Name: Emilio B. Alvarez
Country: Republic of the Philippines
Organization Belonging:
Philippine Atomospheric Geophysical and Astronomical Services Administration (P. A. G. A. S. A.)
Position: Senior Meteorologist

GENERAL CONDITION OF MY COUNTRY

The Philippines is an archipelago of some 7,107 islands united by the sea. It is bounded in the North and West by the South China Sea and the coastal waters of Borneo. Its northern-most island Yami is 105 kilometers southeast of Taiwan, while its southern-most island Seluag is only 48 kilometers east of Borneo.

The Philippines is some 965 kilometers from the southeast coast of the Asia mainland, the neighbouring countries of the Philippines are Taiwan, China, and Japan in the North, Viet-Nam, Laos, Cambodia, Thailand and Malaysia in the South. The whole country is divided into 3 main island groups; Luzon in the north, Visayas in the central and Mindanaos, in the south.

The Philippines is located in the tropics, the climate over any particular place in the Philippines is due to its geographical location and the different wind systems that prevail over the locality during different times of the year. The prevailing wind systems over the Philippines are as follows;

a) The Northern (commonly known as the Northeast Monsoon) – prevail from November to February.
b) The Southeast Monsoon, which comes from the southeast prevails during the months of July, August and September.
c) The Trades (Trade Winds); the prevailing wind over the tropics. They generally come from the East. The Trades prevail during the rest of the year.

To mention a few of the numerous rivers in the Philippines namely: the Cagayan river, which is the longest river in the Philippines with length more than 500 kilometers, the Pampanga river, Pasig river, Marikina river and many others.

Larger portions of the lands are utilized in agricultural purposes. Many irrigation canals are constructed to cope with the needed amount of water in farming.

I know only three organizations which deals with water. First one is the local Waterworks and Utility Administration. Second one is the Metropolitan Waterworks and Sewage System. Both are in charge of water supply. Last one is the National Irrigation Administration (NIA) which by its name alone is self-explanatory.

COMPREHENSIVE FLOOD LOSS PREVENTION AND MANAGEMENT FOR THE MARIKINA RIVER BASIN (A PILOT PROJECT)

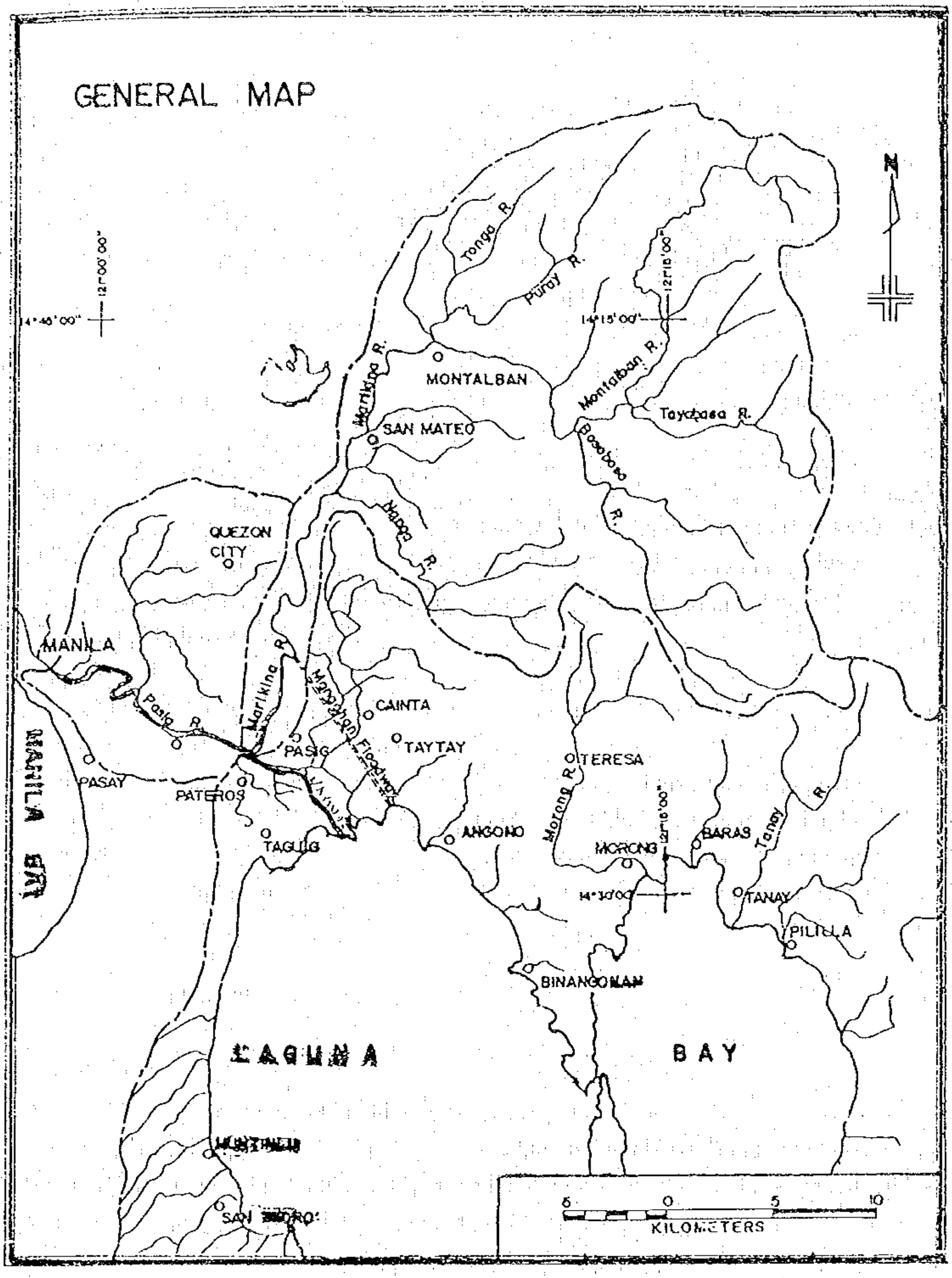
1.0 Introduction

The Marikina, Napindan, Pasig-Laguna de Bay river basin complex is located in the Southern Tagalog region, which also includes the metropolitan Manila area. The basin complex has an aggregate watershed area of about 4,000 km^2.

With the shift of location of the Government Center from Manila to Quezon City, rapid urbanization, economic growth is expected along the flood plains of the Marikina river and the lake shore area of the Bay. The agricultural requirement of the area is one of the largest in the country. Most industries will continue to be located in the urban areas that constitute their major market or point of transfer. Evidently, the Southern Tagalog region especially the Metropolitan Manila Area will continue to be the highest user of water for industrial use. Future water requirement for domestic and municipal use is projected to concentrate in the Metropolitan Manila area for which the water impounded in the Laguna de Bay shall be tapped.

With the industrial and agricultural development of the area is the consequent increase in population especially in the flood plains. Because of this, the occurrence and recurrence of floods pose a danger to life and property and constitute a definite set back to economic progress. Hence to offset and minimize the effect of this retrogressive factor, flood loss prevention and management becomes a necessity.

The selection of the Marikina river basin complex as a pilot project study will focus to town/city planners and proper authorities the environmental impact of a comprehensive flood loss prevention and management.


