THE SOCIALIST REPUBLIC OF THE UNION OF BURMA

THE MASTER PLAN SURVEY REPORT ON THE IRRAWADDY BASIN INTEGRATED AGRICULTURAL DEVELOPMENT

ANNEX D

HYDROLOGY AND IRRIGATION

MARCH 1980

JAPAN INTERNATIONAL COOPERATION AGENCY

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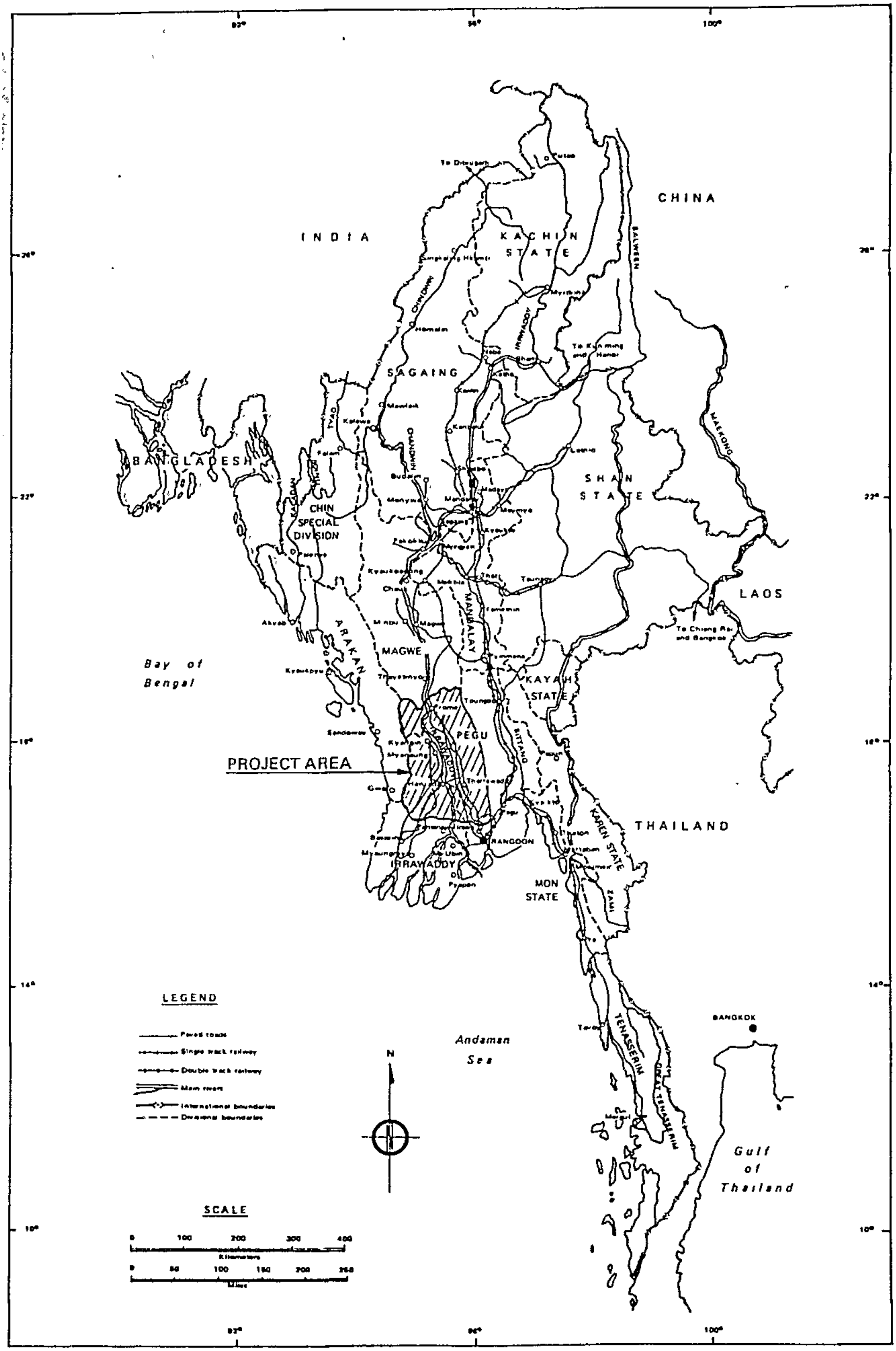
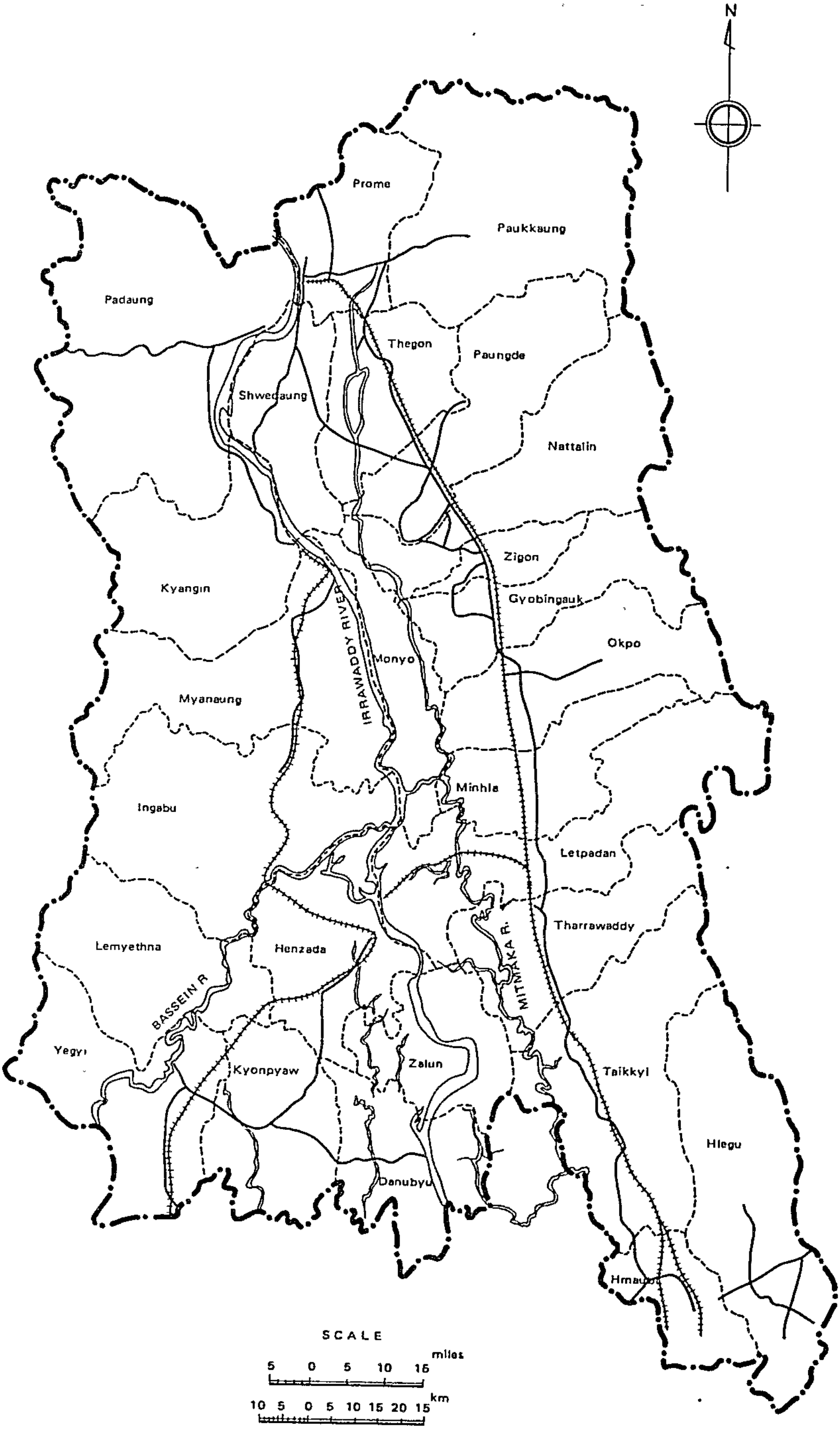


CHINA
INDIA
KACHIN STATE
SAGAING
BANGLADESH
CHIN SPECIAL DIVISION
SHAN STATE
LAOS
ARAKAN
MAGWE
MANDALAY
Bay of Bengal
KAYAH STATE
PEGU
PROJECT AREA
THAILAND
RANGOON
IRRAWADDY
MON STATE
KAREN STATE
Andaman Sea
TENASSERIM
BANGKOK
Gulf of Thailand
LEGEND
N
SCALE


N
Prome
Paukkaung
Padaung
Thegon
Paungde
Shwedaung
Nattalin
Zigon
Kyangin
Gyobingauk
Okpo
Monyo
IRRAWADDY RIVER
Myanaung
Minhla
Ingabu
Letpadan
Tharrawaddy
Lemyethna
Henzada
MITMAKA R.
BASSEIN R.
Yegyi
Kyonpyaw
Zalun
Taikkyi
Hlegu
Danubyu
Hmawbi
SCALE
miles
5 0 5 10 15
km
10 5 0 5 10 15 20 15

CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

ABBREVIATION, MEASURES AND GLOSSARIES

AC	Agriculture Corporation
ADB	Asian Development Bank
AE	Assistant Engineer
AGM	Assistant General Manager
AFPTC	Agricultural and Farm Produce Trade Corporation
AMD	Agricultural Mechanization Department
APS	Advance Purchase System
Ave	Average
BAG	Bachelor of Agricultural University
BKT	Basket(s)
CIF	Cost Insurance and Freight
°C	Degree Centigrade
DAGM	Deputy Assistant General Manager
DG	Director General
DGM	Deputy General Manager
Dy	Deputy
EE	Executive Engineer
EL	Elevation
EPC	Electric Power Corporation
FC	Foreign Currency
FiD	Fishery Department
FERD	Foreign Economic Relations Department
FIC	Foodstuff Industries Corporation
FOB	Free on Board
FoD	Forest Department
F/S	Feasibility Study
FY	Fiscal Year from April to March
GM	General Manager
GNP	Gross National Product
GWH	Giga Watt Hour
HP	Horsepower

HWL	High Water Level
HYV	High Yielding Variety (of paddy)
Hz	Hertz per second
IBRD	International Bank for Reconstruction and Development
ID	Irrigation Department
IDA	International Development Association
KV	Kilo Volt
KW	Kilo Watt
KWH	Kilo Watt Hour
LC	Local Currency
LDMC	Livestock Development and Marketing Corporation
LIV	Local Improved Variety
LWL	Lower Water Level
LV	Local Variety
MAF	Ministry of Agriculture and Forests
MD	Managing Director
MHD	Meteorological and Hydrological Department
MI 1	Ministry of Industry No. 1
M/P	Master Plan
MPF	Ministry of Planning and Finance
MT	Ministry of Trade
MW	Mega Watt
MWL	Mean Water Level
PD	Project Director
pH	Potential of Hydrogen
PPFC	People's Pearl and Fishery Corporation, MAF
PPM	Part(s) per Million
%	Percent
PSD	Planning and Statistics Department
SD	Survey Department, MAF
SLRD	Settlements and Land Records Department, MAF
TC	Timber Corporation, MAF
TEM	Township Extension Manager
TSP	Triple Super Phosphate

UCC	University Computer Center
UGCF	Union Government Consolidated Fund
VAHD	Veterinary and Animal Husbandry Department
VTB	Village Tract Banks
WPSD	Working People's Settlement Department

MEASURES

Length

mm	millimeter (s)
cm.	centimeter (s)
m	meter (s)
km	kilometer (s)
inch	25.4 mm
ft	foot (feet) = 12 inch = 30.48 cm
mile	5,280 feet = 1.609 km

Area

sq.cm	square centimeter (s)
sq.m	square meter (s)
sq.km	square kilometer (s) = 100 ha
ac	acre (s) = 4,047 sq.m
sq.mile	square mile = 2.59 sq.km = 640 ac
ha	hectare

Capacity

ℓ	litter
cu.m	cubic meter
MCM	Million Cubic Meter
cu.ft	cubic foot (feet) = 28.32 ℓ
cu.yd	cubic yard = 0.765 cu.m
AF	Acre Foot (feet) = 1,233.48 cu.m
Qt	Quart = 1/4 gl = 1.136 ℓ (UK) = 0.946 ℓ (US)
gl	gallon = 4.543 ℓ (UK) = 3.785 ℓ (US)

Note: UK: British Measure
US: US Measure

Weight

g	gram (s)
kg	kilogram (s)
ton	metric ton
oz	ounce = 28.4 g
lb	Pound = 16 oz = 0.454 kg

Others

cm/sec	centimeter per second
m/sec	meter per second
km/sec	kilometer per second
mile /hr	mile per hour= 1.609 km/hr = 0.447 m/sec
ft/second	feet per second
cu.m/sec	cubic meter per second
cfs/cu.sec	cubic foot (feet) per second = 0.0283 cu.m/sec
gl/sec	gallon per second = 4.543 ℓ/sec = 0.0757 ℓ/min

Glossaries

lakh	100,000
crore	10,000,000
viss	1.633 kg
Pyi	2,127 kg
basket	20.9 kg (paddy)
basket	34.0 kg (rice)
bag	75.6 kg (rice)
Chaung	River or Stream
Kyat	Unit of Local Currency (about 30 Japanese Yen)
In	Lake or Swamp area
Yoma	Mountain range
1 US$	6.44 kyats

SUMMARY

In Burma, the Survey Area has been advantageous to other areas in many points for agricultural development such as meteorological conditions, land and human resources, etc.

Under the favourable conditions, the Integrated Agricultural Development aiming at production increase in the Survey Area should be implemented by expansion of areas sown which will be accomplished by converting the traditional rainfed farming to irrigated and modernized farming together with introducing double cropping, and by yield increase which will be secured by applying the advanced farming techniques.

The development strategy of the irrigation projects involved in this Project can be roughly classified into three; a development by gravity irrigation system on the left bank of the Irrawaddy River, a development by reservoir or pumping irrigation on the right bank of the Irrawaddy River, and a development by pumping irrigation in the Delta area.

The development programme of the Okkan, Tonze, Thegon and Kadinbilin areas on the left bank is provisionally called the West Pegu Yoma Reservoir Irrigation Project (Phase I). The Wegyi and Taunyo Reservoir Irrigation Project, which a higher priority is given to, should be implemented preferentially. Therefore, the basic study including preparation of topographical maps should be conducted as urgent matter for these proposed Project Areas.

Raising the local farming techniques of extension workers and farmers is indispensable for successful irrigated agricutlure. In order to meet such requirements, Pilot Land Consolidation Projects should be accomplished prior to implementation of the other irrigation projects so that they can learn the advanced farming practices from the said pilot farms.

I. HYDROLOGICAL AND METEOROLOGICAL DATA

I-1. Collection and Review of the Existing Data Available

The plan formulation of the water resources development indispensably requires the long-term observation data on hydrology. Some of the important hydrological and meteorological data and other records collected for the plan formulation are tabulated as follows:

Data	Source	Remarks
Daily Rainfall (19 gauging stations)	ID, MHD	Refer to III-1.
Daily Run-off Discharge (14 gauging station)	ID, MHD	Refer to IV-1.
Water Level Record on the Irrawaddy River (2 gauging stations)	ID, MHD	1960-1977 at Prome & Henzada
Water Level Records on the Myitmaka River (4 gauging stations)	ID, MHD	1968-1978 at Gamon 1972-1978 at Dawai 1970-1978 at Kunayaik 1974-1978 at Myaungtaunga
Tidal Fluctuation Records (Rangoon River)	Burmese Navy	1972, 1974, 1976
Monthly Mean Meteorological Data (3 gauging stations)	ID, MHD	Prome, Henzada & Tharrawaddy
Cross-section of the Irrawaddy River (2 survey points)	MHD	Prome & Henzada
Rating	ID, MHD	Prome

I-2. Installation of Measuring Equipment

Reviewing the existing data available has revealed that there is no data prepared on the water level and discharge for the tributaries on the right bank of the Irrawaddy River and some data lacking were found on water level and discharge of the main stream and tributaries of the Myitmaka River.

Under the situation, the automatic water level gauges have been installed at the locations shown in Figure D-1-1, on the Kaukper River, the Patshin River and the Mamya River on the right bank of the Irrawaddy River, so as to supply the necessary data for the future study. Also for the Myitmáka River, the automatic water level gauges have been installed at Tabingon and Pogaung.

Furthermore, the automatic water level gauges have been installed in addition to the existing staff gauges on the Okkan River flowing in the southern part of the Survey Area and on the South Nawin River for the basin of which the feasibility study has been undertaken under the technical cooperation of the Japanese Government.

All of the above automatic gauges have been installed in the manner illustrated in Figure D-1-3 as Pogaung gauging station instead of the Burmese conversional South Nawin gauging station (Fig. D-1-2) by wooden bridges which have tended to be destroyed by driftwood in floodings.

In the Survey Area, there have been no rainfall gauging stations provided in the mountain areas, while the total 19 stations existing, all of which are located in the plain areas. In due to consideration of the future development programme, several rain gauge stations have been so established in the mountain areas as to meet the requirements for planning the dam construction as a component of the comprehensive development of the Area. (Refer to Fig. D-1-1 and Appendix D-1).

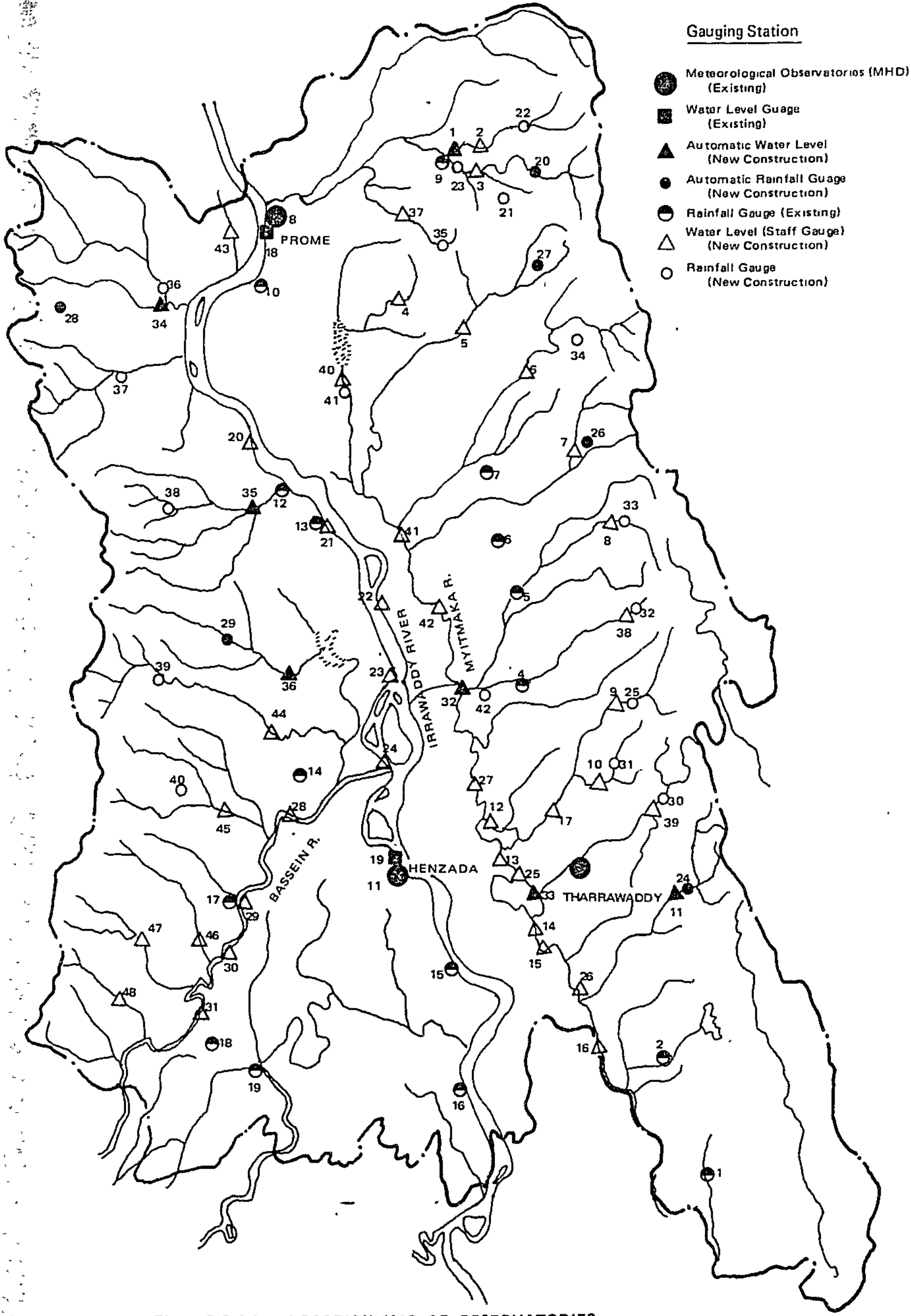


FIGURE D-1-1 LOCATION MAP OF OBSERVATORIES

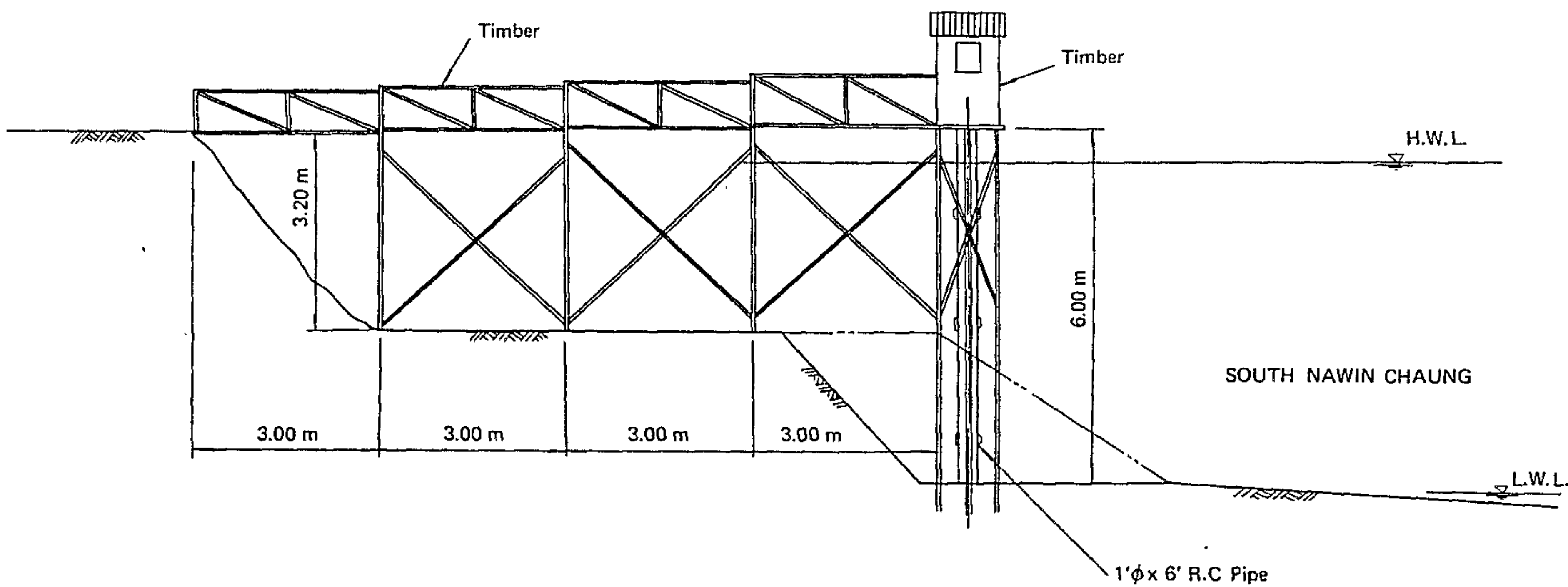


FIGURE D-1-2 AUTOMATIC WATER LEVEL GAUGING STATION (SOUTH NAWIN SITE)

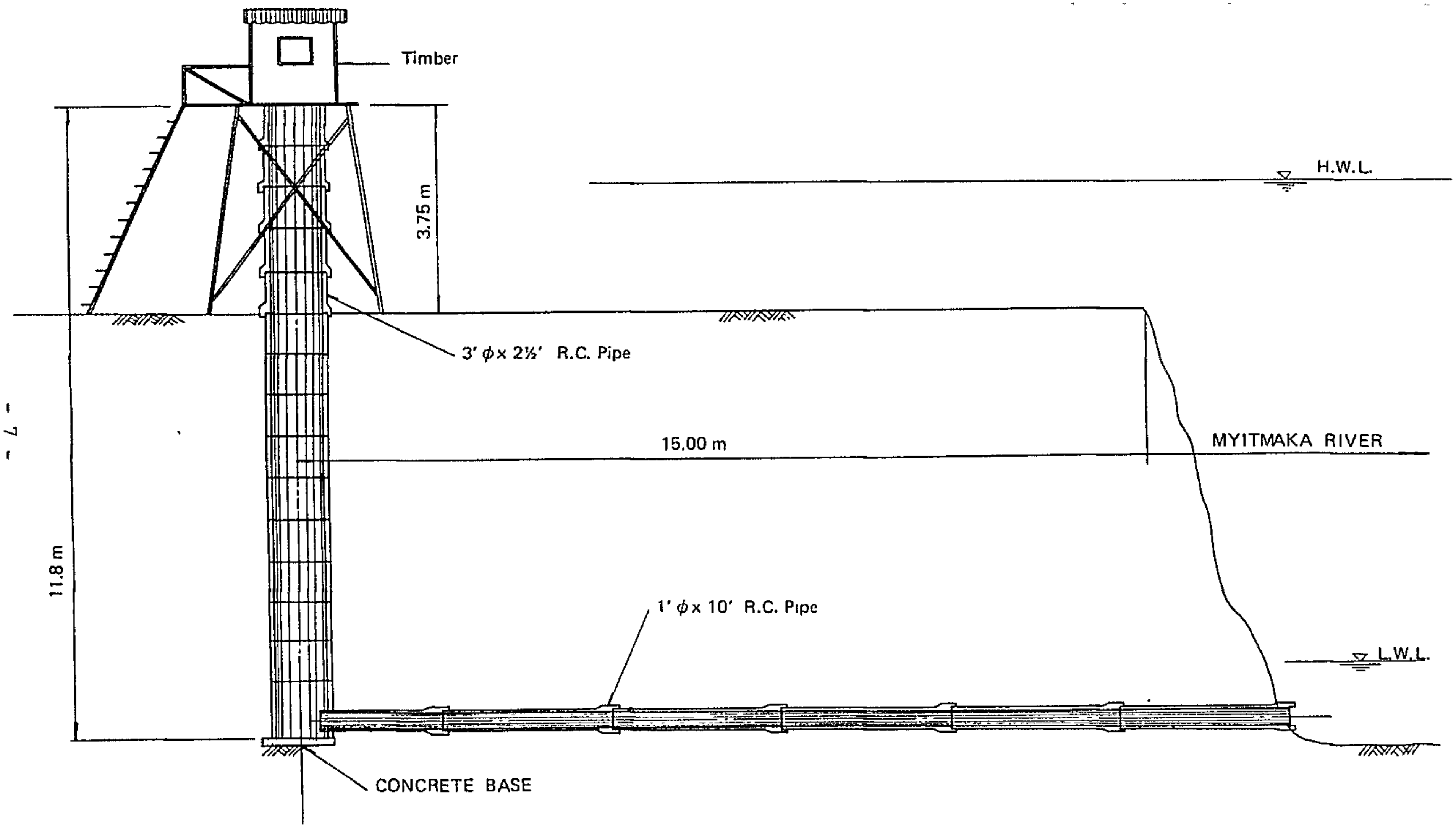


FIGURE D-1-3 AUTOMATIC WATER LEVEL GAUGING STATION (POGAUNG SITE)

II. PRESENT CONDITIONS

II-1. Climate in Burma/*

The country land of Burma extends long from south to north between 9°8'NL and 28°30'NL, bordering Thailand at the Kula Isthmus on the south and China on the north. (Refer to Key Map).

