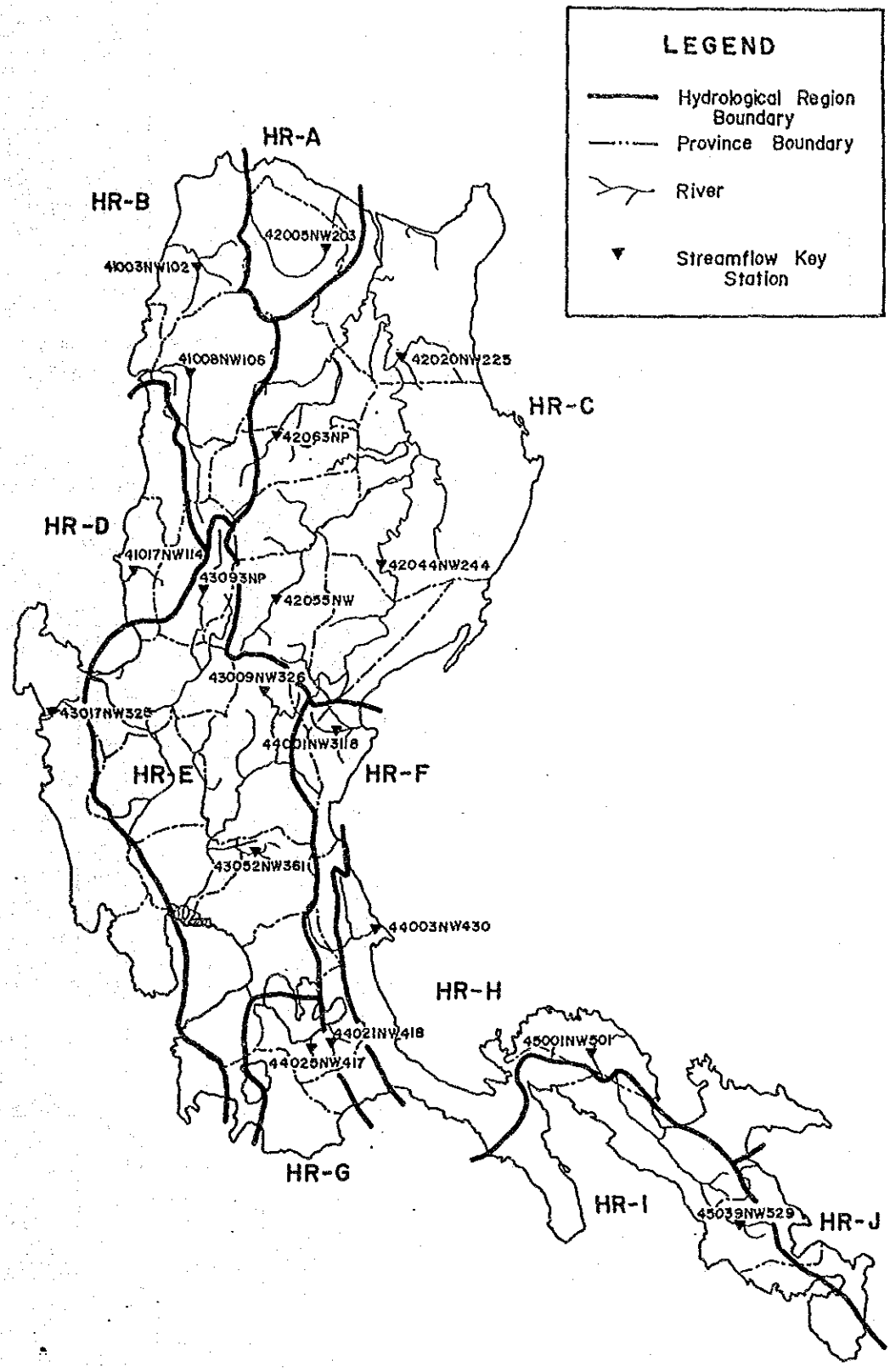


図 4.5　水文地域区分及び基準流量観測所

NATIONAL POWER CORPORATION
STUDY ON HYDROPOWER POTENTIALS IN LUZON ISLAND
JAPAN INTERNATIONAL COOPERATION AGENCY

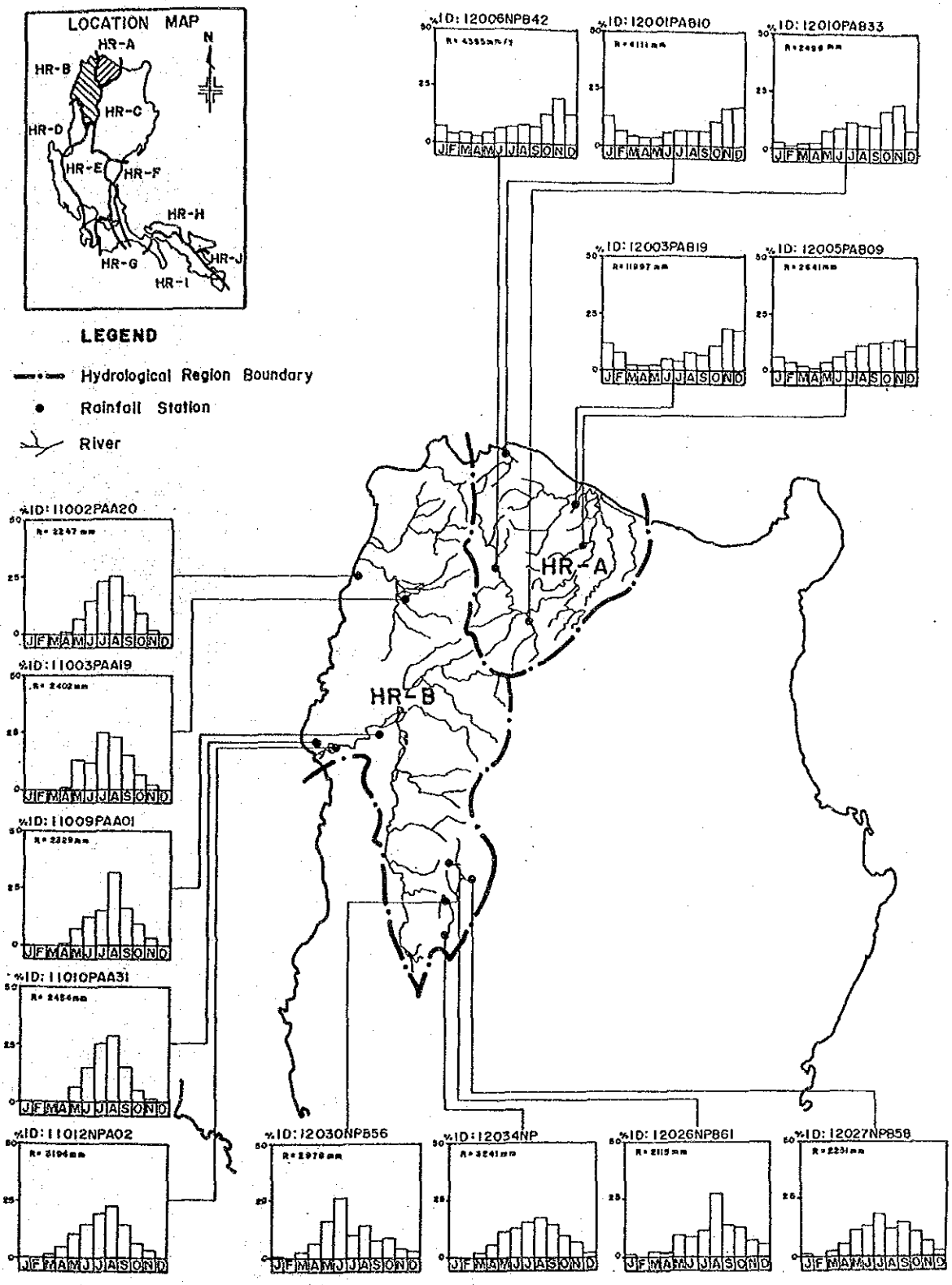


図 4.6　月雨量ハイエトグラフ(水文地域A,B)

NATIONAL POWER CORPORATION
STUDY ON HYDROPOWER POTENTIALS IN LUZON ISLAND
JAPAN INTERNATIONAL COOPERATION AGENCY

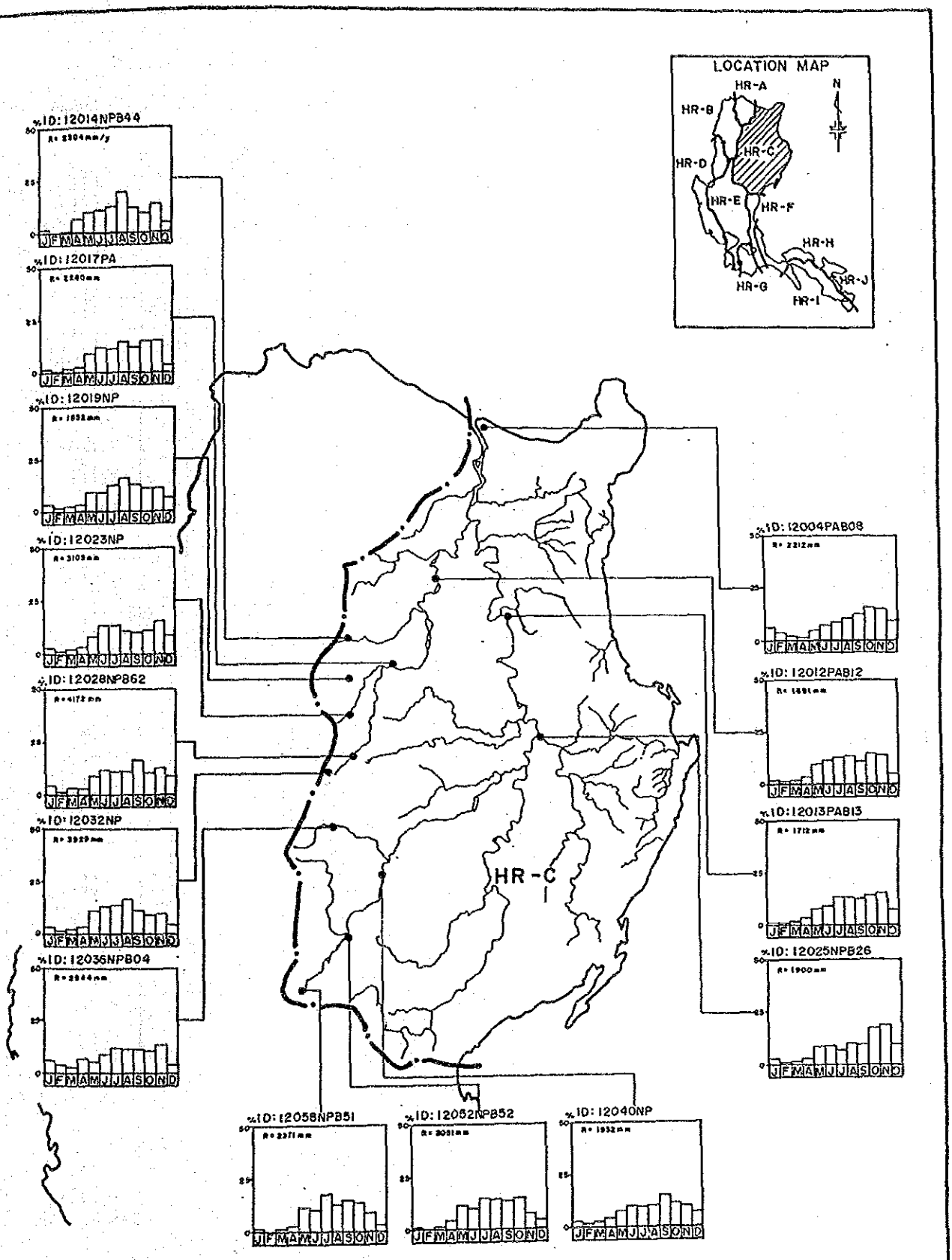


図 4.7　月雨量ハイエトグラフ(水文地域 C)

NATIONAL POWER CORPORATION
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JAPAN INTERNATIONAL COOPERATION AGENCY

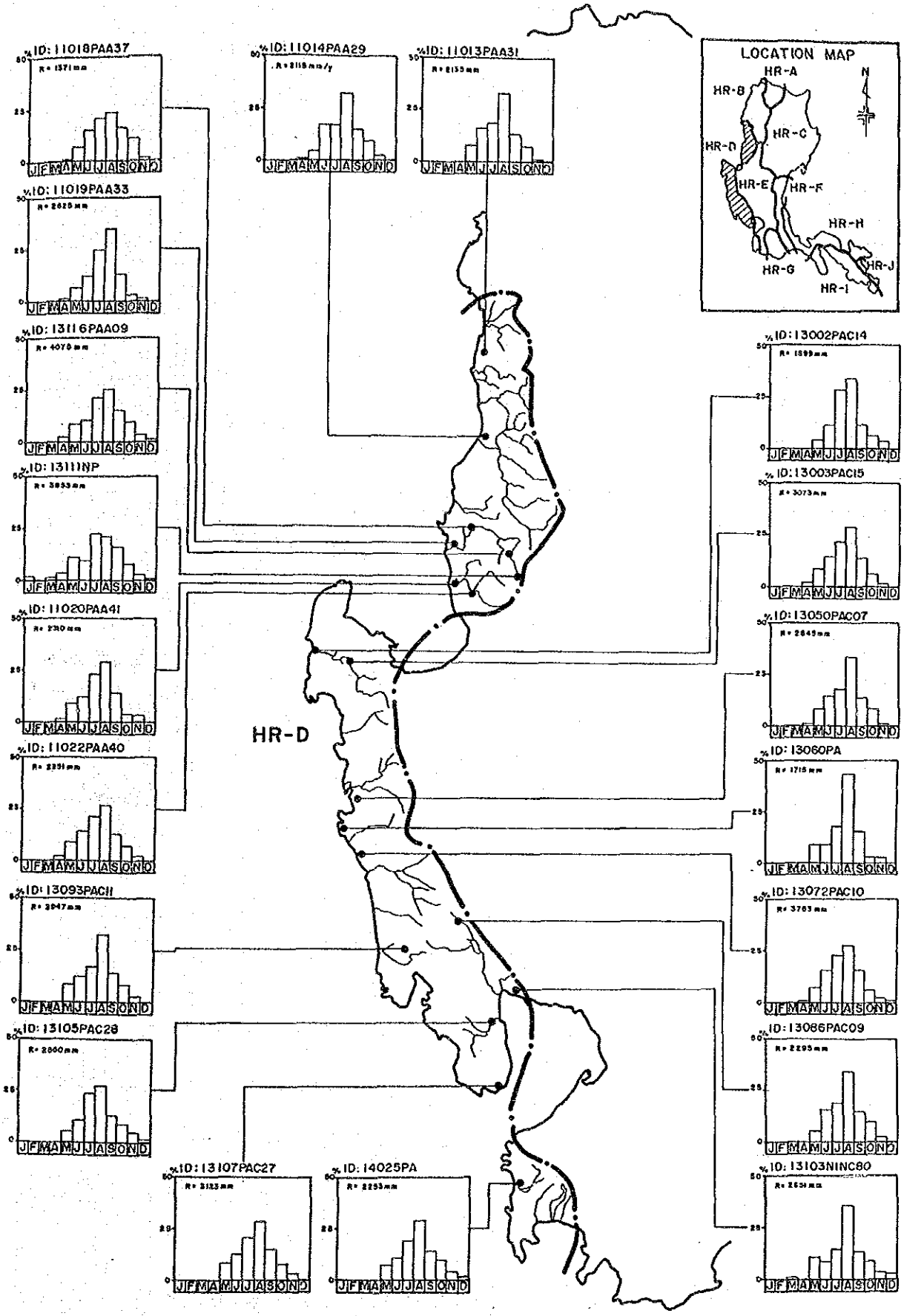

図. 4.8　月雨量ハイエトグラフ(水文地域D)

NATIONAL POWER CORPORATION
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JAPAN INTERNATIONAL COOPERATION AGENCY

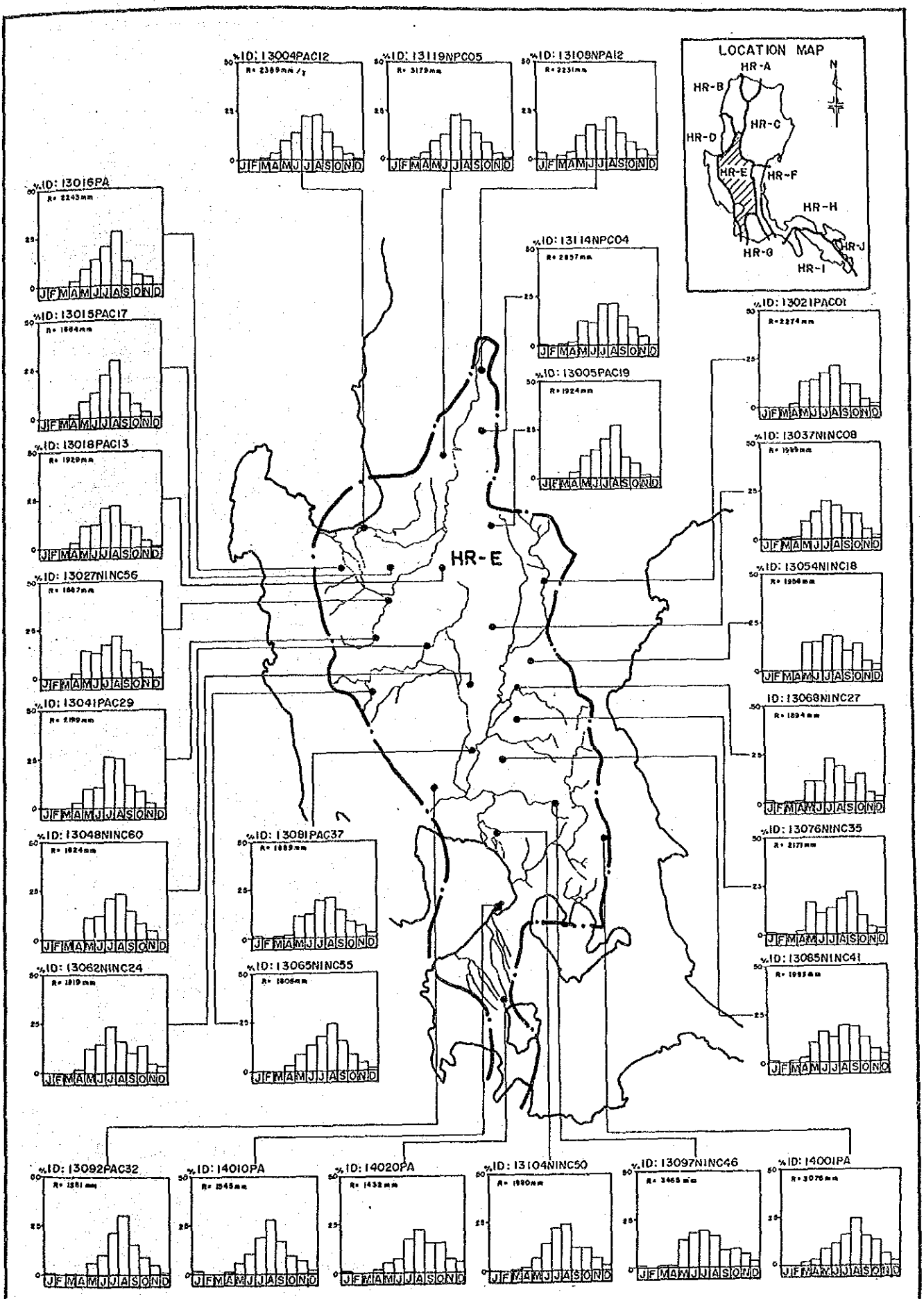

図 4.9　月雨量ハイエトグラフ(水文地域E)

NATIONAL POWER CORPORATION
STUDY ON HYDROPOWER POTENTIALS IN LUZON ISLAND
JAPAN INTERNATIONAL COOPERATION AGENCY

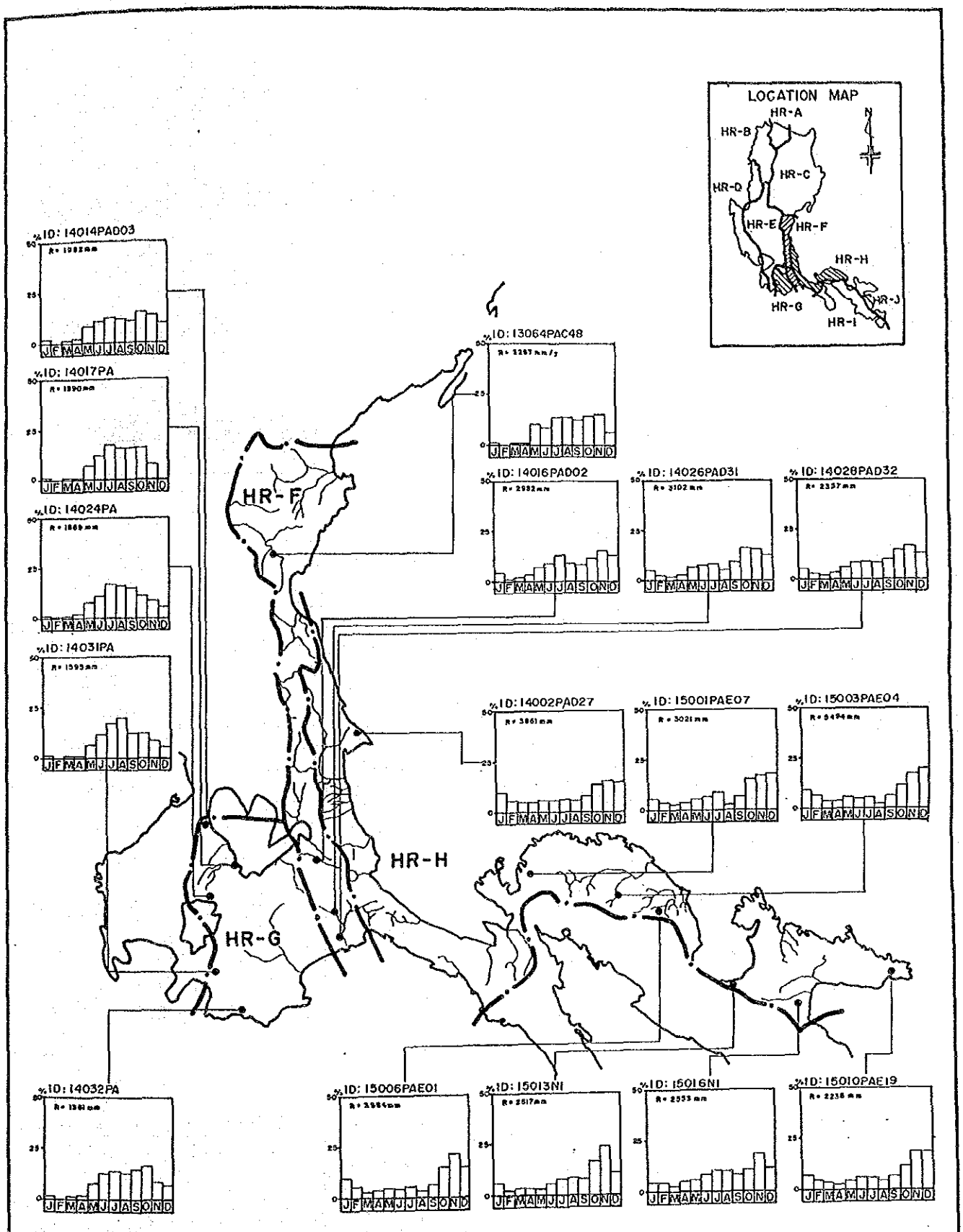

図 4.10　月雨量ハイエトグラフ(水文地域F,G,H)

NATIONAL POWER CORPORATION
STUDY ON HYDROPOWER POTENTIALS IN LUZON ISLAND
JAPAN INTERNATIONAL COOPERATION AGENCY

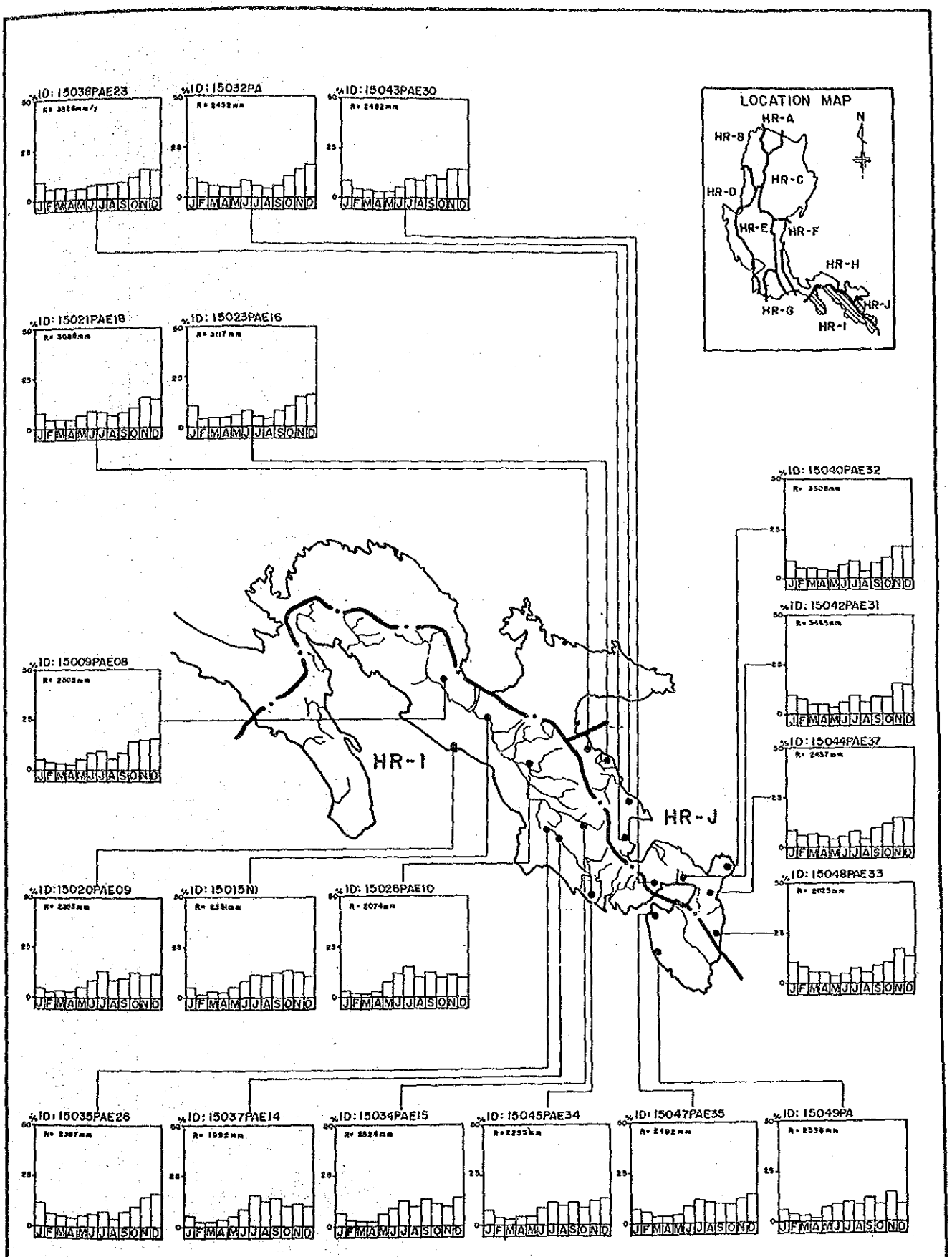

図 4.11 月雨量ハイエトグラフ(水文地域I,J)