GENERAL MAP
MANILA
MANILA BAY
QUEZON CITY
PASAY
PATEROS
TAGUIG
PASIG
CAINTA
TAYTAY
ANGONO
TERESA
MORONG
BARAS
TANAY
PILILLA
BINANGONAN
MONTALBAN
SAN MATEO
LAGUNA
BAY
Pasig R.
Marikina R.
Nangka R.
Tonga R.
Puray R.
Montalban R.
Tayabasa R.
Boso-boso R.
Morong R.
Tanay R.
KILOMETERS

2.0 Outline of the Pilot Area

2.1.0 Topography

2.1.1 The Marikina River

The Marikina River located northeast of Manila flows northwesterly and then turns southwesterly in the vicinity of Montalban. The watershed draws an area of about 513 km^2 and is about equally divided in area between an upper and lower basin. The headwaters of the river are located in the western side of the Sierra Madre Mountain about 35 km northeast of Manila. At the town of Montalban, the river emerges from the foothills of the mountain range turning and flowing through the Marikina Valley until it joins the Pasting river. The upper basin above the Montalban gorge has rolling and rough terrain covered open grassland and scattered trees. Elevation rise from 40 m. at Montalban to 1,448 m at Mt. Irid on the eastern boundary of the watershed.

The lower basin watershed is a flat valley land spreading on either side of the bed of the river. Flood flows of the Marikina river cause some damage as the river meanders in its channel.

2.1.2 Laguna de Bay

The total watershed of Laguna de Bay located southeast of Manila is approximately 3,270 km^2 of which the lake itself occupies approximately 900 km^2 at mean sea elevation of 10.47 meters. The only outlet of the lake is via the Napindan Channel and the Pasig river. Since the outlet has a limited carrying capacity, the lake is a natural detention reservoir and rises during the rainy season from its low dry season elevation of about 10.5 m to as much as 14.03 m.

2.1.3 The Pasig River

The Pasig River with its course of approximately 17 km long flows northwesterly from Marikina–Napindan junction and empties into the Manila Bay passing through the Metropolitan Manila. The bankflow capacity of the Pasig River is insufficient to absorb the frequent Marikina flood flows during the ordinary stage of flow, the full discharge of the Marikina river goes into the Pasig river supplemented with the outflow from the Laguna lake. When the Marikina river is swollen, a large portion of its flow, goes into the lake by way of the Napindan, Pateros and Taguig rivers.

2.1.4 The Napindan River

The Napindan river, the only outlet of the Laguna de Bay rises and flows northwesterly from the Bay with its course of approximately 7 km long up to the Marikina–Napindan junction. The Napindan discharge varies corresponding to the stages of the Laguna de Bay and at the Marikina–Napindan junction or the Manila Bay.

2.2.0 Climate

The Marikina, Napindan, Pasig and Laguna de Bay river basin complex is characterized by two pronounced season; a dry season during the month of November through April and a wet season during the month of May through October. Annual rainfall ranges from 1,600 mm to 2,500 mm with an average rainfall of 2,250 mm. The temperature differentials are relatively small ranging from 25°C in January to 29°C in May with a daily mean of about 27°C. Relative humidity averages 80% during the year. An average of 11 tropical disturbances affects the area each year for which approximately 20–30% of all typhoon have precipitated as much as 1,150 mm in a single 24-hour period associated with extremely high wind velocities.

2.3.0 Socio-Economic Condition:

The province of Rizal exhibits the most spectacular industrial development among the provinces of the Philippines aside from being agriculturally developed. Industrial activity in the Southern Tagalog provinces is concentrated in Metropolitan Manila. The flood plain of the Marikina Valley is used primarily for rice and other agricultural activities, although urban sprawl from Manila is encroaching rapidly upon this agricultural land. The bed of the river is extensively mined for sand and gravel. The lake in utilized for fishing.

3.0 Description of Major Flood in the Past

3.1.0 Rainfall

Copious rainfall due to either tropical disturbances or intensification of the southwest monsoon is the primary cause of flooding in the area. The floods of 1970 and 1972 are discussed below.

3.1.1 Flood of 1970

During the period August to December 1970, sixteen (16) tropical disturbances entered the Philippine area of responsibility. The six disturbances that affected the area are:

Tropical Depression MIDING (31 Aug.–2 Sept.); Typhoon PITANG (Sept. 8–12); Typhhon SENING (Oct. 11–15); Tropical storm UDING (Oct. 24–27); Tropical storm WENING (Oct. 29–Nov. 4) and Typhhon YOLING (Nov. 17–20). Sening, Wening & Yoling passed over the basin.

Rainfall collected from eleven stations in the basin recorded for September and October are 5,389.8 mm and 5,444.2 mm respectively.

3.1.2 Flood of 1972

One of the most destructive floods to occur in the Philippines is the July – August flood of 1972. The flooding of Luzon was caused by the occurrence of several tropical disturbances in succession. Four (4) were attributable for the floods in the Marikina river complex; Typhoon KONSING (June 23–26); Typhoon GLORING (July 10–25); Tropical Depression ISANG (July 26–Aug. 1) and Tropical Depression LUSING (Aug. 10–13). From thirteen (13) rainfall stations, rainfall amount of 4,356.1 mm was recorded in June; 16,177.3 mm in July and 5,613.2 mm in August.

3.2.0 Water Stage

3.2.1 Sto. Nino Gaging Station

Along the Marikina river, flooding takes place when the river stage at upstream of the Rosario weir of the Mangahan Floodway rises above 17.70 m to 18.00 m and part of the Marikina Flood discharge which overflows the banks inundates the vast paddy field thereby. In 1970, Sto. Nino gaging station recorded a maximum reading of 20.48 m corresponding to s discharge value of 4,248,000 sec. liters in Sept. 2. In 1972, the same station recorded a stage of 18.05 m corresponding to a discharge of 1,964,000 sec. li. in August 1.

3.2.2 San Rafael Gaging Station

The gaging station at San Rafael recorded in Sept. 4, 1970 6.72 m (591,600 sec/liter) and in Aug. 1,1972, 6.62 m (569,400 sec/liters).

3.2.3 Laguna de Bay

Laguna de Bay stage traces a cyclic pattern. It starts rising in July up to its maximum stage in October to November and recedes to its minimum stage in June. In 1970 the recorded highest and lowest stage are 12.53 m, 10.40 m respectively; while in 1972 the highest stage was 14.03 and the lowest stage was 10.58. During the latter half of the dry season, the lake stages falls even below the sea level due to evaporation for exceeding the inflow into the lake. However, the minimum stage of the Bay seldom falls below 10.40 m on account of riverse flow of sea water from the Manila Bay through the Pasig and Napindan rivers.

3.3.0 Damages

3.3.1 Flood Loss of 1970

Based on the report on the survey and evaluation of flood damages caused by local storm run off and the overbank flow of the Pasig and Marikina river in 1970, the amount was estimated at ₱43,356,100. The amount is broken down to specific losses like: private properties ₱ 9.8M; public properties ₱ 1.1M; cost of relief ₱ 0.6M and indirect losses ₱ 32.3M. Indirect damages include: (1) estimated losses in profits incurred by commercial, industrial, and other business enterprises; (2) loss in man-hours resulting from interruption caused by floods; (3) cost of relief to flood sufferers, and (4) depreciation of properties. No attempt was made to evaluate the indirect losses caused by the effect of floods on public health.

3.3.2 Flood Loss of 1972

The flood of 1972 created a major disaster in the whole of Central Luzon prompting the President of the Philippines to declare a state of National Calamity in the affected areas. The southern Tagalog provinces were also affected. The National Disaster Control Commission confirmed the dealth of 430 persons which the National Economic Council estimated the damages at ₱ 736 Million for the whole of Luzon and part of Eastern Visayas. For the period July 26–28, Laguna, Rizal and other towns around Laguna Lake, losses on properties was estimated to be ₱60 Million.

4.0 Outline of Flood Control Plan

4.1.0

The plan contemplates the coordination of the Marikina, Napindan, Pasig, Laguna de Bay river complex though implementation of the Mangahan floodway and the Napindan Hydraulic Control Structure for flood control, irrigation, water supply and quality control of the lake water etc.

