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RULE CURVE FOR THE OPERATION OF AN IRRIGATION RESERVOIR

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RULE CURVE FOR THE OPERATION OF AN IRRIGATION RESERVOIR

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ABSTRACT

The purpose of operating an irrigation reservoir is to regulate water supply to meet the irrigation requirements of growing crop. The operation may be guided by a Rule Curve to achieve the optimum irrigation benefit on a long term basis. The method of deriving a rule curve is discussed in this paper, taking the Minteh Reservoir as a sample case.

The Minteh Reservoir, originally named the Houlung Reservoir, is located on the Lao-tien-liao Creek, Miaoli, Taiwan, Republic of China. It serves the irrigation needs of 1,509.41 hectares of farm land planted to rice and upland crops.

This reservoir was built mainly to regulate the seasonal flow of the Lao-tien-liao Creek for irrigation in ordinary years. For extraordinary years when a severe drought may last several months in a year, the flow of the creek would be so low that irrigation must depend entirely on the stored water in the reservoir. Water deficiency in severe drought years is bound to happen. A method to operate the Reservoir that could minimize the crop loss in the irrigated area due to drought, or maximize the irrigation benefit on a long term basis is therefore necessary. Such a method of operation has been studied, and a rule curve to guide such an operation established.

A rule curve is a graph, in which the abscissa represents a date in a year and the ordinate the value of reservoir storage (represented by the Symbol RC). In actual operation on a particular date, one first finds out the current storage of the reservoir (represented by the Symbol S), and then compares S with RC. If S is smaller than RC, this means there is the possibility of water deficiency in the near future and the reservoir release for irrigation must be made 30% less than the normal quantity in order to keep more water stored. If S is larger or equal to RC, then there is no need to reduce the normal release. It is in this way that a rule curve guides the operation of an irrigation reservoir.

In this study, the first step is to hindcast the reservoir opeartion releasing water always in normal quantities. This gives the recurrences of reservoir storage in the period of study. For the Minteh Reservoir, the study period is 19 years from 1951 to 1969 inclusive. The daily effective rainfall for irrigated crops is studied in detail in order to make the estimation of daily irrigation requirement as well as the daily reservoir release more exact.

Based on the recurrences of reservoir storage, five rule curves are obtained. Rule Curve 1 is made of the largest values of recurrences. Rule Curve 2 is made of the smallest values of recurrences. Rule Curves 3, 4 and 5 are made of values which have the recurrence frequences of 75%, 50% and 25%, respectively. An arbitrarily determined curve is adopted as Rule Curve 6.

Then, each of the six curves is taken successively to guide the operation of the reservoir. This means that the reservoir operation in the study period is hindcast six times, taking into consideration one rule curve at one time.

The results of these six hindcast calculations are then compared and discussed, and Rule Curve 4, which is made of values having a recurrence frequency of 50%, is selected as the best rule curve.

The entire study is done by the use of a computer program written in PL/I language. It takes 45 minutes to run the program on an IBM System 360 Model 40 computer.

Contents of this study are described in two parts. Part A explains the principle of reservoir operation and the best rule curve for the Minteh Reservoir, and Part B explains the computer program.

This study can be updated whenever necessary by re-running the program with new data available.

The computer program can also be applied to the study of other irrigation reservoirs, requiring only some minor changes in the statements of the program.

Part A. Principle of Operation and the Best Rule Curve for the Minteh Reservoir

1. Rule Curve for an irrigation reservoir

An irrigation reservoir may be operated without the guidance of a rule curve. In such a case, the daily release of water from the reservoir can be done according to the normal irrigation requirement of the day. Reservoir inflow in the next few weeks and the current storage of the reservoir are not taken into consideration. Should the inflow drop appreciably in the next few weeks due to lack of rains, and should the reservoir be currently at a low storage level, then the reservoir would deplete rapidly. In this way, the release would be insufficient to meet the irrigation need, and the crop yield in the irrigated area would be affected.

If there were reliable weather forecasts which tell the timing and the quantities of rainfall in the near future, the above mentioned problem could easily be solved.

Since there is no weather forecast of this kind at present, the only practical way of solving this problem is to regulate the daily reservoir release by referring the current reservoir storage to a pre-set indicator. This indicator must fully reflect the real long-term experience or the result of a hindcast study of the operation of the reservoir in past years.

This indicator is the Rule Curve. A typical rule curve assumes the shape of the curve shown in Figure 1.

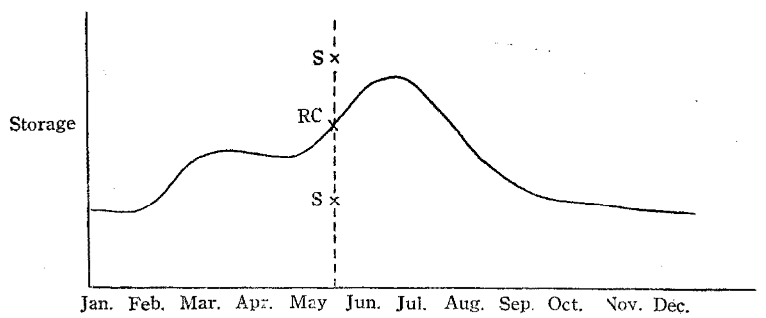


Fig. 1. A typical rule curve

The abscissa of this graph represents the irrigation season, indicating the dates in a whole year. The ordinate tells the values of storage (or elevation of water surface) of the reservoir. The rule curve thus gives the value of storage at any given time in the irrigation season.

For a particular date in consideration, one compares the current storage at that date (represented by the symbol S) and the value of storage shown by the rule curve at that date (represented by the symbol RC). In case the position of S is above or equal to that of RC in the graph, this means that water deficiency will not occur in the near future and there is no need to regulate the reservoir release at that date, and the release remains to be the normal quantity of irrigation requirement of that date. If the position of S is lower than RC, then regulation of reservoir release is necessary.

By regulation it means simply the reduction of the normal amount of reservoir release. A conventional way is to reduce it by 30%, as the yield of crops would not be appreciably affected by this lowered water supply amounting to 70% of the normal irrigation requirement in a short period.

This regulating method can help narrow the difference in magnitude between RC and S in later dates. If the magnitude of S is brought up to that of RC or larger, the regulating should be stopped.

By this way, one could avoid or minimize the danger of serious irrigation deficiency in drought periods. Therefore, the loss of crop yield in the irrigated area could be minimized.

2. The Minteh reservoir

The Minteh reservoir is located on the Lao-tien-liao creek, Miaoli, Taiwan, Republic of China. By constructing a rolled fill earth dam of 35.3 meters in height, this reservoir was created for the main purpose of irrigation.

The effective storage capacity of this reservoir is 1,650 hectare-meters. (1 hectare-meter equals to 10,000 cubic meters.)

The total irrigated area is 1,509.41 hectares.

The outlet structure on the north side of the reservoir connects with a tunnel and a main canal of 15.022 kilometers. The maximum capacity of the canal is 4.224 c. m. s., The main canal branches into laterals and sub-laterals. All sub-laterals and ditches are arranged according to the needs of rotational irrigation and topography.

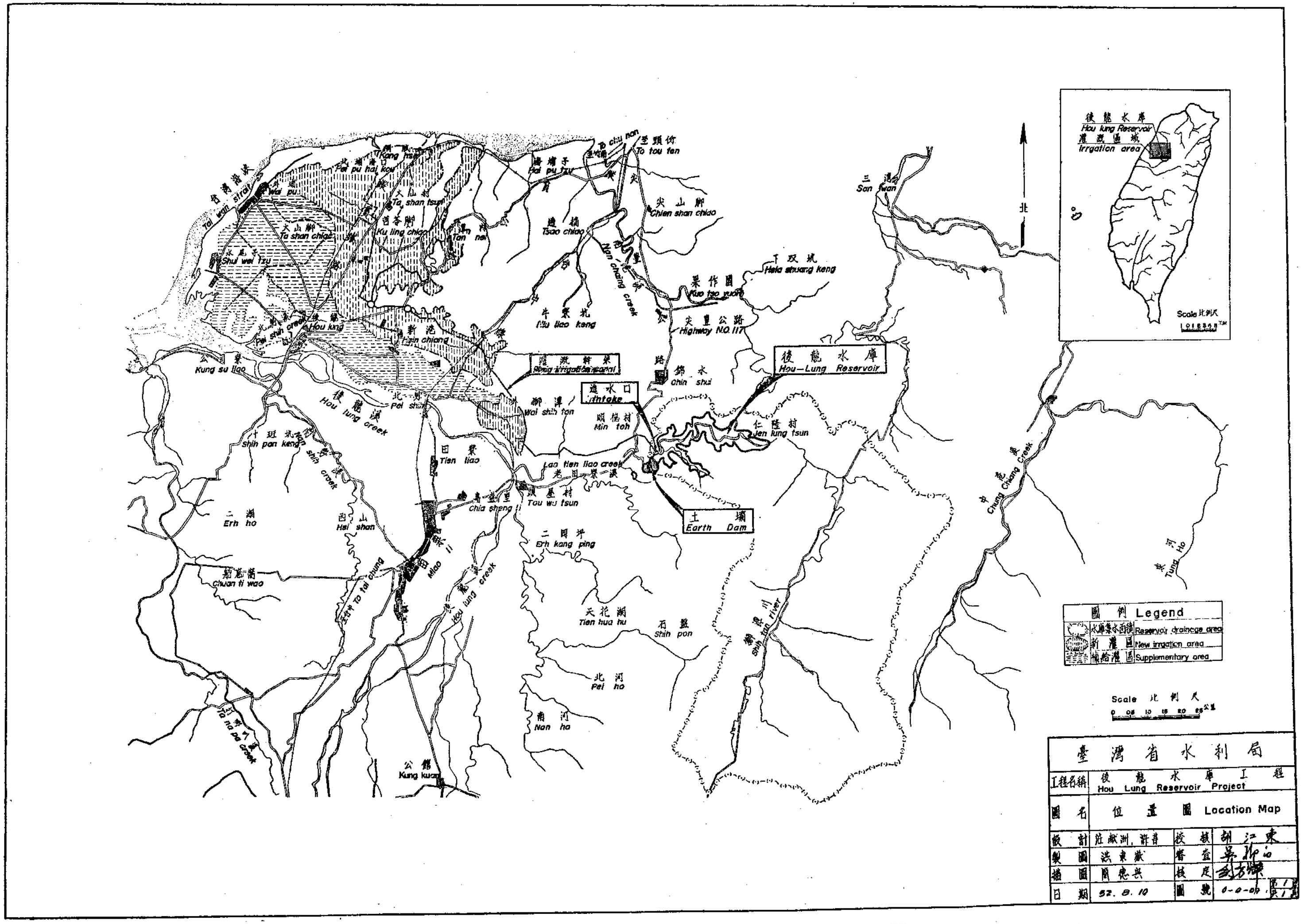


Fig. 2. Location Map of Minteh Reservoir (originally named Houlung Reservoir)

There is concete lining for all main, lateral and sub-lateral canals. Seepage loss in the canal system is nearly non-existent. Regulating gates and structures are provided at all controlling points in the system. Effective management and control of irrigation water is thus possible.

The Minteh reservoir is operated for the seasonal regulation of the flow of Lao-tien-liao creek in ordinary years. For extraordinary years when a severe drought may last several months, the flow of the creek would be so low that irrigation depends entirely on the stored water in the reservoir. It was recognized in the planning stage of this project that the reservoir could not be built big enough to take care of all droughts for economic reasons. A method to operate the reservoir that could minize the crop loss in the irrigated area because of droughts, or maximize the irrigation benefit on a long-term basis, is therefore necessary.

3. Irrigated area, soil and crop

The irrigated area of the Minteh reservoir is a piece of land sloping from foothills to the sea coast. Land configuration is rather complex. It is divided into 4 zones according to topography and soil.

Soil texture of this area varies from medium to coarse. Distributed most extensively is the sandy soils of aeolian origin, which account for 64.95% of the area. Alluvial soils occupy 6.62% and reddish and brown soils 28.43%.

Multiple cropping is practised in this area. The first crop is cultivated from March to June, the second crop July to November, and the winter crop November to February.

The areas, soils and crops of the respective zones are shown in the following table:

Table 1

	Zone 1	Zone 2	Zone 3	Zone 4	Total
Area (ha.)	381.12	260.84	532.94	334.51	1,509.41
Soil	Silty-loamy	Silty-loamy	Loamy-sandy	Sandy	
First crop	Rice	Rice	Upland crop	Upland crop	
Second crop	Rice	Rice	Upland crop	Upland crop	
Winter crop	Upland crop or vegetable	Upland crop or vegetable	Upland crop or vegetable	Upland crop or vegetable	

4. Hydrological data

This study is a hindcast study utilizing hydrological data covering 19 years from 1951 to 1969 inclusive. (the Minteh reservoir started its operation in 1970.)

Three kinds of hydrological data are used in this study. The first kind is the daily stream flow data of the Lao-tien-liao creek. This is used for the reservoir inflow estimation.

The second kind is the daily rainfall data at Houlung, a town situated near to the irrigated area. Such rainfall data are used for the effective rainfall estimation in the Irrigation Requirement calculations.

The third kind is the pan evaporation data at Hsinchu. Although Hsinchu is located some distance away, it belongs to the same climatic region of the Minteh reservoir and its irrigated area as far as evaporation is concerned.

The evaporation data are used to estimate the Evapo-transpiration of crops, and to calculate the evaporation loss from the water surface of the reservoir. As Hsinchu is located in a plain area and the Minteh reservoir in a hilly area, an empirical factor of 0.6 is applied to the evaporation data in the evaporation loss calculations.

5. Seepage loss in reservoir

The reservoir site is composed of tight rock of good quality. The geological structure there is simple. It was judged that the seepage loss in reservoir would be negligible.

6. Effective rainfall and irrigation requirement for rice

It has been a good practice in Taiwan to estimate the effective rainfall for crops in the irrigated areas. This can make the estimation of irrigation requirement and the reservoir release more exact.

The method of calculating the effective rainfall and irrigation requirement for rice is explained in the following:

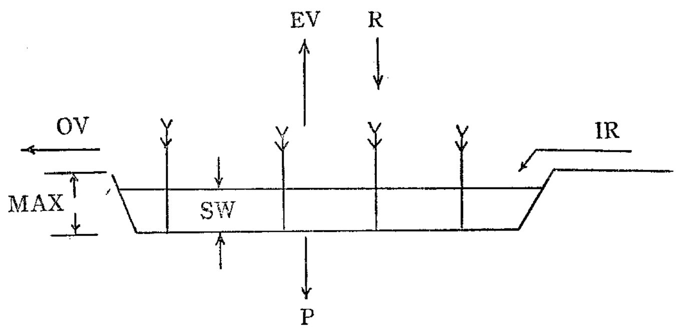


Fig. 3. A schematic graph illustrating effective rainfall for rice

Referring to Fig. 3 of a schematic paddy field, let

MAX be the maximum depth of water in the paddy field.

SW be the depth of water standing in the paddy field on the day of consideration.

EV be the daily evapo-transpiration of rice.

P be the daily percolation loss from the bottom of paddy field.

E=EV+P

R be the daily rainfall.

IR be the daily irrigation (represented by depth of water).

OV be the overland overflow from the paddy field.

ER be the effective rainfall of the day.

At the beginning of the day of consideration (in fact the same as the end of the day before this day), the SW is termed $(SW)_o$. At the end of the day, the SW is termed $(SW)_n$.

Calculate first $SW=(SW)_o+R-E$

Case 1: If SW is greater than Max, then

$OV=SW-Max$

$ER=R-OV$

IR=0 (Irrigation is not necessary for this case, since the rainfall is more than enough.)

$(SW)_n=Max$ (After overflowing, water standing in paddy field at the end of the day is the maximum depth.)

Case 2: If SW is equal to or less than Max and is greater than 0, then

$ER=R$

IR=0 (Irrigation is not necessary, since water stored in paddy field plus rainfall is enough to meet the requirement.)

$(SW)_n=SW$

Case 3: If SW is equal to or less than 0 (This is a hypothetical SW. Actually it means that water stored in paddy field plus rainfall is not enough to meet the requirement.)
then
ER=R
IR=(−SW) (The amount of irrigation is just equal to the amount of deficiency.)
$(SW)_n=0$ (No water is standing at the end of the day.)

This method provides for day-to-day calculations to give both the effective rainfall (ER) and the irrigation required (IR).

In this method, Max is set at 60 millimeters by experience.

From the above, it is clear that irrigation is provided basically by the Continuous Irrigation method. It is assumed in this study that the results of the calculations can be regarded close to the effective rainfall and irrigation required under the Rotational Irrigation condition.

7. Effective Rainfall and irrigation requirement for Upland Crops

Let

AM be the amount of Readily Available Moisture in soil.
$(AM)_o$ be the AM at the beginning of the day of consideration.
$(AM)_n$ be the AM at the end of the day of consideration.
Max be the maximum amount of readily available moisture in soil, which is set at 50% of the soil's field capacity.
R be the amount of rainfall on the day.
EV be the evapo-transpiration of upland crop on the day.
LOS be the irrigation loss through surface runoff and/or deep percolation.
IR be the amount of irrigation needed to be applied on the day.

First calculate $AM=(AM)_o+R-EV$

Case 1: If AM is greater than Max, then
LOS=AM−Max
ER=R−LOS
IR=0
$(AM)_n$=Max

Case 2: If AM is equal to or less than Max and is greater than 0, then
ER=R

$IR=0$

$(AM)_n=AM$

Case 3: If AM is equal to or less than 0, then

$ER=R$

$IR=(-AM)+Max$

$(AM)_n=Max$ (After irrigation, the readily available moisture is brought back to its maximum amount.)

It is deliberately arranged that for both rice and upland crops, the cases and expressions in the calculation of effective rainfall are in identical form. This will give much convenience in the computer programming.

As the lands planted to upland crops in the irrigated area are of sandy soils, the value of Max is determined to be 45 millimeters by soil test.

8. Daily reservoir release

The daily release of the Minteh reservoir is composed of irrigation requirement, water for industrial and domestic use, and supplemental supply to outside areas. The latter two factors remain fixed in this study; it is the irrigation requirement that changes from day to day.

On a typical day of consideration, the respective irrigation requirements for the four zones in the irrigated area (derived from calculations explained above in paragraphs 6 and 7) are multiplied by the repective areas of the zones to give respective amounts of net irrigation for the zones. A field irrigation efficiency factor of 0.7 is then considered for upland crop irrigation, and that for rice irrigation is 1.

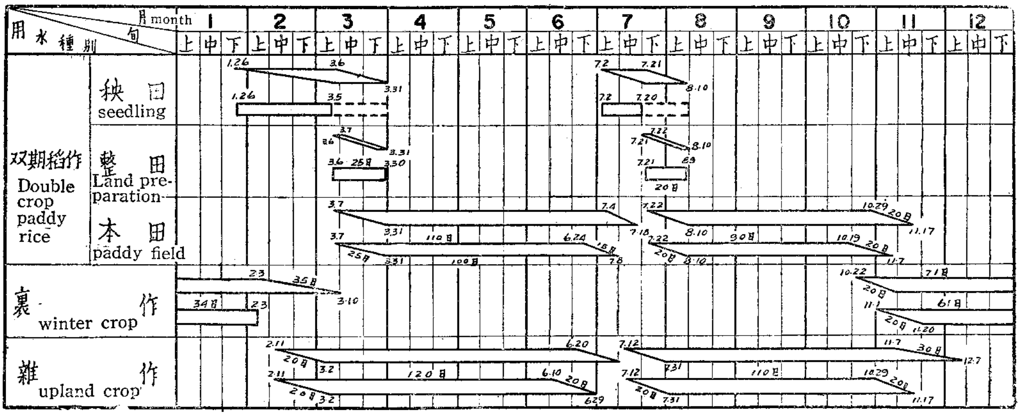
Although the canal system is all concrete lined, a conveyance loss factor of 0.25 is still applied to give the gross amount of reservoir release.

This day-to-day calculation of irrigation requirement is much complicated by the presence of seedlings, land preparation and staggering of transplanting times for the paddy fields. Separate calculations are made for water requirements of these items. This is done by following the irrigation schedule previously planned. This schedule is thus attached to the end of this paragraph.

The industrial and domestic supply is 26,700 cubic meters per day.

The supply to outside areas is 34,560 cubic meters per day in the period from July 21 to October 20.

Table 2. Irrigation Schedule of Minteh Reservoir
明德水庫灌區供水計劃



Upper 作物栽培或田間操作期間 represent the cropping period
Lower 灌溉期間 represent the irrigation period

Remarks:
1. Seedling period: 1st crop—40 days, 2nd crop—20 days.
2. Water for seedbeds is combined into the requirement for land preparation when the latter begins.
3. Water for land preparation is supplied one day before transplanting. Times of transplanting are staggered in 25 days for the 1st crop and 20 days for the 2nd crop.
4. Irrigation period for the first crop is 110 days, and for the second crop 90 days.

9. Evapo-transpiration of Crops

a. For Rice

The evapo-transpiration of rice and the seepage loss of paddy field are combined in a single term—the Consumptive Use of rice. For Zones 1, 2 and 3 where rice is planted, the corresponding amounts of consumptive use in millimeters per day have been determined as 7.92, 11.85, 17.53 respectively. (Refer to p. 41, Addendum to Houlung Reservoir Planning Report, published by the Taiwan Provincial Water Conservancy Bureau, in Chinese, as its Monograph No. 22, August 1963.)

b. For Upland Crops

The Hargreaves' ratio of evapo-transpiration to pan evaporation is used for estimating the daily evapo-transpiration value of crops. To simplify the problem, standard crops are chosen to represent planted crops on the land for this study. The standard crops for the first crop, the second crop and winter crop are respectively Corn, Corn, and Small Grains.

The following table shows the Hargreaves' ratios of the standard crops. These ratios are used in the calculation of this study.

Table 3. Hargreaves' Ratio for Standard Crops

Crops	Relative Growth in %										
	0	10	20	30	40	50	60	70	80	90	100
First crop (corn)	.20	.30	.50	.65	.80	.90	.90	.85	.75	.60	.50
Second crop (corn)	.20	.30	.50	.65	.80	.90	.90	.85	.75	.60	.50
Winter crop (grains)	.15	.25	.35	.40	.50	.60	.70	.80	.90	.90	.30

10. Hindcast study of reservoir operation

The reservoir operation is hindcast studied.

The starting date selected for this hindcast operation is July 1, 1951 under the reservoir full condition. This selection is considered proper because the reservoir tends to be full in July nearly every year.

The operation is first performed without the guidance of a Rule Curve.

The first set of calculations is carried out on a day-to-day basis. Steps involved in the calculations are as follows:

(a) Net Inflow is obtained by substracting from the Inflow the Evaporation Loss. Seepage Loss is considered negligible.

(b) Substracting Reservoir Release of the day from the Net Inflow gives the Storage Difference ΔS.

(c) This ΔS, when added to the Storage at the beginning of the day, gives the storage at the end of the day.

(d) If the resulting storage from step (c) is larger than the reservoir-full capacity, overflow occurs. The storage is thus made equal to the reservoir-full capacity.

(e) If the resulting storage from step (c) is smaller than the reservoir-empty capacity, the storage is made equal to the reservoir-empty capacity.

(f) The period from the first through the tenth day inclusive of a month is termed the First Part, the 11th to 20th the Second Part, and the 21th to the last day of a month the Third Part. The storage values resulting from step (c) calculated on the 10th, 20th and the last day are printed out.

Summary values of each Part on rainfall, effective rainfall, irrigation requirement, domestic and industry requirement, reservoir inflow, evaporation loss, net inflow, spillage, and deficiency are all calculated and printed out.

Table 4. Sample Print-out by Computer of Calculations on Effective Rainfall, Irrigation Requirement and Reservoir Operation Study for Minteh Reservoir

YEAR 1951

Mon Pt	Rainfall	Effective Rainfall				Irrigation Requirement	Domestic Industry Require-ment	Required Reservoir Release	Reservoir Inflow	Evapo-ration Loss	Net Reservoir Inflow	Storage	Spillage	Deficiency
	M. M.	Area (1) M. M.	Area (2) M. M.	Area (3) M. M.	Area (4) M. M.	Cub. M.	Cub. M.	Cub. M.	Cub. M.	Cub. M.	Cub. M.	Cub. M.	Cub. M.	Cub. M.
Jul. 1	41.1	41.1	41.1	41.1	13.5	681,267 (IR4 216,421)	267,000	948,267	2,770,848	51,124	2,719,724	17,000,000	1,771,457	0
Jul. 2	.8	.8	.8	.8	.8	89,944 (IR4 0)	267,000	356,944	1,147,392	63,285	1,084,107	17,000,000	727,163	0
Jul. 3	.0	.0	.0	.0	.0	2,048,884 (IR4 214,749)	293,700	2,342,584	859,680	68,530	791,150	15,448,566	0	0
Aug. 1	12.9	12.9	12.9	7.8	12.9	1,927,034 (IR4 0)	267,000	2,194,034	2,495,232	49,456	2,445,776	15,700,308	0	0
Aug. 2	23.5	23.5	23.5	16.8	23.5	1,359,462 (IR4 215,752)	267,000	1,626,462	5,851,008	43,416	5,807,592	16,631,982	3,249,456	0
Aug. 3	4.3	4.3	4.3	4.3	4.3	2,169,018 (IR4 237,829)	293,700	2,462,718	628,992	69,592	559,400	14,728,664	0	0
Sep. 1	.0	.0	.0	.0	.0	2,533,084 (IR4 226,456)	267,000	2,800,084	321,408	55,256	266,152	12,194,732	0	0
Sep. 2	.0	.0	.0	.0	.0	2,079,671 (IR4 230,136)	267,000	2,346,671	161,568	48,257	113,311	9,961,372	0	0
Sep. 3	34.7	34.7	34.7	22.5	34.7	975,930 (IR4 0)	267,000	1,242,930	223,776	24,652	199,124	8,917,566	0	0
Oct. 1	3.6	3.6	3.6	3.6	3.6	1,529,438 (IR4 215,752)	267,000	1,796,438	209,088	31,755	177,333	7,298,461	0	0
Oct. 2	82.2	81.5	82.2	9.1	20.9	1,086,223 (IR4 0)	267,000	1,353,223	3,617,568	27,570	3,589,998	9,535,236	0	0
Oct. 3	6.0	6.0	6.0	6.0	6.0	515,933 (IR4 0)	293,700	809,633	688,608	27,069	661,539	9,387,142	0	0
Nov. 1	9.8	1.6	1.6	9.8	9.8	683,896 (IR4 0)	267,000	950,896	349,056	30,403	318,653	8,754,899	0	0
Nov. 2	4.8	.7	.7	4.8	4.8	0 (IR4 0)	267,000	267,000	513,216	19,216	494,000	8,981,899	0	0
Nov. 3	.0	.0	.0	.0	.0	749,458 (IR4 216,756)	267,000	1,016,458	357,696	23,171	334,525	8,299,966	0	0
Dec. 1	13.5	13.5	13.5	7.2	7.2	0 (IR4 0)	267,000	267,000	605,664	25,160	580,504	8,613,470	0	0
Dec. 2	.0	.0	.0	.0	.0	559,769 (IR4 0)	267,000	826,769	310,176	26,924	283,252	8,069,953	0	0
Dec. 3	40.8	14.9	14.9	9.0	9.0	769,120 (IR4 222,442)	293,700	1,062,820	969,408	19,467	949,941	7,957,074	0	0
	278.0	239.1	239.8	142.8	151.0	19,758,131 (IR4 1,996,293)	4,912,800	24,670,931	22,080,384	704,303	21,376,081		5,748,076	0

(g) Summary values of each year on rainfall, effective rain fall, irrigation requirement, domestic and industry requirement, reservoir inflow, evaporation loss, net inflow, spillage and deficiency are calculated and printed out.

(h) The above steps (a) to (g) are repeated for the 19 years.
Table 4 is a sample sheet of the Print-out

11. Derivation of rule curves

One of the results of calculations in step (f) mentioned in Paragraph 10 above is a print-out of the value of storage on the 10th, 20th and the last day of a month, for every month of the 19 year hindcast study period.

To explain the derivation of Rule Curves, these values of storage are regrouped in the following manner:

(a) Set out a table of 36 columns, corresponding to the 36 parts of a year by dividing each month into 3 parts.

(b) Storage values of the 10th, 20th and the last day of a month are used to represent the storage of the 1st, 2nd and 3rd part of the month.

(c) Fill in by the order of year the storage values of the same part under the corresponding column.

Such a table is given as Table 5.

In Table 5, there are 36 columns each containing 18 or 19 storage values. By picking up or computing the values from these columns, one gets 36 storage values which constitute the 36 points of a rule curve.

Five rule curves are obtained this way:

(a) Rule Curve 1—by picking up the largest value in each column. (this is the upper envelop)

(b) Rule Curve 2—by picking up the smallest value in each column. (this is the lower envelop) In case the smallest is the value of reservoir-empty storage, then the next smallest is selected instead.

(c) Rule Curve 3—A computed value which has the recurrence frequency of 75% of all values in each column.

(d) Rule Curve 4—A computed value which has the recurrence frequency of 50% of all values in each column.

(e) Rule Curve 5—A computed value which has the recurrence frequency of 25% of all values in each column.