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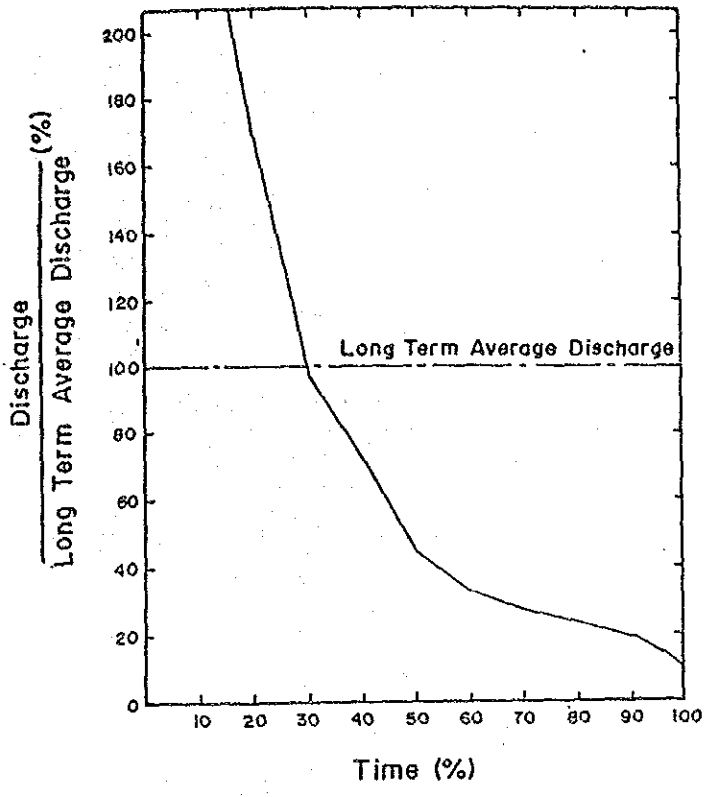
(1) Flow Duration Curve



Station : Bumagcat

I.D. Code : 41008NW106

River System : Abra

Hydrological Region : B

Drainage Area : 2,575 km.^{2}

(2) Storage Draft Curve

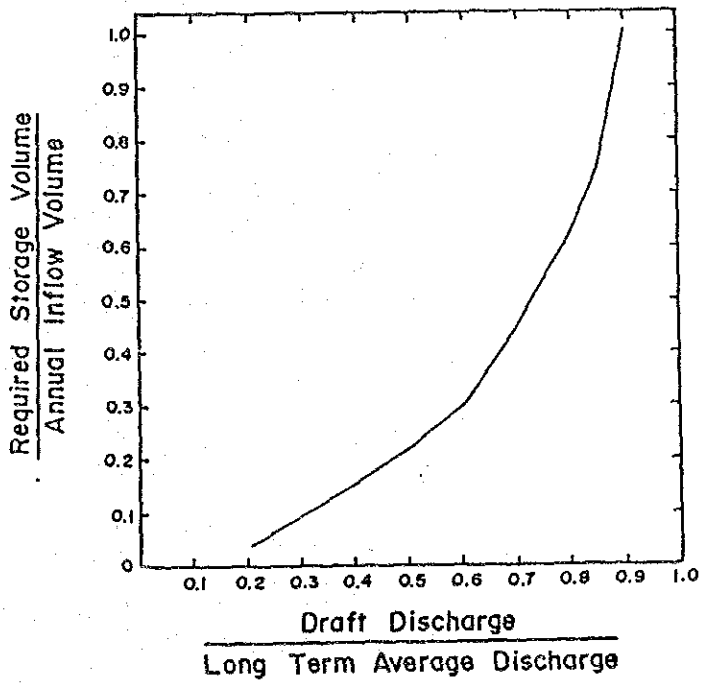


図 4.12 流況曲線並びに貯水池利用曲線

NATIONAL POWER CORPORATION
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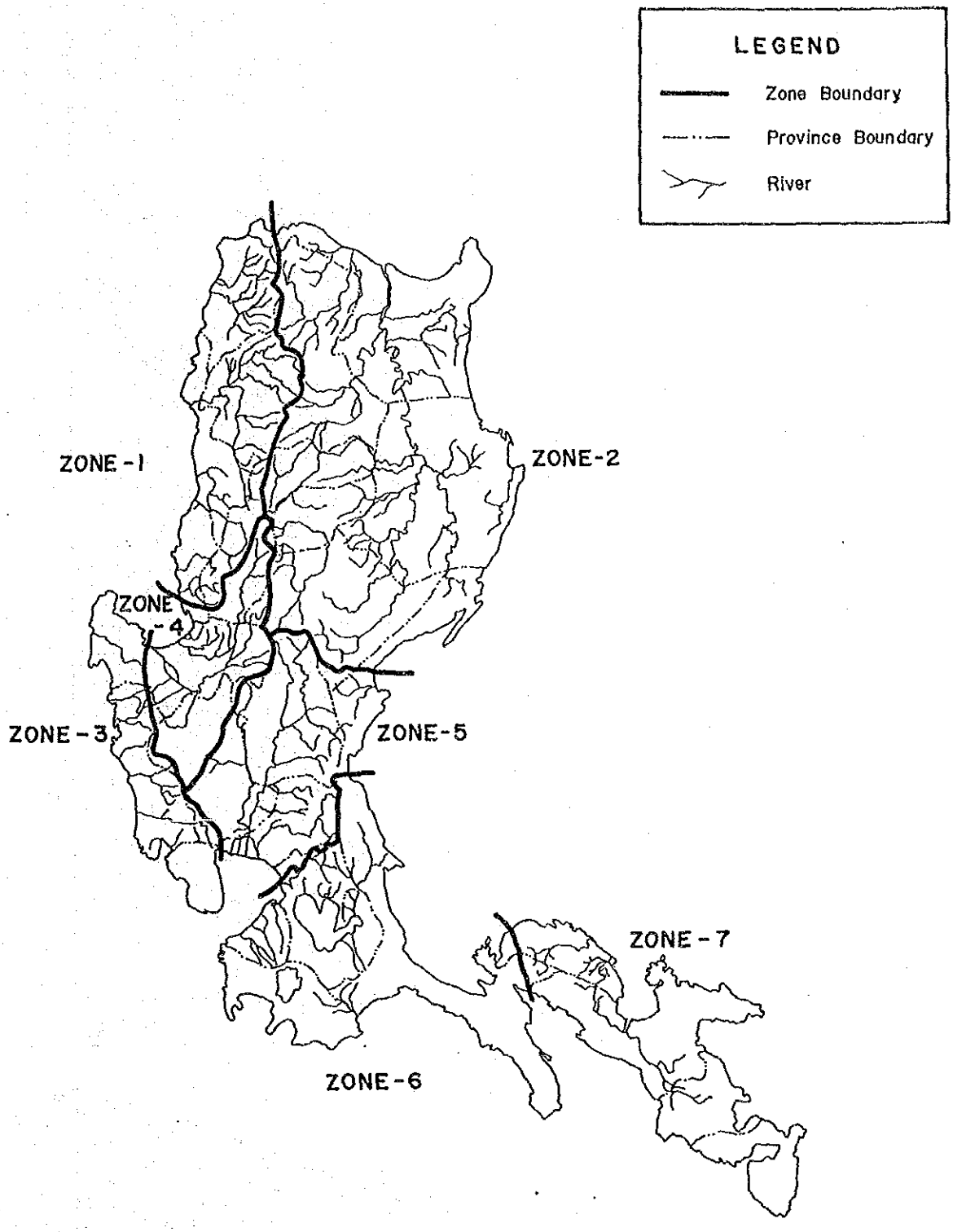

図 4.13　洪水解析に係る地域分割

NATIONAL POWER CORPORATION
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JAPAN INTERNATIONAL COOPERATION AGENCY

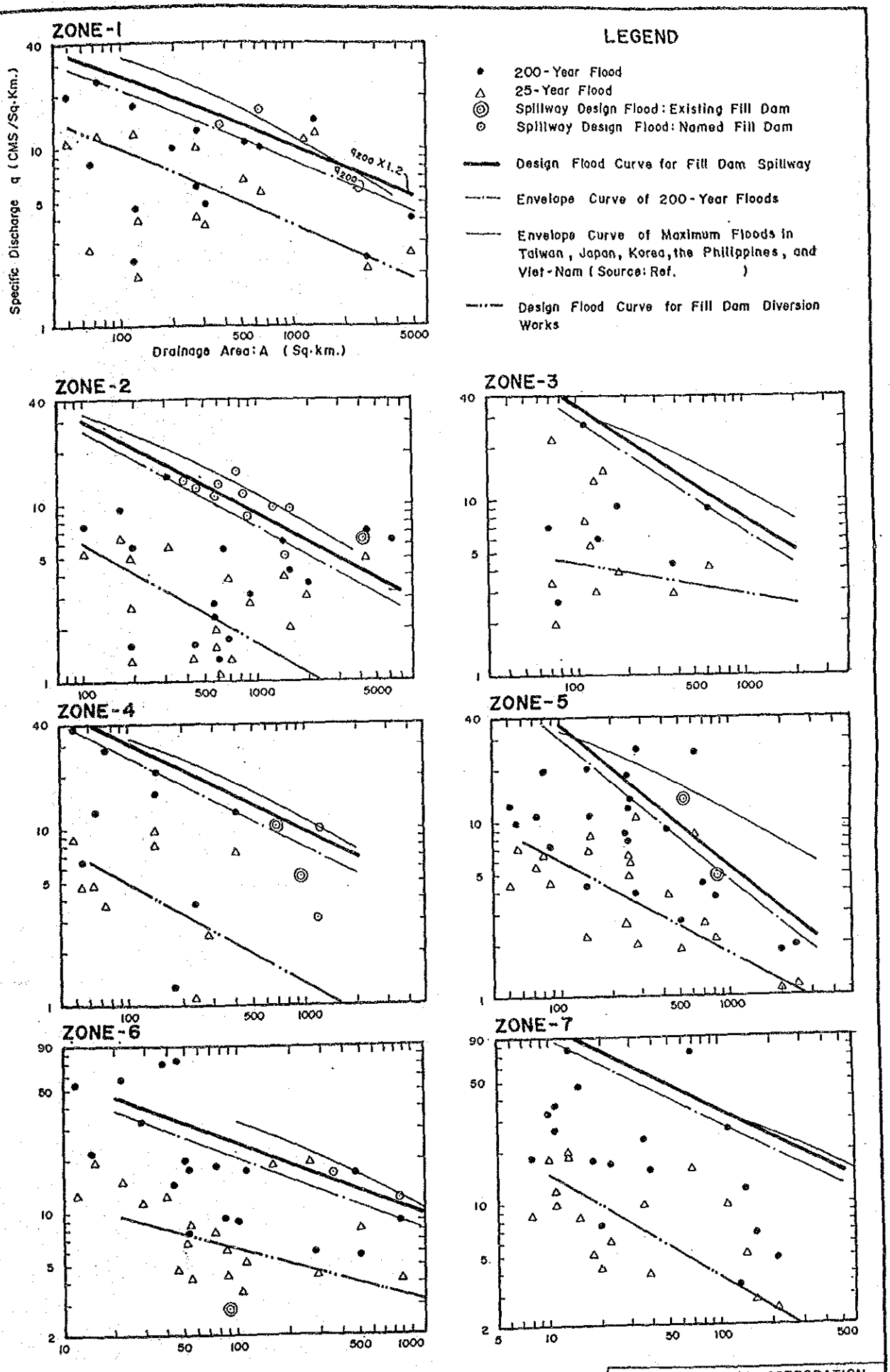

図 4.14 洪水吐並びに転流工設計洪水流量曲線

NATIONAL POWER CORPORATION
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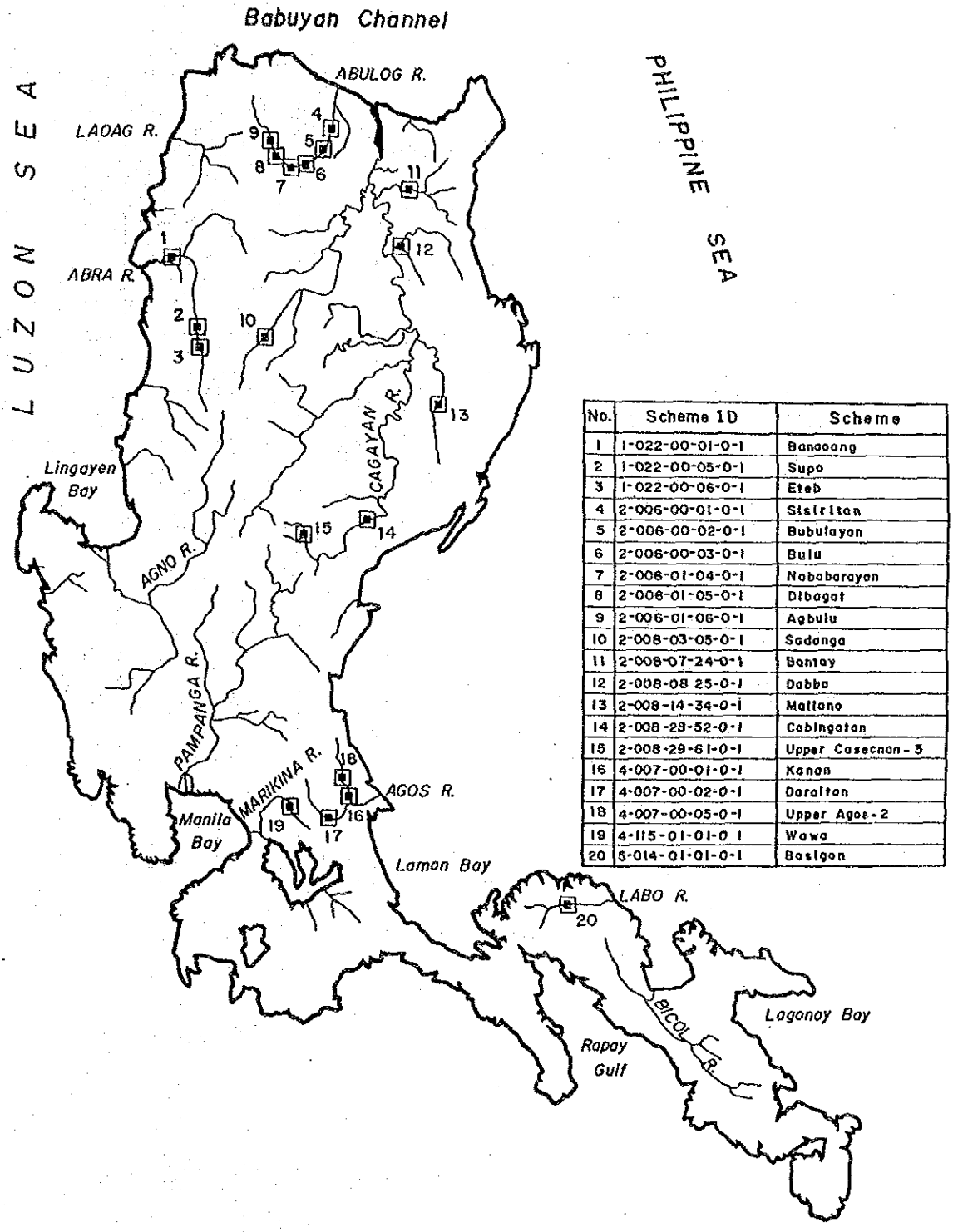
JAPAN INTERNATIONAL COOPERATION AGENCY



No.	Scheme ID	Scheme
1	1-022-00-01-0-1	Banaoang
2	1-022-00-05-0-1	Supo
3	1-022-00-06-0-1	Eteb
4	2-006-00-01-0-1	Sisiritan
5	2-006-00-02-0-1	Bubulayan
6	2-006-00-03-0-1	Bulu
7	2-006-01-04-0-1	Nababarayan
8	2-006-01-05-0-1	Dibagat
9	2-006-01-06-0-1	Agbulu
10	2-008-03-05-0-1	Sadanga
11	2-008-07-24-0-1	Bantay
12	2-008-08 25-0-1	Dabba
13	2-008-14-34-0-1	Mallano
14	2-008-28-52-0-1	Cabingotan
15	2-008-29-61-0-1	Upper Casecnan-3
16	4-007-00-01-0-1	Kanan
17	4-007-00-02-0-1	Daraitan
18	4-007-00-05-0-1	Upper Agos-2
19	4-115-01-01-0 1	Wawa
20	5-014-01-01-0-1	Bastgon

図 4.15 第一次スクリーニングを通過した貯水池式水力地点-位置図

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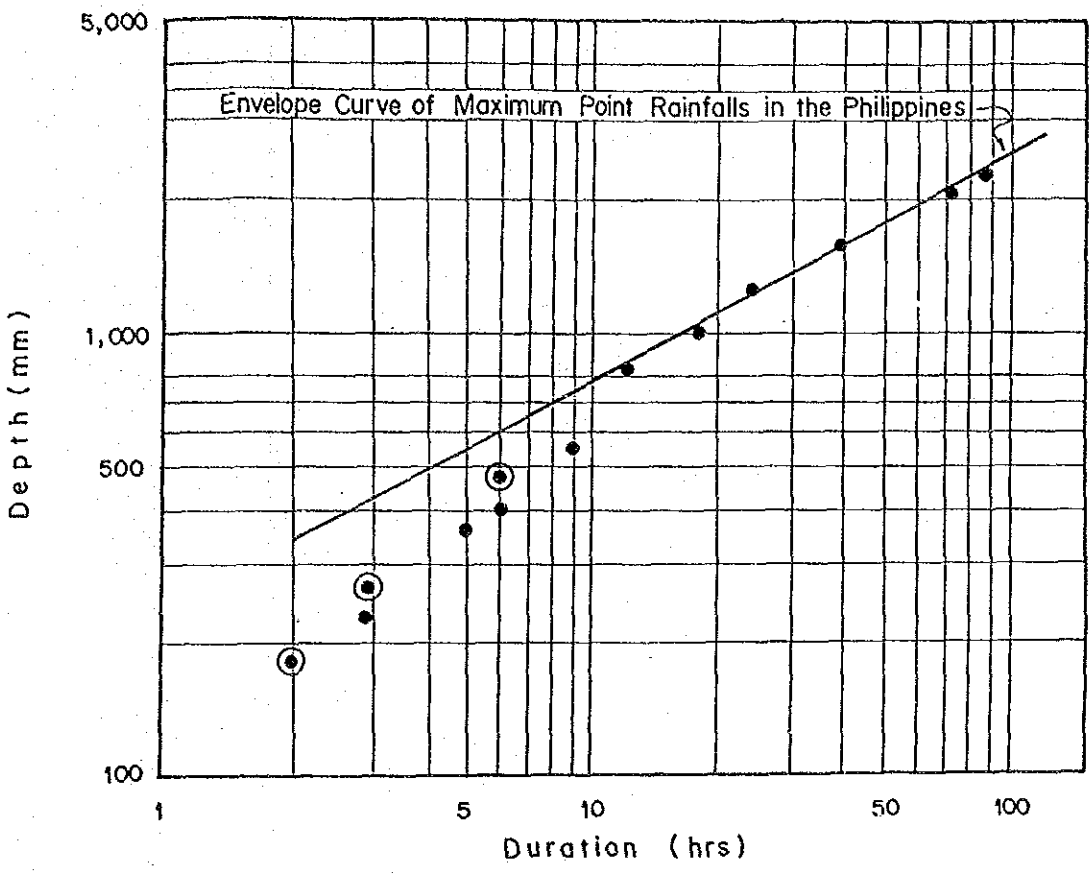

Note: • Observed maximum point rainfall in the Philippines (All rainfalls were observed in Baguio City)
Source : Spillway design flood for potential dam & reservoir sites in Central Luzon Basin, BPW, July, 1964

◉ Based on the data collected in this study.

図 4.16 最大雨量-継続時間曲線(フィリピン)

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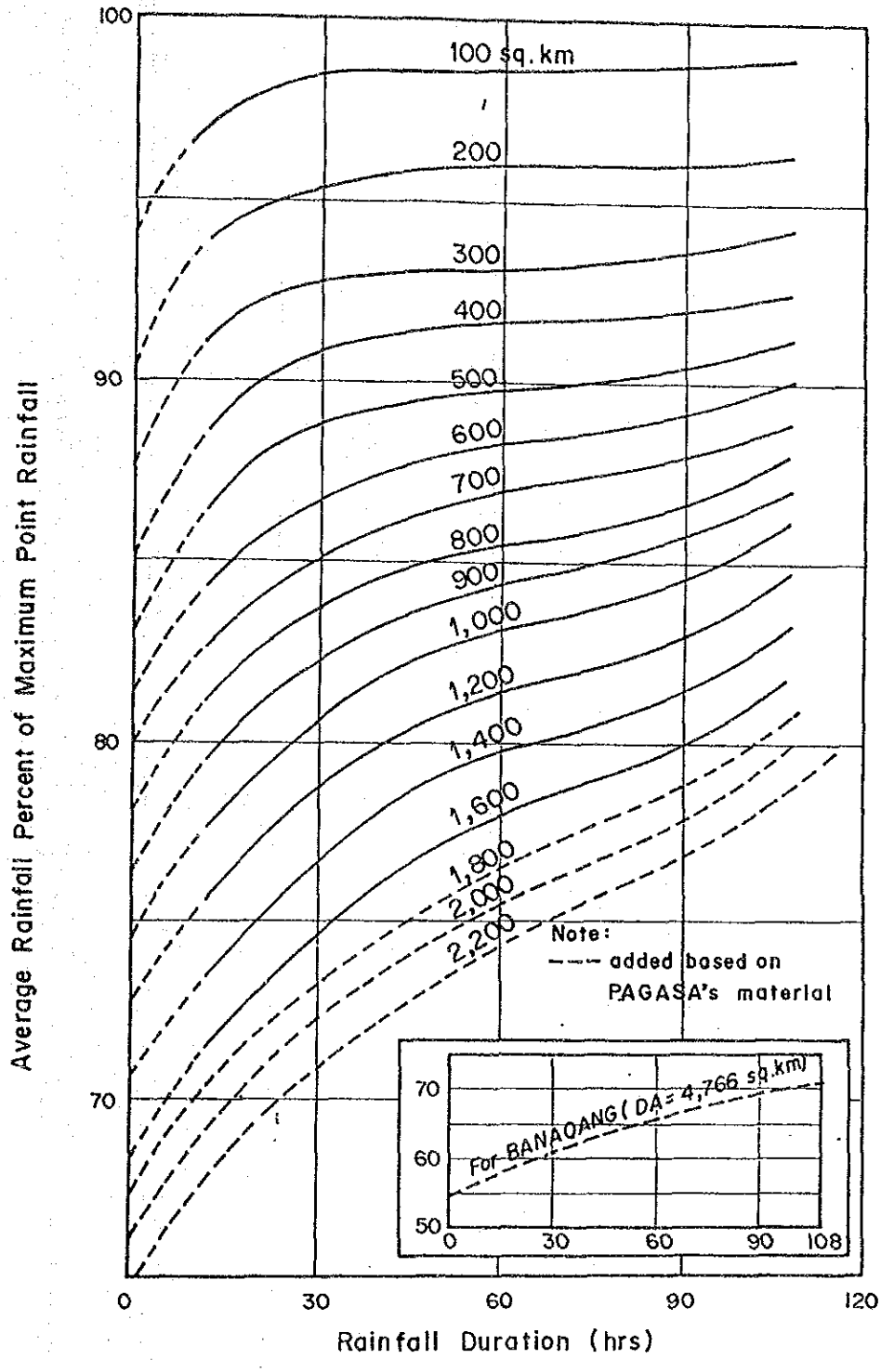