4.1.1 Mangahan Floodway

Generally, the Mangahan Floodway located at Rosario, Pasig, Rizal is to control the Marikina floods and protect Manila from being damaged. It is embodied to divert part of the Marikina flood discharge in excess of the bank flow capacity of the Pasig river directly into the Laguna de Bay. The Mangahan floodway now under construction is the most practical and economical solution to the overbarking problem of the Pasig river.

4.1.2 Napindan Hydraulic Control Structure

The structure now under construction, just upstream of the junction is mainly composed of the following structure; (a) gated dam equipped with four (4) steel roller type spillway gates, (b) navigation lock, (c) mooring facilities, (d) control tower and other structure to the project. It will be used to cut off the back flow of saline and polluted waters from the main Pasig river, especially during summer, when the lake level is lower than the high tide in the Manila Bay. It will also be used to regulate water supply and lake-shore flooding aspects. Operation will be in coordination with the Paranaque Spillway and Mangahan Floodway operations.

4.1.3 Paranaque Spillway

Detailed plans and tender documents for the construction of the Paranaque Spillway have been completed. The spillway is proposed as an additional outlet for Laguna de Bay to regulate the lake level and reduce flooding along the lakeshore areas.

EPP/EGS/zsa
2.19.80

Monthly Rainfall in the Marikina River Basin Complex for 1970 (in millimeters)

Station	August	September	October	November	December
1. Ambulong, Batangas	189.7	242.2	401.1	236.0	75.1
2. Cavinti, Laguna	199.9	162.4	598.1	539.5	–
3. Lumban, Laguna	63.8	412.0	1301.3	966.4	38.9
4. Los Baños, Laguna	128.0	294.5	560.4	414.0	13.1
5. Sta Cruz, Laguna	134.0	359.2	516.6	577.0	178.8
6. Alabang, Muntinlupa Rizal	222.9	395.0	277.7	400.8	66.0
7. BPI Cuyombay, Rizal	460.4	470.6	532.7	–	100.3
8. Angono, Rizal	274.6	654.9	313.3	427.6	59.3
9. Port Area, Manila	358.6	885.1	258.5	97.0	7.0
10. Diliman, Quezon City	514.5	872.9	436.0	–	–
11. IA, Pasay City	292.1	641.0	248.5	145.0	–
Total	2838.5	5389.8	5444.2	3803.3	538.5

Monthly Rainfall in the Marikina River Basin Complex for 1972 (in millimeters)

Station	June	July	August
1. Amadeo, Cavite	170.2	1204.7	189.8
2. Cavinti, Laguna	246.1	676.5	199.9
3. Lumban, Laguna	265.3	741.4	228.9
4. Los Baños, Laguna	333.9	810.8	321.2
5. Sta Cruz, Laguna	325.0	753.1	274.9
6. Sao Pedro, Laguna	257.9	1077.9	408.3
7. Alabang, Muntinlupa, Rizal	356.9	1169.9	400.1
8. Cuyambay, Tanay, Rizal	304.7	1382.9	659.0
9. Romarosa, Tanay Rizal	304.5	1383.2	668.7
10. Angono, Rizal	489.2	1534.6	539.0
11. Port Area, Manila	417.8	1742.8	535.1
12. Diliman, Quezon City	492.7	1885.3	583.7
13. IA, Pasay City	391.9	1814.2	604.6
Total	4356.1	16177.3	5613.2

DESCRIPTION OF PILOT RIVER BASIN

I. The Marikina River:

The Marikina Water Shed drains an area of about 506 sq.m., and is about equally divided in area between an upper and lower basin.

The headwaters of the river are located in the Western side of the Sierra Madre Mountains about 35 km. Northeast of Manila. At the town of Montalban, the River emerges from the Foothills of the mountain range turning and flowing through the Marikina Valley until it joins the Pasig River.

The watershed of the upper basin above the Montalban gorge has been established by a decree as a government reservation a future source for Domestic Water Supply of the Manila and Suburbs. This portion of the basin has rolling and rough terrain covered open grassland and scattered trees. Elevations rise from 40 meters at Montalban to 1,448 meters at Mt. Irid on the eastern boundary of the watershed.

The lower basin watershed is a flat valley land spreading on either side of the bed of the river. This land is used primarily for rice and other agricultural activities, although urban sprawl from Manila is encroaching rapidly upon this agricultural land. Flood flows of the Marikina River cause some damage as the river meaders in its channel. The bed of the river through this reach is extensively mined for sand and gravel.

The Marikina River is an unregulated streams. It contains a small dam at Wawa in the upper basin, but this reservoir does not influence the River's flood flows. Until it exists from the Sierra Mountains about 25 kms. Northeast of Marikina, the River is turbelent steep gradient stream. The Tanza and Purany Rivers join the Marikina just downstreams of WAWA DAM. For 16 kms. from downstreams of these junctures, the gradient flattens to about 1.8 meters/km. Below this gradient changes the river undergoes several transitions in channel characteristics from a wide flood plain type channel to a narrow confined channel where natural obstructions contain the River. In the lower reach of the river, the gradient decreases again from 1.0 meter/km./to 0.3 meter/km. The Bureau of Flood Control has estimated that under existing channel conditions, the maximum discharge capacity of the Marikina River with negligible resultant flood damage is about 2,000 cumecs.

The area is characterized by two pronounced seasons; a dry season during the month of November through April and a wet season during the month of May through October, the wet season can extend up to December. The normal annual rainfall in the Montalban area averages 3,174 mm. The temperature differentials (established from nearby Manila records) are relatively small. The daily mean for the year is about 27°C varying from a maximum of 29°C in May to a minimum of 25°C in January. Relative humidity is basically quite high, averaging about 80% during the year.

Approximately 20 to 30 percent of all typhoons have precipitated as much as 1,150 mm. in a single 24 hour period; coupled with the effect of extremely high winds velocities, this magnitude of rainfall has caused severe damage in terms of property and human life. An average of 11 typhoons pass over the area each year.

II. Hydrology:

Precipitation Data:

Referring to the Map-network of Hydrologic station of the study area as shown in the map, there are 17 rainfall stations and 13 gaging stations. Run-off data for Marikina Basin are available in 3 stations.

The gaging station (Staff Gage) at Sto. Niño on the Marikina River is the principal downstream station for this stream. The gage was installed in August 1958, and records with some breaks, have been collected since that date (as shown in plate III–3). From hydrologic point of view, significant problems exist with the data from this station. In addition to lack of continuity, the record is short for flood frequency analysis. (catchment area – 499 km^2).

The other long period of record maintained, on the Marikina River is at the gaging station at Wawa Dam Montalban, Rizal as the River leaves the upper basin. This station was installed in 1912, and measures the run-off from 282 sq.km.; or about one half the Marikina River Basin. (Period 1912–1936).

A staff gauge was installed in 1956 at San Rafael 1.5 km. downstreams of Wawa Dam (catchment area – 294 km^2). An automatic recorder was provided but it seldom in operation; gauge readings are made 2–3 times a day, but there are frequent interruptions in the records. The river bed is not particularly stable which results in frequent modifications of the rating curve for discharge lower than about $30 m^3/sec$. The records are more or less complete from April 1956 to December 1977.

III. Marikina Complex:

The Marikina River is a branch or tributary of the Pasig River. During the ordinary stage of flow, the full discharge of the Marikina River goes into the Pasig River supplemented with the outflow from the Laguna Lake. When the Marikina River is swollen, a large portion of its flow, goes into the lake by way of the Napindan, Pateros and Taguig Rivers. During big floods, more than 50% of the flood flow of the Marikina River, goes over bank. Of the discharge in the channel proper, reaching the junction at Pasig, about 60% at peak stage flows, into the lake thru the Napindan, Taguig and Pateros Rivers, and the remainders goes down to Pasig River to Manila Bay.