The climate of Burma is affected by monsoon, because the country, having a similar climatic condition to those countries in the Southeast Asia, laid in the tropical monsoon zone.

The climate of Burma can be specified into three as follows similar to the climate in Thailand, the neighboring country.

a) Dry season (Winter season) ---------- The cool season with little rainfall (End of October to February)

b) Dry season (Summer season) ---------- The hot season with little rainfall (March to early May)

c) The rainy season (May to October)

The south-westerly monsoon bring the rainfalls to the country from the Ocean. On the other hand, the north-easterly monsoon blows from the continent in its dry season. It is natural that the wind directions of these monsoons should vary from a place to another by local topographical condition. (Refer to Fig. D-2-1 and Fig. D-2-2).

The north-easterly or north monsoon in the winter season is the extremely dry wind blowing from the continent, while the south-westerly monsoon is the fully humid and warm wind blowing from the southern Indian Ocean. The south-westerly monsoon brings much rainfall to the areas along the seashore and the mountain slopes against the wind

/* -- Refer to H. Hatakeyama, "The Climate of Asia", Climate of the World, Volume, 1964.

direction. Especially, the western mountain-side of the Arakan Yoma and the Tenasserim Division in the southeast of the country are the most wet areas where the monthly rainfall totals over 1,000 mm (about 40 inches) of July. Whereas the central part of the country, around Mandalay is the so-called Dry-zone where the average monthly rainfall in July does not exceed 100 mm (about four inches). This is because the south-westerly monsoon is affected by the topographical conditions, in other words, the humid wind is blocked in blowing up to the inland areas by the Arakan Yoma ranging in the west of the country.

On the other hand, in the winter season when the north-easterly wind blows, the country has very little rainfall in every area, and there is an extremely large fluctuation in rainfall between the dry season and the rainy season. Hence, the distribution of annual rainfall accords with that in the rainy season.

Some areas along the seashore in the west of the country or west sides of the mountain slopes have the heaviest annual rainfall that exceeds 5,000 mm (about 200 inches), while the areas in the central plain have the annual mean rainfall less than 1,000 mm (about 40 inches), suffering from drought in the dry year. (Refer to Figs. D-2-3 ~ D-2-5 and Appendix D-2).

There is no correlationship observed between temperature and latitude, and the northern inland areas have recorded higher temperature than the southern areas in the summer season. The temperature in Mandalay increases to 37°-38°C on an average maximum in April and May before the rainy season starts. (In Mandalay, the maximum temperature was recorded by 43.9°C in May).

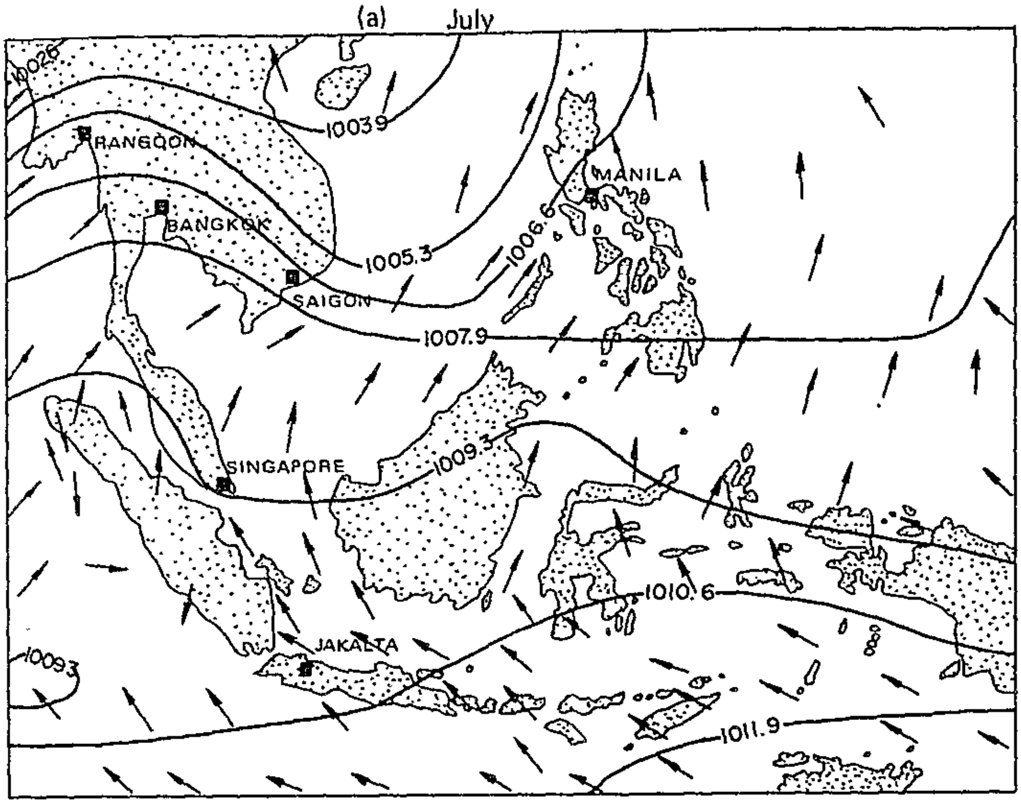
In Bhamo in the northern part of Burma, the temperature drops to around 3°C in January, while rising up to 41.1°C recorded in the hottest month of May. Therefore, the temperature difference through the year grows larger, as the location is deeper into the inland area. (Refer to Figs. D-2-4 and D-2-5, and Table D-2-1).

The wind velocity is recorded very low throughout the country because of the geographical condition that most of the country lands extend between the Arakan Yoma and the India-China mountain ranges, except for Akyab area where there is sometimes a strong south-westerly wind blowing from the Bay of Bengal. (Refer to Fig. D-2-6).

The annual mean humidity is more than 75 percent almost throughout the country, except the dry zone, especially exceeding 85 percent in the rainy season.

In the Indian Ocean, the tropical low atmospheric depressions, the cyclone, takes place, and high frequency in their occurrence is recorded in a period between September and December.

(a) July



(b) January

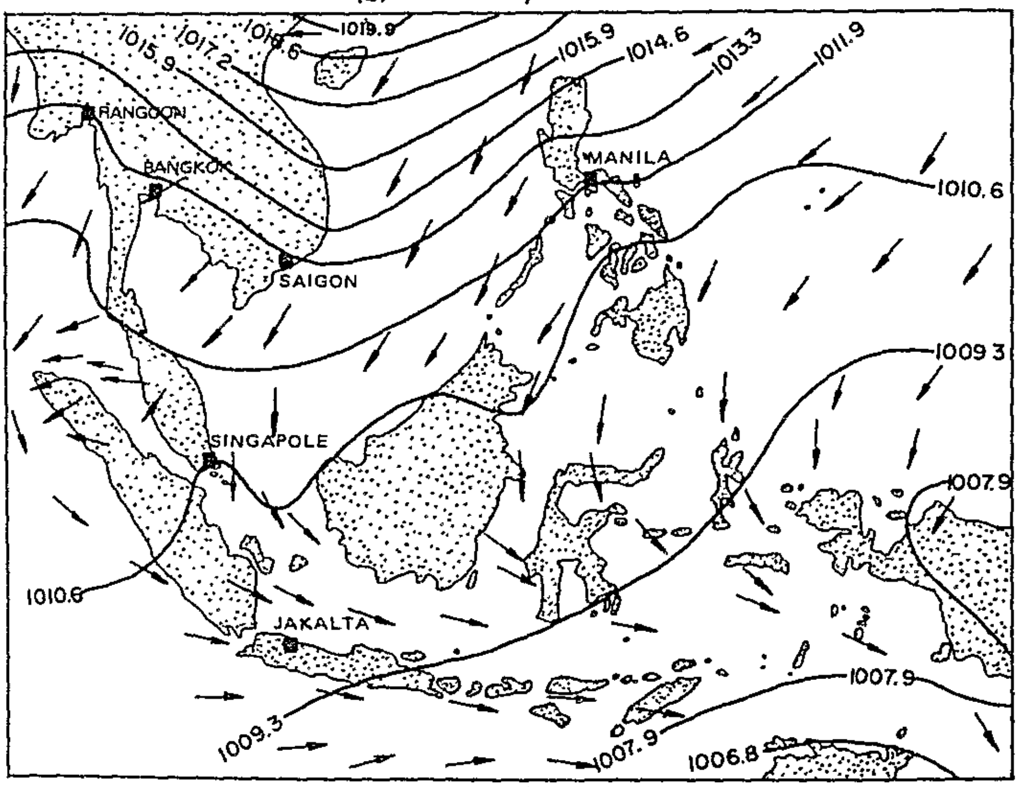


FIGURE D-2-1 ISOBARIC LINES AND WIND DIRECTION OVER SOUTHEAST ASIA

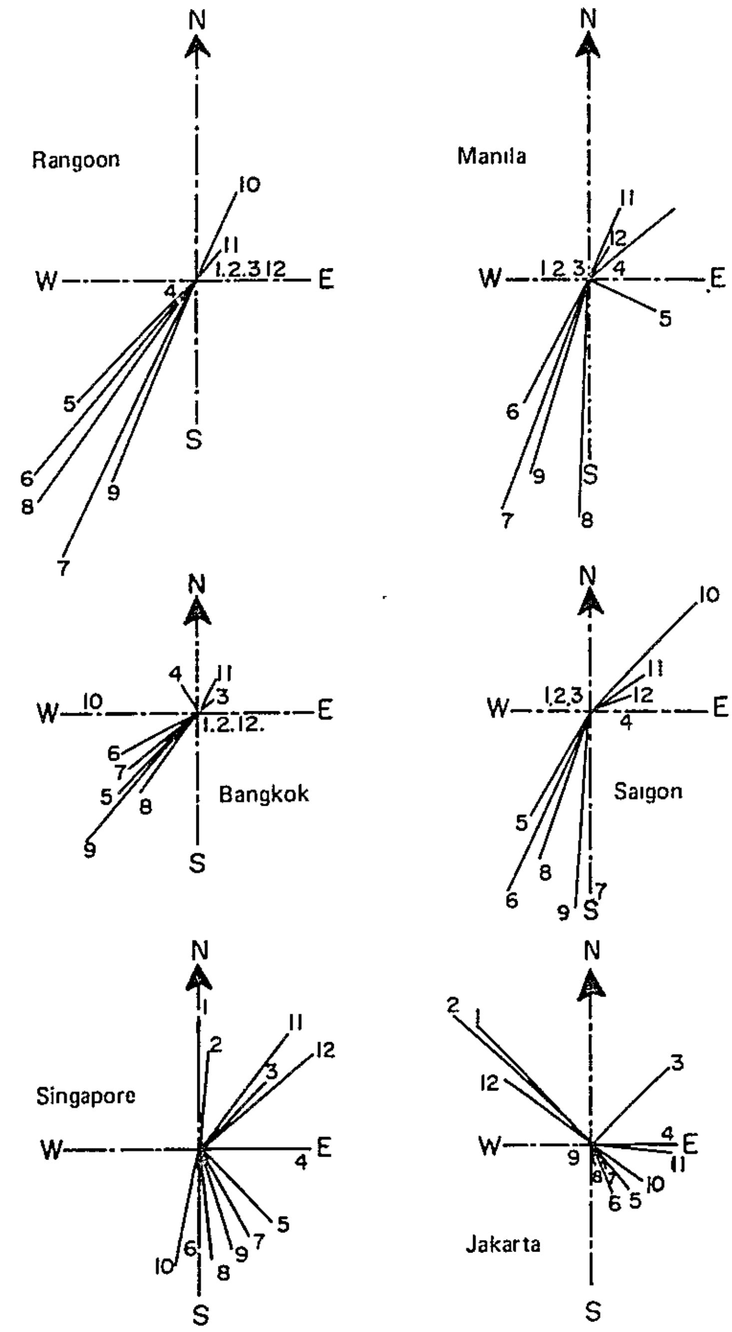


FIGURE D-2-2 CORRELATION OF MONTHLY MEAN RAINFALL AND WIND DIRECTION OVER SOUTHEAST ASIA

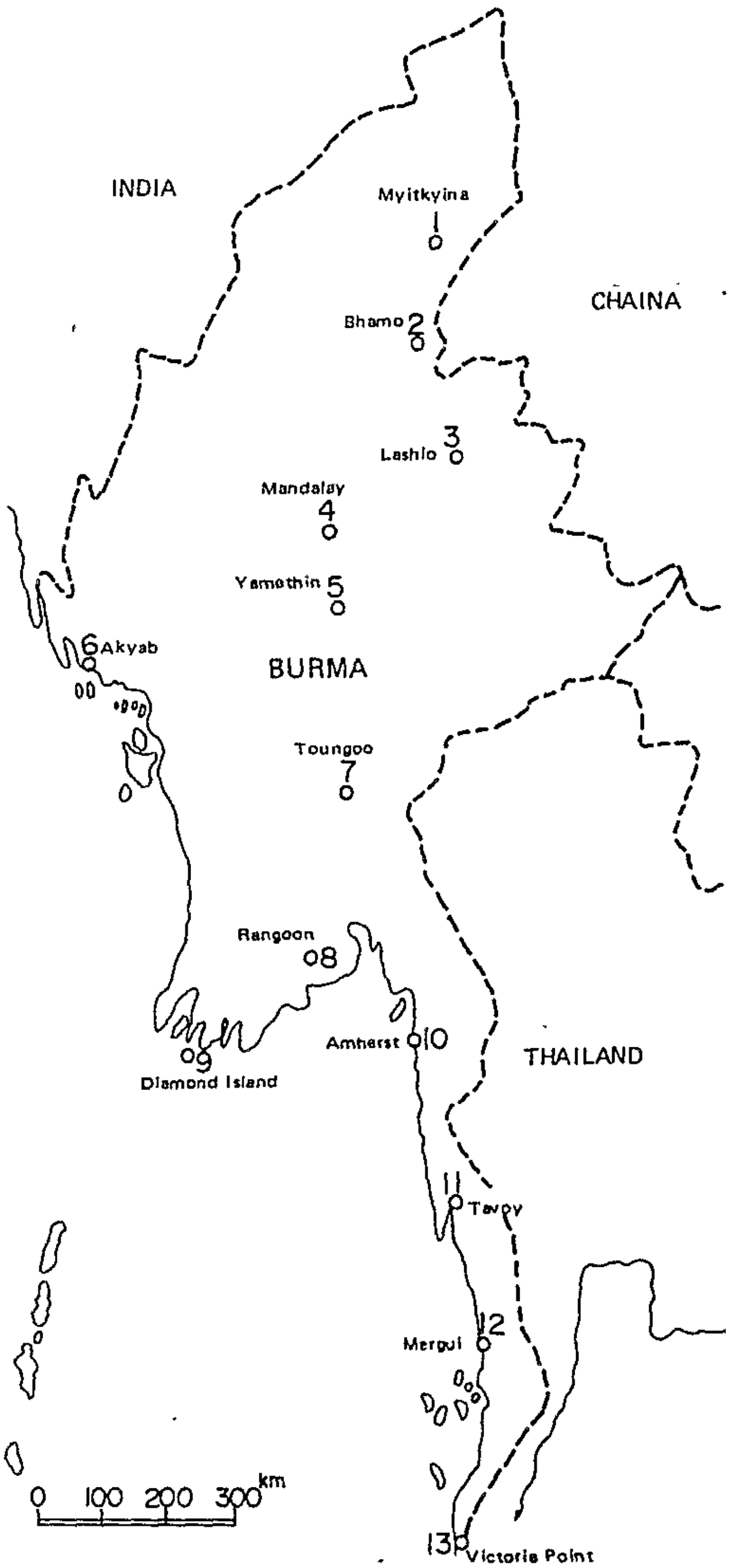


FIGURE D-2-3 LOCATION OF MAJOR METEOROLOGICAL OBSERVATORIES

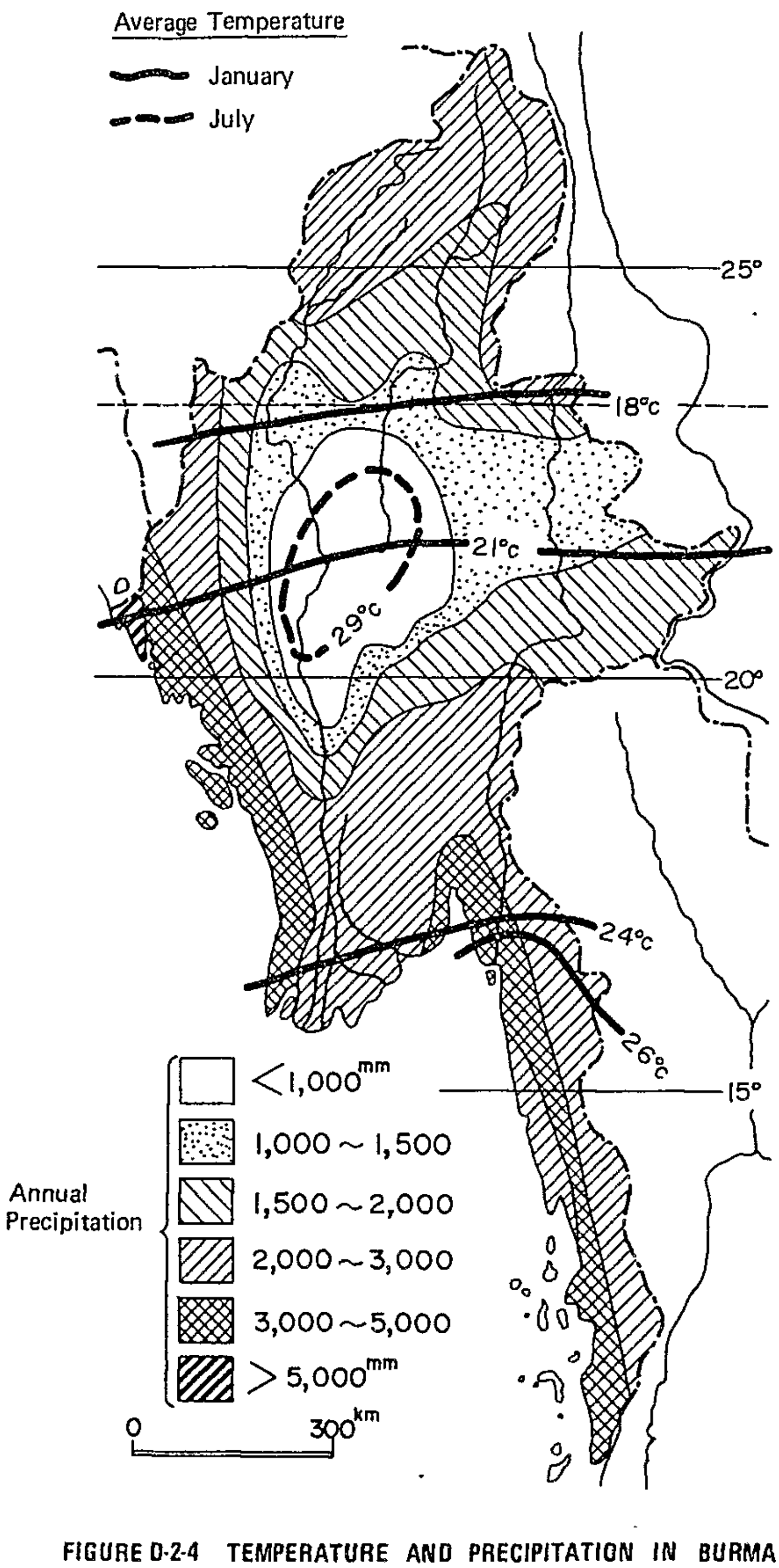


FIGURE D-2-4 TEMPERATURE AND PRECIPITATION IN BURMA

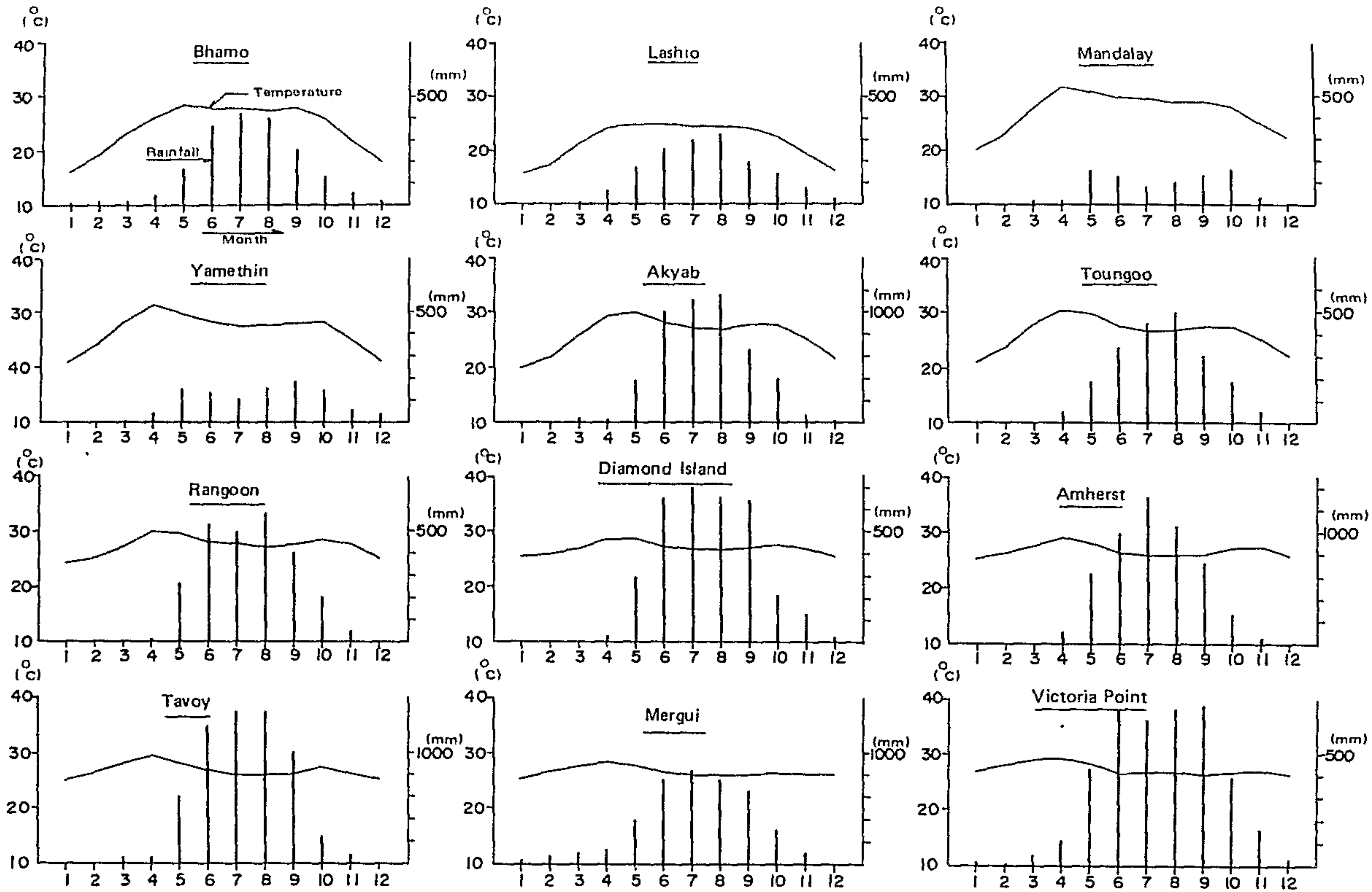


FIGURE D-2-5 MONTHLY MEAN TEMPERATURE AND PRECIPITATION IN BURMA

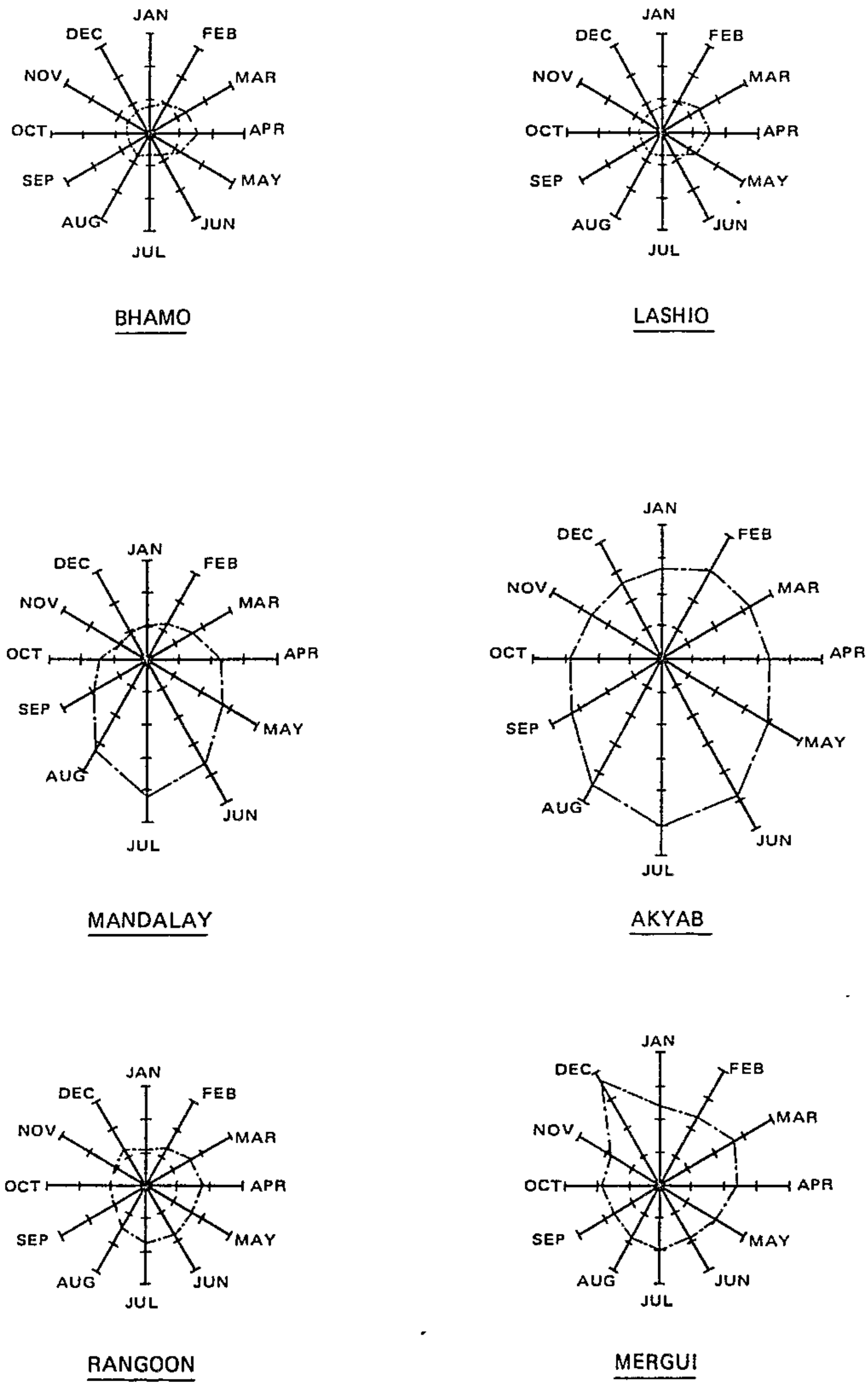


FIGURE D-2-6 MONTHLY MEAN WIND VELOCITY IN BURMA

TABLE D-2-1. CLIMATIC CONDITIONS IN BURMA

Station	Latitude	Elevation (m)	A.M.T[1/] (°C)	Max.T[2/] (°C)	Min.T[3/] (°C)	Humidity[4/] (%)	Rainfall[5/] (mm)
1. Myitkyina	25°23'N	145	-	-	-	-	-
2. Bhamo	24 16	118	24.2	41.1	2.8	81	1857
3. Lashio	22 58	854	21.7	37.2	1.6	77	1574
4. Mandalay	21 59	76	27.1	43.9	6.6	67	776
5. Yamethin	20 25	199	26.6	-	-	-	996
6. Akyab	20 08	5	25.9	37.8	8.3	80	4778
7. Toungoo	18 55	48	26.3	-	-	-	2106
8. Rangoon	16 46	23	27.3	41.1	12.8	74	2530
9. Diamond Island	15 51	12	26.9	36.6	16.1	78	3117
10. Amherst	16 05	22	26.7	35.5	12.2	76	5156
11. Tovoy	14 07	6	26.7	37.7	8.9	84	5886
12. Mergui	12 26	20	26.4	37.2	11.6	80	4123
13. Victoria Point	9 58	47	27.2	-	-	81	3964

Note : Above figures are observed from 10 to 60 years.

