By: Abdul Aziz
Indonesia

1. Country: Indonesia

2. Designated river basin: Bah Bolon River Basin 1500 sq. km., five tributary streams, namely, Bah Binaman, Bah Biak, Bah During, Bah Tanggaran and Bah Boluk.

2.1 Location:

The Bah Bolon river basin is situated at the northern area of North Sumatra island, between 2°50' to 3°31' North latitude and 98°35' to 99°30' East longitude.

2.2 General description of the basin

i) Topography and geology

The Bah Bolon river has its origin in the Bukit barisan mountain and flows toward the north coast to fall into the strait of Malacca. The river covers about 90 km of length at Tanjung Muda where it divides into two branch rivers, namely Gambus, which is 25 km long. Another river, Sipare-pare takes off from left bank of Tanjung river and has a length at 28 km. These rivers form an alluvial delta of about 100 sq. km. area and subsequent fall into the strait of Malacca.

The river basin has 17,954 ha of oil palm, 13,073 ha of rubber, 26,483 ha of tea, 253 ha of coconut and 43,693 ha of rice. There thus, cover 101,456 of area.

Geology and soils on the Bah Bolon river runs through an area covered with audisite farming the Barisan volcano range but the basin of the river is widely covered with wide tuff, under which dicite and dreibe tuff are found exposed on the banks. The delta area is covered with fluvial and alluvial deposits mainly consisting of clay, sand and gravel.

Hear the coast line facing the strait of Malacca, marine deposits are found. Most of the soils in the project area are classified as gray hydromorphic soils. In addition, red yellow podzaic soils are scattered over the isolated hilly land to small extent in the upstream area of the Bah Bolon river.

ii) Meteorology

The isohyetal map of annual rainfall of the Bah Bolon river basin is shown Fig. 4. There are 13 raingauge stations in the basin and daily rainfall is recorded at these stations. The mean annual rainfall is 2,000 mm to 3,500 mm in the delta area. It increases upstream of the junction of Gambus and Tanjung rivers to 3,500 mm in the hilly area and decreases to further upstream to 2,000 mm in the upper most plateau. Rainy season in the Bah Bolon usually from July to December and dry season from January to June. Mean daily relative humidity varies about 60% to 80% at noon and about 95% in the night and flood occurs almost every rainy season.

iii) Population

The population consists of Kabupaten Simalungun 700,000 peoples and in the Kabupaten Asahan 600,000 peoples.

iv) Economy

Dinas Pekeryaan Umun, North Sumatra Province has assessed the project area at about 35,000 ha. This contains 7,000 ha of land under cultivation 5,000 ha of land that could be brought under cultivation provided proper water facility for irrigation could be rendered fit for cultivation provided it could be reclaimed with proper drainage facility.

The remaining land contains oil palm, rubber and coconut area and also village areas, roads and other infrastructural area etc.

3. Present condition of the river

3.1 Bah Bolon river

Bah Bolon river from Perdagangan road bridge to junction of Gambus and Tanjung river covers a length of about 9 km. The river flow is contained within the banks which are 2 m to 3.5 m high above the river bed, the average river bed is 1/1,225.

3.2 Gambus river

The 25 km long Gambus river has an average bed slope of 1/1,200. The river has been provided with dikes on either bank in a length of about 18.5 km. These dikes often get overtopped and breach during the rainy season.

3.3 Tanjung river

Tanjung river is 26 km long and has an average bed slope 1/400, Tihe river has a dike on the right banks in a length of about 9 km below junction section but appears to have small length of dike on the left bank. The dike section is more or less similar to that of Gambus river in these often get overtopped and breach during the rainy season.

3.4 Sipare-pare river

The river has a dike on either bank in a length about 19.5 km from the junction Tanjung river. The dike section is similar to that of Gambus and Tanjung river and has breached at places after having been damaged by flood.

4. Problems of the Bah Bolon river basin

The main problem of the Bah Bolon river basin in the Fig. 10 are inundations during 1966 and 1970 floods. The delta area of 18,000 ha, bounded by Gambus and Sipare-pare rivers is subjected to flooding almost every rainy season.

In the 1966 flood, the flood water of the Tanjung river overflowed at several print downstream of Tudrapura and inundated nearly 2,000 ha.

In the 1969, flood damages bridges, dikes and rice fields.

On October 1970 the Bah Bolon river overflowed at several points just downstream from the branching point and inundated an inland more than 1,700 ha.

Flood were influenced naturally by climate, topography, geology, flora and so on facts but not so serious to cause flood. Situation and condition of the Bah Bolon river basin which caused flood especially as follows; condition of forest, farming system, land surface erosion, banks erosion and sedimentation.

5. Flood control and river improvement plan

The Bah Bolon river system comprises three rivers, Gambus, Tanjung and Sipare-pare in the delta area of 100 sq. km. These rivers are 25 km, 26 km and 28 km long respectively from the point of offtake (Bah Bolon river in the case of Gambus and Tanjung river in the case of Sipare-pare river) up to the river mouth in the strait of Malacca. The flood carrying capacity of the three rivers of 100 m^3/s, 230 m^3/s and 150 m^3/s respectively is much less than the estimated maximum or large flood discharge of Bah Bolon river 1,500 m^3/s or 900 m^3/s. This results in over spilling of flood waters in rainy season, thus inundating large cultivated areas and other public utilities and disrupting the normal economy of the region. With a view to rehabilitate this area is of necessity that.

i) Flood control and river improvement works are designed for 25 year or 30 year flood.

ii) Cross-sections of Gambus, Tanjung and Sipare-pare rivers are improved by excavation of the river bed, sides or both, and by provision of new levees or heightening and strengthening of existing levees to pass normal and maximum flood discharges without damages.

iii) Adequate control is provided at the point of offtake of the three rivers so that measured discharge are passed through the respective rivers without causing any damage.

5.1. Design discharge and water level

For determining the design discharge of Bah Bolon, Gambus, Tanjung and Sipare-pare rivers.

i) Daily and hourly rainfall data over the whole river basin is required to be analysed.

ii) Water levels and discharge data at perdagangan road bridge across Bah Bolon river needs to be studied.

iii) Water levels and discharge data at Gambus, Taijung and Sipare-pare road bridges needs to be analysed.

iv) The daily rainfall data is available for 13 raingauge stations in the entire Bah Balon river basin for the years 1960-1973.

5.1.1 Discharge

Water level data is available for Bah Bolon, Gambus, Tanjung and Sipare-pare rivers at the road bridges. The return period of peak discharges could be estimated by Thomas Plot method, Gumbel method or

Ven to chow method. This data should enable the estimation of 25 year or 30 year flood discharge for which flood control and river improvement works are to be designed.

5.2. River improvement plan

1) Sipare-pare River

Bah Bolon river bifurcates into Gambus and Tanjung rivers at Tanjung Muda. Sipare-pare river takes off from the left bank of Tanjung river a little lower down. Sipare-pare river independently fed from Bah Lins river which has a catchment at its own and appears to carry sufficient discharge. It could not be readily ascertained as to in what year and in what circumstances Tanjung river flow was diverted into it. This appears to cause excessive flooding of Sipare-pare river. It now needs to be investigated of Tanjung river flow could be cut off and Sipare-pare river is fed from Bah Lins river alone. The river flow should be sufficient to meet the irrigation requirements all the year round and other necessities.

2) Flood control, proposal 3.

We have suggested that Gambus river should be improved from Tanjung Muda for the design flood and this be diverted through 7 km long channel from Simpang Gambus bridge into Tanjung river, proposal 3 Fig. 12. Such a proposal involves improvement of Gambus river in upper portion and leaving the river mouth free from floods. On the other hand, Tanjung river is burdened with flood flows in the vicinity of the mouth. This is considered unsatisfactory in view of the construction of smelting aluminium factory and harbour there. It is advantageous to improve the Gambus river alone through the mouth for the design flood flow because of superior river bed conditions there and keep the Tanjung river mouth free from floods.

3) Network of hydrological observation stations and communication stations.

i) Rain gauge stations.

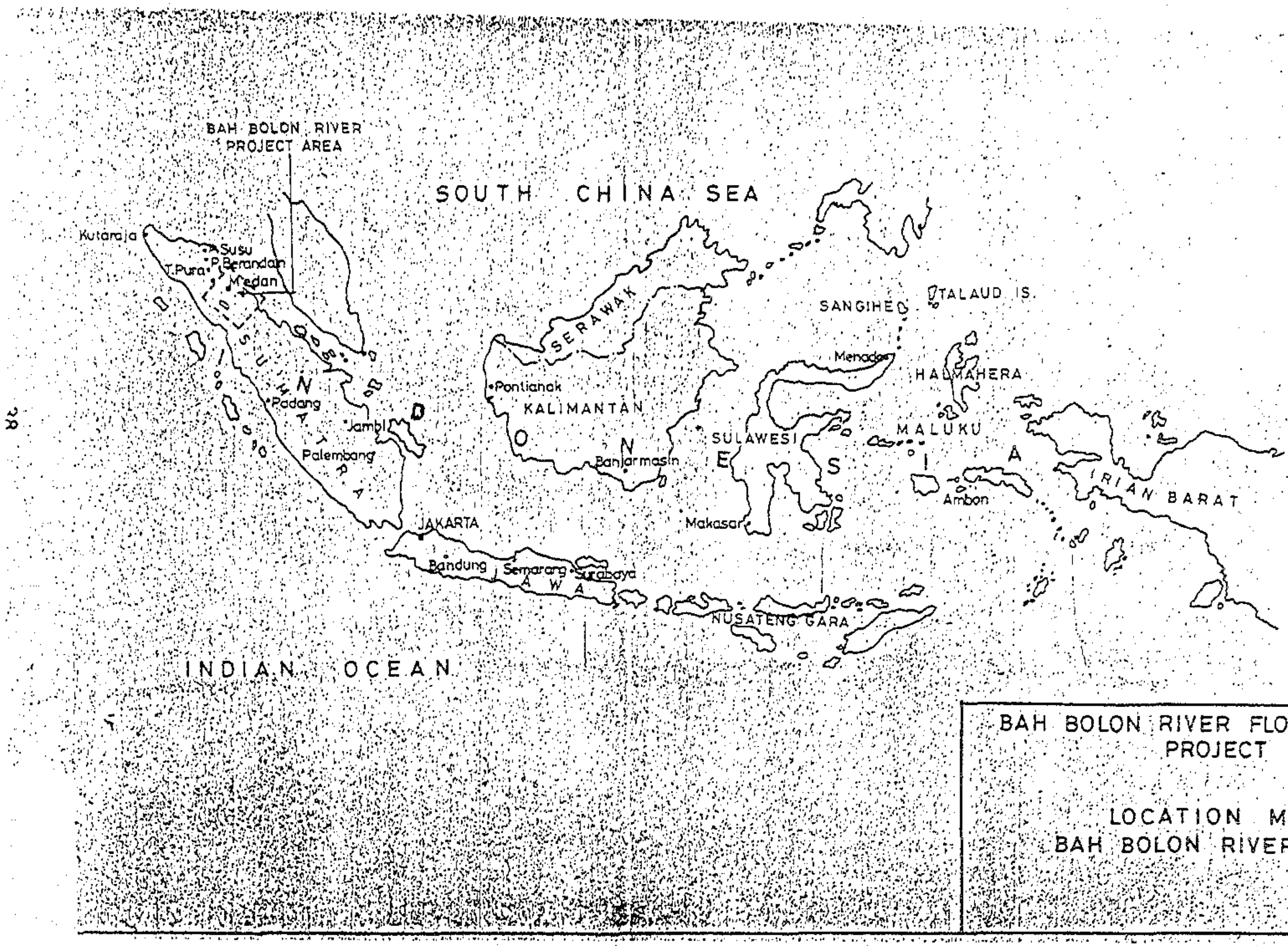
At present, there are 13 rain gauge stations in the basin of Bah Bolon river. The density of distribution of the existing rain gauge stations appears thin.

ii) Water level gauge stations.

At present, water level gauge stations exist at Perdagangan road bridge on Bah Bolon river and road bridges

Stations on Bah Bolon, Gambus and Tanjung rivers at Tanjung Muda and in the vicinity of river mouths. Likewise, there should be one water level river gauge stations at Sipare-pare where Bah Lins river flow joined with that of Tanjung river and one, in the vicinity of the river mouth. Besides the observation of water level, discharge observation work should be initiated at all these locations. This will enable improved analysis of floods flows and will serve to supply information about floods. During the analysis, study must also be made of the density of distribution of gauging stations which will serve for supplying data on water levels or discharges to be used for future flood warning and forecasting.

In order to improve the present system of communication of information on floods, it is desirable to set up 3 to 6 VHF-radio mobile stations.