図 4.17　D-A-D 曲線

NATIONAL POWER CORPORATION
STUDY ON HYDROPOWER POTENTIALS IN LUZON ISLAND
JAPAN INTERNATIONAL COOPERATION AGENCY

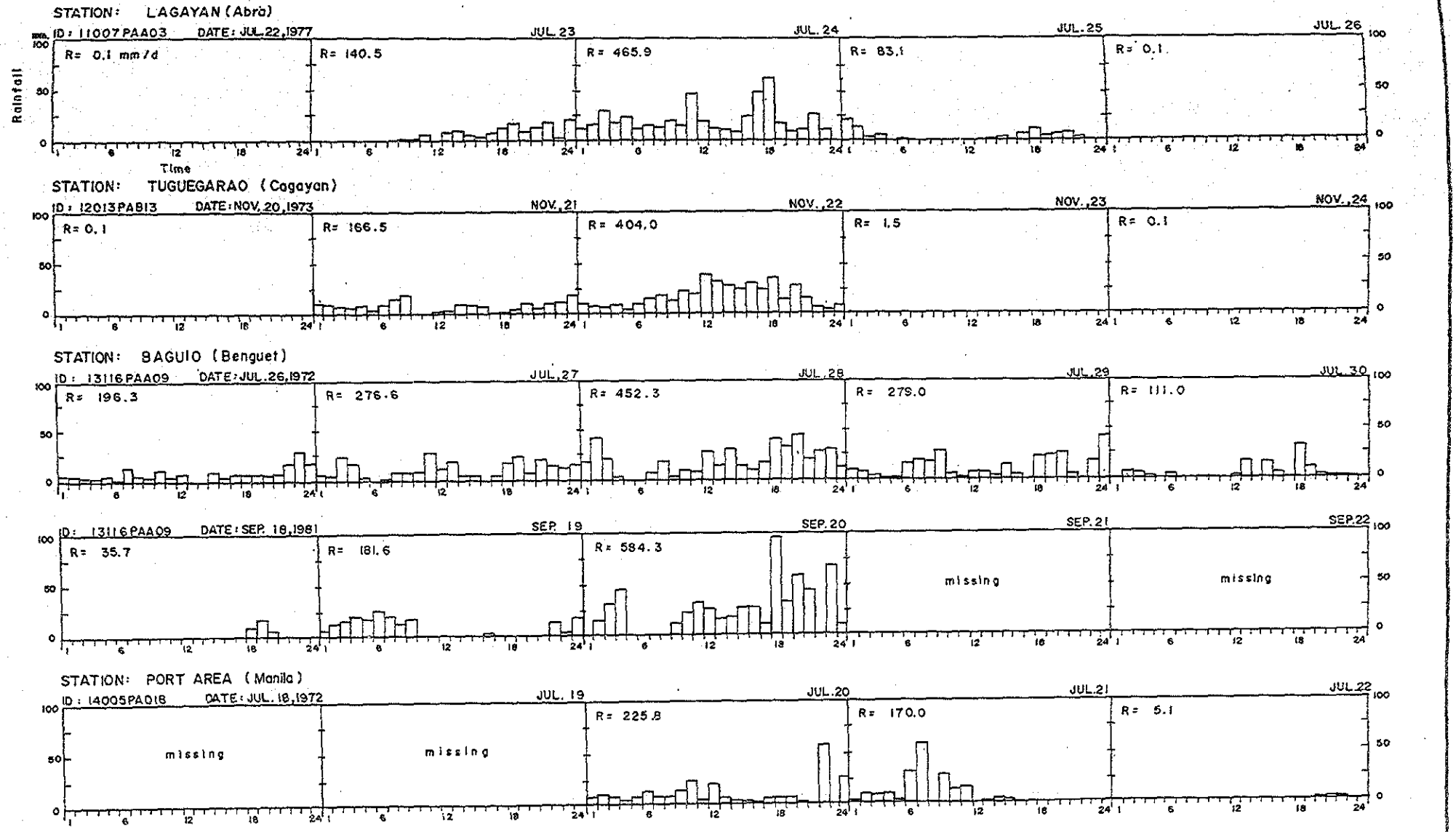


図 4.18 ルソン島内豪雨時間分布図

NATIONAL POWER CORPORATION
STUDY ON HYDROPOWER POTENTIALS IN LUZON ISLAND
JAPAN INTERNATIONAL COOPERATION AGENCY

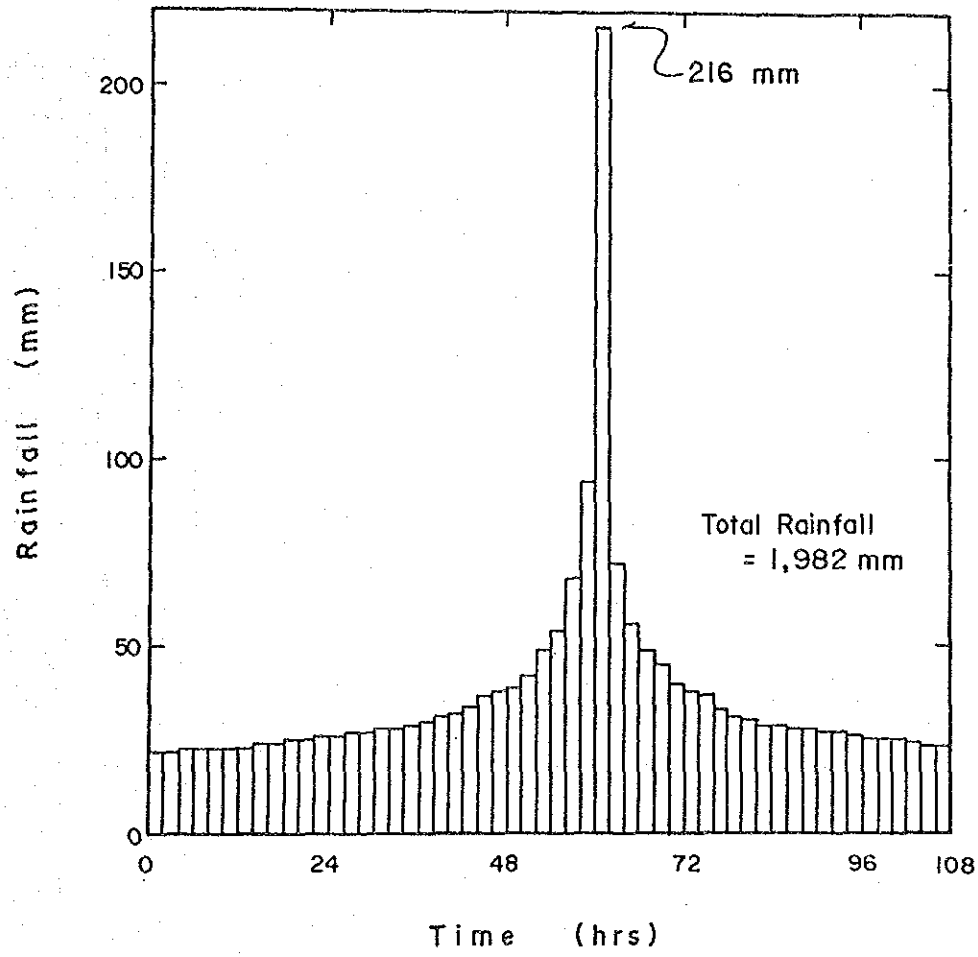
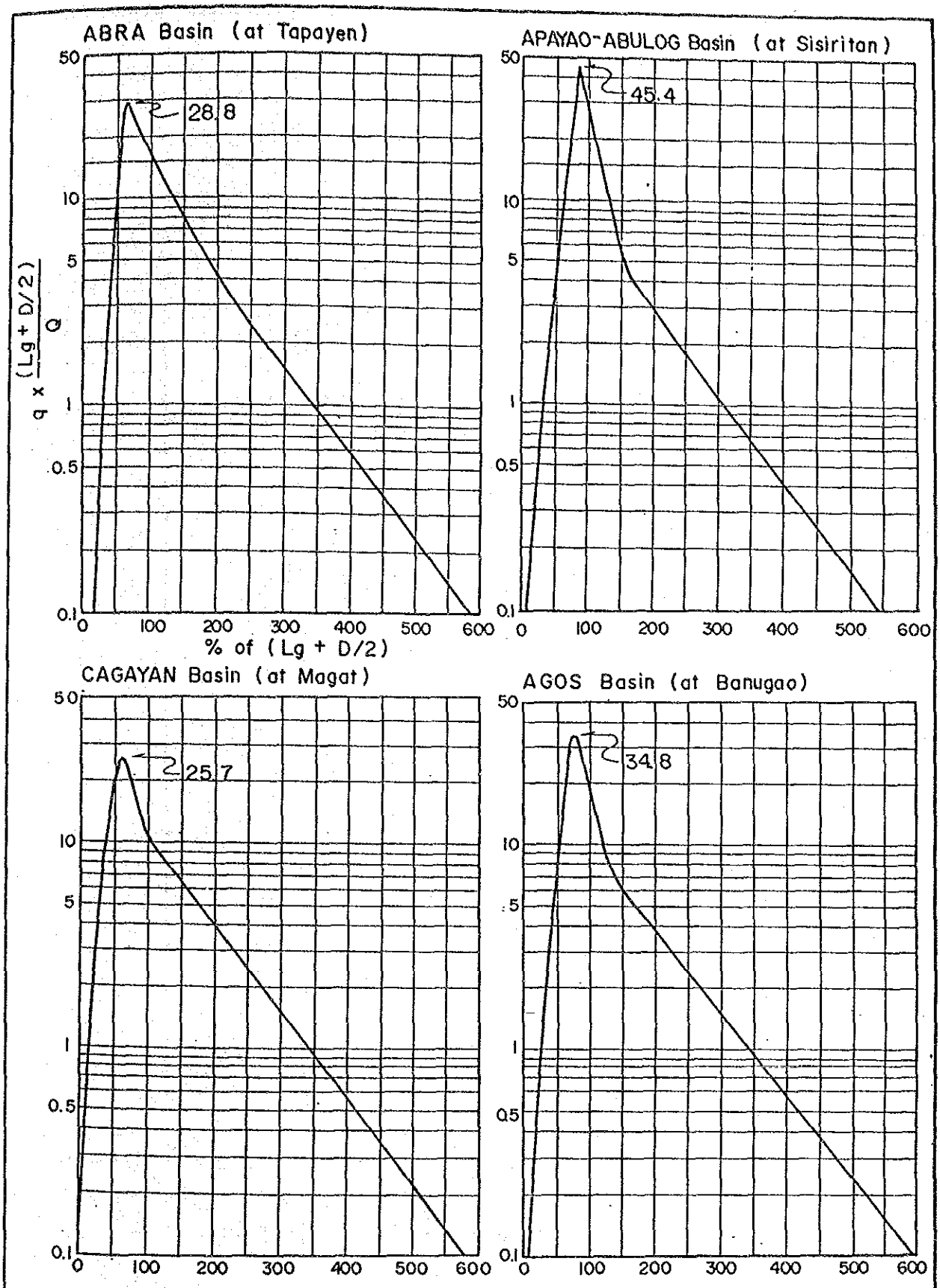


図 4.19 洪水吐設計降雨(シシリタン流域)

NATIONAL POWER CORPORATION
STUDY ON HYDROPOWER POTENTIALS IN LUZON ISLAND
JAPAN INTERNATIONAL COOPERATION AGENCY



q = discharge of direct runoff (m^3/s)
Lg = basin lag (h)
D = duration of rainfall excess (h)
Q = direct runoff volume (m^3/s - days)

図 4.20 水系別無次元ハイドログラフ

NATIONAL POWER CORPORATION
STUDY ON HYDROPOWER POTENTIALS IN LUZON ISLAND
JAPAN INTERNATIONAL COOPERATION AGENCY

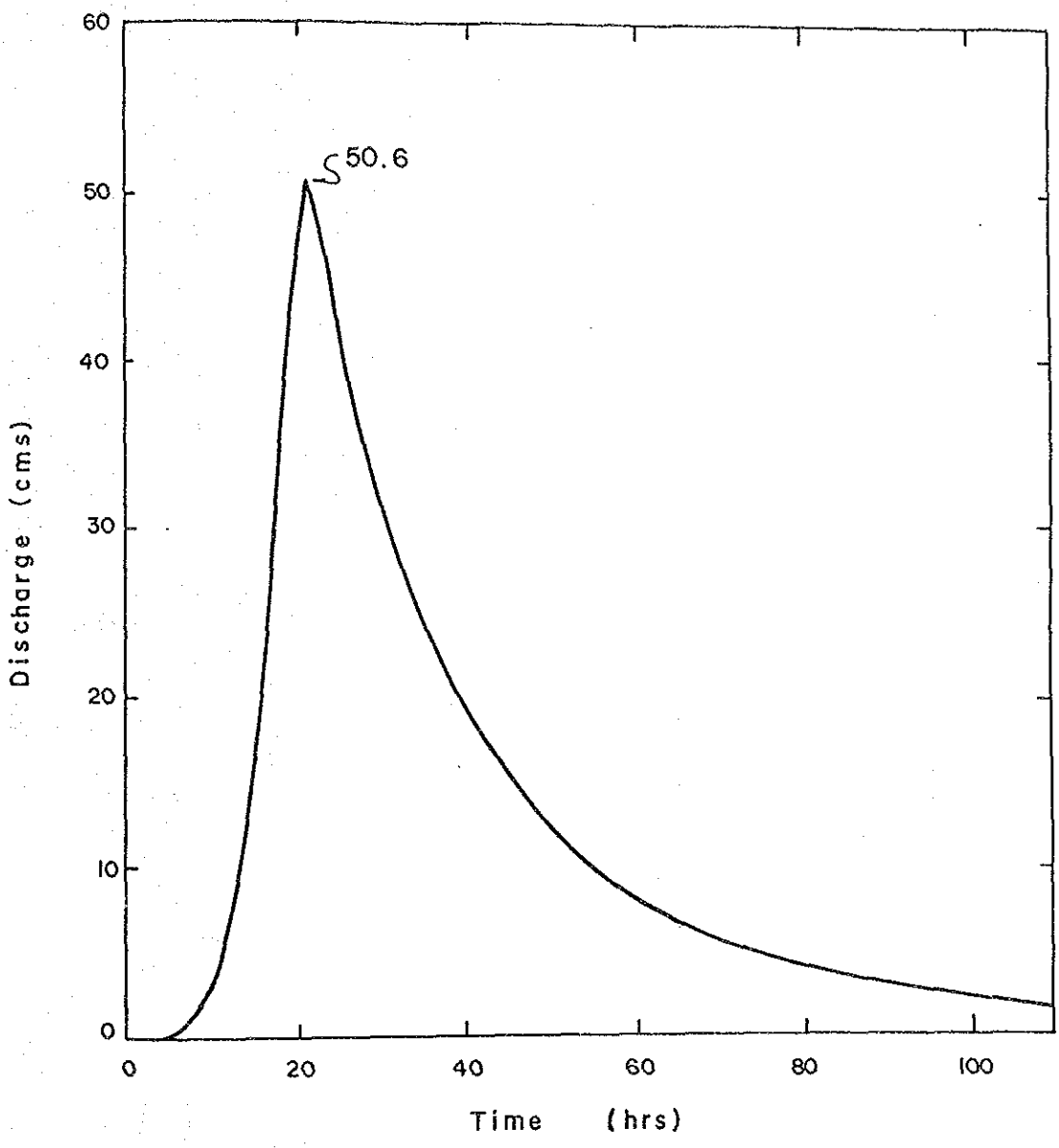
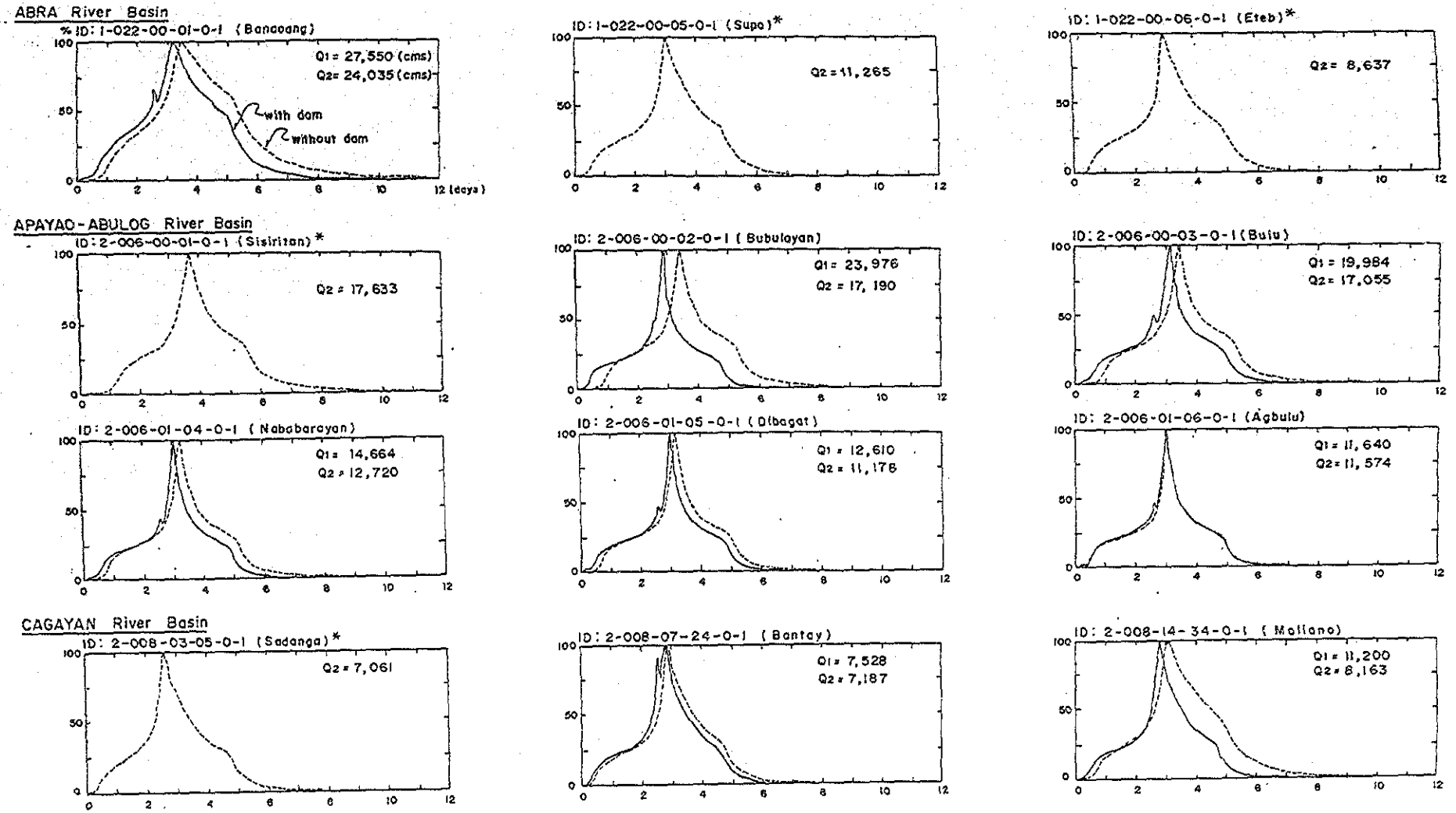


図 4.21　2時間-1mm単位図(バナオアン地点)

NATIONAL POWER CORPORATION
STUDY ON HYDROPOWER POTENTIALS IN LUZON ISLAND
JAPAN INTERNATIONAL COOPERATION AGENCY

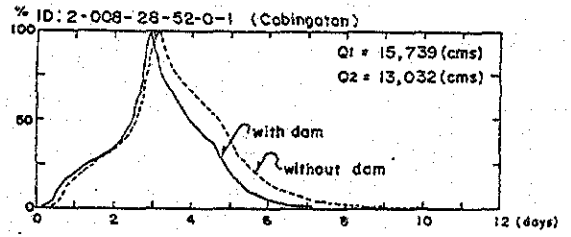


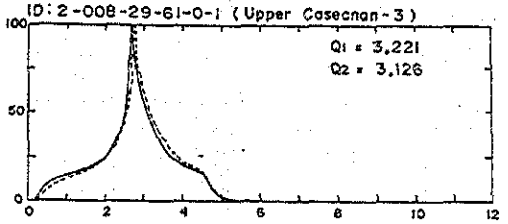
Note : Q1 = Flood peak in with dam case
Q2 = Flood peak in without dam case
As for scheme with (*), it is presumed that the hydrograph is common for without cases.

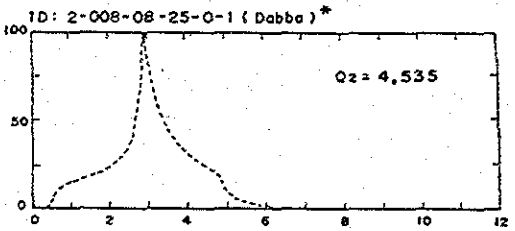
図 4.22 洪水吐設計のための洪水ハイドログラフ (1/2)

NATIONAL POWER CORPORATION
STUDY ON HYDROPOWER POTENTIALS IN LUZON ISLAND
JAPAN INTERNATIONAL COOPERATION AGENCY

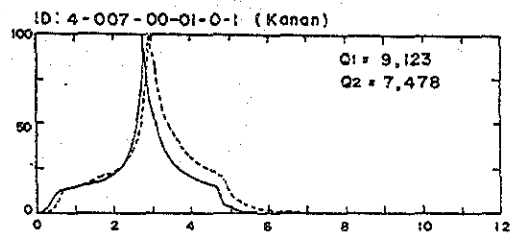
CAGAYAN River Basin

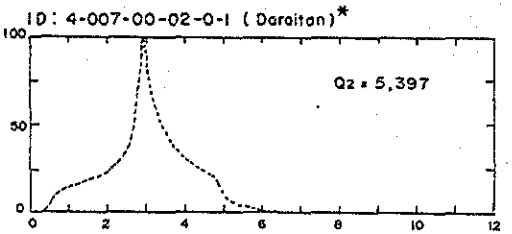


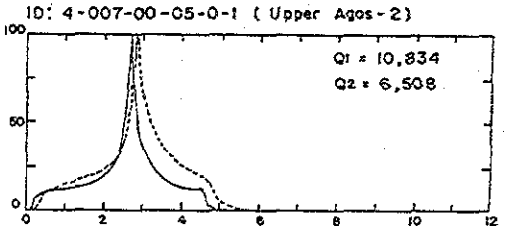




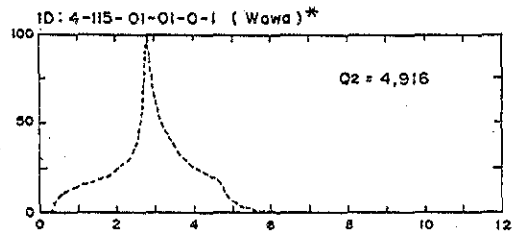
AGOS River Basin



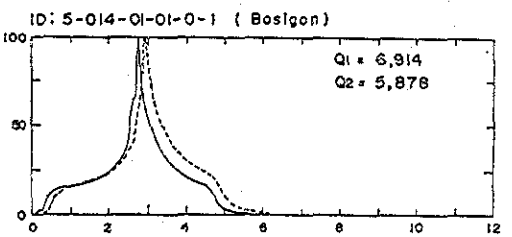




MARIKINA River Basin



LABO River Basin



Note : Q1 = Flood peak in with dam case

Q2 = Flood peak in without dam case

As for scheme with (*), it is presumed that the hydrograph is common for with and without cases.

図 4.22 洪水吐設計のための洪水ハイドログラフ (2/2)

NATIONAL POWER CORPORATION
STUDY ON HYDROPOWER POTENTIALS IN LUZON ISLAND
JAPAN INTERNATIONAL COOPERATION AGENCY

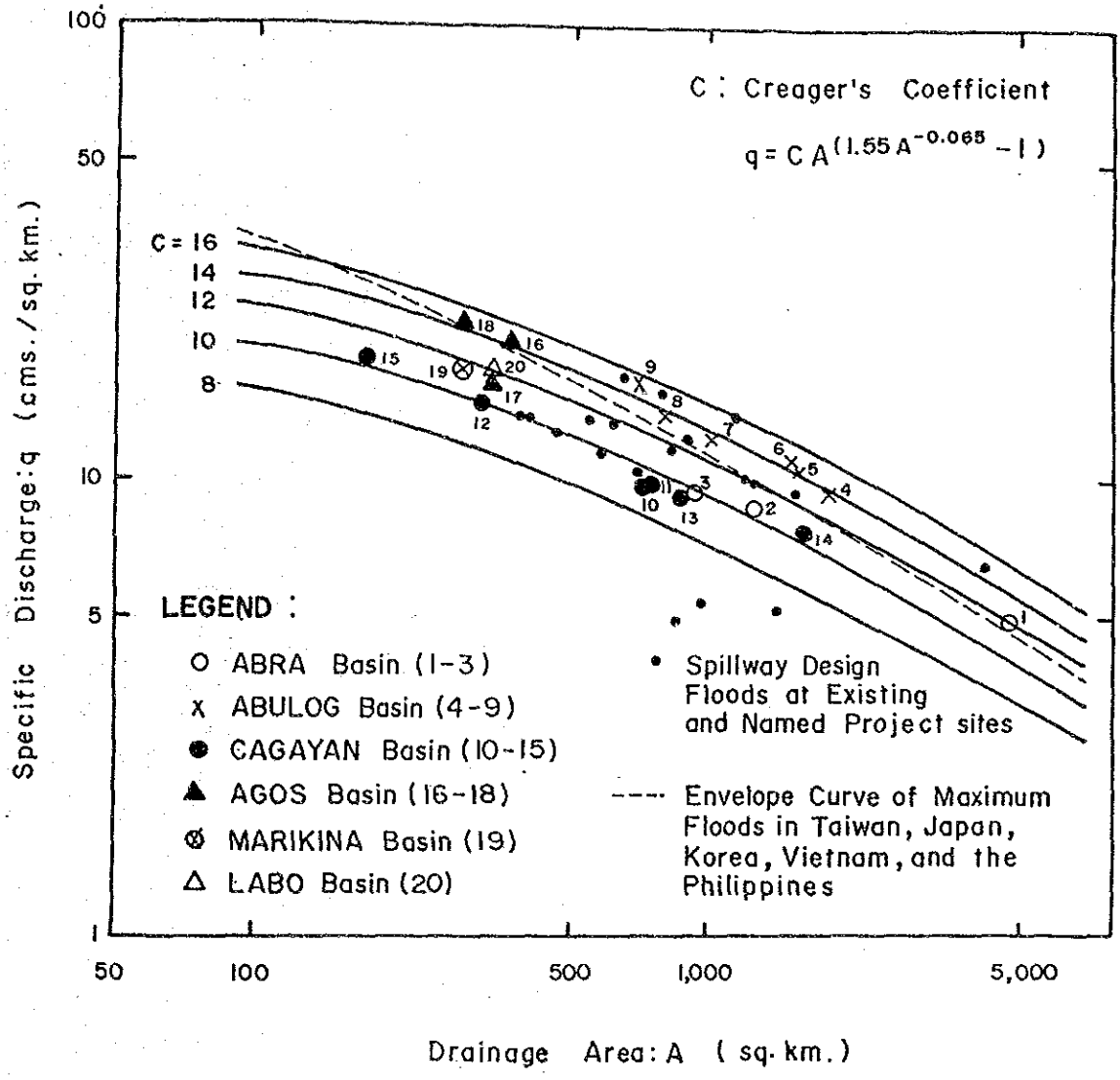


図 4.23 貯水池式水力地点のPMF

NATIONAL POWER CORPORATION
STUDY ON HYDROPOWER POTENTIALS IN LUZON ISLAND
JAPAN INTERNATIONAL COOPERATION AGENCY

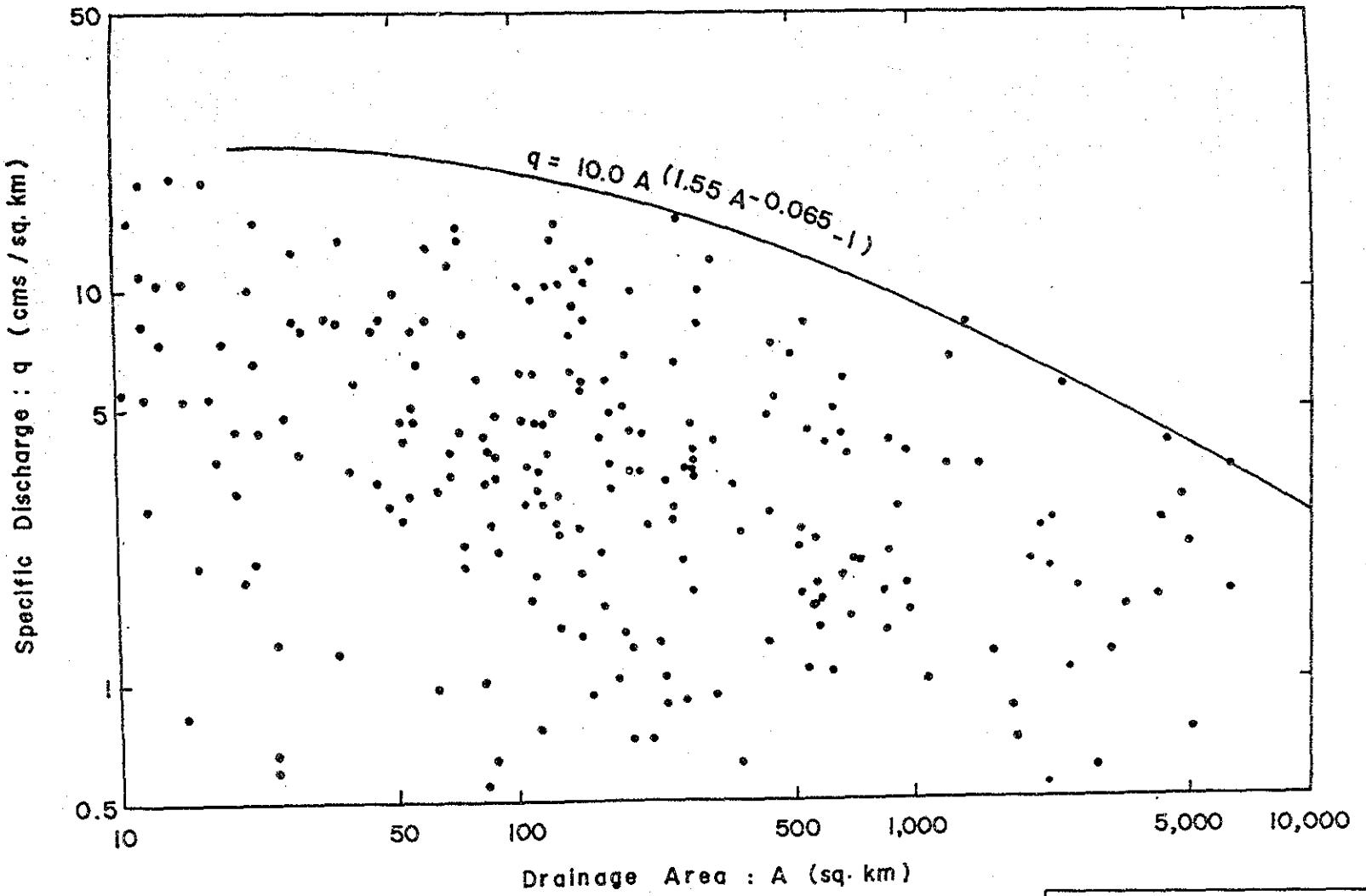
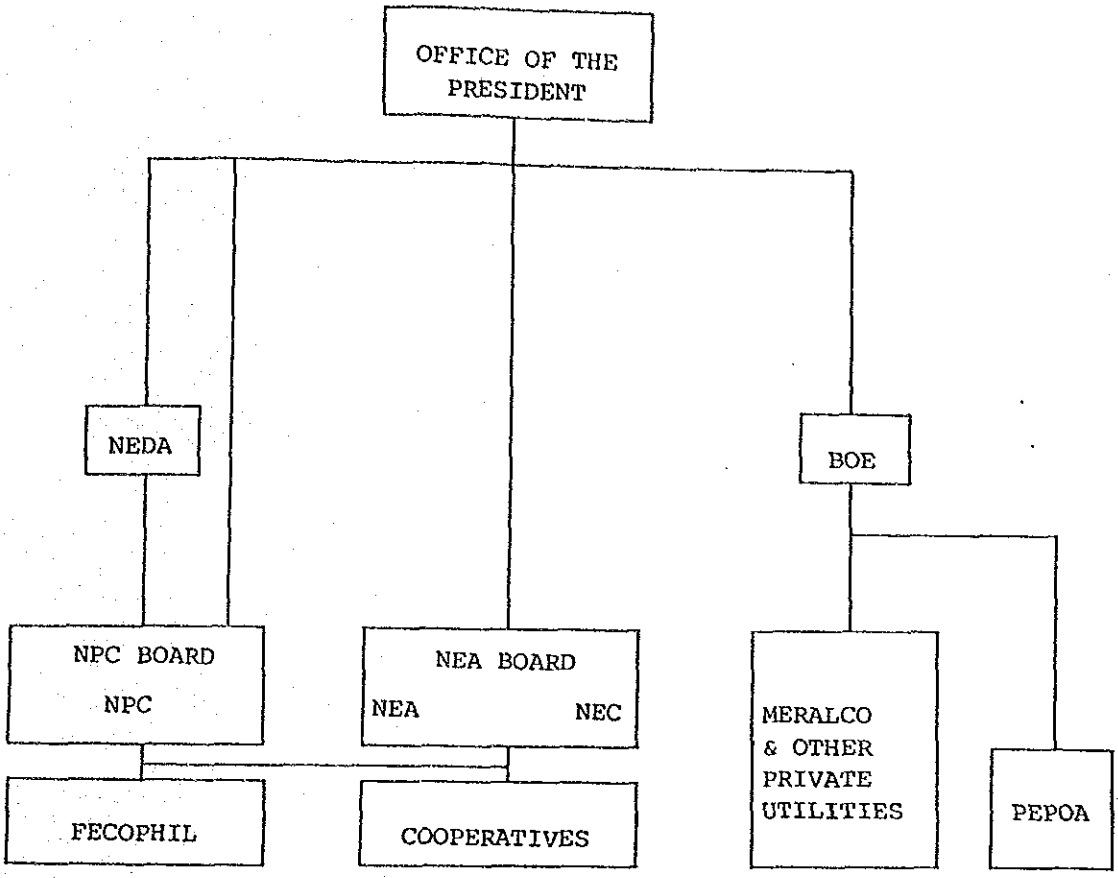