Flood Control Planning: (Structural Measures)

Flood control planning in Metro Manila and surrounding areas has seen some significant development in response to the very substantial damages caused by typhoon Didang in May 1975. The various studies and analyses that had been carried forward, to that date have since been firmly established in a project with various stages of implementation.

The first and foremost in relation to the Marikina and Laguna de Bay watersheds is the design and construction of the Mangahan Floodway. Further developments include the installation of hydraulic control structures on the Markina at Mangahan, and on the Napindan river at the junction with the Pasig and Marikina Rivers. By means of these works and installation, it will be possible to substantially reduce the damage caused by peak river flows of up to 1:100 years frequently.

Comprehensive Plan:

A) Marikina River:

A study of a multi-purpose Arch Dam in 1955 by an international board of consultants on high dams proposed for construction at the upstream edge of the Montalban gorge was fizzled out due to safety consideration because of the presence of a major fault intersecting the dam axis.

Recently, a move was made to review the study on this multi-purpose dam and now being under study by the PICOREM for single purpose only. (Presidential Inter-Agency Committee for the Re-Study of the Marikina River Project).

B) Laguna Lake

The total watershed of Laguna de Bay is approximately 3,270 sq.km. of which the lake itself occupies about 823 sq.km. at mean sea elevation, 10.47 meters. The lake has been utilized for fishing, whose only outlet is via the Napindan Channel and the Pasig River, serves as a natural detention reservoir. Since the outlet has a limited carrying capacity, the lake rises during the rainy season from its low dry-season elevation of about 10.5 m. to as much as 14.03 m. Elevation refer to a common datum 10.47 m. below.

C) Mangahan Floodway:

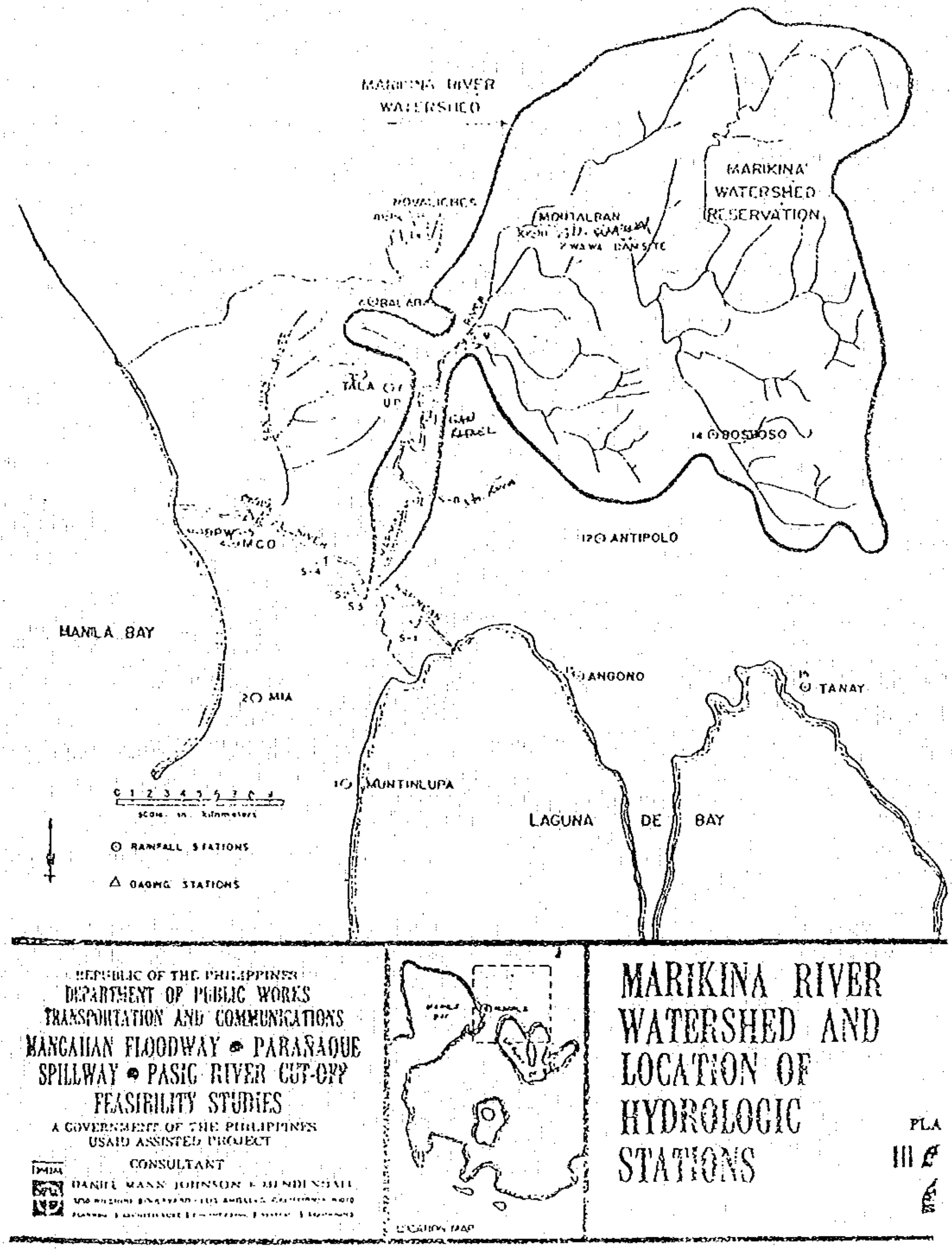
Now under construction, located at Mangahan, Pasig, Rizal, is the most practical and economical solution to the overbanking problem of the Pasig River. The floodway will control/limit the discharge flowing through Manila by diverting the excess floodwaters of the Marikina River to Laguna de Bay.

D) Napindan Hydraulic Control Structure:

Now under construction. This gate structure which will be located strategically at the Napindan River channel proper, just upstream of the junction, will cut off the back flows of saline and polluted waters from the main Pasig River, especially during the summer, when the lake level is lower than the high tide in the Manila Bay. It will also be used to regulate water supply and lakeshore flooding aspects. Operation will be in combination with the Parañaque, Spillway and Mangahan Floodway operations.

E) Parañaque Spillway:

The Parañaque Spillway is proposed as an additional Outlet for Laguna de Bay to regulate the lake level and reduce flooding along the lake foreshore areas. (Detailed plans and tender document for construction have been completed.)



MARIKINA RIVER WATERSHED
MARIKINA WATERSHED RESERVATION
NOVALICHES
MONTALBAN
WAWA DAM SITE
TALA
14 BOSOBOSO
12 ANTIPOLO
MANILA BAY
20 MIA
ANGONO
TANAY
10 MUNTINLUPA
LAGUNA DE BAY
S-1
S-3
S-4
RAINFALL STATIONS
GAGING STATIONS
REPUBLIC OF THE PHILIPPINES
DEPARTMENT OF PUBLIC WORKS
TRANSPORTATION AND COMMUNICATIONS
MANGAHAN FLOODWAY • PARAÑAQUE
SPILLWAY • PASIG RIVER CUT-OFF
FEASIBILITY STUDIES
A GOVERNMENT OF THE PHILIPPINES
USAID ASSISTED PROJECT
CONSULTANT
DANIEL MANN JOHNSON & MENDENHALL
LOCATION MAP
MARIKINA RIVER
WATERSHED AND
LOCATION OF
HYDROLOGIC
STATIONS
PLA

Geology

Three basic rock materials underlie the Manila area. The oldest formation, believed to be the basement rock, is the Guadalupe tuff formation. The youngest portion of this formation is located several meters from the existing ground surface in the tuff escarpment region and is on the order of 12 to 30 meters below the surface in the Marikina Valley area.