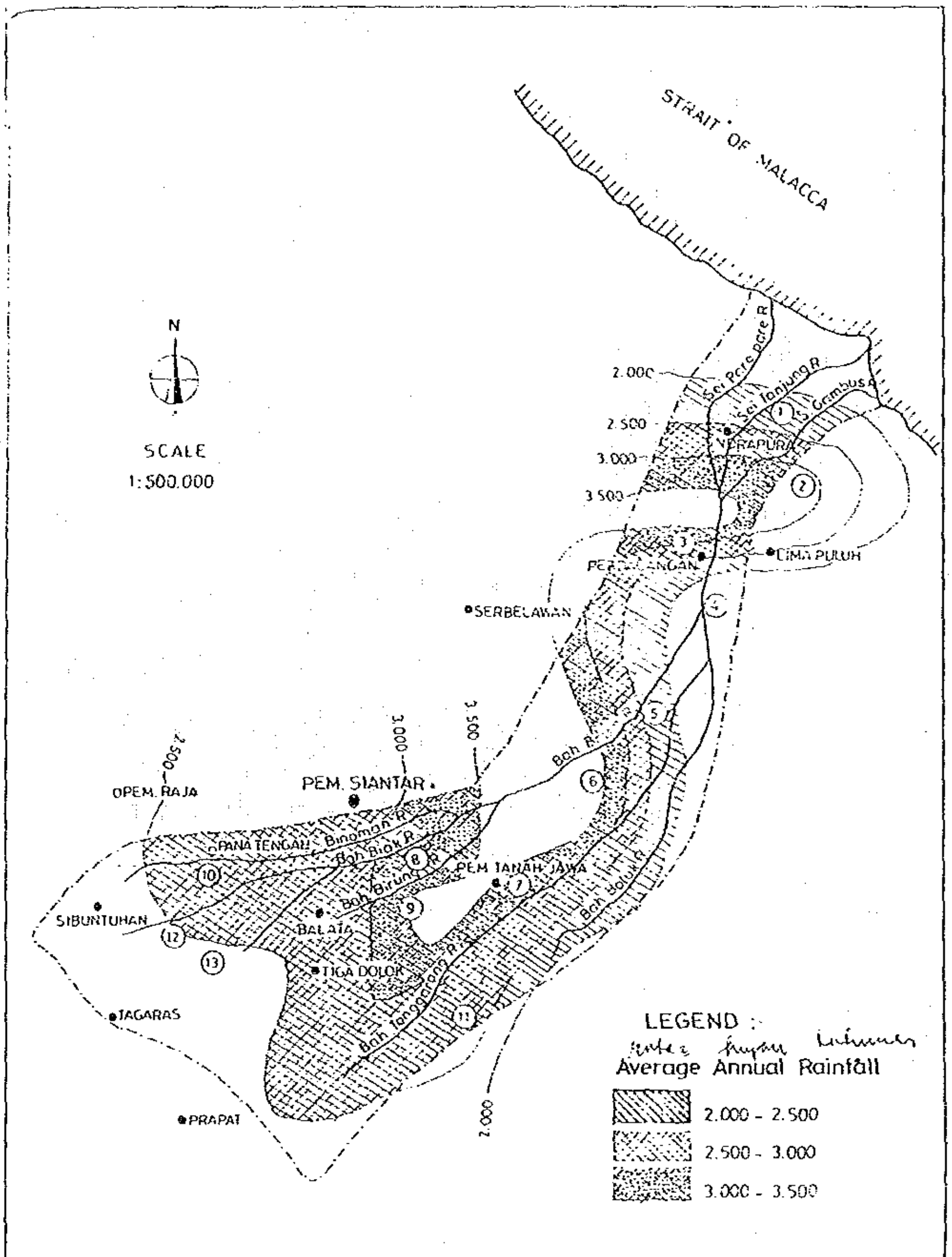


BAH BOLON RIVER FLOOD CONTROL PROJECT

LOCATION MAP
BAH BOLON RIVER BASIN

Figure : 1

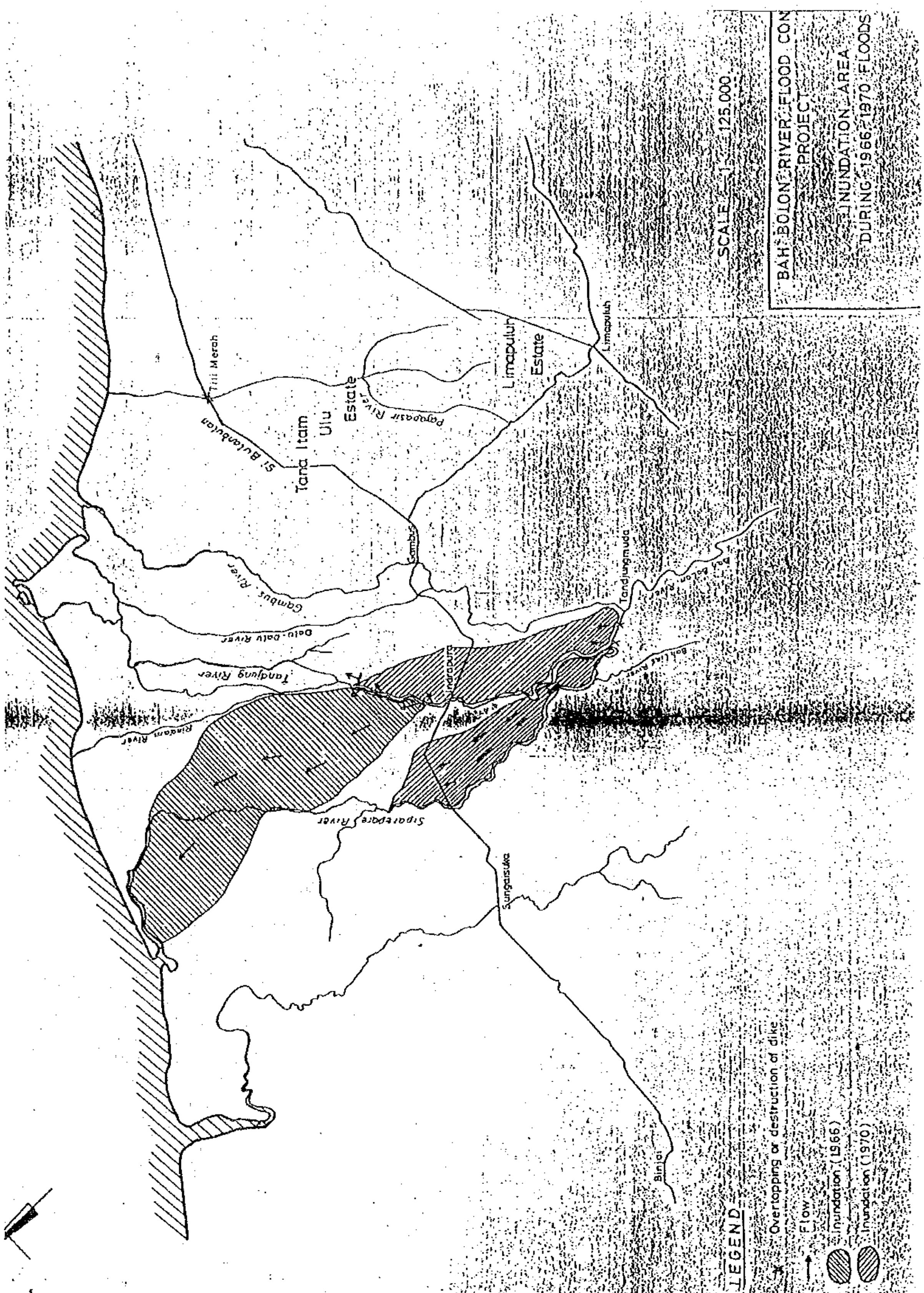
38

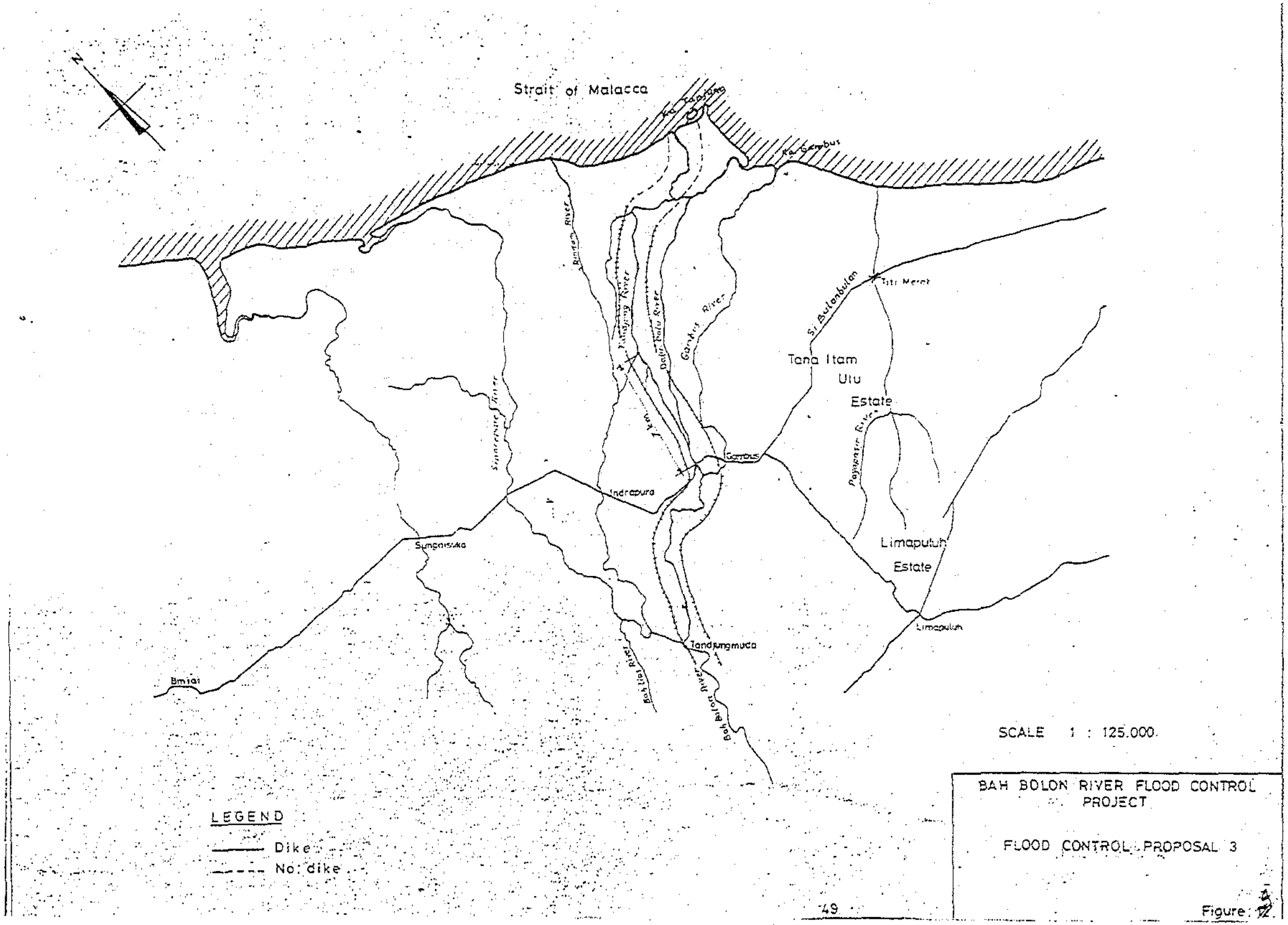


BAH BOLON RIVER FLOOD CONTROL PROJECT

ISOHYETAL MAP
ANNUAL - RAINFALL

Figure : 2


BAH BOLON RIVER FLOOD CON
PROJECT
INUNDATION AREA
DURING 1966-1970 FLOODS
SCALE 1 : 125,000
LEGEND
Overtopping or destruction of dike
Flow
Inundation (1966)
Inundation (1970)
Tali Merah
Tana Itam Ulu Estate
Limapuluh Estate
Limapuluh
Gambus River
Tandjung River
Indrapura
Sungaisuka
Tandjungmuda
Bah Bolon River
Binjai



BAH BOLON RIVER FLOOD CONTROL PROJECT

FLOOD CONTROL PROPOSAL 3

49

Figure: 12

By: Yin Cheng Liao
China

A Basic Account of Flood Measuring and Forecasting System over the Puyang River Drainage Area

I. The Name of the Member State:

the People's Republic of China
(The Water Conservancy Bureau of Zhejiang Province)

II. Facts Gathered about the Drainage Area

The Name of the River: The Puyang River

The Catchment Area: 3,431 square km

Location: 29.5°- 30.2° North Latitude
120° - 120.5° East Longitude

For the river system, refer to Figure I

For the index to the drainage area, see Figure II

A General Description of the Puyang River

Drainage Area:

The Puyang River, a tributary of the Qiantang River, rises in Datianwan, Pujiang County. It flows south-north across the four counties of Pujiang, Yiwu, Zhuji and Xiaoshan, emptying into the Qiantang River when it reaches Wenjiayan.

Stretching over a slightly oval area of 3,431 square km, the 151 km long river receives on its way such branches as the Dachen River, Kaihua River, Wuxie Stream, Fengjiao River, and Fengtong River.

Surrounded by hills and mountains on its three sides, east, south and west, the drainage area extends between Mt. Kuaiji, to its east, and Mt. Longmen, to its west. The dividing ridges elevate between 500 m and 800 m, with the main peaks of Mt. Dongpei and others towering 1,000 m and upwards.

Hilly regions account for 70% of the drainage area, which with one million mu of farmland and a population of 1.4 million, boasts of its developed agriculture and is known as one of the high-yielding producers of grain in the province. Industry has registered a considerable growth in the past few years. Running parallel to the river course is the Hangzhou-Nanchang Railway, which covers a distance of 100.4 km in the drainage area. Apart from that, the road system works rather efficiently, thus facilitating the communications.

Lying close to the southeast coast, the drainage area is of a typical sub-tropical monsoon climate, which serves as a decisive precipitation factor. The precipitation which brings about comparatively big floods is mostly frontal rains and typhoon rains. Rain often comes in the six months from April to October, hence two rainy seasons.

At the turn of spring, the polar front remains stationary over the drainage area. The meeting of cold and warm currents results in a marked spell of precipitaion, popularly known as plum rains or mold rains. As a part of frontal rains, the plum rains are characterized by their rather recompular distribution, fairly long duration and low intensity. The floods that occur in this spell tend to be great in total amount and long in duration. Widespread coverage of the frontal rains often leads to the simultaneous swelling of the Qiantang River, so a resistance from the Qiantang floods is often observed in the lower reaches.

As a rule, the plum rains spell goes out round in the last ten days of June to the first ten days of July. Then it is mid-summer. With the area under the control of the sub-tropical high, the weather is hot and dry. From the end of summer through autumn is the typhoon rain season. With its time-table not as marked as the plum rains season, the typoon rain season has its own features: short duration of rainfall, great intensity, and uneven distribution that varies from time and space --- the center of rainstorm is often found in the middle and lower reaches of the Kaihua and the Puyang Rivers.

According to hydrographical data statistics, floods of extraordinary force as observed at Zhuji station are brought about by typhoon rains though there are more times when the plum rains send the waters rising above the warning levels.

Within the drainage area, the annual distribution of precipitation is not even enough. The average annual rainfall ranges from 1,400 to 1,500 mm, with the maximum over 2,000 mm and the minimum about 1,000 mm. The variation coefficient (Cv) for annual rainfall fluctuates between 0.22 and 0.24, and the deviation coefficient (Cs) is about twice as big as Cv. The average annual run-off is from 700 mm to 900 mm in depth, the coefficient of annual run-off 0.50 to 0.55.