図 4.24　フィリピン内既往最大洪水包絡線

NATIONAL POWER CORPORATION
STUDY ON HYDROPOWER POTENTIALS IN LUZON ISLAND
JAPAN INTERNATIONAL COOPERATION AGENCY



Notes:

BOE	:	Board of Energy
NEDA	:	National Economic and Development Authority
NEC	:	National Electrification Commission
NEA	:	National Electrification Administration
NPC	:	National Power Corporation
FECOPHIL	:	The Federation of Electric Cooperatives of the Philippines
PEPOA	:	Philippine Electric Plant Owners Association

Source: NPC, NEA, and MERALCO

図 6.1　フィリピン電力事業機構図

NATIONAL POWER CORPORATION
STUDY ON HYDROPOWER POTENTIALS IN LUZON ISLAND
JAPAN INTERNATIONAL COOPERATION AGENCY

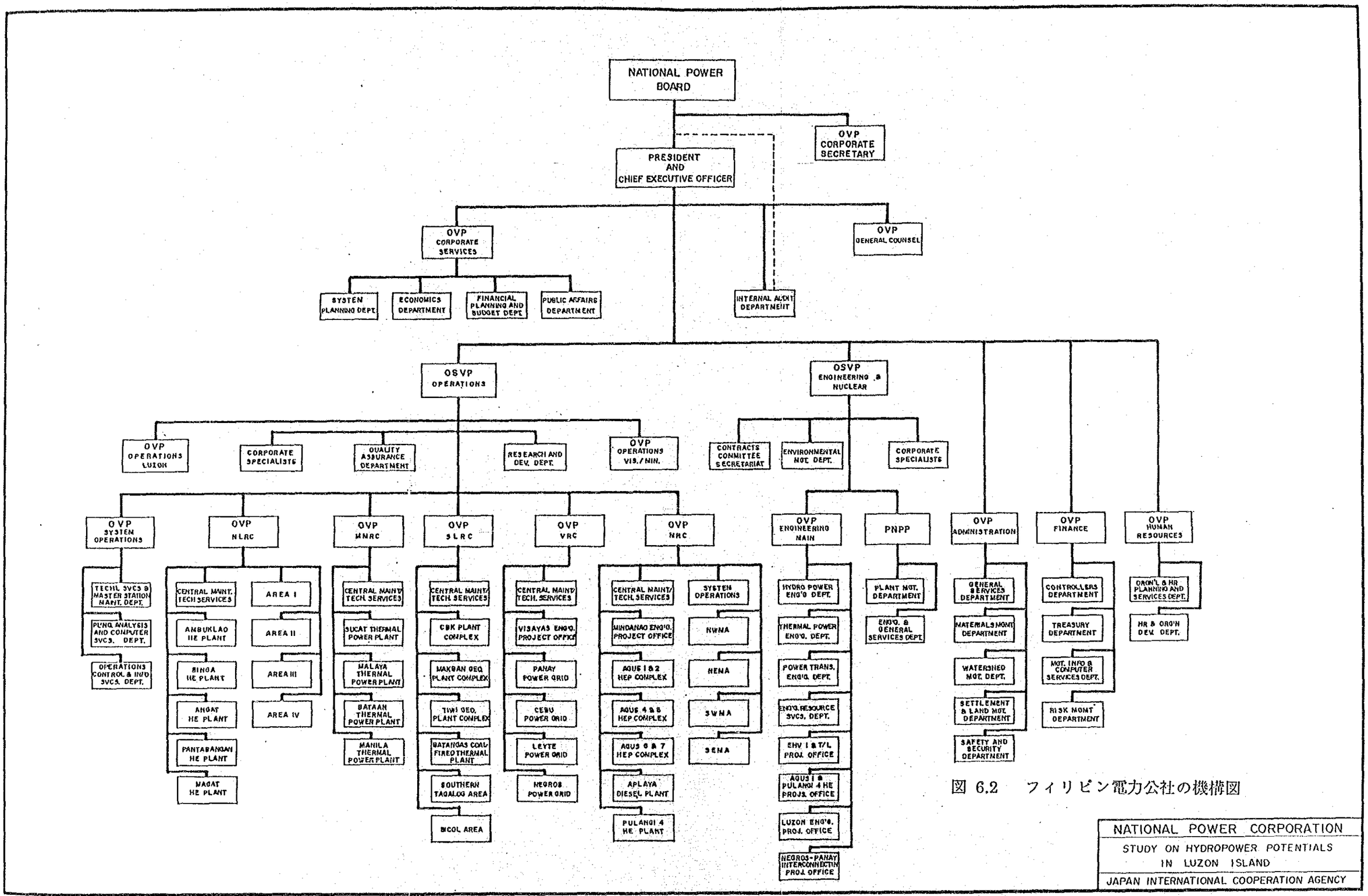


図 6.2　フィリピン電力公社の機構図

NATIONAL POWER CORPORATION
STUDY ON HYDROPOWER POTENTIALS IN LUZON ISLAND
JAPAN INTERNATIONAL COOPERATION AGENCY

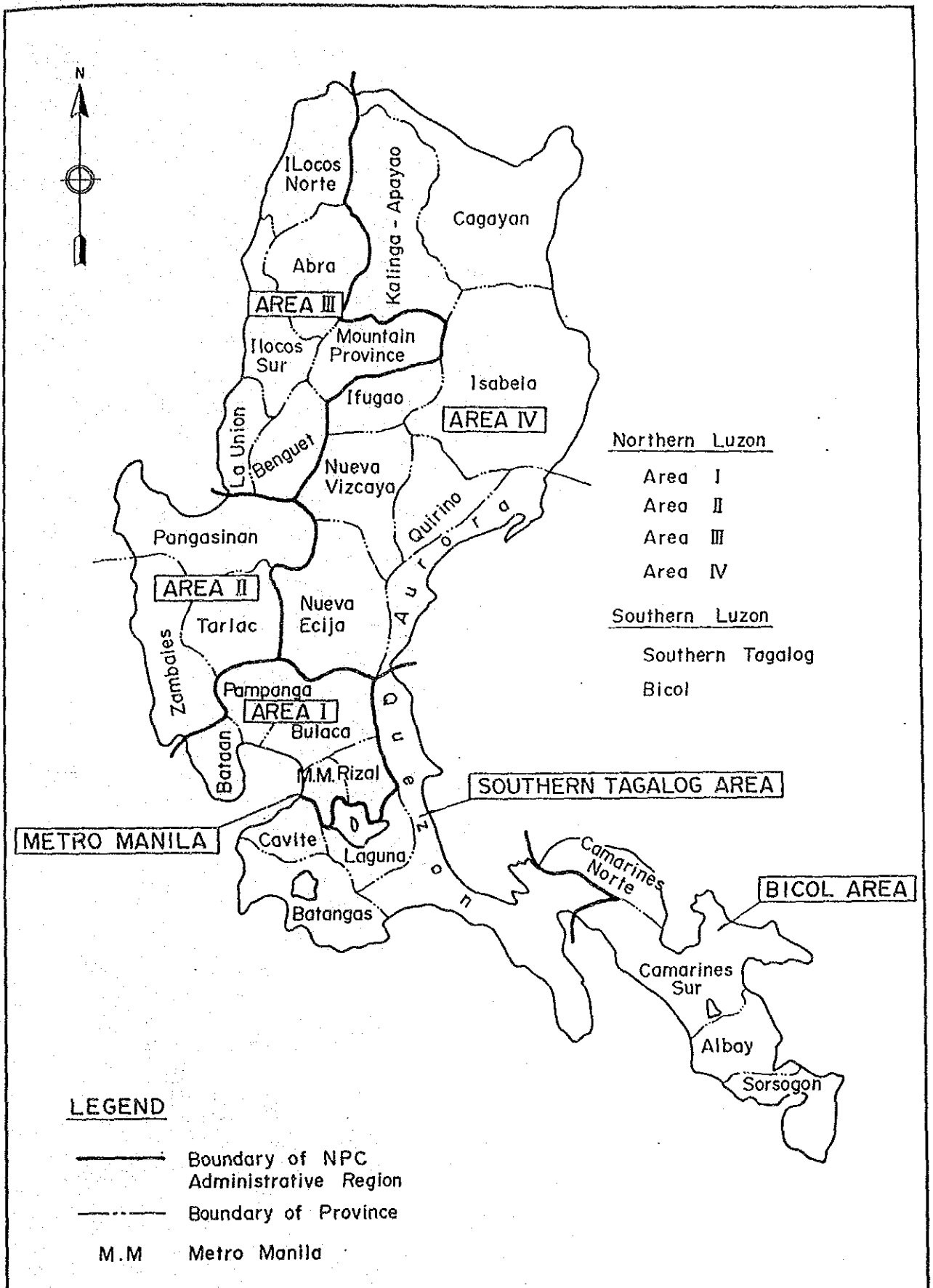


図 6.3　ルソン島の電力区画図

NATIONAL POWER CORPORATION
STUDY ON HYDROPOWER POTENTIALS IN LUZON ISLAND
JAPAN INTERNATIONAL COOPERATION AGENCY

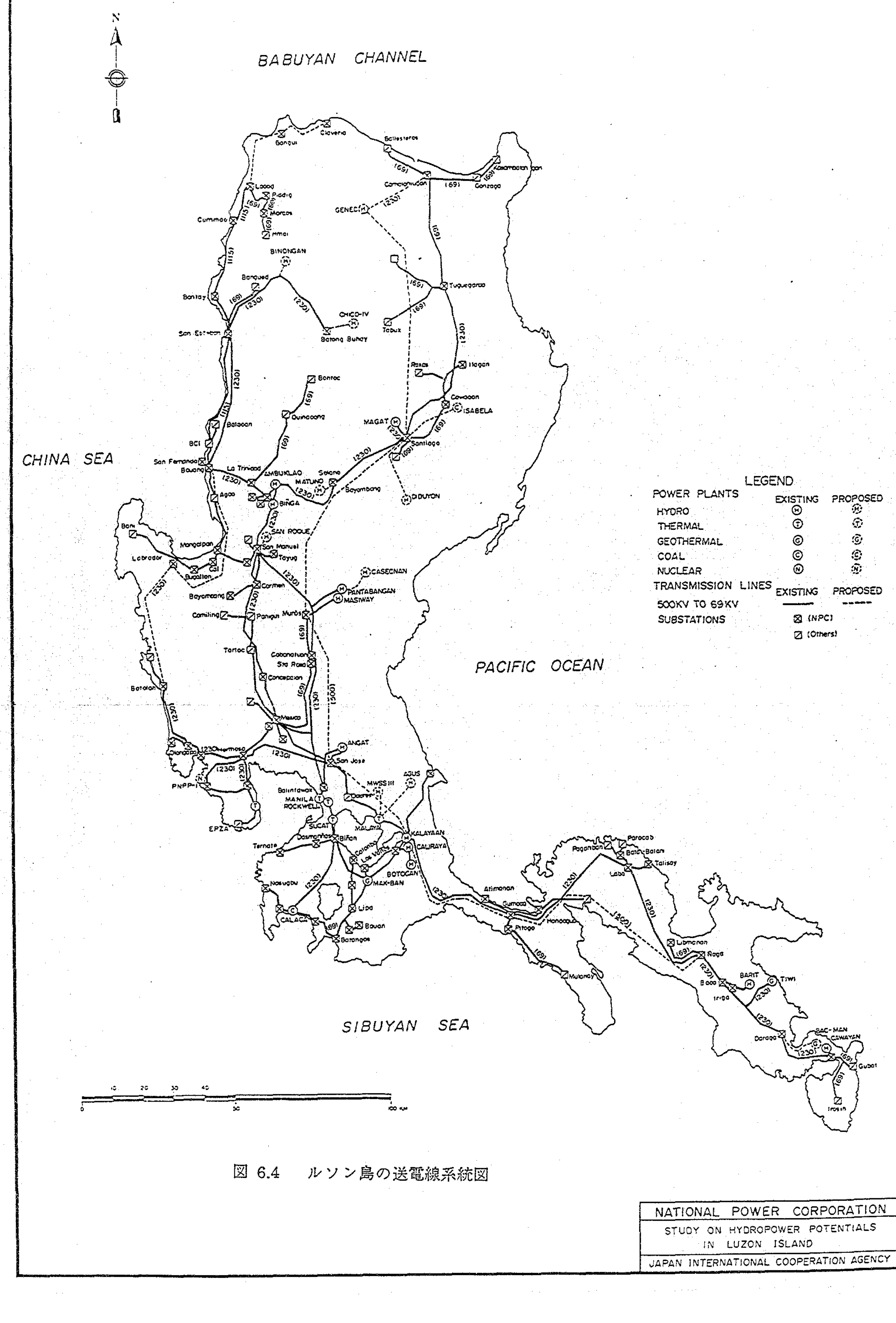
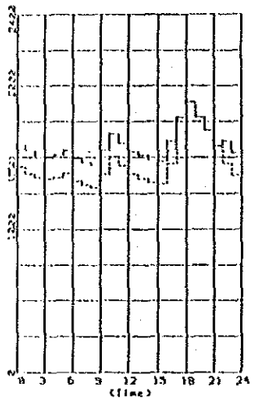


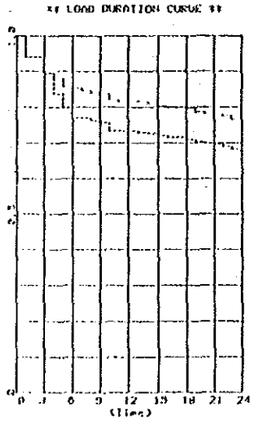
図 6.4　ルソン島の送電線系統図

NATIONAL POWER CORPORATION
STUDY ON HYDROPOWER POTENTIALS IN LUZON ISLAND
JAPAN INTERNATIONAL COOPERATION AGENCY

APRIL 6, 1986 (SUN)

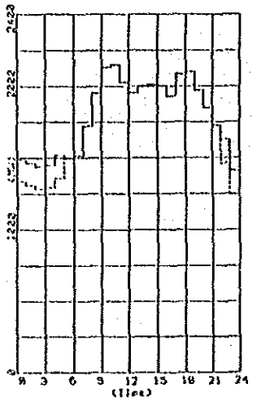
PEAK LOAD = 1834 MW (1834 MW)
LOAD FACTOR = 83 % (77 %)

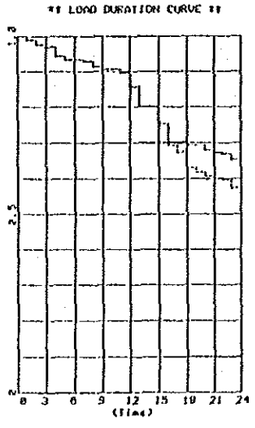




APRIL 7, 1986 (MON)

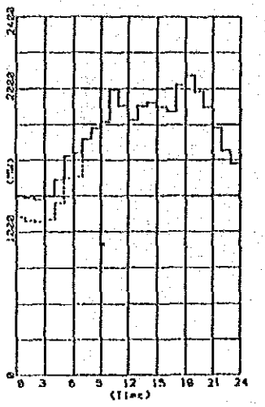
PEAK LOAD = 2168 MW (2168 MW)
LOAD FACTOR = 83 % (81 %)

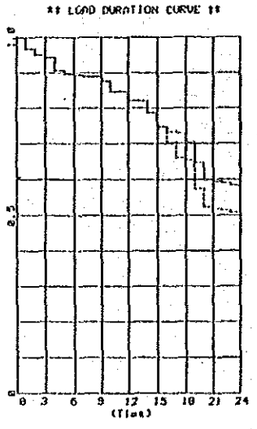




APRIL 8, 1986 (TUE)

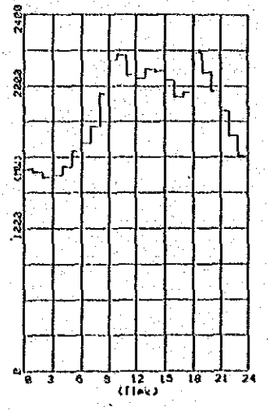
PEAK LOAD = 2185 MW (2185 MW)
LOAD FACTOR = 80 % (78 %)

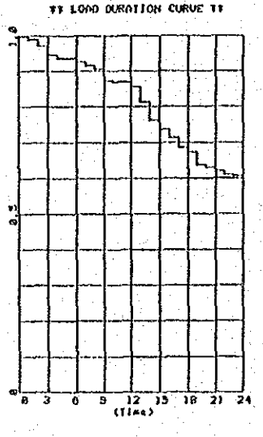




APRIL 9, 1986 (WED)

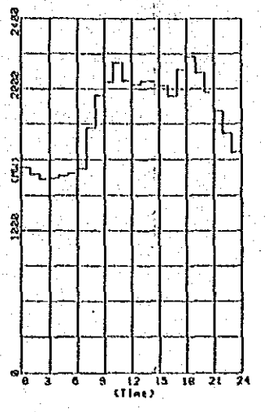
PEAK LOAD = 2247 MW
LOAD FACTOR = 81 %

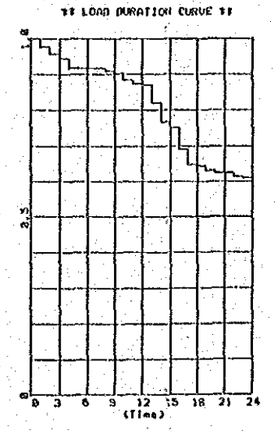




APRIL 10, 1986 (THU)

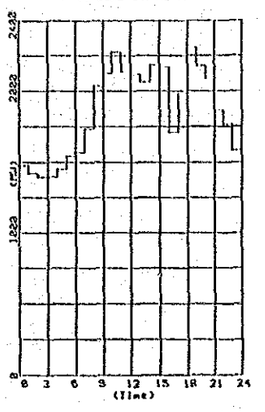
PEAK LOAD = 2241 MW
LOAD FACTOR = 81 %

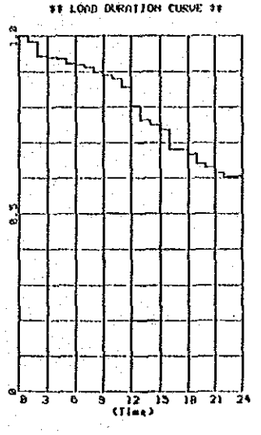




APRIL 11, 1986 (FRI)

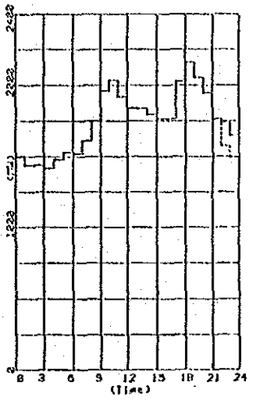
PEAK LOAD = 2320 MW
LOAD FACTOR = 88 %

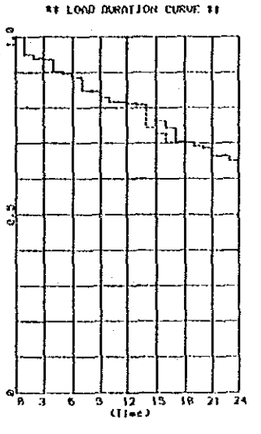


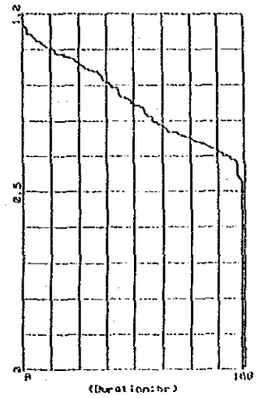


APRIL 12, 1986 (SAT)

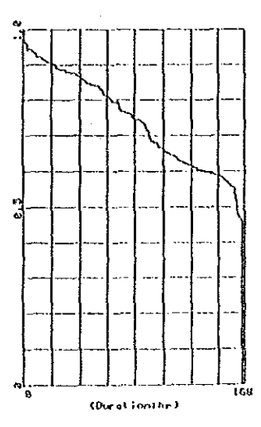
PEAK LOAD = 2171 MW (2171 MW)
LOAD FACTOR = 88 % (88 %)







REMARK: INCL. POWER FOR PUMPING.



REMARK: EXCL. POWER FOR PUMPING.

Remarks: (1): Figures in parenthesis show peak load and load factor in case of w/o pumping for Kalayaan P/S.

(2): Dotted lines show load duration curve in case of w/o pumping for Kalayaan P/S.