Table 5. Storage Value Recurrences of Minteh Reservoir from July 1, 1951 to end of 1969

Year	Jan.			Feb.			Mar.			Apr.			May.			Jun.		
	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
1951																		
1952	8.3	8.8	8.8	9.3	10.7	11.2	10.7	9.5	7.4	13.0	12.0	10.3	7.7	5.6	4.9	6.0	4.9	7.8
1953	8.4	8.2	9.0	10.5	17.0	17.0	16.5	16.9	16.2	16.7	17.0	17.0	17.0	17.0	17.0	17.0	16.9	15.4
1954	6.0	5.3	6.2	6.2	6.3	7.7	7.5	7.5	6.4	4.7	8.1	10.0	8.5	6.6	4.8	4.0	2.1	1.2
1955	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.7	1.2	1.2	1.2	1.2	4.2	6.4	5.5	3.2
1956	16.7	17.0	17.0	17.0	17.0	17.0	17.0	17.2	16.1	14.9	14.0	16.8	17.0	17.0	16.4	16.7	17.0	16.2
1957	17.0	17.0	17.0	17.0	17.0	17.0	17.0	17.0	17.0	17.0	16.6	14.6	12.3	12.4	17.0	17.0	17.0	17.0
1958	11.8	12.3	13.2	15.6	17.0	17.0	16.6	15.2	14.5	15.0	13.9	12.0	9.8	7.7	7.3	5.9	7.5	9.2
1959	7.1	7.0	6.9	7.1	8.4	14.7	16.0	15.7	13.1	11.5	10.8	17.0	16.1	14.2	15.5	17.0	16.0	14.3
1960	11.5	10.8	10.8	10.7	10.6	9.6	8.8	7.1	5.4	5.6	3.8	5.6	5.5	5.3	17.0	17.0	17.0	16.3
1961	11.5	11.4	10.0	10.1	10.3	12.3	12.3	14.1	16.8	15.1	14.8	14.3	13.7	12.3	14.0	13.3	10.9	10.5
1962	8.8	8.7	8.6	8.5	8.4	8.4	7.6	6.1	12.9	13.6	13.9	13.6	13.1	10.8	9.4	7.9	12.0	10.1
1963	7.6	7.5	6.0	5.8	5.8	5.7	4.9	3.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	2.1	1.6
1964	8.3	8.7	11.8	12.7	12.8	15.2	15.1	13.5	10.6	8.4	5.9	3.4	1.9	1.2	1.2	3.3	5.7	4.1
1965	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.5	2.9	3.9	8.4	7.6	7.0	10.4	10.1
1966	2.9	2.7	2.6	2.5	2.3	2.3	1.5	1.2	4.3	4.6	2.8	1.3	2.1	1.2	1.2	17.0	16.9	15.8
1967	7.1	7.1	7.0	7.6	7.6	7.8	7.6	5.9	3.1	1.6	1.2	1.2	1.2	1.2	17.0	16.9	16.6	14.5
1968	1.9	1.8	1.7	7.5	10.1	12.2	12.4	10.8	16.2	16.4	15.4	16.1	13.8	12.1	17.0	17.0	17.0	16.9
1969	4.0	4.1	4.1	4.6	4.6	5.0	6.9	9.0	7.1	5.8	4.4	2.0	1.2	1.2	5.8	12.1	17.0	16.9

Year	Jul.			Aug.			Sep.			Oct.			Nov.			Dec.		
	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
1951	17.0	17.0	15.4	15.7	16.6	14.7	12.1	9.9	8.9	7.2	9.5	9.3	8.7	8.9	8.2	8.6	8.0	7.9
1952	6.9	17.0	16.9	17.0	17.0	16.9	17.0	16.4	14.5	12.2	10.6	9.0	8.7	8.6	7.7	7.6	7.7	8.3
1953	17.0	16.0	15.7	13.1	17.0	15.6	14.8	13.0	11.0	11.8	9.8	9.1	9.0	8.4	8.4	6.9	6.8	6.0
1954	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2
1955	10.1	12.6	16.9	15.1	16.2	17.0	17.0	17.0	16.3	15.1	13.4	12.6	12.8	13.5	15.2	15.1	15.2	15.8
1956	16.2	17.0	17.0	17.0	17.0	17.0	17.0	17.0	17.0	16.2	15.7	17.0	17.0	17.0	16.0	15.7	16.5	17.0
1957	17.0	17.0	15.8	15.5	14.3	14.8	12.8	10.7	9.8	10.7	10.9	11.4	11.6	11.5	11.5	11.3	10.9	11.4
1958	10.0	10.7	10.7	11.0	8.9	8.9	16.8	16.8	14.9	13.9	11.8	11.0	10.0	9.9	8.5	7.0	7.0	7.1
1959	13.6	17.0	16.4	17.0	16.9	16.9	17.0	17.0	16.4	14.6	13.5	12.1	11.9	12.7	13.0	11.7	11.7	11.6
1960	15.7	15.5	17.0	17.0	17.0	17.0	16.9	17.0	16.9	15.2	13.3	12.8	11.4	12.0	12.2	11.0	11.2	11.3
1961	12.3	14.2	15.9	17.0	16.1	15.5	15.6	17.0	16.8	14.9	13.7	12.3	11.4	11.4	10.1	10.0	8.6	8.6
1962	10.0	9.0	13.6	17.0	16.0	14.3	16.5	15.0	12.9	13.0	11.9	10.4	9.8	10.2	8.9	8.9	7.6	7.6
1963	2.2	5.7	4.8	2.7	1.2	1.2	9.8	17.0	15.8	14.2	12.1	10.6	10.4	9.2	9.2	9.6	9.1	8.3
1964	3.4	2.3	1.2	1.2	3.7	9.7	8.8	8.5	6.6	5.5	4.2	3.6	2.6	1.2	1.2	1.2	1.2	1.2
1965	9.9	10.2	14.9	13.1	17.0	15.7	14.6	12.4	10.2	9.9	7.8	7.0	6.1	6.0	6.0	4.5	3.1	3.0
1966	15.2	15.3	14.9	12.6	17.0	16.9	16.2	17.0	15.4	14.1	12.0	10.5	10.3	8.9	8.8	7.9	7.3	7.2
1967	13.6	14.0	15.2	16.7	15.1	13.3	11.7	8.8	8.4	6.2	4.9	4.3	3.3	3.3	1.9	1.9	1.9	1.9
1968	17.0	16.9	15.0	16.6	15.1	16.6	14.7	12.6	10.5	10.3	9.1	7.5	7.3	6.3	5.7	4.8	4.2	4.1
1969	16.8	16.8	16.6	17.0	16.6	13.8	13.3	14.8	17.0	16.9	16.4	15.5	15.5	15.6	15.0	14.5	13.7	13.7

Remarks: 1. Value of storage in million M^3
2. Reservoir-full storoge at 17.0
3. Reservoir-empty storage at 1.2

In additional to these 5 curves, there is also Rule Curve 6 which is the original rule curve worked out in the planning stage of the Minteh reservoir project.

Numerical values of the six Rule Curves are listed in Table 6.

Table 6. Rule Curves for Minteh Reservoir

N	Curve 1	Curve 2	Curve 3	Curve 4	Curve 5	Curve 6
1	17,000,000	1,288,238	11,537,459	7,978,797	3,756,469	8,500,000
2	17,000,000	1,247,883	11,038,076	7,869,011	3,815,962	8,500,000
3	17,000,000	1,763,273	11,071,409	7,868,047	3,742,637	7,800,000
4	17,000,000	2,501,561	11,258,068	8,085,696	5,589,379	8,000,000
5	17,000,000	2,365,718	13,915,199	9,300,737	5,530,871	8,800,000
6	17,000,000	2,345,032	15,662,358	10,445,407	5,566,854	9,200,000
7	17,000,000	1,579,627	16,181,410	9,772,529	6,429,716	9,790,000
8	17,000,000	3,296,907	15,382,353	9,261,582	5,288,085	9,500,000
9	17,000,000	3,177,406	16,133,581	9,047,466	4,058,290	9,300,000
10	17,000,000	1,638,360	15,099,877	10,046,603	3,883,915	9,200,000
11	17,000,000	1,276,193	14,224,989	9,516,533	2,522,761	9,000,000
12	17,000,000	1,315,450	14,990,852	10,198,907	1,899,343	7,550,000
13	17,000,000	1,903,397	13,776,845	8,164,325	1,727,547	4,700,000
14	17,000,000	5,306,725	12,380,815	7,205,575	1,200,000	3,000,000
15	17,000,000	4,234,370	17,000,000	8,550,903	4,674,890	2,850,000
16	17,000,000	3,340,379	17,000,000	12,739,354	6,003,349	2,500,000
17	17,000,000	2,123,214	17,000,000	14,037,150	5,696,674	1,200,000
18	17,000,000	1,695,550	16,285,901	12,423,642	6,936,485	1,900,000
19	17,000,000	2,289,291	16,884,884	13,673,885	9,999,513	3,400,000
20	17,000,000	2,355,780	17,000,000	15,410,039	10,616,033	13,450,000
21	17,000,000	4,869,510	16,722,265	15,607,508	14,632,169	13,450,000
22	17,000,000	2,775,833	17,000,000	16,169,903	13,012,525	13,450,000
23	17,000,000	3,761,126	17,000,000	16,453,653	14,911,542	13,450,000
24	17,000,000	8,986,723	16,936,975	15,602,212	13,696,809	13,450,000
25	17,000,000	8,859,907	16,982.030	15,250,494	12,719,702	11,800,000
26	17,000,000	8,500,531	17,000,000	15,761,817	12,044,797	10,700,000
27	17,000,000	6,666,173	16,582,938	14,758,304	10,168,847	10,600,000
28	16,971,729	5,585,296	14,991,511	13,478,169	10,247,225	10,300,000
29	16,430,520	4,292,069	13,511,668	11,873,846	9,427,357	10,200,000
30	17,000,000	3,648,090	12,439,989	10,592,682	8,665,495	9,790,000
31	17,000,000	2,690,009	11,687,804	10,186,509	8,377,095	9,400,000
32	17,000,000	1,258,245	12,199,831	9,600,714	7,943,805	9,300,000
33	16,079,077	1,982,282	12,460,152	8,906,662	7,280,260	8,650,000
34	15,733,737	1,922,446	11,431,345	8,798,583	6,436,924	8,650,000
35	16,503,218	1,931,572	11,369,208	7,915,083	6,166,960	8,500,000
36	17,000,000	1,915,328	11,506,382	8,128,568	5,596,581	8,500,000

12. Reservoir operation under the guidance of rule curve

Starting from Rule Curve 1, each of the six curves is successively used to guide the reservoir operation hindcast calculations. A part of a month is taken up as the unit period in calculation.

For a part of month in consideration, the storage at the beginning of period is first looked up and is compared with the Rule Curve value of the same period. Two cases may happen:

Case 1: $S \geqslant RC$ (the storage is greater than or equal to the rule curve value) in this case, the reservoir release of this period is made equal to the whole amount of irrigation, domestic and industrial requirements.

Case 2: $S < RC$ (the storage is less than the rule curve value) in this case, a reduction of 30% on the irrigation requirement is made, but there will be no reduction on domestic and industrial requirements. Hence the reservoir release of the period equals to the 70% of the irrigation requirement plus the 100% of domestic and industrial requirements.

Substracting the reservoir release from the net inflow gives the difference in storage, which is then added to the storage at the beginning of the period to give the storage at the end of the period.

Four additional items are calculated as follows:

(a) Utilized inflow —equals to the amount of net inflow if there is no overflow occurred over the spillway, or equals to the amount of net inflow minus spillage if there is overflow.

(b) Spillage —when the storage at the end of the period is calculated, compare it with the reservoir-full capacity. If the former is larger, overflow occurs, then the amount of spillage is the difference of the former and the latter.

(c) Deficiency —deficiency occurs when the calculated storage at the end of the period falls below the reservoir-empty capacity. The amount of deficiency equals to the difference of the former and the latter.

(d) Time of deficiency—if deficiency occurs in the period, the time of deficiency is made equal to 1.

The above steps are repeated for every part of all months in the 19 year study period. This forms one set of calculations. For 6 rule curves, 6 sets of calculations are made.

The result of calculations for every part, as well as the yearly and total sums are printed out. The following attached Table 7 are six sample print-out sheets for these six rule curves.

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Table 7. Minteh Reservoir Operation Study Based on Operation Curve 1

Q YEAR	PT	IRRIGATION REQUIREMENT (CUB.M.)	DOMESTIC & INDUSTRY REQUIREMENT (CUB.M.)	REQUIRED RESERVOIR RELEASE (CUB.M.)	NET RESERVOIR INFLOW (CUB.M.)	OPERATION CURVE (CUB.M.)	STORAGE (CUB.M.)	SPILLAGE (CUB.M.)	AMOUNT OF UTILIZED INFLOW (CUB.M.)	DEFICIENCY (CUB.M.)	DI
1951	19	681,267	267,000	948,267	2,770,848	17,000,000	17,000,000	1,771,379	999,469	0	0
1951	20	89,944	267,000	356,944	1,147,392	17,000,000	17,000,000	727,159	420,233	0	0
1951	21	2,048,884	293,700	2,342,584	859,680	17,000,000	15,446,860	0	859,680	0	0
1951	22	1,927,034	267,000	1,615,923	2,495,232	17,000,000	16,277,624	0	2,495,232	0	0
1951	23	1,359,462	267,000	1,218,623	5,851,008	17,000,000	17,000,000	3,867,336	1,983,672	0	0
1951	24	2,169,018	293,700	2,462,718	628,992	17,000,000	15,093,944	0	628,992	0	0
1951	25	2,533,084	267,000	2,040,158	321,408	17,000,000	13,316,556	0	321,408	0	0
1951	26	2,079,671	267,000	1,722,769	161,568	17,000,000	11,702,144	0	161,568	0	0
1951	27	975,930	267,000	950,151	223,776	17,000,000	10,947,722	0	223,776	0	0
1951	28	1,529,438	267,000	1,337,606	209,088	16,971,729	9,781,888	0	209,088	0	0
1951	29	1,086,223	267,000	1,027,356	3,617,568	16,430,520	12,341,771	0	3,617,568	0	0
1951	30	515,933	293,700	654,353	688,608	17,000,000	12,343,967	0	688,608	0	0
1951	31	683,896	267,000	745,727	349,056	17,000,000	11,911,375	0	349,056	0	0
1951	32	0	267,000	267,000	513,216	17,000,000	12,134,903	0	513,216	0	0
1951	33	749,458	267,000	791,620	357,696	16,079,077	11,673,408	0	357,696	0	0
1951	34	0	267,000	267,000	605,664	15,733,737	11,981,849	0	605,664	0	0
1951	35	559,769	267,000	658,838	310,176	16,503,218	11,600,747	0	310,176	0	0
1951	36	769,120	293,700	832,084	969,408	17,000,000	11,713,244	0	969,408	0	0
		19,758,131	4,912,800	20,240,221	22,080,384			6,365,874	15,714,510	0	0

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Table 7. Minteh Reservoir Operation Study Based on Operation Curve 1

O	YEAR	PT	IRRIGATION REQUIREMENT (CUB.M.)	DOMESTIC & INDUSTRY REQUIREMENT (CUB.M.)	REQUIRED RESERVOIR RELEASE (CUB.M.)	NET RESERVOIR INFLOW (CUB.M.)	OPERATION CURVE (CUB.M.)	STORAGE (CUB.M.)	SPILLAGE (CUB.M.)	AMOUNT OF UTILIZED INFLOW (CUB.M.)	DEFICIENCY (CUB.M.)	DT
	1952	1	0	267,000	267,000	673,920	17,000,000	12,102,710	0	673,920	0	0
	1952	2	0	267,000	267,000	821,664	17,000,000	12,638,393	0	821,664	0	0
	1952	3	0	293,700	293,700	266,112	17,000,000	12,589,184	0	266,112	0	0
	1952	4	0	267,000	267,000	832,896	17,000,000	13,134,708	0	832,896	0	0
	1952	5	0	267,000	267,000	1,656,288	17,000,000	14,502,789	0	1,656,288	0	0
	1952	6	0	240,300	240,300	705,024	17,000,000	14,943,453	0	705,024	0	0
	1952	7	619,356	267,000	700,549	425,088	17,000,000	14,660,097	0	425,088	0	0
	1952	8	1,414,498	267,000	1,257,148	463,104	17,000,000	13,844,404	0	463,104	0	0
	1952	9	2,655,136	293,700	2,152,295	902,016	17,000,000	12,567,471	0	902,016	0	0
	1952	10	206,095	267,000	411,266	6,086,016	17,000,000	17,000,000	1,221,143	4,864,873	0	0
	1952	11	1,586,770	267,000	1,853,770	883,872	17,000,000	15,982,326	0	883,872	0	0
	1952	12	2,010,291	267,000	1,674,203	618,624	17,000,000	14,895,818	0	618,624	0	0
	1952	13	2,372,832	267,000	1,927,982	123,552	17,000,000	13,034,591	0	123,552	0	0
	1952	14	2,098,459	267,000	1,735,921	254,016	17,000,000	11,496,777	0	254,016	0	0
	1952	15	935,149	293,700	948,304	603,072	17,000,000	11,105,449	0	603,072	0	0
	1952	16	299,149	267,000	476,404	1,636,416	17,000,000	12,226,390	0	1,636,416	0	0
	1952	17	1,505,441	267,000	1,320,808	730,080	17,000,000	11,580,910	0	730,080	0	0
	1952	18	580,367	267,000	673,256	3,793,824	17,000,000	14,655,468	0	3,793,824	0	0
	1952	19	771,244	267,000	806,370	209,088	17,000,000	13,987,720	0	209,088	0	0
	1952	20	89,944	267,000	329,960	11,144,736	17,000,000	17,000,000	7,749,509	3,395,227	0	0
	1952	21	1,190,207	293,700	1,483,907	5,925,312	17,000,000	17,000,000	4,385,254	1,540,058	0	0
	1952	22	1,292,647	267,000	1,559,647	2,829,600	17,000,000	17,000,000	1,218,656	1,610,944	0	0
	1952	23	1,902,290	267,000	2,169,290	2,546,208	17,000,000	17,000,000	322,290	2,223,918	0	0
	1952	24	725,500	293,700	1,019,200	4,163,616	17,000,000	17,000,000	3,084,839	1,078,777	0	0
	1952	25	880,928	267,000	1,147,928	2,204,064	17,000,000	17,000,000	1,013,785	1,190,279	0	0
	1952	26	1,941,608	267,000	2,208,608	2,776,032	17,000,000	17,000,000	519,553	2,256,479	0	0
	1952	27	2,029,811	267,000	2,296,811	402,624	17,000,000	15,059,845	0	402,624	0	0
	1952	28	2,049,796	267,000	1,701,357	95,040	16,971,729	13,400,753	0	95,040	0	0
	1952	29	1,272,580	267,000	1,157,806	17,280	16,430,520	12,218,558	0	17,280	0	0
	1952	30	1,361,501	293,700	1,246,750	19,008	17,000,000	10,949,347	0	19,008	0	0
	1952	31	102,424	267,000	338,696	105,408	17,000,000	10,680,804	0	105,408	0	0
	1952	32	0	267,000	267,000	167,616	17,000,000	10,556,382	0	167,616	0	0
	1952	33	761,024	267,000	799,716	143,424	16,079,077	9,876,295	0	143,424	0	0
	1952	34	0	267,000	267,000	273,024	15,733,737	9,864,360	0	273,024	0	0
	1952	35	0	267,000	267,000	349,920	16,503,218	9,927,592	0	349,920	0	0
	1952	36	0	293,700	293,700	848,448	17,000,000	10,465,317	0	848,448	0	0
			32,655,047	9,772,200	36,095,652	55,696,032			19,515,029	36,181,003	0	0

Minteh Reservoir Operation Study Based on Operation Curve 2

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0 YEAR	PT	IRRIGATION REQUIREMENT (CUB.M.)	DOMESTIC & INDUSTRY REQUIREMENT (CUB.M.)	REQUIRED RESERVOIR RELEASE (CUB.M.)	NET RESERVOIR INFLOW (CUB.M.)	OPERATION CURVE (CUB.M.)	STORAGE (CUB.M.)	SPILLAGE (CUB.M.)	AMOUNT OF UTILIZED INFLOW (CUB.M.)	DEFICIENCY (CUB.M.)	DT
1951	19	681,267	267,000	948,267	2,770,848	2,289,291	17,000,000	1,771,379	999,469	0	0
1951	20	89,944	267,000	356,944	1,147,392	2,355,780	17,000,000	727,159	420,233	0	0
1951	21	2,048,884	293,700	2,342,584	859,680	4,869,510	15,446,860	0	859,680	0	0
1951	22	1,927,034	267,000	2,194,034	2,495,232	2,775,833	15,699,513	0	2,495,232	0	0
1951	23	1,359,462	267,000	1,626,462	5,851,008	3,761,126	17,000,000	2,882,188	2,968,820	0	0
1951	24	2,169,018	293,700	2,462,718	628,992	8,986,723	15,093,944	0	628,992	0	0
1951	25	2,533,084	267,000	2,800,084	321,408	8,859,907	12,556,630	0	321,408	0	0
1951	26	2,079,671	267,000	2,346,671	161,568	8,500,531	10,320,107	0	161,568	0	0
1951	27	975,930	267,000	1,242,930	223,776	6,666,173	9,274,947	0	223,776	0	0
1951	28	1,529,438	267,000	1,796,438	209,088	5,585,296	7,653,497	0	209,088	0	0
1951	29	1,086,223	267,000	1,353,223	3,617,568	4,292,069	9,891,733	0	3,617,568	0	0
1951	30	515,933	293,700	809,633	688,608	3,648,090	9,742,989	0	688,608	0	0
1951	31	683,896	267,000	950,896	349,056	2,690,009	9,109,849	0	349,056	0	0
1951	32	0	267,000	267,000	513,216	1,258,245	9,336,620	0	513,216	0	0
1951	33	749,458	267,000	1,016,458	357,696	1,982,282	8,654,179	0	357,696	0	0
1951	34	0	267,000	267,000	605,664	1,922,446	8,967,329	0	605,664	0	0
1951	35	559,769	267,000	826,769	310,176	1,931,572	8,423,266	0	310,176	0	0
1951	36	769,120	293,700	1,062,820	969,408	1,915,328	8,309,140	0	969,408	0	0
		19,758,131	4,912,800	24,670,931	22,080,384			5,380,726	16,699,658	0	0

Minteh Reservoir Operation Study Based on Operation Curve 2

O YEAR	PT	IRRIGATION REQUIREMENT (CUB.M.)	DOMESTIC & INDUSTRY REQUIREMENT (CUB.M.)	REQUIRED RESERVOIR RELEASE (CUB.M.)	NET RESERVOIR INFLOW (CUB.M.)	OPERATION CURVE (CUB.M.)	STORAGE (CUB.M.)	SPILLAGE (CUB.M.)	AMOUNT OF UTILIZED INFLOW (CUB.M.)	DEFICIENCY (CUB.M.)	DT
1952	1	0	267,000	267,000	673,920	1,288,238	8,701,731	0	673,920	0	0
1952	2	0	267,000	267,000	821,664	1,247,883	9,240,675	0	821,664	0	0
1952	3	0	293,700	293,700	266,112	1,763,273	9,195,037	0	266,112	0	0
1952	4	0	267,000	267,000	832,896	2,501,561	9,743,941	0	832,896	0	0
1952	5	0	267,000	267,000	1,656,288	2,365,718	11,115,403	0	1,656,288	0	0
1952	6	0	240,300	240,300	705,024	2,345,032	11,563,925	0	705,024	0	0
1952	7	619,356	267,000	886,356	425,088	1,579,627	11,091,607	0	425,088	0	0
1952	8	1,414,498	267,000	1,681,498	463,104	3,296,907	9,854,952	0	463,104	0	0
1952	9	2,655,136	293,700	2,948,836	902,016	3,177,406	7,786,299	0	902,016	0	0
1952	10	206,095	267,000	473,095	6,086,016	1,638,360	13,383,355	0	6,086,016	0	0
1952	11	1,586,770	267,000	1,853,770	883,872	1,276,193	12,371,735	0	883,872	0	0
1952	12	2,010,291	267,000	2,277,291	618,624	1,315,450	10,686,387	0	618,624	0	0
1952	13	2,372,832	267,000	2,639,832	123,552	1,903,397	8,123,659	0	123,552	0	0
1952	14	2,098,459	267,000	2,365,459	254,016	5,306,725	5,969,761	0	254,016	0	0
1952	15	935,149	293,700	1,228,849	603,072	4,234,370	5,314,025	0	603,072	0	0
1952	16	299,149	267,000	566,149	1,636,416	3,340,379	6,360,522	0	1,636,416	0	0
1952	17	1,505,441	267,000	1,772,441	730,080	2,123,214	5,282,072	0	730,080	0	0
1952	18	580,367	267,000	847,367	3,793,824	1,695,550	8,201,402	0	3,793,824	0	0
1952	19	771,244	267,000	1,038,244	209,088	2,289,291	7,322,505	0	209,088	0	0
1952	20	89,944	267,000	356,944	11,144,736	2,355,780	17,000,000	1,074,478	10,070,258	0	0
1952	21	1,190,207	293,700	1,483,907	5,925,312	4,869,510	17,000,000	4,385,254	1,540,058	0	0
1952	22	1,292,647	267,000	1,559,647	2,829,600	2,775,833	17,000,000	1,218,656	1,610,944	0	0
1952	23	1,902,290	267,000	2,169,290	2,546,208	3,761,126	17,000,000	322,290	2,223,918	0	0
1952	24	725,500	293,700	1,019,200	4,163,616	8,986,723	17,000,000	3,084,839	1,078,777	0	0
1952	25	880,928	267,000	1,147,928	2,204,064	8,859,907	17,000,000	1,013,785	1,190,279	0	0
1952	26	1,941,608	267,000	2,208,608	2,776,032	8,500,531	17,000,000	519,553	2,256,479	0	0
1952	27	2,029,811	267,000	2,296,811	402,624	6,666,173	15,059,845	0	402,624	0	0
1952	28	2,049,796	267,000	2,316,796	95,040	5,585,296	12,785,814	0	95,040	0	0
1952	29	1,272,580	267,000	1,539,580	17,280	4,292,069	11,222,961	0	17,280	0	0
1952	30	1,361,501	293,700	1,655,201	19,008	3,648,090	9,547,438	0	19,008	0	0
1952	31	102,424	267,000	369,424	105,408	2,690,009	9,250,693	0	105,408	0	0
1952	32	0	267,000	267,000	167,616	1,258,245	9,128,140	0	167,616	0	0
1952	33	761,024	267,000	1,028,024	143,424	1,982,282	8,221,547	0	143,424	0	0
1952	34	0	267,000	267,000	273,024	1,922,446	8,211,403	0	273,024	0	0
1952	35	0	267,000	267,000	349,920	1,931,572	8,276,603	0	349,920	0	0
1952	36	0	293,700	293,700	848,448	1,915,328	8,815,985	0	848,448	0	0
		32,655,047	9,772,200	42,427,247	55,696,032			11,618,855	44,077,177	0	0

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Minteh Reservoir Operation Study Based on Operation Curve 3

0 YEAR	PT	IRRIGATION REQUIREMENT (CUB.M.)	DOMESTIC & INDUSTRY REQUIREMENT (CUB.M.)	REQUIRED RESERVOIR RELEASE (CUB.M.)	NET RESERVOIR INFLOW (CUB.M.)	OPERATION CURVE (CUB.M.)	STORAGE (CUB.M.)	SPILLAGE (CUB.M.)	AMOUNT OF UTILIZED INFLOW (CUB.M.)	DEFICIENCY (CUB.M.)	DT
1951	19	681,267	267,000	948,267	2,770,848	16,884,884	17,000,000	1,771,379	999,469	0	0
1951	20	89,944	267,000	356,944	1,147,392	17,000,000	17,000,000	727,159	420,233	0	0
1951	21	2,048,884	293,700	2,342,584	859,680	16,722,265	15,446,860	0	859,680	0	0
1951	22	1,927,034	267,000	1,615,923	2,495,232	17,000,000	16,277,624	0	2,495,232	0	0
1951	23	1,359,462	267,000	1,218,623	5,851,008	17,000,000	17,000,000	3,867,336	1,983,672	0	0
1951	24	2,169,018	293,700	2,462,718	628,992	16,936,975	15,093,944	0	628,992	0	0
1951	25	2,533,084	267,000	2,040,158	321,408	16,982,030	13,316,556	0	321,408	0	0
1951	26	2,079,671	267,000	1,722,769	161,568	17,000,000	11,702,144	0	161,568	0	0
1951	27	975,930	267,000	950,151	223,776	16,582,938	10,947,722	0	223,776	0	0
1951	28	1,529,438	267,000	1,337,606	209,088	14,991,511	9,781,888	0	209,088	0	0
1951	29	1,086,223	267,000	1,027,356	3,617,568	13,511,668	12,341,771	0	3,617,568	0	0
1951	30	515,933	293,700	654,353	688,608	12,439,989	12,343,967	0	688,608	0	0
1951	31	683,896	267,000	950,896	349,056	11,687,804	11,706,206	0	349,056	0	0
1951	32	0	267,000	267,000	513,216	12,199,831	11,929,985	0	513,216	0	0
1951	33	749,458	267,000	791,620	357,696	12,460,152	11,468,770	0	357,696	0	0
1951	34	0	267,000	267,000	605,664	11,431,345	11,777,565	0	605,664	0	0
1951	35	559,769	267,000	326,769	310,176	11,369,208	11,223,874	0	310,176	0	0
1951	36	769,120	293,700	832,084	969,408	11,506,382	11,341,882	0	969,408	0	0
		19,758,131	4,912,800	20,613,321	22,080,384			6,365,874	15,714,510	0	0

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Minteh Reservoir Operation Study Based on Operation Curve 3

O YEAR	PT	IRRIGATION REQUIREMENT (CUB.M.)	DOMESTIC & INDUSTRY REQUIREMENT (CUB.M.)	REQUIRED RESERVOIR RELEASE (CUB.M.)	NET RESERVOIR INFLOW (CUB.M.)	OPERATION CURVE (CUB.M.)	STORAGE (CUB.M.)	SPILLAGE (CUB.M.)	AMOUNT OF UTILIZED INFLOW (CUB.M.)	DEFICIENCY (CUB.M.)	DT
1952	1	0	267,000	267,000	673,920	11,537,459	11,731,716	0	673,920	0	0
1952	2	0	267,000	267,000	821,664	11,038,076	12,267,763	0	821,664	0	0
1952	3	0	293,700	293,700	266,112	11,071,409	12,218,922	0	266,112	0	0
1952	4	0	267,000	267,000	832,896	11,258,068	12,764,793	0	832,896	0	0
1952	5	0	267,000	267,000	1,656,288	13,915,199	14,133,227	0	1,656,288	0	0
1952	6	0	240,300	240,300	705,024	15,662,358	14,579,205	0	705,024	0	0
1952	7	619,356	267,000	700,549	425,088	16,161,410	14,291,025	0	425,088	0	0
1952	8	1,414,498	267,000	1,257,148	463,104	15,382,353	13,475,674	0	463,104	0	0
1952	9	2,655,136	293,700	2,152,295	902,016	16,133,581	12,199,178	0	902,016	0	0
1952	10	206,095	267,000	411,266	6,086,016	15,099,877	17,000,000	853,209	5,232,807	0	0
1952	11	1,586,770	267,000	1,853,770	883,872	14,224,989	15,982,326	0	883,872	0	0
1952	12	2,010,291	267,000	2,277,291	618,624	14,990,852	14,292,730	0	618,624	0	0
1952	13	2,372,832	267,000	2,639,832	123,552	13,776,845	11,721,016	0	123,552	0	0
1952	14	2,098,459	267,000	1,735,921	254,016	12,380,815	10,186,596	0	254,016	0	0
1952	15	935,149	293,700	948,304	603,072	17,000,000	9,798,425	0	603,072	0	0
1952	16	299,149	267,000	476,404	1,636,416	17,000,000	10,921,986	0	1,636,416	0	0
1952	17	1,505,441	267,000	1,320,808	730,080	17,000,000	10,280,270	0	730,080	0	0
1952	18	580,367	267,000	673,256	3,793,824	16,285,901	13,357,969	0	3,793,824	0	0
1952	19	771,244	267,000	806,870	209,088	16,884,884	12,694,156	0	209,088	0	0
1952	20	89,944	267,000	329,960	11,144,736	17,000,000	17,000,000	6,458,958	4,685,778	0	0
1952	21	1,190,207	293,700	1,483,907	5,925,312	16,722,265	17,000,000	4,385,254	1,540,058	0	0
1952	22	1,292,647	267,000	1,559,647	2,829,600	17,000,000	17,000,000	1,218,656	1,610,944	0	0
1952	23	1,902,290	267,000	2,169,290	2,546,208	17,000,000	17,000,000	322,290	2,223,918	0	0
1952	24	725,500	293,700	1,019,200	4,163,616	16,936,975	17,000,000	3,084,839	1,078,777	0	0
1952	25	880,928	267,000	1,147,928	2,204,064	16,982,030	17,000,000	1,013,785	1,190,279	0	0
1952	26	1,941,608	267,000	2,208,608	2,776,032	17,000,000	17,000,000	519,553	2,256,479	0	0
1952	27	2,029,811	267,000	2,296,811	402,624	16,582,938	15,059,845	0	402,624	0	0
1952	28	2,049,796	267,000	2,316,796	95,040	14,991,511	12,785,814	0	95,040	0	0
1952	29	1,272,580	267,000	1,157,806	17,280	13,511,668	11,604,735	0	17,280	0	0
1952	30	1,361,501	293,700	1,246,750	19,008	12,439,989	10,336,811	0	19,008	0	0
1952	31	102,424	267,000	338,696	105,408	11,687,804	10,069,378	0	105,408	0	0
1952	32	0	267,000	267,000	167,616	12,199,831	9,945,736	0	167,616	0	0
1952	33	761,024	267,000	799,716	143,424	12,460,152	9,266,395	0	143,424	0	0
1952	34	0	267,000	267,000	273,024	11,431,345	9,255,080	0	273,024	0	0
1952	35	0	267,000	267,000	349,920	11,369,208	9,318,995	0	349,920	0	0
1952	36	0	293,700	293,700	848,448	11,506,382	9,857,295	0	848,448	0	0
		32,655,047	9,772,200	38,025,529	55,696,032			17,856,544	37,839,488	0	0