The records in the last thirty years show that within the drainage area the maximum 24-hour precipitaion averages from 105 mm to 130 mm for a long term. As for the precipitaion on the station, the maximum one-hour precipitaion is 77.4 mm, the maximum 6-hour precipitation 141.8 mm, the maximum 24-hour precipitation 308.5 mm, and the maximum 72-hour precipitation 410.6 mm.

According to the hydrometeorological data analysis, the possible maximum 24-hour precipitation (P.M.P.) in the area can reach 800 mm to 1,000 mm.

As for the volume of runoff, Zhuji station with a catchment area of 1,715 square km can be considered as typical. In a cycle of many years, the average annual flow discharge is 30.8 cubic m/sec., the maximum average annual discharge 68.8 cubic m/sec., the maximum flood flow actually measured is 1,490 cubic m/sec. The average peak flood flow is 1,000 cubic m/sec. in a cycle of many years. The variation coefficient (Cv) is 0.60 and the deviation coefficient (Cs) equals 3.50 times Cv. In a return period of ten years (N=10), the peak flood flow is 1,770 cubic m/sec., and in a return period of one hundred years (N=100), the peak flood flow is 3,200 cubic m/sec.

III. Flood Control Measures Taken within the Drainage Area:

Eight reservoirs are constructed in the upper reaches, each with a capacity of holding more than ten million cubic m of water. The Shibi and Anhua reservoirs are but two of them. Also, there are eighteen other reservoirs, each with a capacity of holding one million to ten million cubic m of water. When the Chencai reservoir, now under construction and designed with a capacity of holding 97.5 million cubic m of water, is put into operation, the total capacity can run to 371 million cubic m of water, inclusive of the 188 million cubic m counted as flood control capacity.

Embankments have been constructed along both sides of the river, a stretch of 418 km. Not far from the county seat of Zhuji is Guohu flood detention basin, with a capacity of detaining 85 million cubic m of flood-water. Below Zhuji County in the lower reaches stands a length of embankment which will collapse of itself when water rises to a warning level. For the size of the reservoirs and their individual functions, see Figure I.

These flood control works are made to function in a given way. In the light of the plan for taming and harnessing the river and also on the basis of over twenty years of practice, a guideline has been laid out: Retaining flood water in the upper reaches, diverting in the middle and facilitating its flowing in the lower. In the course of flood rising, all the reservoirs in the upper reaches are required to let out a proper amount of water some time sections before peak flood occur at Zhuji, and then to detain and hold as much of the flood water as possible on condition that the security of the reservoirs is not endangered. What's more, the key flood detention works as the Anhua and Guohu must be brought into full play, preventing the peak flood from coming in rapid succession, and reducing the height of flood peak. Only in this way can the embankments be protected from being burst, the railway communication from being interrupted and the loss from waterlogging be minimized. The following are the specific demands made on every reservoir in the course of controlled functioning:

A. The Anhua Reservoir

1. On the premise that the security of the Hangzhou-Nanchang Railway and the embankments in the lower reaches is ensured, its water level, if possible, is not to exceed 31 m so that production can go on uninterrupted in the upper reaches.
2. Within the 12 hours (about four time sections) after the flood waters begin to well up, it is to spill in advance but the spillage should not, if possible, exceed the safety discharge in the lower reaches, 750 cubic m/sec.
3. The flood gate must be shut nine hours before it is forecast that the peak flood will rise to 14 m and upwards at Zhuji. When the water level at Zhuji drops to less than 14 m, the gate can be lifted again. When the water level in the reservoir falls to 32.0 m, controlled spilling is done in the ratio of 900 cubic m/sec. at Zhuji to 750 cubic m/sec. at Anhua. When the water level in the reservoir falls to 31.0 m, it should keep a balance between the inflow and the outflow, and not let the water level drop further.
4. When the 6-hour rainfall up the reservoir is greater than 140 mm, or the 3-hour rainfall is greater than 100 mm, the reservoir is thought to be at stake and so the flood gate is not to be lowered or shut.

B. The Shibi Reservoir:

1. In the course of the flood abating spilling is to be done but the outflow is not to exceed the safety discharge in the lower reaches, 60-100 cubic m/sec.

2. When it has been forecast that the water level of the peak flood will exceed 14.0 m at Zhuji, the gate should be shut to retain the waters nine hours before the peak flood are to occur. But the gate can be hoisted again once the water level in the reservoir exceeds the limit of 41.8 m.

C. The Guohu Flood Diversion Sluice:

1. After the floodwater has been detained at Shibi and Anhua reservoirs, flood diversion preparations should be under way if the forecast water level at Zhuji threatens to rise above 14.5 m or if the flow is equal to 1,120 cubic m/sec.

2. Diversion should be carried out before the peak flood arrives. Considering the possible error of the forecast, the sluice must be opened to divert the floodwater when the water level at Zhuji rises to 14.0 m and the 3-hour abating rate is greater than one meter. Any delay would lead to the ineffective reduction of the peak flood, and further to the bursting of the embankments in the lower reaches and to the immersion of the Hangzhou-Nanchang Railway.

D. The Chencai Reservoir specific demands are to be made on it after its completion.

E. The other reservoirs:

For the time being, they are not to be included in the network of controlled functioning because of their low capacity of flood-relief and their uncontrollable spillways.

IV. The Present Flood Forecasting and Warning System

The automatic radio measuring and forecasting system is set up in the drainage area of the Puyang River for the achievement of many goals. The time needed for the deliverance of messages can be shortened. Messages by telegraph can be collected more than two hours after they are sent, while with the digital telemetering apparatus, the time is cut to one or two minutes and the messages can be put into the electronic computer directly. The time of prediction can be lengthened and the accuracy of flood forecast increased. With the computer making the best choice, water irrigation and flood prevention can be carried out most desirably throughout the drainage area. While the security of the reservoirs and the protection embankments is ensured, the contradiction between the flood control on the one hand and the irrigation and the electric energy production on the other can be solved, and so, also, the contradiction between the storage and discharge in the reservoirs. With all this achieved, loss from waterlogging can be avoided as much as possible.

As its main task, this system is to forecast the process of flood at Zhuji Hydrographic Station and at the same time forecast respectively the processes of flood at Anhua and Shibi, at Jieting Station and at the Chencai Reservoir in the upper reaches as well as the process of flood at Meichi Station in the lower reaches. The drainage area of the Puyang River had been notorious for the high frequency of waterlogging, so hydrographic forecast was started as far back as the early 1950's. The research and manufacturing of remote measuring apparatus began in June 1977 and completed six months later, in November. In February 1978, a communication test was successfully done. Besides, twenty ultrashort wave transceivers were installed as a preparation for the transmission of messages from the telemetering apparatuses. In August of the same year three telemetering stations were set up at Zhuji, Meichi and Linpu. Also there was a receiving centre installed. The more telemetering stations came into being at Jieting and Shibi in May 1979. A relay station went into operation at Hugongshan in January 1980; a telemetering station at Anhua in May; two more stations at Henglingding and Chencai in August, and then in November, a telemetering station at Suxi was added to the list. So far we have set up nine precipitation stations and seven water level stations. Yet there are two telemetering stations at Shangzhitouwu and Waijiang that remain uncompleted but will be finished soon. For the distribution of the networked stations, see Figure III.

The system is at present equipped with a DJS-130 electronic computer, whose random access memory is 32 k and the rate of operations a half million per second. Other peripheral equipment, such as YC-1202 broadline teleprinter and X-Y plotter stand in use. Work is afoot for forecasting by means of real-time on-line operation.

The forecasting center is housed in the General Hydrographic Station of Zhejiang Province, Hangzhou. The water information section is put in charge of daily forecasting. The radio communication section is responsible for radio communication, the management and maintenance of the telemetering stations, the receiving as well as the running of the computer. All work is divided among a 16-member staff. Seven members are in charge of the establishment, maintenance of the telemetering stations, the receiving of telemetered data and the support and retrofitting of the telemetering apparatus. Eight members are for the hardware and software of the computer. Among them, four are held responsible for the management, maintenance of the computer and for the interface design; the other four for the software and the application programming, debugging, historical flood records checking, the priority-deciding of forecast parameter and the improvement of mathematical physical models.

The DJS-130 electronic computer and the peripheral equipment amounts to an accumulated cost of 0.6 million yuan, Chinese currency and the investment in the telemetering system over 0.2 million yuan.

For the data-collecting system of precipitation, water level and flow, see Figures II and III.

Data are transported by one of the following: Telemetering apparatus, ultrashort wave transceiver, telegraph and mailing.

The telemetered hydrographical data are checked. The data messages are put to an amplitude and width detection when they are received. Then the procedures are followed to recognize and correct errors.

1. First, check is done on a group of five numeral codes to see if

they contain three "1" and two "0" and if they are in right ratio. If not, they are rejected. The parity check is done at the same time for error recognition.

2. When the numeral codes are found to be up to the standard, three "1"s and two "0"s, the message is received three times successively. Then the three messages thus obtained are put into a deciding instrument in which one message will be rejected. The other two are supposed to be reliable for the moment.

3. Then the two messages thus decided are half added to the original three messages. Here errors are detected, recognized and corrected by means of plus-minus error detecting and correcting codes.

After all these procedures are followed one by one, the message is thought to be correct and then can be put into the teleprinter and the computer.

Telemetered data are all processed by the computer, including the transformation of the accumulated rainfall into the rainfall by the time section or by the day, and the recognition of the positions of the arithmetic points and of the number of stations and their addresses.

As this drainage area has not yet been introduced to the practice of forecasting the definite rainfall in future three hours, the method of putting precipitation forecast into the forecasting model is still left out of consideration.

To strive for lengthening the prediction time and improving forecast accuracy, we have adopted ti method of precipitation run-off forecast. When a specific plan is being made, our thought is given to the physical factors in the run-off production and concentration. In calculating the run-off production, we do it by the unit excluding the loss of water in every layer of the ground. In calculating the concentration, we do it by dividing the source of water into surface run-off and underground run-off and at the same time by dividing the whole area into stages, such as slopes and river networks. Considering that the uneven distribution of precipitation is more marked from east to west, we divide the drainage area south west into several units. Please refer to the present network of the hydrographic stations and the acreage within the reach of reservoirs, our specific procedures are as follows:

From the precipitation, we get the amount of surface and underground net run-off for every drainage unit. From the respective unit curves of surface run-off and underground run-off, we get the run-off process for every unit. For every drainage unit within the reach of a particular reservoir, we do, in the meanwhile, operations on flood release. From the run-off process of every drainage unit and the flow-off process after reservoir's flood release, we do further operations till we get to the exit cross-section at Zhuji. At this point we get the flow and water level process for forecasting.

Flood forecast model is shown in Figure V.

Basing ourselves on the flood forecast model of the Puyang River, we have designed an application computer checking programming. A checkout on ten or more big floods shows that greater accuracy has been achieved than by manual arithmetic operations on the simplified forms. Now we are engaged in working out an application control programming for the real-time on-line operation.

It is up to the flood control headquarters on the province, prefecture and county levels to decide whether flood warning signals should be given or not. Warnings are generally given out over the telephone, but with the hydrographic stations at the reservoirs or county seats, contacts can be made through the ultrashort wave transceivers, for some of the transceivers are joined by telemetering channels and can be resorted to either for digital transmission or direct conversation.

The drainage area of the Puyang River is free from storm tide. But when the Qiantung River is under the influence of storm tide, the discharge of the flood waters is somewhat is affected.

In the early periods the telemetering system was put into operation, normal work efficiency was low due to various reasons. But after a period of consolidation and improvement, the normal work efficiency has reached 80% and upwards in the past two months. As the rainfall and water level coders are not always reliable enough, manual pushbutton coding is still used instead of automatic coding. Therefore, the measuring and forecasting are in fact semiautomatic. Either direct of alternative current can be used as power supply at the telemetering stations. But as the battery cells are of small storage, and then there are often long black-outs in urban power supply, the normal measuring and forecasting efficiency is affected. So cells of greater storage are in urgent need. During thunderstorm seasons, there have been several accidents that caused damage to the equipment. From 1981 on, those stations where thunder and lightning is frequent can get their power supply from battery cells only, in case that lightning should be attracted from the alternating electricity network to cause further damage.

At present, many staff members are not quite proficient at electronics, a short course for them is under consideration.

V. The Network of Hydrographical and Other Stations over the Drainage as well as the Surrounding Areas.

Over the drainage area, there have been set up 22 precipitation measuring stations, 6 water level measuring stations including the three at the reservoirs, and 4 flow measuring stations which include the two established in 1980 at Fengjiao and Fangdi. For the network and the surrounding stations, see Figure IV.

The number of hydrographic stations:

1. Flow stations: 4
2. Water level stations: 6
3. Precipitation stations and their types:
   A. Manual recording stations: zero.
   B. Automatic recording stations: 22, including the 11 telemetering stations
   C. Other types: zero

Besides, there are two weather stations at Zhuji and Pujiang set up by the meteorological department.

VI. Flooding Calamities:

The steep riverbed in the upper reaches cause the waters to flow sharp and fast. Towards its middle and lower reaches, the river runs into the plains, where there used to be very many lakes dotted in the low-lying land. From Zhuji downstream, the elevation is only 2.5 m to 5 m. The embankments along the river extended at an elevation from 12 to 15 m. What's worried about the river is its narrowing and meandering all the more, for the river gets silted, making flow of discharge difficult. And the discharge is resisted by the tides and flow in the Qiantung River. When typhoon and rainstorm come on the drainage area, waters comes over unexpectedly quick but empty slowly enough, thus causing the collapse embankments and waterlogging often follows. The Puyang River is among those in the province that frequentely cause rather serious waterlogging. Before liberation, heavy rains caused big calamities, light rains small calamities, and rainless spell was followed by a drought. As is recorded in the annuals of Zhuji and Ziaoshan Counties, in the 246 years from 1665 to 1911, 21 big floods took place as much as once in every twelve years. In the years of 1668, 1669, 1777 and 1922, serious waterlogging occurred. From August 6 to September 30, typhoon swept over the agea six times. The drainage area of the Puyang River was hit by the typhoon rains four times. The whole of Zhuji County presented a serious scene of waterlogging. Embankments were burst by a distance of over twenty km; out of the 72 lakeside villages at the time, 69 immersed; towns flooded as a result of the embankment collapse; 0.7408 million mu of farmland affected, accounting for over 90% of the total. More than 550 inhibitant were dead in the flood; more than 3,500 missing; more than 14,000 injured. On the heels of the flood came the plaque, which took the lives of more than 500 people. 22,130 peasant households were destroyed. Reduced to rubble were 21,210 one-story huts and 58,390 two-story houses. 430 bridges were washed away. More than 500 heads of farm cattle were drowned together with 3,400 of pigs and 600 of sheep.