図 6.5 代表的な日負荷曲線及び日負荷継続曲線(1986年4月6日-12日)

NATIONAL POWER CORPORATION
STUDY ON HYDROPOWER POTENTIALS IN LUZON ISLAND
JAPAN INTERNATIONAL COOPERATION AGENCY

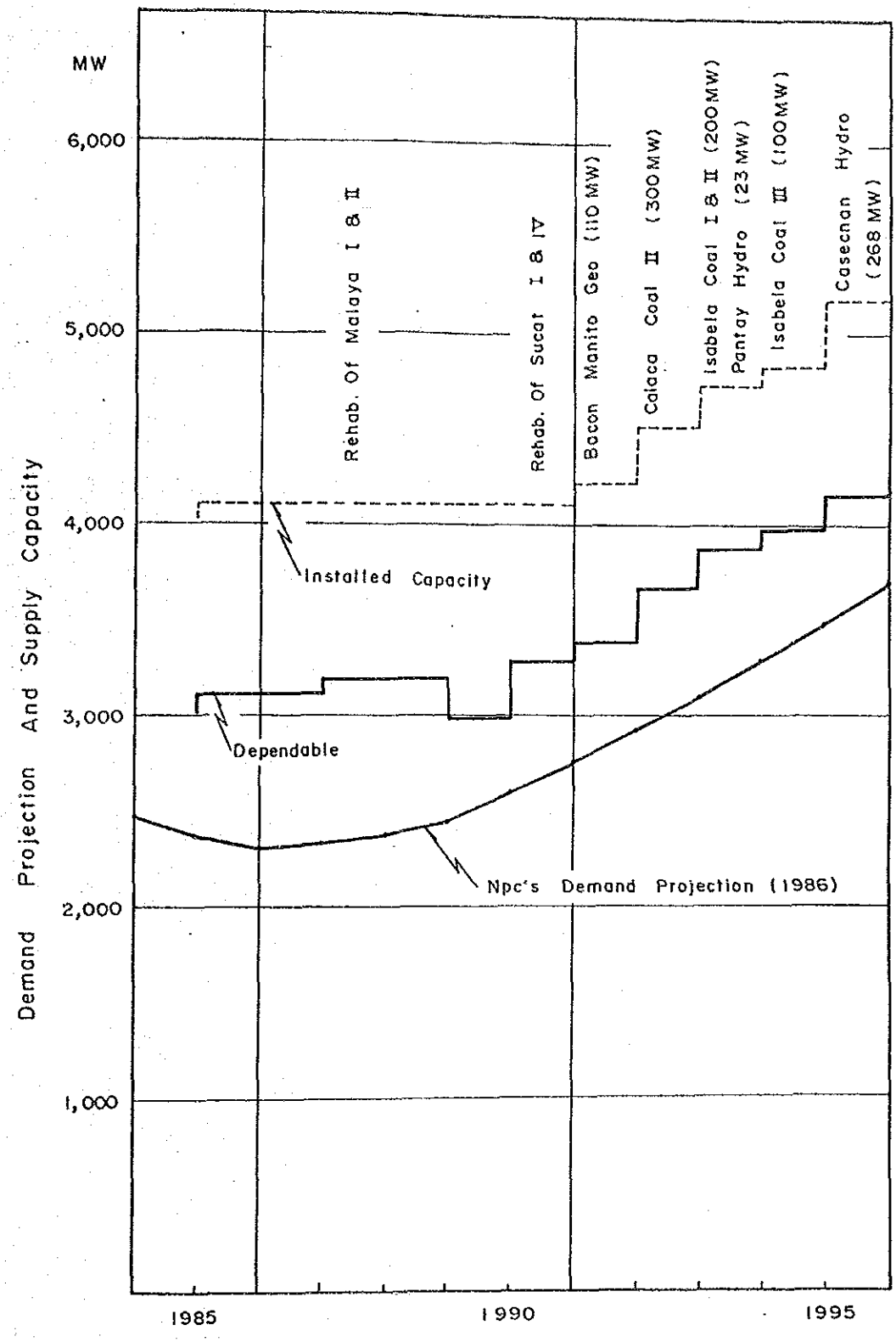
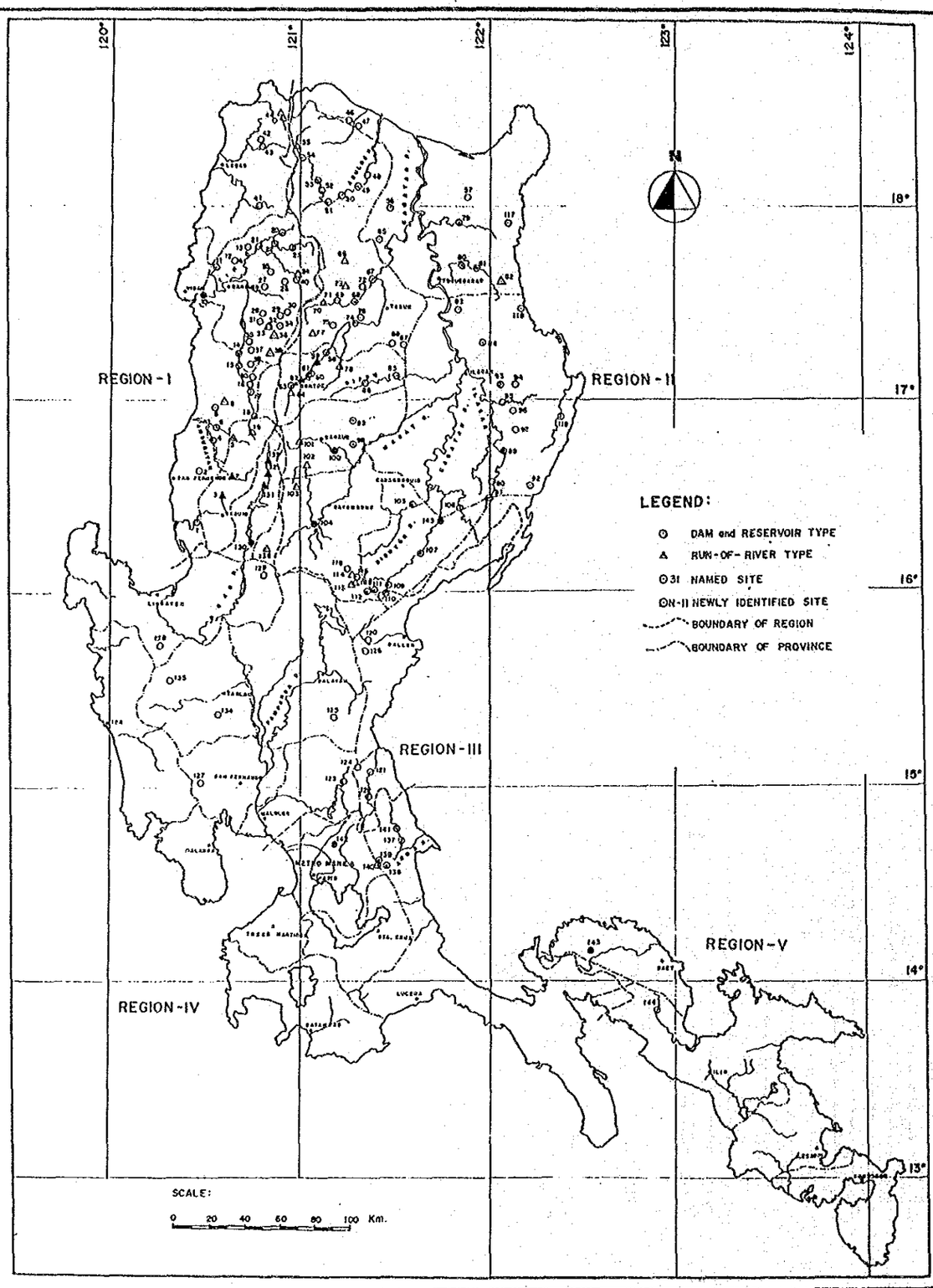
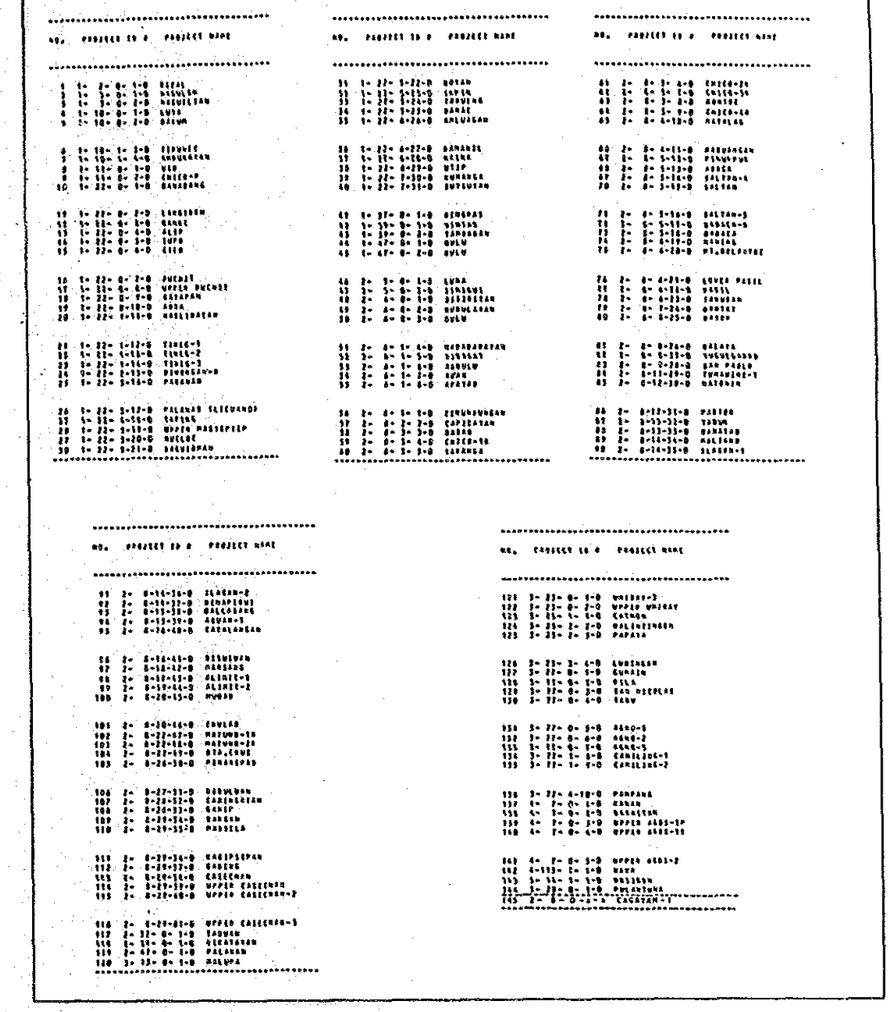


図 6.6　ルソン系統の電力需要予測及び設備投入計画(1986年-1995年)

NATIONAL POWER CORPORATION
STUDY ON HYDROPOWER POTENTIALS IN LUZON ISLAND
JAPAN INTERNATIONAL COOPERATION AGENCY



List of Assessment Sites



LEGEND

	Dam and Reservoir Type	Run of River Type
Assessment Sites		
Visited Sites	●	▲
Over flight Survey Sites	⊙	△
Non Visited Sites	⊙	△
Proposed Assessment Sites	○	△