Sediments beneath the Marikina Valley contain near-shore marine fauna in the deeper strata overlain by thick non-marine sediments. Terraces along the eastern side of the valley and the existence of these marine sediments provide evidence of the VAlley's marine origins. The river bottom in the Marikina Valley consists of interbedded lenticular fluvial deposits consisting primarily of unconsolidated clays, silty sands and gravel.

Laguna de Bay was formerly a part of Manila Bay and was separated from it during quaternary times by movement along the Marikina fault. Vertical displacements along the fault is estimated to be 150 meters in the Pasig area. The fault scarp, comprised of tuff (called "adobe" in Philippine vernacular) constitutes the north-south trending ridge separating the lowlands of Laguna de Bay and Manila.

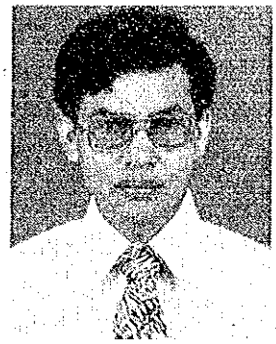
Structually, the Marikina Valley is a graven that is bounded by the north-east – trending normal faults extending from the rolling foothills of the Sierra Madre near Montalban southward to the lake. The Marikina River flows near the western escarpment of the Marikina fault.

There are two groups of faults found in the area. One has a strike in NNE – SSE and the other in NW – SE. The first one, called "Graben" faults are located along both sides of the alluvial plain, Marikina Valley, in a belt of about 3 km. in width running in the NNE – SSW direction. The latter group, designated as the Montalban faults, appear on the sides of Mt. Pamitinan and Mt. Haponang Banog, characterized by steep sections with horizontal displacements of approximately 600 meters between the beds in the both sides of the fault. This fault can easily be found geographically and geologically and the average strike is N50°W and the average dip is 70–75°NE.

A fault is also suspencted to exist on the left bank of the proposed reservoir, along the Marikina-Bosoboso River. The presumption is based on the observed difference of natural features of the left and right bank areas which share the border along the river.

Lapille tuff, a very hard and fine-to-medium ground tuff, is generally encountered at the riverbed level. The tuff layer extends to a depth of about 5 meters and is underlain by an interbedded silty and layer of about 1 meter in thickness. Below the sand layer, various types of tuff with interbedded tuffaceous shale and sandstone are found extending to the end of the borings which were taken up to 77 meters below, the surface. Overburden above the upper tuff with the river banks approximate 8 meters in height.

Name: Zulkefli Bin Hassan
Country: Malaysia
Organization: Drainage and Irrigation Department
Position: Resident Engineer



1. Introduction

Malaysia with a population of around 12 million people consists namely East Malaysia, a peninsular comprising of 11 states and West Malaysia comprising the states of Sabah and Sarawak.

The climate is characterized by a uniform temperature, high relative humidity, abundant but seasonal precipitation. By virtue of its geographical position and the meteorological pattern, Malaysia experiences two monsoon seasons namely the North-Easterly and South-Westerly monsoons. These monsoons especially the former often cause wide spread flooding and bring great economic and social impact to the people. Steps have been taken by the Malaysian Government to deal with major flood problems such as the establishment of a Permanent Flood Control Commission and the establishment of the Natural Disaster Relief Machinery.

Intermonsoon period, occurrence of intensive convective thunderstorms has frequently caused flash flood in urban areas especially in the capital city of Malaysia, Kuala Lumpur. This is because of rapid urbanization of the city itself and the bowl-like topographical section of the area. Several flood mitigation projects have been initiated at mitigating flood for towns prone to flooding.

2. Flood Forecasting & Warning System in Malaysia

2.1 Summary of Flood-prone Rivers and the Forecasting Methods

Major flood-prone rivers	Forecasting method
Perak River	Stage-correlation
Kalantan River	Sacramento
Trengganu River	Sacramento
Pahang River	Black–Box
Johore River	Black–Box

2.2 Flood Warning Facilities

i. Telemetric flood forecasting networks
See Appendix I.

ii. Siren system
These automatic flood warning devices are located at strategic locations such that once the rapidly rising river level reaches the danger point, a siren is automatically triggered off. This system is particularly useful when flush flood occurs at night.

iii. Flood warning board
This system gives the relationship between the local flood levels and the water levels observed at upstream.

3. Kelantan River in Lieu to Pilot River Basin

Since Malaysia does not have a pilot river designated for the comprehensive flood loss prevention study and as there is so much variation for each of the rivers mentioned in section 2.1. I would like to elaborate on the Kelantan River on the issues of topography, geology, meteorology, causes of flood, past floods and damages.

The Kelantan River Basin is located at the north-eastern corner of Peninsular and drains an area of 12,867 km^2. The total length of the river is about 250 km. The upland area of the Kelantan River Basin are rugged ranging in elevation from 1,000 to 1,500 meters. With peaks over 2,000 meters in the Central Range to the west and on the Pahang State Border in the south.

The river valleys in the basin lie generally between granite messes which form the more prominent mountain ranges bounding the Kelantan State and are occupied by sedimentally volcanic and metamorphic rocks.

The rain fall in Kelantan is influenced by altitude differences and the highest annual rainfall occurs on the coastal mountain ranges which intercept the north-easterly monsoon airstream. The maximum annual rainfall of about 3,400 mm occurs in these areas. Immediately inland of the coastal ranges the average rainfall drops to about 2,200–2,500 mm, because of a rain shadow effect. Average annual ranfall is about 2,700 mm.

Flooding on the plain is generated from two sources namely rainfall and oversill from the Kelantan River and Gdok River. Rainstorms on the plain and the run-off from the surrounding hills cause flood water to accumulate on the flood plain. The plain is characterized by very low lowland grades and inefficient natural drainage.

Annual flooding in the Kelantan River Basin occurs during the North-East Monsoon and it causes an estimated average annual loss of M$ 20 million, while occasional disastrous floods could cost over M$ 100 million and dislocate half of the population in the River Basin.

4. Overall Land Use in Malaysia in Flood-Prone Area and with Respect to Water Resources Development

See Appendix II.

NOTE:

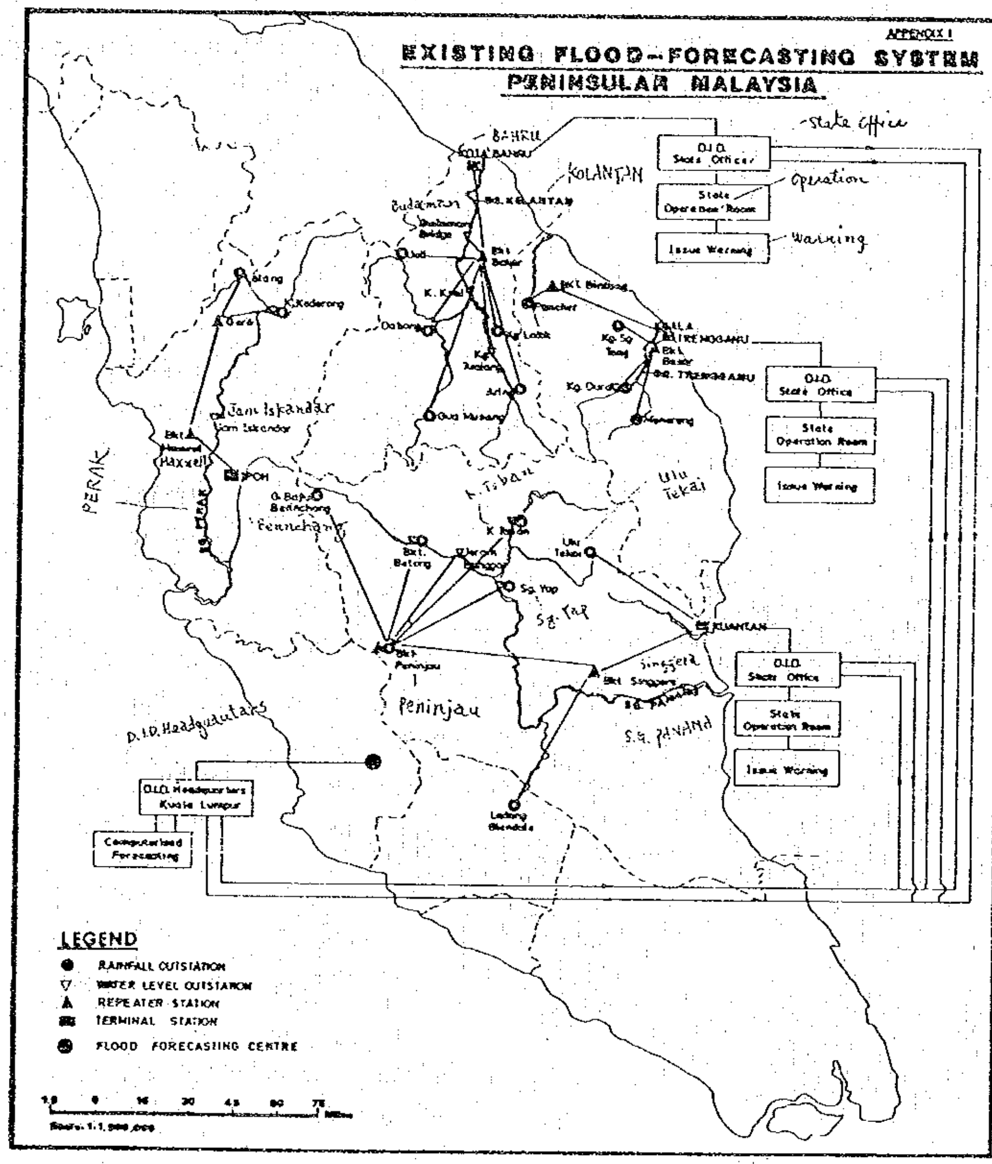
1. I am sorry for the improper layout of this report and the insufficient data and maps that are supposed to be presented. This is because of the very short notice given to me back in Malaysia.

2. In Malaysia we still do not have a Pilot River Basin.

3. Regarding the flood risk map, we do not make one.

4. We do not have a specific body/bodies dealing with Water Administration compared as that in Japan.

APPENDIX I


APPENDIX I
EXISTING FLOOD-FORECASTING SYSTEM
PENINSULAR MALAYSIA
D.I.D. State Office
State Operation Room
Issue Warning
D.I.D. Headquarters Kuala Lumpur
Computerised Forecasting
LEGEND
RAINFALL OUTSTATION
WATER LEVEL OUTSTATION
REPEATER STATION
TERMINAL STATION
FLOOD FORECASTING CENTRE
KUANTAN
IPOH
Bkt. Peninjau
Jam Iskandar
Haxwell
PERAK
KOLANTAN
Peninjau
D.I.D. Headquaters
S.G. PAHANG
Ulu Tekai
Singgera

APPENDIX II

Overall land use in Malaysia with respect to water resources development. The data is for 1975/1976 as the latest information for 1981/1982 is not yet released.

I. Water Resources Development

A. Irrigation and drainage

1. Land use

Arable land	(1000 ha)	530.8
Land under permanent crops and permanent meadows	(1000 ha)	2,536.4
Cultivated land under crops	(1000 ha)	3,013.5
Estimated total irrigable areas	(1000 ha)	982

2. Irrigated areas

Command irrigated area	(1000 ha)	443.0
Total irrigated area with assured water supply in wet season	(1000 ha)	320.2
Total irrigated areas of two crops a year with assured water supply	(1000 ha)	240.6
Total irrigated area of three crops a year with assured water supply	(1000 ha)	NIL

3. Average crop yields (paddy)

Irrigated area (wet season)	(tons/ha)	3.21
Irrigated area (dry season)	(tons/ha)	3.51

B. Flood control

1. Flood-prone areas and population

Flood-prone urban area	(1000 ha)	50
Flood-prone rural area	(1000 ha)	1,550
Urban population in flood-prone area	(1000)	180
Rural population in flood-prone area	(1000)	275

2. Flood damage

Lives lost

Damage in monetary terms, million local currency:–

crop losses		2
public works & utilities		0.2
property		0.1
others		0.1

3. Existing structural and non-structural flood control measures

Total effective storage capacity specifically for flood detention	(million cubic m)	NIL
Total length of dikes	(km)	405.73
Area of flood zoning	(1000 ha)	100.5
No. of basin with flood forecasting		5

C. Hydroelectric power

1. Existing power plants

a. Reservoir type		
– Installed capacity	(1000 kw)	277
– Annual electricity generation	(10^6 kwh)	1,010
b. Run-of-river type		
– Installed capacity	(1000 kw)	20.4
– Annual electricity generation	(10^6 kwh)	103.2

2. Estimated hydro potential (including existing plants)

a. Technical potential		
– Estimated capacity	(1000 kw)	23,380
– Average annual electricity generation	(10^6 kwh)	123,000
b. Economic potential		
– Estimated capacity	(1000 kw)	2,190
– Average annual electricity generation	(10^6 kwh)	7,960

D. Urban and rural water supply

1. Existing urban waterworks

Total production capacity	(cu.m/day)	795,000
Annual production	(million cu.m)	290
Total urban population	(1000)	3,460
Total urban population served from house connexions	(1000)	2,810

Total urban population supplied from public outlets	(1000)	320
Range of water charges	(M$/cu.m)	$(0.13–0.53)

2. Existing rural waterworks

Total production capacity	(cu.m/day)	429,000
Annual production	(million cu.m)	157
Total rural population	(1000)	8,480
Total rural population with easy access to safe water	(1000)	4,180
Range of water charges	(M$/cu.m)	$(0.13–0.44)

II. Public Capital Expenditure and Reimbursement Policy

A. Total investment in public water resources projects, million local currency:–

Irrigation & drainage	51.88
Flood control	4.05
Hydroelectric power	61.7
Urban water supply	47
Rural water supply	20.94

B. Policy or practice concerning reimbursement of capital cost by direct beneficiaries

1. Major irrigation & drainage project

Percentage of capital cost to be repaid	NIL
Interest	NIL

2. Minor irrigation & drainage project

Percentage of capital cost to be repaid	NIL
Interest	NIL

3. Urban water supply projects

Percentage of capital cost to be repaid	90
Interest	7 1/2%

4. Rural water supply projects

Percentage of capital cost to be repaid	NIL
Interest	NIL

揚子江の洪水防禦

林　万泉

翻訳：山本晃一
　　　末次忠司

1　自然条件と洪水防禦

中国はアジア大陸の東に位置し，その総面積は，約９６０万k㎡である。中国の国土は高緯度から低緯度に及ぶ地域にまで拡がっている。

中国には非常に多数の河川がある。そしてその中で１,０００k㎡以上の流域を持つものは1,500を超え，その中でも揚子江，黄河，Haihe，Zhujiang，Lioohe，Shonghua川ははるかに大きな流域を有する河川である。これらの河川によって供給される水資源は莫大であり，平常年で総流出量２７億㎥，水力発電5.8億kWである。