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Minteh Reservoir Operation Study Based on Operation Curve 4

0 YEAR	PT	IRRIGATION REQUIREMENT (CUB.M.)	DOMESTIC & INDUSTRY REQUIREMENT (CUB.M.)	REQUIRED RESERVOIR RELEASE (CUB.M.)	NET RESERVOIR INFLOW (CUB.M.)	OPERATION CURVE (CUB.M.)	STORAGE (CUB.M.)	SPILLAGE (CUB.M.)	AMOUNT OF UTILIZED INFLOW (CUB.M.)	DEFICIENCY (CUB.M.)	DT
1951	19	681,267	267,000	948,267	2,770,848	13,673,885	17,000,000	1,771,379	999,469	0	0
1951	20	89,944	267,000	356,944	1,147,392	15,410,039	17,000,000	727,159	420,233	0	0
1951	21	2,048,884	293,700	2,342,584	859,680	15,607,508	15,446,860	0	859,680	0	0
1951	22	1,927,034	267,000	1,615,923	2,495,232	16,169,903	16,277,624	0	2,495,232	0	0
1951	23	1,359,462	267,000	1,218,623	5,851,008	16,453,653	17,000,000	3,867,336	1,983,672	0	0
1951	24	2,169,018	293,700	2,462,718	628,992	15,602,212	15,093,944	0	628,992	0	0
1951	25	2,533,084	267,000	2,040,158	321,408	15,250,494	13,316,556	0	321,408	0	0
1951	26	2,079,671	267,000	1,722,769	161,568	15,761,817	11,702,144	0	161,568	0	0
1951	27	975,930	267,000	950,151	223,776	14,758,304	10,947,722	0	223,776	0	0
1951	28	1,529,438	267,000	1,337,606	209,088	13,478,169	9,781,888	0	209,088	0	0
1951	29	1,086,223	267,000	1,027,356	3,617,568	11,873,846	12,341,771	0	3,617,568	0	0
1951	30	515,933	293,700	809,633	688,608	10,592,682	12,189,187	0	688,608	0	0
1951	31	683,896	267,000	950,396	349,056	10,186,509	11,551,685	0	349,056	0	0
1951	32	0	267,000	267,000	513,216	9,600,714	11,775,660	0	513,216	0	0
1951	33	749,458	267,000	1,016,458	357,696	8,906,662	11,089,815	0	357,696	0	0
1951	34	0	267,000	267,000	605,664	8,798,583	11,399,249	0	605,664	0	0
1951	35	559,769	267,000	826,769	310,176	7,915,083	10,851,232	0	310,176	0	0
1951	36	769,120	293,700	1,062,820	969,408	8,128,568	10,734,030	0	969,408	0	0
		19,758,131	4,912,800	21,223,675	22,080,384			6,365,874	15,714,510	0	0

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Minteh Reservoir Operation Study Based on Operation Curve 4

0 YEAR	PT	IRRIGATION REQUIREMENT (CUB.M.)	DOMESTIC & INDUSTRY REQUIREMENT (CUB.M.)	REQUIRED RESERVOIR RELEASE (CUB.M.)	NET RESERVOIR INFLOW (CUB.M.)	OPERATION CURVE (CUB.M.)	STORAGE (CUB.M.)	SPILLAGE (CUB.M.)	AMOUNT OF UTILIZED INFLOW (CUB.M.)	DEFICIENCY (CUB.M.)	DT
1952	1	0	267,000	267,000	673,920	7,978,797	11,124,432	0	673,920	0	0
1952	2	0	267,000	267,000	821,664	7,869,011	11,661,099	0	821,664	0	0
1952	3	0	293,700	293,700	266,112	7,868,047	11,612,889	0	266,112	0	0
1952	4	0	267,000	267,000	832,896	8,085,696	12,159,370	0	832,896	0	0
1952	5	0	267,000	267,000	1,656,288	9,300,737	13,523,377	0	1,656,288	0	0
1952	6	0	240,300	240,300	705,024	10,445,407	13,974,858	0	705,024	0	0
1952	7	619,356	267,000	886,356	425,088	9,772,529	13,501,212	0	425,088	0	0
1952	8	1,414,498	267,000	1,681,498	463,104	9,261,582	12,262,255	0	463,104	0	0
1952	9	2,655,136	293,700	2,948,336	902,016	9,047,466	10,190,627	0	902,016	0	0
1952	10	206,095	267,000	473,095	6,086,016	10,046,603	15,784,944	0	6,086,016	0	0
1952	11	1,586,770	267,000	1,853,770	883,372	9,516,533	14,769,113	0	883,872	0	0
1952	12	2,010,291	267,000	2,277,291	618,624	10,198,907	13,080,751	0	618,624	0	0
1952	13	2,372,832	267,000	2,639,332	123,552	8,164,325	10,511,971	0	123,552	0	0
1952	14	2,098,459	267,000	2,365,459	254,016	7,205,575	8,351,385	0	254,016	0	0
1952	15	935,149	293,700	948,304	603,072	8,550,903	7,967,679	0	603,072	0	0
1952	16	299,149	267,000	476,404	1,636,416	12,739,354	9,095,453	0	1,636,416	0	0
1952	17	1,505,441	267,000	1,320,808	730,080	14,037,150	8,458,543	0	730,080	0	0
1952	18	580,367	267,000	673,256	3,793,824	12,423,642	11,540,554	0	3,793,824	0	0
1952	19	771,244	267,000	806,370	209,088	13,673,885	10,882,256	0	209,088	0	0
1952	20	89,944	267,000	329,960	11,144,736	15,410,039	17,000,000	4,651,567	6,493,169	0	0
1952	21	1,190,207	293,700	1,483,907	5,925,312	15,607,508	17,000,000	4,385,254	1,540,058	0	0
1952	22	1,292,647	267,000	1,559,647	2,829,600	16,169,903	17,000,000	1,218,656	1,610,944	0	0
1952	23	1,902,290	267,000	2,169,290	2,546,208	16,453,653	17,000,000	322,290	2,223,918	0	0
1952	24	725,500	293,700	1,019,200	4,163,616	15,602,212	17,000,000	3,034,839	1,078,777	0	0
1952	25	880,928	267,000	1,147,928	2,204,064	15,250,494	17,000,000	1,013,785	1,190,279	0	0
1952	26	1,941,608	267,000	2,208,608	2,776,032	15,761,817	17,000,000	519,553	2,256,479	0	0
1952	27	2,029,811	267,000	2,296,811	402,624	14,758,304	15,059,845	0	402,624	0	0
1952	28	2,049,796	267,000	2,316,796	95,040	13,478,169	12,785,814	0	95,040	0	0
1952	29	1,272,580	267,000	1,539,580	17,280	11,873,846	11,222,961	0	17,280	0	0
1952	30	1,361,501	293,700	1,655,201	19,008	10,592,682	9,547,438	0	19,008	0	0
1952	31	102,424	267,000	338,696	105,408	10,186,509	9,281,421	0	105,408	0	0
1952	32	0	267,000	267,000	167,616	9,600,714	9,158,833	0	167,616	0	0
1952	33	761,024	267,000	1,028,024	143,424	8,906,662	8,252,190	0	143,424	0	0
1952	34	0	267,000	267,000	273,024	8,798,583	8,242,007	0	273,024	0	0
1952	35	0	267,000	267,000	349,920	7,915,083	8,307,163	0	349,920	0	0
1952	36	0	293,700	293,700	848,448	8,128,568	8,846,509	0	848,448	0	0
		32,655,047	9,772,200	41,142,127	55,696,032			15,195,944	40,500,088	0	0

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Minteh Reservoir Operation Study Based on Operation Curve 5

0 YEAR	PT	IRRIGATION REQUIREMENT (CUB.M.)	DOMESTIC & INDUSTRY REQUIREMENT (CUB.M.)	REQUIRED RESERVOIR RELEASE (CUB.M.)	NET RESERVOIR INFLOW (CUB.M.)	OPERATION CURVE (CUB.M.)	STORAGE (CUB.M.)	SPILLAGE (CUB.M.)	AMOUNT OF UTILIZED INFLOW (CUB.M.)	DEFICIENCY (CUB.M.)	DT
1951	19	681,267	267,000	948,267	2,770,848	9,999,513	17,000,000	1,771,379	999,469	0	0
1951	20	89,344	267,000	356,944	1,147,392	10,616,033	17,000,000	727,159	420,233	0	0
1951	21	2,048,884	293,700	2,342,584	859,680	14,632,169	15,446,860	0	859,680	0	0
1951	22	1,927,034	267,000	2,194,034	2,495,232	13,012,525	15,699,513	0	2,495,232	0	0
1951	23	1,359,462	267,000	1,626,462	5,851,008	14,911,542	17,000,000	2,832,188	2,968,820	0	0
1951	24	2,169,018	293,700	2,462,718	628,992	13,696,809	15,093,944	0	628,992	0	0
1951	25	2,533,084	267,000	2,800,084	321,408	12,719,702	12,556,630	0	321,408	0	0
1951	26	2,079,671	267,000	2,346,671	161,568	12,044,797	10,320,107	0	161,568	0	0
1951	27	975,930	267,000	1,242,930	223,776	10,168,847	9,274,947	0	223,776	0	0
1951	28	1,529,438	267,000	1,337,606	209,088	10,247,225	8,112,329	0	209,088	0	0
1951	29	1,086,223	267,000	1,027,356	3,617,568	9,427,357	10,675,339	0	3,617,568	0	0
1951	30	515,933	293,700	809,633	688,608	8,665,495	10,525,446	0	688,608	0	0
1951	31	683,896	267,000	950,896	349,056	8,377,095	9,890,996	0	349,056	0	0
1951	32	0	267,000	267,000	513,216	7,943,805	10,116,875	0	513,216	0	0
1951	33	749,458	267,000	1,016,458	357,696	7,280,260	9,433,379	0	357,696	0	0
1951	34	0	267,000	267,000	605,664	6,436,924	9,745,302	0	605,664	0	0
1951	35	559,769	267,000	826,769	310,176	6,166,960	9,199,966	0	310,176	0	0
1951	36	769,120	293,700	1,062,820	969,408	5,596,581	9,084,794	0	969,408	0	0
		19,758,131	4,912,800	23,886,232	22,080,384			5,330,726	16,699,658	0	0

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Minteh Reservoir Operation Study Based on Operation Curve 5

0 YEAR	PT	IRRIGATION REQUIREMENT (CUB.M.)	DOMESTIC & INDUSTRY REQUIREMENT (CUB.M.)	REQUIRED RESERVOIR RELEASE (CUB.M.)	NET RESERVOIR INFLOW (CUB.M.)	OPERATION CURVE (CUB.M.)	STORAGE (CUB.M.)	SPILLAGE (CUB.M.)	AMOUNT OF UTILIZED INFLOW (CUB.M.)	DEFICIENCY (CUB.M.)	DT
1952	1	0	267,000	267,000	673,920	3,756,469	9,476,621	0	673,920	0	0
1952	2	0	267,000	267,000	821,664	3,815,962	10,014,824	0	821,664	0	0
1952	3	0	293,700	293,700	266,112	3,742,637	9,963,375	0	266,112	0	0
1952	4	0	267,000	267,000	832,896	5,589,379	10,516,511	0	832,896	0	0
1952	5	0	267,000	267,000	1,656,288	5,530,871	11,887,236	0	1,656,288	0	0
1952	6	0	240,300	240,300	705,024	5,566,854	12,335,042	0	705,024	0	0
1952	7	619,356	267,000	886,356	425,088	6,429,716	11,862,277	0	425,088	0	0
1952	8	1,414,498	267,000	1,681,498	463,104	5,288,085	10,624,814	0	463,104	0	0
1952	9	2,655,136	293,700	2,948,836	902,016	4,058,290	8,555,279	0	902,016	0	0
1952	10	206,095	267,000	473,095	6,086,016	3,883,915	14,151,262	0	6,086,016	0	0
1952	11	1,586,770	267,000	1,853,770	883,872	2,522,761	13,133,148	0	883,872	0	0
1952	12	2,010,291	267,000	2,277,291	618,624	1,899,343	11,451,862	0	518,624	0	0
1952	13	2,372,832	267,000	2,639,832	123,552	1,727,547	8,887,095	0	123,552	0	0
1952	14	2,098,459	267,000	2,365,459	254,016	1,200,000	6,730,759	0	254,016	0	0
1952	15	935,149	293,700	1,228,849	603,072	4,674,890	6,071,957	0	603,072	0	0
1952	16	299,149	267,000	566,149	1,636,416	6,003,349	7,115,894	0	1,636,416	0	0
1952	17	1,505,441	267,000	1,772,441	730,080	5,696,674	6,034,254	0	730,080	0	0
1952	18	580,367	267,000	673,256	3,793,824	6,936,485	9,124,768	0	3,793,824	0	0
1952	19	771,244	267,000	806,370	209,088	9,999,513	8,474,001	0	209,088	0	0
1952	20	89,944	267,000	329,960	11,144,736	10,616,033	17,000,000	2,249,070	8,895,666	0	0
1952	21	1,190,207	293,700	1,483,907	5,925,312	14,632,169	17,000,000	4,385,254	1,540,058	0	0
1952	22	1,292,647	267,000	1,559,647	2,829,600	13,012,525	17,000,000	1,218,656	1,610,944	0	0
1952	23	1,902,290	267,000	2,169,290	2,546,208	14,911,542	17,000,000	322,290	2,223,918	0	0
1952	24	725,500	293,700	1,019,200	4,163,616	13,696,809	17,000,000	3,084,839	1,078,777	0	0
1952	25	880,928	267,000	1,147,328	2,204,064	12,719,702	17,000,000	1,013,785	1,190,279	0	0
1952	26	1,941,608	267,000	2,208,608	2,776,032	12,044,797	17,000,000	519,553	2,256,479	0	0
1952	27	2,029,811	267,000	2,296,811	402,624	10,168,847	15,059,845	0	402,624	0	0
1952	28	2,049,796	267,000	2,316,796	95,040	10,247,225	12,785,814	0	95,040	0	0
1952	29	1,272,580	267,000	1,539,580	17,280	9,427,357	11,222,961	0	17,280	0	0
1952	30	1,361,501	293,700	1,655,201	19,008	8,665,495	9,547,438	0	19,008	0	0
1952	31	102,424	267,000	369,424	105,408	8,377,095	9,250,693	0	105,408	0	0
1952	32	0	267,000	267,000	167,616	7,943,805	9,128,140	0	167,616	0	0
1952	33	761,024	267,000	1,028,024	143,424	7,280,260	8,221,547	0	143,424	0	0
1952	34	0	267,000	267,000	273,024	6,436,924	8,211,403	0	273,024	0	0
1952	35	0	267,000	267,000	349,920	6,166,960	8,276,603	0	349,920	0	0
1952	36	0	293,700	293,700	848,448	5,596,581	8,815,985	0	848,448	0	0
		32,655,047	9,772,200	41,994,778	55,696,032			12,793,447	42,902,585	0	0

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Minteh Reservoir Operation Study Based on Operation Curve 6

0 YEAR	PT	IRRIGATION REQUIREMENT (CUB.M.)	DOMESTIC & INDUSTRY REQUIREMENT (CUB.M.)	REQUIRED RESERVOIR RELEASE (CUB.M.)	NET RESERVOIR INFLOW (CUB.M.)	OPERATION CURVE (CUB.M.)	STORAGE (CUB.M.)	SPILLAGE (CUB.M.)	AMOUNT OF UTILIZED INFLOW (CUB.M.)	DEFICIENCY (CUB.M.)	DT
1951	19	681,267	267,000	948,267	2,770,848	3,400,000	17,000,000	1,771,379	999,469	0	0
1951	20	89,944	267,000	356,344	1,147,392	13,450,000	17,000,000	727,159	420,233	0	0
1951	21	2,048,884	293,700	2,342,584	859,680	13,450,000	15,446,860	0	859,680	0	0
1951	22	1,927,034	267,000	2,194,034	2,495,232	13,450,000	15,699,513	0	2,495,232	0	0
1951	23	1,359,462	267,000	1,626,462	5,851,008	13,450,000	17,000,000	2,882,188	2,968,820	0	0
1951	24	2,169,018	293,700	2,462,718	628,992	13,450,000	15,093,944	0	628,992	0	0
1951	25	2,533,084	267,000	2,800,084	321,408	11,800,000	12,556,630	0	321,408	0	0
1951	26	2,079,671	267,000	2,346,671	161,568	10,700,000	10,320,107	0	161,568	0	0
1951	27	975,930	267,000	950,151	223,776	10,600,000	9,567,726	0	223,776	0	0
1951	28	1,529,438	267,000	1,337,606	209,088	10,300,000	8,404,539	0	209,088	0	0
1951	29	1,086,223	267,000	1,027,356	3,617,568	10,200,000	10,966,879	0	3,617,568	0	0
1951	30	515,933	293,700	809,633	688,608	9,790,000	10,816,525	0	688,608	0	0
1951	31	683,896	267,000	950,896	349,056	9,400,000	10,181,597	0	349,056	0	0
1951	32	0	267,000	267,000	513,216	9,300,000	10,407,168	0	513,216	0	0
1951	33	749,458	267,000	1,016,458	357,696	8,650,000	9,723,288	0	357,696	0	0
1951	34	0	267,000	267,000	605,664	8,650,000	10,034,769	0	605,664	0	0
1951	35	559,769	267,000	826,769	310,176	8,500,000	9,483,976	0	310,176	0	0
1951	36	769,120	293,700	1,062,820	969,408	8,500,000	9,373,440	0	969,408	0	0
		19,758,131	4,912,800	23,593,453	22,080,384			5,390,726	16,699,658	0	0

Minteh Reservoir Operation Study Based on Operation Curve 6

D YEAR	PT	IRRIGATION REQUIREMENT (CUB.M.)	DOMESTIC & INDUSTRY REQUIREMENT (CUB.M.)	REQUIRED RESERVOIR RELEASE (CUB.M.)	NET RESERVOIR INFLOW (CUB.M.)	OPERATION CURVE (CUB.M.)	STORAGE (CUB.M.)	SPILLAGE (CUB.M.)	AMOUNT OF UTILIZED INFLOW (CUB.M.)	DEFICIENCY (CUB.M.)	DT
1952	1	0	267,000	267,000	673,920	8,500,000	9,765,012	0	673,920	0	0
1952	2	0	267,000	267,000	821,664	8,500,000	10,302,931	0	821,664	0	0
1952	3	0	293,700	293,700	266,112	7,800,000	10,256,198	0	266,112	0	0
1952	4	0	267,000	267,000	832,896	8,000,000	10,804,067	0	832,896	0	0
1952	5	0	267,000	267,000	1,656,288	8,800,000	12,174,521	0	1,656,288	0	0
1952	6	0	240,300	240,300	705,024	9,200,000	12,622,096	0	705,024	0	0
1952	7	619,356	267,000	886,356	425,088	9,790,000	12,149,182	0	425,088	0	0
1952	8	1,414,498	267,000	1,681,498	463,104	9,500,000	10,911,450	0	463,104	0	0
1952	9	2,655,136	293,700	2,948,836	902,016	9,300,000	8,841,576	0	902,016	0	0
1952	10	206,095	267,000	411,266	6,086,016	9,200,000	14,499,093	0	6,086,016	0	0
1952	11	1,586,770	267,000	1,853,770	883,872	9,000,000	13,485,329	0	883,872	0	0
1952	12	2,010,291	267,000	2,277,291	618,624	7,550,000	11,793,608	0	618,624	0	0
1952	13	2,372,832	267,000	2,639,332	123,552	4,700,000	9,232,888	0	123,552	0	0
1952	14	2,098,459	267,000	2,365,459	254,016	3,000,000	7,075,646	0	254,016	0	0
1952	15	935,149	293,700	1,228,849	603,072	2,850,000	6,415,638	0	603,072	0	0
1952	16	299,149	267,000	566,149	1,636,416	2,500,000	7,453,354	0	1,636,416	0	0
1952	17	1,505,441	267,000	1,772,441	730,080	1,200,000	6,375,370	0	730,080	0	0
1952	18	580,367	267,000	847,367	3,793,824	1,900,000	9,290,405	0	3,793,824	0	0
1952	19	771,244	267,000	1,038,244	209,088	3,400,000	8,407,740	0	209,088	0	0
1952	20	89,944	267,000	329,960	11,144,736	13,450,000	17,000,000	2,183,029	8,961,707	0	0
1952	21	1,190,207	293,700	1,483,907	5,925,312	13,450,000	17,000,000	4,385,254	1,540,058	0	0
1952	22	1,292,647	267,000	1,559,647	2,829,600	13,450,000	17,000,000	1,218,656	1,610,944	0	0
1952	23	1,902,290	267,000	2,169,290	2,546,208	13,450,000	17,000,000	322,290	2,223,918	0	0
1952	24	725,500	293,700	1,019,200	4,163,616	13,450,000	17,000,000	3,084,839	1,078,777	0	0
1952	25	880,928	267,000	1,147,928	2,204,064	11,800,000	17,000,000	1,013,785	1,190,279	0	0
1952	26	1,941,608	267,000	2,208,608	2,776,032	10,700,000	17,000,000	519,553	2,256,479	0	0
1952	27	2,029,811	267,000	2,296,811	402,624	10,600,000	15,059,845	0	402,624	0	0
1952	28	2,049,796	267,000	2,316,796	95,040	10,300,000	12,785,814	0	95,040	0	0
1952	29	1,272,580	267,000	1,539,580	17,280	10,200,000	11,222,961	0	17,280	0	0
1952	30	1,361,501	293,700	1,655,201	19,008	9,790,000	9,547,438	0	19,008	0	0
1952	31	102,424	267,000	369,424	105,408	9,400,000	9,250,693	0	105,408	0	0
1952	32	0	267,000	267,000	167,616	9,300,000	9,128,140	0	167,616	0	0
1952	33	761,024	267,000	1,028,024	143,424	8,650,000	8,221,547	0	143,424	0	0
1952	34	0	267,000	267,000	273,024	8,650,000	8,211,403	0	273,024	0	0
1952	35	0	267,000	267,000	349,920	8,500,000	8,276,603	0	349,920	0	0
1952	36	0	293,700	293,700	848,448	8,500,000	8,815,985	0	848,448	0	0
		32,655,047	9,772,200	42,338,434	55,696,032			12,727,406	42,968,626	0	0

13. Results of study

A summary table is obtained as the result of this study.

Table 8. Summary Reservoir Operation Based on Six Rule Curves

Curve	Total Spillage		Total Utilized Inflow		Total Deficiency		Total Times of Deficiency	
	million M^3	order	million M^3	order	million M^3	order	times	order
1	810.9	(1)	684.0	(6)	20.0	(6)	33	(6)
2	726.9	(6)	768.0	(1)	39.2	(1)	65	(1)
3	788.6	(2)	706.4	(5)	21.9	(5)	34	(5)
4	762.5	(3)	732.4	(4)	27.7	(4)	41	(4)
5	738.1	(5)	756.9	(2)	31.5	(2)	50	(2)
6	738.5	(4)	756.5	(3)	30.0	(3)	46	(3)

14. Selection of the best rule curve

A first glance at Table 8, Summary of Reservoir Operation Based on Six Rule Curves, would favor Rule Curve 1, because it gives the least Total Deficiency (20.0 million cubic meters) (order 6). However, a close examination reveals that, with the guidance of Rule Curve 1, the reservoir will be operating almost always with its storage below the corresponding rule curve value. This means that the reservoir would release water to meet only 70% of the irrigation requirement nearly all the time. This continuous shortage of water will certainly affect the crop yield. Rule Curve 1 is therefore left out of consideration.

Rule Curve 2 is apparently not worth for consideration, since it has the largest Total Deficiency among the six rule curves.

Rule Curve 3 which gives the second least Total Deficiency (21.9 million cubic meters) (order 5) is considered inadequate for adoption because the irrigation it provides will also always fall short of requirement.

Rule Curves 4, 5, and 6 are analyzed more in depth. Two more items are introduced for comparison, namely, the number of continuous times of deficiency and the number of continuous times when current storage is below rule curve storage. The table 9 shows the comparison.

From Table 9, it seems that the continuous deficiency occurred in 1954–1955 for Rule Curves 4, 5 and 6 would have caused same damage. Moreover, in 1964–1965, the numbers of continuous times when current storage is below rule curve storage for these 3 curves are quite close.

Table 9

Rule Curve	Number of continuous times of deficiency*	Number of continuous times when current storage is below rule curve storage**
4	27 parts (9 months)	34 parts (11 1/3months)
5	30 parts (10 months)	30 parts (10 months)
6	29 parts (9 2/3 months)	31 parts (10 1/3 months)

* occurred in 1954-1955 ** occurred in 1964-1965

The difference between Rule Curves 4, 5 and 6 in the sense of avoiding water deficiency is slight. However, since Rule Curve 4 has the least amount of total deficiency (27.7 million cubic meters, order 4) among the three, it is selected as the best rule curve. This curve is shown in Figure 4.

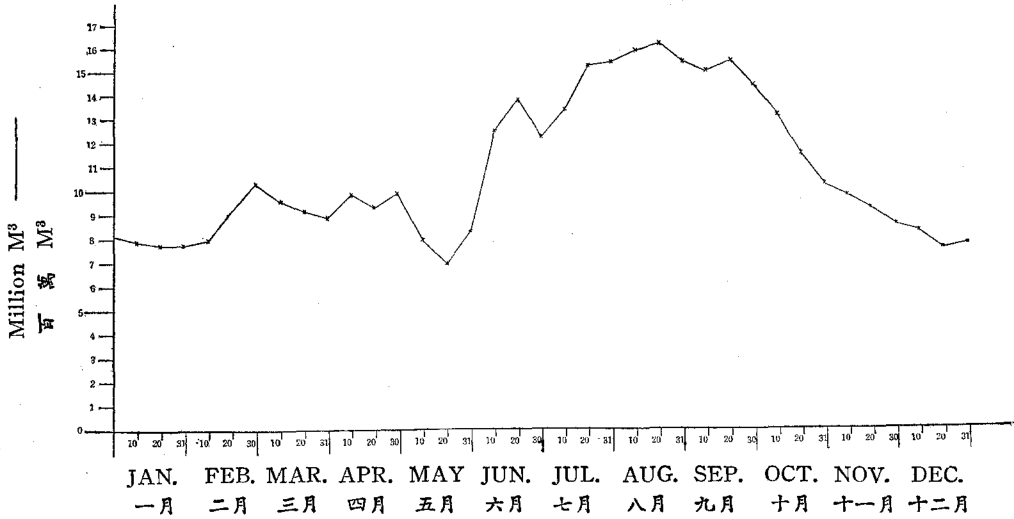


Fig. 4. Minteh Reservoir Rule Curve

The adequate figures of total spillage and total utilized inflow given by Rule Curve 4 also support this selection.

15. Updating of the rule curve

Rule curve should be updated preferably every two or three years because additional hydrological data will be available and there is the possibility of a change in the cropping area.

The computer program used in this study has taken this need into consideration. This program can be easily re-run if additional and/or new data are put into the data card set.

16. Application of this study to other reservoirs

The computer program for this study can be revised for use on other reservoirs constructed mainly for irrigation. Only some minor changes in the statements is needed for this purpose.

Part B. The Computer Program

1. The computer language

This program is written in PL/I language, which is capable of handling large volume of data for scientific problems.

2. The program

The entire work consists of 3 programs, one work program and two utility programs. The first utility program is designed to write data from punched cards onto a tape, which is used for the input of the work program. The output from the work program is on another tape, and the second program is used to print out the contents from this tape. These two utility programs are required for the multi-programming operation of the IBM 360/40 computer.

Only the work program is explained here, and the word program mentioned hereafter means the work program.

3. Nomenclature of symbols used in the program

ZA	—number of years.
RAIN(11)	—an one dimensional array consisting of 11 daily rainfall values.
EVP(11)	—an one-dimensional array consisting of daily evaporation values.
INF(11)	—an one-dimensional array consisting of 11 daily reservoir inflow values.
H(4)	—an one-dimensional array consisting of 4 numbers. Each number is either 1 or 0. 1 stands for paddy rice condition and 0 stands for upland crop condition. Thus the 1st, 2nd, 3rd and 4th number of the array represent the paddy rice/upland crop condition of the corresponding 1st, 2nd, 3rd and 4th zone of the irrigated area.
V(3, 4)	—a two-dimensional array of 3 rows each containing 4 numbers. Each number is either 1 or 0, standing for paddy rice or upland crop condition. 3 rows represent 3 cropping periods, the first crop, the second crop and the winter crop. 4 numbers in a row represent 4 zones.

E	—for paddy rice condition, E stands for evapo-transpiration plus percolation loss. For upland crop condition, E stands for evapotranspiration.
SOIL(7, 4)	—a two-dimensional array of 7 rows each containing 4 numbers. The first row SOIL(1, 4) consists of the values of evapo-transpiration plus percolation for paddy field of the 4 zones. The second row SOIL(2, 4) consists of the values of depth of water standing in paddy field of the 4 zones. The third row SOIL(3, 4) consists of the values of readily available moisture in soils of upland crop field of the 4 zones. The fourth row SOIL(4, 4) consists of the values of area in hectares of the 4 zones. The fifth row SOIL(5, 4) consists of reserved spaces to receive temporary values which shall be picked up from the sixth or the seventh row of this same array, or shall be assigned zeroes. The sixth row SOIL(6, 4) consists of the values of water requirement for land preparation in first crop period for the 4 zones. The seventh row SOIL(7, 4) consists of the values of water requirement for land preparation in second crop period for the 4 zones.
G	—a reserved space to receive temporary value from MAX or shall be assigned zero.
D	—under paddy rice condition, D stands for the depth of water in paddy field. Under upland crop condition, D stands for the amount of readily available moisture in soil.
MAX	—a reserved space to receive values from YD or YE.
F	—the overland overflow from paddy field under paddy rice condition. Under upland crop condition, F stands for overland overflow plus deep percolation loss.
YD	—the maximum depth of standing water in paddy field.
YE	—the maximum amount of readily available moisture in soil.

EFF —irrigation efficiency.

INTER1 —a reserved space to hold temporarily the quotient of two values.

ALPHA —the fraction of total land area under irrigation.

INTER2 —a reserved space to hold temporarily the product of two values.

TA(25) —an one-dimensional array of 25 numbers which are fractions of total area of paddy fields under irrigation in the 25 days after the starting of first crop irrigation.