図 7.1　地質評価を行った水力地点位置図

NATIONAL POWER CORPORATION
STUDY ON HYDROPOWER POTENTIALS IN LUZON ISLAND
JAPAN INTERNATIONAL COOPERATION AGENCY

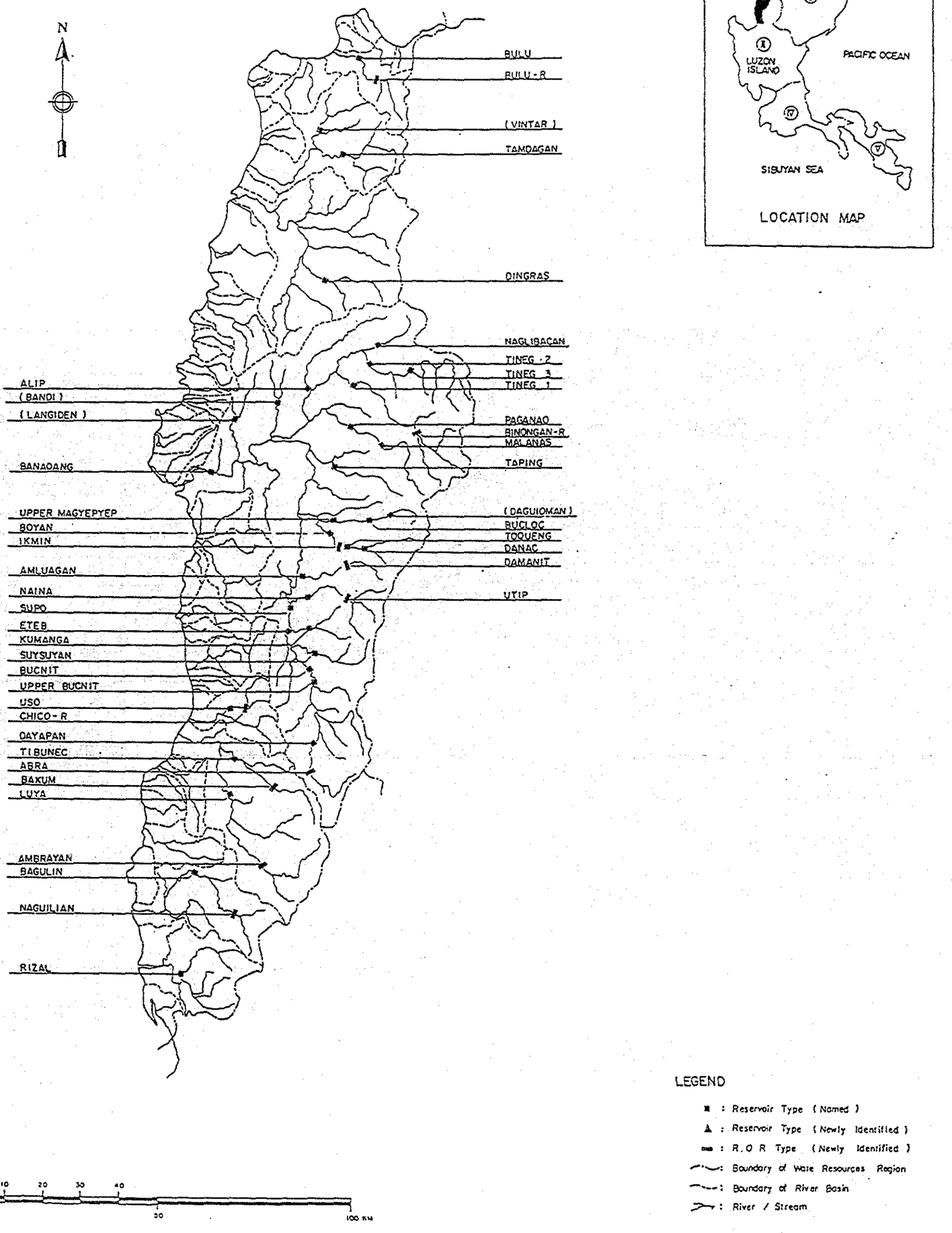


図 7.2　計画水力地点位置図，水資源区　1

NATIONAL POWER CORPORATION
STUDY ON HYDROPOWER POTENTIALS IN LUZON ISLAND
JAPAN INTERNATIONAL COOPERATION AGENCY

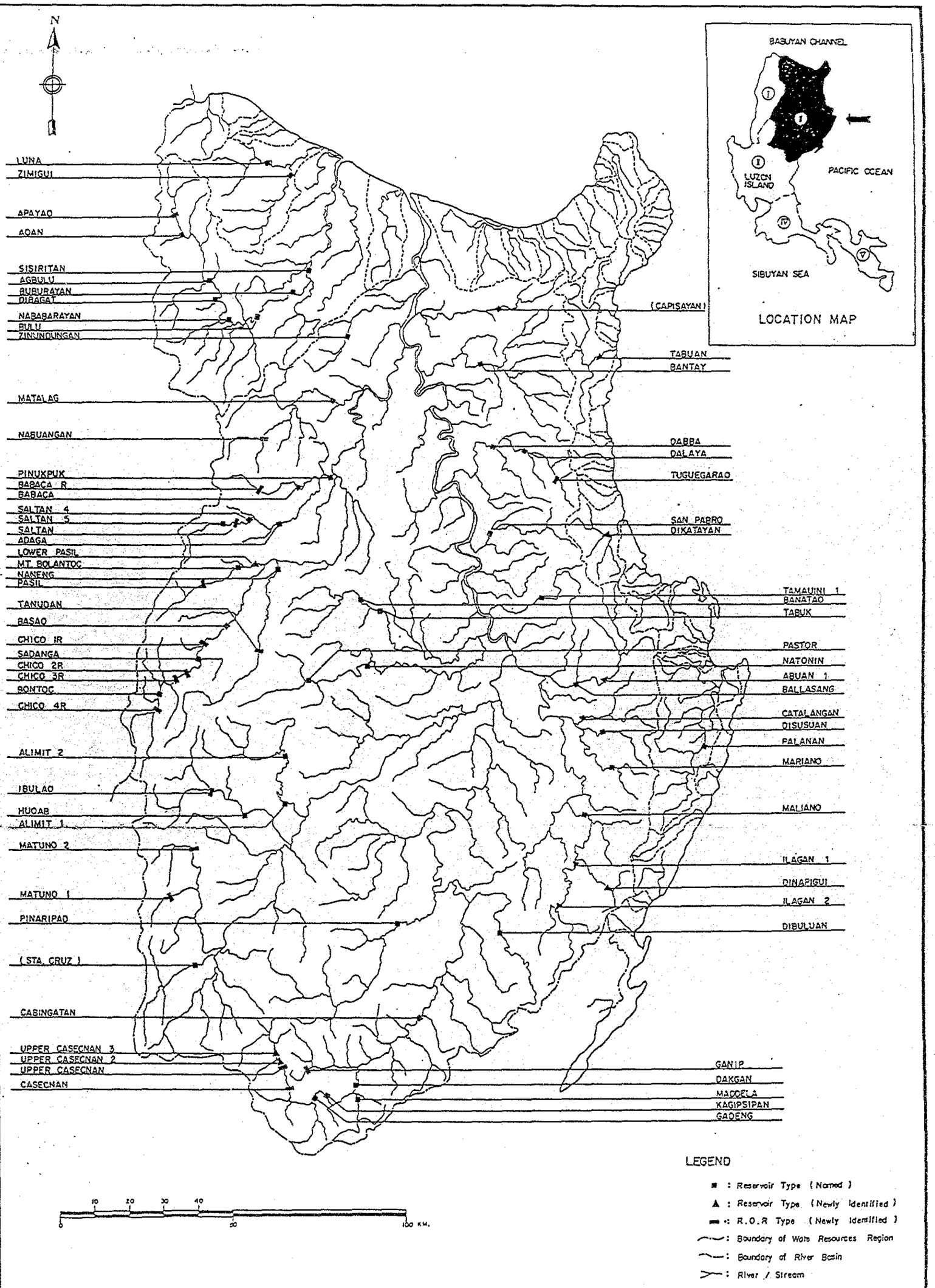


図 7.3　計画水力地点位置図，水資源区　2

NATIONAL POWER CORPORATION
STUDY ON HYDROPOWER POTENTIALS IN LUZON ISLAND
JAPAN INTERNATIONAL COOPERATION AGENCY

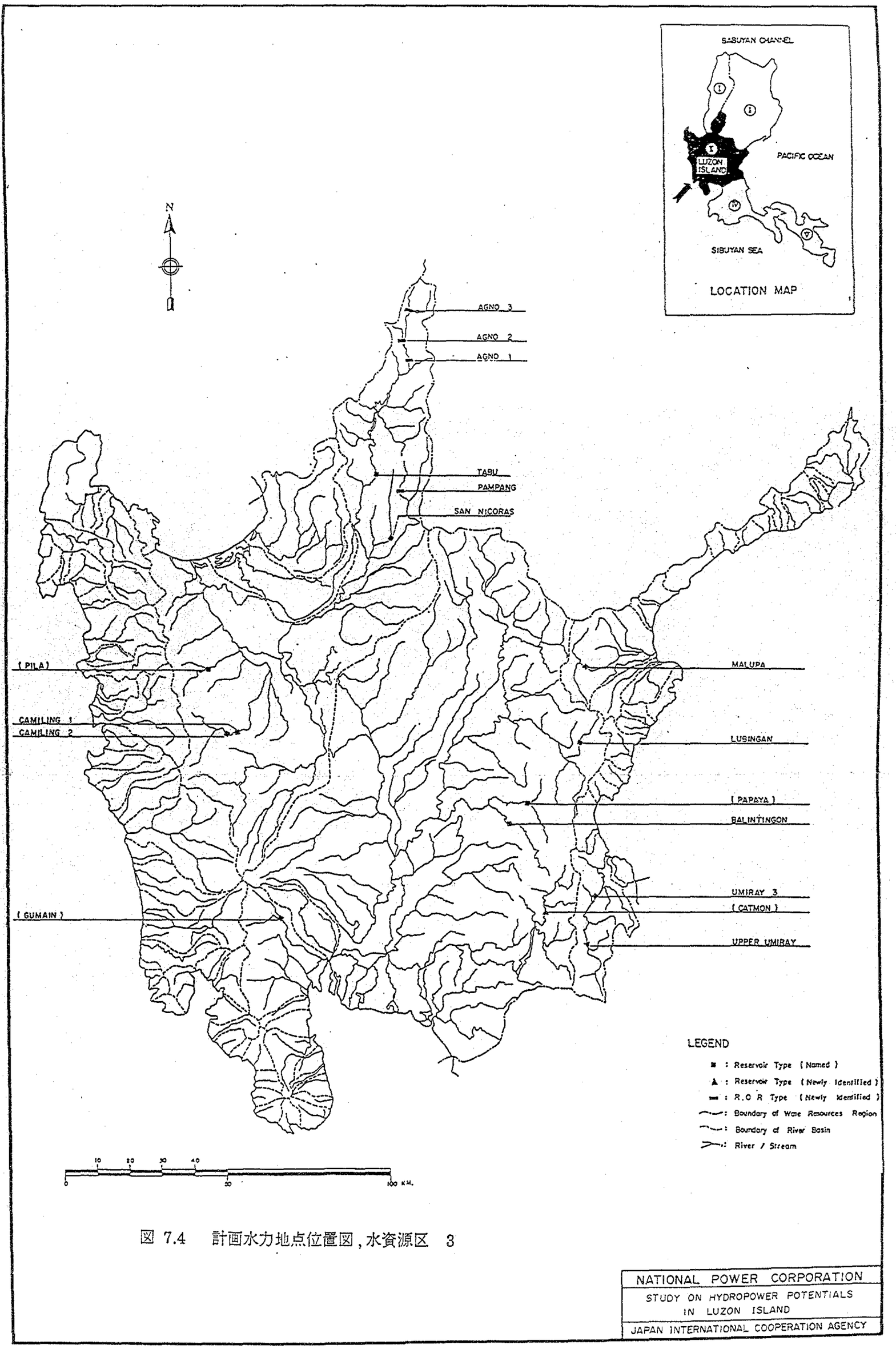


図 7.4　計画水力地点位置図，水資源区　3

NATIONAL POWER CORPORATION
STUDY ON HYDROPOWER POTENTIALS IN LUZON ISLAND
JAPAN INTERNATIONAL COOPERATION AGENCY

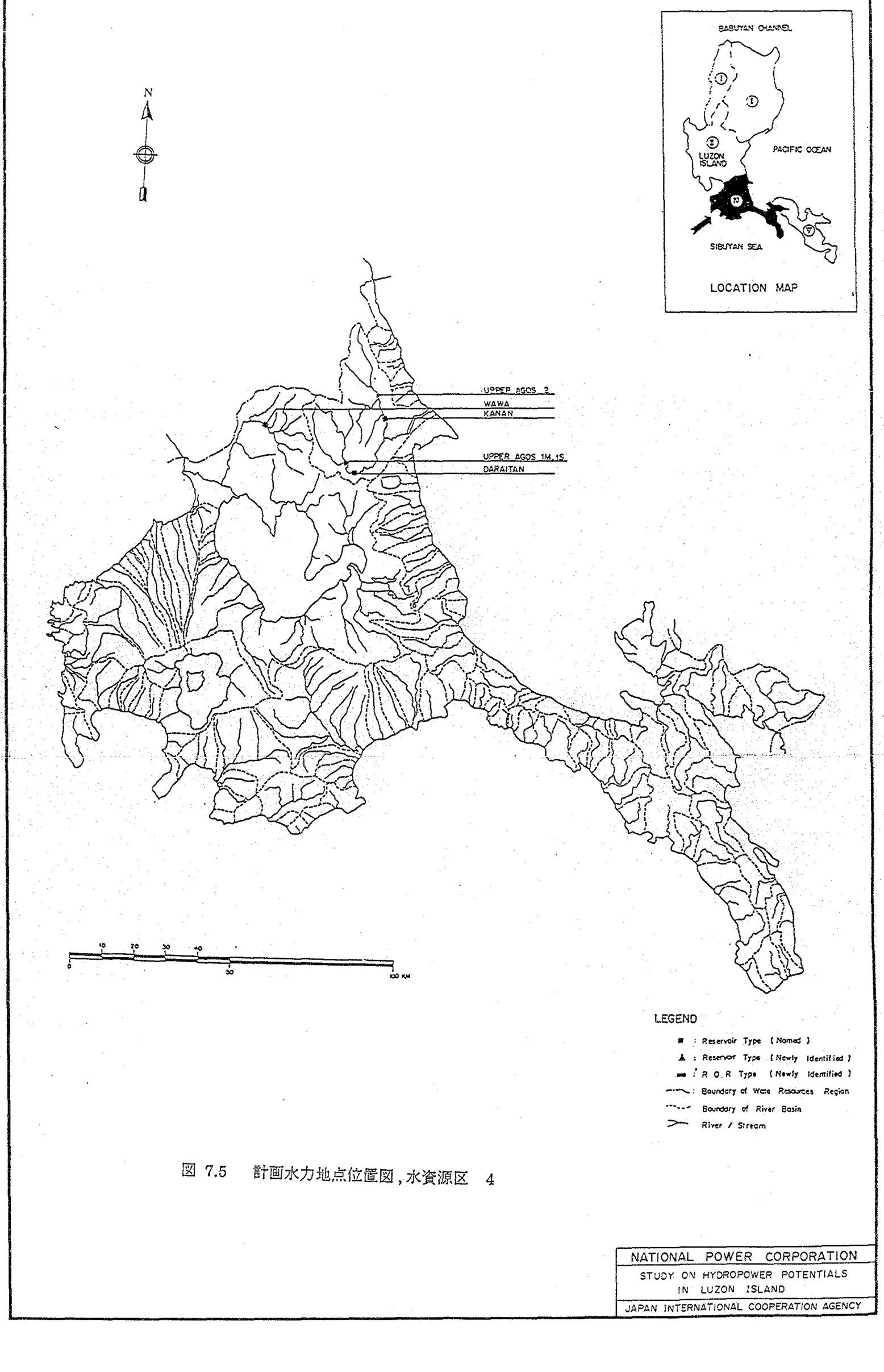


図 7.5　計画水力地点位置図，水資源区　4

NATIONAL POWER CORPORATION
STUDY ON HYDROPOWER POTENTIALS IN LUZON ISLAND
JAPAN INTERNATIONAL COOPERATION AGENCY

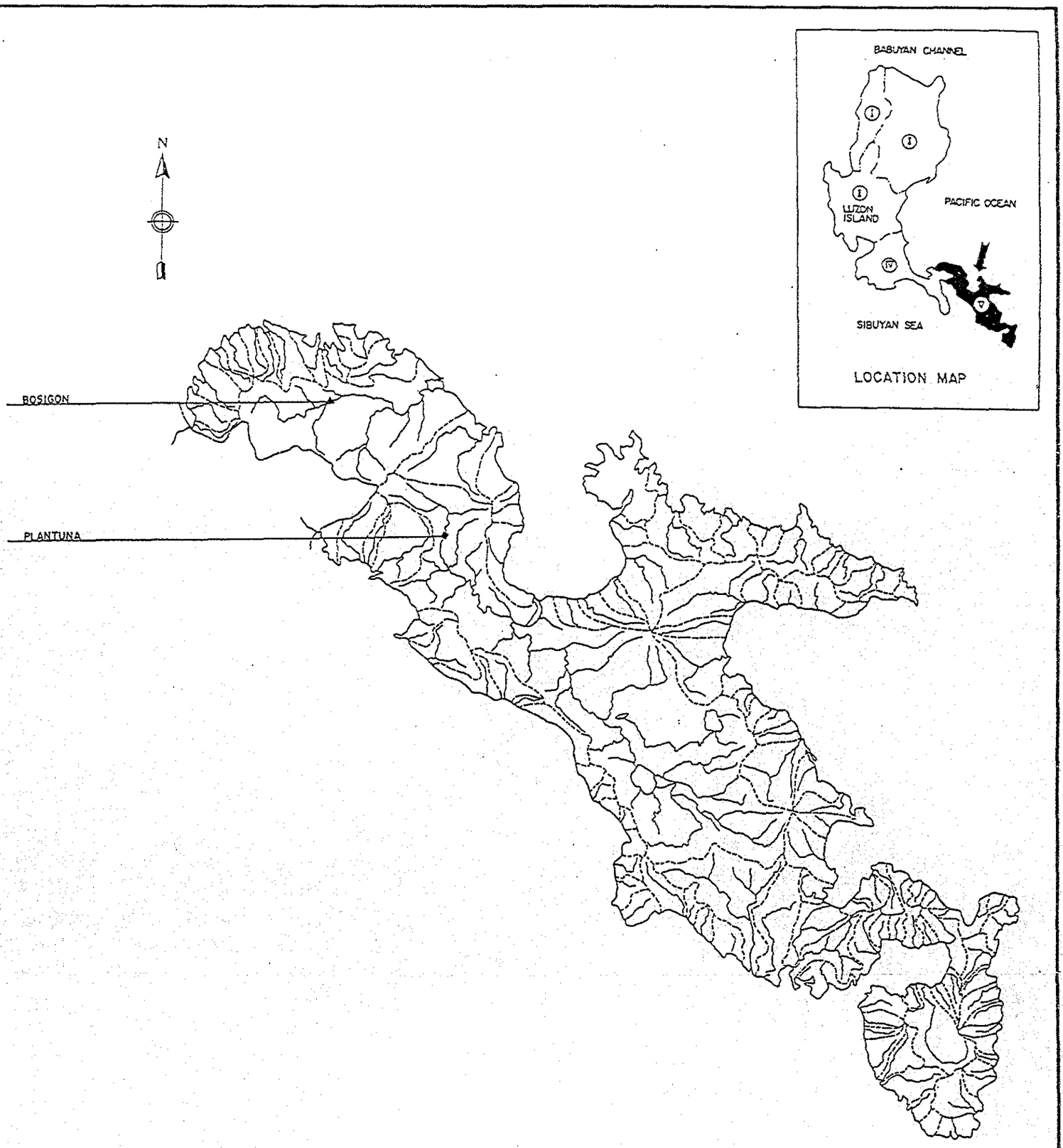


図 7.6　計画水力地点位置図, 水資源区　5

NATIONAL POWER CORPORATION
STUDY ON HYDROPOWER POTENTIALS IN LUZON ISLAND
JAPAN INTERNATIONAL COOPERATION AGENCY

Station ID : 41008 NW106
Station : Bumagcat
River : Abra

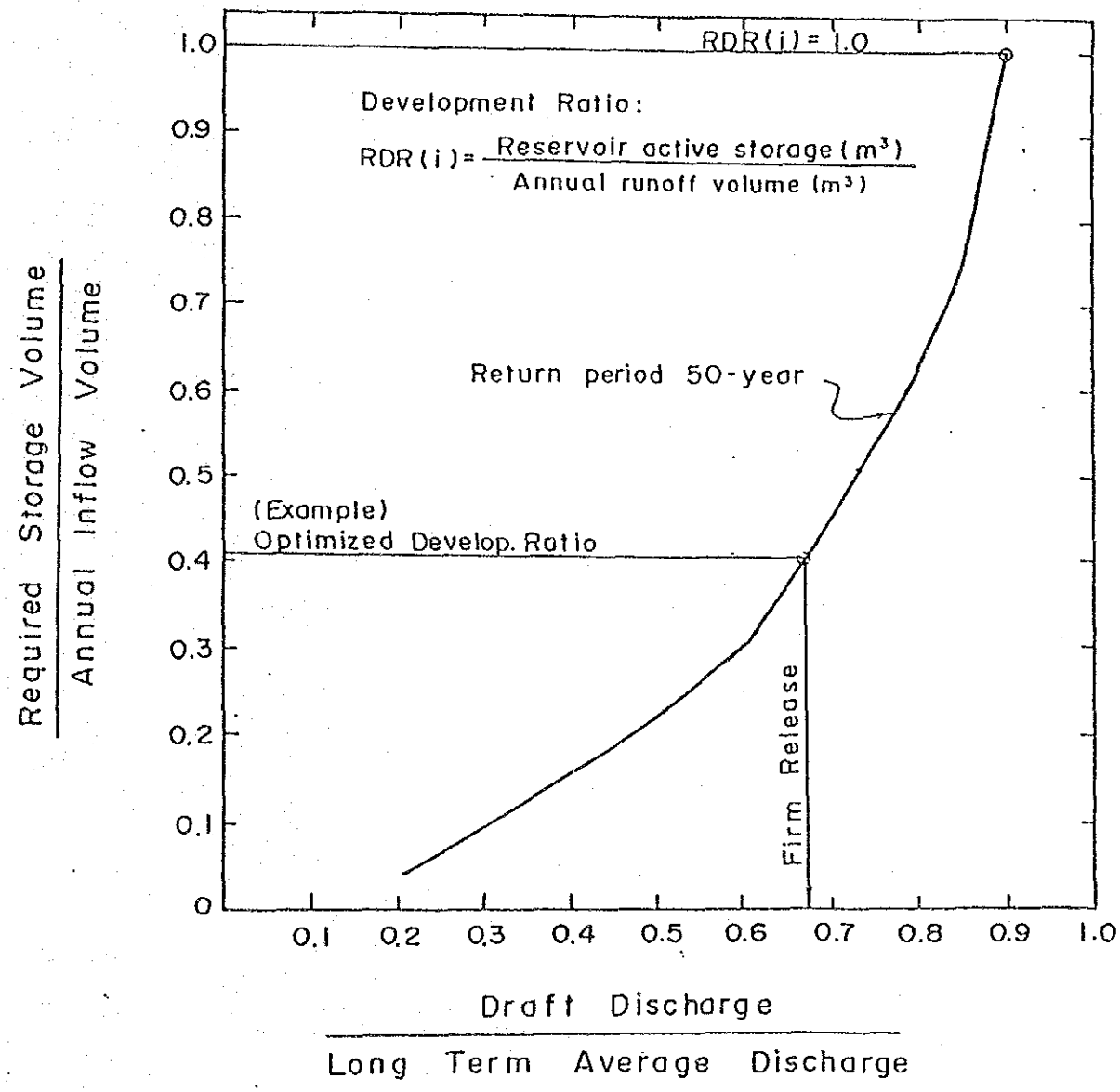


図 8.1 貯水池利用曲線

NATIONAL POWER CORPORATION
STUDY ON HYDROPOWER POTENTIALS IN LUZON ISLAND
JAPAN INTERNATIONAL COOPERATION AGENCY

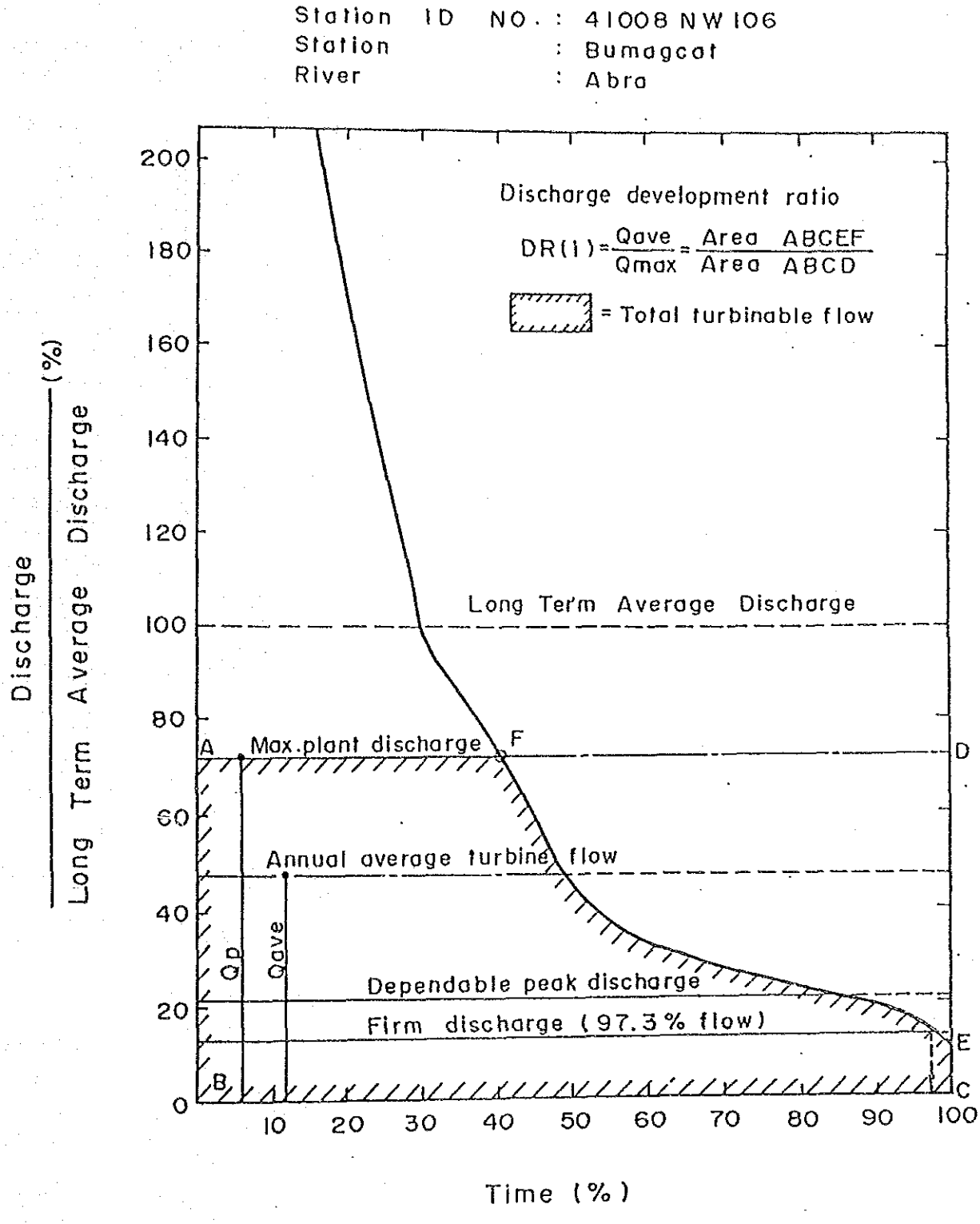
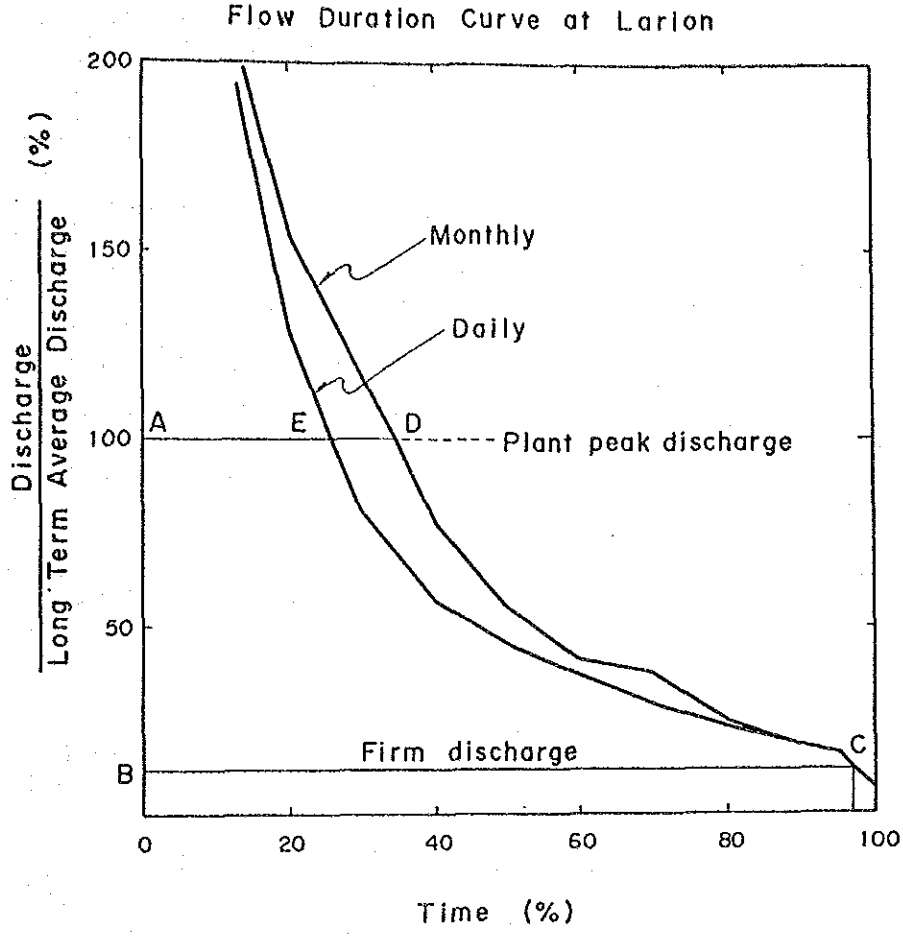


図 8.2　流況曲線

NATIONAL POWER CORPORATION
STUDY ON HYDROPOWER POTENTIALS IN LUZON ISLAND
JAPAN INTERNATIONAL COOPERATION AGENCY



$$\frac{\text{Secondary Energy estimated by Daily Curve}}{\text{Secondary Energy estimated by Monthly Curve}}$$

$$= \frac{\text{Area A B C E}}{\text{Area A B C D}}$$

$$\fallingdotseq 0.9$$

図 8.3　月流況曲線と日流況曲線から算定される二次エネルギーの比較

NATIONAL POWER CORPORATION
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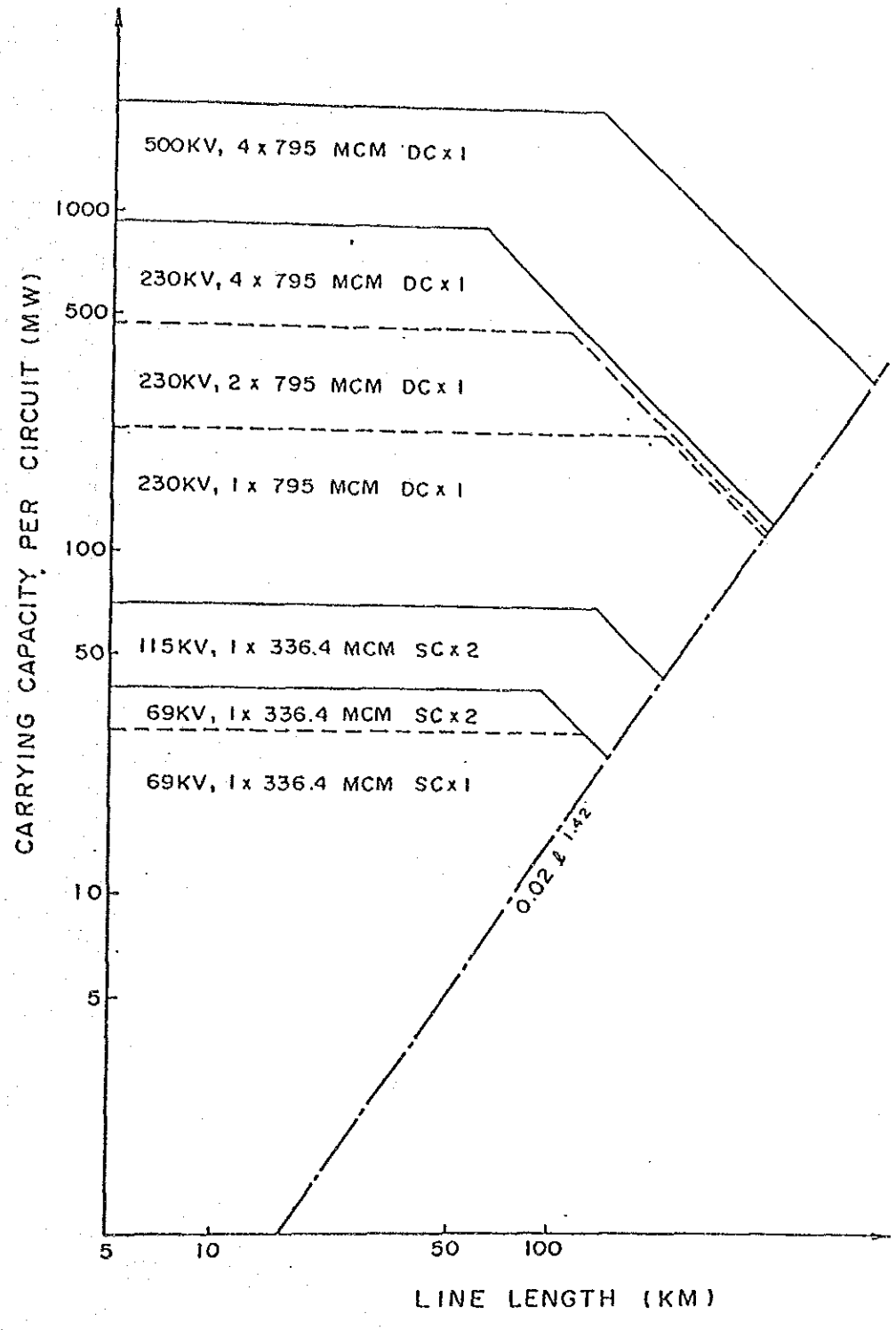

図 9.1　送電線容量と送電線長の関係

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JAPAN INTERNATIONAL COOPERATION AGENCY

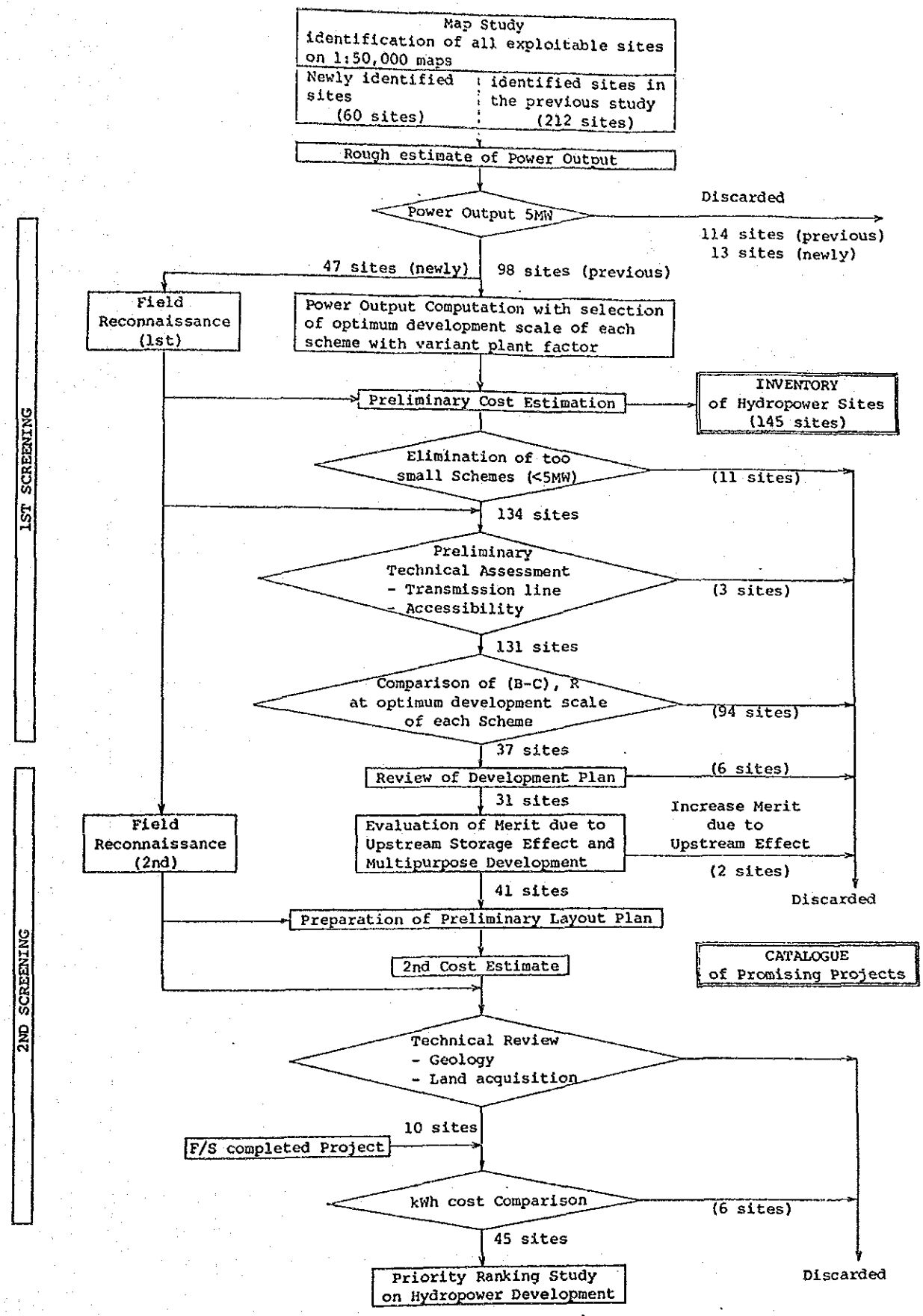

図 13.1 スクリーニング作業の流れ図

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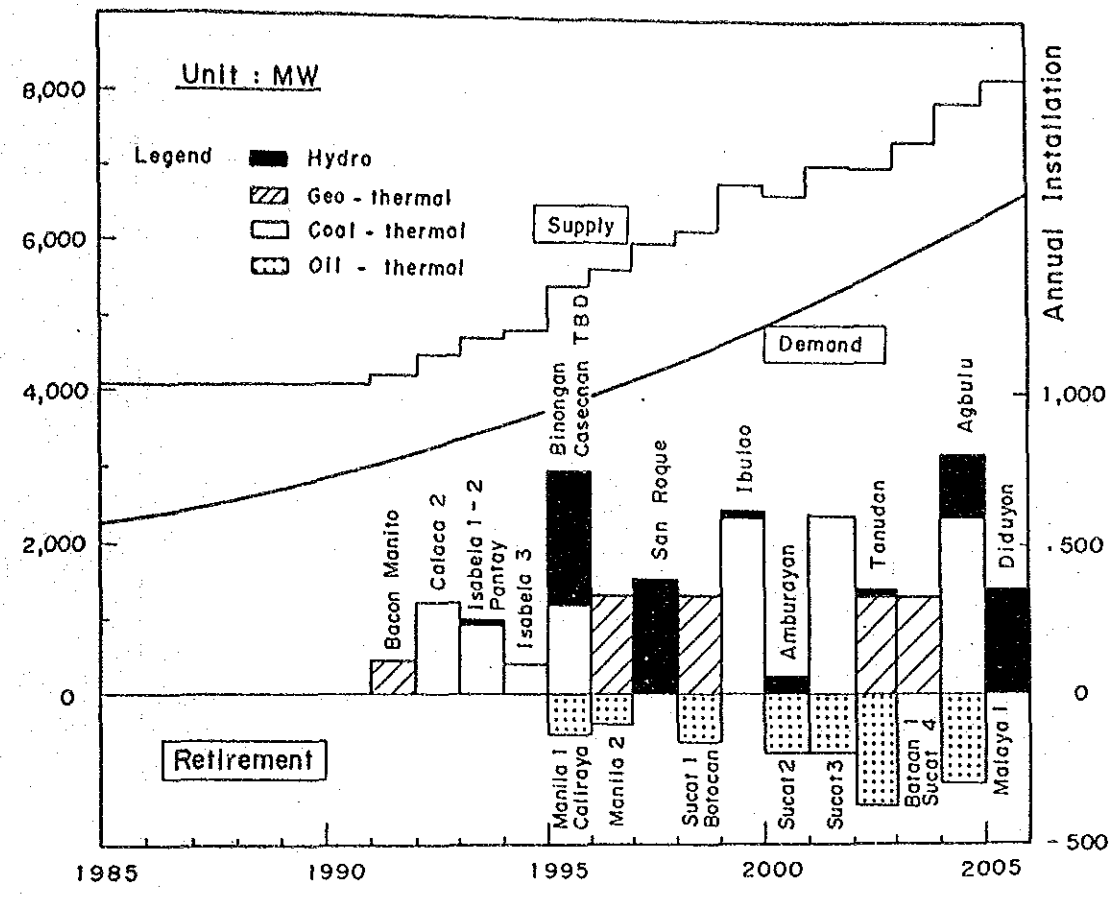
JAPAN INTERNATIONAL COOPERATION AGENCY



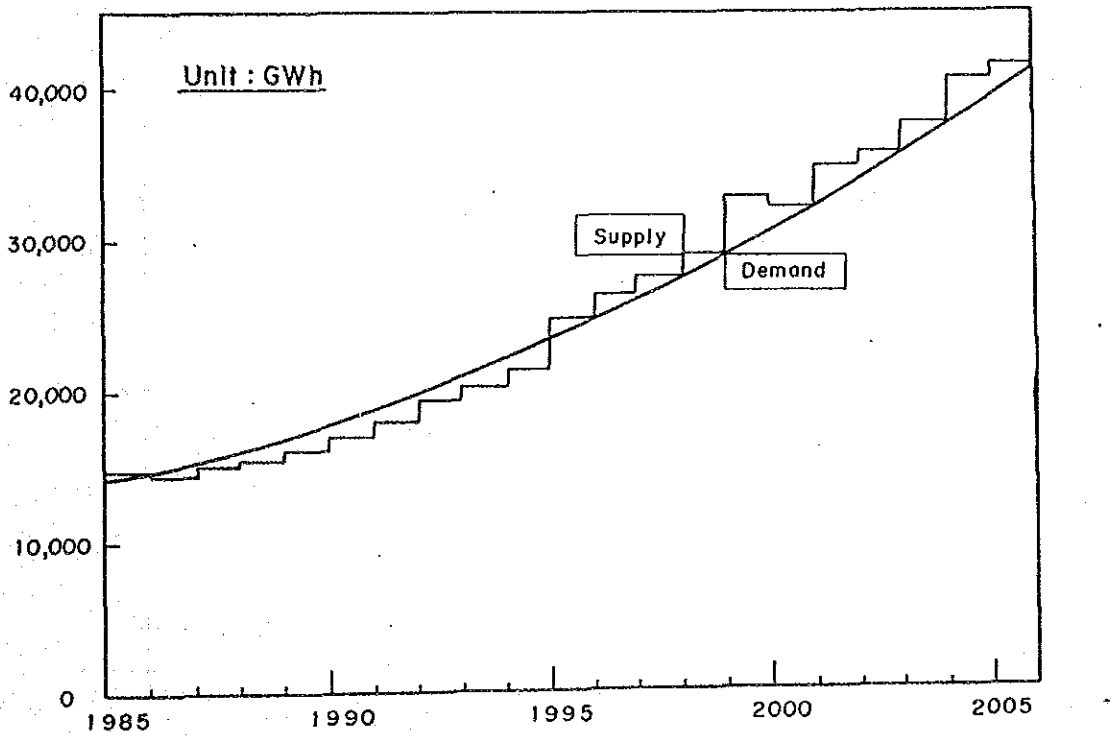


図 14.1 尖頭出力とエネルギーのバランス (1/8)
(ケースA,最適案)

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JAPAN INTERNATIONAL COOPERATION AGENCY