1/ A.M.T : Annual Mean Temperature
2/ Max.T : Maximum Temperature
3/ Min.T : Minimum Temperature
4/ Humidity: Annual Mean Humidity
5/ Rainfall: Annual Mean Rainfall
\- : No data

II-2. The Survey Area

The Survey Area of about 2.9 million hectares is located north west of Rangoon within a range from 16°55'NL to 19°10'NL and 94°40'EL to 96°20'EL. The borders of the Survey Area at the east and the west are the watershed of the hilly Pegu Yoma at some 600 m elevation and the watershed of the Arakan Yoma at some 1,200 m elevation, respectively.

Since the Survey Area is bordered by the townships' boundary, the administrative unit in Burma, some parts of the eastern border line of the Survey Area do not accord with the watershed of the Pegu Yoma, and a small portion of the Sittang River basin is included in the Survey Area. (Refer to General Map and Fig. D-2-9).

The Irrawaddy River flowing through the Survey Area from north to south has about five kilometer width (three mile width) measured at its widest portion in the Survey Area. However, there is no bridge existing to cross over the River in or around the Survey Area.

Only the means of transportation available in linking the left and the right banks of the River are ferry boats and absence of means of man-transportation is a bottleneck for smooth flow of passengers and goods.

The north boundary of the Survey Area accords with the administrative boundary of the Prome township and the south boundary is those of the Kyonpyow and the Danubyu townships.

For convenience sake, the country is divided into two, the Upper Burma and the Lower Burma, and the north boundary of the Survey Area almost accords with the boundary between the above two divisions, the Upper and the Lower Burma. In the southern part, a part of the northern Irrawaddy Delta Area is included in the Survey Area.

On the right bank of the Irrawaddy River, the hilly areas and plateau between the opposite site to Prome and Kyangin extend very closely to the River side; thereby there will be little possibility to be damaged by flooding in most of the areas. Because the plain areas extending on the left bank of the Irrawaddy River is elevated lower than those on the right bank, flooding have damaged the area sometimes even Prome township.

The downstream area from Henzada on the right bank is the vast delta formed by the Irrawaddy River. The elevation of the area around Henzada is about 12 m (40 ft) on an average. The southern part of the said area has been somestimes damaged by floodings in the rainy season.

In the upperstream part of the Delta, there have been the embankment provided along the Irrawaddy and Bassein Rivers, which was constructed in the British administration, so that the floodings from the Irrawaddy River can be controlled to some extent.

The Survey Area topographically inclines very gently at the slope of 1/10,000 from north toward south. The inclination in east-west direction in the plain areas is also very gentle ranging from 1/5,000 to 1/10,000 toward the Myitmaka River. In these flat areas, about one million hectare except some flooded areas, are used as rainfed paddy fields in the rainy season.

The Pegu Yoma, hilly mountains, has elevated ranging from 500 to 700 m (1,700-2,000 ft.), functioning as the watershed of the Myitmaka River basin and the Sittang River basin. The Pegu Yoma origin tributaries of the Irrawaddy River and the Myitmaka River have a very gentle river bed slope and their valleys have been well-developed. Thereby, it is expected that reservoirs with large capacity can be constructed only with small dam height to be provided if any suitable site are found out.

The major municipalities in the Survey Area are Prome and Henzada. Prome is located about 250 km northwest of Rangoon, the capital of Burma and at the extreme north in the Survey Area. The transportation facilities available between Prome and Rangoon are the national highway and the national railway.

Henzada, located in the extremely northern part of the Irrawaddy Delta, is a central municipality in the southern part of the Survey Area. Henzada, however, has no direct railway and road linking with Rangoon because it is situated on the right bank of the Irrawaddy River. The above railway from Rangoon are available only up to Tharrowaw on the opposite side (left bank) to Henzada, and further transportation depends upon the ferry boats. As direct means of transportation available between Rangoon and Henzada are navigation through rivers and creeks.

II-3. Topography

Topographically speaking, the Survey Area is roughly specified into two, the hilly areas and the plain areas.

The hilly areas extend to the mountains of the Arakan and the Pegu Yomas, and the plain areas are the lands developing along the Irrawaddy River and the Myitmaka River, including a part of the Irrawaddy Delta. The cross-section of the Survey Area at northern Irrawaddy Delta. The cross-section of the Survey Area at Monyo is illustrated in the following figure (Figure D-2-7).

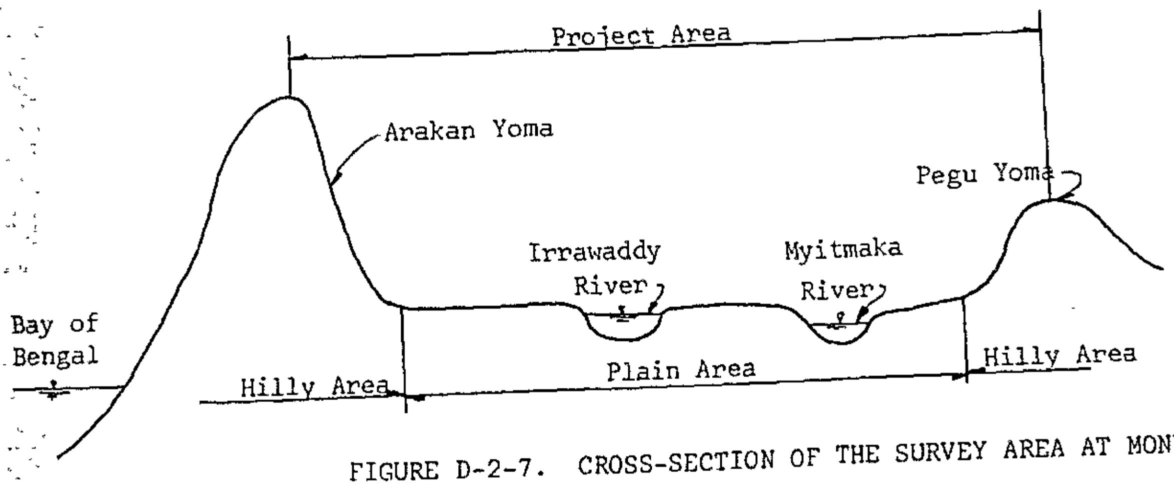


FIGURE D-2-7. CROSS-SECTION OF THE SURVEY AREA AT MONYO

The Arakan Yoma, which is considerably steep mountain range with some 1,200 m (about 4,000 ft) elevation, is the watershed of the Irrawaddy River basin and the basin of the rivers pouring into the Bay of Bengal.

The Arakan Yoma, although having many suitable dam sites, will not be expected to provide reservoirs with a large capacity so easily because the river bed slope in the Arakan Yoma is steeper than that in the Pegu Yoma.

II-4. Climate

The Survey Area is under the tropical climate, being affected by monsoon. There are three seasons in a year, the rainy season, the winter season and the summer season. (Refer to II-1).

The rainy season lasts from the middle of May to the middle of October and most of the rainfall in a year takes place in this season. The annual mean rainfall is about 1,300 mm (about 50 inches) recorded at Prome in the northern part of the Survey Area, while about 2,600 mm (about 100 inches) recorded in Kyonpvaw in the southern part of the Survey Area. Much more rainfall takes place in the southern part of the Project Area than in the northern part.

The rainfall put the northern limit of the rainfed paddy cropping on the Prome area, and the Survey Area is considered as the most suitable area for paddy cropping in the country in terms of rainfall.

The winter season lasts about three months from October, the past rainy season, to January in the following year. The monthly mean minimum temperature in these months is about 16°C and the lowest temperature in a year has been recorded in this season; while the temperature becomes minimum in this season throughout the year. The relative humidity also becomes lowest in a year and is measured by about 40 percent in Prome. The winter season is most comfortable to live in.

The summer season, the hottest season of the year, lasts about three months from February to April. The monthly mean maximum temperature has been recorded by 40°C in Prome and 38°C in Henzada, respectively. When the monsoon comes, the summer season is over and the rainy season starts. (Refer to Figure D-2-8).

Several typhoons occurring in the South China Sea or Pacific Ocean reach the country in a period from July to October in a year. However, the typhoons, weakened in force by crossing over the Indon-China Peninsula, have little damaged the country.

The cyclone, originating in the Ocean, have rarely come to the Survey Area.

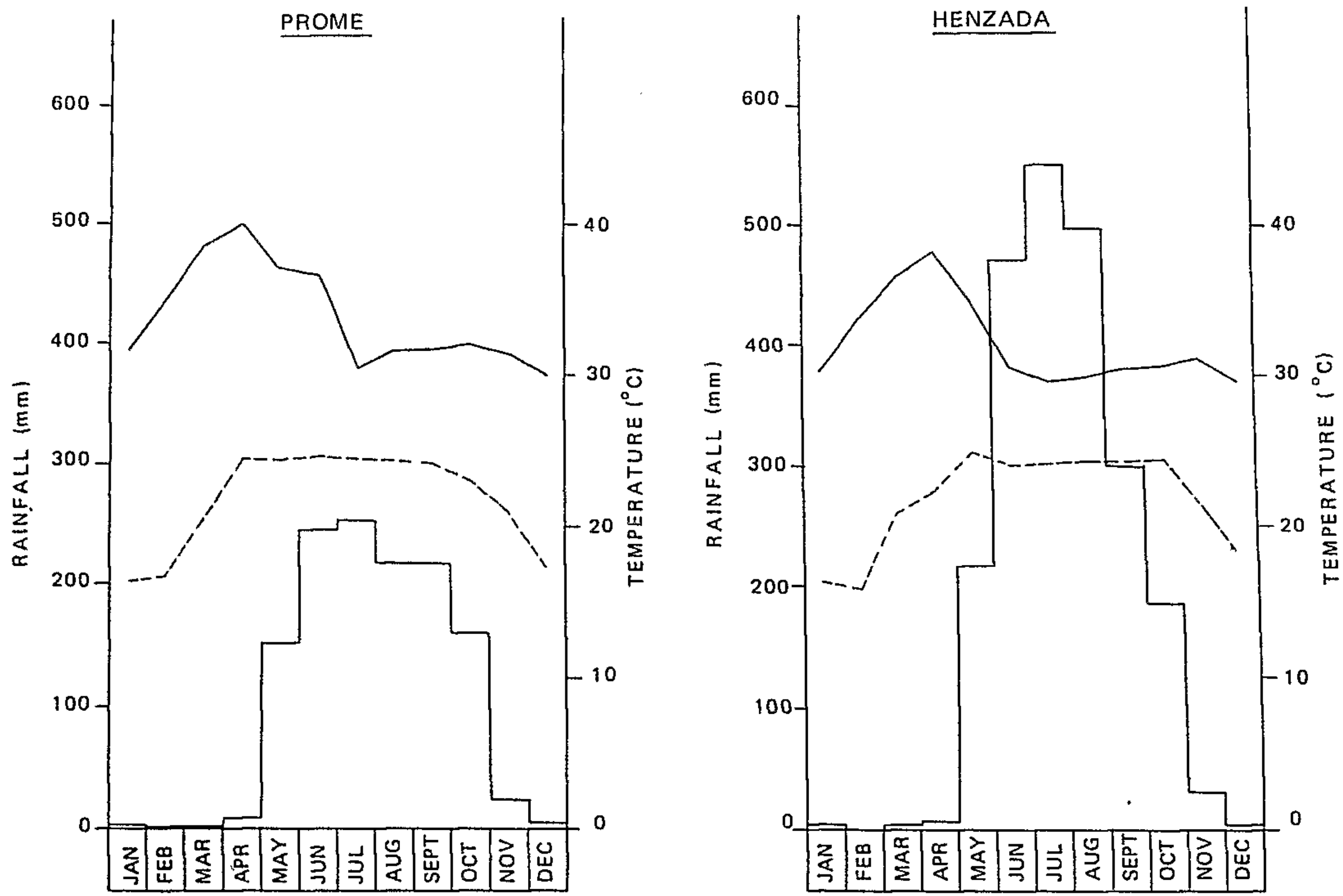


FIGURE D-2-8 RAINFALL AND TEMPERATURE AT PROME AND HENZADA

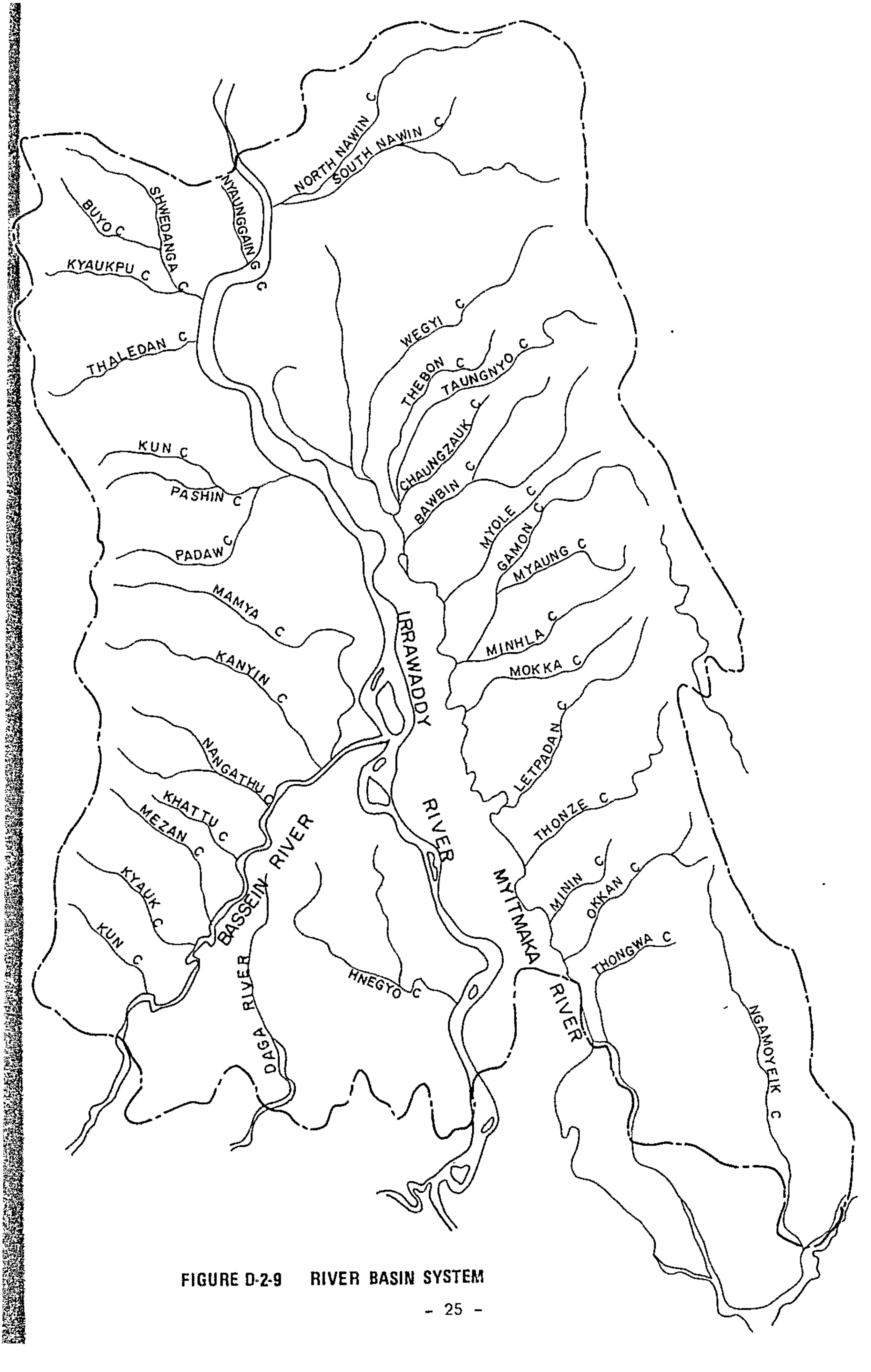


FIGURE D-2-9 RIVER BASIN SYSTEM

II-5. Present Conditions of the Area

The total area of the Survey Area amounts to about 2.9 million hectares, about 40 percent of which, about 1.18 million hectares (2.91 million acres) is existing areas sown. The remaining 60 percent, about 1.71 million hectares are forest lands, waste lands and lands used for other purposes.

The cultivable waste lands occupying about eight percent of the Survey Area, about 240 thousand hectares (about 600 thousand acres), are mostly the lands have been given up in cultivation. These lands have sporadically located in the Survey Area. Approximately 85 percent of the existing cultivated area, about one million hectares (2.47 million acres) are the rainfed paddy fields. (Refer to Table D-2-2).

The Kaing-lands and swampy area extend to strips along the Irrawaddy River, the Myitmaka River and the Bassein River. In Kaing-lands, the upland crops such as groundnut are grown on the river-transporting fertile soils in the dry season, although no cultivation is carried out in the rainy season due to floodings over the lands.

The swampy area are submerged by floodings in the rainy season and uncultivable even in the dry season due to chronical floodings or long-standing water. These uncultivable swampy area are utilized for inland fisheries.

These uncultivable lands have suffered from ill-drainage even in the dry season when the water level of the major drainage river of the areas, such as the Irrawaddy, the Myitmaka, the Bassein, etc. is reduced by about 10 meters as compared with that in the rainy season. Such ill-drainage would be caused from the facts that the elevation of these lands is very low and the terminal drainage facilities have not been consolidated in the area.

Most of the remaining parts in the Survey Area are paddy fields with some Ya-lands or garden existing sporadically in high-elevated lands.

The peripheral hilly lands and mountainous areas are forest lands. The forest in the hilly lands have been the resources of firewood used as fuel by farmers. However, no reforestation after taking firewood from the forests has heavily deteriorated the vegetation only with bamboo, bushes and weeds growing in the recent years. The forest vegetation in the deep mountains has been reserved well as compared with that in the hilly forest lands because of its location remoted from the villages. But as the shortage in supply of fuel firewood has become more serious, the villagers' tree-cutting has been encroaching the deep mountain forests.

The forests in the Pegu Yoma have been more quickly deteriorated than those in the Arakan Yoma. This has resulted from the facts that the villagers can easily access to the hilly Pegu Yoma for getting firewood and the slash-and-burn farming has been frequently carried out there.

The acreage sown per farmer in the Area is about 2.01 ha (about 4.97 acres) which is slightly smaller than the national average of 2.19 ha (about 5.4 acres).

TABLE D-2-2 PRESENT LAND USE (1976/77)

Description	Area (x 100 ha)	Percentage of Grand Total (%)	Percentage of Cultivated Area (%)
Cultivated area			
Paddy	10,001	34.6	85.0
Ya-land	122	0.4	1.0
Kaing-land	874	3.0	7.4
Garden	717	2.5	6.1
Dani	14	0.0	0.1
Shifting	46	0.2	0.4
Total	11,774	40.7	100.0
Reserved forest	9,203	31.9	
Unreserved forest	1,121	3.9	
Culturable waste	2,424	8.4	
Unculturable land	4,353	15.1	
Grand Total	28,875	100.0	

Note: Cultivated area includes area cultivated within reserved forest area and demarcated grazing lands.

Source: Settlement and Land Records Department.

II-6. River Conditions

The Survey Area, in terms of river basin, can be divided into three, the Irrawaddy River basin, and its two branch river basins, namely, the Bassein and the Myitmaka.

The right bank area of the Irrawaddy River belongs to the basins of the Irrawaddy River and the Bassein River, with 11 tributaries flowing from west to east. The left bank area belongs to the Myitmaka River basin except the area covered by the Nawin chaung flowing into the Irrawaddy River. (Refer to Figure D-2-9).

The Irrawaddy River, which flows down through the Survey Area, is one of the largest rivers in Burma (Irrawaddy, Sittang and Salween), having the total catchment area of 430 thousand square kilometers. (This figure is 1.15 times as large as 370 thousand square kilometers of the whole country-land of Japan.)

The Irrawaddy River, originating in the great Tibetan mountain range in China, flows into Burma territory at the Kachin State, and then runs through almost the central part of the country from the extreme north to the south to empty itself in the Andaman Sea. The total length of the Irrawaddy reaches about 2,090 km.

The Irrawaddy River, branching off the Bassein River in the Survey Area, pours into the Andaman Sea after running down intersecting the southern part of the Irrawaddy Delta like cobwebs.

The Irrawaddy river, having the Bassein river only as draining branch in the Survey Area rises high in the water level in the rainy season, and the water level fluctuation is about 10 m between the dry season and the rainy season.

However, at the lower part of the Irrawaddy Delta, the water level of the Irrawaddy River does not fluctuate so large as in the Survey Area because so many rivers and waterways branched-off from the main stream of the Irrawaddy control the flood discharge in the rainy season, and the inundation depth in the area measures about 30 cm due to the tidal effect. The tidal range of the Irrawaddy River can not be determined due to lack of adequate observation records of the water level, although the tidal part of the River is said to reach up to Zalun located south of Henzada.

The average flood discharge of the Irrawaddy River which was observed at Prome, is about 35,500 cu.m/sec and the peak discharge, reaching 50,000-60,000 cu.m/sec, takes place in August and September. The maximum flood discharge recorded is 63,800 cu.m/sec in 1974. There are no data available for the discharge in the downstream from Prome because heavy shifting of the River course has prevented the regular observation from being practised.

On the right bank of the Irrawaddy River, there have been river dikes, constructed under the British Administration in the downstream parts from Kyangin to avoid flood from the Irrawaddy River.

On the left bank, there had been the river dikes provided as well but they were sometimes broken by flooding and an inadequate maintenance since then has resulted in only very few traces observed.

The collapse of the left bank embankments are considered to have caused by the fact that the said embankment were constructed 0.3-0.6 m lower than the right bank embankments so as to protect Henzada, the major municipality in the area concerned, from being flooded. In 1974, however, the large-scale flood with about 50-year probability collapsed the right bank embankments at Myanaung and Henzada and damaged the area.

The Myitmaka River flows through the eastern part of the Survey Area in parallel with the Irrawaddy River. The Myitmaka, originating in the Pegu Yoma, flows down about 390 km including the most downstream part called the Rangoon river. The said river is specified into two portions in terms of its characteristic features, the upstream portion from the confluence of the Thenet chaung and the downstream thereof.

The former portion, having average width of 20-50 m, is a natural river running about 240 km in meandering heavily. In the rainy season, run-off discharge from its own catchment area and overflow from the Irrawaddy at northern part of the Monyo township have raised the water level of the river to cause the flooded areas in strip in the low-lying hinterland along the Myitmaka River. The relevant area totals 206,000 ha (about 509 thousand acres) with estimated flood volume of 4,120 MCM and the maximum flood depth is estimated at one to five meters (about three to fifteen ft.). There are many swampy areas existing even in the dry season due to absence of proper drainage system in this low-lying hinterland.

For the latter, the flood water from the Irrawaddy has flown into its downstream portion through the Thenet river. The river width at this portion measures 200-500 m, having the similar river conditions to the upstream portion. The tidal compartment reaches around Thaikkyi township. There are about 119,000 ha (about 294 thousand acres of inundation areas existing in this area as well.

The water level of the Myitmaka River, affected by change of that of the Irrawaddy River, has its peak in August and September and its annual change can be graphed in trapezoidal with gentle slope.

The Bassein River, which branches-off at Henzada from the Irrawaddy River and one of the branches of the Irrawaddy River, flows towards south-west through the southern part of the Survey Area, and runs about 350 km in total (about 220 km of the length runs within the Survey Area). The River forms the northern boundary of the Irrawaddy Delta, and branches off at Bassein so many rivers and waterways intersecting the Delta lands like cobwebs to pour into the Andaman Sea.

The Bassein River is the natural river with width ranging from 200 to 500 m. There are embankments constructed along the left bank, downstream portion from Henzada, but no embankments provided on the right bank. The swampy area of about 50,000 ha (about 124 thousand acres) is formed around Henzada. The annual water level change has a similar tendency to that of the Irrawaddy River. The tidal compartment reaches up to around Lemythena township. (Refer to Annex E Hydraulic Analysis and Reclamation.)

There are 26 branches or tributaries of the Rivers mentioned previously running in the Survey Area, all of which are the natural river with the water course shifting to a considerable extent. They are running dry in April and May in the dry season, and their discharges becomes largest after concentrative rainfall in the rainy season.

The general tendency of water level change of these rivers is almost the same as those of the rivers in Japan in showing the upward curve for several hours and the downward curve within a day or so. There have been few weirs and other facilities on these rivers for diverting the water.

II-7. Groundwater

The foundation of the Survey Area is composed of shales and sand stones of the Tertiary stratum which are covered with the Quaternary deposits. The shales and sand stones are the impervious foundation and the Quaternary layers form an aquifer. The aquifer consists of chiefly coarse particle layers with silt and loam layers lying in between, but in the upper part of the layers the clay contents increase in quantity. Both of permeability coefficient and storage coefficient are small.