TB(15) —an one-dimensional array of 15 numbers which are fractions of total area of paddy fields under irrigation in the last 15 days of the first crop irrigation.

TCD(2, 20) —a two-dimensional array of 2 rows each containing 20 numbers. The first and second row represent fractions of total area of paddy field under irrigation in the 20 days of the starting and ending, respectively, of the second crop irrigation.

BETA —the fraction of area of rice seedling bed under irrigation.

PA(67) —an one dimensional array of 67 numbers, which represent fraction of area of rice seedling bed under irrigation of the 67 day nursing period of the first crop.

PB(40) —an one dimensional array of 40 numbers, which represent fraction of area of rice seedbed under irrigation of the 40-day nursing period of the second crop.

CTR(12, 4) —a two-dimensional array of 12 rows each ontaining 4 numbers.

Those in the first row CTR(1, 4) are used as counters for the 4 zones. They help operate another set of counters CTR(4, 4).

Those in the second row CTR(2, 4) are used as counters for the 4 zones. They help operate another set of counters CTR(5, 4).

Those in third row CTR(3, 4) are used as counters for the 4 zones. They help operate another set of counters CTR(6, 4).

Those in the fourth row CTR(4, 4) are used as counters for the 4 zones. They help pick up a number from the first row of array XABC to be a temporary value of A.

Those in the fifth row CTR(5, 4) are used as counters for the 4 zons. They help pick up a number from the second row of array XABC to be a temporary value of A.

Those in the sixth row CTR(6, 4) are used as counters for the 4 zones. They help pick up a number from the third row of array XABC to be a temporary value of A.

Those in the seventh row CTR(7, 4) are used as counters for the 4 zones. They help pick up a number from the array TA to be a temporary value of ALPHA.

Those in the eighth row CTR(8, 4) are used as counters for the 4 zones. They help pick up a number from the array TB to be a temporary value of ALPHA.

Those in the nineth row CTR(9, 4) are used as counters for the 4 zones. They help pick up a number from the first row of array TCD to be a temporary value of ALPHA.

Those in the tenth row CTR(10, 4) are used as counters for the 4 zones. They help pick up a number from the second row of array TCD to be a temporary value of ALPHA.

Those in the eleventh row CTR(11, 4) are used as counters for the 4 zones. They help pick up a number from array PA to be a temporary value of ALPHA.

Those in the twelfth row CTR(12, 4) are used as counters for the 4 zones. They help pick up a number from array PB to be a temporary value of ALPHA.

WW —a reserved space to hold temporary intermediate value.

XABC(3, 10) —a two-dimensional array of 3 rows each containing 10 numbers.

The first row XABC(1, 10) consists of 10 Hargreaves' ratios corresponding to the 10 successive stages of growth of upland crop in the first crop period.

The second row XABC(2, 10) consists of 10 Hargreaves' ratios corresponding to the 10 successive stages of growth of upland crop in the second crop period.

The third row XABC(3,10) consists of 10 Hargreaves' ratios corresponding to the 10 successive stages of growth of upland crop in the winter crop period.

A —the ratio when multiplying the evaporation gives the evapo-transpiration of upland crop.

EIR(2,4,11) —a three dimensional array containing two sub-arrays.

The first sub-array EIR(1,4,11) has 4 rows representing the 4 zones. Each row consists of 11 numbers representing values of daily effective rainfall.

The second sub-array EIR(2,4,11) has 4 rows representing the 4 zones. Each row consists of 11 numbers representing the daily irrigation.

QPS(3,4) —a two-dimensional array of 3 rows each containing 4 numbers.

Numbers of the first row QPS(1,4) are the daily irrigation requirements of paddy rice or upland crop for the 4 zones.

Numbers of the second row QPS(2,4) are the daily water requirements for land preparation for paddy rice for the 4 zones. For upland crop condition, these numbers will be made equal to zeroes.

Numbers of the third row QPS(3,4) are the daily irrigation requirements of rice seedling bed for the 4 zones. For upland crop condition, these numbers will be made equal to zeroes.

SUPQ —the daily water requirement for supplemental irrigation of outside area.

X —the sum of the daily irrigation requirements for rice or upland crop for the whole irrigated area.

Y —the sum of the daily irrigation requirements of rice seedling bed for the whole irrigated area. For upland crop condition, Y will equal to zero.

Z —the sum of the daily land preparation requirements for the whole irrigated area. For upland crop condition, Z will equal to zero.

SQ —the daily total irrigation requirement.

CAP(19) —an one-dimensional array of 19 numbers representing the numerical values of reservoir capacity on the Capacity-Area curve.

TSPIL	—the total amount of spillage from the reservoir in the study period.
TTSPIL	—same as TSPIL.
TDEF	—the total amount of deficiency in the study period.
TTDEF	—same as TDEF.
S	—the reservoir storage.
ARGS	—same as S.
SS	—same as S.
RAR(19)	—an one-dimensional array of 19 numbers representing the numerical values of reservoir area on the Capacity-Area curve.
WSA	—the water surface area of the reservoir.
INTER3	—a reserved space to hold temporarily the result of a calculation.
INTER4	—a reserved space to hold temporarily the result of a calculation.
WSAA	—same as WSA.
LNR(3, 11)	—a two-dimensional array of 3 rows each containing 11 numbers The numbers of the first row LNR(1, 11) are values of daily evaporation loss from reservoir's water surface. Numbers of the second row LNR (2, 11) are values of daily net inflow of the reservoir. Numbers of the third row LNR (3, 11) are values of daily release of the reservoir.
DELTS	—the difference in storage of the reservoir at the beginning and at the end of the day.
MAXS	—the reservoir-full storage of the reservoir.
MINS	—the reservoir-empty storage of the reservoir.
LSPIL	—the spillage of the day.
LDEF	—the deficiency of the day.
DOMIND	—the daily domestic and industrial water requirements.
PDI	—the sum of domestic and industrial requirements in a part of a month.
PPDI	—same as PDI.
PRAIN	—the sum of rainfall in a part of a month.
PEVP	—the sum of evaporation in a part of a month.
YRAIN	—the sum of rainfall in a year.

YYRAIN	—same as YRAIN.
PER1	—the sum of effective rainfall in a part of a month for zone 1.
PER2	—the sum of effective rainfall in a part of a month for zone 2.
PER3	—the sum of effective rainfall in a part of a month for zone 3.
PER4	—the sum of effective rainfall in a part of a month for zone 4.
YER1	—the sum of effective rainfall in a year for zone 1.
YER2	—the sum of effective rainfall in a year for zone 2.
YER3	—the sum of effective rainfall in a year for zone 3.
YER4	—the sum of effective rainfall in a year for zone 4.
YYER1	—same as YER1.
YYER2	—same as YER2.
YYER3	—same as YER3.
YYER4	—same as YER4.
PSQ	—the sum of total irrigation requirement of a part of a month.
PPSQ	—same as PSQ.
YSQ	—the sum of total irrigation requirement of a year.
YYSQ	—same as YSQ.
YDI	—the sum of domestic and industrial requirements of a year.
YYDI	—same as YDI.
PRELES	—the sum of reservoir release of a month.
PPRELES	—same as PRELES.
PINF	—the sum of reservoir inflow of a part of a month.
PPINF	—same as PINF.
PLOSSEV	—the sum of evaporation loss of a part of a month.
PPLOSSEV	—same as PLOSSEV.
YRELES	—the sum of reservoir release in a year.
YYRELES	—same as YRELES.
YINF	—the sum of reservoir inflow in a year.
YYINF	—same as YINF.
YLOSSEV	—the sum of evaporation loss in a year.
YYLOSSEV	—same as YLOSSEV.
PNETINF	—the sum of net inflow of a part of a month.
PPNETINF	—same as PNETINF.

YNETINF —the sum of net inflow of a year.

YYNETINF —same as YNETINF.

YR —year.

MN —month.

SARY(19, 36) —a two-dimensional array of 19 rows each containing 36 numbers.
The 19 rows represent 19 years. The 36 numbers in a row represent numeric values of storage at the ends of the 36 parts in a year.

CDF(4, 19, 36) —a three-dimensional array containing 4 sub-arrays. Each sub-array contains 19 rows representing 19 years, and each row contains 36 numbers.
The numbers of the first sub-array CDF(1, 19, 36) are values of PINF in 36 parts of a year for 19 years.
The numbers of the second sub-array CDF(2, 19,36) are values of PDI in 36 parts of a year for 19 years.
The numbers of the third sub-array CDF(3, 19, 36) are values of PSQ in 36 parts of a year for 19 years.
The numbers of the fourth sub-array CDF(4, 19, 36) are values of PEVP×10 in 36 parts of a year for 19 years.

CCDF(4, 19, 36) —same as CDF(4, 19, 36).

XX(19) —recurrence frequency.

XY(19) —recurrence of reservoir storage.

ARGJ —percentage.

ARGAA —a value of a rule curve.

NS —a counter.

ZZ —a number equal to (ZA–1)

INTER5 —a number equal to I/ZA. I varies from 1 to ZA.

T —a reserved space to hold temporary value.

AA(6, 36) —a two-dimensional array of 6 rows each containing 36 numbers. The 6 rows represent 6 rule curves. The 36 numbers in a row represent the 36 values of a rule curve.

AAA(6, 36) —same as AA(6, 36).

W —a number equal to (ZA—J). J varies from 1 to (ZA—1).

P —a number equal to either (N+1) or (N−1). N varies from 1 to 36.

THETA —a reduction factor on irrigation requirement, the value of which depends on whether the current storage is equal to or above, or below the corresponding rule curve value.

CR —amount of reservoir release in a part of a month.

CCR —same as CR.

LOSSPEV —amount of evaporation loss from reservoir surface in a part of a month.

SPIL —the spillage from reservoir in a part of a month.

SSPIL —same as SPIL.

U —the utilized inflow of the reservoir in a part of a month.

UU —same as U.

DEF —the amount of deficiency which results in a part of a month when the water requirement, after multiplied by the reduction factor THETA, can not be fully met.

DDEF —same as DEF.

DT —in a part of a month, if there is deficiency, DT is set at 1; otherwise DT is set at 0.

YCR —the amout of reservoir release in a year.

YCCR —same as YCR.

YCF —the amount of irrigation requirement in a year.

YCCF —same as YCF.

YCD —the amount of domestic and industrial requirement in a year.

YCCD —same as YCD.

YCC —the amount of reservoir inflow in a year.

YCCC —same as YCC.

YSPIL —the amount of spillage in year.

YSSPIL —same as YSPIL.

YU —the amount of utilized inflow in a year.

YUU —same as YU.

YDEF —the total deficiency in a year.

YDDEF —same as YDEF.

YDT —the total number of parts in which there are deficiency.

YYSUD(3, 6) —a two-dimensional array of 3 rows each containing 6 numbers.

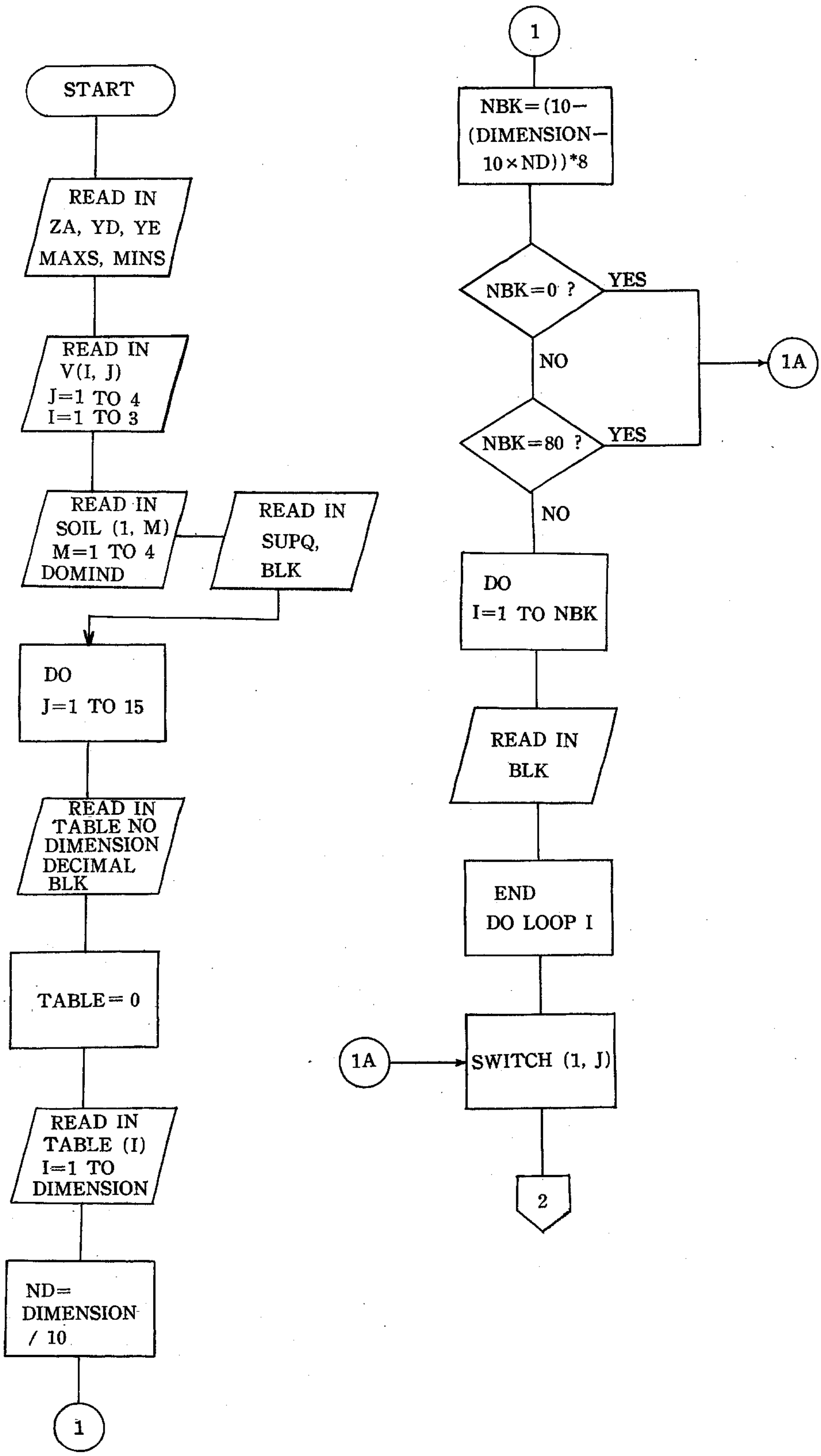
Those in the first row YYSUD(1, 6) represent the respective values of total YSPIL for the 6 rule curves.

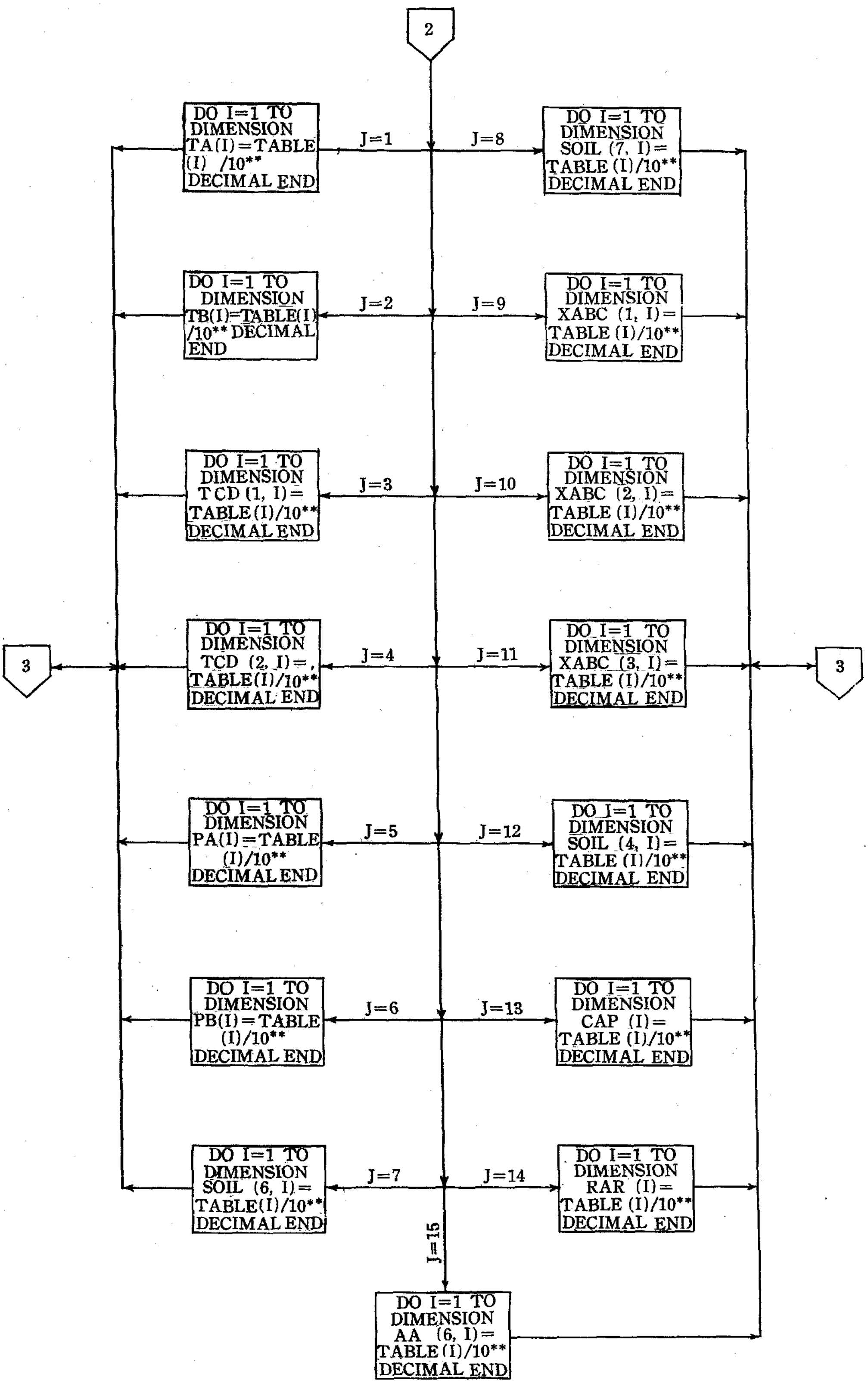
Those in the second row YYSUD(2,6) represent the respecitve values of total YU for the 6 rule curves.

Those in the third row YYSUD (3,6) represent the respective values of total YDEF for the 6 rule curves.

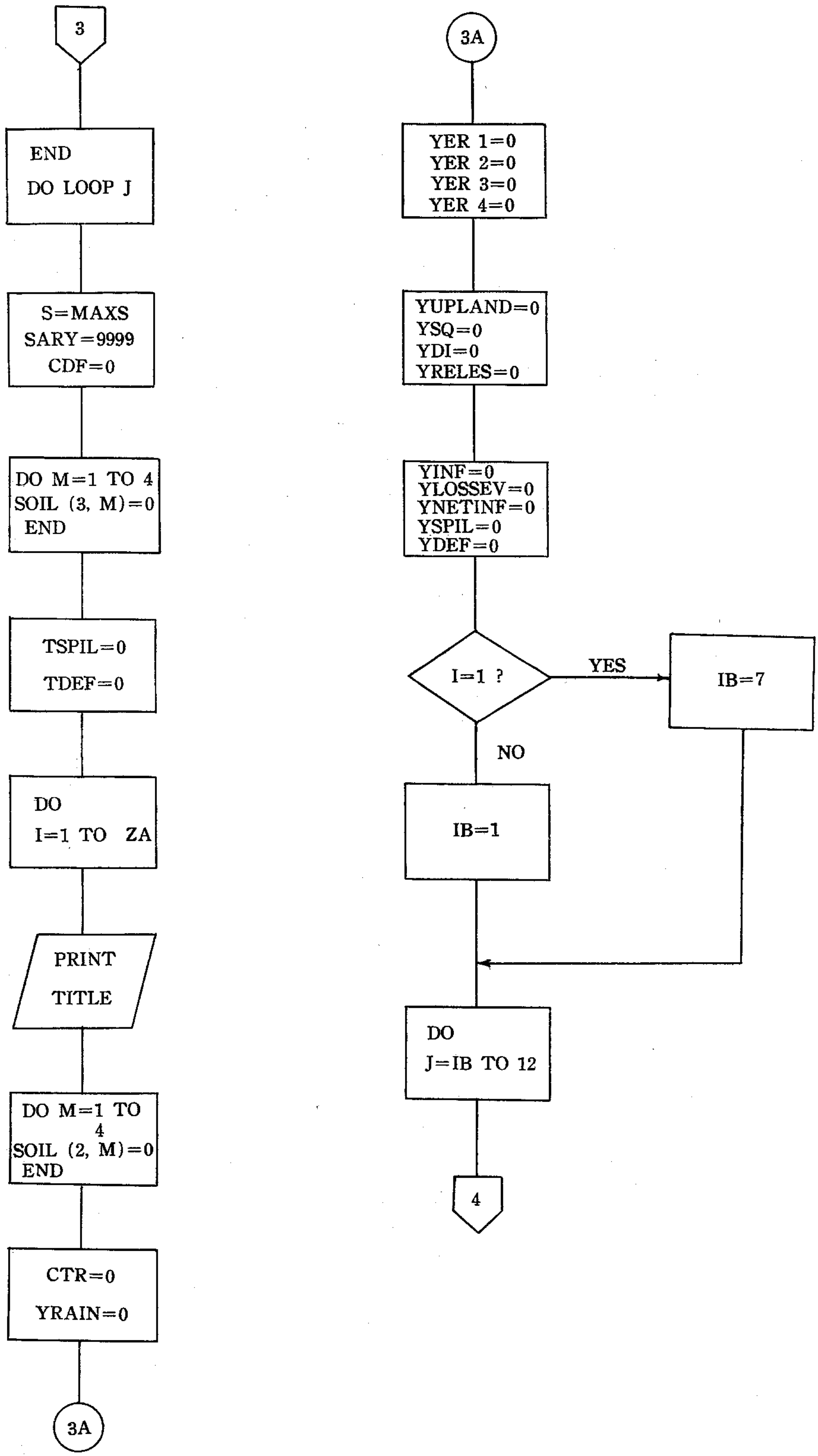
YYSSUD(3,6)	—same as YYSUD(3,6).
YYDT(6)	—an one-dimensional array of 6 numbers which represent the respective values of total YDT for the 6 rule curves.
SWITCH(8,15)	—a two-dimensional array of 8 rows, each containing 15 label constants. For example, reference to SWITCH (5,13) means reference to the 13th label constant of the 5th row of this array.
DIMENSION	—a number.
DECIMAL	—the position of the decimal point of a number
TABLE(67)	—an one-dimensional array of 67 numbers. This array is used to hold temporarily numbers of other arrays
ND	—the integer part of DIMENSION/10.
TABLENO	—the table number.
NBK	—the number of blanks.
PUPLAND	—the amount of upland crop irrigation requirement of zone 4 in a part of a month.
PPUPLAND	—same as PUPLAND.
YUPLAND	—the amount of upland crop irrigation requirement of zone 4 in a year.
YYUPLAND	—same as YUPLAND.
BLK	—blank.
I	—an iteration number.
J	—ditto
K	—ditto
L	—ditto
M	—ditto
N	—ditto

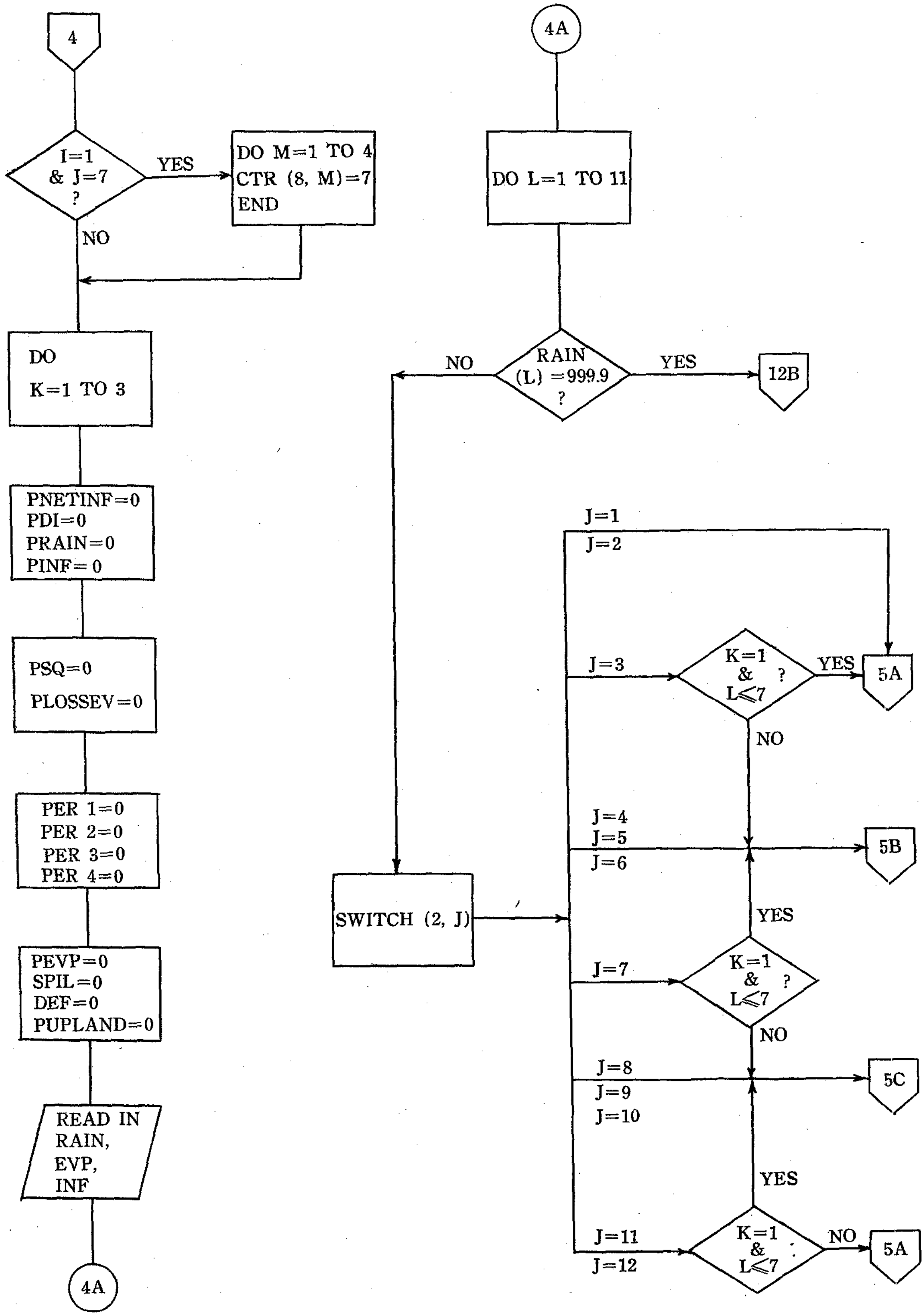
4. Flow Chart

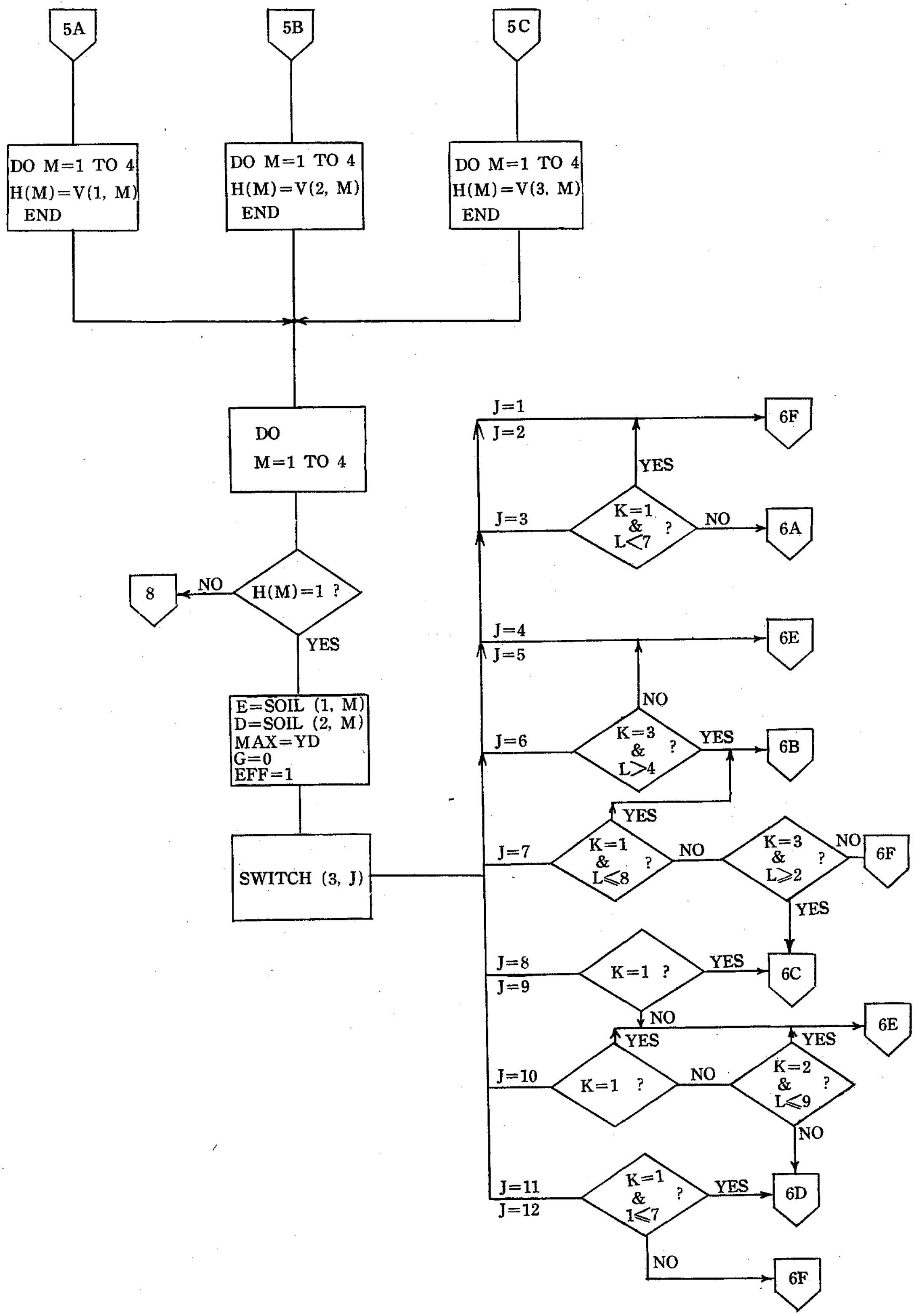

START
READ IN
ZA, YD, YE
MAXS, MINS
READ IN
V(I, J)
J=1 TO 4
I=1 TO 3
READ IN
SOIL (1, M)
M=1 TO 4
DOMIND
READ IN
SUPQ,
BLK
DO
J=1 TO 15
READ IN
TABLE NO
DIMENSION
DECIMAL
BLK
TABLE= 0
READ IN
TABLE (I)
I=1 TO
DIMENSION
ND=
DIMENSION
/ 10
1
1
NBK=(10−
(DIMENSION−
10×ND))*8
NBK=0 ?
YES
NO
1A
NBK=80 ?
YES
NO
DO
I=1 TO NBK
READ IN
BLK
END
DO LOOP I
1A
SWITCH (1, J)
2