中国は広大な国である。年間の気候変化は，季節変化と良く適合しており，南西モンスーンによる降雨の影響で湿潤であり，冬期は，北西からの冷たい気流の影響で乾燥している。平常年の年間総雨量は，全土で６兆３２０億㎥であり，これは６３０㎜の降雨量に相当する。しかし，降雨量は単に地理上の位置によって大きく変化するばかりでなく，季節や年によっても大きく変化する。通常年における東南沿岸の総降水量は１,６００㎜を超え，北西方向に徐々に降水量は減少し，北西部では２００㎜以下になってしまう。出水期（７～９月）の降雨は，通常総降雨量の５０％を超え，しばしば，洪水や内水を引き起す。一方，北西太平洋で発生した台風は，中国の気候や暴風雨に大きな影響を与える。

１９４９年から１９７９年の３１年間の統計資料によると，西太平洋（南シナ海を含む）に８８２個の台風が発生し，そのうち２１０個，年平均して，７個の台風が中国沿岸に上陸した。１９６１年には，１１個の台風が上陸したが，１９５０年には３個しか上陸しなかった。上陸した台風は，しばしば，近辺の地域に悲惨な結果，重大な損害を与える。上陸した台風の約３５％は，内陸深く侵入し，しばしば異常な暴風雨を引き起す。

解放以前の歴史文献に依れば，中国でB.C.２０６年からA.D.１９４９年の２１５５年間に，大災害をもたらした大出水は１０２９回であった。これは平均して，２年に１回の割合で被害をもたらす出水があったことになる。上流域では，洪水防禦のために，２，３の土木工事が行なわれたにすぎず，提防はあっても小さく，かつ，中流域では適切な維持管理を行なわずに，洪水を防ぐことができなかった為，下流域では，洪水の流下能力が不十分となり，その結果，たびたび水害が発生した。

新生中国の成立以来，多数の水プロジェクトが中国人の手によって始められ，旧提の改築や水路の掘削，上流域では，防災調節池や貯水池が建設され，中流域では，洪水防禦のたゆの分水路を建設し，下流域では，洪水疎通能力の拡大工事等，多数の土木工事が為されてきた。今日までに，貯水池の総貯水容量は，４０８１億㎥に達し，提防の総延長は，解放後の４2,000㎞から１６５,０００㎞にまで延長された。これらのプロジェクトの完成は，洪水防禦，湛水地

域からの排水，渇水対策に多大の貢献を為した。更に，水力発電・航路維持・漁業等にも大きな利益をもたらした。

現在，中国の河川改修では前述した7大河川で，50年に1回起る洪水に対処する事が目標とされ，更に，異常洪水に対して，各地方で洪水対策に目が注がれる様になっている。

中国における洪水防禦の根本原理は，以下の通りである。………上流と下流の両方に目を配り，洪水を遅らすことと，洪水を流下させる二つの方法をうまく組合わせること………

洪水防御工事における我々の方針は，………防禦は補修よりも良策であり，早急な災害復旧よりも重要である。………

2　水管理に関わる組織

洪水防禦を行なうことは，流域に住む人々の生命や財産・国家の経済に最も重要な関係があり，中国政府はこの事にかなりの重要性を置いてきた。中国政府に水保全・電力省が設立され，水管理の責任を負っている。同様な組織が，各省・地区に組織された。これに加えて，河川流域にも組織が設立された。この組織が，計画・設計・施工等に責任を負っている。

中央政府によって，「洪水防禦指令部」が設立され，この指令部が，各地方の洪水禦御工事の指導に責任を負っている。各省・地方では，それとは異なったレベルで，洪水防禦工事の指導に責任を負う様に，洪水防禦指令部が設立された。

3　揚子江の洪水防禦の概要

中国には，非常に多数の河川が在るので，洪水防禦工事は，非常に幅広く貢献している。計画されている様に，河川の特性によって，河川改修の目的と洪水防禦工事とは全く異なっている。

揚子江の洪水防禦の概要は，以下の様なものである。

揚子紅はSinhai－Tibet高原を源とし，上海で東シナ海に注ぎ込む河道長6,300㎞，流域面積180万㎢の河川である。海への年平均流出量は，約1兆㎥である。標高差（源頭部と海）は約5,400m，発電能力は約2.68億kWである。Yichang（宜昌）より上流は，上流域と呼ばれ，Yichangより上流の河道長は4,500㎞以上，流域面積は100万㎢である。中流域と呼ばれるYichangとHukou（湖口）との間は，900㎞以上である。Hukouより下流は，下流域と呼ばれ，長さ800㎞以上である。そして，中・下流域の総流域面積は80万㎢である。

流域の地形特性は，流域面積のうち山岳地域が65.6%，丘陵地域が24%，平野と湖が

１０.４％である。全流域の平均年降水量は約1,１００㎜であり，流域の大部分が1,０００㎜を超えている。年平均流出量は，Yichang（宜昌）およびDatung観測点で，各々4,５１０億㎥，9,１５０億㎥である。（これは，年平均流量で１4,３００㎥／s，２9,０００㎥／sに相当する）。

１９７８年の統計に依ると，揚子江流域の総人口は，３億4,２００万人，耕地は3.７４億畝（約2,５００万ha）である。揚子江流域では，中国の全穀物生産量の約７０％を生産している。また，森林・鉱物資源も非常に豊富である。交通も大部分の流域で便利である。工業生産量は，中国の総生産量の約４０％に達する。以上の様に，揚子江流域は中国の経済発展において，非常に重要な位置を占めている。しかし，流域の大部分，特に肥沃で豊かな平野地帯は，依然，洪水に脅かされている。それ故，現在，洪水制禦は流域で重要，かつ，重も緊急な問題となっている。

洪水に最も脅かされている地域は，揚子江本川の中・下流域および支川の平野部，平野をとりまく低い段丘である。

揚子江の中・下流域の洪水制禦に関して，最も危険，かつ，重要な区間は，ZhichengからChenglingji間のJingjjang区間である。（揚子江中流域の水系図・提防図参照のこと）

Jingjiang区間の流出は，主として，Yiehang（宜昌）より上流の揚子江本川からである。

平年の洪水流量は，約5,０００㎥／sであるが，１９５４年には６6,８００㎥／sに達した。

揚子江流域は，西太平洋に発生した亜熱帯高気圧とインド洋のベンガル湾から補給された湿気によって，４月９月にかけて，洪水期となる。雨量は揚子江上・中流域で多く，年平均1,000～1,２００㎜程度で，最多雨量は1,６００㎜に達する。洪水期の雨量は，通常，年間総雨量の７５％以上を占め，しばしば，中・下流域に大洪水をもたらす。

歴史記録に依ると，過去2,０００年間，約２００回以上洪水が生じている（１０年に１回程度）。解放以前，揚子江の中・下流域の提防では，ほとんど洪水防禦工事は為されず，提防も小さく，多くの弱点があった為に，洪水を防ぐことはできなかった。

例えば，１９３１年の洪水（Yichang（宜昌）の量水所で，ピーク流量６3,６００㎥／s）では，提防はJingjiang区間で破堤し，耕地の浸水面積は５千万畝（３３０万ha），被災者約３千万人，死者１４万５千人に達した。このとき，Wuhan市（武漢）は，約３ケ月も水に漬かった。１９３５年のWuhanの洪水は，１４万２千人の死者を出し，２2.６４畝の耕地を浸水させ，1,００３万人の住民に影響を与えた。

新生中国の建国以来，中国政府はJingjiang区間の洪水防禦に多大の注意を払ってきた。Jingjiang区間の洪水防御能力は全く変わった。治水の根本原則は，次の様に決定された……