The groundwater table in the Survey Area has a considerably large seasonal fluctuation in rising closely to the ground surface in the rainy season and lowering some 10 m below the ground surface in the dry season.

The domestic water supply almost depends upon the shallow wells, but the water in these wells is liable to dry up in the dry season. There exist no areas systematically irrigated by groundwater in the Survey Area.

The present groundwater conditions studied as above revealed that there would be little possibility to use the groundwater resources for large-scale agricultural developments in the Survey Area as compared with the possibility by surface water resources.

II-8. Present Water Use

The irrigation project currently executed in Burma are generally classified into three, the projects implemented on the force account basis by the Irrigation Department, on the community basis by villages and on the small-scale basis in pumping irrigation by the Agricultural Mechanization Department. The total beneficial area was estimated at 950,000 ha, which occupies about nine percent of the total acreage sown in the country. (Refer to Table D-2-3).

The projects on the force account basis are defined as those projects the total construction cost exceeds one million Kyat (US$154,000). Up to date, 31 projects (covering about 413,000 ha) have already been completed in this way. (Refer to Table D-2-4). Most of these projects provide fill-type dams and diversion dams as main facilities.

Almost all of canals provided are earth canals and the canal density was estimated at 8 m/ha, which is too small to carry out successful irrigation.

The on-going irrigation projects account to three and cover about 93,000 ha of beneficial area. Five projects are now under contemplation and to cover the beneficial area of about 156,000 ha in total. (Refer to Tables D-2-5 and D-2-6.)

Thirty-eight village irrigation works in two divisions, concerned Pegu and Irrawaddy, have already been completed and their beneficial area covers about 21,000 ha in total, and 33 of 38 works located in the Survey Area, covering about 19,000 ha of the beneficial area. (Refer to Table D-2-7). The village irrigation works are designed and implemented by ID, but 30 percent of the cost required should be borne by the townships concerned and farmers. (Refer to Appendix D-3).

The small-scale pump irrigation projects have been executed by AMD since 1970. In the projects, the AMD has sold portable pumps with 5-6 Hp to the cooperative societies or individual farmers. The projects aimed at irrigating the fields for jute and cotton croppings.

On top of the above, there have been many water tanks and weirs for irrigation existing in the country, but the detailed study has not been made due to absence of the data available. These facilities are utilized not only for irrigation but for supply of the domestic use water in the dry season. However, some of these facilities have been time-worn and functioning insufficiently.

The irrigation method carried out in the country is flooding irrigation for paddy fields and furrow irrigation for upland fields.

The water management has been carried out by the way that the assistant engineers, who control the farmers' requirements given through gate keepers and canal inspectors, give instructions on gate operation to gate keepers. (Refer to Fig. D-2-10).

The water charges have been collected as a part of the land tax paid by farmers concerned. The average amount of water charges is K 4-5/acre, but K 10-12/acre have been collected from the beneficial farmers in the newly completed project areas.

TABLE D-2-3 IRRIGATION AREA

(Unit: '000 ha)

Major Facility	1975/76 National Level		1975/76 Project Area		1976/77 National Level (1)		1976/77 Project Area (2)		(2)/(1) (%)
Canals	631.5	(64)	20.9	(46)	626.9	(66)	20.2	(51)	3
Tanks	105.6	(11)	2.2	(5)	88.8	(10)	2.2	(6)	2
Wells	12.4	(1)	0.6	(1)	11.9	(1)	0.9	(2)	8
Pumps	103.0	(11)	17.6	(39)	94.4	(10)	13.6	(35)	14
Wind mills	0.7	(0)	-	(-)	0.5	(0)	-	(-)	-
Others	129.4	(13)	3.8	(9)	126.5	(13)	2.4	(6)	2
Total	982.6	(100%)	45.1	(100%)	949.0	(100%)	39.3	(100%)	4

Source: Project Area --- Township office

TABLE D-2-4 MAJOR IRRIGATION PROEJCT IN BURMA

Project	Location	Irrigable Area (ha)	Consturction Period	Major Facilities: Dam	Weir	Pump	Canals (km): Main	Secondary
Pyugan Tank	Mandalay Div.	1,550	1961-62	1	-	-	6.2	2.7
Meiktila Lake	-ditto-	18,420	Burmese King age*	1	-	-	1.0	36.1
Mondaing Tank	-ditto-	2,750	1962-67	1	-	-	-	-
Alongsithu Tank	-ditto-	4,630	1957-58	1	-	-	-	7.4
Taungpulu Tank	-ditto-	3,050	1954-55	1	-	-	0.6	-
Thitson Tank	-ditto-	8,580	1959-62	1	-	-	22.3	29.4
Kyetmauktaung T.	-ditto-	11,910	1961-68	1	-	-	30.4	117.8
Pyaungbya Tank	-ditto	2,340	1965-70	1	-	-	20.8	8.0
Khetlan Tank	-ditto-	2,800	1967-73	1	-	-	24.6	4.2
Heho Tank	Shan State	2,000	1962-65	1	-	-	16.7	10.3
Ngwedaung T.	Kayah State	2,730	1964-65	1	-	-	14.0	10.6
Yezin Tank	Mandalay	6,400	1966-76	1	-	-	9.5	93.4
Washawng	Kachin	6,980	1962-67	-	1	-	19.5	71.3
Shwebo	Sagaing	91,930	1901-07	-	1	-	112.6	543.1
Ye-U	-ditto-	51,560	1911-19	-	1	-	101.9	308.0
Mandalay	Mandalay	42,360	Burmese King age	-	1	-	108.3	212.5
Htonbo Sedaw	-ditto-	1,080	Burmese King age	-	1	-	5.4	11.5

(Cont'd)

Note: * 1892 English Government repaired.

Project	Location	Irrigable Area (ha)	Construction Period	Major Facilities				
				Dam	Weir	Pump	Canals (km) Main	Canals (km) Secondary
Panlaung	-ditto-	34,770	Burmese King age*	-	1	-	110.9	232.7
Zawgyi	-ditto-	38,650	Burmese King age	-	1	-	160.0	226.4
Trans-Samon	-ditto-	1,200	1958-59	-	1	-	ND	ND
Sameikkon	Mandalay Div.	600	1966-65	-	-	1	3.3	3.2
Letpan Chibaw	-ditto-	400	1965-66	-	-	1	6.2	-
Mezali	Magwe Div.	38,710	Burmese King age*	-	1	-	86.1	270.0
Aingma	-ditto-	10,200	Burmese King age**	-	1	-	32.8	70.6
Salin	-ditto-	11,370	Burmese King age**	-	1	-	60.2	57.3
South Man	-ditto	4,780	1965-70	-	1	-	32.0	27.4
Yinmale	-ditto-	2,480	1963-64	-	1	-	2.6	-
Kinmundaung	-ditto-	4,000	1959-60	-	1	-	2.1	-
Intein	Shan State	1,520	1963-64	-	1	-	9.6	-
Phailon	-ditto-	2,000	1965-68	-	1	-	19.2	-
Nymyang	-ditto-	1,200	1964-67	-	1	-	4.8	-
TOTAL		412,950					1,023.6	2,353.9

Note: * 1912 English Government repaired.
** 1926 - ditto -
ND: Non-Detail Data

TABLE D-2-5 IRRIGATION PROJECT UNDER CONSTRUCTION

Name	Location	Irrigable Area (ha)	Construction Period	Major Facilities: Dam	Weir	Canals (Km): Main	Secondary
Chaung Ma Gyi Dam	Pyawbwe	3,710		1	1	19.7	35.5
North Nawin	Prome	38,700	- 1981	1	-	72.0	445.0
Sedaweyi	Mandalay	50,800		1	1*	113.6	1,518.4
Total		93,210				205.3	1,998.9

Note: * Existing
Source: Irrigation Dept.

TABLE D-2-6 PROPOSED IRRIGATION PROJECT
(Under the 3rd 4 years Development Plan)

Name	Location (Township)	Irrigable Area (ha)	Major Facilities: Dam	Weir	Pump	Canals (Km): Main	Secondary
Mobye Irri.	Loikan	7,980	1*	-	-	58.9	132.5
Pump Irr.	Monywa+4	21,900	-	-	1	**	**
Pyinmana	Pyinmana	8,080	1	1	-	19.5	204.8
South Nawin***	Paukkaung	32,000	1	-	-	**	**
Nyaunggyat***	Myittha	86,000	2	-	-	197.6	944.4
Total		155,960					

Note: * Existing Dam ** Under detail investigation and design
*** The feasibility study of this project will be started within FY 1978
Source: Irrigation Dept.

TABLE D-2-7 VILLAGE IRRIGATION WORKS IN THE SURVEY AREA

Division/Township	No. of Project	Irrigable Area (ha)
I. Pegu Division		
Prome	6	3,262
Paukkaung	4	1,715
Shwedaung	7	4,050
Paungde	6	4,052
Thegon	8	5,776
Padaung	6	2,153
Sub-total	37	21,008
II. Irrawaddy Division		
Myanaung	1	266
Total	38	21,274

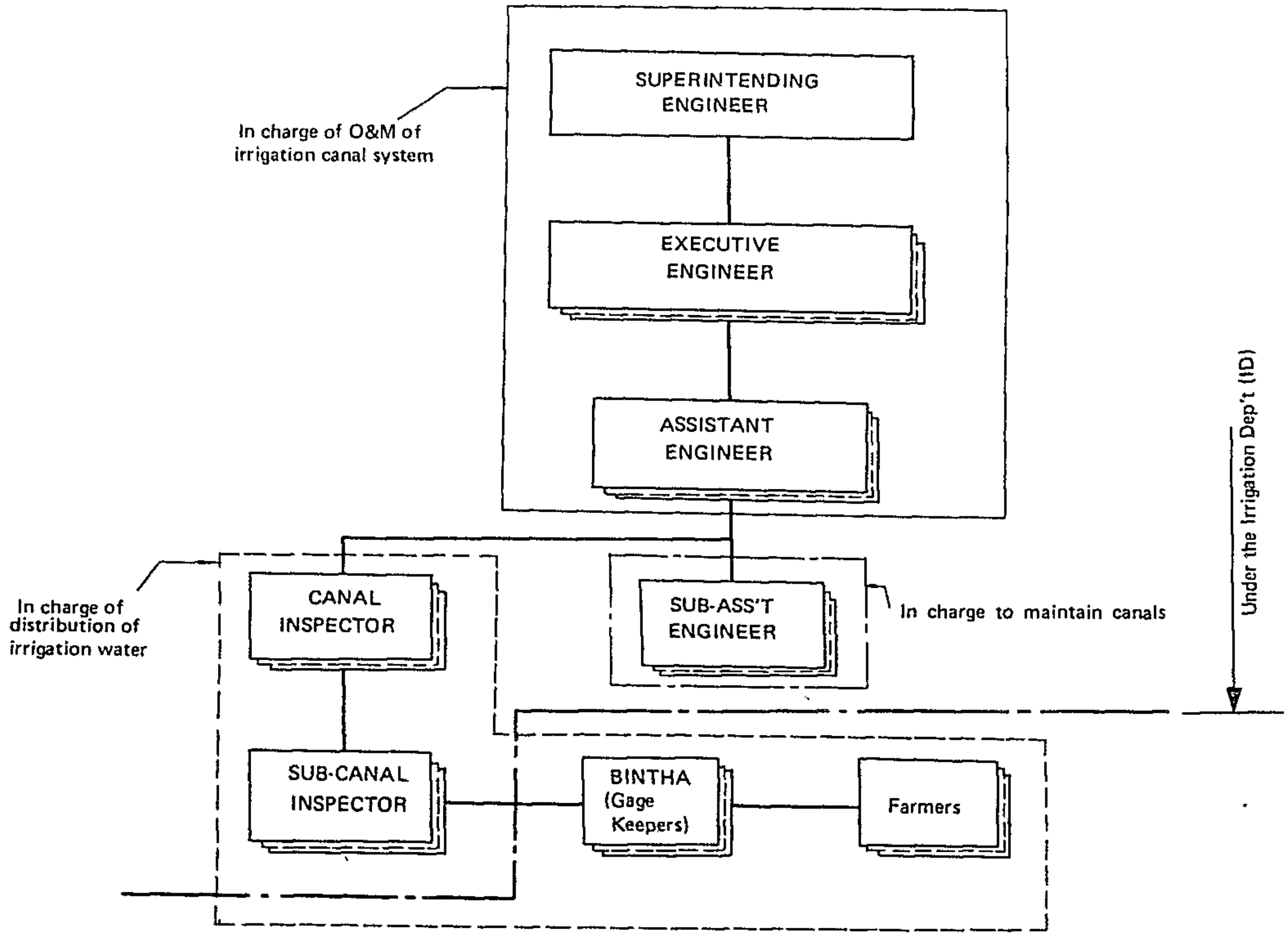


FIGURE D-2-10 ORGANIZATION CHART OF OPERATION AND MAINTENANCE FOR IRRIGATION SYSTEM

III. METEOROLOGY

III-1. Rainfall

1) Gauging Station

There have total of 19 rainfall gauging stations located in the Survey Area, 10 of which are on the left bank of the Irrawaddy River and 9 of which are on the right bank. All of the measuring devices provided with these stations are not automatic rain gauges but those for measuring the daily rainfall.

The Irrigation Department (ID) established four rainfall gauging stations in the South Nawin chaung basin about four years ago in order to prepare the rainfall data for the South Nawin Irrigation Project. Furthermore, the Master Plan Study Team has established another 23 stations in the Survey Area under the cooperation of the Colombo Plan experts dispatched by the Japanese Government and the Burmese officials concerned so as to start observation from the 1979 rainy season. The six important gauging stations out of the newly established 23 stations have provided the automatic recording devices. These new stations have strengthened the observation activities in the Survey Area by increasing the density of gauging networks from 152,000 sq. km/station to 68,000 sq. km/station in the Area, and all of these stations are expected to supply necessary data by their permanent observation. (Refer to Fig. D-1-1).

Among the existing stations, three stations at Prome, Tharrawaddy and Henzada are the observatories belonging to the Meteorological and Hydrological Department (MHD) and keeping considerably long-term records which have high reliability. Other 16 stations have been keeping the observation records for the respective periods as shown in Fig. D-3-1. However, there have been many data lacking found for long-term observations.

2) Rainfall

The nine-years' basis moving average of annual rainfalls observed at Rangoon for the past 108 years suggest that there is a tendency to run into the drought period in terms of long-range observation as shown in Fig. D-3-2. It is considered that the drought period would return at 100-120 years interval. In the medium-range, the drought period and the wet period return at 15-years interval, and in the short-range, the return period is considered to be 3-4 years.

The secular change of the rainfall is so heavy that every gauging station has observed the fluctuation ranges from 70 percent to 140 percent against the respective average rainfall. Such heavy secular change in rainfalls have caused frequent drought damages or flood damages to agriculture and prevented agriculture in the Area from stable farm management. (Refer to Table D-3-1).

The annual mean rainfall is recorded less in the northern part of the Survey Area than in the southern part, and that observed at Prome located extremely north in the Survey Area is 1,276 mm, while that observed at Kyonpyaw located extremely south is 2,649 mm which is almost double of that at Prome. (Refer to Table D-3-2 and Fig. D-3-3).

The monthly rainfall distribution at every station can be classified into two patterns. A pattern has the month which has a maximum amount of over 500 mm (about 20 inches) rainfall in July. Annual rainfall of these stations is more than about 2,000 mm (about 80 inches). These stations are located in the southern part of the Survey Area. Other pattern has no particular month such as above mentioned. Annual rainfall of these stations are less than about 1,500 mm (about 60 inches). (Refer to Fig. D-3-4).

About 85 percent of the total annual rainfalls generally takes place for five months from June to October.

The monthly basis rainfall distribution in the most wet areas and the less wet areas is illustrated in the following Table D-3-3 and Fig. D-3-4(a).

TABLE D-3-3 RAINFALL DISTRIBUTION

(Unit: %)

Month	Most Wet Areas	Less Wet Areas	Month	Most Wet Areas	Less Wet Areas
Jan.	0.2	0.2	Jul.	24.4	19.4
Feb.	0	0	Aug.	22.1	18.3
Mar.	0.1	0.1	Sept.	12.9	15.7
Apr.	0.1	0.8	Oct.	7.6	10.4
May	10.3	11.6	Nov.	1.3	2.1
Jun.	19.8	21.0	Dec.	0.2	0.4
			Total	100.0	100.0

The secular change in monthly rainfalls show the similar heavy change to that of the annual rainfalls. When a small rainfall is recorded in May, the rainfall in October is small as well, and the total annual rainfall tends to decrease in such years; in other words, the rainfall available in May and October largely affect the current rainfed farming. The rainfall in May soaks the soils hardened during the dry season to permit the plowing and harrowing works for nursery to be easily practised, and the rainfall in October serves to supply water to paddy plants in their ripening period. Under the circumstances, the yield of paddy that is a major crop in the Survey Area is liable to largely depending upon the rainfalls in May and October. (Refer to Table D-3-4).

TABLE D-3-1 FLUCTUATION RANGE OF ANNUAL RAINFALL

Station	Annual Mean Rainfall (mm)	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977
Paukkaung	1,165.5	*	*	*	*	*	0.873	*	0.984	1.274	*	0.940	0.789	1.446	*	*	*	*
Prome	1,276.0	1.167	1.057	0.841	1.025	1.163	0.829	0.810	0.697	1.146	1.006	0.887	0.639	1.371	1.235	1.176	1.009	0.970
Shwedaung	1,388.6	1.134	1.273	0.989	0.853	0.997	*	*	*	1.278	1.042	0.764	0.657	1.322	*	0.972	*	0.956
Zigon	1,571.2	1.048	*	1.066	1.162	1.143	0.876	0.894	0.853	1.123	0.933	0.822	1.061	0.849	1.006	0.914	*	*
Gyobingauk	1,352.9	1.431	0.910	*	*	1.059	0.942	*	0.780	1.298	1.083	0.713	0.644	0.894	*	*	1.109	*
Okpo	1,397.9	*	*	*	*	*	*	*	*	*	*	*	*	1.103	1.044	0.958	*	0.804
Minhla	1,840.4	0.951	0.901	0.891	0.963	1.199	1.113	0.832	*	*	1.007	0.926	0.820	1.108	.300	0.985	1.124	*
Tharrawaddy	2,185.7	1.110	0.914	1.179	0.930	1.108	0.922	*	1.099	0.958	0.095	1.007	0.852	1.072	1.177	1.016	0.961	0.906
Taikkyi	2,539.9	*	*	*	*	*	*	*	1.025	1.172	1.261	0.818	1.096	1.010	*	1.110	*	*
Hmawbi	2,561.4	1.210	*	1.028	*	1.102	0.975	0.796	1.053	1.109	1.000	0.959	0.892	1.155	1.131	1.083	1.089	0.832
Kyangin	1,534.7	1.080	*	*	1.379	*	*	0.758	0.915	*	1.038	*	0.785	*	*	*	*	*
Myanaung	1,495.5	0.850	*	*	*	*	*	*	0.863	*	1.049	0.842	*	1.000	*	*	*	0.742
Ingabu	1,968.8	*	*	*	*	*	*	*	*	*	0.854	*	0.928	1.230	*	0.836	*	*
Lemyethna	2,749.1	*	*	*	*	*	*	*	*	1.064	0.989	*	*	*	*	*	*	*
Yegyi	2,528.9	*	*	*	*	*	*	*	*	1.204	0.910	0.935	*	*	*	0.884	*	0.621
Henzada	2,256.8	1.251	0.878	1.112	1.180	*	*	*	1.064	1.077	0.922	1.102	0.826	1.069	0.978	0.990	0.977	0.896
Zalun	2,080.0	1.333	0.987	*	1.173	1.080	*	1.176	1.044	*	0.818	*	0.723	*	*	*	*	*
Kyonpyaw	2,648.7	*	*	*	*	*	0.905	*	1.212	1.188	0.911	*	0.817	*	*	*	*	*
Danubyu	2,223.9	1.089	0.954	0.989	0.980	1.040	1.004	0.996	1.006	1.116	1.015	1.079	0.771	1.149	0.977	1.076	*	*

TABLE D-3-2 ANNUAL AND MONTHLY RAINFALL

(Unit: mm)

No.	Station	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sept.	Oct.	Nov.	Dec.	Total	Observation Period
1	Paukkaung	0.5	0.0	0.9	7.0	142.9	256.3	231.1	233.1	185.6	81.7	26.0	0.4	1165.5	12 years
2	Prome	4.7	1.0	0.7	10.0	149.8	234.0	250.9	218.5	218.9	152.9	26.4	8.2	1276.0	31 years
3	Shwedaung	0.5	0.4	1.4	13.1	156.6	262.1	255.7	239.7	274.7	157.5	20.6	6.3	1388.6	22 years
4	Zigon	2.0	0.4	1.8	14.8	160.6	358.0	341.3	291.0	211.2	150.5	38.8	0.8	1571.2	20 years
5	Gyobingauk	3.9	0.4	0.0	6.8	179.0	263.2	307.6	250.5	203.0	118.0	13.4	7.1	1352.9	19 years
6	Okpo	1.3	0.0	4.3	1.7	211.6	216.0	278.4	294.8	216.6	128.1	40.4	4.7	1397.9	6 years
7	Minhla	7.3	0.5	0.7	15.7	174.3	362.8	432.9	421.5	243.5	156.2	22.2	2.8	1840.4	19 years
8	Tharrawaddy	8.3	0.5	3.3	13.3	196.3	443.5	511.4	466.6	308.8	187.6	34.6	11.5	2185.7	31 years
9	Taikkyi	1.8	1.0	5.0	18.9	242.0	523.4	606.8	551.7	355.3	193.0	28.6	12.4	2539.9	21 years
10	Hmawbi	5.5	4.1	8.4	15.2	302.6	478.7	561.2	567.1	391.9	186.9	28.3	11.5	2561.4	24 years
11	Kyangin	6.7	1.5	2.7	15.8	163.8	337.9	284.1	257.7	239.2	194.7	21.5	9.1	1534.7	23 years
12	Myanaung	4.1	0.0	0.5	16.7	189.4	323.2	289.1	271.8	244.5	135.7	15.8	4.7	1495.5	23 years
13	Ingabu	8.7	0.0	7.7	14.4	176.9	402.9	531.8	381.1	281.6	142.8	20.6	0.3	1968.8	12 years
14	Lemyethna	4.8	0.0	0.0	57.7	243.0	545.3	725.1	668.2	315.8	177.7	11.1	0.4	2749.1	6 years
15	Yegyi	0.0	0.0	4.3	7.2	340.7	519.5	617.0	563.2	254.5	200.5	17.7	4.3	2528.9	7 years
16	Henzada	5.2	0.0	5.0	8.8	208.4	466.4	541.4	495.4	306.5	185.1	29.9	4.6	2256.8	30 years
17	Zalun	2.0	0.0	1.5	20.6	184.1	446.4	512.0	440.9	317.1	135.8	17.4	2.2	2080.0	17 years
18	Kyonpyaw	0.9	0.0	0.0	74.4	277.6	469.9	689.4	597.6	309.2	159.3	69.6	0.8	2648.7	5 years
19	Danubyu	3.0	1.1	3.9	18.0	218.6	449.8	495.9	492.5	331.6	172.4	25.9	11.2	2223.9	28 years

TABLE D-3-4 CORRELATION COEFFICIENT

Name of Township	Annual Rainfall to					Rainfall of May to				
	Paddy		Acreage of Paddy			Paddy		Acreage of Paddy		
	Yield	Production	Sown	Matured	No Harvest	Yield	Production	Sown	Matured	No Harvest
1. Paukkaung	0.66	0.58	0.48	0.50	-0.56	0.86	0.82	0.76	0.77	-0.82
2. Prome	0.73	0.74	0.71	0.72	-0.67	0.63	0.63	0.57	0.61	-0.60
3. Shwedaung	0.64	0.68	0.64	0.70	-0.66	0.53	0.53	0.59	0.53	-0.35
4. Zigon	-0.13	-0.25	-0.23	-0.25	0.22	-0.24	-0.51	-0.59	-0.56	0.00
5. Gyobingauk	0.80	0.97	0.95	0.96	-0.56	-0.10	0.27	0.53	0.74	-0.65
6. Okpo	-0.77	-0.72	0.57	-0.06	0.28	-0.74	-0.67	-0.00	0.06	-0.06
7. Minhla	0.16	0.22	0.63	0.31	0.64	-0.01	0.15	0.77	0.55	-0.48
8. Tharrawaddy	-0.04	-0.44	-0.12	-0.57	0.60	-0.08	0.11	0.06	0.09	-0.09
9. Taikkyi	-0.33	0.19	0.06	0.48	-0.69	-0.51	-0.46	-0.08	0.11	-0.21
10. Hmawbi	-0.02	0.02	-0.18	0.09	-0.20	0.34	0.35	-0.27	0.27	-0.31
11. Kyangin	*	*	*	*	*	0.99	1.00	0.95	0.95	-0.88
12. Myanaung	0.28	0.91	0.47	0.82	-0.76	0.02	0.66	0.28	0.73	-0.69
13. Ingabu	0.09	-0.09	-0.01	-0.62	-0.57	0.14	-0.06	0.37	-0.59	0.68
14. Yegyi	-0.96	-0.66	-0.02	0.73	-0.96	0.11	-0.27	0.08	-0.40	0.57
15. Henzada	-0.20	-0.06	0.05	-0.23	0.23	0.41	0.37	0.26	0.19	-0.15
16. Zalun	*	*	*	*	*	*	*	*	*	*
17. Kyonpyaw	*	*	*	*	*	*	*	*	*	*
18. Danubyu	0.55	-0.04	-0.78	-0.26	0.14	0.31	-0.40	-0.28	-0.51	0.45

Note: * marks mean no effective result.

TABLE D-3-4 CORRELATION COEFFICIENT (Cont'd)

Name of Township	Rainfall of Oct. to					Rainfall of May+Oct. to				
	Paddy		Acreage of Paddy			Paddy		Acreage of Paddy		
	Yield	Production	Sown	Matured	No Harvest	Yield	Production	Sown	Matured	No Harvest
1. Pakkaung	-0.13	-0.23	-0.25	-0.32	0.55	0.51	0.42	0.33	0.35	-0.41
2. Prome	0.47	0.57	0.57	0.61	-0.59	0.89	0.96	0.90	0.97	-0.95
3. Shwedaung	0.22	0.29	0.41	0.40	-0.33	0.44	0.49	0.59	0.56	-0.42
4. Zigon	0.33	0.67	0.73	0.71	-0.03	0.33	0.57	0.51	0.47	0.30
5. Gyobingauk	0.58	0.56	-0.01	0.38	-0.58	0.71	0.89	0.74	0.85	-0.71
6. Okpo	0.46	0.46	0.36	0.23	0.07	-0.69	-0.61	-0.10	0.11	-0.17
7. Minhla	0.16	0.10	0.13	-0.03	0.31	0.31	0.37	0.68	0.41	0.56
8. Tharrawaddy	0.67	0.53	0.35	0.34	-0.29	0.25	0.22	0.15	0.15	-0.14
9. Taikkyi	-0.42	-0.43	-0.50	-0.18	-0.16	-0.50	-0.47	-0.30	-0.03	-0.20
10. Hmawbi	0.01	0.12	-0.02	0.35	-0.07	0.29	0.33	-0.23	0.35	-0.28
11. Kyangin	0.86	0.83	0.81	0.58	0.12	1.00	0.99	0.89	0.90	-0.94
12. Myanaung	-0.06	0.87	-0.15	0.98	-0.92	-0.03	0.81	0.19	0.90	-0.87
13. Ingabu	0.57	0.57	0.17	0.33	-0.15	0.45	0.30	0.36	-0.25	0.41
14. Yegyi	0.78	-0.73	-0.37	-0.18	0.02	-0.43	-0.62	-0.23	-0.35	0.36
15. Henzada	0.17	-0.07	0.14	-0.23	0.25	0.35	0.21	0.24	0.02	0.02
16. Zalun	*	*	*	*	*	*	*	*	*	*
17. Kyonpyaw	*	*	*	*	*	*	*	*	*	*
18. Danubyu	0.64	0.73	-0.81	0.41	0.56	0.73	0.44	-0.88	0.10	-0.27

Note: * marks mean no effective result.