Since the liberation in 1949, water conservancy projects have been constructed in a big way. Now, floods caused by the 24-hour precipitation of 100 mm can be successfully brought under control. The waterlogging acreage has been greatly reduced as compared with the pre-liberation days, thus preliminarily changing the look of the entire drainage area.

Nevertheless, waterlogging still takes place from time to time. Answerable for it have been the swiftness of the waters flowing downstreams, the inadequate volume of flood detention in the reservoirs and the slow discharge in the lower reaches. In the thirty years after liberation, waterlogging occurred in ten years and drought in three years. The accumulated area of affected farmland is 3.58 million mu with a loss of grain 282.8 million kg. For details of waterlogging distribution in Zhujiand Ziaoshan Counties, see Tables V and VI. There have been 22 years and 46 times when the warning water level got to 12.5 m at Zhuji station, 11 years and 14 times when flood levels exceeded the warning point of 14.00 m The typhoon rains on August 1. 1956 and five others caused big floods. inflicting rather serious damages on the area.

Generally speaking. today when the 24-hour precipitation over the drainage area exceeds 100 mm, or the flood flow at Zhuji is greater than 1,100 cubic m/sec., we are still left with little time for flood control, road protection and water draining in the lower reaches. The embankments in the middle reaches are still short of the standard to resist the once-in-five-year flood; the embankments in the lower reaches are close to the standard to resist the once-in-twenty-year flood, and the railway is to be made capable of resisting the *once-in-a-hundred-year flood. Therefore, for the protection of* the embankments and the railway, there is a necessity to use the emergency flood diversion basins such as Dinghufan and Congxianghu.

Table I. Reservoirs with a capacity of holding more than 10 million cubic m of water over the Puyang River drainage area:

No.	Names of Reservoirs	Catchment area km^2	Drainage area of	Dam Height (m)	Capacity 10 m	Flood Detention Volume	Maximum Outflow m/sec.	Functions
1	Shibi	108.8	Kaihua R.	38.0	72.00	37.00	274	Chiefly for flood control, irrigation plus electricity production
2	Anhua	634.7	Anhua R.	15.4	45.00	39.00	952	For flood control
3	Gaohu		Puyang R.	36-Gate F.D.S.,* 180 m	85.00	85.00	636	For flood detention
4	Tongji Qiao	104.5	Anhua R.	34.0	77.31	18.55	504	Chiefly for irrigation, flood control plus electricity production
5	Qiaoxi	43.12	Dechen R.	42.3	12.50	3.75	229	Chiefly for irrigation
6	Qingshan	50.0	Wuxie R.	23.0	10.06	4.77	480	Chiefly for irrigation
7	Wuxie	31.5	Wuxie R.	43.0	10.01	2.44	576	Chiefly for irrigation plus electricity production
8	Zhengtian	13.4 plus 5.0 led in	Fengqiao R.	24.5	13.10	5.16	493	Chiefly for irrigation plus electricity production

* 36- Gate Flood Diversion Sluice, 180 m

Table II. Precipitation Measuring Station

No.	Names of Stations	Location		Above Sea Level		Type of Recording	Data Recording	Others
		E. Longitude	N. Latitude	Latitude	Base Level			
							Started	
1	Xiazhai	119°46'	29°27'		Wusong	Automatic	1/1962	
2	Tongji Qiao	119°52'	28°28'				5/1957	
3	Lizhang	119°57'	29°31'	109.5	"	"	4/1964	
4	Huangzhai	120°00'	29°28'	36.5	"	"	4/1961	
5	Suqi	120°08'	29°25'	85.0	"	"	3/1957	
6	Anhua	120°07'	29°33'	24.0	"	"	5/1951	
7	Lingbei Zhou	120°19'	29°24'	155.2	"	"	1/1961	
8	Shibi	120°20'	29°31		"	"	4/1966	
9	Henglingding	120°12'	29°32'	293.0	"	"	1/1961	
10	Waijiang	120°24'	29°32		"	"	4/1966	
11	Chencai	120°23'	29°35'	57.0	"	"	5/1951	
12	Zhuji	120°14'	29°42'	14.5	"	"	4/1929	
13	Jieting	120°13	29°33'	33.0	"	"	5/1966	
14	Yangjiashan	120°03'			"	"	1/1962	
15	Dalingshan	120°02'	29°47'	330.0	"	"	1/1961	
16	Fengqiao	120°25'	29°47'	16.7	"	"	3/1963	
17	Wangjiazhai	120°26'	29°41'	84.0	"	"	1/1964	
18	Yangmeiqiao	120°27'	29°54'			"	1/1971	
19	Tantou	120°18'	29°55'	12.5	"	"	8/1952	
20	Yingdianjie	120°17'	29°50'	90.2	"	"	3/1957	
21	Linpu	120°15'	30°08'	19.3	"	"	11/1958	
22	Heshang	120°10'	29°57'	18.3	"	"	5/1957	

Table III. Flow Measuring Stations

No.	Names of stations	Location		Distance to the Estuary km	Types: buoy or flowmeter	Times of measuring	Date recording started	Remarks
		E. Longitude	N. Latitude					
1	Zhuji	120°14'	29°42'	68	flowmeter	100 - 120	9/4/1924	From station to estuary
2	Jieting	120°16'	29°38'	9-0	flowmeter	100 - 120	5/1956	From the branch to the main stream
3	Frengqiao	120°25'	29°48'		flowmeter		1979	From the branch to the main stream
4	Frangdi	119°57'	29°31'		flowmeter	30	1980	

Water Level Measuring Stations

No.	Names of stations	Location		Base level	Types of recording	Date recording started	Others
		E. Longitude	N. Latitude				
1	Anhua	120°07'	29°33'	0-0000 (Wusong)	automatic	26/5/1957	
2	Tantou	120°18'	29°55'	0-0000 (Wusong)	automatic	12/8/1952	
3	Linpu	120°15'	30°08'	0-0000 (Wusong)	automatic	30/11/1958	
4	Shibi	120°20'	29°31'	0-000 (Wusong)	automatic		
5	Chenchai	120°23'	29°35'	0-000 (Wusong)	automatic		
6	Anhua Reservoir			0-000 (Wusong)	automatic		

Table IV.

No.	Names of stations	by phone	by telegraph	short wave transceiver	Ultrashort wave transceiver 100 MHL	Telemeter 160 MhZ	by mail	Others
1.	Linpu					X		
2.	Maichi					X		
3.	Zhuji					X		
4.	Suxi					X		
5.	Anhua Reservoir					X		
6.	Henglingding					X		
7.	Shibi Reservoir					X		
8.	Jieting					X		
9.	Chenchai					X		
10.	Waijiang				X			
11.	Shangzhitouwu				X			
12.	Pengqiao		X					
13.	Pangdi					X	X	
14.	Anhua		X					
15.	Heshang							
16.	Xingfu Reservoir				X			
17.	Yangmeiqiao						X	
18.	Wangjiazhai						X	
19.	Dalingshan						X	
20.	Yangjiashan						X	
21.	Huangzhai				X		X	
22.	Lizhang				X			
23.	Tongjiqiao				X			
24.	Xiazhaixi		X					

Table V. Waterlogging in Zhuji (1949-1979)

Date			Average Precipitation		Wter level in Zhuji	Waterlogging acreage (ten thousand mu)	Loss of rice (ton)	Remarks
Year	Month	Day	mm	Duration				
1950	6	24			14.37	14.0	1805	
1952	6	1	107.7	48	14.52	8.3	1144	
1953	6	30	126.0	48	14.45	7.4	1650	
1954	5	9	163.1	72	14.06			
	5	26	117.2	40	14.22	16.7	2118	
1955	6	19	113.3	26	14.31	13.5	1240	Be diverted by the Guohu
1956	6	25			14.28			
	8	2	175.0	26	14.87	22.0	6000	
1961	10	5	110.0	27	14.00	17.0	3980	
1962	6	24	84.6	48	14.19	11.0		
	9	6	277.0	72	14.83	27.2	8946	by Gauhu
1970	6	25	103.0	18	14.53	11.9	4100	
1973	5	17	96.0	22	14.58	14.9	2780	
1977	6	16	120.0	24	14.82	23.5	4400	
Amount						187.6	38000	

Table VI. Waterlogging in Xiaoshan (1949-1979)

Date	Month	Year	Average Precipitation		Flood level at Linpu (m)	Waterlogging acreage (ten thousand mu)	Loss of rice (ton)	Remarks
			mm	Duration				
	7	1949				10.0	4500	
		1950				10.0	5500	
		1951				12.0	6000	
	6	1952				8	4250	
	5	1953				2.5	500	
	6	1954			9.48	13	16500	
	6	1955			10.53	7.87	4270	Embankment burst 1.6 km
	5	1956			9.72	8.58	5820	
	8							
	9	1957				5.0	1650	
	6	1958				6.56	2150	
	5	1959				8.86	4500	
	8							
	7	1960			7.5	7.5	2150	
	5	1961				9.05	2000	
	9	1962			8.83	20.90	16500	
	9	1963			9.08	4.35	2580	
	7	1966			9.05	0.74	200	
	7	1968			9.82	1.85	600	
	6	1970			9.40	4.06		
	6	1971			9.00	7.09	2175	
14-16	5	1973			9.65	8.24		
20	8	1974			9.58	6.29	9000	
14-16	6	1977			9.26	8.20	1200	
Amount						170.59	90000	

Fig.— 1

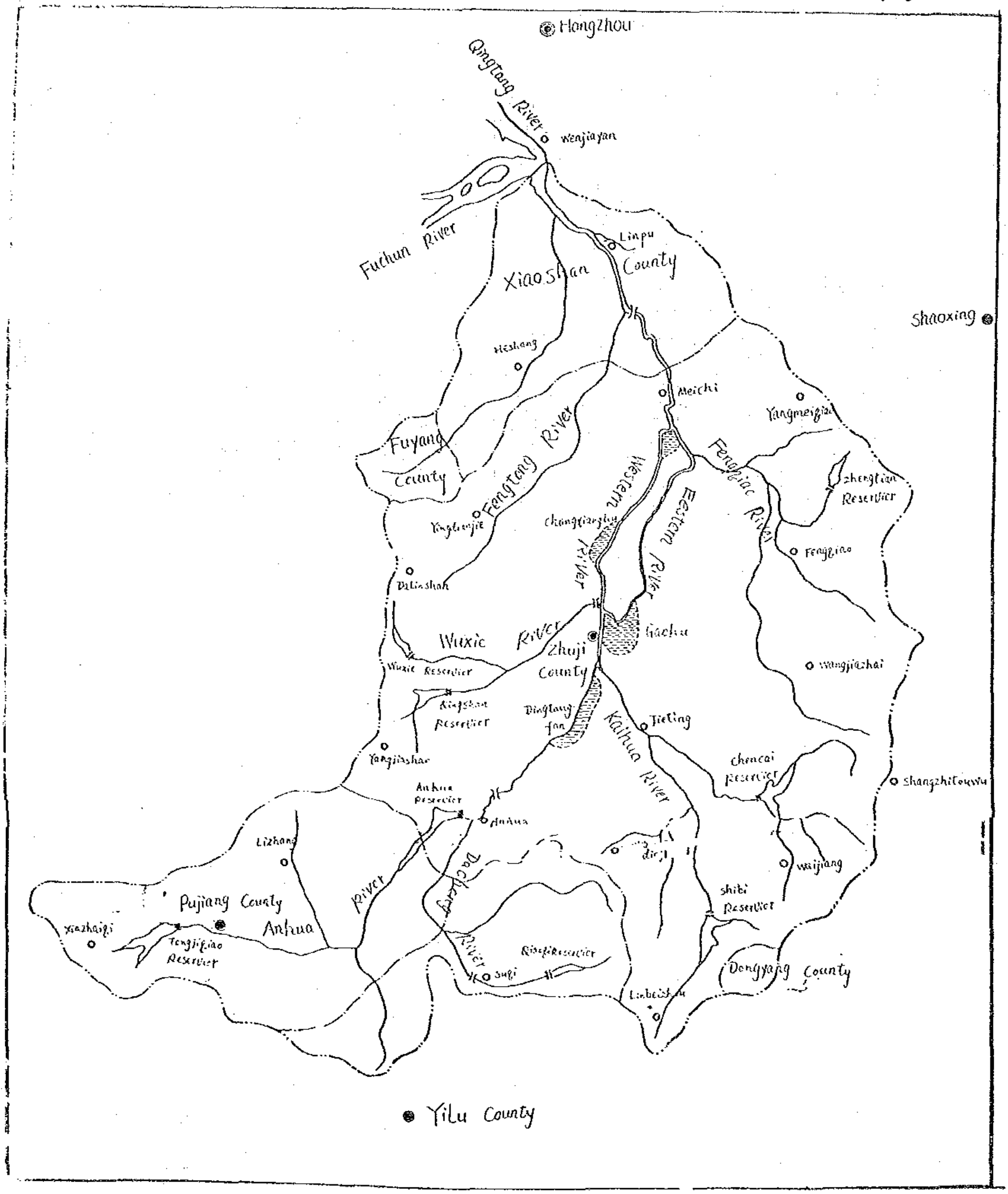
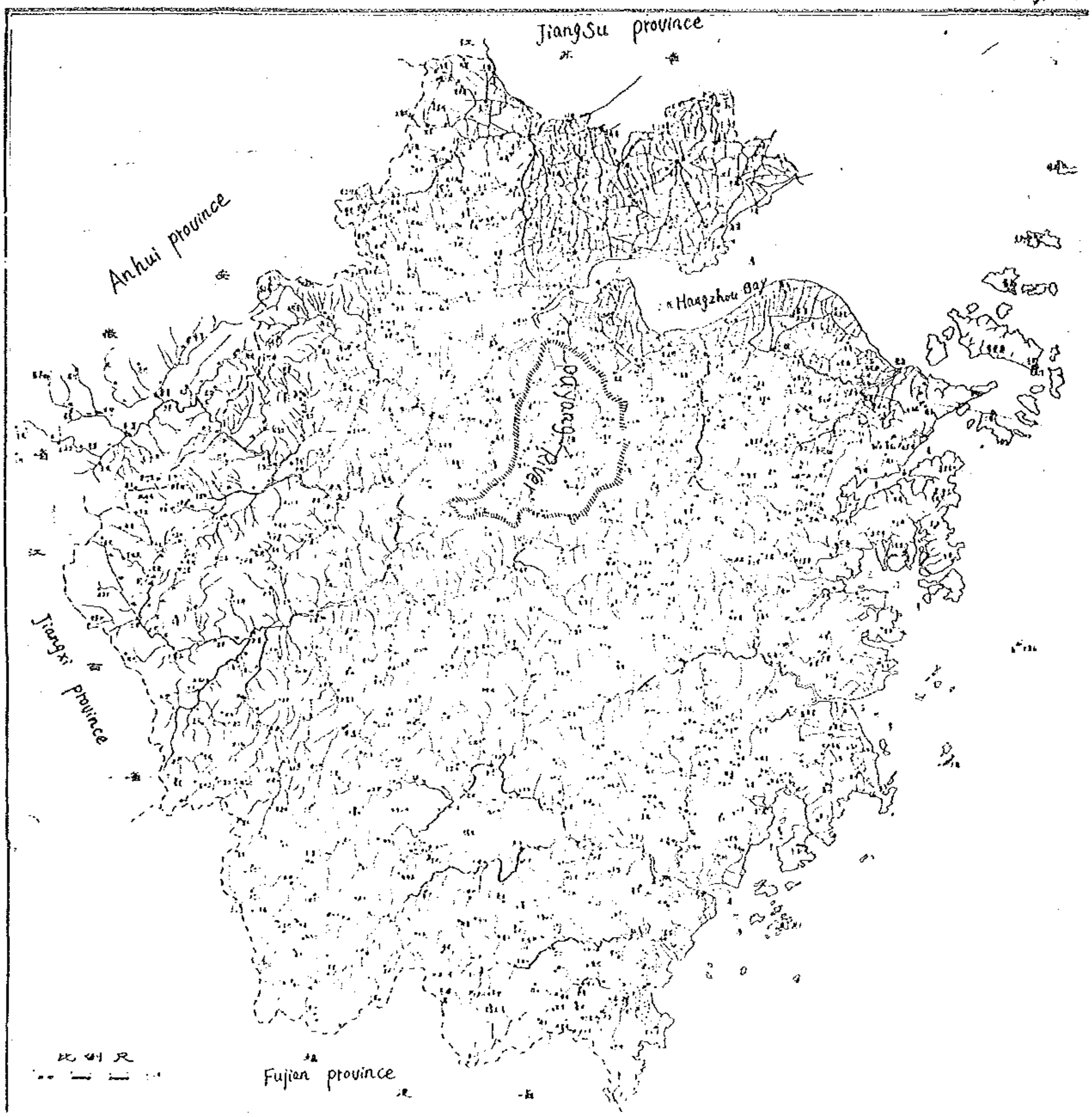