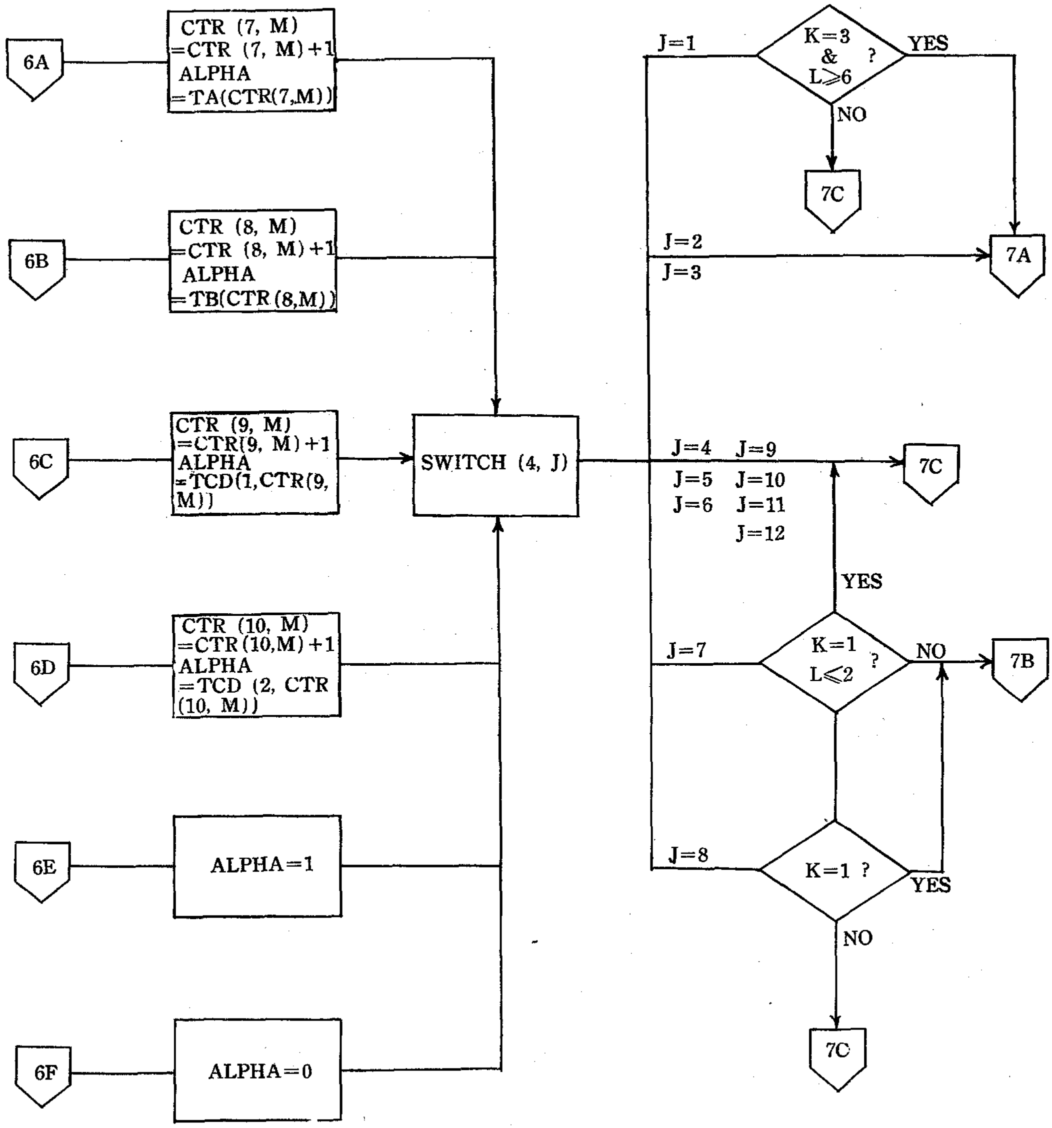


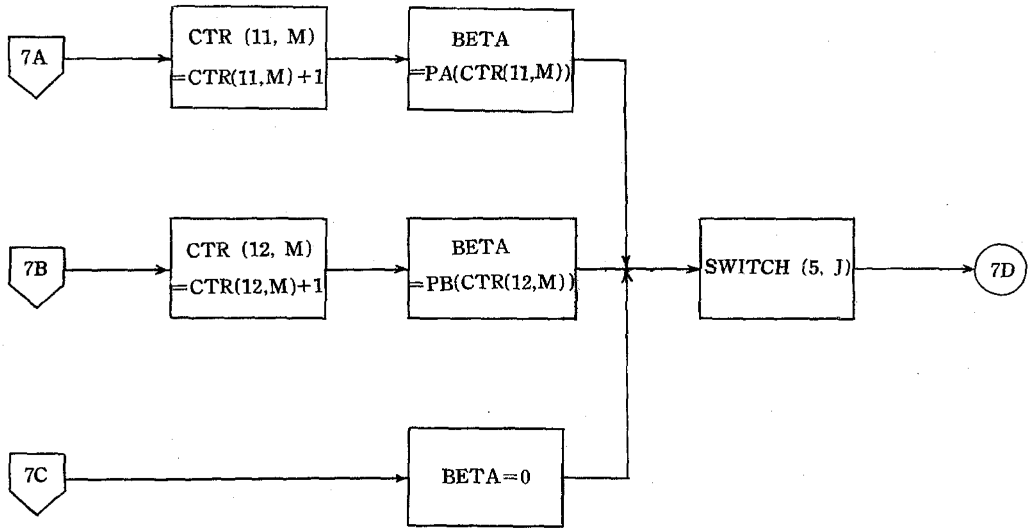
2
DO I=1 TO DIMENSION TA(I)=TABLE (I) /10** DECIMAL END
J=1
J=8
DO I=1 TO DIMENSION SOIL (7, I)= TABLE (I)/10** DECIMAL END
DO I=1 TO DIMENSION TB(I)=TABLE(I) /10** DECIMAL END
J=2
J=9
DO I=1 TO DIMENSION XABC (1, I)= TABLE (I)/10** DECIMAL END
DO I=1 TO DIMENSION TCD (1, I)= TABLE (I)/10** DECIMAL END
J=3
J=10
DO I=1 TO DIMENSION XABC (2, I)= TABLE (I)/10** DECIMAL END
3
DO I=1 TO DIMENSION TCD (2, I)= TABLE(I)/10** DECIMAL END
J=4
J=11
DO I=1 TO DIMENSION XABC (3, I)= TABLE (I)/10** DECIMAL END
3
DO I=1 TO DIMENSION PA(I)=TABLE (I)/10** DECIMAL END
J=5
J=12
DO I=1 TO DIMENSION SOIL (4, I)= TABLE (I)/10** DECIMAL END
DO I=1 TO DIMENSION PB(I)=TABLE (I)/10** DECIMAL END
J=6
J=13
DO I=1 TO DIMENSION CAP (I)= TABLE (I)/10** DECIMAL END
DO I=1 TO DIMENSION SOIL (6, I)= TABLE(I)/10** DECIMAL END
J=7
J=14
DO I=1 TO DIMENSION RAR (I)= TABLE (I)/10** DECIMAL END
J=15
DO I=1 TO DIMENSION AA (6, I)= TABLE (I)/10** DECIMAL END

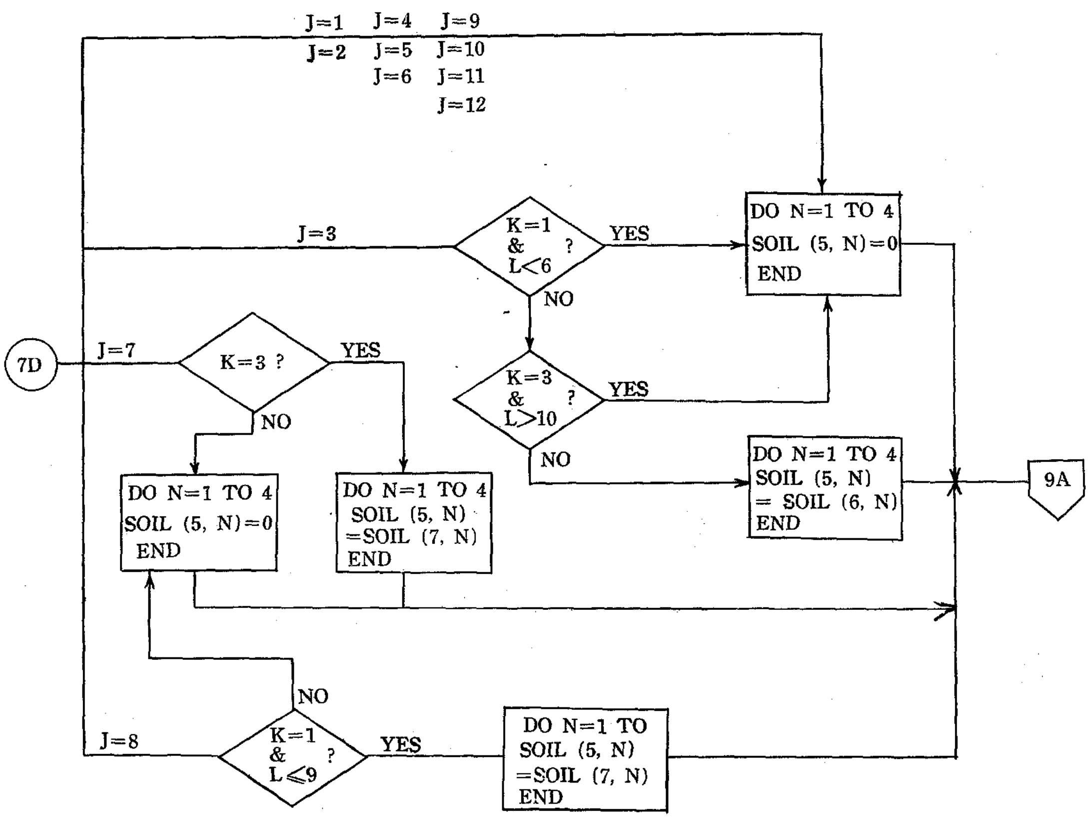

3
END
DO LOOP J
S=MAXS
SARY=9999
CDF=0
DO M=1 TO 4
SOIL (3, M)=0
END
TSPIL=0
TDEF=0
DO
I=1 TO ZA
PRINT
TITLE
DO M=1 TO 4
SOIL (2, M)=0
END
CTR=0
YRAIN=0
3A
3A
YER 1=0
YER 2=0
YER 3=0
YER 4=0
YUPLAND=0
YSQ=0
YDI=0
YRELES=0
YINF=0
YLOSSEV=0
YNETINF=0
YSPIL=0
YDEF=0
I=1 ?
YES
IB=7
NO
IB=1
DO
J=IB TO 12
4

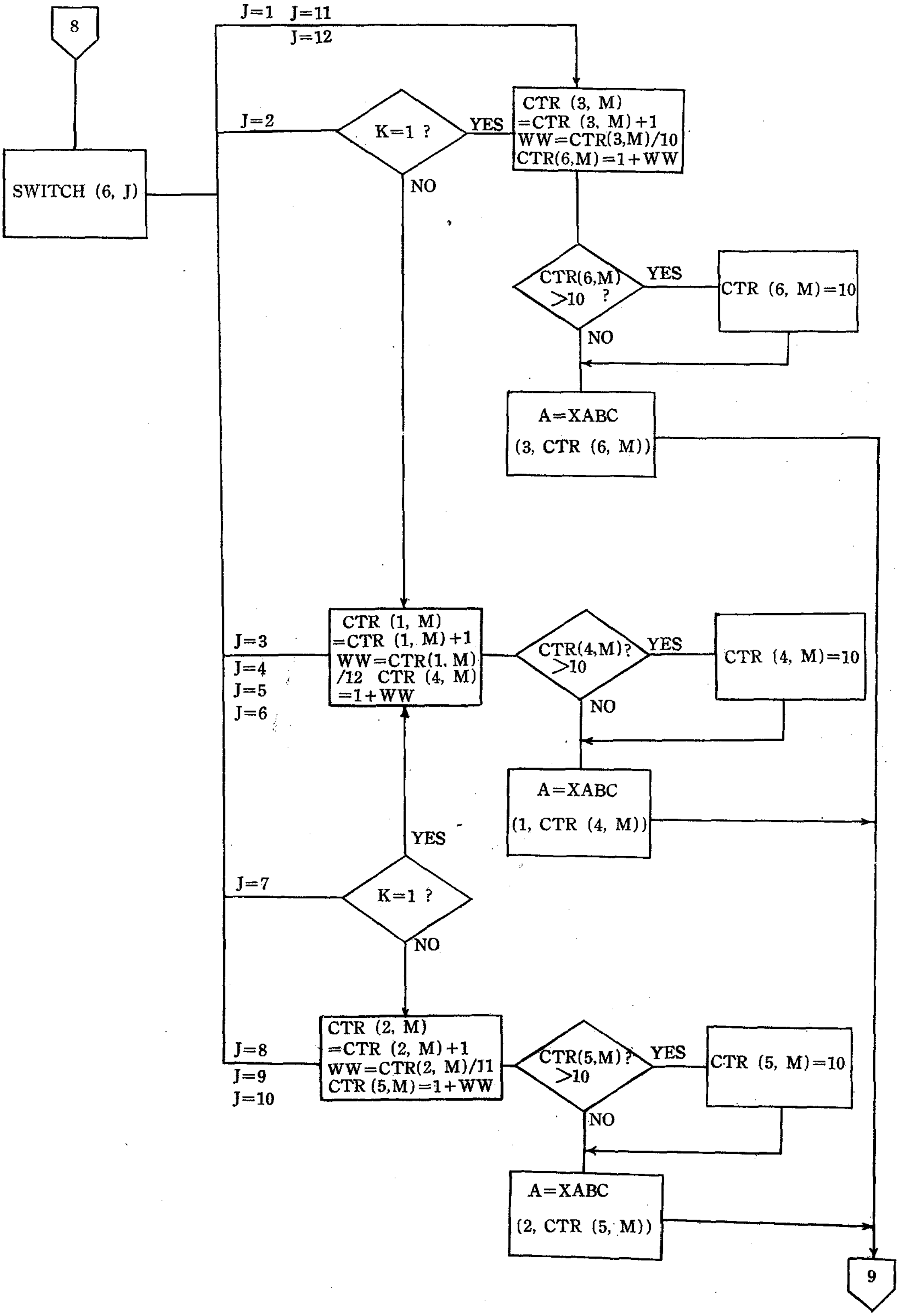

4
I=1 & J=7 ?
YES
DO M=1 TO 4
CTR (8, M)=7
END
NO
DO K=1 TO 3
PNETINF=0
PDI=0
PRAIN=0
PINF=0
PSQ=0
PLOSSEV=0
PER 1=0
PER 2=0
PER 3=0
PER 4=0
PEVP=0
SPIL=0
DEF=0
PUPLAND=0
READ IN RAIN, EVP, INF
4A
4A
DO L=1 TO 11
RAIN (L) =999.9 ?
NO
YES
12B
SWITCH (2, J)
J=1
J=2
J=3
K=1 & L≤7 ?
YES
5A
NO
J=4
J=5
J=6
5B
YES
J=7
K=1 & L≤7 ?
NO
J=8
J=9
J=10
5C
YES
J=11
J=12
K=1 & L≤7
NO
5A


5A
5B
5C
DO M=1 TO 4
H(M)=V(1, M)
END
DO M=1 TO 4
H(M)=V(2, M)
END
DO M=1 TO 4
H(M)=V(3, M)
END
DO
M=1 TO 4
H(M)=1 ?
NO
8
YES
E=SOIL (1, M)
D=SOIL (2, M)
MAX=YD
G=0
EFF=1
SWITCH (3, J)
J=1
J=2
6F
YES
J=3
K=1 & L<7 ?
NO
6A
J=4
J=5
6E
NO
J=6
K=3 & L>4 ?
YES
6B
YES
J=7
K=1 & L≤8 ?
NO
K=3 & L≥2 ?
NO
6F
YES
J=8
J=9
K=1 ?
YES
6C
NO
YES
YES
6E
J=10
K=1 ?
NO
K=2 & L≤9 ?
NO
J=11
J=12
K=1 & 1≤7 ?
YES
6D
NO
6F

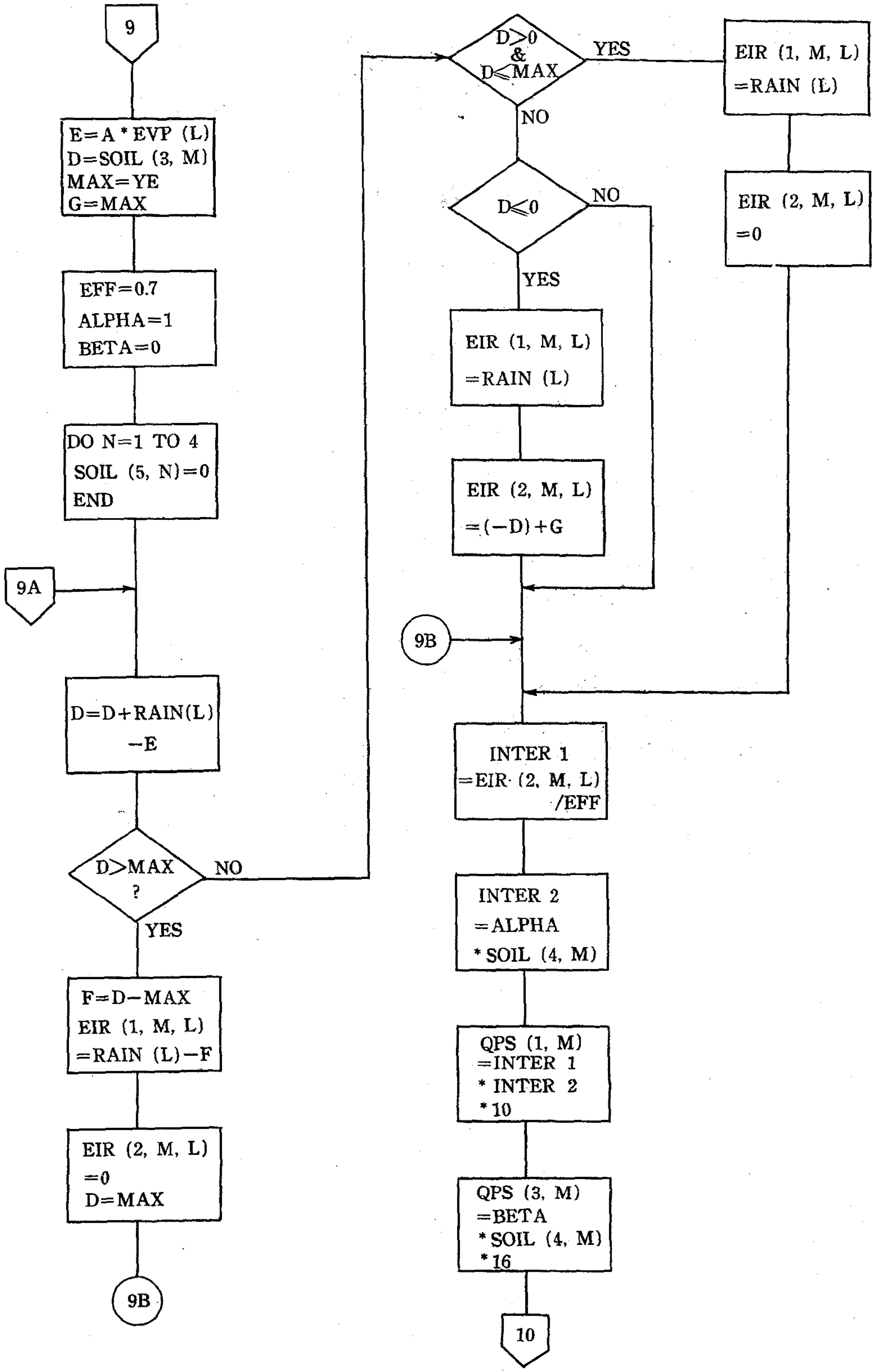

6A
CTR (7, M) =CTR (7, M)+1 ALPHA =TA(CTR(7,M))
6B
CTR (8, M) =CTR (8, M)+1 ALPHA =TB(CTR(8,M))
6C
CTR (9, M) =CTR(9, M)+1 ALPHA =TCD(1,CTR(9, M))
6D
CTR (10, M) =CTR(10,M)+1 ALPHA =TCD (2, CTR (10, M))
6E
ALPHA=1
6F
ALPHA=0
SWITCH (4, J)
J=1
K=3 & L≥6 ?
YES
NO
7C
J=2
J=3
7A
J=4 J=9
J=5 J=10
J=6 J=11
J=12
7C
YES
J=7
K=1 L≤2 ?
NO
7B
J=8
K=1 ?
YES
NO
7C

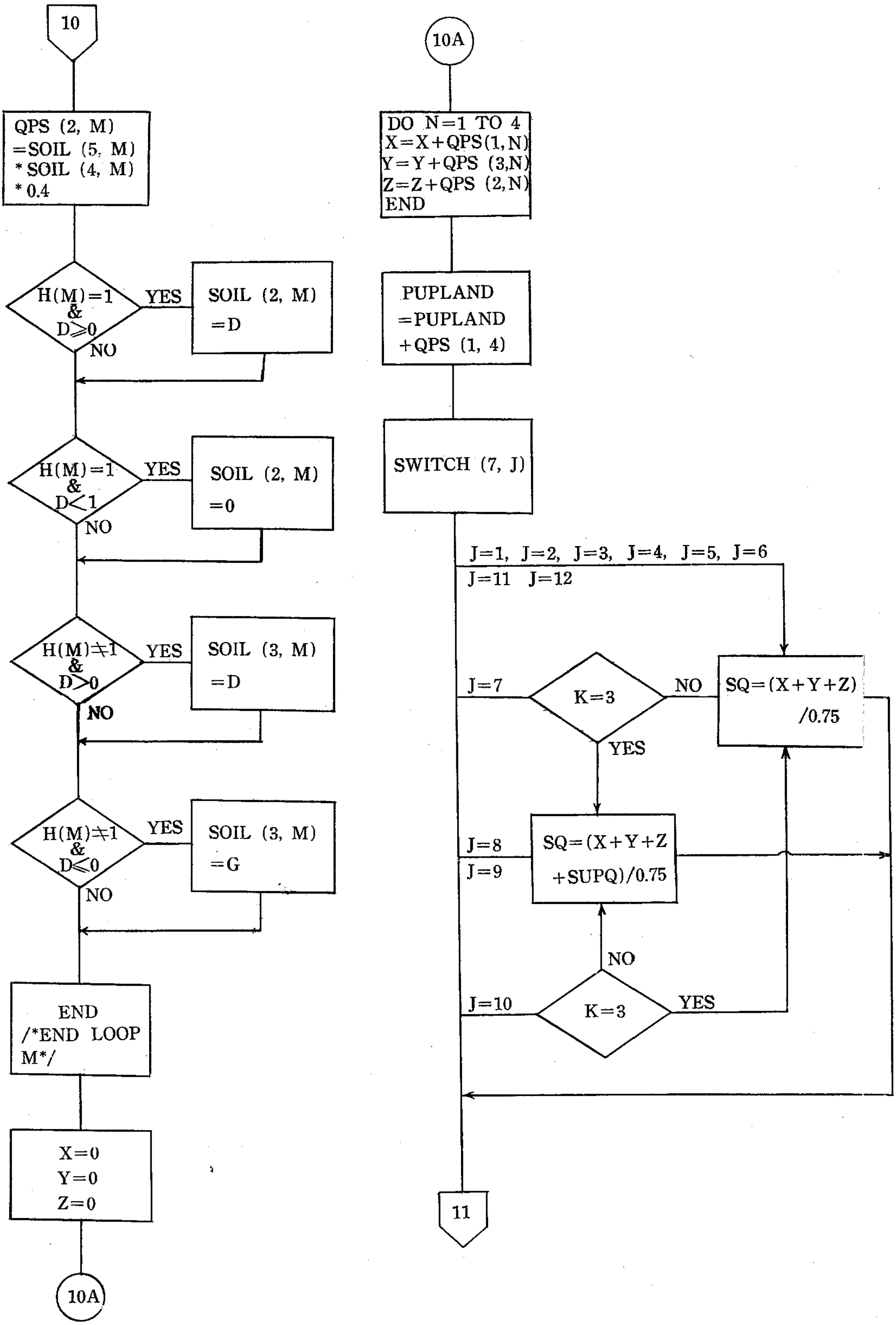

7A
CTR (11, M) =CTR(11,M)+1
BETA =PA(CTR(11,M))
7B
CTR (12, M) =CTR(12,M)+1
BETA =PB(CTR(12,M))
SWITCH (5, J)
7D
7C
BETA=0

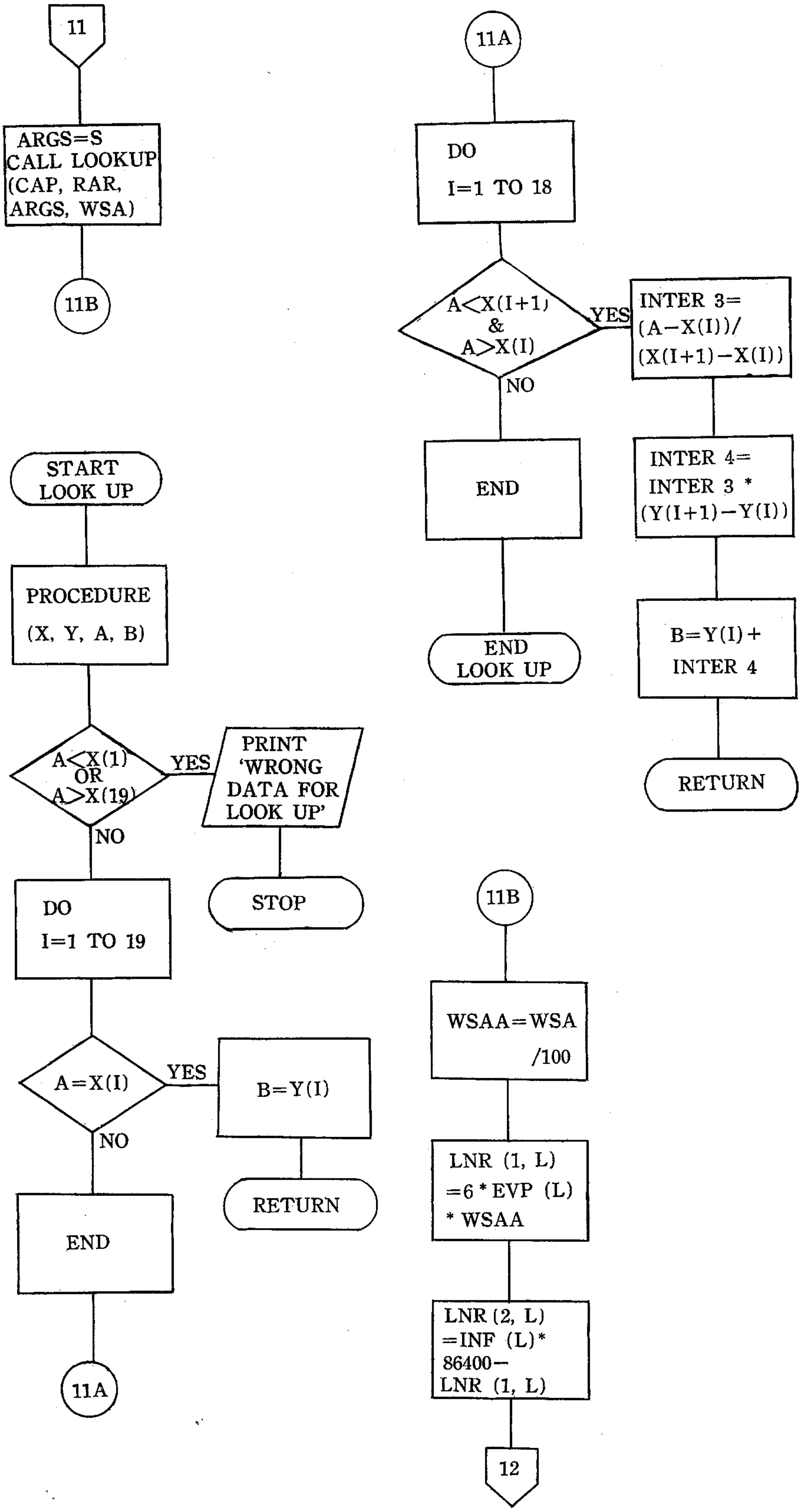

J=1
J=2
J=4
J=5
J=6
J=9
J=10
J=11
J=12
J=3
K=1 & L<6 ?
YES
NO
DO N=1 TO 4 SOIL (5, N)=0 END
7D
J=7
K=3 ?
YES
NO
K=3 & L>10 ?
YES
NO
DO N=1 TO 4 SOIL (5, N)=0 END
DO N=1 TO 4 SOIL (5, N) =SOIL (7, N) END
DO N=1 TO 4 SOIL (5, N) = SOIL (6, N) END
9A
NO
J=8
K=1 & L≤9 ?
YES
DO N=1 TO SOIL (5, N) =SOIL (7, N) END