TABLE D-3-4 CORRELATION COEFFICIENT (Cont'd)

Name of Township	Rainfall of Jun. to					Rainfall of Jul. to				
	Paddy		Acreage of Paddy			Paddy		Acreage of Paddy		
	Yield	Production	Sown	Matured	No Harvest	Yield	Production	Sown	Matured	No Harvest
1. Paukkaung	0.38	0.33	0.21	0.29	-0.51	0.01	0.00	0.10	-0.01	0.41
2. Prome	0.21	0.32	0.20	0.36	-0.50	0.46	0.37	0.35	0.15	0.08
3. Shwedaung	0.42	0.52	0.38	0.59	-0.77	0.33	0.22	0.27	0.09	0.17
4. Zigon	-0.89	-0.65	0.49	0.51	-0.23	-0.54	-0.87	-0.68	-0.66	-0.11
5. Gyobingauk	0.16	0.29	0.35	0.35	-0.15	0.58	0.57	0.68	0.29	0.41
6. Okpo	-0.40	-0.31	-0.01	0.35	-0.38	0.38	0.27	-0.55	-0.49	0.18
7. Minhla	-0.37	-0.30	0.26	0.01	0.47	0.16	0.03	-0.27	-0.31	0.04
8. Tharrawaddy	0.34	0.12	0.24	-0.02	0.09	-0.04	-0.51	-0.27	-0.64	0.65
9. Taikkyi	-0.37	-0.29	-0.03	-0.06	0.05	-0.89	-0.86	-0.34	-0.20	-0.00
10. Hmawbi	-0.12	-0.10	0.37	-0.04	0.39	-0.15	-0.16	-0.06	-0.12	-0.04
11. Kyangin	0.23	0.27	0.60	0.38	0.18	-0.12	-0.22	-0.24	-0.50	0.54
12. Myanaung	0.62	0.79	0.24	0.49	-0.39	-0.42	0.40	-0.26	0.68	-0.67
13. Ingabu	0.22	0.01	0.42	-0.60	0.71	-0.51	-0.58	-0.50	-0.46	0.04
14. Yegyi	-0.31	-0.61	0.36	-0.43	0.34	-0.58	-0.74	-0.84	-0.37	0.10
15. Henzada	-0.20	-0.35	-0.14	-0.30	0.28	-0.29	0.25	0.06	-0.12	0.12
16. Zalun	*	*	*	*	*	*	*	*	*	*
17. Kyonpyaw	*	*	*	*	*	*	*	*	*	*
18. Danubyu	0.32	-0.08	-0.37	-0.23	0.15	-0.30	-0.02	0.28	0.11	-0.06

Note: * marks mean no effective results.

TABLE D-3-4 CORRELARION COEFFICIENT (Cont'd)

Name of Township	Rainfall of Nov. to				
	Paddy		Acreage of Paddy		
	Yield	Production	Sown	Matured	No Harvest
1. Pakkaung	-0.78	-0.83	-0.88	-0.85	0.64
2. Prome	-0.19	-0.10	-0.15	-0.05	-0.05
3. Shwedaung	-0.17	-0.10	-0.18	-0.01	-0.22
4. Zigon	0.13	-0.14	-0.53	-0.57	0.39
5. Gyobingauk	0.02	0.04	-0.31	0.06	-0.45
6. Okpo	-0.91	-0.88	-0.31	-0.05	-0.20
7. Minhla	-0.81	-0.85	-0.61	-0.71	0.11
8. Tharrawaddy	-0.48	0.02	-0.33	0.28	-0.38
9. Taikkyi	-0.19	-0.20	-0.58	-0.17	-0.20
10. Hmawbi	-0.69	-0.75	-0.50	-0.68	-0.42
11. Kyangin	-0.81	-0.78	-0.88	-0.56	-0.27
12. Myanaung	-0.60	-0.10	-0.70	0.28	-0.41
13. Ingabu	-0.83	-0.78	0.73	-0.20	-0.29
14. Yegyi	0.61	0.41	-0.32	-0.46	0.27
15. Henzada	-0.73	-0.28	0.07	0.17	-0.26
16. Zalun	⁂	⁂	⁂	⁂	⁂
17. Kyonpyaw	⁂	⁂	⁂	⁂	⁂
18. Danubyu	-0.19	-0.70	0.36	-0.59	0.65

Note: ⁂ marks mean no effective result.

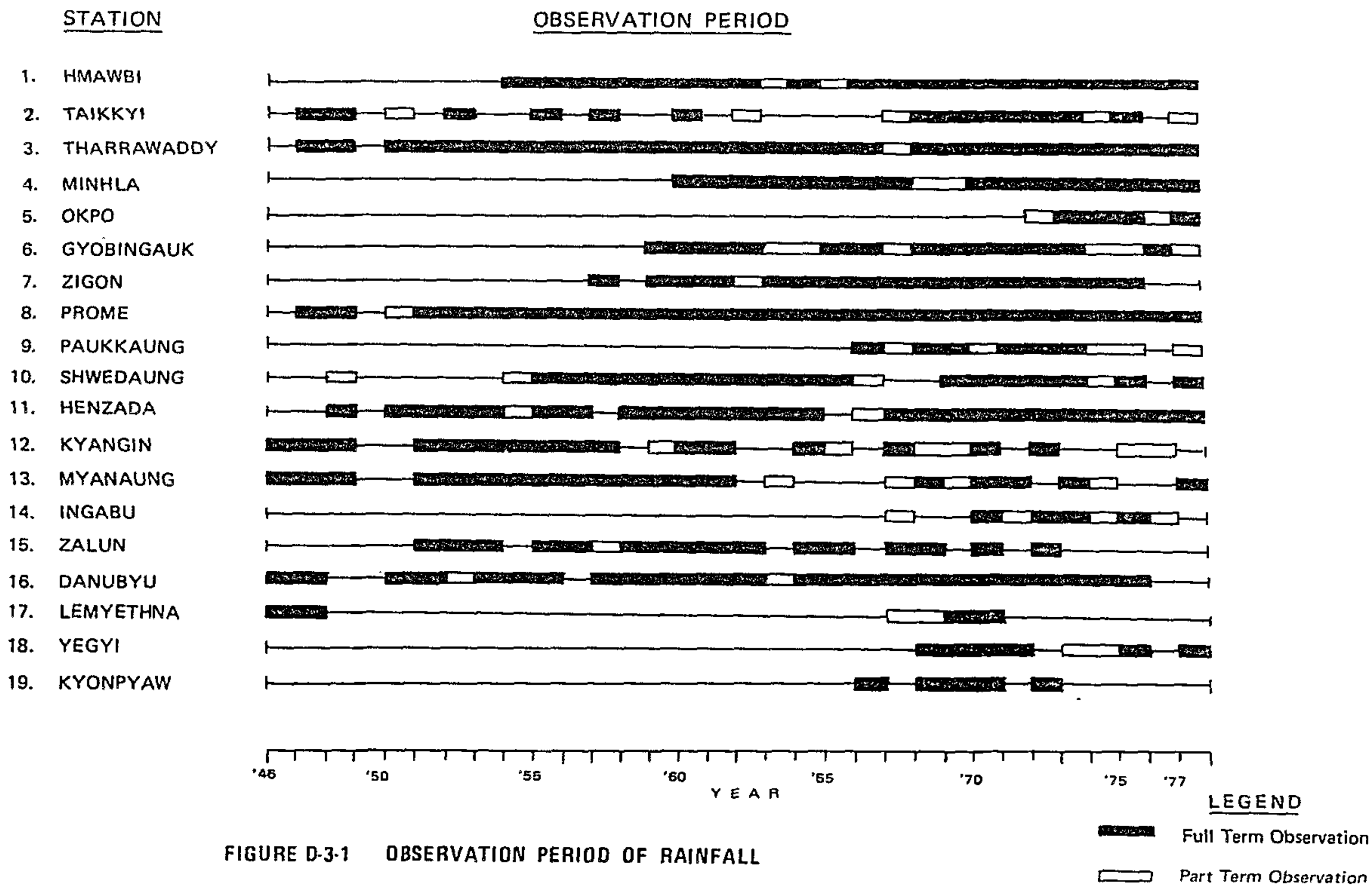


FIGURE D-3-1 OBSERVATION PERIOD OF RAINFALL

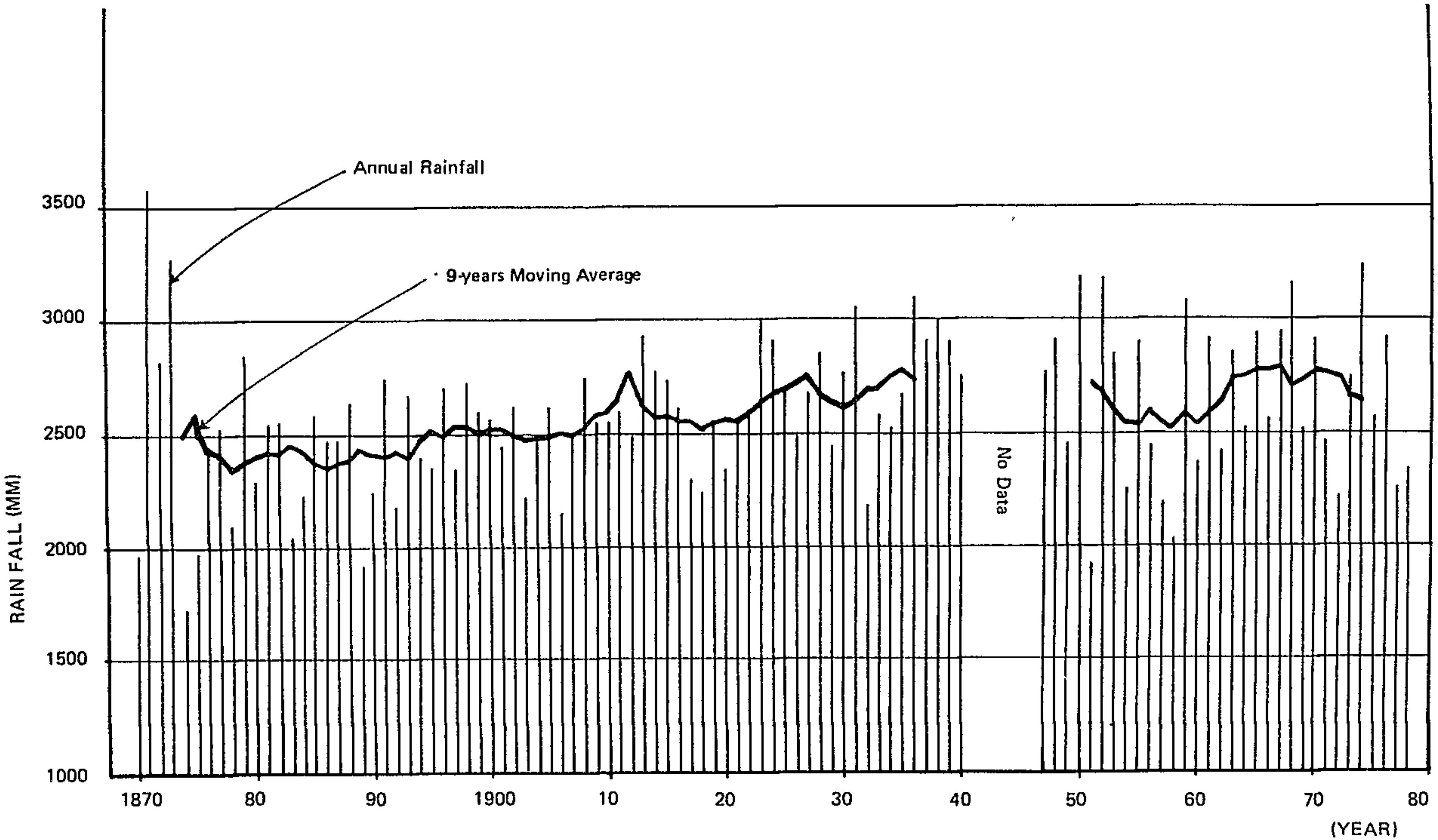


FIGURE D-3-2 STOCHASTIC TREND BY MOVING AVERAGE OF ANNUAL RAINFALL
(RANGOON)

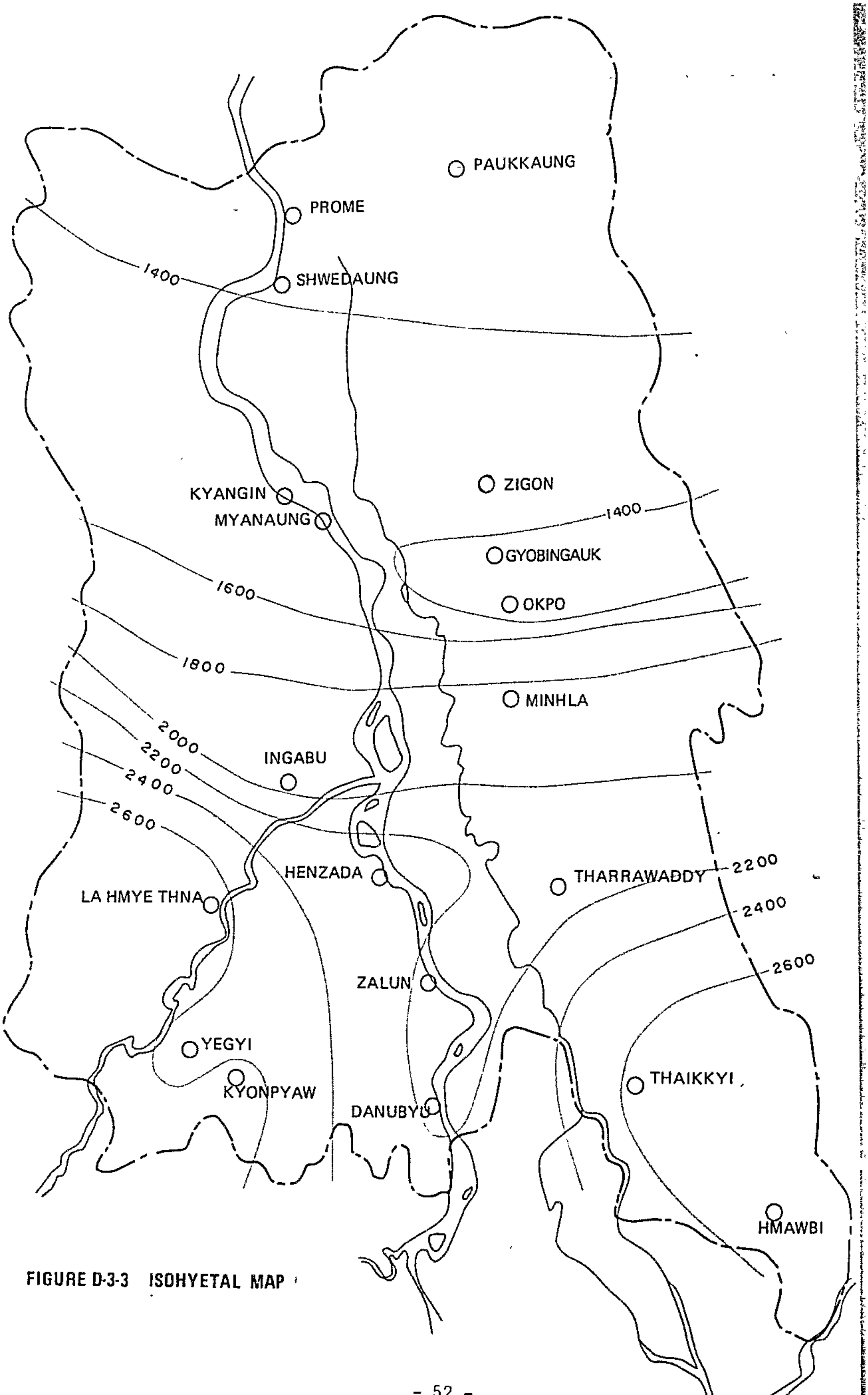
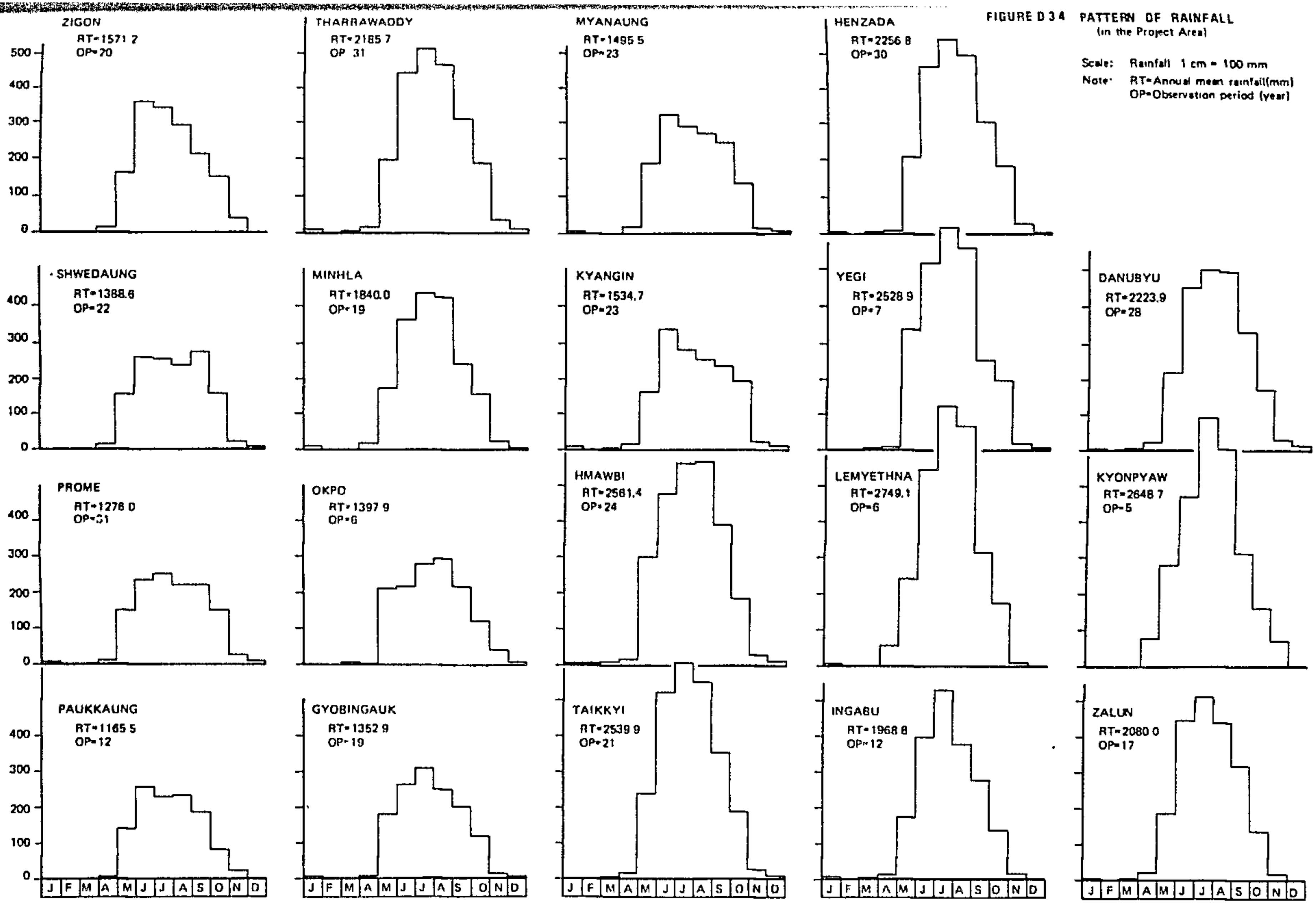


FIGURE D-3-3 ISOHYETAL MAP

FIGURE D 3 4 PATTERN OF RAINFALL
(in the Project Area)

Scale: Rainfall 1 cm = 100 mm
Note: RT=Annual mean rainfall(mm)
OP=Observation period (year)



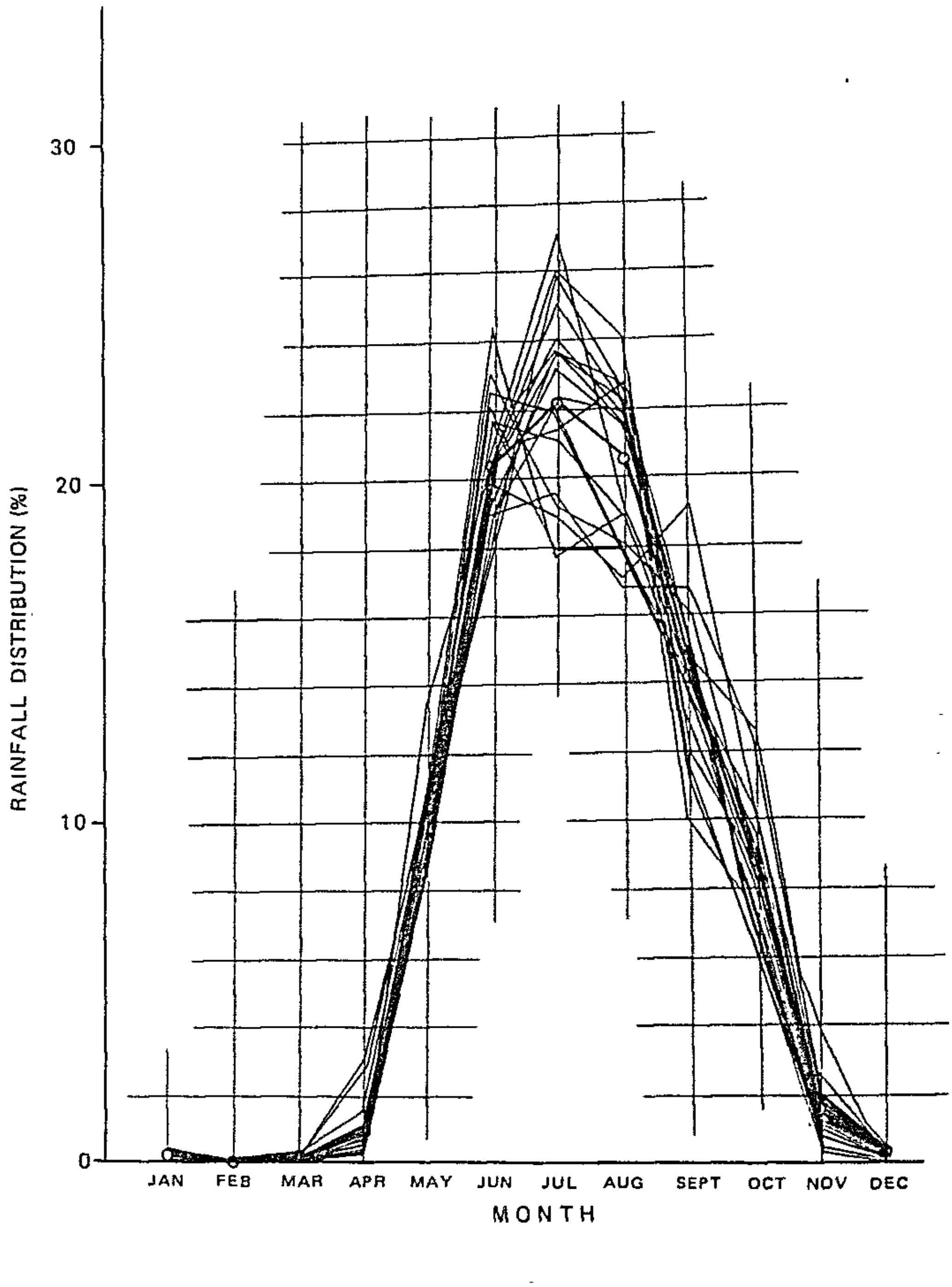


FIGURE D-3-4(a) RAINFALL DISTRIBUTION

The rainfall pattern shows a tropical squall type with raining zone of 30-40 sq.km moving at about 10 km/hr. Hence, there are no correlations of the rainfall records observed by 19 stations in the Survey Area. (Refer to Table D-3-5).

The total amount of one rainfall is not so much due to comparatively short rainfall duration within about 30 minutes, although the rainfall in density is estimated at 50-60 mm/hr. Therefore, there is no particular runoff discharge concentration to cause flood damages, except in the low-lying swampy areas where the drained water concentrates after rainfall.

However, considerable erosions have been observed in those areas where there is little coverage by vegetation or fine particle soils such as clayey soil distribution.

III-2. Other Meteorological Conditions

The MHD's observatories at Prome, Tharrawaddy and Henzada have been conducting observations on the captioned items.

The maximum temperature is measured in April, sometimes exceeding 40°C. The temperature measured in the Survey Area shows the similar tendency to that of the national average (refer to II-1); higher temperature is recorded in the northern part of the Area than that recorded in the southern part. The minimum temperature is recorded as low as 16°C in February. The diurnal range of temperature is 15-16°C on an annual average, although reaching as large as 18°C in February. (Refer to Table D-3-6).

The relative humidity in the Survey Area marks more than 90 percent at maximum in the rainy season, while around 50 percent of minimum in the dry season. (Refer to Table D-3-7).

The monthly mean sunshine hour is observed at the Prome observatory, and it is observed by less than 200 hrs/month from June to September in the rainy season, particularly only 120 hrs/month in August. The sunshine hour increases gradually from October to reach 289 hrs/month in January, February and March in the dry season. The annual mean sunshine hour totals 2,692 hours, which is longer by more than 30 percent than that (about 2,000 hrs) recorded in Japan. (Refer to Table D-3-8).

The annual mean evaporation ranges from 1,750 to 1,890 mm. The daily maximum pan-evaporation is recorded by 7-9 mm in a period from March to May, while by about 4.0 mm in other months of the year. A large-size pan (Pan-A class) with 1.2 m dia. (about 4 ft. dia.) is used for measuring the pan-evaporation. The ratio of pan-evaporation to natural evaporation is 0.76 on an average. The natural evaporation was obtained by Penman method calculation due to lack of the actual measurement data available. (Refer to Table D-3-9).