Hangzhou
Qingtang River
Wenjiayan
Fuchun River
Linpu
Xiaoshan County
Shaoxing
Meichi
Fuyang County
Fengtang River
Western River
Eastern River
Fengqiao River
Wuxie River
Zhuji County
Gaohu
Kaihua River
Dachang River
Pujiang County
Anhua
River
Dongyang County
Yilu County

Fig. -2


Jiangsu province
Anhui province
Hangzhou Bay
Jiangxi province
Fujian province

MAP OF PUYANY RIVER BASIN

一. Outline

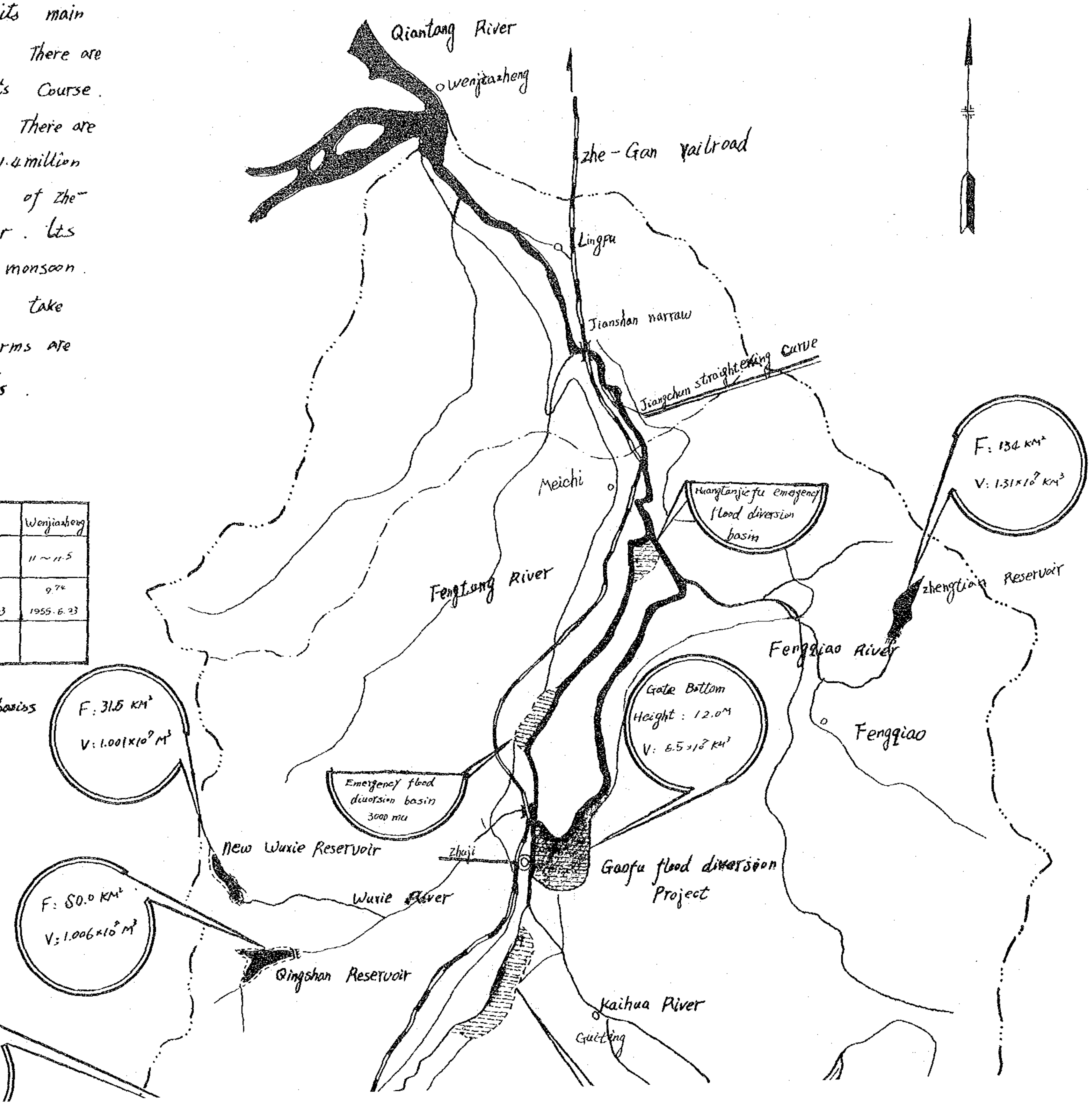
Puyang River is one of the tributaries of Qianton River. The total length of its main stream. is 151KM. Its basin covers 3431 KM². There are many curves and narrows along its course. and many shallows in the river. There are 1.6 million mu of farm land and 1.4 million inhabitants within the basin. Part of Zhe-Gan railroad passes by the river. Its climate is of typical nature of monsoon. In the rain season, heavy storms take place frequently. and the rainstorms are often accompanied by heavy floods.

二. Main Station

Station	Anhua	Taipingiao	Meichi	Lingpu	Wenjiazheng
dyke top height (M)	24°	15 ~ 16	12⁵ ~ 13	12 5	11 ~ 11.5
Hmax (M)	23.6	14.87	11.67	10.53	9.74
Time	1953.6.30	1956.8.1	1977.5.16	1955.6.23	1955.6.23
Qmax (M³/s)	1400	1490	1280	1370	
Time	1956.8.2	1956.8.1	1970.6.25		

三. Area of main stream basin and tributaries basins

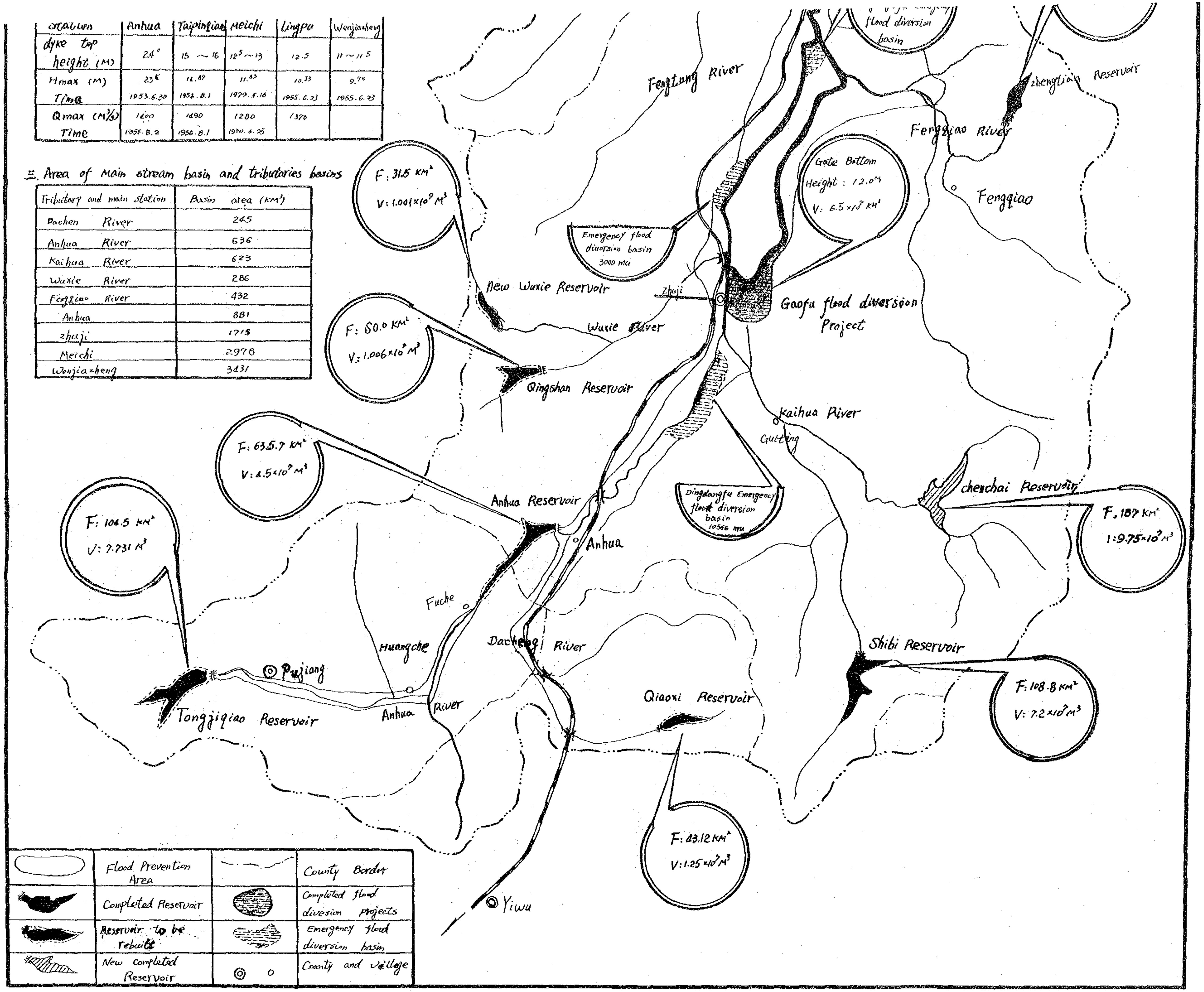
Tributary and main station	Basin area (KM²)
Dachen River	245
Anhua River	636
Kaihua River	623
Wuxie River	286
Fengqiao River	432
Anhua	881
zhuji	1715
Meichi	2978
Wenjiazheng	3431