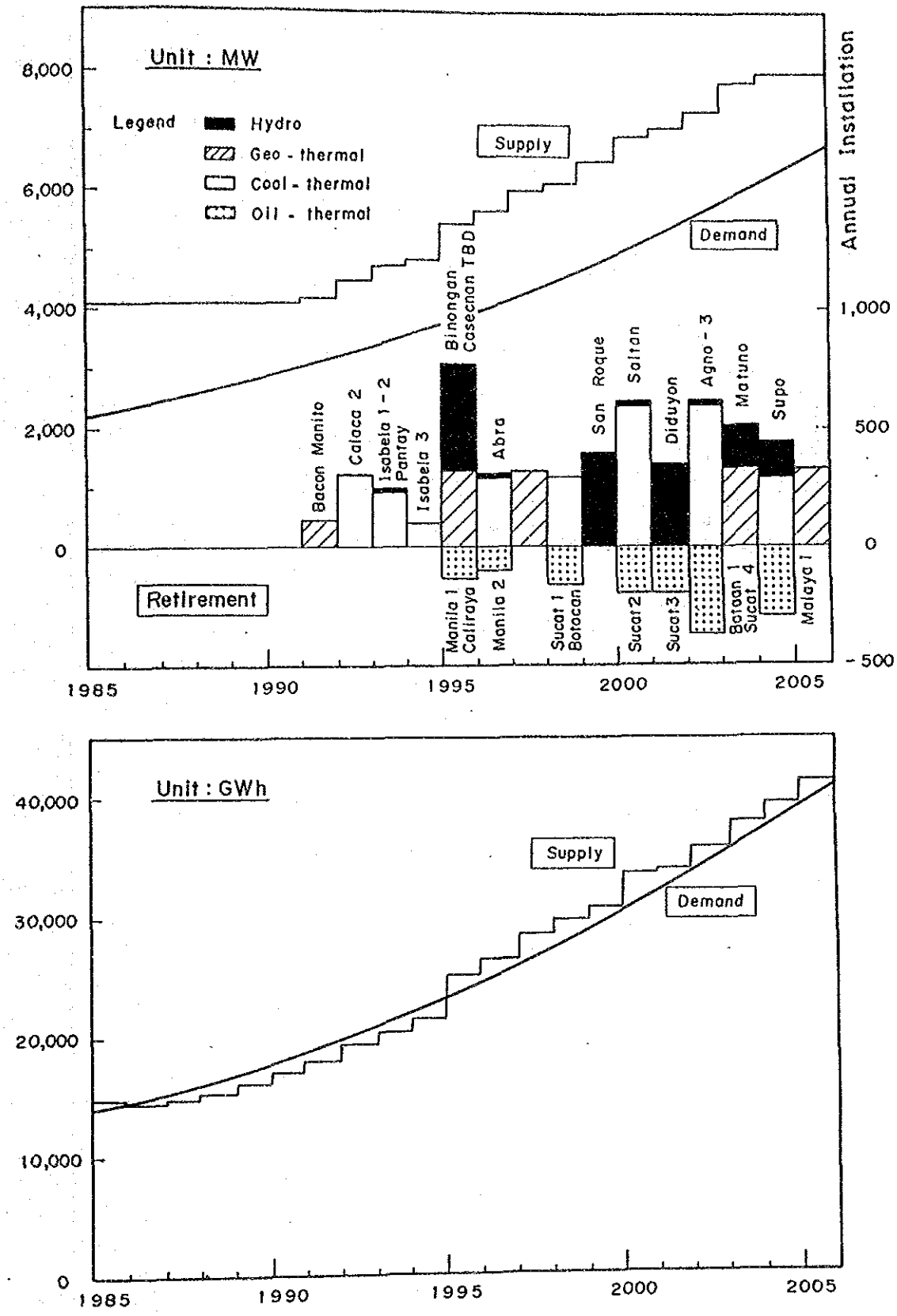

図 14.1 尖頭出力とエネルギーのバランス (2/8)
(ケースA,第二案)

NATIONAL POWER CORPORATION
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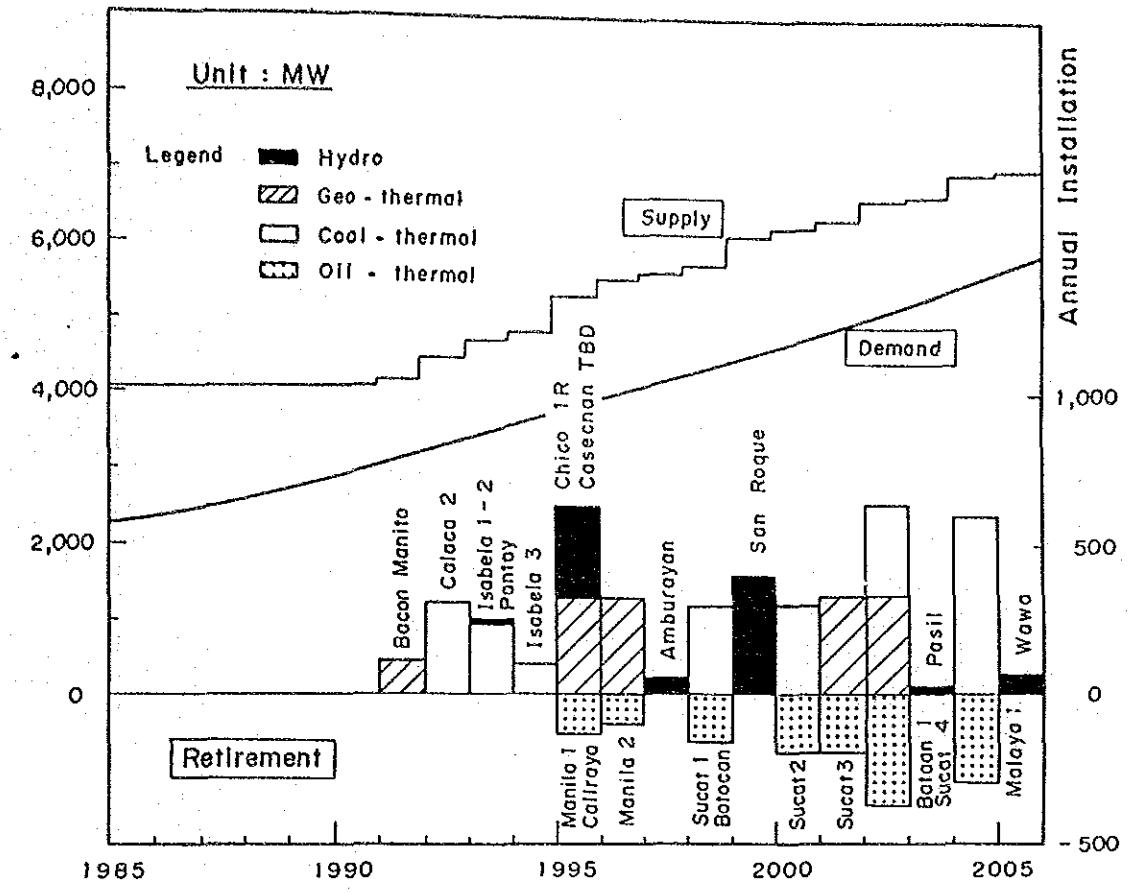
JAPAN INTERNATIONAL COOPERATION AGENCY



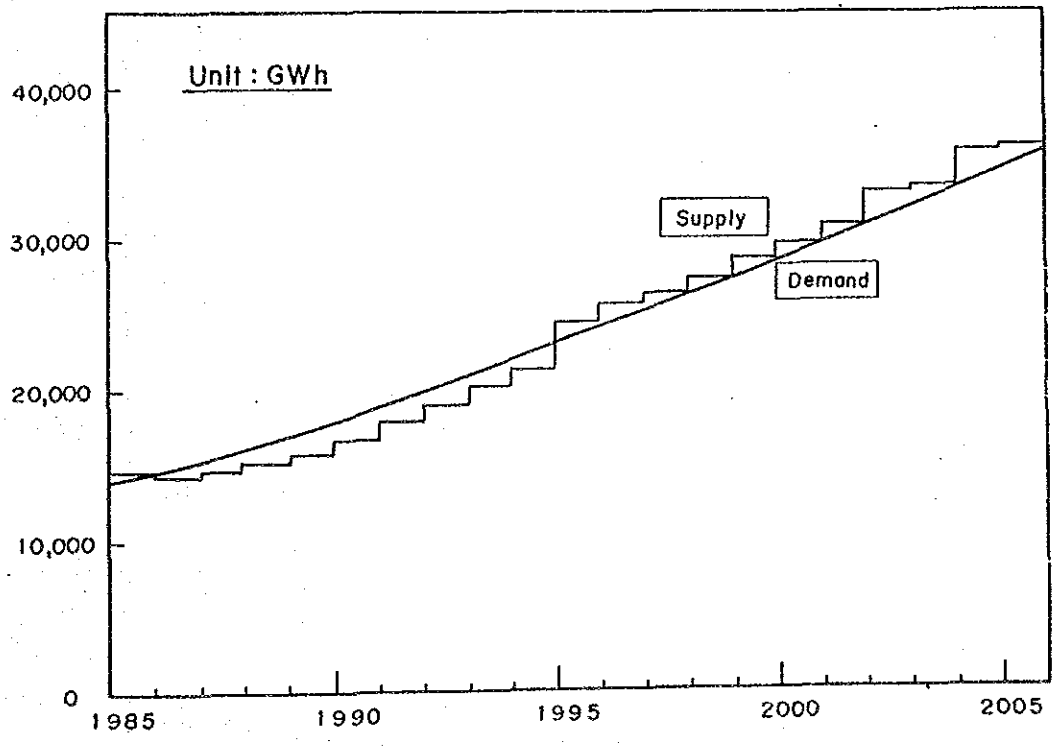


図 14.1 尖頭出力とエネルギーのバランス (3/8)
(ケースB,最適案)

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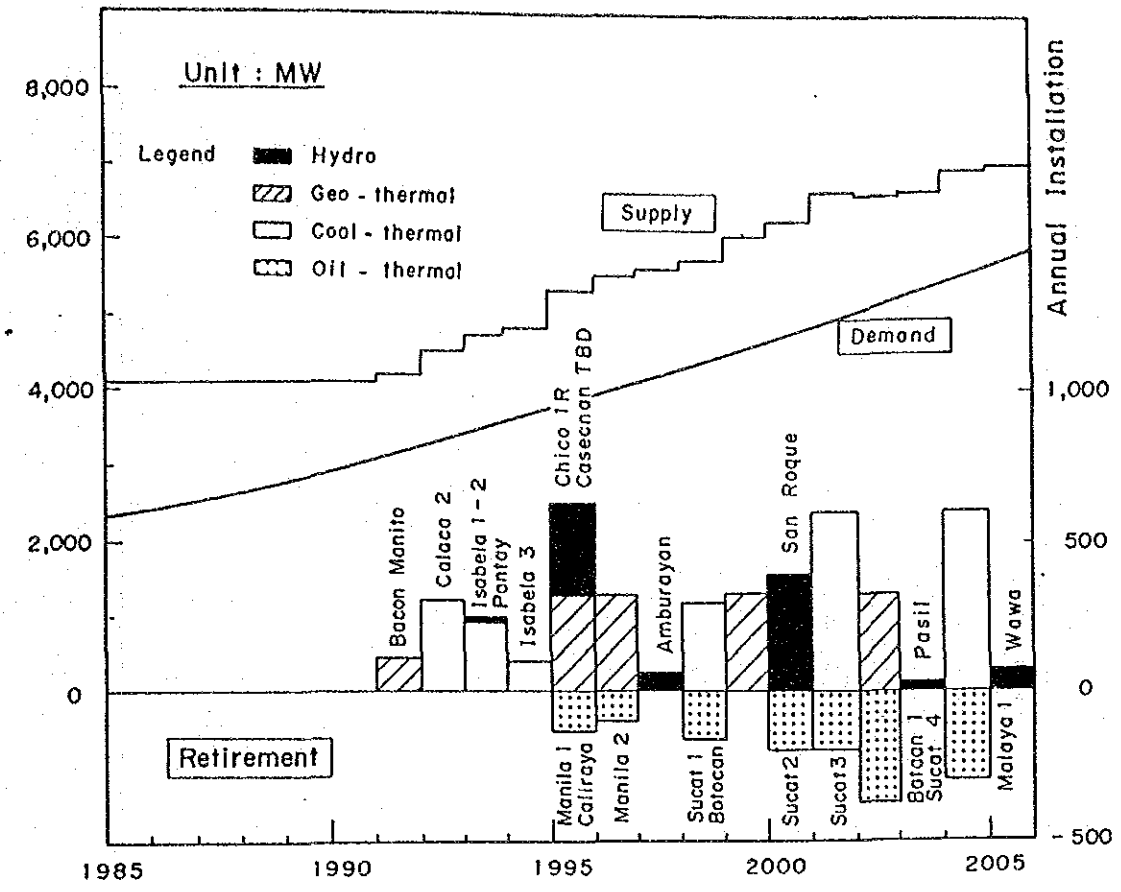
JAPAN INTERNATIONAL COOPERATION AGENCY



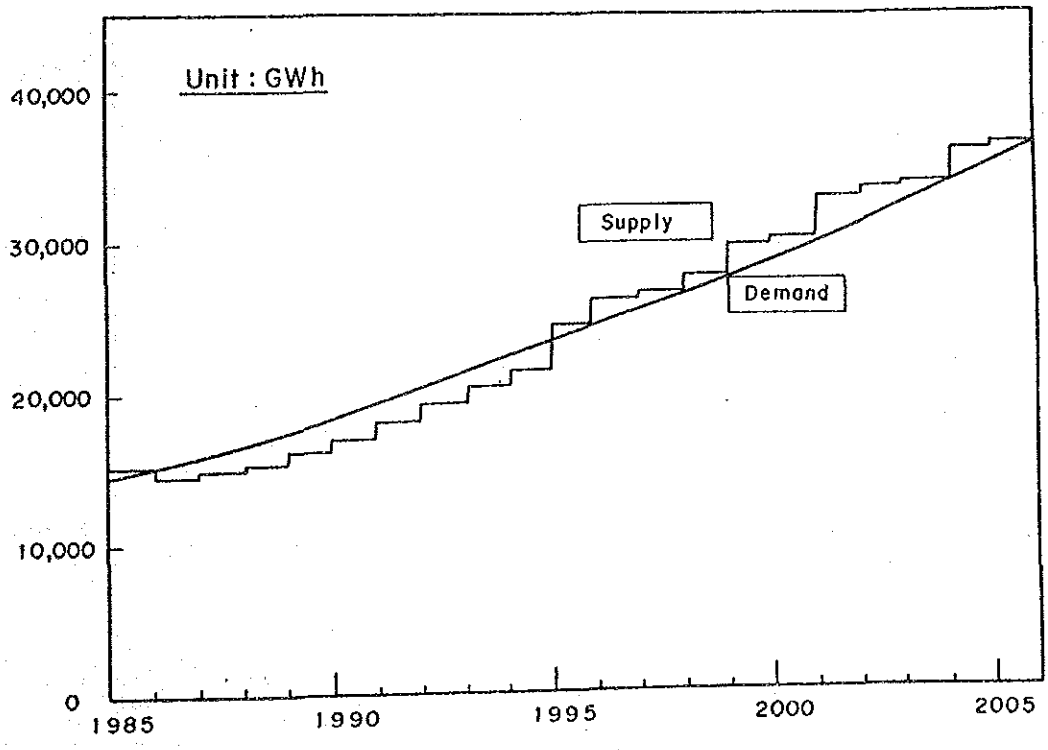


図 14.1 尖頭出力とエネルギーのバランス (4/8)
(ケース-B, 第二案)

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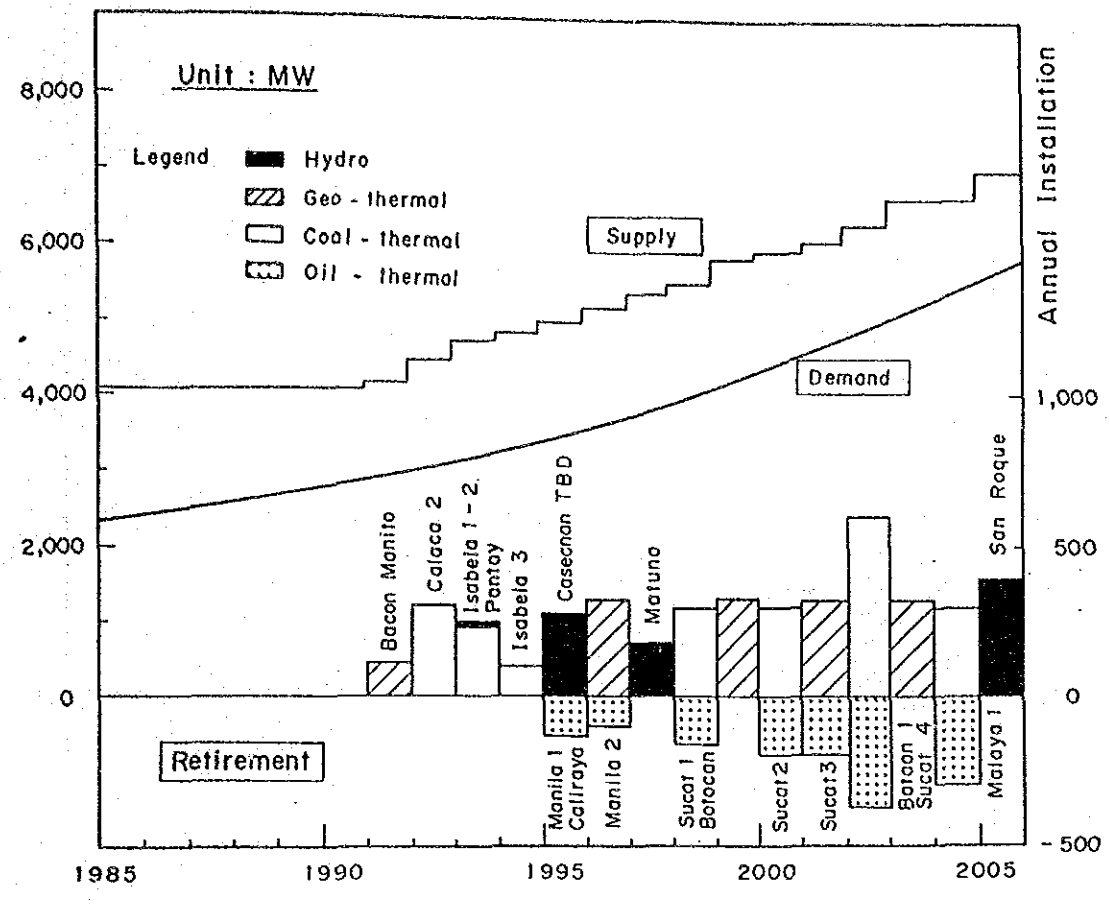
JAPAN INTERNATIONAL COOPERATION AGENCY



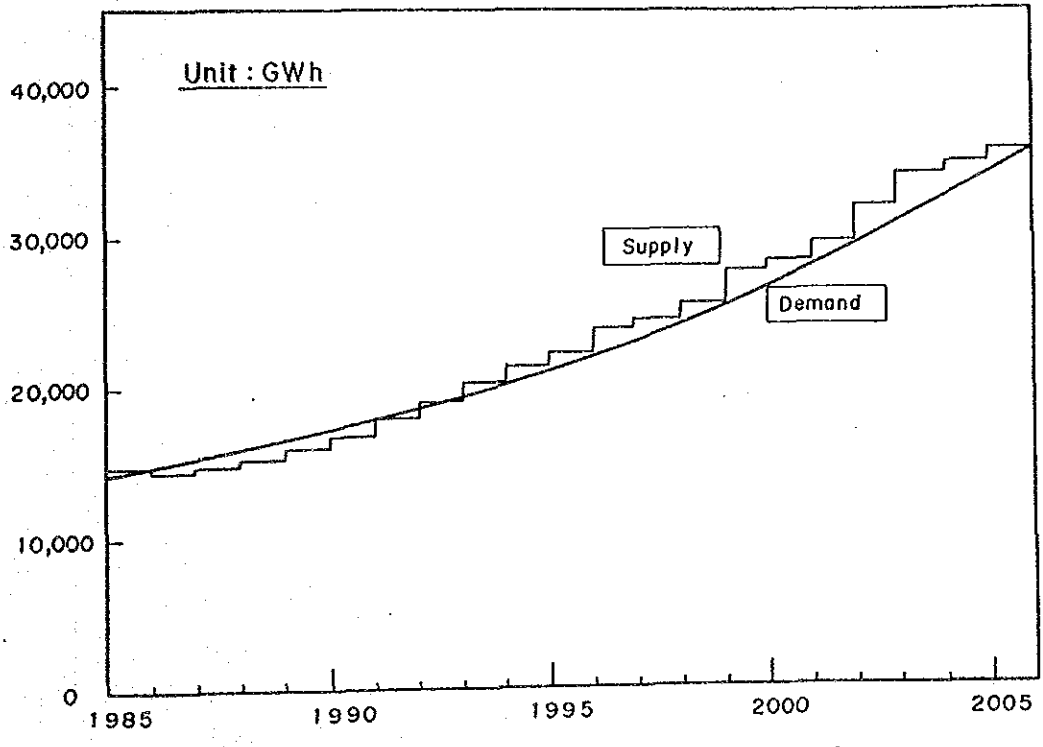


図 14.1 尖頭出力とエネルギーのバランス (5/8)
(ケースC,最適案)

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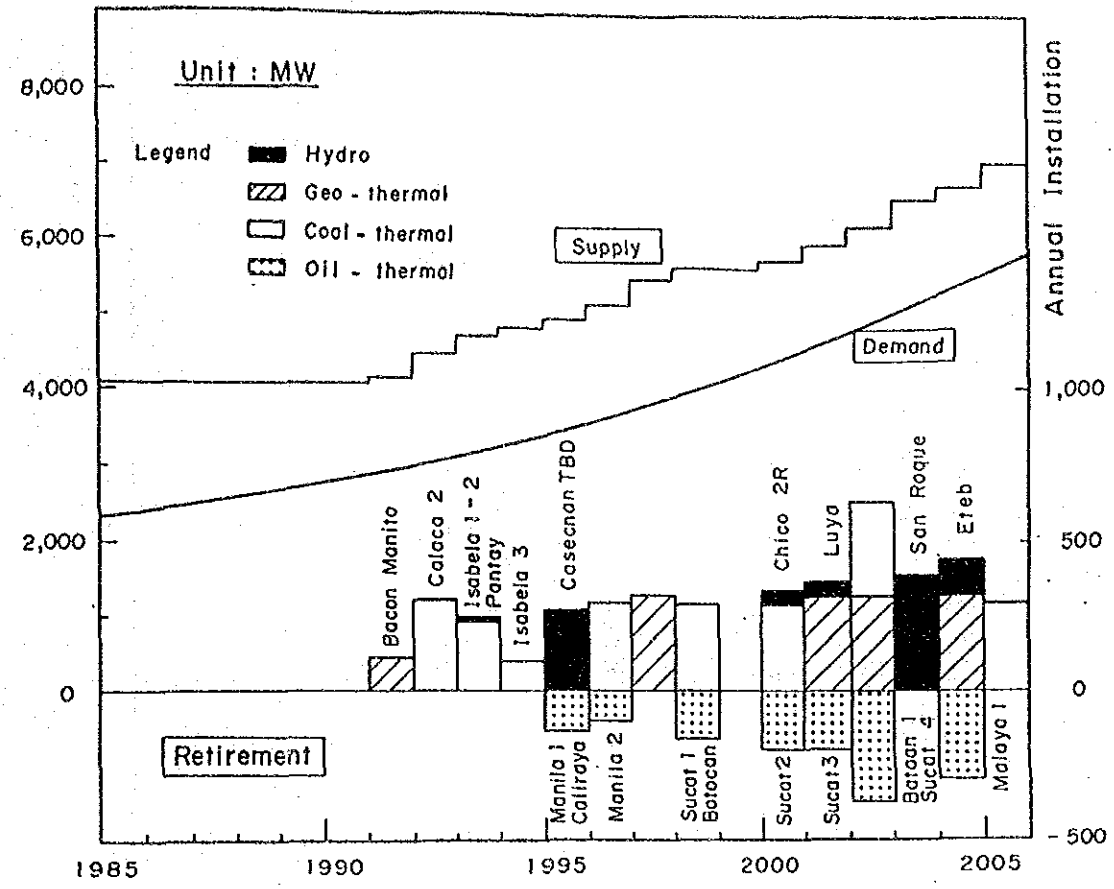
JAPAN INTERNATIONAL COOPERATION AGENCY



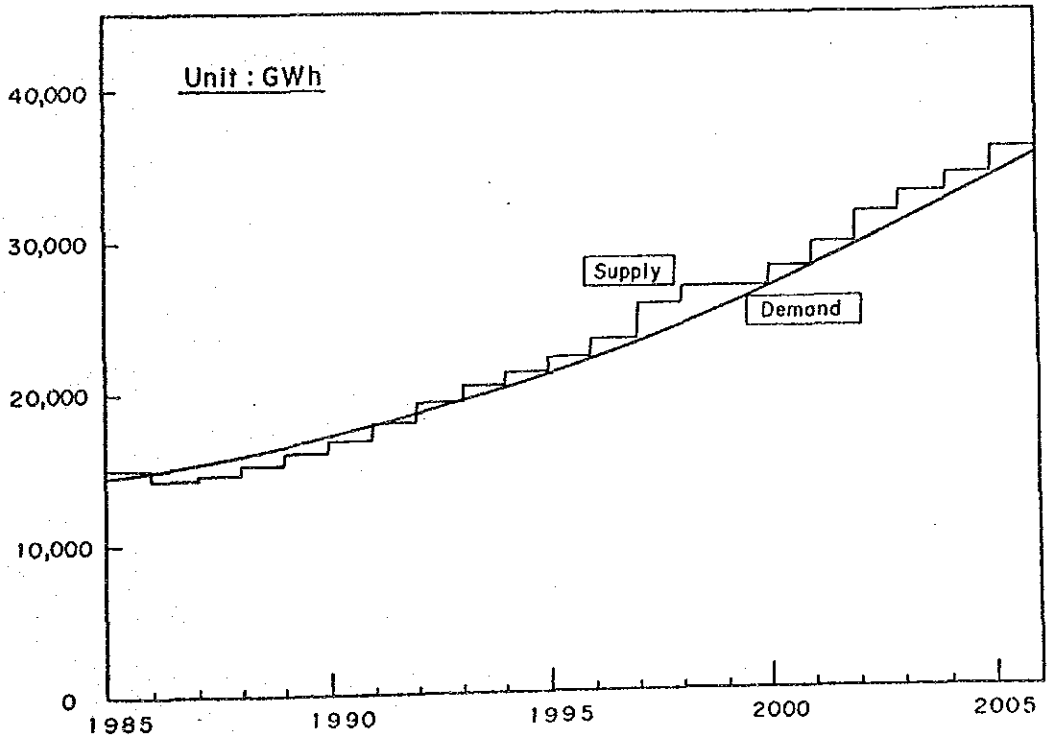


図 14.1 尖頭出力とエネルギーのバランス (6/8)
(ケースC,第二案)

NATIONAL POWER CORPORATION
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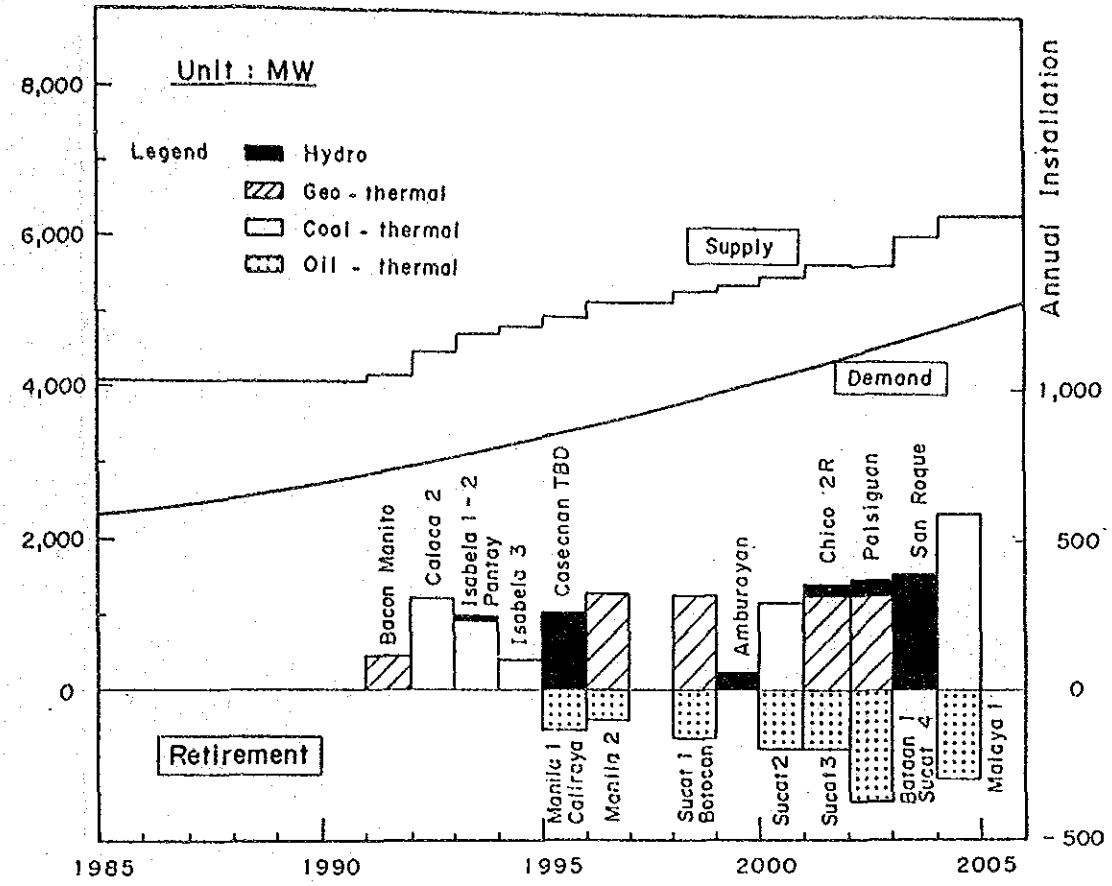
JAPAN INTERNATIONAL COOPERATION AGENCY