Both of the wind velocity and direction largely depend upon the monsoon as discussed in the previous paragraph. In general, the wind velocity is not so high and the highest velocity observed at Prome where the strong wind is said to blow is only 6.44 km/hr (1.79 m/s) in April.

The south-westerly monsoon blows from the end of the dry season to the early rainy season, and when the wind direction changes from south to north in the early dry season, the wind velocity decreases to breeze. Strong wind may blow locally immediately before raining in the rainy season, but lasts only about half hour or so to stop. Therefore, there are few wind damages recorded. (Refer to Table D-3-10 and Table D-3-11).

TABLE D-3-5 CORRELATION COEFFICIENT AMONG STATIONS

Station	1	2	3	4	5	6	7	8	9	10
1. Paukkaung	*	0.947	0.980	0.023	0.590	-	0.600	0.541	0.222	0.946
2. Prome	0.947	*	0.713	0.166	0.592	0.987	0.534	0.358	0.308	0.595
3. Shwedaung	0.980	0.713	*	0.132	0.586	-	0.380	0.330	0.468	0,728
4. Zigon	0.023	0.166	0.132	*	0.430	-	0.195	-0.092	0.413	0.239
5. Gyobingauk	0.590	0.592	0.586	0.430	*	-	0.332	0.327	0.625	0.681
6. Okpo	-	0.987	-	-	-	*	-	0.837	-	0.963
7. Minhla	0.600	0.534	0.380	0.195	0.332	-	*	0.354	0.059	0.446
8. Tharrawaddy	0.541	0.358	0.330	-0.092	0.327	0.837	0.354	*	0.339	0.612
9. Taikkyi	0.222	0.308	0.468	0.413	0.625	-	0.059	0.339	*	0.534
10. Hmawbi	0.946	0.595	0.728	0.239	0.681	0.963	0.446	0.612	0.534	*
11. Kanyin	-	0.400	0.339	0.362	0.890	-	0.297	0.469	0.487	0.622
12. Myanaung	-	0.382	0.540	0.562	0.089	-	0.728	-0.079	0.551	0.209
13. Ingabu	-	0.109	0.646	-0.501	-	-	0.551	-0.272	-0.707	0.560
14. Lemythna	-	-	-	-	-	-	-	-	-	-
15. Yegyi	-	0.438	0.583	0.872	-	-	-	0.245	0.195	0.850
16. Henzada	0.573	0.226	0.269	0.017	0.494	0.921	-0.080	0.491	-0.240	0.723
17. Zalun	-	0.423	0.378	-0.112	0.712	-	-0.019	0.577	0.008	0.401
18. Kyonpyaw	0.840	0.378	-	0.043	0.455	-	-	0.478	-0.301	0.927
19. Danubyu	0.784	0.247	0.616	-0.123	0.437	-	0.097	0.445	0.303	0.714
20. Rangoon	0.310	0.267	0.413	-0.157	0.315	0.756	0.344	0.486	0.419	0.592

(cont'd)

TABLE D-3-5 CORRELATION COEFFICIENT AMONG STATIONS (cont'd.)

Station	11	12	13	14	15	16	17	18	19	20
1. Paukkaung	-	-	-	-	-	0.573	-	0.840	0.784	0.310
2. Prome	0.400	0.382	0.109	-	0.438	0.226	0.423	0.378	0.247	0.267
3. Shwedaung	0.339	0.540	0.646	-	0.583	0.269	0.378	-	0.616	0.413
4. Zigon	0.362	0.562	-0.501	-	0.872	0.017	-0.112	0.043	-0.123	-0.157
5. Gyobingauk	0.890	0.089	-	-	-	0.494	0.712	0.455	0.437	0.315
6. Okpo	-	-	-	-	-	0.921	-	-	-	0.756
7. Minhla	0.297	0.728	0.551	-	-	-0.080	-0.019	-	0.097	0.344
8. Tharrawaddy	0.469	-0.079	-0.272	-	0.245	0.491	0.577	0.478	0.445	0.486
9. Taikkyi	0.487	0.551	-0.707	-	0.195	-0.240	0.008	-0.301	0.303	0.419
10. Hmawbi	0.622	0.209	0.560	-	0.850	0.723	0.401	0.927	0.714	0.592
11. Kanyin	*	0.200	-0.093	-	-	0.735	0.553	-	0.522	0.224
12. Myanaung	0.200	*	0.216	-	-	-0.129	-0.043	-	-0.041	0.197
13. Ingabu	-0.093	0.216	*	-	-	0.373	-	-	0.559	0.087
14. Lemythna	-	-	-	*	-	-	-	-	-	-
15. Yegyi	-	-	-	-	*	0.737	-	-	0.705	0.363
16. Henzada	0.735	-0.129	0.373	-	0.737	*	0.755	0.991	0.761	0.393
17. Zalun	0.553	-0.043	-	-	-	0.755	*	-	0.551	0.370
18. Kyonpyaw	-	-	-	-	-	0.991	-	*	0.722	0.520
19. Danubyu	0.522	-0.041	0.559	-	0.705	0.761	0.551	0.722	*	0.497
20. Rangoon	0.224	0.197	0.087	-	0.363	0.393	0.370	0.520	0.497	*

TABLE D-3-6 TEMPERATURE (MONTHLY MEAN)

(Unit: °C)

Station	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Remarks
Prome	31.6	34.9	38.5	40.0	37.1	36.7	30.4	31.6	31.6	32.0	31.3	30.0	MAX
	16.2	16.7	20.6	24.4	24.2	24.5	24.4	24.3	24.1	23.0	20.9	17.2	MIN
Henzada	30.3	33.8	36.5	38.3	34.9	30.5	29.6	29.9	30.4	30.6	31.1	29.7	MAX
	16.3	15.7	20.9	22.4	24.9	24.0	24.1	24.3	24.3	24.4	21.8	18.1	MIN
Tharrawaddy	31.0	33.7	36.6	37.9	35.5	30.9	30.1	30.1	30.8	31.0	31.6	30.0	MAX
	14.3	15.6	19.4	23.4	24.6	24.4	24.2	24.4	24.4	23.6	21.3	16.8	MIN

TABLE D-3-7 RELATIVE HUMIDITY (MONTHLY MEAN)

(Unit: %; $\frac{9.30}{18.30}$)

Station	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Remarks
Prome	41	61	48	55	65	85	88	89	86	86	77	70	24 years
	48	35	35	42	60	86	86	86	39	82	70	60	data
Henzada	76	78	69	65	75	88	91	83	86	88	79	72	10 "
	66	45	46	54	65	91	93	82	88	77	79	72	
Tharrawaddy	79	73	73	72	79	89	91	89	88	85	85	81	7 "
	62	48	42	48	76	90	91	0	90	88	87	86	

TABLE D-3-8 ACTURAL SUNSHINE HOUR (MONTHLY MEAN)

(Unit: hrs)

Station	MONTH												Observation Period
	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	
Prome	289	286	289	284	224	136	157	119	175	228	231	274	11 years data (1966/1976)
Henzada	-	-	-	-	-	-	-	-	-	-	-	-	
Tharrawaddy	-	-	-	-	-	-	-	-	-	-	-	-	

TABLE D-3-9 PAN EVAPORATION (MONTHLY MEAN)

(Unit: mm/day)

Station	MONTH												Total
	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	
Prome	4.5	5.8	8.0	8.8	7.1	4.2	3.9	3.9	4.1	4.1	4.0	3.9	1892.8
Henzada	-	-	-	-	-	-	-	-	-	-	-	-	
Tharrawaddy	4.2	5.7	7.0	7.9	5.1	3.3	3.2	3.6	4.1	4.3	4.4	4.7	1745.7

TABLE D-3-10 WINDSPEED (MONTHLY MEAN)

(Unit: Km/hr)

Station	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
	M O N T H											
Prome	4.02	4.51	4.67	6.44	6.11	5.15	4.67	4.51	3.70	3.54	4.35	5.79
Henzada	1.13	1.61	1.61	3.38	1.93	2.41	1.61	1.61	1.77	1.13	1.61	1.77
Tharrawaddy	2.90	4.12	4.12	6.12	5.40	6.75	6.11	6.11	5.88	3.22	2.74	3.38

TABLE D-3-11 PREVAILING WIND DIRECTION (MONTHLY MEAN)

(Unit: %)

Station	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
	M O N T H											
Prome	N/39	N/23	SW/37	SW/56	SW/44	S/45	S/53	S/47	S/38	Calm/30	N/32	N/53
Henzada	Calm/52	Calm/50	Calm/32	Calm/25	SW/26	SW/30	SW/29	Calm/37	Calm/48	Calm/58	Calm/53	Calm/50
Tharrawaddy	Calm/51	-	-	SW/31	-	-	SW/32	-	-	Calm/37	Calm/43	Calm/43

IV. WATER RESOURCES

IV-1. Discharge

1) Gauging Stations

The water level and discharge gauging station in the Survey Area are located as shown in Fig. D-1-1 in Chapter I.

The water level and discharge of the Irrawaddy River have been observed at Prome gauging station under MHD.

There are 19 gauging stations established by ID along observations have been carried out by only staff gauge measurement at three times a day (6:00 AM, 12:00 and 6:00 PM) to cover only the rainy season period from May to December.

As mentioned in the previous paragraph III-1 on rainfall gauging stations, another five stations with automatic level gauges and 12 stations with staff gauges have been provided in the Survey Area under the cooperation of both Governments of Burma and Japan, the Colombo Plan experts and Burmese ID officials concerned. Furthermore, the old measurement devices at South Nawin and Okkan Stations have been replaced with new ones. With these new facilities, the water level gauging stations in the Survey Area total 48 stations.

2) Discharge and Water Level

Most of the rivers in the Survey Area, except the Irrawaddy, the Myitmaka and the Bassein Rivers, have run dry in the dry season, and no discharge observation has been carried out for these rivers in the dry season. The discharge in the dry season is so small compared with in the rainy season that the specific discharge is estimated at 0.1 mm/day. This is considered to result from the small storage coefficient of the aquifers in the related river basins as discussed in the previous paragraph II-7 Groundwater.

The Irrawaddy River, the largest river in Burma, has the catchment area of 340,390 sq.km, commanded at Prome in the extreme north of the Survey Area (this is almost equal to the whole national land of Japan, 370,000 sq. km).

The annual average discharge was estimated at 10,200 cu.m/s and the maximum discharge in the past was recorded by 60,120 cu.m/s on August 15, 1974, which is considered a flood with 50-year probability.

The diurnal fluctuation of discharges in the Irrawaddy, the Myitmaka and the Bassein Rivers is very small. The hydrographs on these rivers show a simple pattern of discharges that are increasing in the early part of the rainy season to reach the peak in August and decreasing toward the end of the rainy season. Thereby, the water level of the Irrawaddy River fluctuate in the pattern with the rising period in June, high water period from July to September, reducing period from October to November and low water period from December to May in the following year. This is illustrated in the following figure.

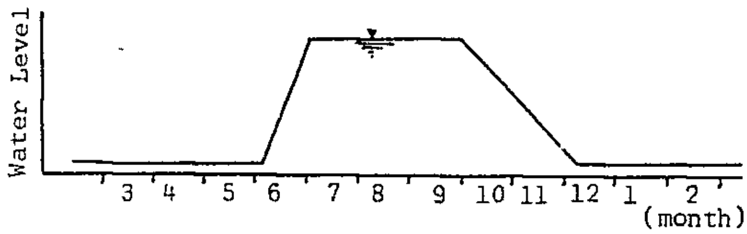


FIG. D-4-1. TYPICAL HYDROGRAPH

The water level difference between the high water level and the low water level is about 10 m. In June when the rising period, the water level sometimes increases by one meter per day, and in the reducing period, it lowers by 0.2-0.3 m per day. The fluctuations in the Myitmaka and the Bassein show the similar tendency to the above. (Refer to Fig. D-4-2 & Fig. D-4-3 and Annex E, Hydraulic Analysis and Reclamation).

Fourteen (14) tributaries of the left bank of the Irrawaddy River have the gauging stations to carry out the discharge observation during eight months from May to December. These observations can supply the daily discharge records available on the above 14 tributaries. During the dry season from January to April, their discharges reduce to very little or almost zero, and the base flow of these tributaries has not been observed.

The flood water levels of these tributaries can be specified into two periods, indicating very similar pattern of hydrograph to those rivers in Japan that the peak water level lasts only one or two hours.

The hydrograph on the South Nawin chaung which has been prepared in this Master Plan Study, shows that the water level rise lasts about six hours and decrease lasts about one day. (Refer to Fig. D-4-4).

Since the hourly rainfall data are not available, the detailed study on the time of concentration can not be made in this study; however, roughly speaking, it would take several hours or one day at maximum for the related concentration of water. It is also expected that there is the similar tendency shown in the other branch rivers to the above South Nawin case.

Such tendency allows to assume that the rainfall takes place with locally and hourly high intensity in the very limited area in the related catchment area, and such concentrative strong rainfall causes an abrupt rise of the water level in the river. Also, the comparatively short duration of the reducing period within the similar scale rivers in Japan of the water level is assumed to result from the short duration of rainfall in the area concerned.

The annual discharge and the specified discharge of the respective rivers are shown in the following Table D-4-1. The said table suggests that the specific discharges are variable according to the annual discharges, and the discharges of the rivers in the southern part of the Survey Area has more than double of those in the rivers of the northern part.

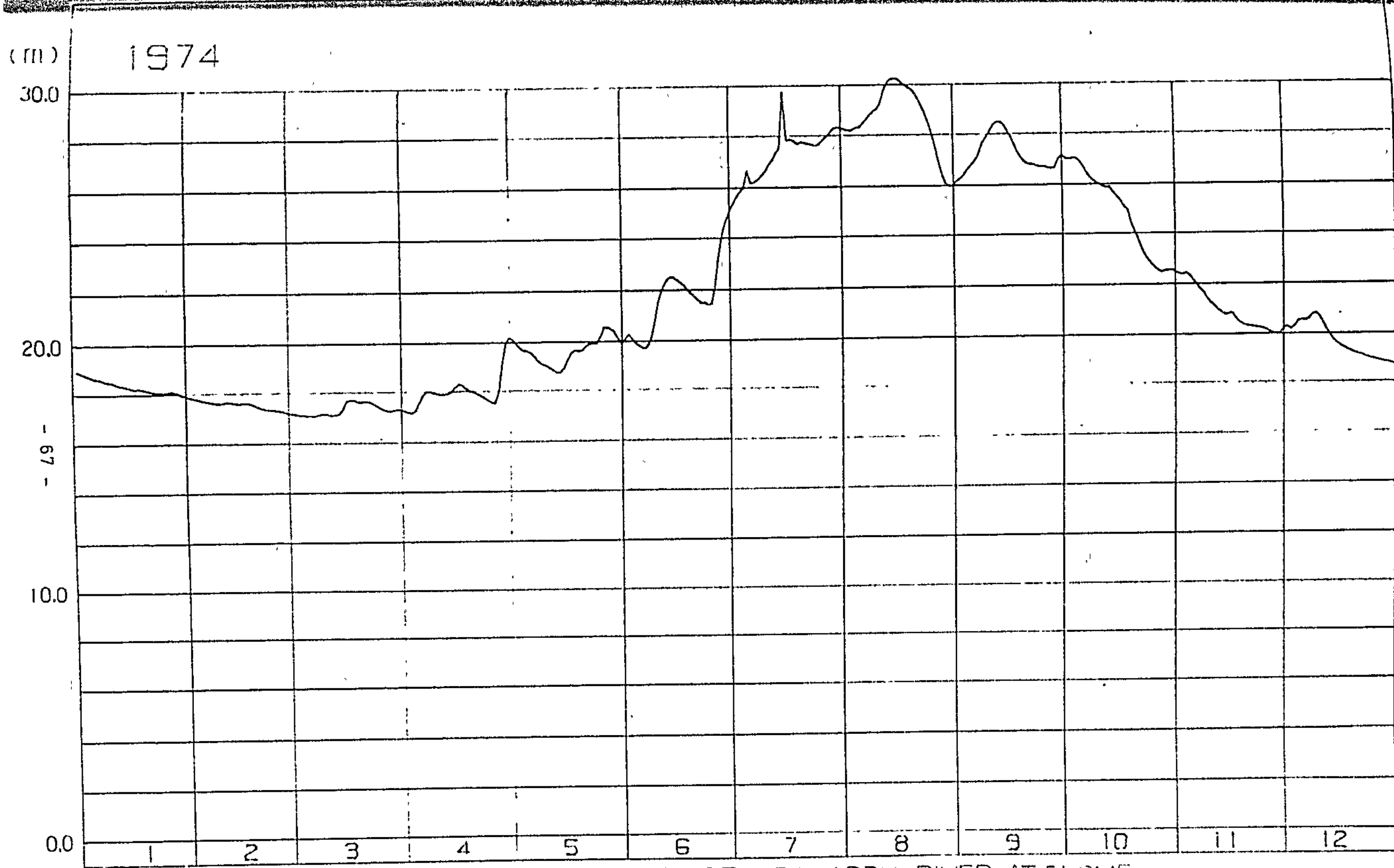


FIGURE D-4-2 WATER LEVEL OF IRRAWADDY RIVER AT PROME

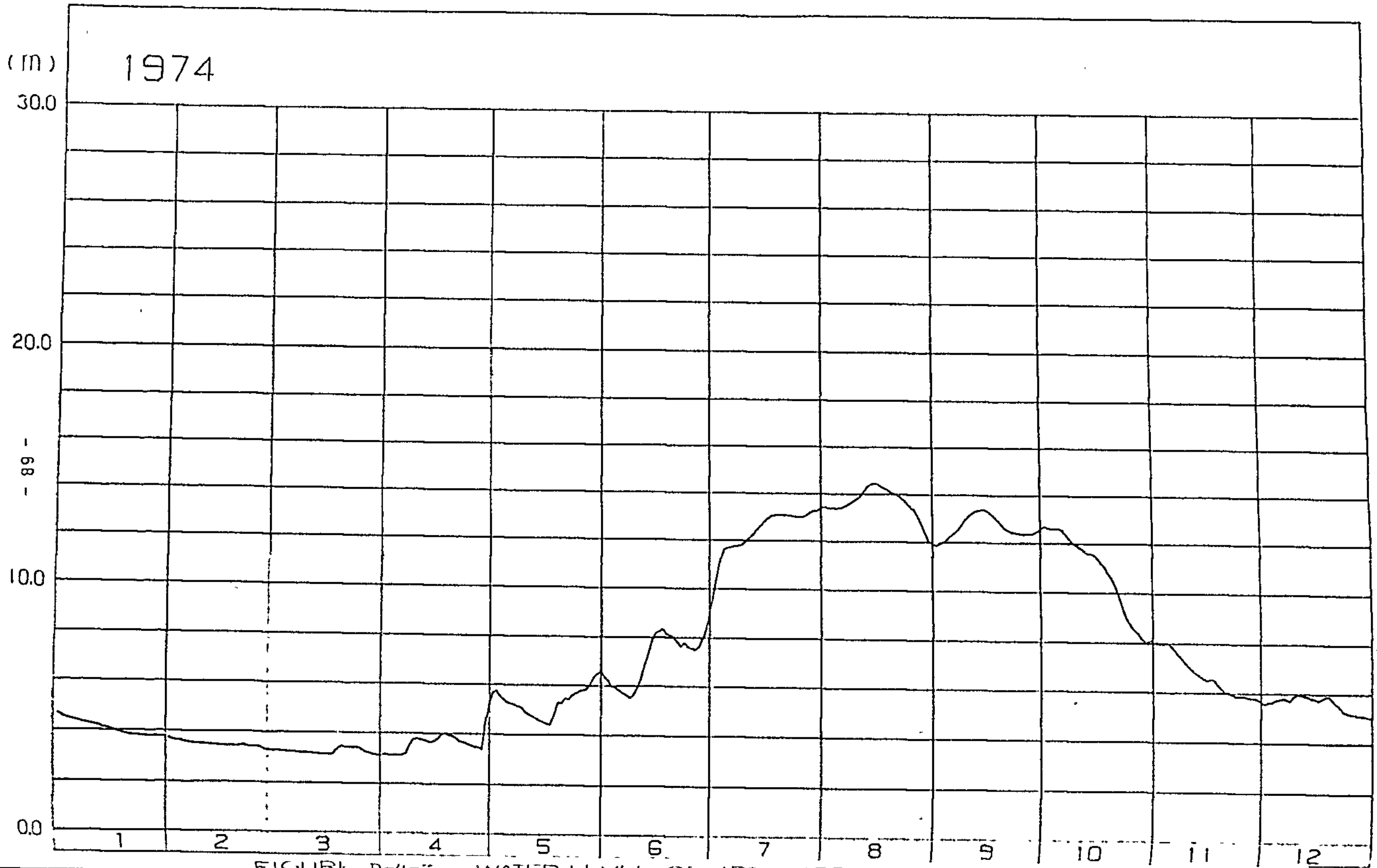


FIGURE D-4-3 WATER LEVEL OF IRRAWADDY RIVER AT HENZADA

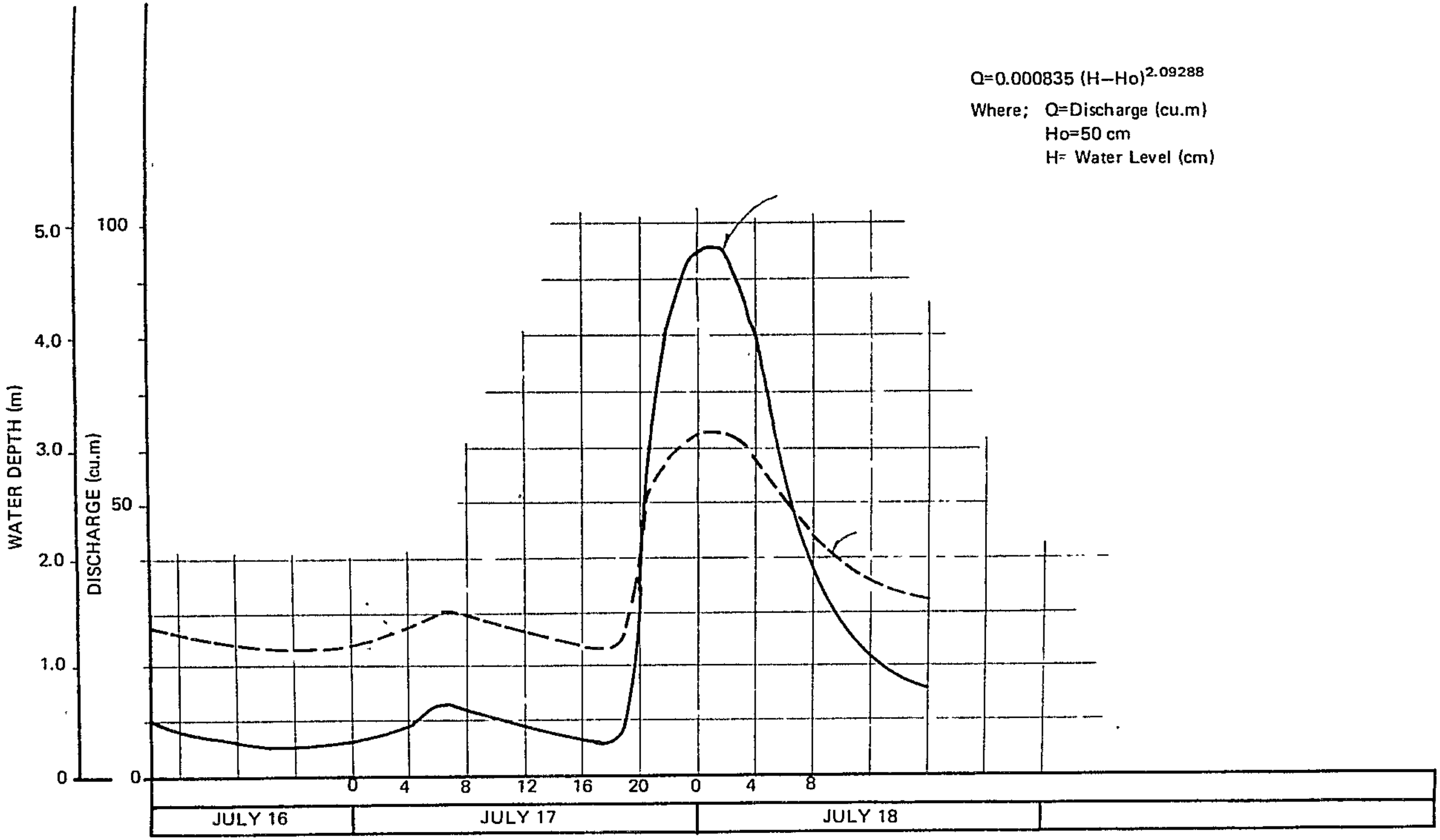


FIGURE D-4-4 HYDROGRAPH OF SOUTH NAWIN RIVER, 1979

TABLE D-4-1 SPECIFIC DISCHARGE

River	Catchment Area (sq.km)	Annual Discharge (MCM) 1970	1971	1972	1973	1974	1975	1976	Average (MCM)	Specific Discharge (cum/sec/km²)
Okkan	313.4	188.6	264.3	351.0	184.9	368.2	*	*	271.3	865,700
Thegaw	88.1	*	61.6	45.9	37.4	136.7	22.9	117.5	87.0	987,500
Kadinbilin	240.9	*	*	256.7	200.4	342.8	233.5	522.0	311.1	1,291,400
Gamon	80.3	*	*	*	23.4	*	*	*	23.4	291,400
Bawbin	261.6	156.6	59.3	25.2	25.5	47.7	79.3	60.1	64.8	247,700
Taungnyo	549.1	*	*	93.4	99.7	*	*	*	96.7	176,100
Wegyi	538.7	285.8	359.1	156.5	223.3	250.6	183.6	258.8	245.5	455,700
Thegon	69.8	*	41.1	35.8	17.2	*	*	8.3	25.6	366,800
Shwele	64.0	*	*	7.9	32.5	*	*	*	20.2	315,600
S. Nawin	639.7	*	*	*	222.6	264.4	328.5	336.7	288.1	450,400

IV-2. Water Quality

Water quality analysis has not been either qualitatively or quantitatively. Various conditions in the related River basins, however, suggest that the water of the Irrawaddy River, the Myitmaka River and their branches would not be harmful as irrigation water. It would be required to carry out the quality analysis and control for the water of these rivers in future when the industrial development will provide mining plants and other factories in the river basins concerned. Furthermore, a strict water quality analysis should be made when the irrigation water is used as the domestic water such as potable water.

The tidal compartment of the Irrawaddy and the Bassein Rivers reaches around Henzada and that of the Myitmaka River reaches around Tharrawaddy. However, the salinity would be dispelled and mixed in the river waters around the tidal compartments, and it is assumed that the salinity concentration is increased in the water in the dry season. Therefore, the salinity measurement should be made on the water to be diverted for irrigation from the downstreams of the Irrawaddy River and the Myitmaka River, and a thorough study should be made on the diversion method to supply harmless water to crop by taking the surface water.

IV-3. Sediment Volume

The volume of sediments transported to a reservoir is one of the important factors to determine the scale of the reservoir; the inflow sediments to reservoir within a life of its reservoir should be estimated into the reservoir capacity as dead water.