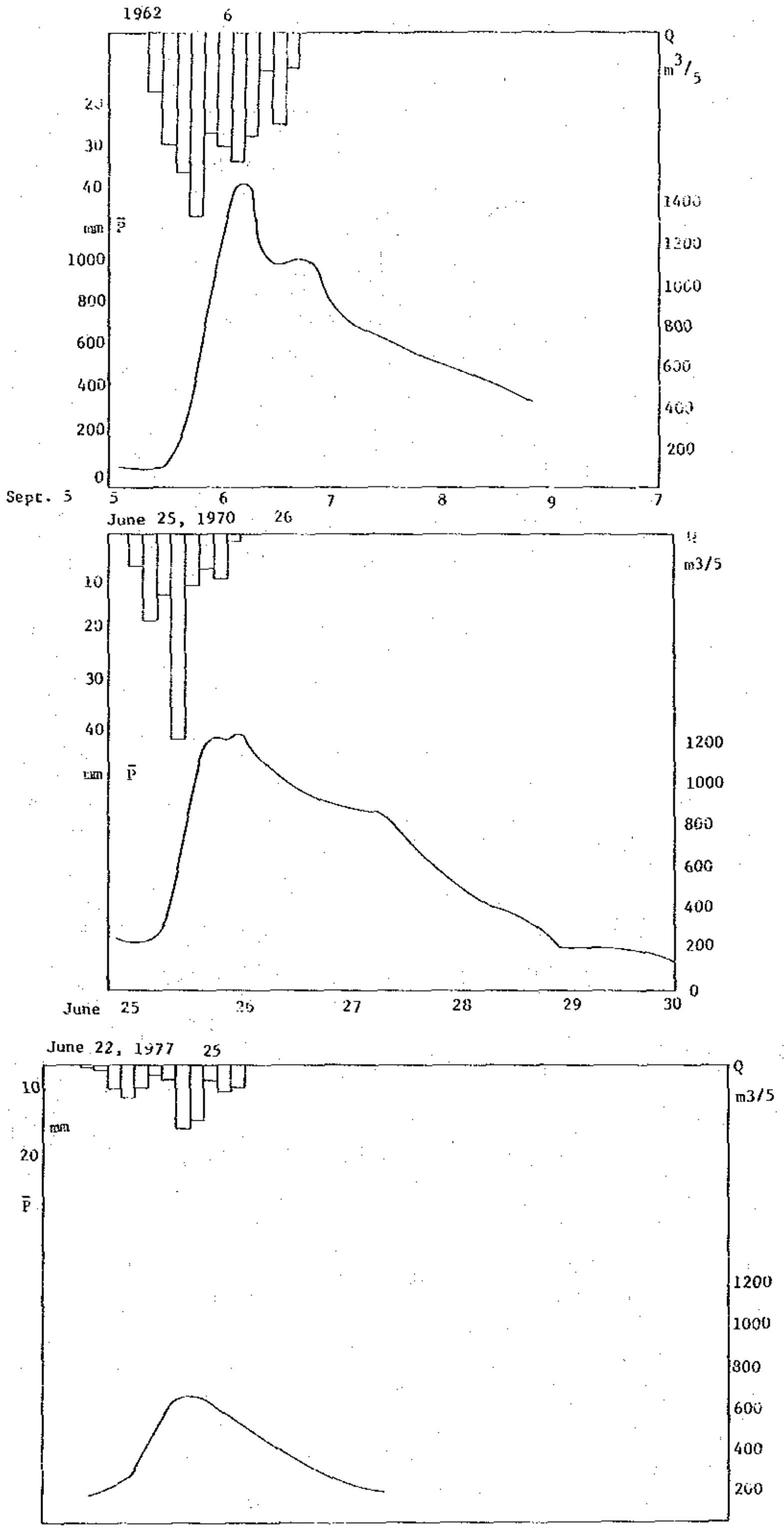


Station	Anhua	Taipingiao	Meichi	Lingpu	Wenjiazheng
dyke top height (M)	24°	15 ~ 16	12^{5} ~ 13	12.5	11 ~ 11^{5}
Hmax (M)	23^{6}	$16.^{87}$	$11.^{67}$	$10.^{53}$	$9.^{76}$
Time	1953.6.30	1956.8.1	1977.6.16	1955.6.23	1955.6.23
Qmax (M^3/s)	1400	1490	1280	1370	
Time	1955.8.2	1956.8.1	1970.6.25		

三, Area of Main stream basin and tributaries basins

Tributary and main station	Basin area (KM^2)
Dachen River	245
Anhua River	636
Kaihua River	623
Wuxie River	286
Fengqiao River	432
Anhua	881
zhuji	1715
Meichi	2978
Wenjiazheng	3431





Zhuji Station of Puyang River
Precipitation - hydrographs

Fig.

Fig. — 3

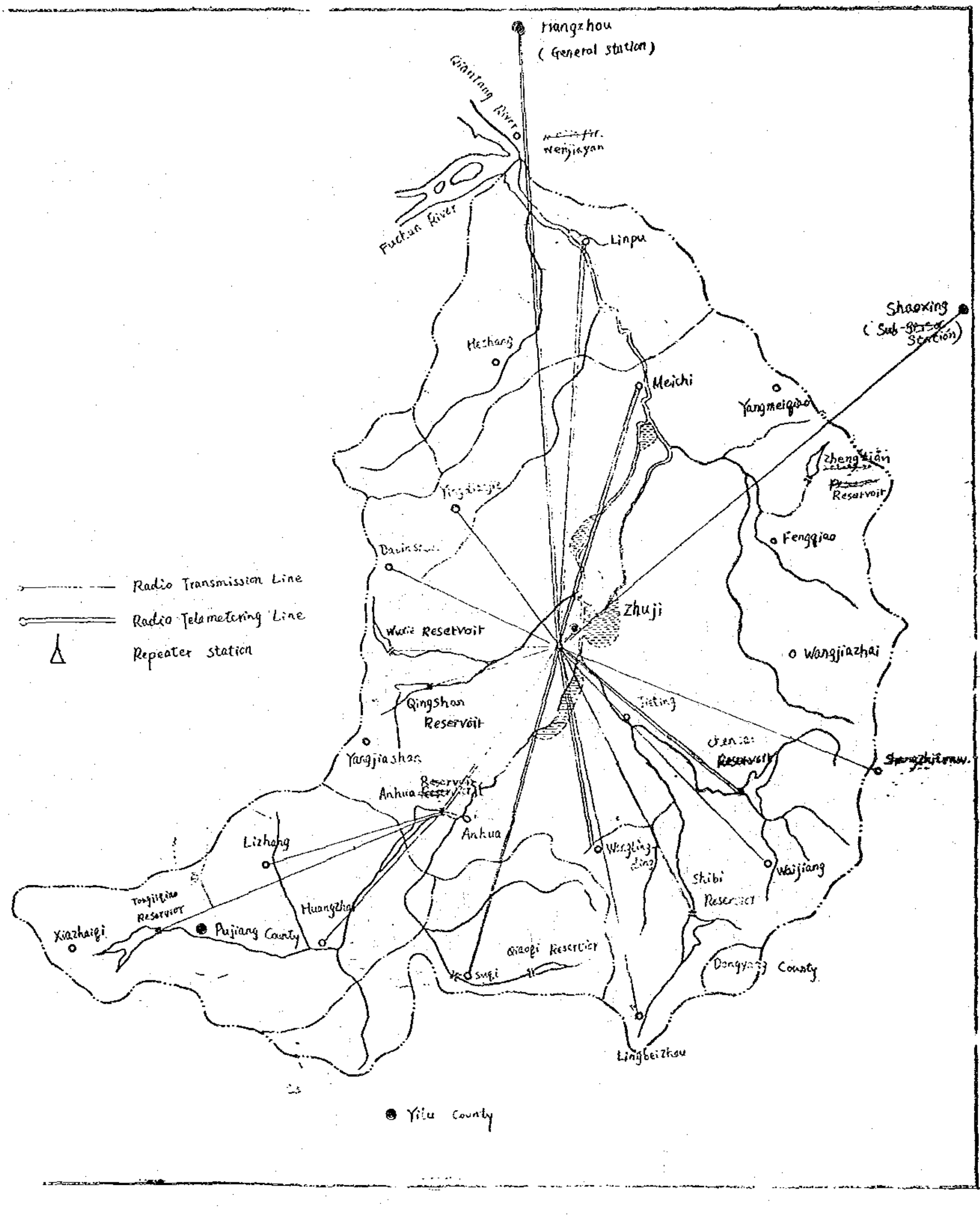

Hangzhou
(General station)
Qiantang River
Wenjiayan
Fuchun River
Linpu
Shaoxing
(Sub-Station)
Hezhang
Meichi
Yangmeiqiao
Zhengxian
Reservoir
Fengqiao
Dachenshan
Radio Transmission Line
Radio Telemetering Line
Repeater station
Wuxie Reservoir
Zhuji
Wangjiazhai
Qingshan
Reservoir
Yangjiashan
Anhua Reservoir
Anhua
Lizhang
Wangjiazing
Waijiang
Shibi
Reservoir
Tongjiling Reservoir
Xiazhaiqi
Pujiang County
Huangzhai
Qiaoqi Reservoir
Dongyang County
Lingbeizhou
Yiwu County

Fig. —4

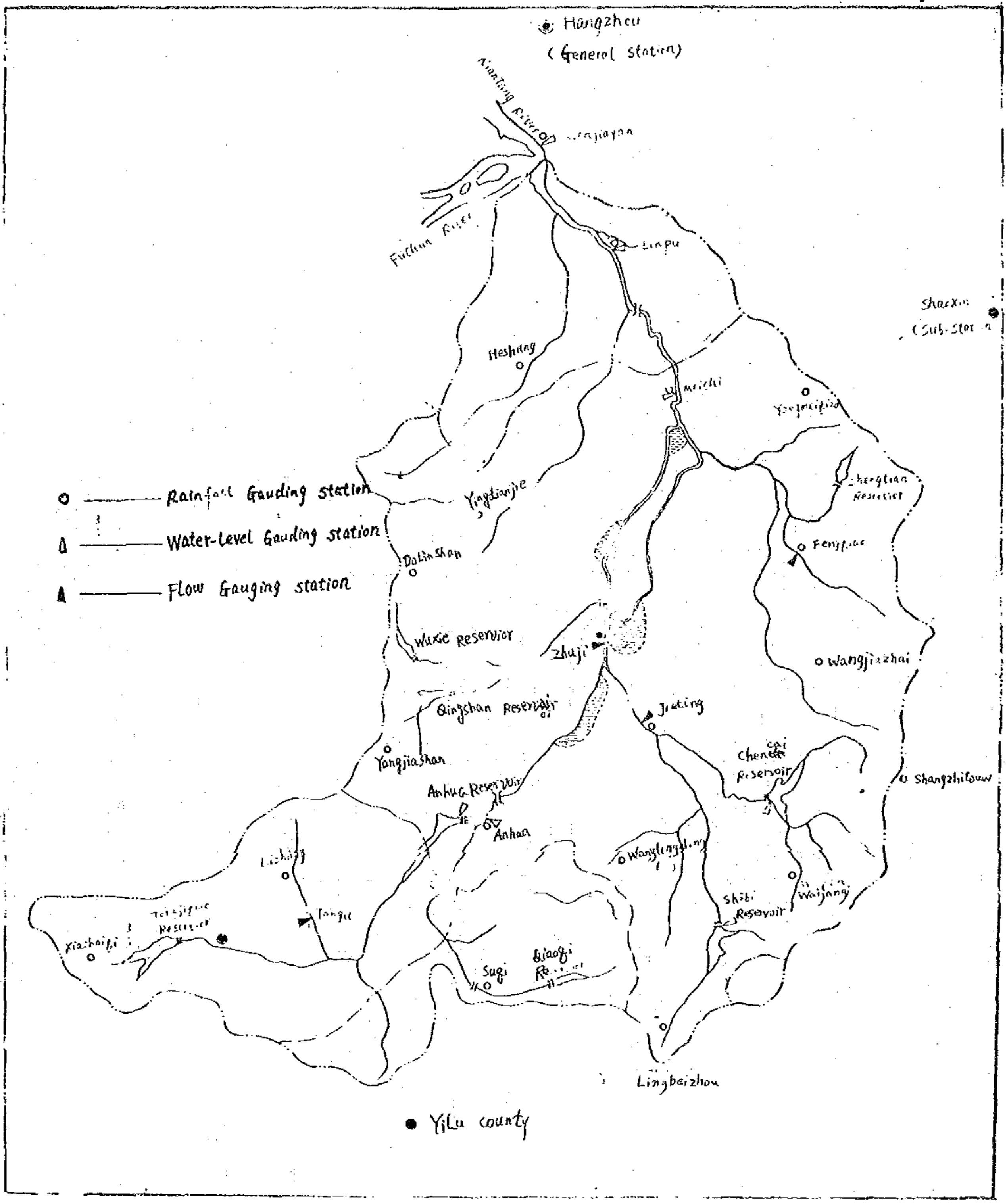
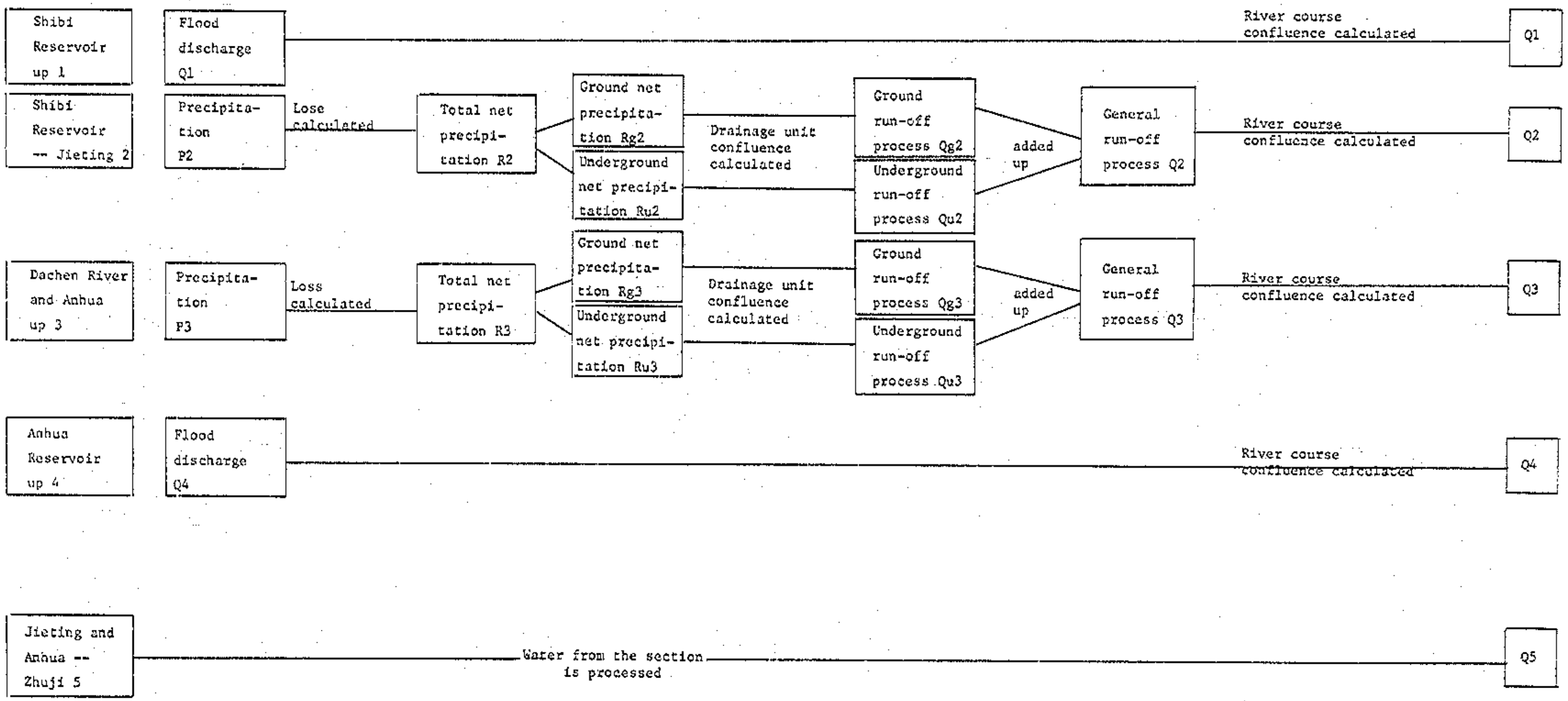

Hangzhou
(General station)
Fuchun River
Linpu
Heshang
Yingdianjie
Rainfall Gauding station
Water-Level Gauding station
Flow Gauging station
Dalinshan
Wuxie Reservoir
Zhuji
Qingshan Reservoir
Yangjiashan
Anhua Reservoir
Anhua
Suxi
Jieting
Chencai Reservoir
Wangjiazhai
Fengqiao
Shibi Reservoir
Lingbeizhou
Yilu county
Shaoxing
(Sub-Station)

Table VII. Mathematical Physical Model for Flood Forecast Over the Puyang River Drainage Area



Flood Risk Map

1. Concept:

A flood risk map means that for a given return period flood, what places would be inundated. By using a flood risk map, people can predicate the flood damage and thus take some countermeasures to mitigate the damage. Furthermore, people can make a good land use planning for a river basin with reference to the flood risk maps.