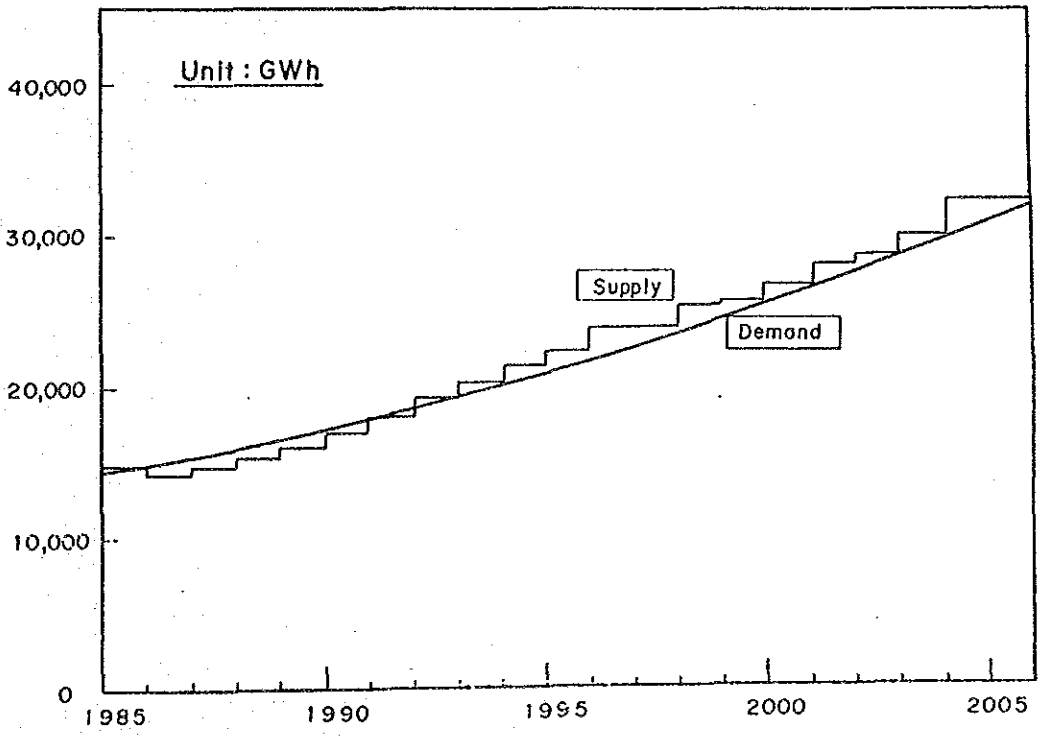
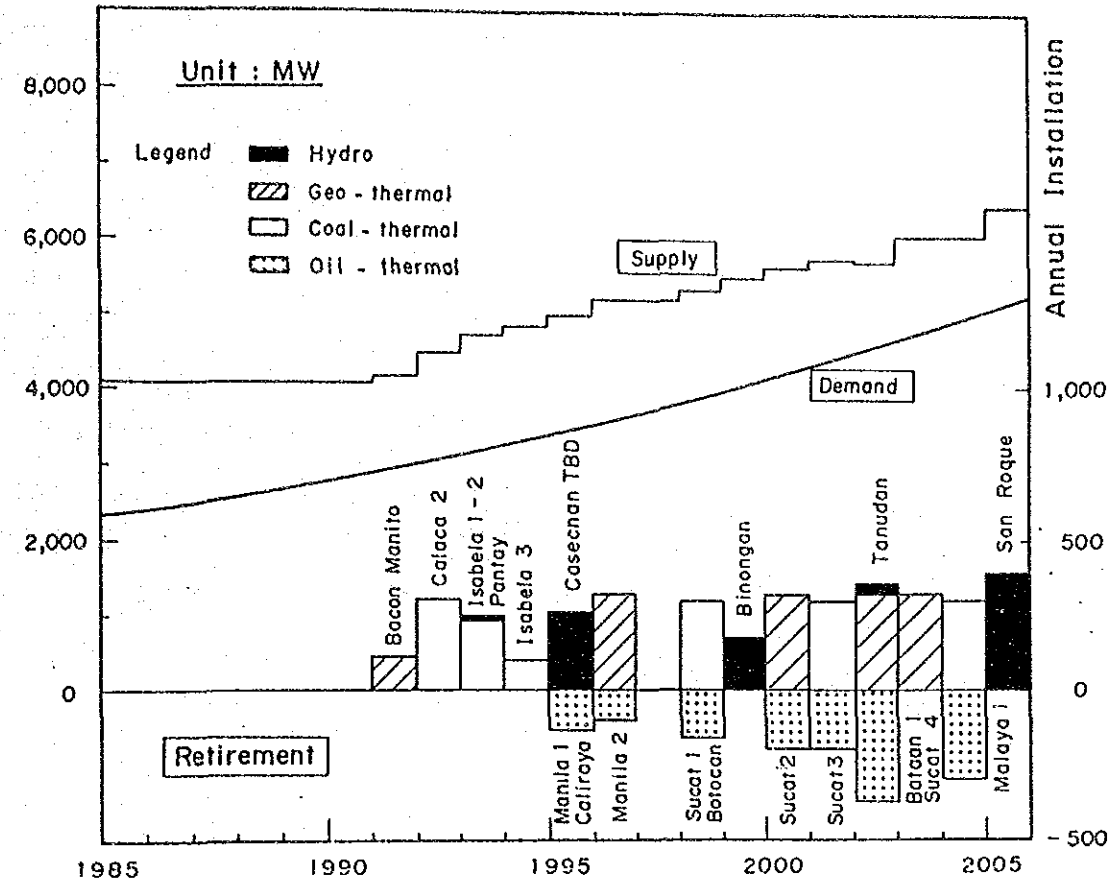


図 14.1 尖頭出力とエネルギーのバランス (7/8)
(ケースD,最適案)

NATIONAL POWER CORPORATION
STUDY ON HYDROPOWER POTENTIALS IN LUZON ISLAND
JAPAN INTERNATIONAL COOPERATION AGENCY



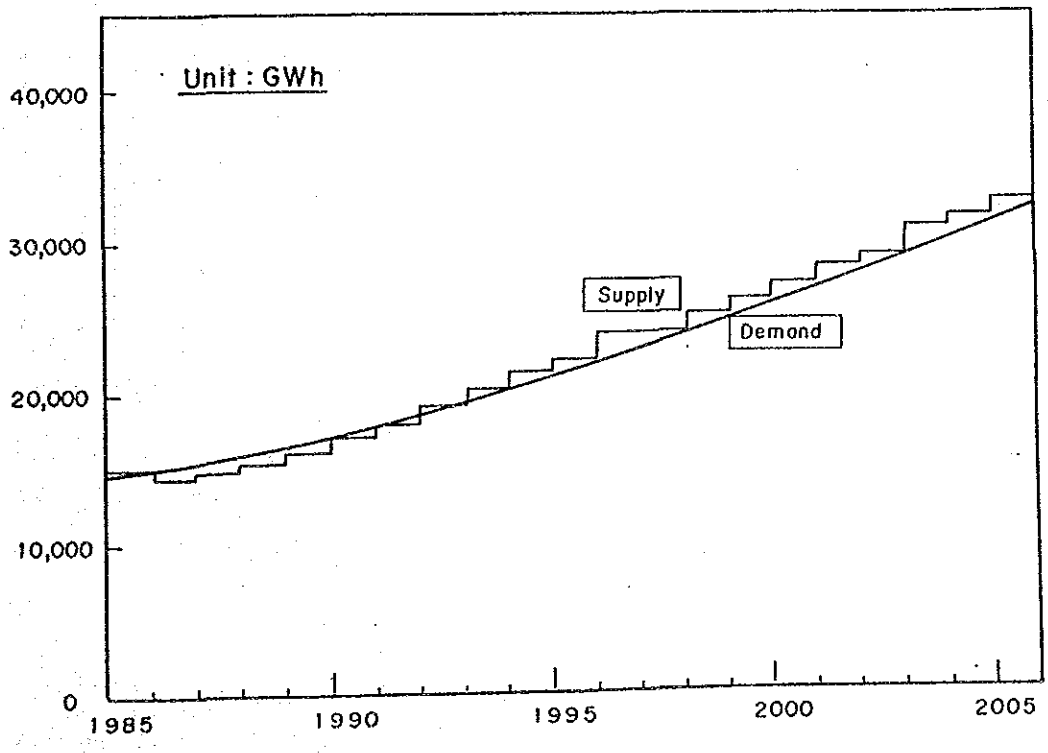


図 14.1 尖頭出力とエネルギーのバランス (8/8)
(ケースD,第二案)

NATIONAL POWER CORPORATION
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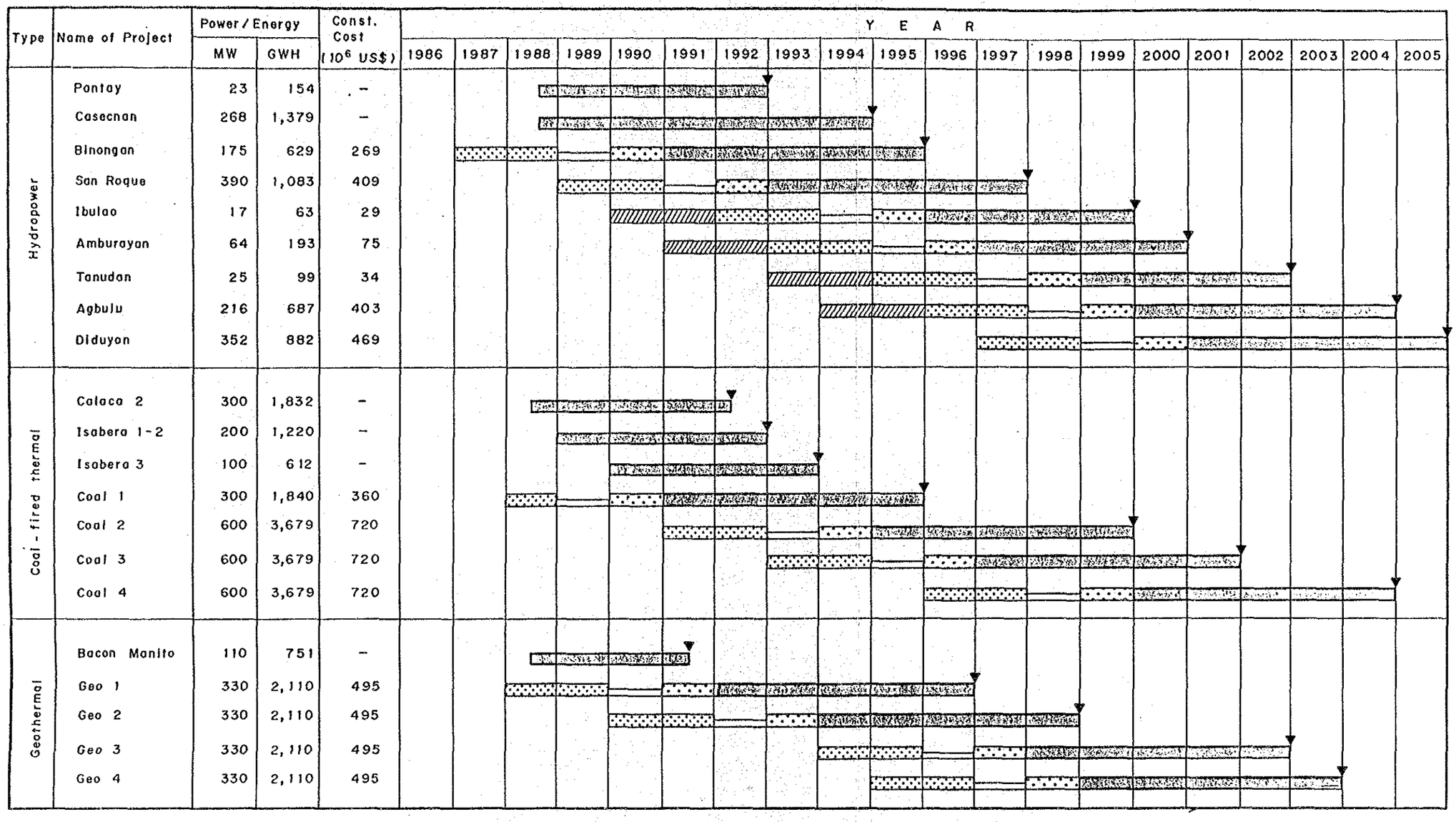
JAPAN INTERNATIONAL COOPERATION AGENCY

Type	Name of Project	Power / Energy MW	Power / Energy GWH	Const. Cost (10^6 US$)
Hydropower	Pontay	23	154	-
	Casecnan	268	1,379	-
	Binongan	175	629	269
	San Roque	390	1,083	409
	Ibulao	17	63	29
	Amburayan	64	193	75
	Tanudan	25	99	34
	Agbulu	216	687	403
	Diduyon	352	882	469
Coal - fired thermal	Calaca 2	300	1,832	-
	Isabera 1-2	200	1,220	-
	Isabera 3	100	612	-
	Coal 1	300	1,840	360
	Coal 2	600	3,679	720
	Coal 3	600	3,679	720
	Coal 4	600	3,679	720
Geothermal	Bacon Manito	110	751	-
	Geo 1	330	2,110	495
	Geo 2	330	2,110	495
	Geo 3	330	2,110	495
	Geo 4	330	2,110	495



LEGEND
- : Feasibility Study
- : Detailed Design
- : Finance
- : Tender / Contract
- : Construction
- ▼ : Commissioning of Power Plant

Remarks:
1. Construction period and commissioning of the committed project are represented as scheduled in the Power Development Program by NPC (May 1986)
2. Construction cost of the committed project is not represented.

図 15.1 発電設備投入計画

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JAPAN INTERNATIONAL COOPERATION AGENCY

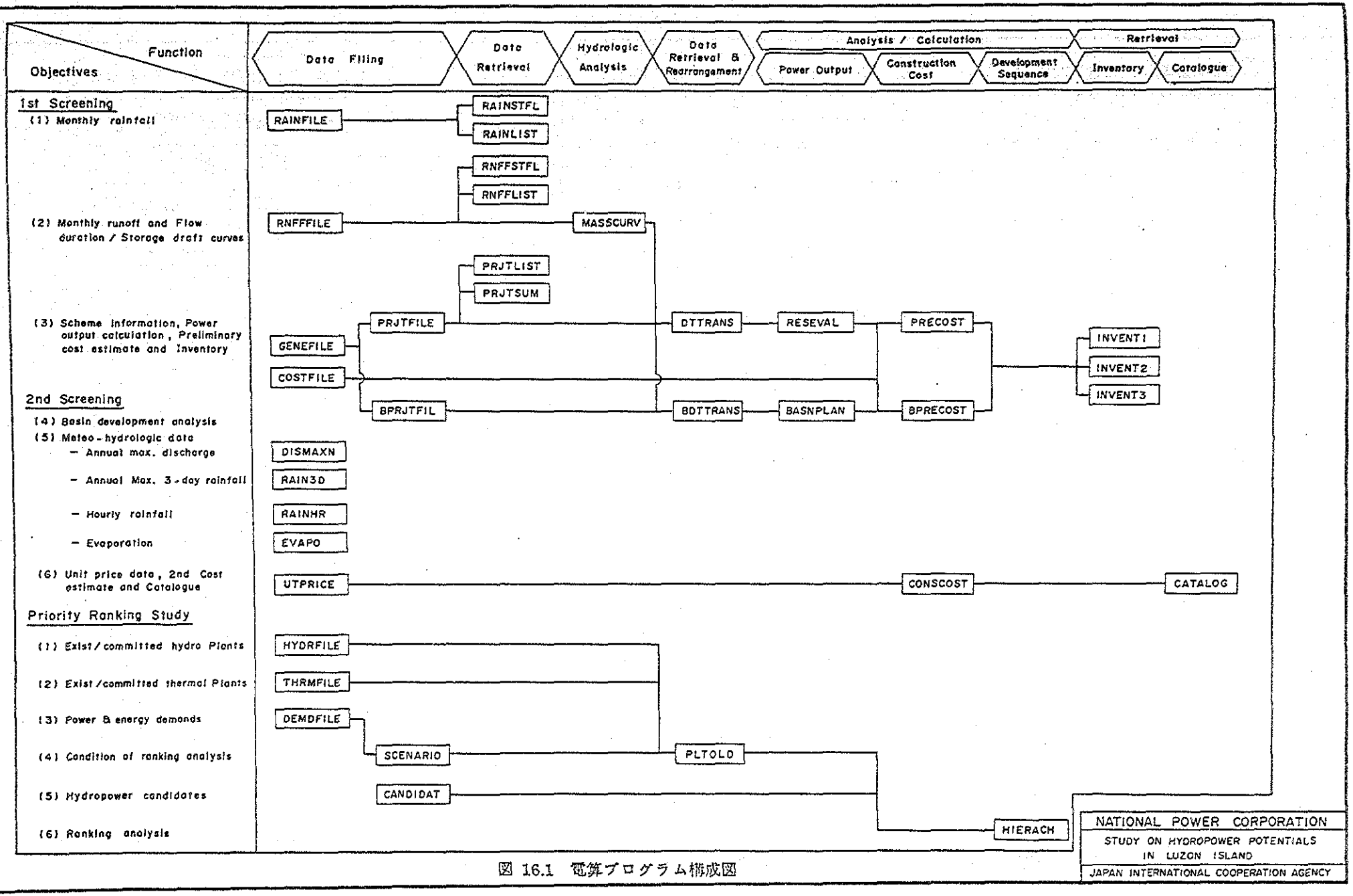

図 16.1 電算プログラム構成図

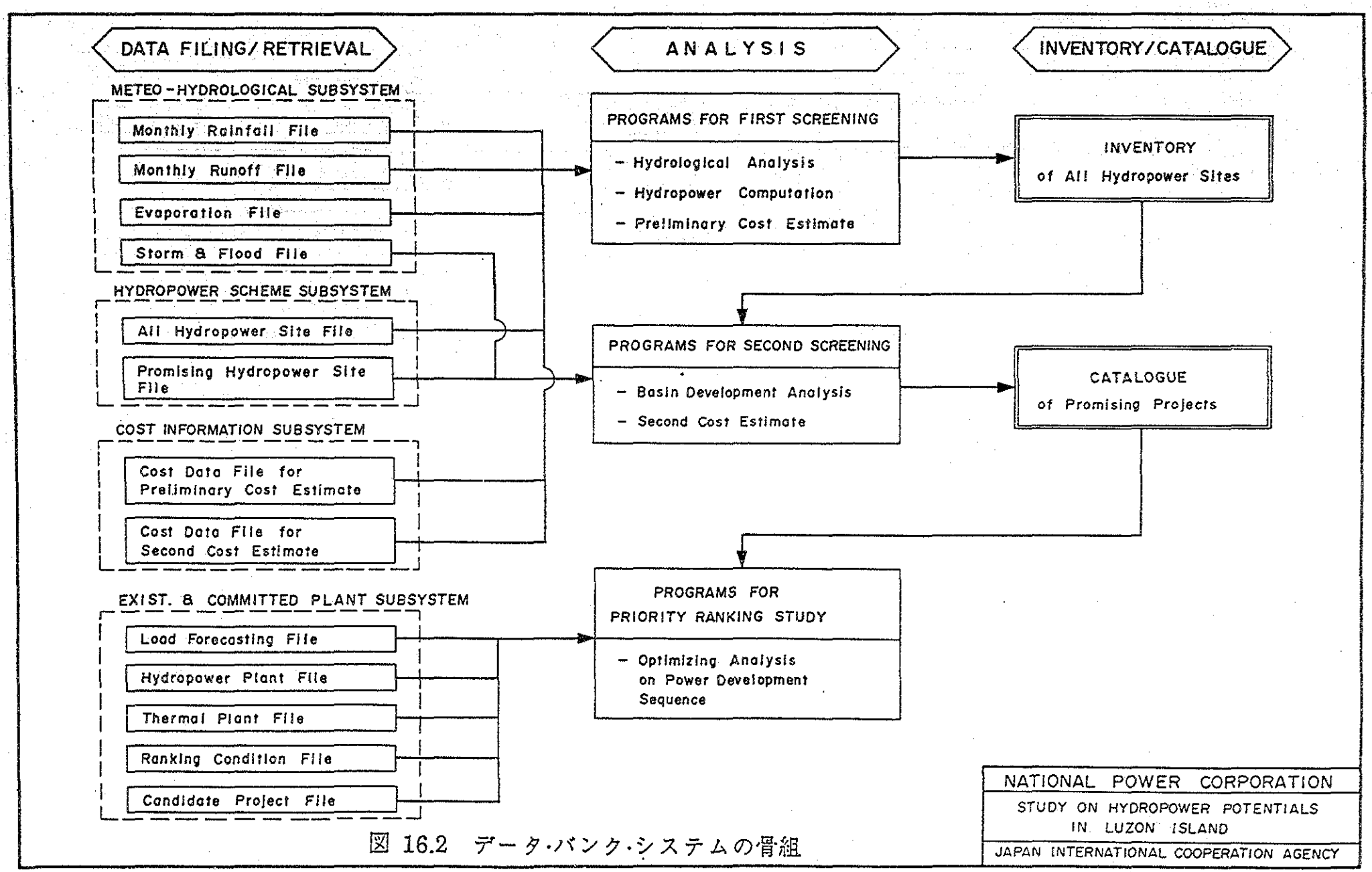

図 16.2 データ・バンク・システムの骨組

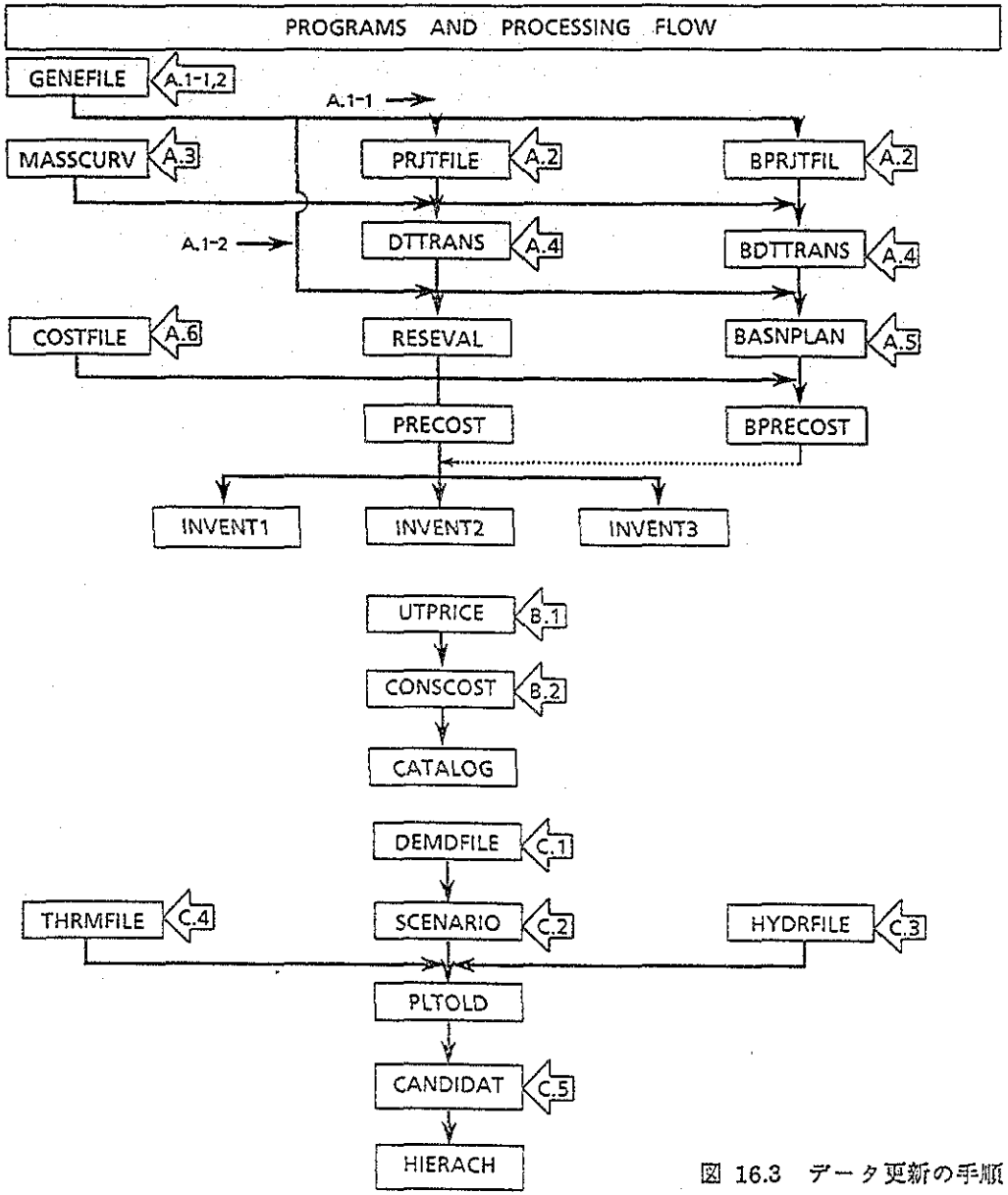

図 16.3 データ更新の手順

DATA TO BE UPDATED	
	D a t a
A.1-1	Dam excavation depth,Dam vol.multiplier,Free board
A.1-2	General calculation condition,Flood data,etc.
A. 2	Scheme information
A. 3	Selected runoff gages,Monthly runoff data
A. 4	Scheme 1D#,Condition of power output calculation
A. 5	Combination of schemes for basin development
A. 6	Cost formula,Unit price
B. 1	Unit price
B. 2	Feature of promising schemes
C. 1	Power and energy demands
C. 2	Condition of priority ranking study
C. 3	Data on existing/committed hydropower plants
C. 4	Data on existing/committed thermal plants
C. 5	Data on candidate hydropower projects

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