The sediment data are available for the Survey Area, and measurement was made on the Thegaw chaung to obtain 1,350 cu.m/sq.km/year. The detailed information was not available on measurement method and term, and analysis method of the records observed, but judging from the general land conditions and the vegetation along the Thegaw chaung, the value seems to be larger than that in general cases in the country. This value has been adopted for designing of the North Nawin dam.

On the other hand, the measured value of 482 cu.m/sq.km/year has been taken for designing of the Sedawyi Dam located in the Irrawaddy River basin at the east side of the Pegu Yoma, and the Pyinmana Irrigation Project located along the Pegu Yoma.has adopted 1,000 cu.m/sq.km/year.

In due consideration of the above data, results and reforestation plan in future, the sediment volume per annum is to be adopted by 1,000 cu.m/sq.km/year (2.1 AF/sq.mile/year) for designing dams.. However, the future dam planning should adopt the measurement values on the case-by-case basis, because the above 1,000 cu.m/sq.km/year is only an estimated value which might not be avoided for every case.

V. HYDROLOGICAL ANALYSIS

The following hydrological analyses were made on the basis of various hydrological data, meteorological data, etc. that had been collected since the preliminary survey was started.

V-1. Probable Rainfall

The probability computation was statistically made by Iwai's method on the annual maximum rainfall, daily maximum rainfall, 2-to-3-days consecutive rainfall, 10-days consecutive rainfall based on the data prepared at 19 gauging stations in the Survey Area.

The Iwai's method is the probability treatment of the data concerned by logarithmic regular distribution, when a sample has any substantial value even in the lowest extremity.

The respective probable rainfalls for 19 gauging stations are shown in the following Table D-5-1. (Refer to Annex E). The said table suggests that there will not always be correlations found between the daily maximum rainfall tends to take place in the early part of the rainy season and to shift to the middle of the rainy season as the period of consecutive rainy days becomes longer and longer; in other words, the rainfalls in the early rainy season can be defined to be inconsecutive. Hence, it is considered that the farmers in the Survey Area have been forced to practise unstable farming due to starting their farming works depending upon unstable rainfall in this period.

On the other hand, the long consecutive rainfalls taking place in the middle of the rainy season has caused long-lasting flood damages to the low-lying areas in the Survey Area.

Under the circumstances, it is required to provide reservoirs which can store the unstable rainfalls, in the Survey Area reservoirs which can store the unstable rainfalls, release the stored water in the early rainy season and the dry season to serve for executing planned farming, and reduce the flood damage by storing water in the middle through the end of the rainy season.

2) Number of Rainy Days

The average number of the rainy days in the Survey Area counts 119 days; the highest by 148 days at the Hmawbi and the lowest by 85 days at Gyaubingauk. Regarding the number of the rainy days, there is not so much local difference observed in the Survey Area as to be in the case of study on the annual rainfall. The rainy days with the over 1.0 mm rainfall.

The following table (Table D-5-2) shows the breakdown of the number of rainy days in a year by rainfalls.

TABLE D-5-2 NUMBER OF RAINY DAYS

Rainfall	Days
Non-rainfall	246
0 - 1 mm	4
1 - 5 mm	30
5 - 10 mm	21
10 - 30 mm	41
30 mm	23
Total	365

The average number of the rainy days in a year covers about 67 percent of 180 days of the rainy season between mid-May and mid-November, and the remaining 37 percent, about 71 days, is non-rainfall days which tends to concentratively take place in periods from May to June and from October to November. Hence, in such years as 1979 when rainfall had concentrated up to early June and non-rainfall days had last since then, the farming works had been delayed to a large extent. Then, if an adequate rainfall would not take place in the following period, there would be a very poor harvest expected. (Refer to Appendix D-5).

TABLE D-5-1 PROBABILITY OF EXCEEDANCE OF DAILY MAXIMUM RAINFALL

(Unit: mm/day)

Station	Return Period (years)								
	2	5	10	30	50	100	200	500	1000
Paukkaung	63.5	90.5	110.9	145.2	162.2	186.6	212.7	249.7	280.0
Prome	84.4	109.7	125.6	148.7	158.9	172.7	186.2	204.0	217.5
Shwedaung	85.3	126.1	156.0	204.9	228.7	262.5	298.0	347.9	388.0
Zigon	90.6	138.0	176.5	245.0	280.6	333.3	391.1	476.1	547.5
Gyobingauk	87.9	126.1	152.6	194.3	214.0	241.4	269.5	308.0	338.4
Okpo	109.9	162.4	197.4	250.8	275.4	309.0	343.1	388.9	424.5
Minhla	103.4	136.9	158.9	192.2	207.4	228.2	249.1	277.0	298.6
Tharrawaddy	110.9	147.4	173.9	217.0	237.8	267.3	298.2	341.3	375.9
Taikkyi	103.9	121.2	131.3	145.2	151.2	158.9	166.3	175.7	182.7
Hmawbi	119.1	171.4	214.6	292.8	333.7	394.7	462.1	561.9	646.4
Kyangin	86.8	118.1	139.2	171.6	186.7	207.4	228.5	257.0	279.2
Myanaung	83.2	120.5	152.7	213.0	245.5	294.7	350.2	434.0	506.3
Ingabu	114.6	151.0	175.5	213.1	230.5	254.4	278.7	311.5	337.1
Lemyethna	129.3	169.9	196.0	234.4	251.8	275.1	298.3	329.0	352.4
Yegyi	96.9	140.2	169.3	213.8	234.4	262.7	291.3	330.0	360.1
Henzada	104.4	132.2	152.3	184.9	200.6	222.9	246.2	278.7	304.8
Zalun	84.3	113.1	134.2	168.5	185.3	208.9	233.8	268.6	296.7
Kyonpyaw	182.8	150.3	164.5	185.7	195.4	208.5	221.7	239.2	252.8
Danubyu	95.7	113.6	124.9	140.8	147.9	157.3	166.6	178.7	187.8

Note: Calculated by Iwai Method

TABLE D-5-1 PROBABILITY OF EXCEEDANCE OF TWO DAYS CONTINUOUS RAINFALL (cont'd.)

(Unit: mm/2-days)

Station	Return Period (years)								
	2	5	10	30	50	100	200	500	1000
Paukkaung	84.7	132.2	172.3	243.4	285.8	345.0	411.3	510.4	595.3
Prome	111.6	144.3	164.5	193.2	205.9	222.7	239.1	260.4	276.4
Shwedaung	115.5	170.5	211.3	278.8	311.9	359.1	409.0	479.4	536.4
Zigon	119.9	166.5	200.3	255.3	281.9	319.5	358.8	413.8	457.9
Gyobingauk	109.4	147.0	175.1	222.0	245.1	278.1	313.1	362.7	403.0
Okpo	121.9	179.0	217.7	277.4	305.2	343.4	382.4	435.2	476.5
Minhla	127.3	164.6	189.3	226.5	243.6	266.8	290.2	321.5	345.6
Tharrawaddy	146.9	185.8	214.8	262.8	286.4	320.2	355.9	406.3	447.2
Taikkyi	151.1	175.2	193.1	222.6	237.1	257.8	279.7	310.5	335.5
Hmawbi	163.3	223.4	268.7	344.8	382.5	436.6	494.3	576.2	643.0
Kyangin	103.2	146.1	178.8	234.0	261.6	301.2	343.7	404.2	453.7
Myanaung	110.1	152.5	190.9	265.7	307.1	371.1	444.7	558.4	658.3
Ingabu	164.6	217.2	250.2	298.0	319.2	347.5	375.3	411.8	439.3
Lemyethna	212.2	275.3	315.5	374.4	400.7	436.1	471.1	517.3	552.4
Yegyi	143.6	218.1	280.8	396.0	457.2	549.0	651.4	804.4	935.1
Henzada	148.1	187.1	213.3	253.5	272.1	297.6	323.6	358.6	385.8
Zalun	130.0	155.3	170.4	191.5	200.6	212.6	224.1	238.8	249.8
Kyonpyaw	170.4	221.0	260.7	329.2	364.0	414.7	469.4	548.6	614.1
Danubyu	138.5	173.4	194.7	225.1	238.4	255.9	273.1	295.3	311.9

Note: Calculated by Iwai Method

TABLE D-5-1 PROBABILITY OF EXCEEDANCE OF THREE-DAYS CONTINUOUS RAINFALL (cont'd)

(Unit: mm/3-days)

Station	Return Period (years)								
	2	5	10	30	50	100	200	500	1000
Paukkaung	100.6	162.4	213.4	305.6	354.0	425.9	505.5	623.3	723.0
Prome	129.0	166.5	190.1	224.6	239.9	260.5	280.8	307.5	327.7
Shwedaung	136.2	194.8	239.1	313.5	350.5	403.6	460.1	540.5	606.0
Zigon	143.8	191.4	222.2	268.1	288.8	316.8	344.8	382.0	410.5
Gyobingauk	128.3	164.6	189.1	227.0	244.6	268.8	293.5	327.0	353.1
Okpo	141.8	186.5	221.9	274.5	298.3	330.5	362.6	405.3	437.9
Minhla	151.0	185.6	207.7	240.1	254.7	274.2	293.7	319.3	338.9
Tharrawaddy	173.6	218.4	249.8	299.5	323.1	356.0	389.9	436.7	473.7
Taikkyi	190.0	221.3	247.9	297.2	323.4	363.0	407.3	473.8	530.8
Hmawbi	205.8	269.6	316.0	391.7	428.5	480.4	535.0	611.2	672.5
Kyangin	124.9	165.8	193.7	237.0	257.2	285.0	313.4	352.0	382.2
Myanaung	126.0	168.2	204.2	271.4	307.4	361.7	422.7	514.4	593.3
Ingabu	191.4	268.4	323.3	411.3	453.5	512.7	574.3	659.6	727.6
Lemyethna	250.5	323.7	370.0	437.8	468.0	508.5	548.7	601.5	641.6
Yegi	184.9	274.1	349.6	489.0	563.1	674.6	799.3	986.1	1,145.9
Henzada	182.6	223.6	250.0	288.9	306.5	330.2	353.8	385.0	408.9
Zalun	162.6	188.6	203.8	224.7	233.5	245.0	256.1	270.1	280.3
Kyonpyaw	210.9	266.8	311.9	392.1	433.6	494.8	561.9	660.4	743.0
Danubyu	167.8	210.9	237.5	275.7	292.5	314.7	336.6	365.0	386.3

Note: Calculated by Iwai Method

TABLE D-5-1 PROBABILITY OF EXCEEDANCE OF TEN-DAYS CONTINUOUS RAINFALL (cont'd.)

(Unit: mm/10-days)

Station	Return Period (years)								
	2	5	10	30	50	100	200	500	1000
Paukkaung	157.6	282.2	408.7	681.0	843.0	1,105.6	1,423.4	1,941.3	2,419.9
Prome	204.7	255.2	288.2	337.5	360.0	390.4	420.9	461.6	492.9
Shwedaung	217.4	286.8	333.8	406.0	439.5	485.6	532.5	596.0	645.6
Zigon	248.5	311.8	351.1	407.4	432.2	465.2	497.6	539.8	571.6
Gyobingauk	220.7	270.7	301.2	344.3	363.1	388.0	412.2	443.5	466.9
Okpo	203.2	234.1	252.1	276.6	287.0	300.5	313.3	329.6	341.6
Minhla	272.8	329.5	373.2	447.7	485.1	539.1	597.2	680.5	749.0
Tharrawaddy	326.6	373.7	401.0	438.1	453.8	474.0	493.4	517.8	535.7
Taikkyi	391.3	456.2	500.4	568.8	600.8	644.8	689.8	750.9	798.8
Hmawbi	379.2	450.2	493.6	554.9	581.7	617.1	651.5	696.0	729.3
Kyangin	212.7	278.8	325.2	398.7	433.7	482.5	532.9	602.3	657.3
Myanaung	225.2	280.7	320.4	384.2	414.9	458.0	502.9	565.2	614.9
Ingabu	354.1	436.7	487.4	559.3	590.8	632.4	673.0	725.6	765.1
Lemyethna	483.0	545.1	580.6	628.5	648.7	674.6	699.2	730.2	752.7
Yegyi	341.3	499.6	612.6	794.0	881.1	1,003.4	1,130.6	1,307.1	1,447.7
Henzada	343.4	408.4	450.0	511.0	538.4	575.2	611.7	660.0	696.7
Zalun	323.1	388.7	427.4	480.8	503.7	533.4	562.0	598.5	625.4
Kyonpyaw	413.6	500.7	552.5	624.4	655.3	695.7	734.6	784.4	821.3
Danubyu	326.7	297.3	439.4	497.9	523.1	556.1	587.9	628.6	658.8

Note: Calculated by Iwai Method

V-2. Discharge Analysis

In taking the catchment, areal rainfalls observed at the respective discharge gauging stations as those observation values at the related rain gauge stations in the said area, the annual mean run-off ratio was estimated at 30 percent, the maximum of 45 percent and the minimum at 20 percent. The relationship between the accumulated rainfall and the accumulated discharge was plotted and is shown in Fig. D-5-1. The figure reveals that the initial loss is estimated at 200 mm and the more accumulated rainfall takes place, the higher run-off coefficient becomes. The broken line in the figure indicates the average basis relationship between the accumulated rainfall and the accumulated specific discharge. (Refer to Appendix D-7).

In taking the accumulated rainfall by R and the accumulated discharge by Q, relationship can be expressed by the following equations:

$$R \leqq 200 \text{ mm} \qquad Q = 0.0$$

$$200 < R \leqq 1{,}200 \qquad Q = 0.3R-60$$

$$1{,}200 < R \qquad Q = 0.5R-300$$

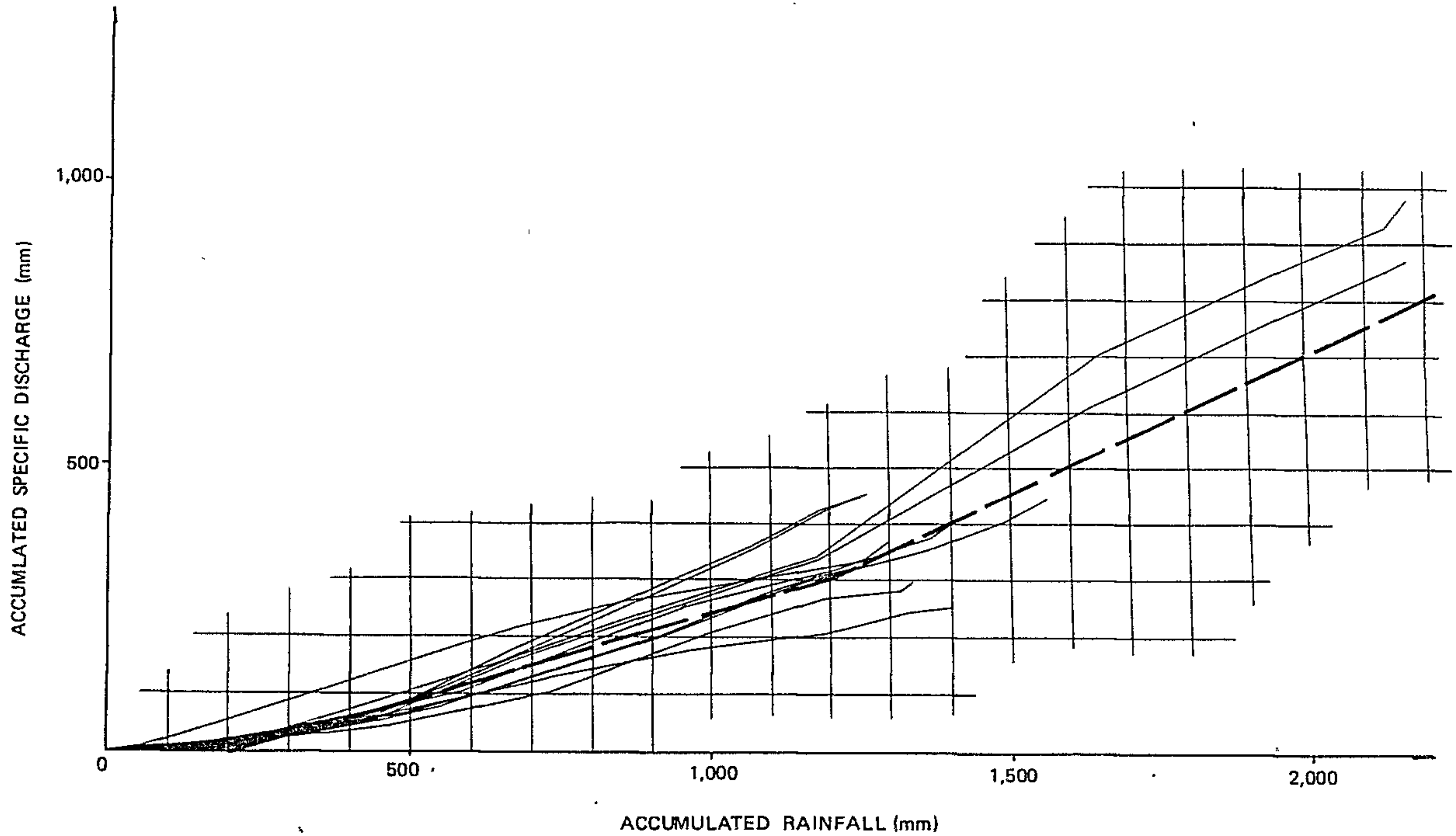


FIGURE D-5-1 RELATIONSHIP BETWEEN ACCUMULATED RAINFALL AND SPECIFIC DISCHARGE

VI. IRRIGATION SCHEME

VI-1. General

1) Necessity of Irrigation

The rainfed farming, which is the major way of agriculture in the Survey Area, makes it hard to achieve the target of long-range agricultural development programme. Accomplishment of this target requires to take a measure for effective use of the rain water that tends to occur inadequately and sometimes unseasonably to farming works. On the other hand, it is essential to utilize as much as possible such favorable natural conditions to farming as abundant sunshine and high temperature in the dry season. Under the situation, it will be a fundamental issue to secure the irrigation water to meet the requirement.

2) Water and Other Resources for Irrigation

In this connection, the natural water resources of rivers, lakes, and groundwater are considered as the sources for irrigation water supply. These natural water resources, however, are liable to being affected by rainfall, except for the water of the three largest rivers in Burma, the Irrawaddy, the Sittang and the Salween. Therefore, the facilities such as dams and weirs are required to effectively use the precious limited water resources for the purpose.

To merely secure the water sources, however, is not effective to utilize the reserve water resources. To secure the necessary human resources plays an important role in the development of irrigated agriculture as well as to secure the water sources. Irrigation projects executed in the past have tended to consider the human factor as being minor in the project. It is no exaggeration to say that the successful utilization of the water resources depends largely on the effective use of human resources both in quality and quantity. In other words, the farmers concerned should thoroughly acquire the knowledge and techniques on irrigated agriculture before securing the water sources of the projects.

3) Intake Methods of Irrigation Water

Pumping facilities, diversion weirs, dams, etc., are considered as major means of diverting water from the water sources.

Pumping facilities will be inevitably required for diverting the water from rivers, lakes and groundwaters, the water levels of which reduce by about 10 m in the dry season. The construction cost of pumping facilities depends largely upon their foundation treatment, lifts, pumping-up water amounts, slope protection works, etc.

All the rivers flowing in the Survey Area are natural rivers,, which have not provided with any flood control facilities. Under the circumstances, the river streams have shifted by floodings year by year as well as collapse of river slopes have taken place at many places on the banks.

The lakes and as water sources, except the sample extending south of Henzada, have caused floodings in the rainy season. As for the installation of pumping facilities, therefore, the special attention should be paid to the location of the facilities.

The estimated water requirements for paddy cropping will be between 900 and 1,000 mm per crop (refer to Chapter VI), and it is expected to develop the irrigable areas with almost the same acreage as that of the surface areas of lakes and swamps in taking into consideration the water surface evaporation by some 1,800 mm and effective water depth by around three meters.

In the dry season, there have been no large scale lakes and swamps observed in the Survey Area. Thereby, pumping irrigation is recommended to be adopted for the small-scale irrigation in the Survey Area in the dry season. However, the pumping irrigation involves several problems of higher running cost, difficulty in operation and maintenance of the facilities in those areas which the spare parts are not available.

The groundwater irrigation has some problems in its yield available as mentioned in the previous paragraph II-7, therefore, a thorough study in the dry season should be made prior to implementation of the groundwater utilization.

The groundwater irrigation projects, which quick-yielding with comparatively short construction period, can cover only limited areas of 10-20 ha (25-50 acres) by one well. Thereby, a large-scale groundwater projects requires to establish the spare parts supply system for the pumping equipment and to bring up repair mechanics to meet the requirements as well as to study the water table intervention among a group of wells.

The diversion dams are the effective facilities to supplement the irrigation water to rainy season cropping; they function more effectively in the areas such as Survey Area where there usually occurs a spot rainfall which cannot be expected to cover evenly the whole area, and in case that there are several consecutive non-rainfall days in the rainy season although there is sufficient river discharge available. Irrigation by diversion dams will give considerably favorable effect to paddy plants in their booting stage and ripening stage coinciding with the end of the rainy season.

On top of the above, the diversion dams, in combination operation with dams as discussed later, will enable to divert the water for power generation as well as to temporarily store the water by runoff discharge from the residual catchment areas.

In the Survey Area, however, large flood discharge ratio to normal discharge will make it unavoidable to provide weirs with large-scale flood sluices, and according to the conditions of foundation, a great amount of cost might be needed for foundation treatment works. Therefore, it is necessary to carry out a thorough investigation on the sites before implementation.

On the other hand, mis-operation of gates would cause much damages to the related areas with the weirs because it takes considerably short period to reach the peak flood discharge from the beginning of the water level rise.

In due consideration of the above matters, it could be recommended to provide the water intake facilities in combination of weirs with dam, instead of the weirs only.

In general, the reservoirs constructed in the Southeast Asian countries where the seasons of the year can be definitely divided into two, the rainy season and the dry season, function to store the surplus water in the rainy season and to release the said water for supplementing the irrigation water in the rainy season or for irrigation the dry season crops. The reservoirs also serve to mitigate the flood damage in the downstream areas by their storage capacity of a greater part of the runoff discharge in the rainy season. Furthermore, the comparatively large amount of power generation can be anticipated by using the water released from the reservoirs, when proper generation facilities are provided. The operation and maintenance costs for these facilities are relatively lower than those for the pumping facilities.

Specifically speaking, in case that the dams, like in the Survey Area, are expected to store the water as much as 100 MCM or so only providing 30 m high embankment, the comparatively low cost dam would enable to command the large irrigable areas, resulting in reducing the total project cost. This would be one of the most effective development strategies, although this will be quick remedial measure for the development due to taking a long time, 7-8 years -- for survey, design and implementation.

In terms of development strategies for this Project, the following approaches are taken into consideration:

1) Left bank of the Irrawaddy River (The Myitmaka River basin) - A reservoir plan shall be made as mainstay of the development program of the area and pumping irrigation shall be introduced to the low-lying flat lands where the land reclamation is implemented.

2) Right bank of the Irrawaddy River - A plan of reservoir is combination of diversion weir shall be made as mainstay.

3) Delta Area - Pumping irrigation plan shall be made as mainstay by utilizing the water diverted from lakes and swamps sporadically located in the Delta.

VI-2. Reservoir Plan

Dam site hunting made on the one-inch map (scale: 1:63,360) both for the Arakan and the Pegu Yomas revealed that topographically favorable dam sites counted more than 30, which have been screened to 23 from the viewpoint of storage capacity and other conditions. The rough estimation was carried out on the reservoir operation for these 23 reservoirs. For references, however, the reservoir operation for the South Nawin Dam was taken from the result obtained by the Feasibility Study of the South Nawin Irrigation Project. (Refer to Fig. D-6-2 ~ Fig. D-6-23 and Fig. D-6-35).

VI-3. Gross Water Requirements

1) Cropping Pattern

The cropping pattern prepared by Agronomist and Soil Expert of the Study Team is the base for various studies. The cropping period for paddy has two types of 135 days and 145 days, and that for upland crops, including various kinds of crops such as pulses, oil-seeds crops and vegetables, shall be represented by pulses (Beans, Dry) and groundnut in considering the simplification of computation. (Refer to Fig. D-6-1 and Annexes B & C).

2) Land Soaking and Land Preparation

The irrigation water for land soaking and land preparation is used for plowing, harrowing and puddling, the preparatory works for paddy transplanting.

The water requirements for these works were estimated with soil type-wise drying ratio ranging from 60 to 80 percent and porosity of about 50 percent. The percolation losses were taken in a range from 1.5 mm/day to 2.5 mm/day. The standing water depth was determined by 50 mm for all cases.

The irrigation water for these works should be applied three times as follows: the first application should be made on two days before plowing, the second application on 11th day from the first irrigation day and the third application on five days prior to transplanting day. The respective works of plowing, harrowing and puddling should be carried out two days later from each irrigation day.

Irrigation water for top soil saturation was planned to be supplied in the first irrigation day and that for standing water was planned to be supplied on the third irrigation day.

3) Water Requirements in Growing Stage

The consumptive use (ETo) computed in item 1) above was converted into monthly basis. The crop factors were quoted from the data of the FAO Report, Crop Water Requirements, Vol. 24 on Paddy.

4) Water Requirements

The respective water requirements computed from items 2) and 3) above were totaled to obtain the net water requirements. (Refer to Table D-6-1 and Appendix D-7).

5) Irrigation Losses

Irrigation losses should include conveyance loss and application loss for each irrigation performance.