2. Methods:

There are four methods to compile a flood risk maps describing as follows:

<1> Geomorphological method (only quantitatively)

For this method, following data are needed:

a. geomorphological map
b. topograph map
c. land use map
d. aerial photograph of this region

<2> Historical method.

Besides data mentioned above this method needs historical data above, some floods occurred in the past time, such as inundated area, inundation depth and so on.

3. Hydraulic-hydrological method (quantitatively):

This method also needs the data for the first two method. Besides following data are needed.

a. roughness coefficients of the river which can be got from historical data.
b. longitudinal profile of the river
c. contour line map
d. a certain number of cross sections along the river.
e. selected rainfall model, run-off model, inundation model, calculation model
f. discharge at any point of the river for a given return period flood.
g. the water level at any point of the river for the flood, which can be got by using a discharge-waterlevel chart.
h. overflow discharge model.
i. the height of the embankment at any point of the river.

4. Hydraulic-hydrological-damage method:

All data used in the second method

Calculation models (All models used in the third method)

Damage rating curves to inundation depth are needed.

Process for compiling a flood risk map

1. First: Collect all the data, mentioned above as much as possible.

2. According to the collected data and the conditions of the pilot river basin. Choose a method from the four methods which is more suitable for the river basin, such as hydraulic-hydrological method.

3. For a given return period flood, by using rainfall model, run-off model, calculation model and some required data such as roughness coefficients of the river, we can get the discharge charts for any point along the river. Then by discharge-water level relation, we can get the water level-time chart for any point. We compare the water level with the height of the corresponding embankment along the river. If there any overflow occurs, we use an overflow model for calculating the overflow discharge, then we must use a contour line map to decide which is the most likely direction for the flood water by geomorphological method by referring to topograph map, land use map, geomorphological map, aerial photograph and some historical data we can compile the flood risk map.

Retarding basin and diversion basin

In Pujiang river basin, we have laid out a guideline for structural countermeasures. That is retarding flood water in the upper reaches, diverting in the middle and facilitating its flowing in the lower stream. By using retarding basins and diversion basins, we can largely improve the condition of a river during the flood season. Since a large volume of flood water is stored, we can change a big flood into a comparative small one.

By dredging the river channel, we can decrease the water level in the river. This mitigate the menace of flood. So retarding basin and diversion basin are very important countermeasures for flood prevention.

Land use planning

Our country is a developing country, with the development of our country's economy, the flood loss prevention would become more and more important. So we should pay much more attention to the land use planning for a flood inundation area now. Besides constructing some hydraulic engineering projects to improve the condition of the river basin for flood control. We must divides the river basin into different parts for different purposes. Power plants, chemical factories can not be built in an inundation area. Residential area must be located on a higher and safe place. The lower land had better be used as grazing land, creation places and paddy fields, the structure design of houses and other buildings must consider flood prevention condition. Besides the above, nonstructural measurements are very important for our country's case because they cost not so much and are much efficient.

By: G. R. Joshi
Nepal

SUNKOSI RIVER IN NEPAL

1. General location of Nepal:

My country Nepal lies between the countries China and India. Northern boarder of Nepal coincides with the boarder of Tibet (China). Whereas southern, eastern and western boarders of Nepal coincide with that of India. Between these countries, Nepal has almost rectangular in its shape with dimentions 800 km in length and 150 km in breadth. In map of world, Nepal occupies the longitude 80° to 88° and latitude 26° to 30°. From north to south in 150 km distance, Nepal has got its altitude from 60 m to 8,890 m above the sea level. So the country has got various kinds of climate. Nepal possess from snowfall to severe hot types of climate. There are fige types of different seasons in a year namely Spring, Summer, Monsoon, Winter and Autumn. They last almost for two and half months.

The average natural slope of the profile from north to south is about six percent. Most of all the rivers of Nepal flow from north to south. Hence Nepal has got good hydro-electricity potential that is about 76 millions kilowatts. Since the north part of the country contains high mountains and hills, the slopes of the rivers are quite high, so the maximum erosion occurs in river bed and banks. It causes the reason for landslides. Inhabitants of the hill have to face economic, public facilities and life loss damages every year. Whereas in southern part there are flooding of agricultural lands and villages. The inundation continues for two to three days. Such inundation causes the development of various kinds of deseases, loss of public properties and so on. Most of all the rivers via Nepal flow to India and then to Bangladesh. These rivers carry from Nepal lot of silts which has got good fertilizing effect to the paddy field. Hence every year Nepal losses million tons of good fertilizing soil.

This is a big and serious problem to the Nepal government. For this work, the department of soil Conservation is responsible agency. But according to the Nepalese people the department still uneffective to this matter. In national panchayat meeting people has demanded to the government to take the necessary action to prevent the flowing of silts from Nepal.

In Nepal there is no river basin which has been recognized as a pilot river basin by the government. So I choose the Sunkosi river basin as a pilot river basin for my course of Flood Loss Prevention and Management. In 1953 there was a big flood in Sunkosi river. The discharge of Sunkosi during the flood time was about 12,000 m^3/sec. The Sunkosi river basin has 17,000 sq km as its catchment area. In supplied map the Sunkosi river basin spreads in between the latitude from 69° to 80°N and the longitude 91° to 07°E.

2. General description of the basin:

Sunkosi River is a mountainous and glassier type river of

Nepal. Nearly 650 sq km of the river area is covered by snow. Being a mountainous river it has got very high gradient. In some portion of its path it has even up to two percent slope. The Sunkosi river has got a number of tributaries which are flowing from the vallies of the mountains. Up to the Sunkosi bazer the Sunkosi river acts as a main river. Nearby the Sunkosi bazar the Sunkosi river meets the Bhote Kosi river which is parallel to the Arniko Highway. The mountain, through which the Sunkosi river flows are very stable mountains which are formed mostly by quartzite and gniess which appears in the northern part of Himalayas. During winter season the Sunkosi river has got its minimum discharge as 300 m^3/sec. In normal case the river has maximum discharge as 4,000 m^3/sec.

Mainly the flood on Sunkosi river is only due to the heavy rainfall on the mountain sides. In the flood of 1953 more than hundreds of persons were injured, more than fifty persons died and number of houses had been collapsed. After this event, public had demanded to the government to take the measure for disaster prevention. The government had decided to construct a hydropower dam over there. After all the administration and construction work in 1962 the hydropower dam was completed. The place becomes very nice and popular. But unluckily in 1981 in the month of July there came a very big flood. According to the hydrological and meteorological section, the rainfall in the Sunkosi river basin up to the July there were 4,000 mm of rainfall. The maximum annual rainfall after the construction of dam was only 3,800 mm. This flood is greater in magnitude than that of 1953. Recent flood on the Sunkosi river destroyed two kilometers road of Arniko Highway, one 100 m span bridge, more than fifty houses had been collapsed, more than 25 persons died and several hundreds of people had been injured. This flood gave a very bad damage to 10,000 kilowatt generating power house.

Sunkosi bazar is a very big village. It is a center of many small mountain village. In the map it is possible to see the dotted line along the ridge of the hill. It is nothing but the foot path to go to the mountainous village areas. Only in the Sunkosi bazar area there are living more than 25,000 people. Most of the inhabitants of this place are the farmers. Mostly all the terrace had been cultivated land. The economic source of the inhavitants of this place is agriculture, horticulture and livesocks.

Recently the department of irrigation, hydrology & meteorology is going to look after the flood control system all over the country again. The organization of the department of Irrigation is as given below.

Ministry of Water Resourcess

↓

Department of Irrigation, Hydrology and Meteorology

↓ Irrigation → ↓ Flood control

↓ Hydrology & Meteorology

↓ Ground water resources

In Nepal the measure against the flood control is only the structural measure. It is clear that the structure is very expensive. For Nepal it is necessary to establish the non-structural measure against the flood loss damage, because it is not so expensive as the structural measure. The non-structural measure against the flood loss prevention is as given below.

1) Establishment of flood warning system
2) Preparation of flood risk mapping.

1) Flood warning system:

In this system the rainfall at different places has been collected using different rainfall measurement instruments such as simple rain gauge, auto rain gauge and radar device etc. From this rainfall data rainfall intensity is calculated. Knowing the discharge and cross section of the river channel the depth of inundation can be calculated on the flood plain. In this way getting the rainfall intensity of upstream of drainage channel the flood risk warning can be given to the inhabitants living on the flood plain area. Knowing the time and depth of flooding, the people can be shift to the higher places with their expensive articles. In this way establishment of flood warning system minimizes flood damage loss.

2) Preparation of flood risk mapping:

In the flood risk map flooding area and depth of inundation will be clearly shown depending upon the intensity of rainfall on river basin areas. By the help of this map the inhabitants of flood plain area can get the former information of the condition of their area during the flood period. There are four methods to prepare the flood risk map.

1) Geomorphological method
2) Historical flood data based method
3) Hydrological method
4) Hydrological damage method

1) Geomorphological method:

For the preparation of flood risk map by this method, it is necessary to have a aerial photographs, stereoscope and geomorphological map of the particular place. Viewing on the aerial photographs by sterescope the land form is decided. The land form of aerial photographs has been compared with geomorphological map of the particular place. Thus having the knowledge of actual field of flood plain, then on the geomorphological map a summit level can be drawn. Summit level is nothing but a curve line which joins only concave portion of the counter line. If a curve line drawn just opposite side of the summit level line, it is called river level. After drawing the summit level line, the flow of the flooding water can be easily determined. After this the relative height of numbers of points of the flood plain area is determined using the method of similar triangles. Then joining the points of same level it is possible to make a flood risk map of different discharge of flood. Knowing the flow section of different places it is possible to find the depth of inundations. At the same time the safe area from the flooding during flood time can be easily detected on the geomorphological map. Thus the distance between the summit level gives the degree of security from flooding on flood plain area. The relative height is directly proportional to the degree of security from flooding on flood plain area. The houses which have been built on natural levee, have got high relative height as compare to the houses which have been built on low land. So the houses built on the natural levee are more safer than the other houses during flood period on the flood plain areas.

2) Historical flood data based method:

In this method the passed flood data is collected. Knowing the passed depth of inundation at particular place, the flood risk map for future is prepared. This is not exact and scientific method. Because the nature of watershed may be change year by year due to urbanization. Due to the urbanization on the watershed area the impervious area will be increased. Hence the discharge flood water will be increase. Therefore the nature of flooding will be completely differ from that of passed flood. So this method may not be so effective.

3) Hydrological method:

This method is an analytical method. In this method all the tributaries of the river get the number by order. Then the catchment area of all the tributaries has been calculated. For this method length of main and each tributaries should be known. Hourly rainfall intensity must be available. In order to calculate runoff, it is necessary to know the urbanized area, cultivated area and rice field area. From which the parameters the initial loss D and the infiltration capability f_c are determined. The parameters K and P in sub-watershed are determined based on the kinematic wave method by assuming flow on the sub-watershed is approximated by Manning's formula. In other word parameter P is 0.6 and K is given by the following,

$$K = 7.35\ (N.1/\sqrt{I})^{P}$$

where,

1: Length of sub-watershed,
I: Average gradient of watershed,
N: Roughness coefficient of sub-watershed.

Then from the equation,

$$S = K\ Q^{P}$$

The discharge Q can be easily calculated. Thus knowing the area of the main river channel and the discharge of the river the flooding condition of the flood plain area can be determined. Hence the data for the preparation of flood risk map.

4) Hydrological damage method:

Due to the depth of inundation h_i during the flood, and if s_i is the scouring developed then the flood risk S is given by the equation,

$$S = s_i \cdot S_2$$

where,

S_2: Potential of flood damage

If the flooding area contain industrial building, big residential building etc. then the flood damage potential is high θ otherwise that is low. If the potential damage is low, there can be used only non-structural countermeasure against flooding. In this way the danger spots has been shown in the flood risk map.

3. Flood risk mapping:

Due to the lack of sufficient necessaries hydrological datas with me it was not possible to make the flood risk map of my own basin (river basin of Nepal). So I took the river basin of Japan as Otoshibori river. To prepare the flood risk map, I used the method of geomorphology. Otoshibori river starts from the mountain Iide. The river has got number of tributaries. At the start of mountain formation, it should be simple in shape as shown in the sketch Fig. 1.