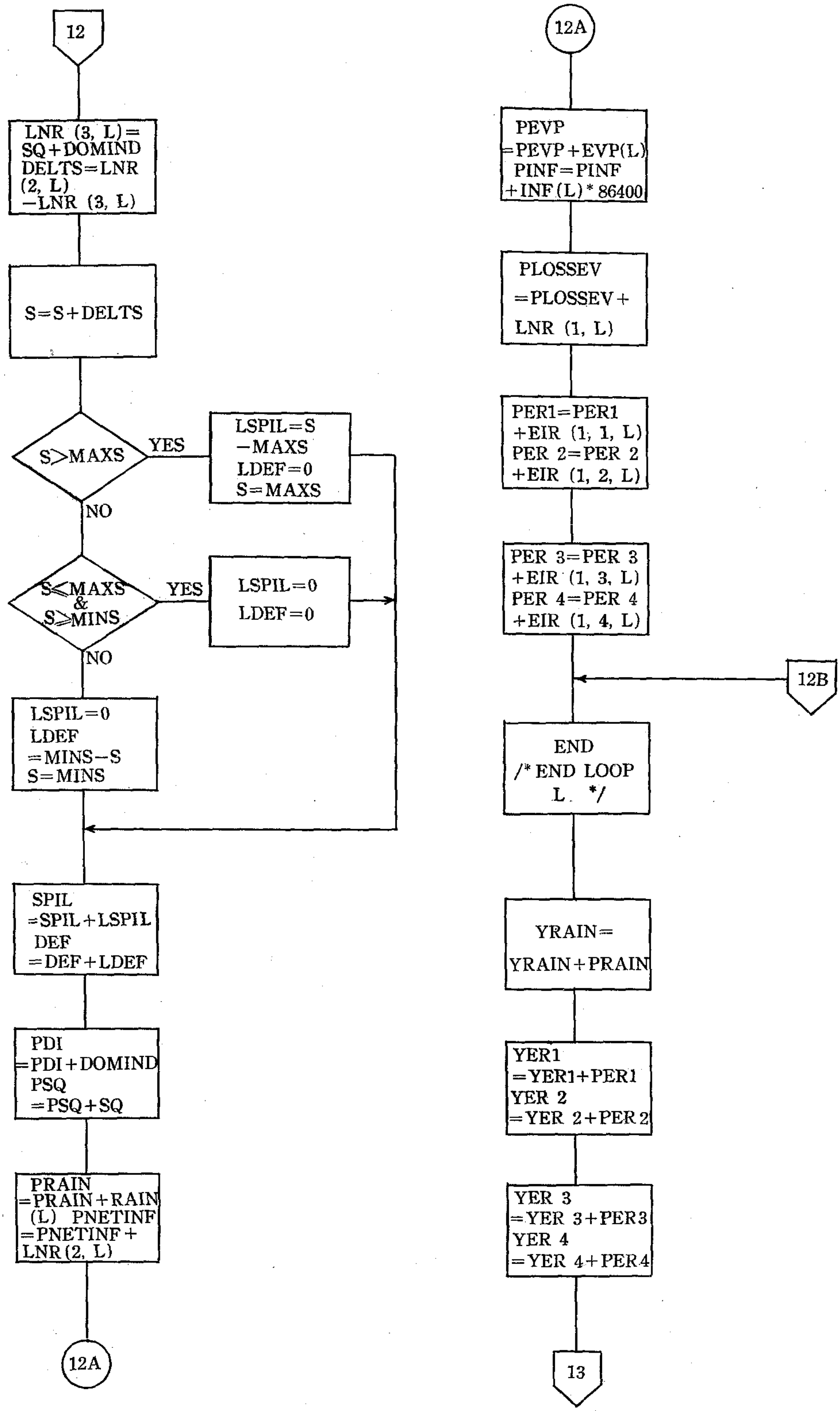


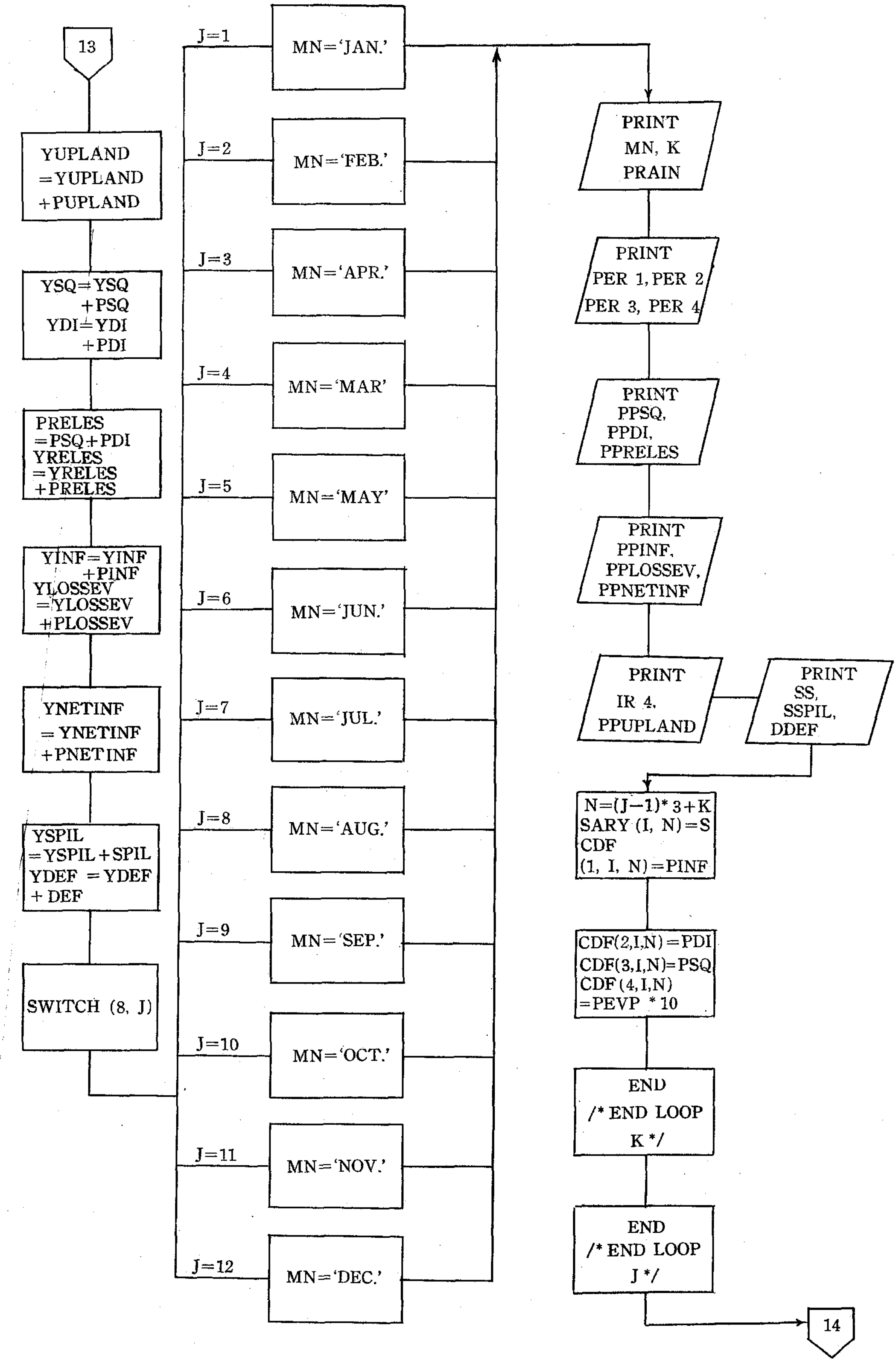
8
SWITCH (6, J)
J=1 J=11
J=12
J=2
K=1 ?
YES
NO
CTR (3, M)
=CTR (3, M)+1
WW=CTR(3,M)/10
CTR(6,M)=1+WW
CTR(6,M)
>10 ?
YES
NO
CTR (6, M)=10
A=XABC
(3, CTR (6, M))
J=3
J=4
J=5
J=6
CTR (1, M)
=CTR (1, M)+1
WW=CTR(1, M)
/12 CTR (4, M)
=1+WW
CTR(4,M)?
>10
YES
NO
CTR (4, M)=10
A=XABC
(1, CTR (4, M))
YES
J=7
K=1 ?
NO
J=8
J=9
J=10
CTR (2, M)
=CTR (2, M)+1
WW=CTR(2, M)/11
CTR (5,M)=1+WW
CTR(5,M)?
>10
YES
NO
CTR (5, M)=10
A=XABC
(2, CTR (5, M))
9

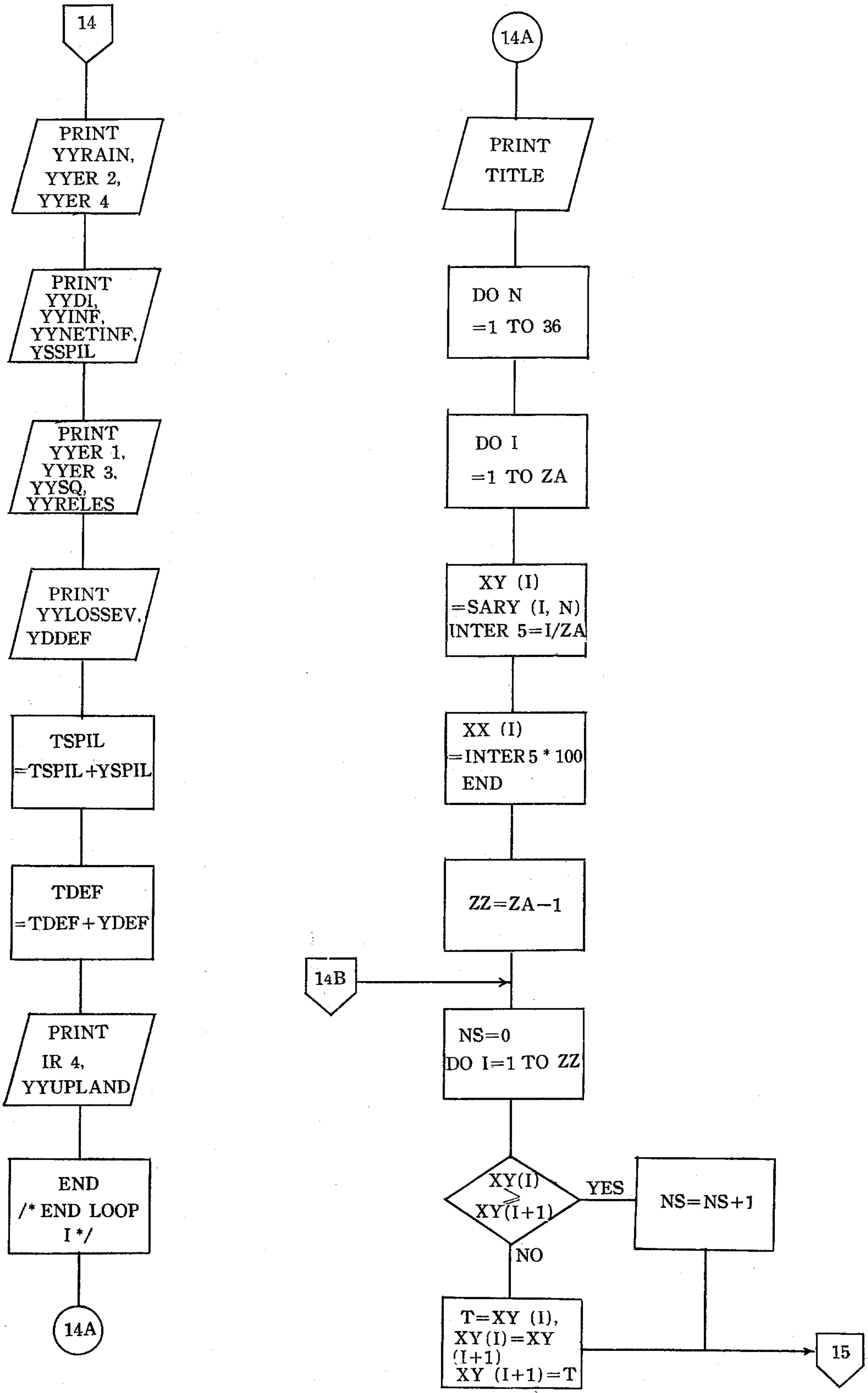

9
E=A * EVP (L)
D=SOIL (3, M)
MAX=YE
G=MAX
EFF=0.7
ALPHA=1
BETA=0
DO N=1 TO 4
SOIL (5, N)=0
END
9A
D=D+RAIN(L)
−E
D>MAX
?
NO
YES
F=D−MAX
EIR (1, M, L)
=RAIN (L)−F
EIR (2, M, L)
=0
D=MAX
9B
D>0
&
D≤MAX
YES
EIR (1, M, L)
=RAIN (L)
NO
D≤0
NO
EIR (2, M, L)
=0
YES
EIR (1, M, L)
=RAIN (L)
EIR (2, M, L)
=(−D)+G
9B
INTER 1
=EIR (2, M, L)
/EFF
INTER 2
=ALPHA
* SOIL (4, M)
QPS (1, M)
=INTER 1
* INTER 2
* 10
QPS (3, M)
=BETA
* SOIL (4, M)
* 16
10

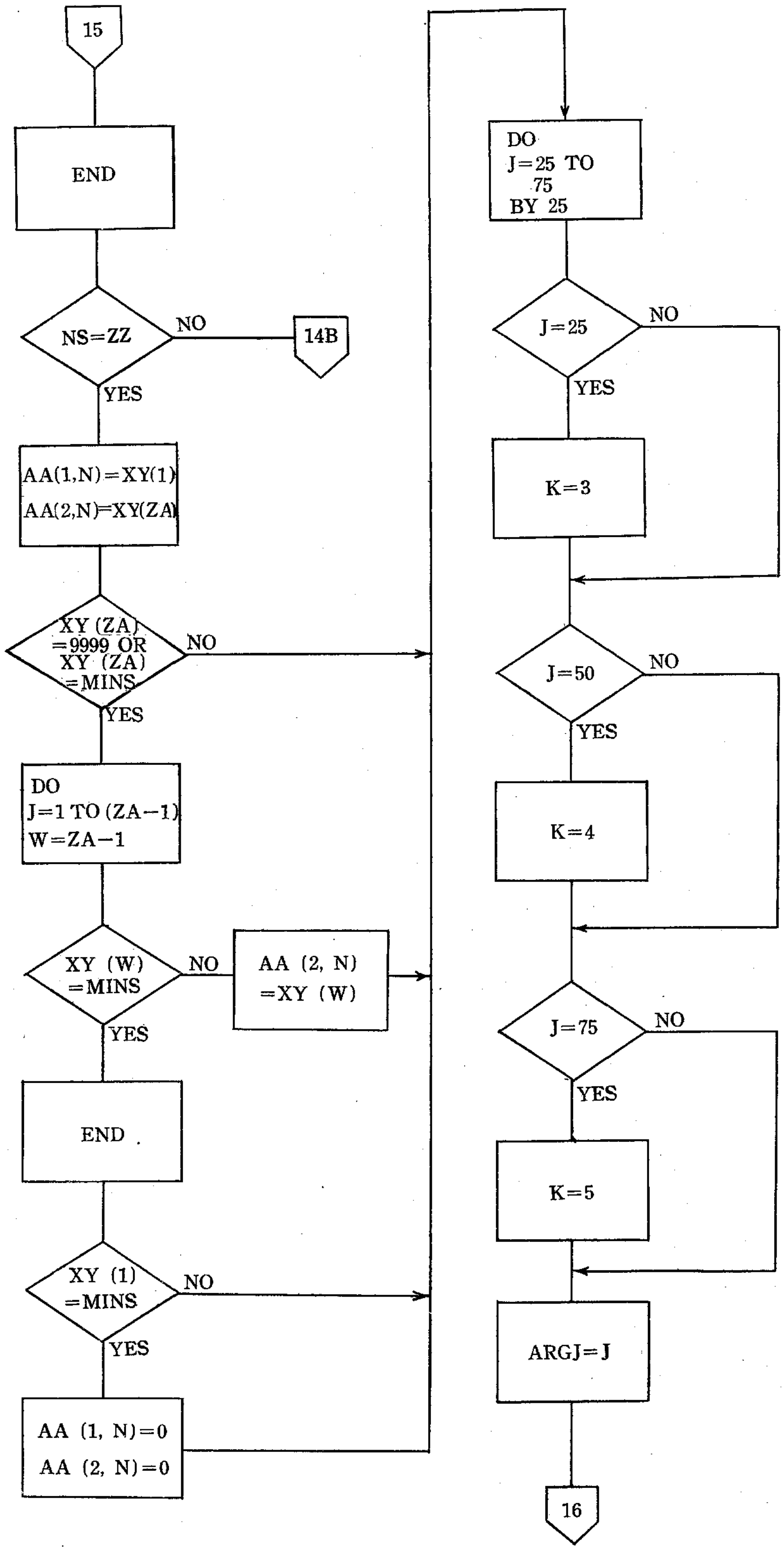

10
QPS (2, M) =SOIL (5, M) * SOIL (4, M) * 0.4
H(M)=1 & D⩾0
YES
SOIL (2, M) =D
NO
H(M)=1 & D<1
YES
SOIL (2, M) =0
NO
H(M)≠1 & D>0
YES
SOIL (3, M) =D
NO
H(M)≠1 & D⩽0
YES
SOIL (3, M) =G
NO
END /*END LOOP M*/
X=0 Y=0 Z=0
10A
10A
DO N=1 TO 4 X=X+QPS(1, N) Y=Y+QPS (3,N) Z=Z+QPS (2,N) END
PUPLAND =PUPLAND +QPS (1, 4)
SWITCH (7, J)
J=1, J=2, J=3, J=4, J=5, J=6
J=11 J=12
J=7
K=3
NO
SQ=(X+Y+Z) /0.75
YES
J=8
J=9
SQ=(X+Y+Z +SUPQ)/0.75
NO
J=10
K=3
YES
11

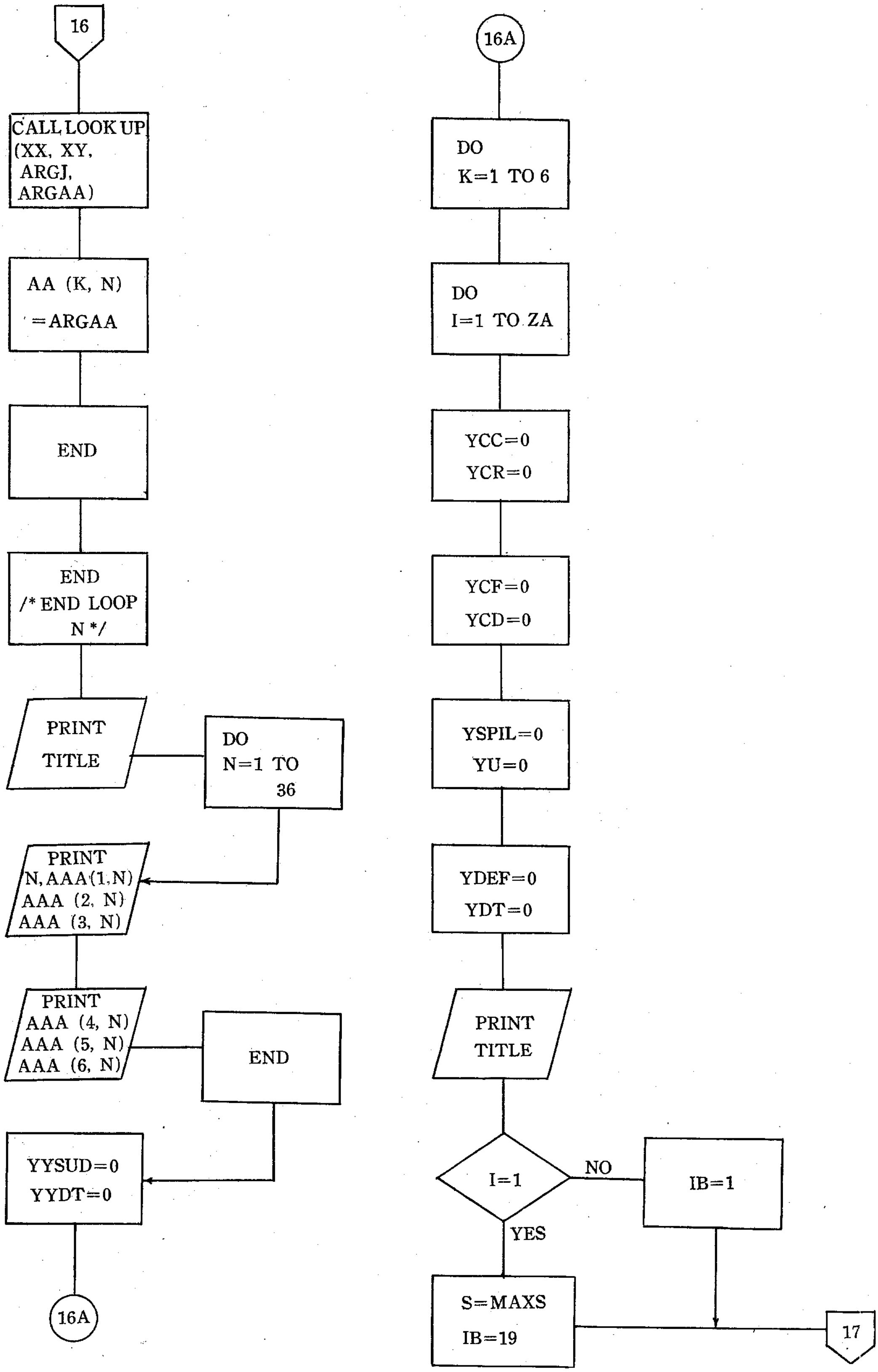

11
ARGS=S
CALL LOOKUP
(CAP, RAR,
ARGS, WSA)
11B
START
LOOK UP
PROCEDURE
(X, Y, A, B)
A<X(1)
OR
A>X(19)
YES
NO
PRINT
'WRONG
DATA FOR
LOOK UP'
STOP
DO
I=1 TO 19
A=X(I)
YES
NO
B=Y(I)
RETURN
END
11A
11A
DO
I=1 TO 18
A<X(I+1)
&
A>X(I)
YES
NO
INTER 3=
(A−X(I))/
(X(I+1)−X(I))
INTER 4=
INTER 3 *
(Y(I+1)−Y(I))
B=Y(I)+
INTER 4
RETURN
END
END
LOOK UP
11B
WSAA=WSA
/100
LNR (1, L)
=6 * EVP (L)
* WSAA
LNR (2, L)
=INF (L)*
86400−
LNR (1, L)
12

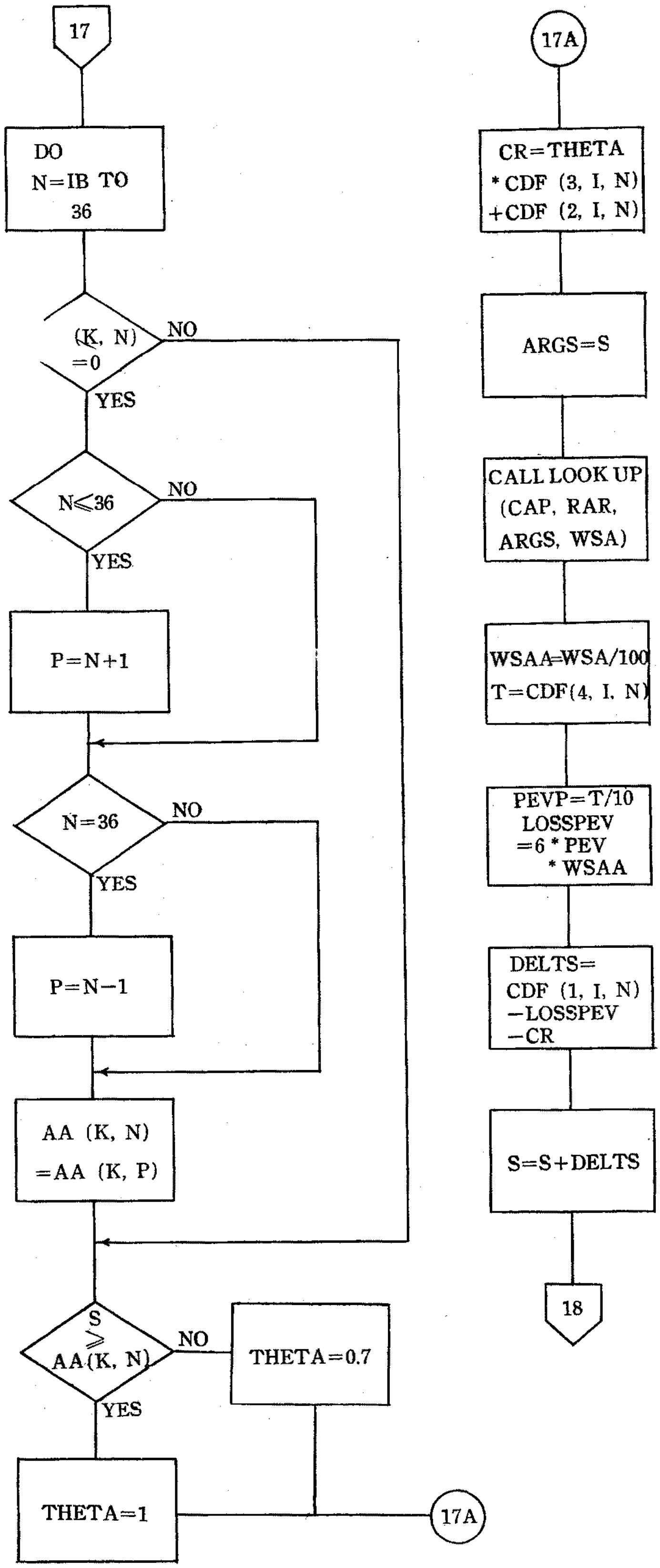

12
LNR (3, L)=SQ+DOMIND
DELTS=LNR (2, L) −LNR (3, L)
S=S+DELTS
S>MAXS
YES
LSPIL=S −MAXS
LDEF=0
S=MAXS
NO
S≤MAXS & S≥MINS
YES
LSPIL=0
LDEF=0
NO
LSPIL=0
LDEF =MINS−S
S=MINS
SPIL =SPIL+LSPIL
DEF =DEF+LDEF
PDI =PDI+DOMIND
PSQ =PSQ+SQ
PRAIN =PRAIN+RAIN (L)
PNETINF =PNETINF+LNR (2, L)
12A
12A
PEVP =PEVP+EVP(L)
PINF=PINF +INF (L) * 86400
PLOSSEV =PLOSSEV+ LNR (1, L)
PER1=PER1 +EIR (1, 1, L)
PER 2=PER 2 +EIR (1, 2, L)
PER 3=PER 3 +EIR (1, 3, L)
PER 4=PER 4 +EIR (1, 4, L)
12B
END /* END LOOP L. */
YRAIN= YRAIN+PRAIN
YER1 =YER1+PER1
YER 2 =YER 2+PER 2
YER 3 =YER 3+PER3
YER 4 =YER 4+PER4
13

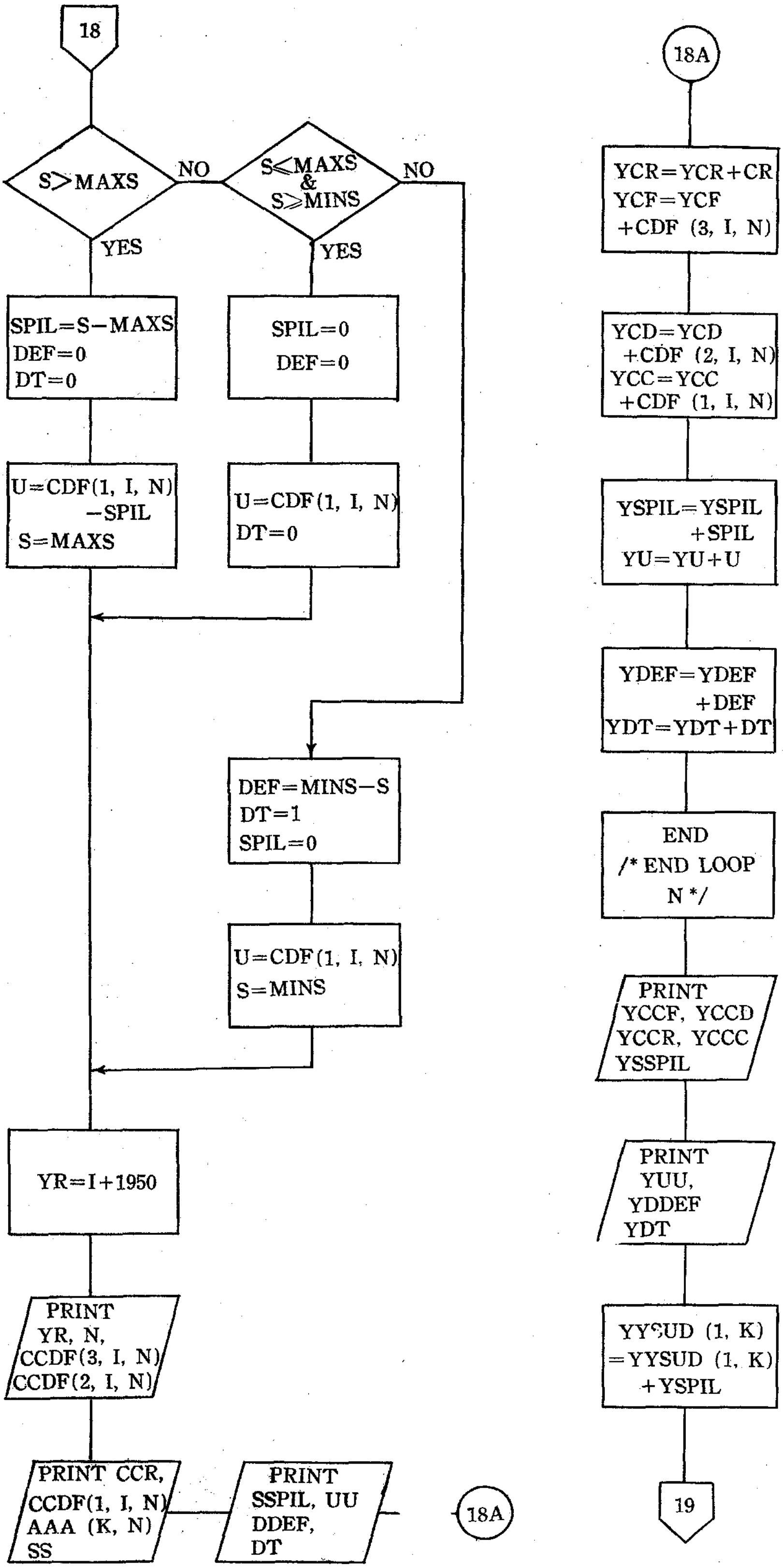

13
YUPLAND =YUPLAND +PUPLAND
YSQ=YSQ +PSQ
YDI=YDI +PDI
PRELES =PSQ+PDI
YRELES =YRELES +PRELES
YINF=YINF +PINF
YLOSSEV =YLOSSEV +PLOSSEV
YNETINF = YNETINF +PNETINF
YSPIL =YSPIL+SPIL
YDEF =YDEF + DEF
SWITCH (8, J)
J=1
MN='JAN.'
J=2
MN='FEB.'
J=3
MN='APR.'
J=4
MN='MAR'
J=5
MN='MAY'
J=6
MN='JUN.'
J=7
MN='JUL.'
J=8
MN='AUG.'
J=9
MN='SEP.'
J=10
MN='OCT.'
J=11
MN='NOV.'
J=12
MN='DEC.'
PRINT MN, K PRAIN
PRINT PER 1, PER 2 PER 3, PER 4
PRINT PPSQ, PPDI, PPRELES
PRINT PPINF, PPLOSSEV, PPNETINF
PRINT IR 4, PPUPLAND
PRINT SS, SSPIL, DDEF
N=(J−1)*3+K
SARY (I, N)=S
CDF (1, I, N)=PINF
CDF(2,I,N)=PDI
CDF(3,I,N)=PSQ
CDF (4,I,N) =PEVP * 10
END /* END LOOP K */
END /* END LOOP J */
14


14
PRINT YYRAIN, YYER 2, YYER 4
PRINT YYDI, YYINF, YYNETINF, YSSPIL
PRINT YYER 1, YYER 3, YYSQ, YYRELES
PRINT YYLOSSEV, YDDEF
TSPIL =TSPIL+YSPIL
TDEF =TDEF+YDEF
PRINT IR 4, YYUPLAND
END /* END LOOP I */
14A
14A
PRINT TITLE
DO N =1 TO 36
DO I =1 TO ZA
XY (I) =SARY (I, N) INTER 5=I/ZA
XX (I) =INTER 5 * 100 END
ZZ=ZA−1
14B
NS=0 DO I=1 TO ZZ
XY(I) ≥ XY(I+1)
YES
NS=NS+1
NO
T=XY (I), XY(I)=XY (I+1) XY (I+1)=T
15