貯留と放流の両者を考慮すること，ただし，先ず番一には放流を考えよ………

１９５４年の洪水は，１９３１年の洪水より，水位が高く，また流量も多かったが，提防が強化されており，また，多少嵩上げされていたこと，Jingjiang遊水池の様な遊水池計画が完成していたこと，それに加えて，流域に住む多数の住民の水防活動によって，被害は大いに軽減され，多数の大・中都市と広大な農地が洪水から守られた。

１９８１年７月，揚子江上流の広い流域に，歴史的に見ても記録的な豪雨が発生した。降雨強度が３日間，５０㎜を超えた流域は約３４万㎢にも及んだ。最大降雨量は４３９.６㎜であった。これは１９５６年に洪水をもたらした降雨より，３日雨量で６０㎜も多かった。Yichang（宜昌）のピーク流量は７１,０００㎥／sに達し，これは１９５４年の洪水より4,２００㎥/sも多かった。この大出水の原因は，主として，次の様なことである。

(1) 気圧の谷が，東へ速いスピードで移動し，かつ，かなりの高さまで広がった。

(2) 北方の非常に冷たい気流が，Sichan地区上空を移動した。

(3) 西太平洋の亜熱帯高気圧の勢力が，強く，安定した。

(3) 南西にあった飛行機雲が，高度３千ｍに達した。

(5) インドにあった気圧の谷が，北方にそれて，勢力が強くなった。

以上の様な時期である。

中国政府（中央省庁から地方部局，各レベルの洪水防御指令部）は，直ちに広範に準備を整えた。気象，水文，交通部局等は互いに協力しあった。官庁によって，指揮された強力な提防防禦隊は，揚子江の中・下流域の提防に集められた。その結果，主要な提防はピーク流量を安全に流下させることができた。

4 揚子江における洪水防禦計画と工事

(1) 提　　防

過去３０年間で，大部分の提防は修復され，土工量7,８００万㎥，５９７万㎥の石工量にも達した。現在，提防高は過去の最高水位より1.０ｍ以上高い。提防の断面は，頂幅８～３０ｍ，表法勾配が３～５割，裏法勾配が３割である。

(2) 洪水の分流と遊水地

早くも１９５２年には，Jingjiang遊水池が建設された。

この工事は３月に始まり，同年７月に完成した，要した日数は７５日であった。このプロジェクトは，次の様な内容からなる。

(a) 水　　　門

全長1,054mの鉄筋コンクリート水門が作られた。

この水門の計画流量は8,000m^3/sである。

(b) 提　　　防

遊水池周囲の提紡総延長は，208kmである。

(c) 避難区域

遊水池の中に，総面積20.6km^2の避難域および盛土区域が作られた，これは，湛水時における住民の一時的な避難場となるものである。

(d) 排水設備

局所降雨による内水，および，分流された外水を排除する為に，2つの排水門と電力によるポンプ排水機場が建設された。総排水能力は700m^3/sである。

1954年，揚子江に100年確率の大出水が起った。分水門は，Jingjiang地区の提防を守る為に，余剰水を分水する操作を3回行なった。分水中，Shashi市の最高水位は，約1mほど低くなった。洪水防禦工事の効果が，大きかったことを証明することになった。

1956年，HanjiangのDujiatai遊水計画が完成し，その後も他のプロジェクトが，続々と完成されていった。

(3) 人工的なショートカット

Jingjiang区間の下流部は，典型的な蛇行河川で，また，下流の流下能力も小さい為に，水路の移動が激しく，しばしば，自然のショートカットが起こり，また提防の側岸侵食が進んだ。

新生中国の建設当初，Jingjiang区間の下流部における一連の人工的ショートカットに関する研究が始められた。詳細な比較検討の後に，一連のショートカットの計画が作成された。即ち，2つの人工的ショートカット（ZhongzouziとShagehewan）が，1966，1968年に完成された。

人工的ショートカットの完成によって，流れの変更は満足のいくものとなり，水文状況が異なっても特に大出水時にも，顕著な効果を挙げることができた。洪水制御に関しては，ショートカット以降，上流の洪水時の水位は低下し，その結果，Jingjiang上流の河川提防沿いの地域は，洪水に依る被害を減少させることができた。この捷水路および護岸工事の完成後は，河川は安定し，提防・農地の潰廃に依る悲惨は過去のものとなり，現在，農業生産の増進にとって好ましい方向に変ってきた。

(4) 貯水池および三峡担プロジェクト

洪水調節池に関しては，Hanjiang川にDanjiangkou 貯水池（貯水容量３０億m^3），Zishui川にZhaxi貯水池（１０億m^3）を建設した。これらの貯水池は，現在，洪水制禦に重要な役割を果たしている。

現在，三峡担プロジェクトが計画中であるが，今や着工直前である。このプロジェクトの完成後は，３７０億m^3の治水容量を有するダム貯水池が出現することになる。これによって，揚子江の中・下流域の洪水制禦問題が解決され，特にJingjiang区間の提防の安全性に決定的な役割を果たそう。

5 洪水予報システムと情報伝達

洪水制禦工事を含む洪水防禦プロジェクトの完成は，洪水制禦に決定的な役割を演じてきたが，完全な洪水予報体制と正確な予測は，また洪水制禦の面で重要な位置を占めてきた。

１９４９年以前は，揚子江沿いには，水文予測の部署もまた，それに関する専門家もいなかった。

１９４９年以来，水保全省の指導で，水文局が１９５２年１０月に設立された。揚子江流域計画公社（Y.V.P.O.）を助ける水文局，水文部が相次いで設立され，揚子江流域の水文および気象予報に責任を負うことになった。

Y.V.P.O.の水文局のもとに，２，３の中央部局が設置された。それらはChongqin，Yichang（宜昌），Hankou（湖口），Nanjing支局等である。各々の支局は，気象観測所，水位観測所と河川調査部を持っている。それと同時に，Y.V.P.O.の水文局は，水分予報課と気象予報課を整理統合した。

新中国の建立当初，外国から学んだ洪水予測手法を基礎として，水位相関と洪水追跡法によって，揚子江本川で洪水予測が始められた。正確な判断と正確な洪水予測は，Jingjiang遊水池の水門操作に応用され，０９５４年の洪水では，非常に良い結果を得ることができた。

洪水予測には，自然状態の最高水位，流量ハイドログラフを予測るのみならず，揚子江沿いの遊水・貯水区域において，合理的な遊水池の水門操作および貯水池の操作の問題に取り組むことが要求された。連続した貯水池，湖を最適に操作するスケジュールが開発され，操作による下流への影響，洪水調節の予測に応用される様になった，これらによってJingjiangの提防と重要な都市が安全に守られる様になった。

Y.V.P.O.の予測サービス，水文予測と気象予測の統合によって，揚子江中・下流域に現れると予測される異常洪水の予測情報を提供している。Yichang（宜昌）の水位，観測所での最大

量が１９８１年７月７１,０００㎥／sになったとき，すでに，その５日前に予測サービス部はピーク流量を正確に予測でき，その予測精度は，わずか1.5％であった。Shichuan（四川）省における最大流量の特性と，中・下流域への影響が予測された。その結果，中国政府は一連の正確な対策を取ることができ，洪水との闘いに勝利を得た。

過去３１年の洪水防禦の闘いに，多大な成功を収めてきたが，大出水時には十分な洪水防禦ができない多数の河川がまだ残っており，また，人間活動によって生じた危険な状況が，中小洪水の場合においてでさえ生じようとしている。将来の洪水防禦に関しては，すべての河川を安全にするという長期的な作業が依然残されている。