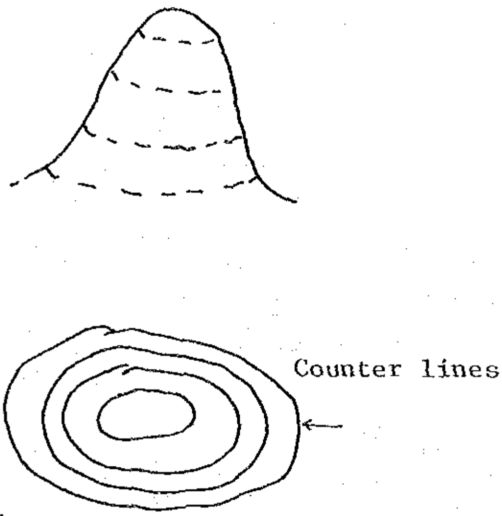


Fig. 1

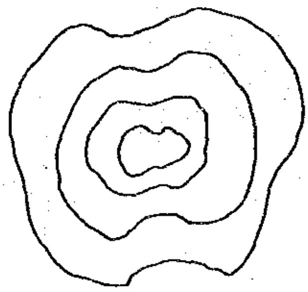
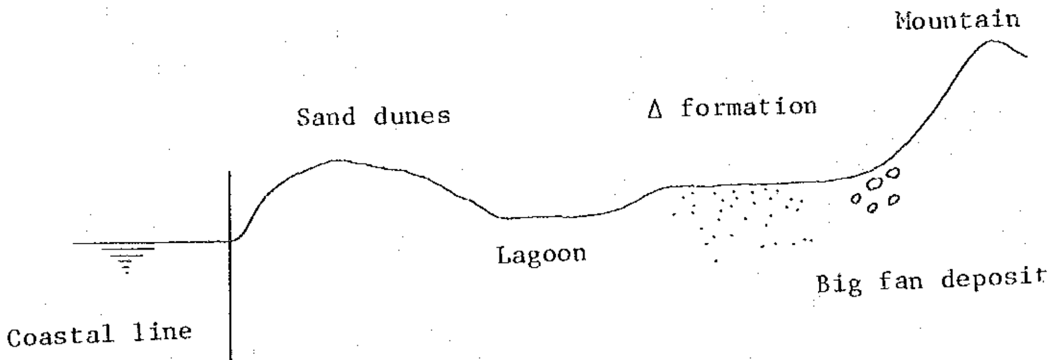


Fig. 2

Naturally when there will be rainfall on the top of mountains, any way the rain water has to flow through the mountain to its foot. Due to the high potential energy of the flowing water, it erodes at the weak points of the mountains and the rain water carries with it such eroded materials to the mountain foot. Continuing this geomorphological phenomenon for more than century there will be formation of vallies that is water flowing channels. Then the counter lines take complex in shape as shown in the sketch Fig. 2. In this way most of the mountain river has got number of tributories. This may be the reason that the Otoshibori river has got number of tributories in the mountain region. From the geomorphological point of view, it has been clearfied that the river starting from its origin to end, it travels with carrying some fans with it and deposits heavy materials at one place, where the river gates its mild gradient that is the deposition of big fans at the bottom of the mountains. This phenomenon can be seen in case of Otoshibori river near by the railway lines in geomorphological map of the river. After this process the carying capacity of the river will be decreased and only small fans can take in its way and deposits the coarse material forming delta. And the next step is to form lagoon that is low land. On the low land some time there may be flow of some channel. During flooding time, flood water may flow through the low land forming natural levee. Houses and any other building standing of natural levees are quite safe from the flooding risk.



Geomorphological process of River

Just having the geomorphological knowledge and carefully looking on the geomorphological map it can be seen that the both side of the low land there is elevated high land. These are nothing but the natural levees. River like Otoshibori river which starts from mountain side and ends at the coastal land, it will heve different slope in different parts of its path. The geomorphological process of the river can be clearly seen in the aerial photographs through the stereoscope as well as on the geomorphological map of the Otoshibori river. Now a days the sand dune places are broadly used for the urbanization purposes.

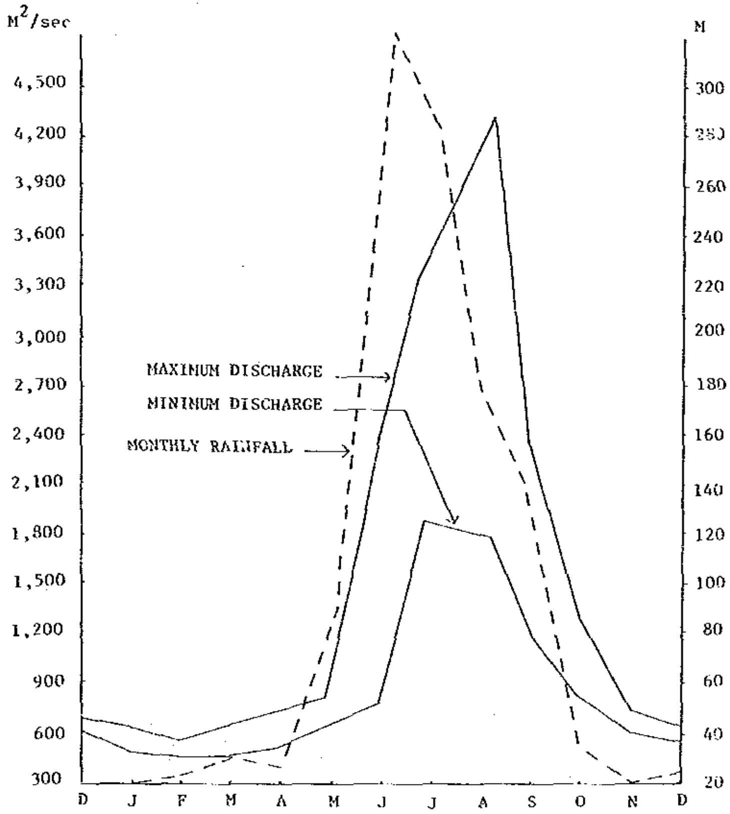
In this method first the summit lines are drawn. The summit line is a curve line where joins the concave portion of conture line. After drawing the summit lines on a geomorphological map, the flow direction of flooding water can be determined. Then along to flow direction for particular section the relative height of different points is calculated using similar triangular method. Knowing the slope of the flow direction velocity of flow can be approximate. Having the flow area and discharge, the depth of flooding water can be calculated. In this way the flood risk map can be prepared.

4. Elementary concepts of flood risk map:

Flood risk map is one of the essential media which can help to minimize the flood damages. The danger spots from the flooding is marked in the map with different height of water depth. In other word in the basis of rainfall intensity the flood risk map is prepared. So the person who has got idea about the flooding, he can get the information of flooding danger just looking on the map. Some times the person works on the flood forecasting system just having the flood risk map and rainfall intensity he can give the warrent to the inhavitants who are living on the flood plain areas during flood period.

5. Flood protection planning in the basin:

For this purpose the retarding basin of sufficient capacity can be constructed. But in the hilly and mountain area it is difficult to construct the retarding basin. So for this purpose for mountain and hilly areas to construct number of check dams is quite reasonable and effective. During the recent flooding period the concerning department use to put the wiremesh gabions on the weak points of the embankment. Some times for flood fighting purposes the sand fill bags are also used. In my country the flood control section is under irrigation section. In my opinion the flood control section should be divided into two sections. One is structural measure section and another is non-structural section. If the flood damage potential of a particular place is low, it is more reasonable to use only the non-structural measure. In other case the use of structural measure is reasonable one. This method I think it will be very economically helpful to the government. Flood damage can be minimize by the controlling the land use also. For example if the low land is used only for paddy field and natural levee high land are used only for residential and industrial buildings. But it may not be practicable in such cases some structures against flooding should be constructed such as embankment, elevated buildings, flood proof walls etc. So the structural measure section should be under the irrigation section. The non-structure measure section should be under hydrology and meteorology section. There should be good correlation between the structural and non-structural measure sections of flood control. The Government should take the necessary action to restore the green zone of river embankment and hill. This will be the effective for countermeasure of erosion process and at the same time to minimize the flood damage loss.



HYDROGRAPH OF SUNKOSI AT

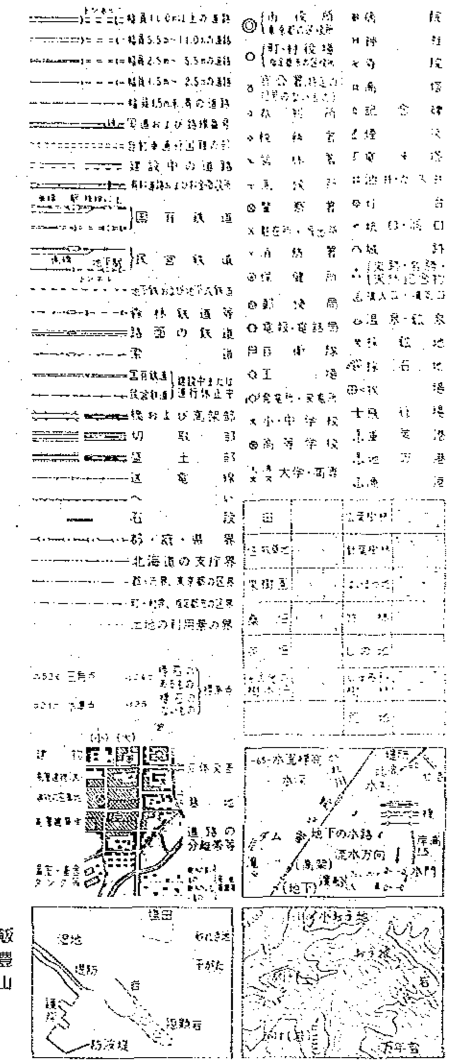
DOLALGHAT

1970-1980

1:50,000 地形図　NJ-54-28-9
しばた　（新潟9号）

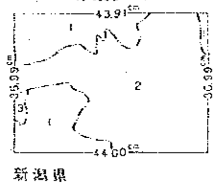
新 発 田

記 号



1. 投影はユニバーサル横メルカトル図法、座標帯は第54帯、中央子午線は東経141°
2. 図郭に付した短線は経緯度差1分ごとの目盛
3. 高さの基準は東京湾の平均海面
4. 等高線の間隔は20メートル
5. 磁針方位は西偏約7°10′(昭和47年)
6. 図式は昭和40年式(昭和44年加除訂正)1:50,000地形図図式

行政区画



新潟県
1. 北蒲原郡　2. 新発田市　3. 豊栄市

索引図

	中条 (村上)	小国
新潟	(新潟)	飯豊山
新津	津川	大日岳

(　)内は所属20万分1図の図名

明治44年測量
昭和45年編集
昭和47年修正
資料：I, II は昭和43年改測1:25,000地形図
III, IV は昭和46年修正測量1:25,000地形図
昭和47年関係官公庁の資料

III	I
IV	II

1:50,000 新 発 田

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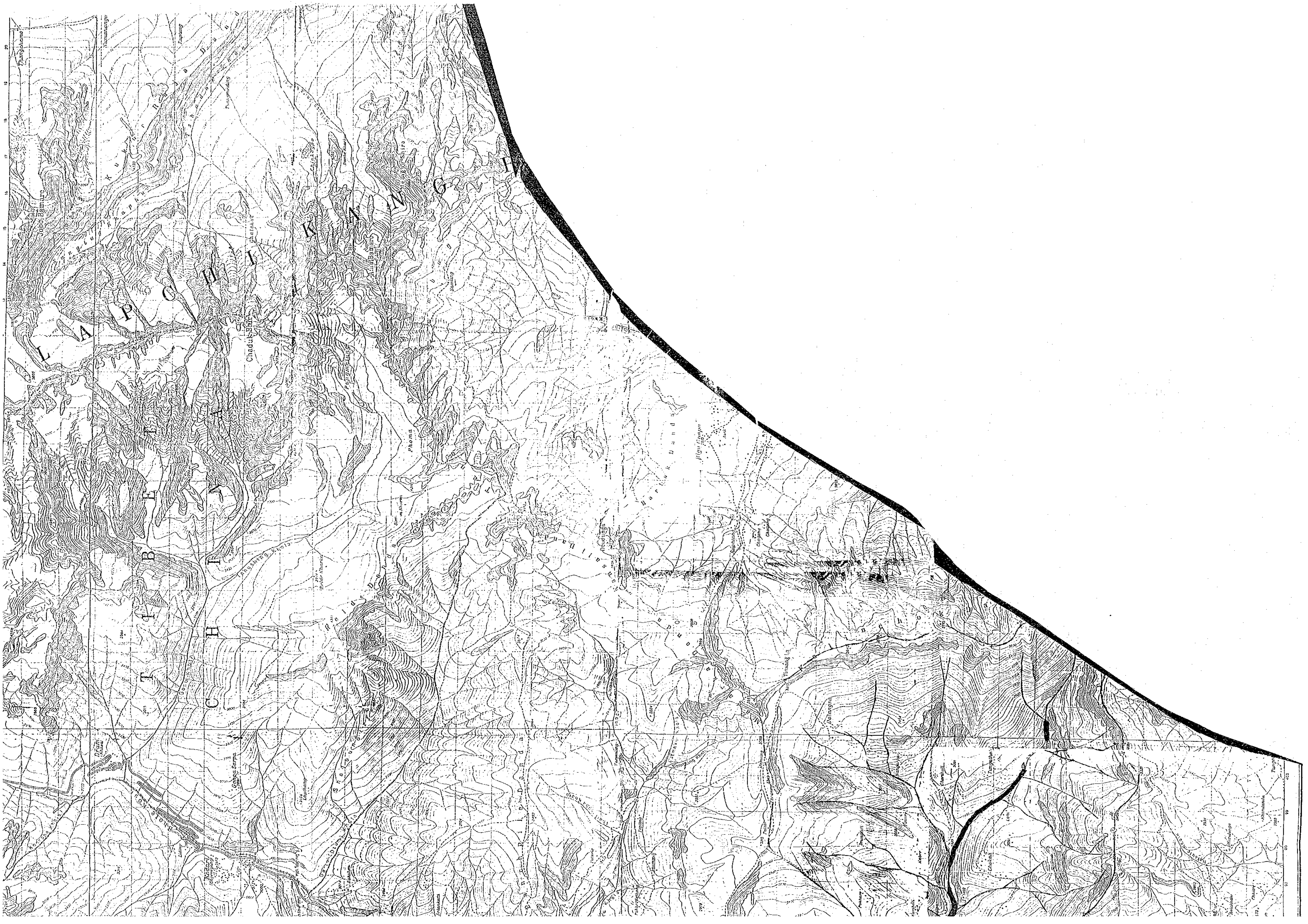

L A P C H I K A N G
Phoma


TIBET
CHINA
Chaduk Bhir
Gonpa Sarpa
Kodari
Phoma
Nambarjung Danda
Dolangsa
Bhote Kosi

1:50000

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