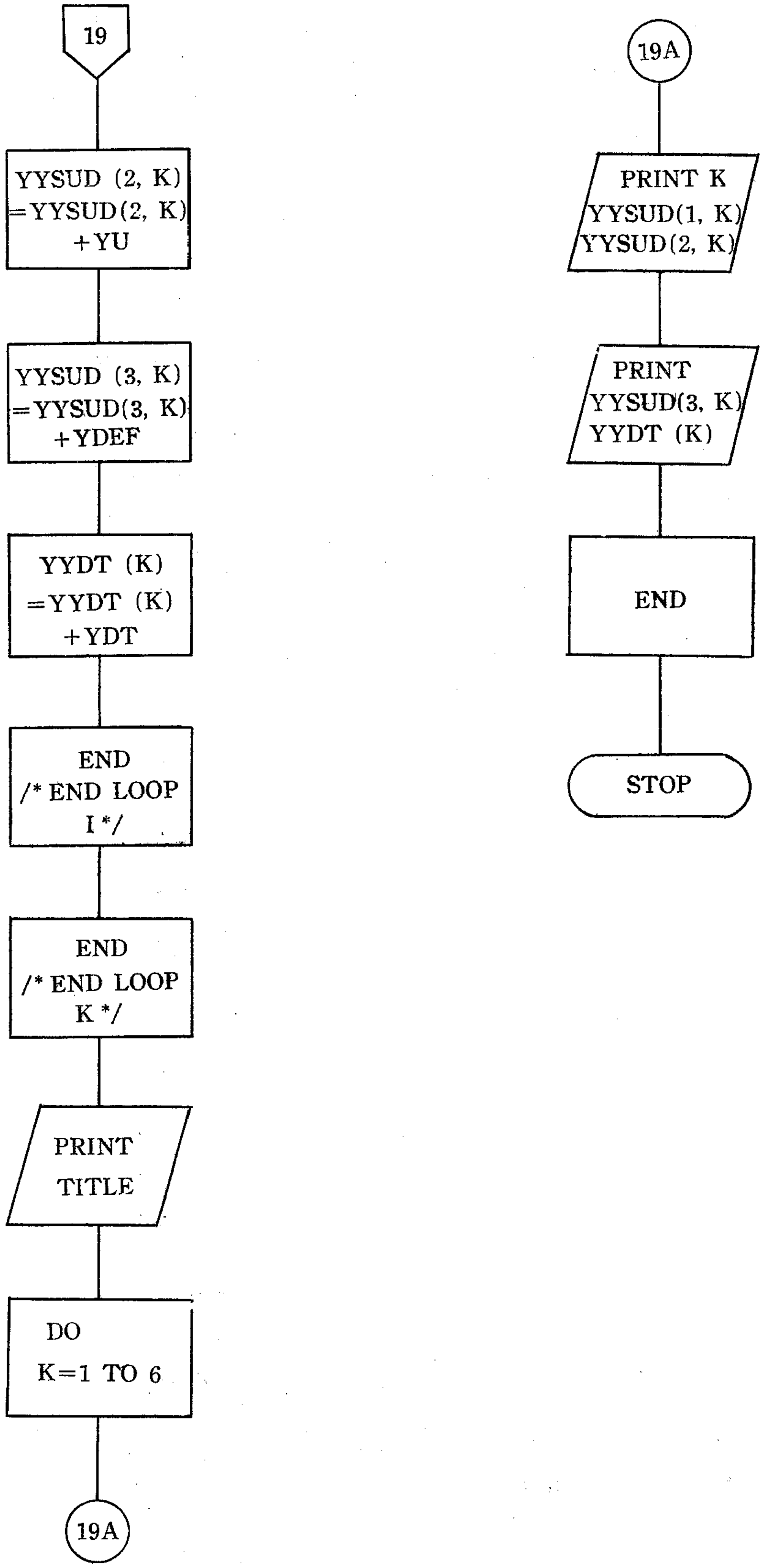

15
END
NS=ZZ
NO
14B
YES
AA(1,N)=XY(1)
AA(2,N)=XY(ZA)
XY (ZA)
=9999 OR
XY (ZA)
=MINS
NO
YES
DO
J=1 TO (ZA−1)
W=ZA−1
XY (W)
=MINS
NO
AA (2, N)
=XY (W)
YES
END
XY (1)
=MINS
NO
YES
AA (1, N)=0
AA (2, N)=0
DO
J=25 TO
75
BY 25
J=25
NO
YES
K=3
J=50
NO
YES
K=4
J=75
NO
YES
K=5
ARGJ=J
16


16
CALL LOOK UP (XX, XY, ARGJ, ARGAA)
AA (K, N) =ARGAA
END
END /* END LOOP N */
PRINT TITLE
DO N=1 TO 36
PRINT N, AAA (1, N) AAA (2, N) AAA (3, N)
PRINT AAA (4, N) AAA (5, N) AAA (6, N)
END
YYSUD=0 YYDT=0
16A
16A
DO K=1 TO 6
DO I=1 TO ZA
YCC=0 YCR=0
YCF=0 YCD=0
YSPIL=0 YU=0
YDEF=0 YDT=0
PRINT TITLE
I=1
NO
IB=1
YES
S=MAXS IB=19
17


17
DO
N=IB TO
36
(K, N)
=0
NO
YES
N≤36
NO
YES
P=N+1
N=36
NO
YES
P=N−1
AA (K, N)
=AA (K, P)
S
≥
AA(K, N)
NO
YES
THETA=0.7
THETA=1
17A
17A
CR=THETA
* CDF (3, I, N)
+CDF (2, I, N)
ARGS=S
CALL LOOK UP
(CAP, RAR,
ARGS, WSA)
WSAA=WSA/100
T=CDF(4, I, N)
PEVP=T/10
LOSSPEV
=6 * PEV
* WSAA
DELTS=
CDF (1, I, N)
−LOSSPEV
−CR
S=S+DELTS
18



18
S>MAXS
NO
S≤MAXS & S≥MINS
NO
YES
YES
SPIL=S−MAXS DEF=0 DT=0
SPIL=0 DEF=0
U=CDF(1, I, N) −SPIL S=MAXS
U=CDF(1, I, N) DT=0
DEF=MINS−S DT=1 SPIL=0
U=CDF(1, I, N) S=MINS
YR=I+1950
PRINT YR, N, CCDF(3, I, N) CCDF(2, I, N)
PRINT CCR, CCDF(1, I, N) AAA (K, N) SS
PRINT SSPIL, UU DDEF, DT
18A
18A
YCR=YCR+CR YCF=YCF +CDF (3, I, N)
YCD=YCD +CDF (2, I, N) YCC=YCC +CDF (1, I, N)
YSPIL=YSPIL +SPIL YU=YU+U
YDEF=YDEF +DEF YDT=YDT+DT
END /* END LOOP N */
PRINT YCCF, YCCD YCCR, YCCC YSSPIL
PRINT YUU, YDDEF YDT
=YYSUD (1, K) +YSPIL
19



19
YYSUD (2, K) =YYSUD(2, K) +YU
YYSUD (3, K) =YYSUD(3, K) +YDEF
YYDT (K) =YYDT (K) +YDT
END /* END LOOP I */
END /* END LOOP K */
PRINT TITLE
DO K=1 TO 6
19A
19A
PRINT K YYSUD(1, K) YYSUD(2, K)
PRINT YYSUD(3, K) YYDT (K)
END
STOP

5. Arrangement of data cards

Data cards are arranged into two groups. The first group covers all the constants needed by this program. The second group is the hydrological data.

The first group includes the 1st to the 50th card. The second group starts with the 51th card and ends with the last card of the data deck.

(a) The first group

The first card contains ZA, YD, YE, MAXS, MINS, V(4,3), SOIL(1,4), DOMIND, SUPQ.

The other cards of the first group are 15 card packs. The purpose of this arrangement is to feed 15 arrays into the computer. Each card pack contains one control card and one or more data cards. The control card is always placed in front of data cards.

The control card contains 5 digits only. The first two digits are for the table numbers of the arrays as follows:

Table Number	Name of Array
01	TA(25)
02	TB(15)
03	TCD(1, 20)
04	TCD(2, 20)
05	PA(67)
06	PB(40)
07	SOIL(6, 4)
08	SOIL(7, 4)
09	XABC(1, 10)
10	XABC(2, 10)
11	XABC(3, 10)
12	SOIL(4, 4)
13	CAP(19)
14	RAR(19)
15	AA(6, 36)

The second two digits of a control card stands for the number of elements in the array. The 5th digit is for the position of decimal point of the element of the array.

The data card is designed to contain 10 elements per card. Therefore.
the second card of the first group is the control card of TA;
the 3rd, 4th, and 5th cards, the data cards of TA;
the 6th card, the control card of TB;
the 7th and 8th cards, the data cards of TB;
and so forth.

b. The second group

This group consists of successive card packs. Each pack is made of three cards. The first is a rainfall card containing records of 11-day rainfall, the second is a evaporation card containing records of 11-day evaporation, and the third is a inflow card containing records of reservoir inflow for 11 days.

The 11-day period constitutes a part of a month. Three parts make a month. A part may cover one or more false days. A false day's data is made to be 999.9.

The packs are arranged in the calendar sequence.

6. The listing of the program

```
HOULUNG: PROCEDURE OPTIONS (MAIN),.                          B5-10010
        DECLARE GLASS FILE INPUT ENVIRONMENT                 B5-10020
               (MEDIUM(SYS020,2400)F(80)),.                  B5-10030
        DECLARE CUP FILE PRINT ENVIRONMENT                   B5-10040
               (MEDIUM(SYS021,2400)F(133)),.                 B5-10050
        DECLARE ZA FIXED (2),                                B5-10060
                RAIN (11)  FIXED (4,1),                      B5-10070
                EVP  (11)  FIXED (4,1),                      B5-10080
                INF (11) FIXED (5,2),                        B5-10090
                ( H(4), V(3,4)) FIXED(1),                    B5-10100
                E FIXED (4,2),                               B5-10110
                SOIL (7,4) FIXED (5,2),                      B5-10120
                ( G, D ) FIXED (5,2),                        B5-10130
                MAX FIXED (3),                               B5-10150
                F FIXED (5,2),                               B5-10160
                YD FIXED (3),                                B5-10170
                YE FIXED (2),                                B5-10180
                EFF FIXED (2,1),                             B5-10190
               INTER1 FIXED(4,1),                            B5-10191
                ALPHA FIXED (4,3),                           B5-10210
               INTER2 FIXED(5,2),                            B5-10211
                TA (25) FIXED (4,3),                         B5-10220
                TB (15) FIXED (4,3),                         B5-10230
               TCD(2,20)FIXED(4,3),                          B5-10240
                BETA FIXED (4,3),                            B5-10270
                PA (67) FIXED (4,3),                         B5-10280
                PB (40) FIXED (4,3),                         B5-10290
               ( CTR(12,4),WW ) FIXED(2),                    B5-10310
                XABC(3,10)FIXED(3,2),                        B5-10320
                A FIXED (3,2),                               B5-10330
                EIR(2,4,11)FIXED(4,1),                       B5-10340
                QPS(3,4)FIXED(6),                            B5-10360
                SUPQ FIXED (5),                              B5-10380
               (X,Y,Z) FIXED(7),                             B5-10381
               SQ FIXED(8),                                  B5-10390
                CAP (19) FIXED (10,2),                       B5-10400
              TSPIL PICTURE 'Z,ZZZ,ZZZ,ZZ9',                 B5-10401
```

```
ITSPIL CHARACTER (13) DEFINED TSPIL,                    B5-10402
TDEF PICTURE 'ZZZ,ZZZ,ZZ9',                             B5-10403
ITDEF CHARACTER (11) DEFINED TDEF,                      B5-10404
  S PICTURE 'Z9,999,999',                               B5-10410
  ARGS FIXED (8),                                       B5-10411
  SS CHARACTER (10) DEFINED S ,                         B5-10420
  RAR (19) FIXED (10,2),                                B5-10430
  WSA FIXED (10,2),                                     B5-10440
 INTER3 FIXED(3,2),                                     B5-10441
 INTER4 FIXED(10,2),                                    B5-10442
 WSAA FIXED(6,2),                                       B5-10443
  LNR(3,11)FIXED(8),                                    B5-10450
  DELTS FIXED (8),                                      B5-10480
  ( MAXS, MINS ) FIXED (8),                             B5-10490
LSPIL FIXED (8),                                        B5-10491
LDEF FIXED (6),                                         B5-10492
  DOMIND FIXED (5),                                     B5-10500
  PDI PICTURE 'ZZ9,999',                                B5-10510
  PPDI CHARACTER (7) DEFINED PDI,                       B5-10520
  PRAIN FIXED (4,1),                                    B5-10530
  PEVP FIXED (4,1),                                     B5-10531
YRAIN PICTURE 'Z,999V.9',                               B5-10540
  YYRAIN CHARACTER (7) DEFINED YRAIN,                   B5-10550
 (PER1,PER2,PER3,PER4)FIXED(4,1),                       B5-10560
  (YER1,YER2,YER3,YER4)PICTURE'Z,999V.9',               B5-10570
  YYER1 CHARACTER(7) DEFINED YER1,                      B5-10580
  YYER2 CHARACTER(7) DEFINED YER2,                      B5-10581
  YYER3 CHARACTER(7) DEFINED YER3,                      B5-10582
  YYER4 CHARACTER(7) DEFINED YER4,                      B5-10583
PSQ PICTURE 'ZZ,ZZZ,ZZ9',                               B5-10590
  PPSQ CHARACTER (10) DEFINED PSQ,                      B5-10600
  YSQ PICTURE 'Z,ZZ9,999,999',                          B5-10610
  YYSQ CHARACTER (13) DEFINED YSQ,                      B5-10620
  YDI PICTURE 'Z9,999,999',                             B5-10630
  YYDI CHARACTER (10) DEFINED YDI,                      B5-10640
  PRELES PICTURE 'ZZ,999,999',                          B5-10650
  PPRELES CHARACTER (10) DEFINED PRELES,                B5-10660
```

```
PINF PICTURE 'ZZ,ZZZ,ZZ9',                                   B5-10670
  PPINF CHARACTER (10) DEFINED PINF,                         B5-10680
PLOSSEV PICTURE 'ZZZ,ZZ9',                                   B5-10690
  PPLOSSEV CHARACTER (7) DEFINED PLOSSEV,                    B5-10700
  YRELES PICTURE 'Z,Z99,999,999',                            B5-10710
  YYRELES CHARACTER (13) DEFINED YRELES,                     B5-10720
  YINF PICTURE 'Z,ZZZ,999,999',                              B5-10730
  YYINF CHARACTER (13) DEFINED YINF,                         B5-10740
  YLOSSEV PICTURE 'ZZ,999,999',                              B5-10750
  YYLOSSEV CHARACTER (10) DEFINED YLOSSEV,                   B5-10760
  PNETINF PICTURE '---,---,--9',                             B5-10770
  PPNETINF CHARACTER (11) DEFINED PNETINF,                   B5-10780
YNETINF PICTURE 'Z,ZZZ,999,999',                             B5-10790
  YYNETINF CHARACTER (13) DEFINED YNETINF,                   B5-10800
  YR FIXED (4),                                              B5-10810
  MN CHARACTER (3),                                          B5-10820
  SARY (19,36) FIXED (8),                                    B5-10830
CDF (4,19,36) PICTURE 'ZZ,ZZZ,ZZ9',                          B5-10840
 CCDF (4,19,36) CHARACTER (10) DEFINED CDF,                  B5-10850
  ( XX(19), XY(19) ) FIXED (10,2),                           B5-10900
  ARGJ FIXED (8),                                            B5-10910
  ARGAA FIXED (10,2),                                        B5-10911
  ( NS, ZZ ) FIXED (2),                                      B5-10920
 INTER5 FIXED(6,5),                                          B5-10921
  T FIXED (8),                                               B5-10930
  AA (6,36) PICTURE 'ZZ,999,999',                            B5-10940
  AAA (6,36) CHARACTER (10) DEFINED AA,                      B5-10950
  W FIXED (2),                                               B5-10960
  P FIXED (2),                                               B5-10970
  THETA FIXED (2,1),                                         B5-10980
  CR PICTURE 'ZZ,999,999',                                   B5-10990
  CCR CHARACTER (10) DEFINED CR,                             B5-11000
  LOSSEV FIXED (8),                                          B5-11001
SPIL PICTURE 'ZZ,ZZZ,ZZ9',                                   B5-11010
  SSPIL CHARACTER (10) DEFINED SPIL,                         B5-11020
U PICTURE 'ZZ,ZZZ,999',                                      B5-11030
  UU CHARACTER (10) DEFINED U,                               B5-11040
```

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DEF PICTURE 'Z,ZZZ,ZZ9',                                          B5-11050
DDEF CHARACTER (9) DEFINED DEF,                                   B5-11060
  DT FIXED (1),                                                   B5-11070
  YCR PICTURE 'Z,Z99,999,999',                                    B5-11080
  YCCR CHARACTER (13) DEFINED YCR,                                B5-11090
  YCF PICTURE 'Z,Z99,999,999',                                    B5-11100
  YCCF CHARACTER (13) DEFINED YCF,                                B5-11110
  YCD PICTURE'ZZ,Z99,999',                                        B5-11120
  YCCD CHARACTER (10) DEFINED YCD,                                B5-11130
  YCC PICTURE 'Z,Z99,999,999',                                    B5-11140
  YCCC CHARACTER (13) DEFINED YCC,                                B5-11150
  YSPIL PICTURE 'Z,ZZZ,999,999',                                  B5-11160
  YSSPIL CHARACTER (13) DEFINED YSPIL,                            B5-11170
  YU PICTURE 'Z,Z99,999,999',                                     B5-11180
  YUU CHARACTER (13) DEFINED YU,                                  B5-11190
YDEF PICTURE 'Z,ZZZ,ZZZ,ZZ9',                                     B5-11200
  YDDEF CHARACTER(13) DEFINED YDEF,                               B5-11210
  YDT FIXED (2),                                                  B5-11220
  YYSUD(3,6) PICTURE 'ZZZ,Z99,999,999',                           B5-11230
  YYSSUD(3,6) CHARACTER (15) DEFINED YYSUD,                       B5-11240
  YYDT (6) FIXED (4),                                             B5-11290
  SWITCH(8,15) LABEL INITIAL(LOCTA,LOCTB,LOCTC,LOCTD,             B5-11340
   LOCPA,LOCPB,LOCNA,LOCNB,LOCXA,LOCXB,LOCXC,LOCAR,               B5-11350
   LOCAP,LOCRAR,LOCAA,                                            B5-11360
   J01,J01,J03,J04,J04,J04,J07,J08,J08,J08,J11,J01,               B5-11361
   J13,J13,J13,                                                   B5-11362
   B01,B01,B03,B04,B04,B06,B07,B08,B04,B10,B11,B01,               B5-11363
   J13,J13,J13,                                                   B5-11364
   C01,C02,C02,C04,C04,C04,C07,C08,C04,C04,C04,C04,               B5-11365
   J13,J13,J13,                                                   B5-11366
   D01,D01,D03,D01,D01,D01,D07,D08,D01,D01,D01,D01,               B5-11367
   J13,J13,J13,                                                   B5-11368
   E01,E02,E03,E03,E03,E03,E07,E08,E08,E08,E01,E01,               B5-11369
   J13,J13,J13,                                                   B5-11370
   S01,S01,S01,S01,S01,S01,S07,S08,S08,S10,S01,S01,               B5-11371
   J13,J13,J13,                                                   B5-11372
   M1,M2,M3,M4,M5,M6,M7,M8,M9,MA,MB,MC,J13,J13,J13),              B5-11373
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        DIMENSION FIXED(2),                                              B5-11374
        DECIMAL  FIXED (1),                                              B5-11380
        TABLE (67) FIXED (8),                                            B5-11390
        ND FIXED (1),                                                    B5-11400
        (TABLENO,NBK)FIXED(2),                                           B5-11410
      PUPLAND PICTURE 'ZZZ,ZZ9',                                         B5-11411
      PPUPLAND CHARACTER (7) DEFINED PUPLAND,                            B5-11412
      YUPLAND PICTURE 'ZZ,ZZZ,ZZ9',                                      B5-11413
      YYUPLAND CHARACTER (10) DEFINED YUPLAND,                           B5-11414
        BLK CHARACTER (1),.                                              B5-11430
GET FILE (GLASS) EDIT (ZA,YO,YE,MAXS,MINS,((V(I,J) DO J=1 TO 4)B5-11450
  DO I=1 TO 3),(SOIL(1,M) DO M=1 TO 4),DOMIND,                           B5-11451
  SUPQ,BLK)(F(2),X(1),F(3),X(1),F(2),X(1),F(8),X(2),F(7),X(1), B5-11460
 12 F(1),X(2),4 F(5,2),X(1),F(5),                                        B5-11470
        X(1),F(5),X(5),A(1)),.                                           B5-11480
        DO J=1 TO 15,.                                                   B5-11490
 GET FILE (GLASS) EDIT (TABLENO,DIMENSION,DECIMAL,BLK)(F(2),    B5-11500
  F(2),F(1),X(74),A(1)),.                                                B5-11510
           TABLE=0,.                                                     B5-11511
 GET FILE (GLASS) EDIT((TABLE(I) DO I=1 TO DIMENSION))(F(8)),. B5-11520
 ND=DIMENSION/10,.                                                       B5-11530
 NBK=(10-(DIMENSION-10*ND))*8,.                                          B5-11540
        IF NBK=0 OR NBK=80 THEN GO TO SWITCH(1,J),.                      B5-11550
 DO I=1 TO NBK,.                                                         B5-11560
 GET FILE (GLASS) EDIT(BLK)(A(1)),.                                      B5-11561
 END,.                                                                   B5-11562
 GO TO SWITCH(1,J),.                                                     B5-11580
  EDLP.. ,.                                                              B5-11581
        END,.                                                            B5-11590
 GO TO START,.                                                           B5-11600
     LOCTA.. DO I=1 TO DIMENSION,.                                       B5-11610
             TA(I)=TABLE(I)/10**DECIMAL,.                                B5-11611
             END,.  GO TO EDLP,.                                         B5-11612
     LOCTB.. DO I=1 TO DIMENSION,.                                       B5-11620
             TB(I)=TABLE(I)/10**DECIMAL,.                                B5-11621
             END,.  GO TO EDLP,.                                         B5-11622
     LOCTC.. DO I=1 TO DIMENSION,.                                       B5-11630
```

```
        TCD(1,I)=TABLE(I)/10**DECIMAL,.                 B5-11631
        END,.  GO TO EDLP,.                             B5-11632
LOCTD.. DO I=1 TO DIMENSION,.                           B5-11640
        TCD(2,I)=TABLE(I)/10**DECIMAL,.                 B5-11641
        END,.  GO TO EDLP,.                             B5-11642
LOCPA.. DO I=1 TO DIMENSION,.                           B5-11650
        PA(I)=TABLE(I)/10**DECIMAL,.                    B5-11651
        END,.  GO TO EDLP,.                             B5-11652
LOCPB.. DO I=1 TO DIMENSION,.                           B5-11660
        PB(I)=TABLE(I)/10**DECIMAL,.                    B5-11661
        END,.  GO TO EDLP,.                             B5-11662
LOCNA.. DO I=1 TO DIMENSION,.                           B5-11670
        SOIL(6,I)=TABLE(I)/10**DECIMAL,.                B5-11671
        END,.  GO TO EDLP,.                             B5-11672
LOCNB.. DO I=1 TO DIMENSION,.                           B5-11680
        SOIL(7,I)=TABLE(I)/10**DECIMAL,.                B5-11681
        END,.  GO TO EDLP,.                             B5-11682
LOCXA.. DO I=1 TO DIMENSION,.                           B5-11690
        XABC(1,I)=TABLE(I)/10**DECIMAL,.                B5-11691
        END,.  GO TO EDLP,.                             B5-11692
LOCXB.. DO I=1 TO DIMENSION,.                           B5-11700
        XABC(2,I)=TABLE(I)/10**DECIMAL,.                B5-11701
        END,.  GO TO EDLP,.                             B5-11702
LOCXC.. DO I=1 TO DIMENSION,.                           B5-11710
        XABC(3,I)=TABLE(I)/10**DECIMAL,.                B5-11711
        END,.  GO TO EDLP,.                             B5-11712
LOCAR.. DO I=1 TO DIMENSION,.                           B5-11720
        SOIL(4,I)=TABLE(I)/10**DECIMAL,.                B5-11721
        END,.  GO TO EDLP,.                             B5-11722
LOCAP.. DO I=1 TO DIMENSION,.                           B5-11730
        CAP(I)=TABLE(I)/10**DECIMAL,.                   B5-11731
        END,.  GO TO EDLP,.                             B5-11732
LOCRAR.. DO I=1 TO DIMENSION,.                          B5-11740
        RAR(I)=TABLE(I)/10**DECIMAL,.                   B5-11741
        END,. GO TO EDLP,.                              B5-11742
LOCAA..  DO I=1 TO DIMENSION,.                          B5-11750
        AA(6,I)=TABLE(I)/10**DECIMAL,.                  B5-11751
```

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            END,. GO TO EDLP,.                                          B5-11752
 START.. S=MAXS,. SARY=9999,. CDF=0,.                                   B5-11760
 DO M=1 TO 4,. SOIL(3,M)=0,. END,.                                      B5-11761
TSPIL=0,.  TDEF=0,.                                                     B5-11762
 YEAR..DO I=1 TO ZA,.                                                   B5-11770
      PUT FILE (CUP) EDIT ('EFFECTIVE RAINFALL, IRRIGATION',            B5-11780
       ' REQUIREMENT AND RESERVOIR OPERATION STUDY FOR HOULUN',B5-11790
       'G RESERVOIR')(PAGE, X(20), A(30), A(53), A(11)),.               B5-11800
      PUT FILE(CUP) EDIT ((95)'-')(SKIP(1), X(20), A),.                 B5-11810
            YR=I+1950,.                                                 B5-14510
      PUT FILE (CUP) EDIT ('YEAR..',YR)(SKIP(1),X(1),A,X(1),            B5-11820
                                      F(4)),.                           B5-11821
      PUT FILE (CUP) EDIT ((11)'-')(SKIP(1),X(1),A),.                   B5-11830
      PUT FILE (CUP) EDIT ('MON','PT','RAIN','EFFECTIVE RAIN',          B5-11840
       'FALL','IRRIGATION','DOMESTIC','REQUIRED','RESERVOIR',           B5-11850
       'EVAPORA-','NET','STORAGE','SPILLAGE','DEFICIEN')                B5-11860
       (SKIP(1),X(1),A,X(1),A,X(1),A,X(5),A,A,X(3),A,X(1),A,            B5-11870
       X(1),A,X(2),A,X(1),A,X(1),A,X(9),A,X(4),A,X(2),A),.              B5-11880
      PUT FILE (CUP) EDIT ('FALL','AREA','AREA','AREA','AREA',          B5-11890
       'REQUIREMENT','INDUSTRY','RESERVOIR','INFLOW','TION',            B5-11900
       'RESERVOIR','-CY')(SKIP(1),X(8),A,X(2),A,X(2),A,X(2),A,  B5-11910
       X(2),A,X(1),A,X(1),A,X(1),A,X(1),A,X(4),A,X(5),A,X(24), B5-11920
       A),.                                                             B5-11930
      PUT FILE (CUP) EDIT ('(1)','(2)','(3)','(4)','REQUIRE-', B5-11940
       'RELEASE','LOSS','INFLOW')(SKIP(1),X(15),A,X(3),A,X(3), B5-11950
       A,X(3),A,X(13),A,X(1),A,X(13),A,X(5),A),.                        B5-11960
      PUT FILE (CUP) EDIT ('MENT')(SKIP(1),X(49),A),.                   B5-11970
      PUT FILE (CUP) EDIT ('M.M.','M.M.','M.M.','M.M.','M.M.',  B5-11980
       'CUB. M.','CUB. M.','CUB. M.','CUB. M.','CUB. M.',               B5-11990
       'CUB. M.','CUB. M.','CUB. M.','CUB. M.')(SKIP(1),X(8),   B5-12000
       A,X(2),A,X(2),A,X(2),A,X(2),A,X(3),A,X(3),A,X(2),A,              B5-12001
       X(3),A,X(3),A,X(4),A,X(4),A,X(4),A,X(4),A),.                     B5-12002
      PUT FILE (CUP) EDIT ((130)'-')(SKIP(1),X(1),A),.                  B5-12010
      DO M=1 TO 4,. SOIL(2,M)=0,. END,.                                 B5-12020
       CTR=0,.                                                          B5-12030
      YRAIN=0,.                                                         B5-12070
      YER1=0,. YER2=0,. YER3=0,. YER4=0,.                               B5-12080
```

```
     YUPLAND=0,.                                                    B5-12081
 YSQ=0,.                                                            B5-12090
 YDI=0,.                                                            B5-12100
 YRELES=0,.                                                         B5-12110
 YINF=0,.                                                           B5-12120
 YLOSSEV=0,.                                                        B5-12130
 YNETINF=0,.                                                        B5-12140
 YSPIL=0,.   YDEF=0,.                                               B5-12141
 IF  I=1 THEN  IB=7,.                                               B5-12150
 ELSE  IB=1,.                                                       B5-12160
MON.. DO J=IB TO 12,.                                               B5-12170
 IF  I=1 AND J=7 THEN DO,.                                          B5-12171
  CTR(8,1)=7,.  CTR(8,2)=7,. CTR(8,3)=7,.  CTR(8,4)=7,.             B5-12172
  END,.                                                             B5-12173
 PAR..  DO K=1 TO 3,.  PNETINF=0,.                                  B5-12180
         PDI=0,. PRAIN=0,. PINF=0,. PSQ=0,. PLOSSEV=0,.             B5-12190
         PER1=0,. PER2=0,. PER3=0,. PER4=0,.                        B5-12191
          PEVP=0,.                                                  B5-12192
 SPIL=0,.   DEF=0,.                                                 B5-12193
     PUPLAND=0,.                                                    B5-12194
         GET FILE (GLASS) EDIT (RAIN, BLK)                          B5-12200
             (11 (F(4,1),X(1)), X(24), A(1)),.                      B5-12210
         GET FILE (GLASS) EDIT (EVP, BLK)                           B5-12220
             (11 (F(4,1),X(1)), X(24), A(1)),.                      B5-12230
         GET FILE (GLASS) EDIT (INF, BLK)                           B5-12240
            (11 F(5,2),X(24),A(1)),.                                B5-12250
   DO L=1 TO 11,.                                                   B5-12270
   IF RAIN(L)=999.9 THEN GO TO DAY,.                                B5-12280
          GO TO SWITCH(2,J),.                                       B5-12310
          J01.. GO TO ONE,.                                         B5-12320
          J03.. IF K=1 AND L LT 7 THEN GO TO ONE,.                  B5-12330
                ELSE GO TO TWO,.                                    B5-12340
          J04.. GO TO TWO,.                                         B5-12350
          J07.. IF K=1 AND L LE 7 THEN GO TO TWO,.                  B5-12360
                ELSE GO TO THREE,.                                  B5-12370
          J08.. GO TO THREE,.                                       B5-12380
          J11.. IF K=1 AND L LE 7 THEN GO TO THREE,.                B5-12390
```

```
        ELSE GO TO ONE,.                                         B5-12400
    ONE.. DO M=1 TO 4,. H(M)=V(1,M),. END,.                      B5-12410
        GO TO ZONE,.                                             B5-12420
    TWO.. DO M=1 TO 4,. H(M)=V(2,M),. END,.                      B5-12430
        GO TO ZONE,.                                             B5-12440
    THREE.. DO M=1 TO 4,. H(M)=V(3,M),. END,.                    B5-12450
ZONE.. DO M=1 TO 4,.                                             B5-12471
     IF H(M)=1 THEN DO,.                                         B5-12480
      E=SOIL(1,M),.                                              B5-12490
      D=SOIL(2,M),.                                              B5-12500
      MAX=YD,.                                                   B5-12510
      G=0,.                                                      B5-12520
      EFF=1.0,.                                                  B5-12530
    GO TO SWITCH(3,J),.                                          B5-12570
     B01.. GO TO TEN,.                                           B5-12580
     B03.. IF K=1 AND L LT 7 THEN GO TO TEN,.                    B5-12590
           ELSE GO TO FIVE,.                                     B5-12600
     B04.. GO TO NINE,.                                          B5-12610
     B06.. IF K=3 AND L GT 4 THEN GO TO SIX,.                    B5-12620
           ELSE GO TO NINE,.                                     B5-12630
     B07.. IF K=1 AND L LE 8 THEN GO TO SIX,.                    B5-12640
           ELSE IF K=3 AND L GE 2 THEN GO TO SEVEN,.B5-12650
                ELSE GO TO TEN,.                                 B5-12660
     B08.. IF K=1 THEN GO TO SEVEN,.                             B5-12670
           ELSE GO TO NINE,.                                     B5-12680
     B10.. IF K=1 THEN GO TO NINE,.                              B5-12690
           ELSE IF K=2 AND L LE 9 THEN GO TO NINE,.  B5-12700
                ELSE GO TO EIGHT,.                               B5-12710
     B11.. IF K=1 AND L LE 7 THEN GO TO EIGHT,.                  B5-12720
           ELSE GO TO TEN,.                                      B5-12730
    FIVE.. CTR(7,M)=CTR(7,M)+1,.                                 B5-12740
           ALPHA=TA(CTR(7,M)),.                                  B5-12750
            GO TO CL,.                                           B5-12760
    SIX..  CTR(8,M)=CTR(8,M)+1,.                                 B5-12770
           ALPHA=TB(CTR(8,M)),.                                  B5-12780
          GO TO CL,.                                             B5-12790
    SEVEN.. CTR(9,M)=CTR(9,M)+1,.                                B5-12800
```

```
            ALPHA=TCD(1,CTR(9,M)),.                              B5-12810
             GO TO CL,.                                          B5-12820
      EIGHT.. CTR(10,M)=CTR(10,M)+1,.                            B5-12830
            ALPHA=TCD(2,CTR(10,M)),.                             B5-12840
             GO TO CL,.                                          B5-12850
      NINE.. ALPHA=1.000,.                                       B5-12860
             GO TO CL,.                                          B5-12870
      TEN.. ALPHA=0,.                                            B5-12880
  CL.. GO TO SWITCH(4,J),.                                       B5-12930
      C01.. IF K=3 AND L GE 6 THEN GO TO ELEVN,.                 B5-12940
            ELSE GO TO THIRTN,.                                  B5-12950
      C02.. GO TO ELEVN,.                                        B5-12960
      C04.. GO TO THIRTN,.                                       B5-12970
      C07.. IF K=1 AND L LE 2 THEN GO TO THIRTN,.                B5-12980
            ELSE GO TO TWELVE,.                                  B5-12990
      C08.. IF K=1 THEN GO TO TWELVE,.                           B5-13000
            ELSE GO TO THIRTN,.                                  B5-13010
      ELEVN.. CTR(11,M)=CTR(11,M)+1,.                            B5-13020
            BETA=PA(CTR(11,M)),.                                 B5-13030
             GO TO DL,.                                          B5-13040
      TWELVE.. CTR(12,M)=CTR(12,M)+1,.                           B5-13050
              BETA=PB(CTR(12,M)),.                               B5-13060
               GO TO DL,.                                        B5-13070
       THIRTN.. BETA=0,.                                         B5-13080
  DL.. GO TO SWITCH(5,J),.                                       B5-13130
      D01.. DO N=1 TO 4,. SOIL(5,N)=0,. END,.                    B5-13140
            GO TO CAL,.                                          B5-13150
      D03.. IF K=1 AND L LT 6 THEN                               B5-13160
            DO N=1 TO 4,. SOIL(5,N)=0,. END,.                    B5-13161
            ELSE IF K=3 AND L GT 10 THEN                         B5-13170
            DO N=1 TO 4,. SOIL(5,N)=0,. END,.                    B5-13171
ELSE DO N=1 TO 4,. SOIL(5,N)=SOIL(6,N),. END,. GO TO CAL,.       B5-13180
D07.. IF K=3 THEN DO N=1 TO 4,. SOIL(5,N)=SOIL(7,N),. END,.      B5-13190
ELSE DO N=1 TO 4,. SOIL(5,N)=0,. END,. GO TO CAL,.               B5-13200
      D08.. IF K=1 AND L LE 9 THEN                               B5-13210
            DO N=1 TO 4,. SOIL(5,N)=SOIL(7,N),. END,.            B5-13211
ELSE DO N=1 TO 4,. SOIL(5,N)=0,. END,. GO TO CAL,.               B5-13220
```