	Conveyance Loss	Application Loss	Total Loss
Paddy	0.8	0.7	0.56
General Crop (Upland Crop)	0.8	0.6	0.48

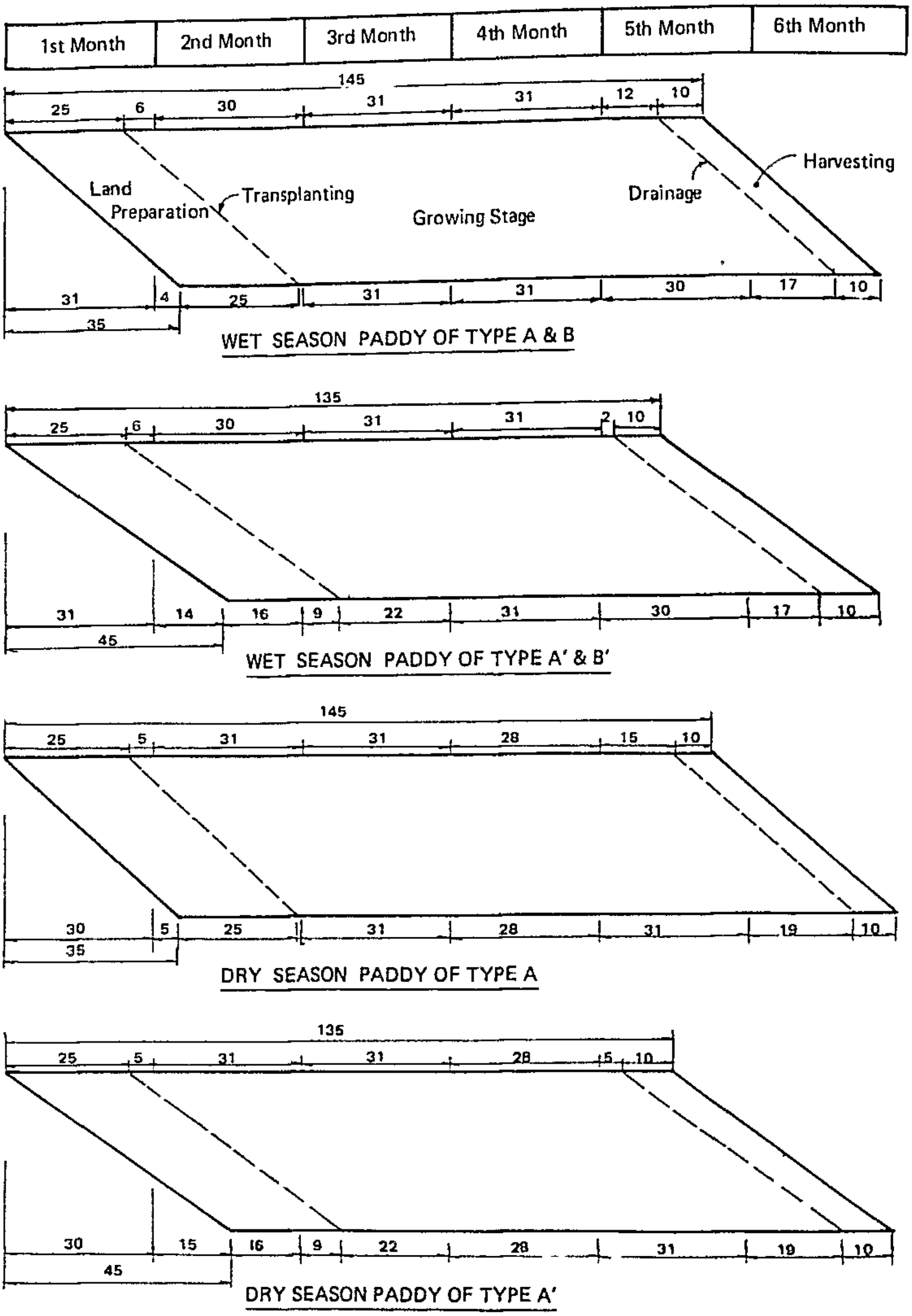


FIGURE D-6-1 PROPOSED CROPPING PATTERN

TABLE D-6-1 WATER REQUIREMENT BY MONTH AND CROP

(Unit: mm/day)

Cropping Pattern	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
PROME												
Wet S. paddy of type A	-	-	-	-	5.00	6.57	5.13	4.76	2.94	0.64	-	-
Wet S. paddy of type B	-	-	-	-	5.50	7.46	6.13	5.76	3.56	0.78	-	-
Dry S. paddy of type A	4.91	6.63	6.35	1.61	-	-	-	-	-	-	3.65	5.20
G. Nuts of type B	2.95	3.08	1.41	-	-	-	-	-	-	-	0.89	1.68
Beans (dry) of type B	3.26	2.97	0.77	-	-	-	-	-	-	-	0.89	1.68
THARRAWADDY												
Wet S. paddy of type A'	-	-	-	-	3.75	6.84	5.60	5.28	3.92	0.49	-	-
Wet S. paddy of type B'	-	-	-	-	4.14	7.73	6.57	6.28	4.62	0.60	-	-
Dry S. paddy of type A'	4.11	6.00	5.10	1.15	-	-	-	-	-	-	2.89	5.15
G. Nuts of type B'	2.38	2.70	1.30	-	-	-	-	-	-	-	0.81	1.49
Beans (dry) of type B'	2.63	2.45	0.71	-	-	-	-	-	-	-	0.81	1.49
HENZADA												
Wet S. paddy of type A'	-	-	-	-	3.41	6.37	4.64	4.55	3.22	0.48	-	-
Wet S. paddy of type B'	-	-	-	-	3.79	6.84	5.61	6.13	4.20	0.60	-	-
Dry S. paddy of type A'	4.11	5.50	4.59	0.93	-	-	-	-	-	-	2.89	5.15
G. Nuts of type B'	2.38	2.40	1.13	-	-	-	-	-	-	-	0.81	1.49
Beans (dry) of type B'	2.63	2.18	0.62	-	-	-	-	-	-	-	0.81	1.49

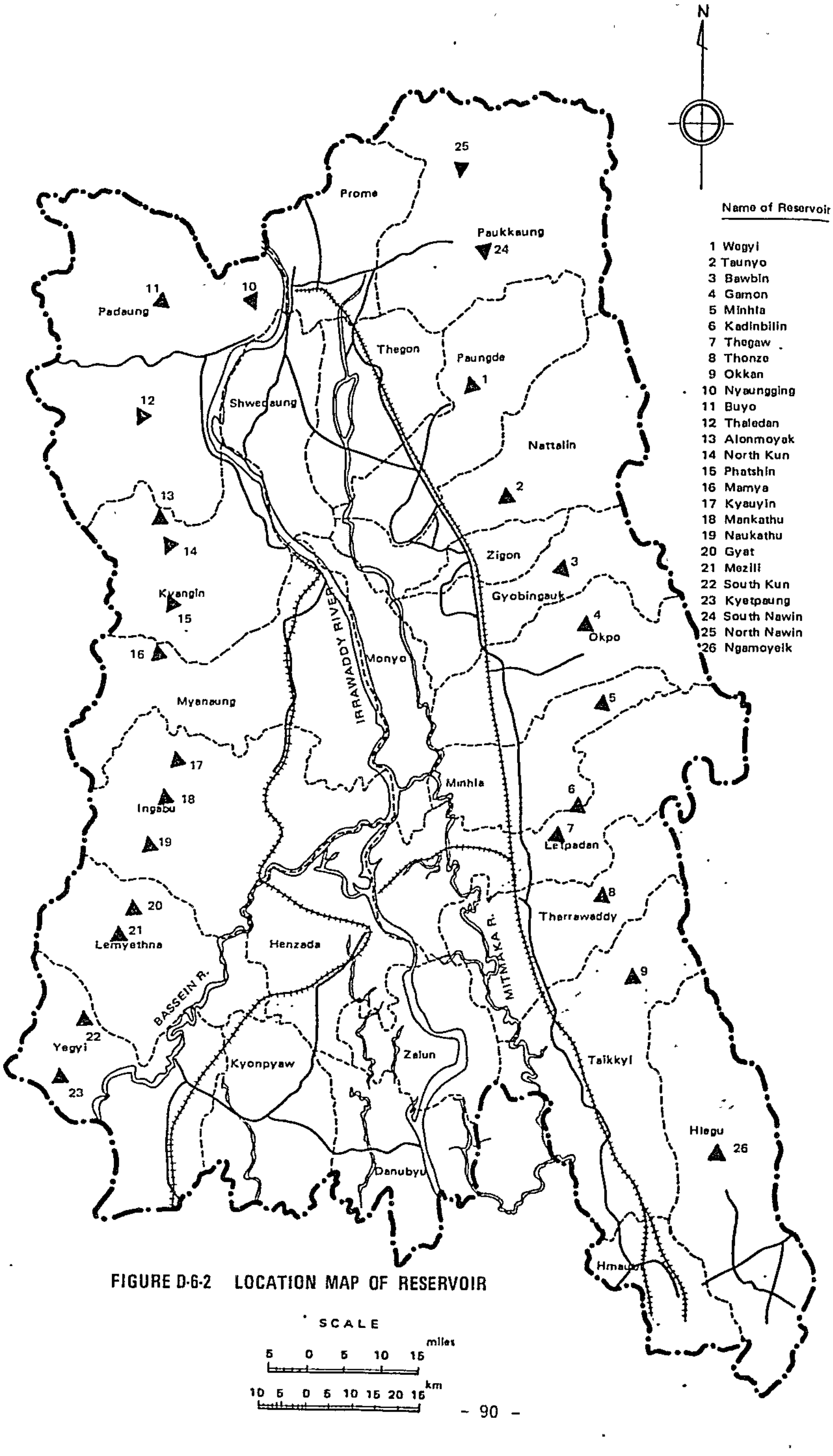


FIGURE D-6-2 LOCATION MAP OF RESERVOIR

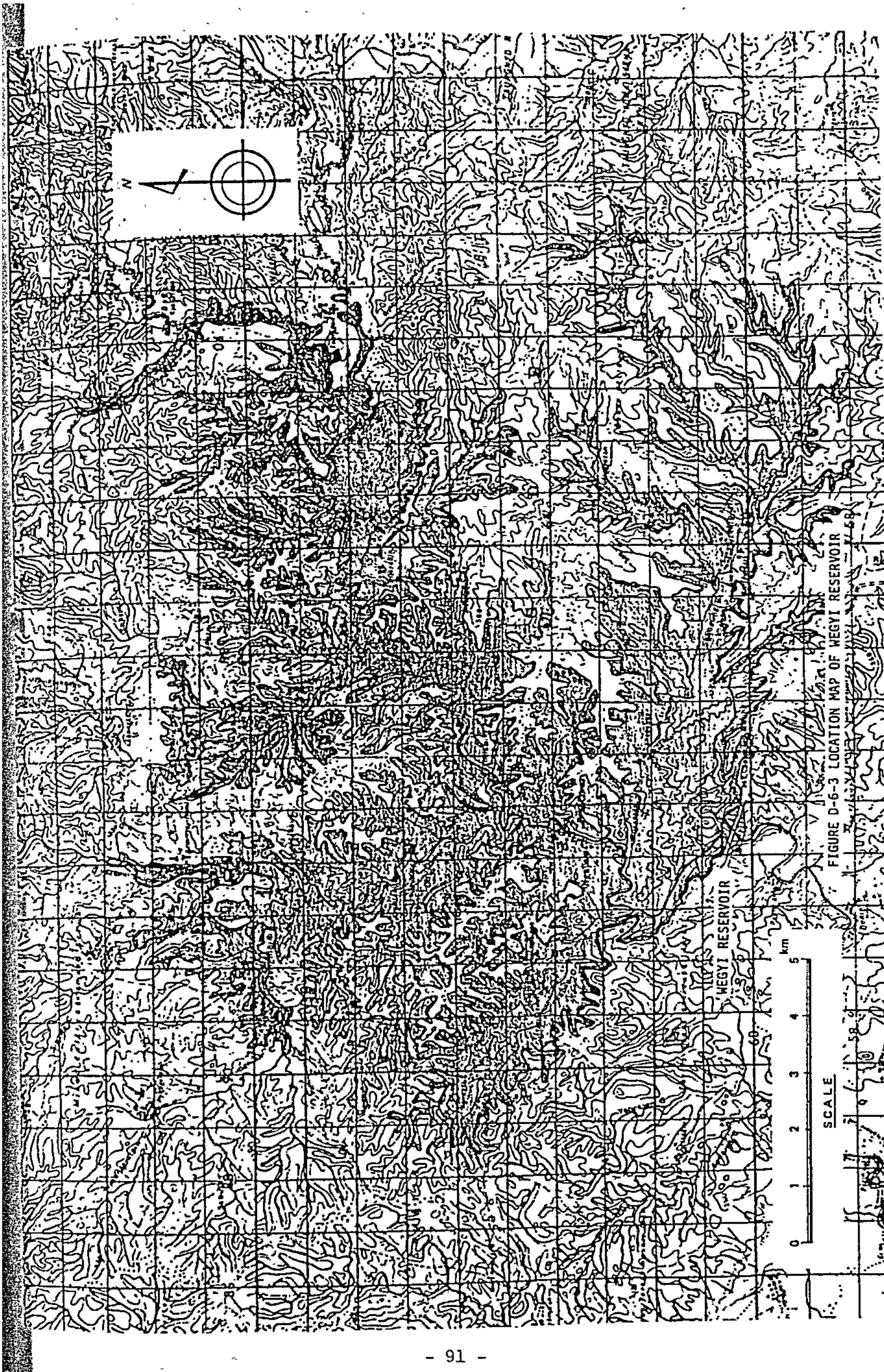


FIGURE D-6-3 LOCATION MAP OF WEGYI RESERVOIR

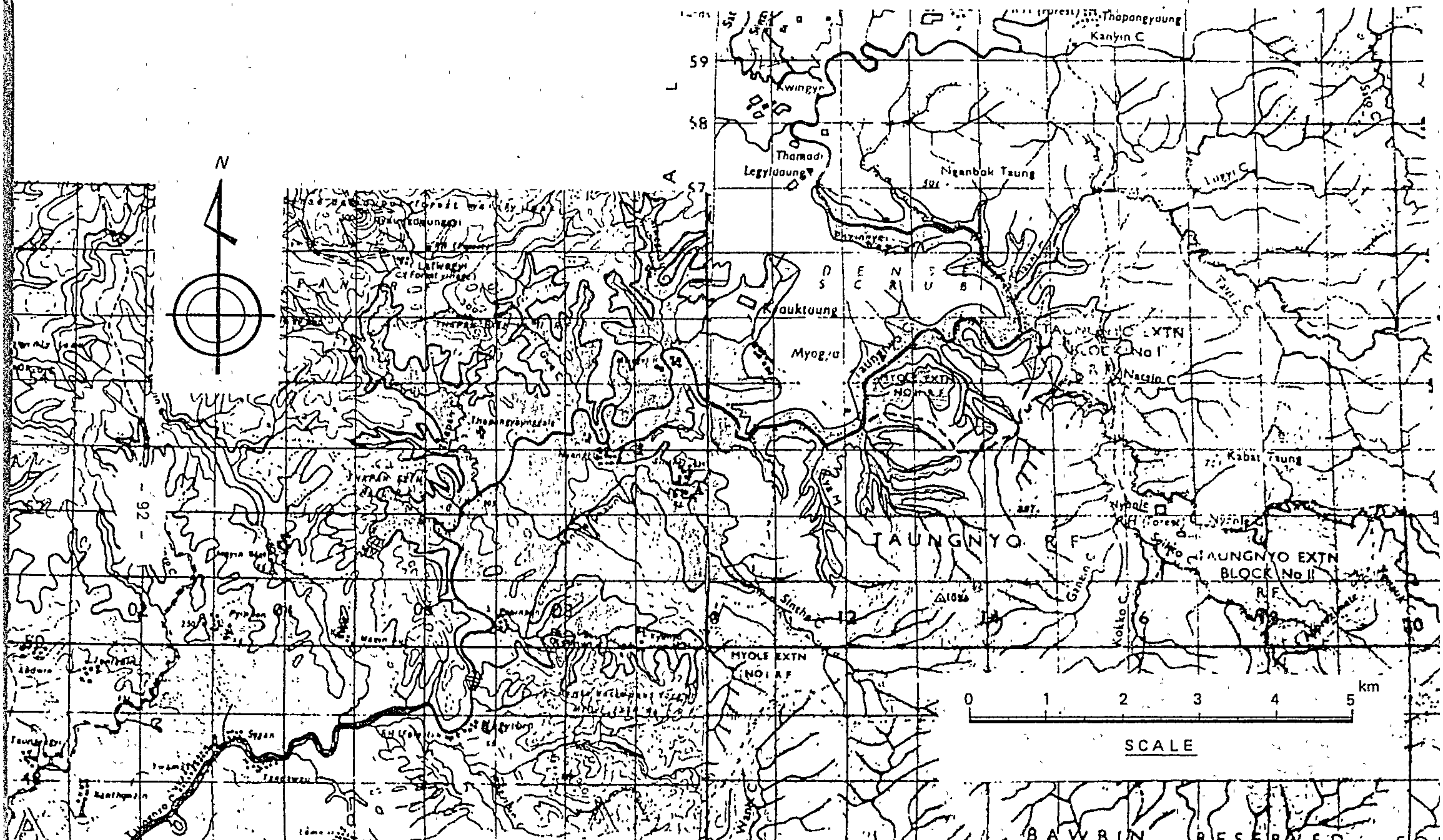


FIGURE D-6-4 LOCATION MAP OF TAUNYO RESERVOIR

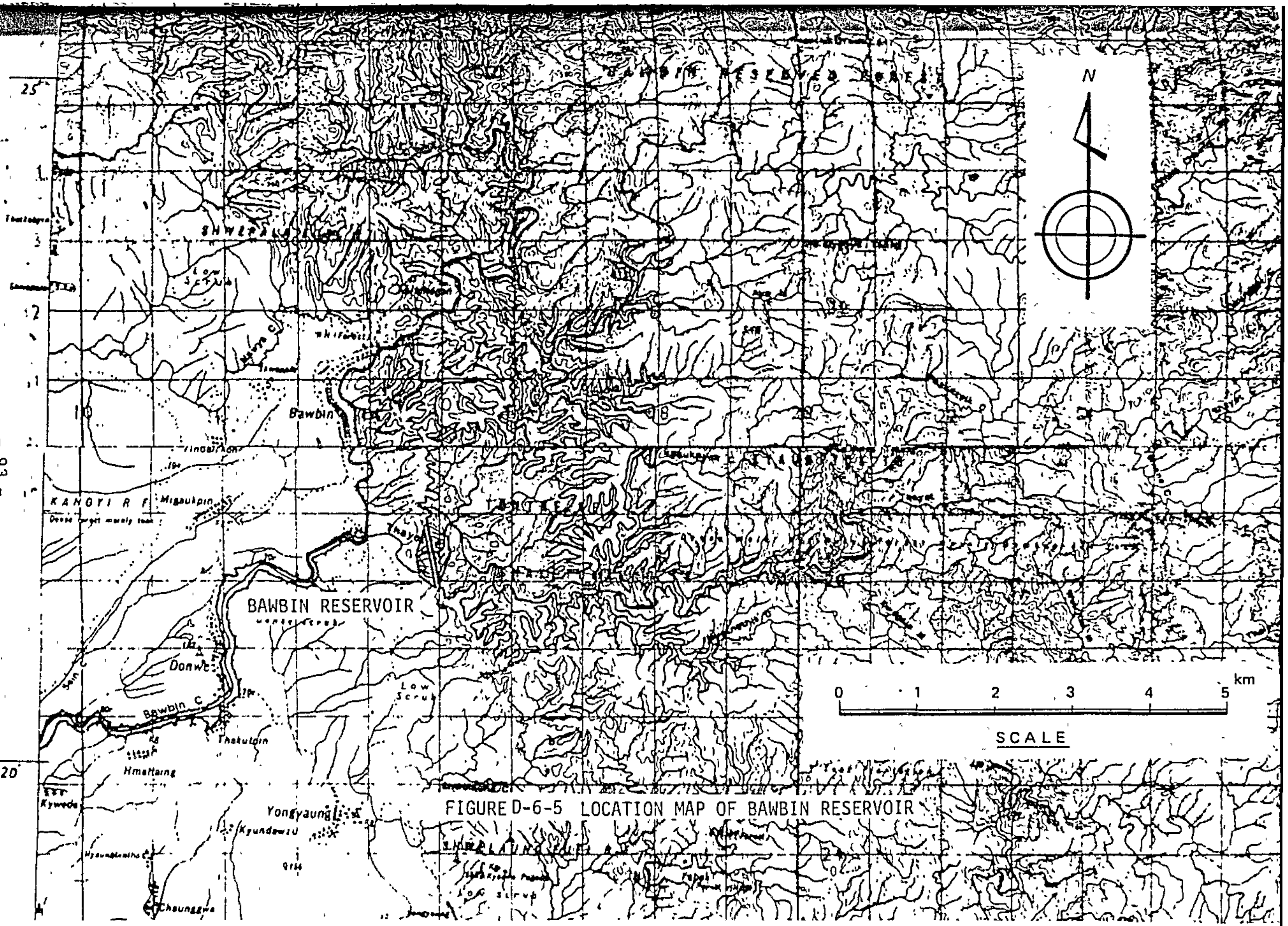


FIGURE D-6-5 LOCATION MAP OF BAWBIN RESERVOIR

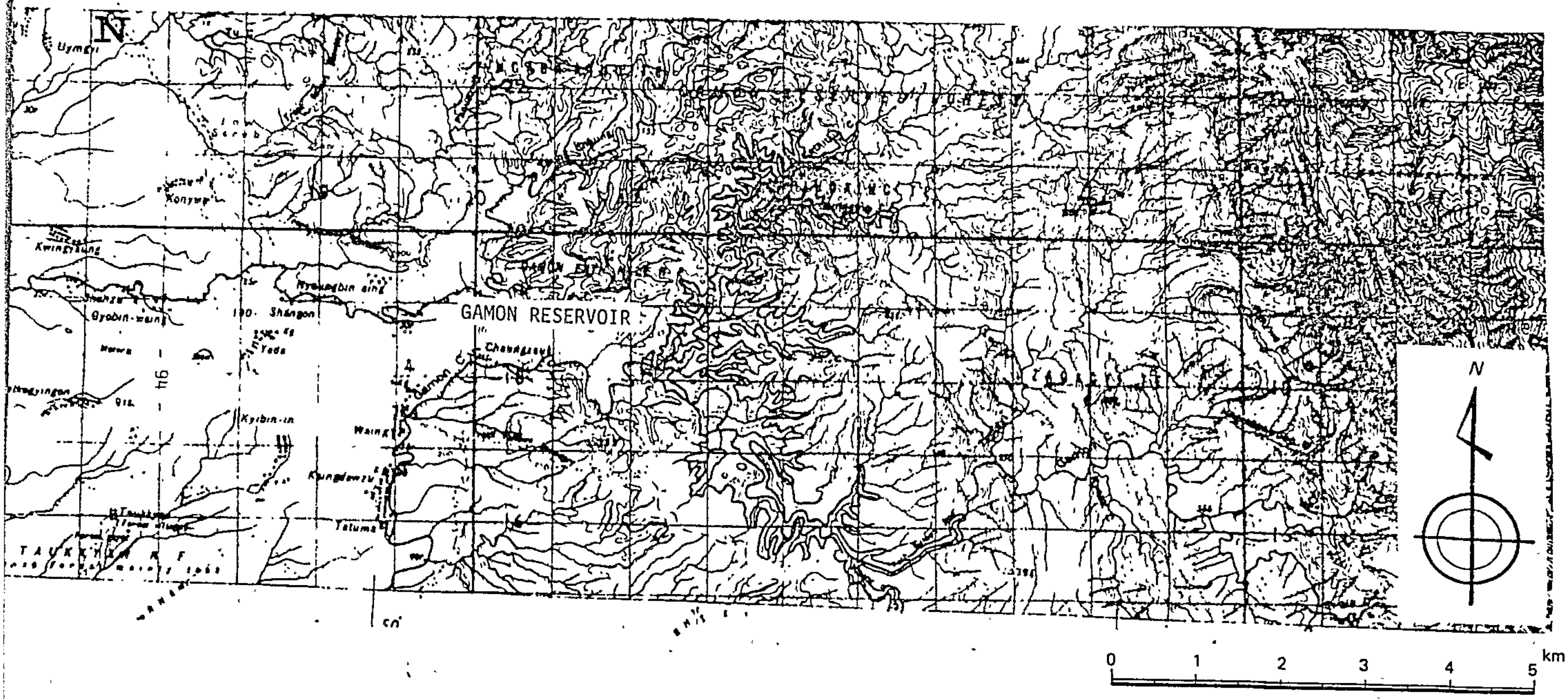


FIGURE D-6-6 LOCATION MAP OF GAMON RESERVOIR

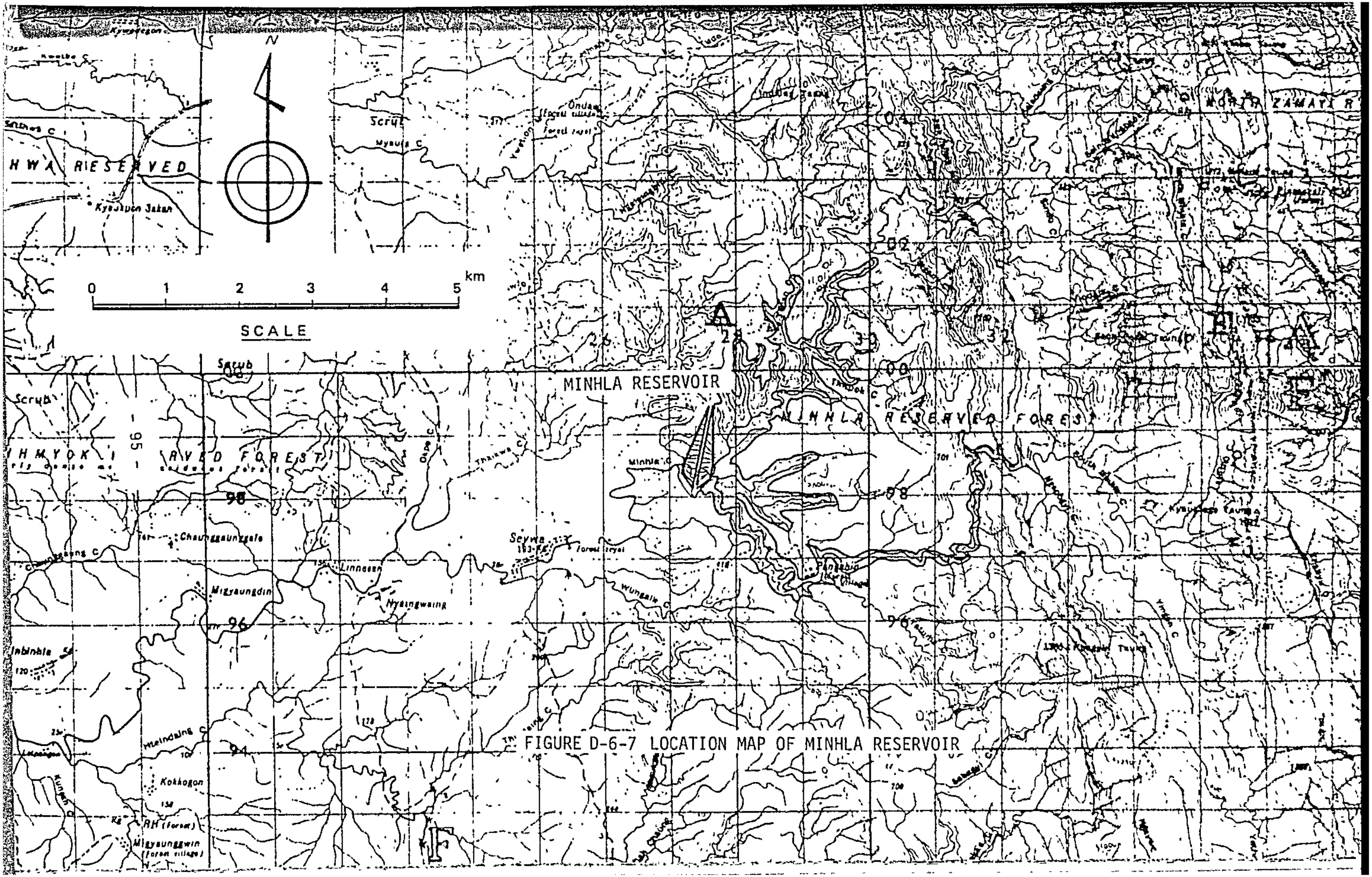


FIGURE D-6-7 LOCATION MAP OF MINHLA RESERVOIR