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          END,.                                                B5-13240
           ELSE DO,.  /* H(M) NE 1 */                          B5-13250
         GO TO SWITCH(6,J),.                                   B5-13300
                 E01.. GO TO NINETN,.                          B5-13310
                 E02.. IF K=1 THEN GO TO NINETN,.              B5-13320
                       ELSE GO TO SEVNTN,.                     B5-13330
                 E03.. GO TO SEVNTN,.                          B5-13340
                 E07.. IF K=1 THEN GO TO SEVNTN,.              B5-13350
                             ELSE GO TO EIGHTN,.               B5-13360
                 E08.. GO TO EIGHTN,.                          B5-13370
SEVNTN.. CTR(1,M)=CTR(1,M)+1,.  WW=CTR(1,M)/12,.               B5-13380
                CTR(4,M)=1+WW,.                                B5-13390
                IF CTR(4,M) GT 10 THEN CTR(4,M)=10,.           B5-13400
                 A=XABC(1,CTR(4,M)),.                          B5-13410
                  GO TO POP,.                                  B5-13420
EIGHTN.. CTR(2,M)=CTR(2,M)+1,.  WW=CTR(2,M)/11,.               B5-13430
                 CTR(5,M)=1+WW,.                               B5-13440
                IF CTR(5,M) GT 10 THEN CTR(5,M)=10,.           B5-13450
                 A=XABC(2,CTR(5,M)),.                          B5-13460
                  GO TO POP,.                                  B5-13470
NINETN.. CTR(3,M)=CTR(3,M)+1,.  WW=CTR(3,M)/10,.               B5-13480
                 CTR(6,M)=1+WW,.                               B5-13490
                IF CTR(6,M) GT 10 THEN CTR(6,M)=10,.           B5-13500
                 A=XABC(3,CTR(6,M)),.                          B5-13510
     POP.. E=A*EVP(L),.                                        B5-13530
           D=SOIL(3,M),.                                       B5-13540
           MAX=YE,.                                            B5-13550
           G=MAX,.                                             B5-13560
           EFF=0.7,.                                           B5-13570
           ALPHA=1.000,.                                       B5-13580
           BETA=0,.                                            B5-13590
           DO N=1 TO 4,. SOIL(5,N)=0,. END,.                   B5-13600
           END,.                                               B5-13620
        CAL.. D=D+RAIN(L)-E,.                                  B5-13630
              IF D GT MAX THEN DO,.                            B5-13640
                 F=D-MAX,.                                     B5-13650
              EIR(1,M,L)=RAIN(L)-F,.                           B5-13660
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```
                    EIR(2,M,L)=0,.                                B5-13670
                       D=MAX,.                                    B5-13680
                       GO TO WATER,.                              B5-13690
                       END,.                                      B5-13700
                     ELSE IF D GT 0 AND D LE MAX THEN DO,.        B5-13710
                          EIR(1,M,L)=RAIN(L),.                    B5-13720
                          EIR(2,M,L)=0,.                          B5-13730
                            GO TO WATER,.                         B5-13740
                            END,.                                 B5-13750
                          ELSE IF D LE 0  THEN DO,.               B5-13760
                         EIR(1,M,L)=RAIN(L),.                     B5-13770
                         EIR(2,M,L)=(-D)+G,.                      B5-13780
                            GO TO WATER,.                         B5-13790
                            END,.                                 B5-13800
WATER.. INTER1=EIR(2,M,L)/EFF,. INTER2=ALPHA*SOIL(4,M),.          B5-13810
        QPS(1,M)=INTER1*INTER2*10,.                               B5-13811
                            QPS(3,M)=BETA*SOIL(4,M)*16,.          B5-13820
                      QPS(2,M)=SOIL(5,M)*SOIL(4,M)*0.4,.          B5-13830
                IF H(M)=1 AND D GE 0 THEN SOIL(2,M)=D,.           B5-13840
                IF H(M)=1 AND D LT 0 THEN SOIL(2,M)=0,.           B5-13841
                IF H(M) NE 1 AND D GT 0 THEN SOIL(3,M)=D,.        B5-13850
                IF H(M) NE 1 AND D LE 0 THEN SOIL(3,M)=G,.        B5-13851
              END,.  /* END LOOP M */                             B5-13860
              X=0,. Y=0,. Z=0,.                                   B5-13870
              DO N=1 TO 4,.    X=X+QPS(1,N),.                     B5-13880
                               Y=Y+QPS(3,N),.                     B5-13881
                               Z=Z+QPS(2,N),. END,.               B5-13890
          PUPLAND=PUPLAND+QPS(1,4),.                              B5-13891
              GO TO SWITCH(7,J),.                                 B5-13940
                    S01.. GO TO SQ1,.                             B5-13950
                    S07.. IF K=3 THEN GO TO SQ2,.                 B5-13960
                              ELSE GO TO SQ1,.                    B5-13970
                    S08.. GO TO SQ2,.                             B5-13980
                    S10.. IF K=3 THEN GO TO SQ1,.                 B5-13990
                              ELSE GO TO SQ2,.                    B5-14000
          SQ1..     SQ=(X+Y+Z)/0.75,. GO TO JUP,.                 B5-14010
          SQ2..     SQ=(X+Y+Z+SUPQ)/0.75,.                        B5-14020
```

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JUP..  ARGS=S,.                                                    B5-14030
        CALL LOOKUP (CAP, RAR, ARGS, WSA),.                        B5-14031
            LOOKUP.. PROCEDURE (X,Y,A,B),.                         B5-14040
                     DECLARE  (X(19),Y(19)) FIXED (10,2),          B5-14050
                                I FIXED(2),                        B5-14051
                               A FIXED (8),                        B5-14060
                               B FIXED (10,2),.                    B5-14061
                     IF A LT X(1) OR A GT X(19) THEN DO,.          B5-14070
  PUT FILE (CUP) EDIT ('WRONG DATA FOR LOOKUP')(SKIP(3),A),.B5-14090
  STOP,. END,.                                                     B5-14100
                     ELSE DO,.                                     B5-14110
                          DO I=1 TO 19,.                           B5-14120
                          IF A=X(I) THEN DO,. B=Y(I),.             B5-14130
                          RETURN,. END,.                           B5-14140
                          END,.                                    B5-14150
                          DO I=1 TO 18,.                           B5-14160
                           IF A GT X(I) AND A LT X(I+1) THENB5-14170
               DO,.  INTER3=(A-X(I))/(X(I+1)-X(I)),.               B5-14180
                     INTER4=INTER3*(Y(I+1)-Y(I)),.                 B5-14190
                     B=Y(I)+INTER4,.                               B5-14191
                           RETURN,. END,.                          B5-14200
                           END,.                                   B5-14210
                          END,.                                    B5-14220
                     END LOOKUP,.                                  B5-14230
             WSAA=WSA/100,.                                        B5-14240
               LNR(1,L)=6*EVP(L)*WSAA,.                            B5-14241
                       LNR(2,L)=INF(L)*86400-LNR(1,L),.            B5-14250
                       LNR(3,L)=SQ+DOMIND,.                        B5-14260
                       DELTS=LNR(2,L)-LNR(3,L),.                   B5-14270
                      S=S+DELTS,.                                  B5-14280
   IF S GT MAXS THEN DO,.                                          B5-14290
              LSPIL=S-MAXS,.                                       B5-14291
              LDEF=0,.                                             B5-14292
              S=MAXS,.                                             B5-14293
              END,.                                                B5-14294
             ELSE IF S LE MAXS AND S GE MINS THEN DO,.             B5-14295
               LSPIL=0,.                                           B5-14296
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        LDEF=0,.                                          B5-14297
        END,.                                             B5-14298
           ELSE DO,.                                      B5-14299
            LSPIL=0,.                                     B5-14300
            LDEF=MINS-S,.                                 B5-14301
            S=MINS,.                                      B5-1430T
            END,.                                         B5-14302
SPIL=SPIL+LSPIL,.                                         B5-14303
DEF=DEF+LDEF,.                                            B5-14304
               PDI=PDI+DOMIND,.      PSQ=PSQ+SQ,.          B5-14310
               PRAIN=PRAIN+RAIN(L),.                      B5-14320
               PNETINF=PNETINF+LNR(2,L),.                 B5-14321
        PEVP=PEVP+EVP(L),.                                B5-14322
               PINF=PINF+INF(L)*86400,.                   B5-14330
               PLOSSEV=PLOSSEV+LNR(1,L),.                 B5-14331
            PER1=PER1+EIR(1,1,L),.                        B5-14332
            PER2=PER2+EIR(1,2,L),.                        B5-14333
            PER3=PER3+EIR(1,3,L),.                        B5-14334
            PER4=PER4+EIR(1,4,L),.                        B5-14335
        DAY..  ,.                                         B5-14336
        END,.  /* END LOOP L */                           B5-14340
       YRAIN=YRAIN+PRAIN,.                                B5-14350
          YER1=YER1+PER1,.  YER2=YER2+PER2,.              B5-14410
          YER3=YER3+PER3,.  YER4=YER4+PER4,.              B5-14420
    YUPLAND=YUPLAND+PUPLAND,.                             B5-14421
       YSQ=YSQ+PSQ,.                                      B5-14430
       YDI=YDI+PDI,.                                      B5-14440
       PRELES=PSQ+PDI,.                                   B5-14450
       YRELES=YRELES+PRELES,.                             B5-14460
       YINF=YINF+PINF,.                                   B5-14470
       YLOSSEV=YLOSSEV+PLOSSEV,.                          B5-14480
       YNETINF=YNETINF+PNETINF,.                          B5-14490
YSPIL=YSPIL+SPIL,.                                        B5-14491
YDEF=YDEF+DEF,.                                           B5-14492
       GO TO SWITCH(8,J),.                                B5-14520
       M1.. MN='JAN',.  GO TO ERT,.                       B5-14521
        M2.. MN='FEB',.  GO TO ERT,.                      B5-14530
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        M3.. MN='MAR',.  GO TO ERT,.                          B5-14540
        M4.. MN='APR',.  GO TO ERT,.                          B5-14550
        M5.. MN='MAY',.  GO TO ERT,.                          B5-14560
        M6..  MN='JUN',.  GO TO ERT,.                         B5-14570
        M7..  MN='JUL',.  GO TO ERT,.                         B5-14580
        M8..  MN='AUG',.  GO TO ERT,.                         B5-14590
        M9..  MN='SEP',.  GO TO ERT,.                         B5-14600
        MA..  MN='OCT',.  GO TO ERT,.                         B5-14610
        MB..  MN='NOV',.  GO TO ERT,.                         B5-14620
        MC..  MN='DEC',.                                      B5-14630
 ERT.. PUT FILE (CUP) EDIT (MN,K,PRAIN,PER1,PER2,PER3,        B5-14650
       PER4,PPSQ,PPDI,PPRELES,PPINF,PPLOSSEV,PPNETINF,        B5-14660
       SS,SSPIL,DDEF)(SKIP(1),X(1),A(3),X(1),F(1),X(1),       B5-14670
       F(5,1),X(1),F(5,1),X(1),F(5,1),X(1),F(5,1),X(1),       B5-14680
       F(5,1),X(1),A(10),X(1),A(7),X(1),A(10),X(1),A(10),B5-14690
       X(1),A(7),X(1),A(11),X(1),A(10),X(1),A(10),            B5-14700
       X(1),A(9)),.                                           B5-14701
     PUT FILE (CUP) EDIT ('(IR4..',PPUPLAND,')')(SKIP(1),     B5-14708
      X(34),A,X(1),A(7),A),.                                  B5-14709
       N=(J-1)*3+K,.                                          B5-14710
             SARY(I,N)=S,.                                    B5-14790
        CDF(1,I,N)=PINF,.                                     B5-14800
           CDF(2,I,N)=PDI,.                                   B5-14810
        CDF(3,I,N)=PSQ,.                                      B5-14820
        CDF(4,I,N)=PEVP*10,.                                  B5-14821
        END,.  /* END LOOP K */                               B5-14830
       END,.   /* END LOOP J */                               B5-14840
 PUT FILE (CUP) EDIT ((130)'-')(SKIP(1),X(1),A),.             B5-14850
      PUT FILE (CUP)EDIT(YYRAIN,YYER2,YYER4,YYDI,             B5-14860
   YYINF,YYNETINF,YSSPIL)(SKIP(1),X(5),A,X(5),A,X(5),A,       B5-14870
   X(6),A,X(9),A,X(7),A,X(9),A),.                             B5-14880
      PUT FILE (CUP)EDIT(YYER1,YYER3,YYSQ,YYRELES,            B5-14890
   YYLOSSEV,YDDEF)(SKIP(1),X(11),A,X(5),A,X(4),A,X(5),A,      B5-14900
   X(9),A,X(31),A),.                                          B5-14910
 TSPIL=TSPIL+YSPIL,.                                          B5-14911
 TDEF=TDEF+YDEF,.                                             B5-14912
     PUT FILE (CUP) EDIT ('(IR4..',YYUPLAND,')')(SKIP(1),     B5-14913
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      X(30),A,X(1),A(10),A),.                                    B5-14914
      END,.       /* END LOOP I */                               B5-14920
PUT FILE (CUP) EDIT ('RESULT OF RESERVOIR OPERATION',            B5-14921
  '(NO OPERATION CURVE)')(PAGE,LINE(5),X(44),A,X(1),A),.         B5-14922
PUT FILE (CUP) EDIT ((52)'-')(SKIP(1),X(44),A),.                 B5-14923
PUT FILE (CUP) EDIT ('TOTAL SPILLAGE ..',TTSPIL,'CUB. M.'        B5-14924
  )(SKIP(2),X(44),A,X(8),A,X(3),A),.                             B5-14925
PUT FILE (CUP) EDIT ('TOTAL DEFICIENCY ..',TTDEF,                B5-14926
  'CUB. M.')(SKIP(2),X(44),A,X(8),A,X(3),A),.                    B5-14927
ORDER.. DO N=1 TO 36,.                                           B5-14930
         DO I=1 TO ZA,.                                          B5-14940
           XY(I)=SARY(I,N),.                                     B5-14950
         INTER5=I/ZA,.                                           B5-14980
           XX(I)=INTER5*100,.                                    B5-14981
           END,.                                                 B5-14990
        ZZ=ZA-1,.                                                B5-15000
        KARA..  NS=0,.                                           B5-15010
                DO I=1 TO ZZ,.                                   B5-15020
                IF XY(I) GE XY(I+1) THEN NS=NS+1,.               B5-15030
                ELSE DO,.                                        B5-15040
                 T=XY(I),.                                       B5-15050
                 XY(I)=XY(I+1),.                                 B5-15060
                 XY(I+1)=T,.                                     B5-15070
                 END,.                                           B5-15080
                END,.                                            B5-15090
        IF NS=ZZ THEN GO TO CRAY,.                               B5-15100
        ELSE GO TO KARA,.                                        B5-15110
        CRAY..  AA(1,N)=XY(1),.                                  B5-15120
                AA(2,N)=XY(ZA),.                                 B5-15130
                IF XY(ZA)=9999 OR XY(ZA)=MINS THEN GO TO         B5-15140
                PAPER,. ELSE GO TO CLEAR,.                       B5-15150
         PAPER.. DO J=1 TO (ZA-1),.                              B5-15170
                   W=ZA-J,.                                      B5-15180
                              IF XY(W)=MINS THEN GO TO           B5-15190
                                THICK,.                          B5-15200
                              ELSE AA(2,N)=XY(W),.               B5-15210
                              GO TO CLEAR,.                      B5-15220
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                         THICK.. ,. END,.                         B5-15230
                     IF XY(1)=MINS THEN DO,.                      B5-15240
                       AA(1,N)=0,.                                B5-15250
                       AA(2,N)=0,. END,.                          B5-15260
                     CLEAR.. DO J=25   TO 75    BY 25,.           B5-15270
                           IF J=25   THEN K=3,.                   B5-15280
                           IF J=50   THEN K=4,.                   B5-15290
                           IF J=75   THEN K=5,.                   B5-15300
                          ARGJ=J,.                                B5-15301
                          CALL LOOKUP (XX,XY,ARGJ,ARGAA),.        B5-15310
                          AA(K,N)=ARGAA,.                         B5-15311
                           END,.                                  B5-15320
                END,.  /* END LOOP N */                           B5-15330
 PUT FILE (CUP) EDIT ('OPERATION CURVES FOR HOULUNG RESERVOIR')B5-15340
      (PAGE, X(45), A),.                                          B5-15350
    PUT FILE (CUP) EDIT ((38)'-')(SKIP(1),X(45),A),.              B5-15360
    PUT FILE (CUP) EDIT ('N','CURVE 1','CURVE 2','CURVE 3',       B5-15370
        'CURVE 4','CURVE 5','CURVE 6')(SKIP(2),X(20),A,X(6),B5-15380
        A,X(8),A,X(8),A,X(8),A,X(8),A,X(8),A),.                   B5-15390
    PUT FILE (CUP) EDIT ((93)'-')(SKIP(1),X(20),A),.              B5-15400
    DO N=1 TO 36,.                                                B5-15410
      PUT FILE (CUP) EDIT (N,AAA(1,N),AAA(2,N),AAA(3,N),          B5-15420
         AAA(4,N),AAA(5,N),AAA(6,N))(SKIP(1),X(20),F(2),          B5-15430
        6 (X(5),A)),.                                             B5-15440
      END,.                                                       B5-15450
    YYSUD=0,.  YYDT=0,.                                           B5-15460
CURVE.. DO K=1 TO 6,.                                             B5-15470
      ANNEE.. DO I=1 TO ZA,.                                      B5-15480
                  YCC=0,. YCR=0,. YCF=0,. YCD=0,.                 B5-15490
                  YSPIL=0,. YU=0,. YDEF=0,. YDT=0,.               B5-15500
    PUT FILE (CUP) EDIT ('HOULUNG RESERVOIR OPERATION STUDY', B5-15510
        BASED ON OPERATION CURVE ',K)                             B5-15520
        (PAGE, X(45), A, A, F(1)),.                               B5-15530
                 PUT FILE (CUP) EDIT ('YEAR','PT','IRRIGATION',B5-15540
                    'DOMESTIC &','REQUIRED','NET','OPERATION', B5-15550
    'STORAGE','SPILLAGE','AMOUNT OF','DEFICIENCY','DT')           B5-15560
        (SKIP(2), X(1), A, X(1), A, X(1), A,                      B5-15570
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          X(5),A,X(2),A,X(6),A,X(11),A,X(2),A,X(5),A,B5-15580
           X(6),A,X(5),A,X(2),A),.                    B5-15590
       PUT FILE (CUP) EDIT ('REQUIREMENT','INDUSTRY',B5-15600
          'RESERVOIR','RESERVOIR','CURVE','UTILIZED')B5-15610
          (SKIP(1),X(9),A,X(4),A,X(4),A,X(5),A,       B5-15620
           X(5),A,X(32),A),.                          B5-15630
       PUT FILE (CUP) EDIT ('REQUIREMENT','RELEASE', B5-15640
           'INFLOW','INFLOW')(SKIP(1),X(24),A,        B5-15650
           X(1),A,X(7),A,X(45),A),.                   B5-15660
       PUT FILE (CUP) EDIT ('(CUB.M.)','(CUB.M.)',    B5-15670
'(CUB.M.)','(CUB.M.)','(CUB.M.)','(CUB.M.)',          B5-15680
'(CUB.M.)','(CUB.M.)','(CUB.M.)')(SKIP(1),            B5-15690
          X(10),A,X(6),A,X(4),A,X(6),A,X(6),A,X(3),   B5-15700
           A,X(5),A,X(5),A,X(6),A),.                  B5-15710
   PUT FILE (CUP) EDIT ((131)'-')(SKIP(1),X(1),A),.   B5-15720
       IF I=1 THEN DO,.                               B5-15740
           S=MAXS,.                                   B5-15750
           IB=19,.                                    B5-15760
           END,.                                      B5-15770
       ELSE IB=1,.                                    B5-15780
       DIS.. DO N=IB TO 36,.                          B5-15790
              IF AA(K,N)=0 THEN DO,.                  B5-15800
                 IF N LE 36 THEN P=N+1,.              B5-15810
                 IF N=36 THEN P=N-1,.                 B5-15820
                 AA(K,N)=AA(K,P),.                    B5-15830
                 END,.                                B5-15840
              IF S GE AA(K,N) THEN                    B5-15850
                 THETA=1.0,.                          B5-15860
              ELSE THETA=0.7,.                        B5-15870
                    CR=THETA*CDF(3,I,N)+CDF(2,I,N),.B5-15880
                    ARGS=S,.                          B5-15881
                    CALL LOOKUP(CAP,RAR,ARGS,WSA),.   B5-15882
                   WSAA=WSA/100,.                     B5-15883
                    T=CDF(4,I,N),.                    B5-15884
                    PEVP=T/10,.                       B5-15885
           LOSSPEV=6*PEVP*WSAA,.                      B5-15886
           DELTS=CDF(1,I,N)-LOSSPEV-CR,.              B5-15890
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               S=S+DELTS,.                              B5-15900
               IF S GT MAXS THEN DO,.                   B5-15910
                 SPIL=S-MAXS,.                          B5-15920
                 DEF=0,.                                B5-15930
                 DT=0,.                                 B5-15940
                 U=CDF(1,I,N)-SPIL,.                    B5-15950
                 S=MAXS,.                               B5-15960
                 END,.                                  B5-15970
               ELSE IF S LE MAXS AND S GE MINS          B5-15980
                THEN DO,.                               B5-15990
                  SPIL=0,.                              B5-16000
                  DEF=0,.                               B5-16010
                  U=CDF(1,I,N),.                        B5-16020
                  DT=0,.                                B5-16030
                  END,.                                 B5-16040
                    ELSE DO,.                           B5-16050
                         DEF=MINS-S,.                   B5-16060
                         DT=1,.                         B5-16070
                         SPIL=0,.                       B5-16080
                         U=CDF(1,I,N),.                 B5-16090
                         S=MINS,.                       B5-16100
                         END,.                          B5-16110
 YR=I+1950,.                                            B5-16111
          PUT FILE(CUP)EDIT(YR,N,CCDF(3,I,N),           B5-16120
      CCDF(2,I,N),CCR,CCDF(1,I,N),AAA(K,N),SS,          B5-16130
            SSPIL,UU,DDEF,DT)(SKIP(1),X(1),F(4),        B5-16140
        X(1),F(2),X(2),A,X(1),A,X(5),A,X(4),A,          B5-16150
        X(4),A,X(1),A,X(3),A,X(4),A ,X(4),A,            B5-16160
           .X(3),F(1)),.                                B5-16170
          YCR=YCR+CR,.                                  B5-16180
          YCF=YCF+CDF(3,I,N),.                          B5-16190
          YCD=YCD+CDF(2,I,N),.                          B5-16200
          YCC=YCC+CDF(1,I,N),.                          B5-16210
          YSPIL=YSPIL+SPIL,.                            B5-16220
          YU=YU+U,.                                     B5-16230
          YDEF=YDEF+DEF,.                               B5-16240
          YDT=YDT+DT,.                                  B5-16250
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                    END,.  /* END LOOP N (CURVE) */              B5-16260
                PUT FILE (CUP) EDIT ((131)'-')(SKIP(1),X(1),     B5-16270
                    A),.                                         B5-16280
                PUT FILE (CUP) EDIT (YCCF,YCCD,YCCR,YCCC,        B5-16290
                  YSSPIL,YUU,YDDEF,YDT)(SKIP(1),X(7),A,X(1),     B5-16300
                  A,X(2),A,X(1),A,X(25),A,X(1),A,A,X(2),         B5-16310
                   F(2)),.                                       B5-16320
                YYSUD(1,K)=YYSUD(1,K)+YSPIL,.                    B5-16330
                YYSUD(2,K)=YYSUD(2,K)+YU,.                       B5-16340
                YYSUD(3,K)=YYSUD(3,K)+YDEF,.                     B5-16350
                YYDT(K)=YYDT(K)+YDT,.                            B5-16360
            END,.          /* END LOOP I (CURVE) */              B5-16370
       END,.               /* END LOOP K (CURVE) */              B5-16380
SELECT.. PUT FILE (CUP) EDIT ('RESULT OF RESERVOIR OPERATION',B5-16660
        ' BASED ON SIX OPERATION CURVES')(PAGE,X(42),A,A),.      B5-16670
    PUT FILE (CUP) EDIT ('OPERATION','TOTAL','TOTAL','TOTAL',B5-16680
   'TOTAL')(SKIP(1),X(20),A,X(9),A,X(16),A,X(18),A,X(14),A),.B5-16690
    PUT FILE (CUP) EDIT ('CURVE','SPILLAGE','UTILIZED',          B5-16700
      'DEFICIENCY','TIME OF')(SKIP(1),X(23),A,X(10),A,X(13),     B5-16710
      A,X(15),A,X(9), A),.                                       B5-16720
    PUT FILE (CUP) EDIT ('INFLOW','DEF.')(SKIP(1),X(59),A,       B5-16730
       X(36),A),.                                                B5-16740
    PUT FILE (CUP) EDIT ('CUB.M.','ORDER','CUB.M.','ORDER',      B5-16750
       'CUB.M.','ORDER','TIMES','ORDER')(SKIP(1),X(35),A,        B5-16760
       X(4),A,X(6),A,X(4),A,X(6),A,X(4),A,X(6),A,X(2),A),.       B5-16770
   PUT FILE (CUP) EDIT ((94)'-')(SKIP(1),X(20),A),.              B5-16780
    DO K=1 TO 6,.                                                B5-16790
     PUT FILE(CUP) EDIT(K,YYSSUD(1,K),'(',')',                   B5-16800
                       YYSSUD(2,K),'(',')',                      B5-16810
                       YYSSUD(3,K),'(',')',                      B5-16820
                       YYDT(K),'(',')')(SKIP(1),X(25),           B5-16830
                     F(1),X(4),A,X(1),A,X(1),A,                  B5-16840
                          X(2),A,X(1),A,X(1),A,                  B5-16850
                          X(2),A,X(1),A,X(1),A,                  B5-16860
                          X(7),F(4),X(3),A,X(1),A),.             B5-16870
     END,.                                                       B5-16880
     J13.. ,.                                                    B5-16881
END HOULUNG.                                                     B5-16890
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